Research Article

Received: 2 November 2022 Revised: 17 August 2023 Accepted article published: 22 August 2023 Published online in Wiley Online Library: 8 September 2023

(wileyonlinelibrary.com) DOI 10.1002/ps.7738

# Pesticide use, arthropod fauna and fruit damage in apple orchards in a Nordic climate

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## Abstract

**BACKGROUND: Integrated pest management (IPM) has a long history in fruit production and has become even more important with the implementation of the EU directive 2009/128/EC making IPM mandatory. In this study, we surveyed 30 apple orchards in Norway for 3 years (2016–2018) monitoring pest- and beneficial arthropods as well as evaluating fruit damage. We obtained growers' diaries of pest management and used these data to study positive and negative correlations of pesticides with the different arthropod groups and damage due to pests.**

**RESULTS: IPM level had no significant effects on damage of harvested apples by arthropod pests. Furthermore, damage by arthropods was mainly caused by lepidopteran larvae, tortricids being especially important. The number of insecticide applications varied between 0 and 3 per year (mean 0.8), while acaricide applications varied between 0 and 1 per year (mean 0.06). Applications were often based on forecasts of important pest species such as the apple fruit moth (*Argyresthia conjugella*). Narrow-spectrum insecticides were commonly used against aphids and lepidopteran larvae, although broad-spectrum neonicotinoid (thiacloprid) insecticides were also applied. Anthocorid bugs and phytoseiid mites were the most abundant natural enemies in the studied orchards. However, we found large differences in abundance of various "beneficials" (e.g., lacewings, anthocorids, parasitic wasps) between eastern and western Norway. A low level of IPM negatively affected the abundance of spiders.**

**CONCLUSION: Lepidoptera was found to be the most important pest group in apple orchards. Insecticide use was overall low, but number of spray applications and use of broad-spectrum insecticides varied between growers and regions. IPM level did not predict the level of fruit damage by insects nor the abundance of important pests or most beneficial groups in an apple orchard.**
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*Supporting information may be found in the online version of this article.*

**Keywords:** Integrated Pest Management; insecticides; natural enemies

## 1 INTRODUCTION

The concept of Integrated Pest Management (IPM) was conceived more than 60 years ago, to improve plant protection and minimize use of pesticides in agricultural systems.[1,2] During the 1960s, IPM was defined as combining knowledge of pests and plants with biological, cultural and chemical measures (see review in Damos et al.[2]) and pome fruit was one of the first productions to adopt IPM. In the 1970s, this was further developed and coined Integrated Fruit Production (IFP), a holistic orchard level approach to minimize undesirable effects of pest management. The Organization for Biological and Integrated Control of Noxious Animals and Plants (IOBC) defined IFP as "the economical production of high quality fruit, giving priority to ecological safer methods, minimizing the undesirable side effects and use of agrochemicals, to enhance the safeguards to the environment and human health".[3] IPM or IFP was in principle voluntary for growers. However, in 2014, IPM became mandatory for all professional users of pesticides in the EU, when the IPM regulation in EU directive 2009/128/EC on sustainable use of pesticides (European Parliament and Council, 2009) came into force. The directive specifies IPM as implementing eight sequential principles on prevention,

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monitoring, sound decision-making, and minimizing pesticide use.[4]

However, there is still much uncertainty about how the principles are actually put into practice, and there is potentially a high degree of different levels of IPM among growers.[5] Furthermore, it is often difficult to draw the line between IPM and non-IPM, i.e, to assess what it takes to follow the eight principles.[4] Although IPM strategies have been available for several decades, orchard systems, such as apple orchards, are still among the agricultural systems where pesticides are used most extensively.[2,6] At the same time, orchards are perennial systems where trees are harvested for many years, thus increasing the need for sustainable solutions. Ecosystem services such as natural enemies of pests and pollinating insects are especially important in such long-term systems.[7,8]

Since the Rio Earth Summit in 1992, there has been more focus on biodiversity loss, which to a large degree also relates to chemical inputs of pesticides and fertilizers in agriculture. During the last decade, a main concern has been that pesticides negatively affect non-target insects and thus may contribute significantly to the decline in diversity and biomass of insects reported in recent studies.[9] In particular, negative effects on pollinating insects have been studied and emphasized.[10–12] Thus, there is a demanding need for reducing the use of chemical pesticides in favor of alternatives such as biological control. Furthermore, if chemical control is the only option, narrow-spectrum pesticides should be preferred over broad-spectrum products.

In Norway, a major effort of IPM research and development in pome orchards started in the 1960s.[13] During the 1970s and into the 1990s, IFP was implemented in Norwegian fruit production by offering educational courses for growers on how to monitor arthropods in orchards with beating funnel and visual examinations including decision support systems (e.g., threshold levels of various pest insects). The decision tools also included forecasting models for codling moth *Cydia pomonella* (L.) (Lepidoptera: Tortricidae) and apple fruit moth *Argyresthia conjugella* Zeller (Lepidoptera: Argyresthiidae), as well as apple scab *Venturia inaequalis* (Cooke) G. Winter ex Thüm. (Pleosporales: Venturiaceae).[14] In addition, there was a focus on minimizing the dosage of chemical pesticides, especially organophosphates (OP), and simultaneously releasing a strain of OP-resistant predatory mites, *Typhlodromus pyri* Scheuten (Mesostigmata: Phytoseiidae), into orchards.[13] Furthermore, no pyrethroids were registered for use in Norwegian in top fruit. However, as it was decided in 1992 not to introduce a Norwegian IFP label, and as OPs were phased out in the 2000s, the trend of reduced number and dosage of sprays ceased or even reversed. In July 2015, Norway, being a member of the European Economic Community, implemented the EU directive on sustainable use of pesticides, making the eight IPM principles mentioned above part of Norwegian law. The EU is now in the process of replacing the directive with a regulation in order to reach their targets on pesticide-reduction and promotion of IPM and alternatives to chemical pesticides.[51]

Thus, evaluating, revising and developing IPM strategies is highly important, but to do this, we need data on existing practices and their relationship with the abundance of important pests and beneficials, and the level of fruit damage.

Here, we present a three-year survey (2016–2018) of 30 commercial apple orchards in which the abundance of selected pest and beneficial arthropods, the amount of fruit damage made by these pests and the number and rationale of insecticide treatments deployed by the growers were examined. We classified the growers' practice as low or high level of IPM to see if this was related to the occurrence of fruit damage or the abundance of selected arthropod groups. The study was a close collaboration between researchers and advisors, and the apple orchards were selected to include variation in pesticide use.

# 2 MATERIALS AND METHODS

## 2.1 Study area

The survey covered 15 apple orchards in each of two main fruit regions in Norway: Hardanger in western Norway, and Viken in eastern Norway. These two regions are 200 km apart and represent different climatic zones, the former situated in an inner fjord area characterized by a slightly oceanic climate with rather mild winters (mean temperature for December-February: 0.4 °C) and cool summers (mean temperatures for June-August: 14.3 °C). Parts of the Viken area are also slightly oceanic but other parts more continental,[15] with colder winter temperatures (mean −4.7 °C) and warmer summer temperatures (mean 15.0 °C) compared to the Hardanger area (www.met.no).

The 30 apple orchards were selected to be as uniform as possible with regard to cultivar ('Aroma'), age (4–10 years) and size (> 0.5 hectare), but also to encompass the variation among growers in their propensity to use pesticides. The minimum distance between two orchards was 220 m (in one case it was smaller: for two neighboring orchards in Viken, one organic and one IPM, this was the only organic orchard included in the study).

## 2.2 Sampling scheme for arthropods

In each orchard, the tree arthropod fauna was sampled with three different methods: (i) The beating funnel method[16] was carried out pre- and post-flowering in three seasons (2016– 2018). A 'beating funnel sample' comprised the arthropods falling into the funnel (covering 0.25 $m^2$) when triple-beating one branch in each of 33 trees along a Z-shaped walk in the orchard. (ii) The leaf washing method,[17] using a 160 μm mesh, was applied post flowering in 2016 and 2017. One 'leaf sample' consisted of arthropods washed off 50 random leaves, taken per orchard and year. (iii) Transparent delta traps with pheromone dispensers (Pherobank DV), one for the codling moth *C. pomonella*, and one for the fruitlet-mining tortrix moth *Pammene rhediella* (Clerck) (Lepidoptera: Tortricidae), were deployed from pre flowering to post flowering in 2016 and 2017. One 'trap sample' consisted of the total number of *C. pomonella* or *P. rhediella* caught in one orchard that year in the respective trap for that species.

The pre-flowering (BBCH 59) samples were taken from beginning to mid-May in all three years, and the post-flowering (BBCH 69) samples about 3–7 weeks later.

All insects and mites from beating-funnel samples and leaf samples were identified to order or family level, and in some cases to genus and/or species level, based on morphology.[18] Other arachnids were grouped as spiders (Araneae) or harvestmen (Opiliones). The two species targeted by pheromone traps were identified morphologically, but without genital examination.

## 2.3 Estimation of fruit damage and assessment of pesticide use

Fruit damage in the 30 orchards was sampled in 2016 and 2017. A few days before commercial harvest started, all apples from six random trees per orchard were collected, counted and weighed, yielding data from a total of 90 trees per region. From each of these trees, a maximum of 50 random apples (i.e., 300 per


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orchard) were then closely inspected for any damage visible on the fruit surface, using the pictorial key by Rein.[19] This included damage due to arthropod pests, fungal diseases, weather conditions and malnutrition.

Finally, to study the relationships between fruit damage, arthropod fauna and pesticide application, we obtained data from the growers on all applications of insecticides and acaricides in the orchards from 2016 to 2017, including the rationale for spraying. We categorized the IPM level in each orchard as low or high for each year. A low level was consigned if the orchard was sprayed without a clear documentation of monitoring the pest, or if using broad-spectrum pesticides as opposed to narrow-spectrum pesticides (i.e., using thiacloprid against aphids instead of flonicamid, or spirotetramat or spirodiclofen against mites). Contrastingly, a high level required that all pesticide treatments during that year were due to forecasting or monitoring, and/or that narrow-spectrum pesticides always were used if available.

### 2.4 Statistical analyses

For the insect abundance data from the beating funnel samples, we initially carried out a principal components analysis and generated a biplot of the first two principal components. Subsequently, we fitted Poisson generalized linear mixed models (GLMMs) using the abundance counts as response variables and including the effect of year as fixed, and the effects of grower within region as random. We also included an observation-level random effect to account for overdispersion.[20] We used likelihood-ratio (LR) tests for nested models to test for the effects of region and year. Finally, we tested for the additive effects of IPM level in the models.

In the leaf sample data, we analyzed the counts of phytoseiids by fitting Poisson GLMMs including all effects described above, and also the natural logarithm of the number of samples leaves as an offset in the linear predictor. We also tested for the significance of the effects of IPM level and acaricide applications using LR tests, the latter included as dummy covariates in the model.

For the trap data, we analyzed the correlation between *C. pomonella* and *P. rhediella* counts by fitting Poisson GLMMs using *P. rhediella* as the response and including different intercepts and slopes over *C. pomonella* for the different years of collection. We also included random intercepts per grower and an observation-level random effect to account for overdispersion and used LR tests to assess the significance of the model effects. Finally, we fitted Poisson GLMMs including the effects of year as fixed and grower within region as random, as well as the observation-level random effect, and tested for the significance of these effects using LR tests.

To analyze the Lepidoptera damage data, we fitted binomial GLMMs using the proportion of damaged apples as the response variable and including the effect of year as fixed and the effects of grower within region as random. Again, we included an observation-level random effect to model overdispersion and used LR tests for nested models to assess the significance of the explanatory variables. Afterwards, we tested for the effects of the number larvae of the Tortricidae, Noctuidae, and Geometridae families as covariates, and also IPM level. Finally, we assessed the significance of the use of narrow-spectrum pesticides as dummy covariates.

All analyses were carried out using R.[21] All mixed models were fitted using package lme4,[22] all graphics generated using package ggplot2,[23] and goodness-of-fit for all models was assessed using half-normal plots with simulation envelopes, using package hnp.[24]

## 3 RESULTS

### 3.1 Abundance of arthropods

In total, 24,040 specimens of arthropods were sampled by the beating funnel method (Appendix A–C). Psyllids (Hemiptera: Psylloidea) were the most abundant group of insects represented by 7803 individuals, followed by 3,981 anthocorid bugs (Hemiptera: Anthocoridae), 1936 spiders, 1618 leafhoppers (Hemiptera: Auchenorrhyncha), 1127 capsid/mirid bugs (Hemiptera: Miridae) and 1,060 ants (Hymenoptera: Formicidae). In the leaf samples we found 8349 arthropods, of which tydeid mites (Trombidiformes: Tydeidae) were the most common group represented by 3032 specimens, followed by 2367 phytoseiid predatory mites (Mesostigmata: Phytoseiidae) and 1646 thrips (Thysanoptera) (Appendix D). Some groups containing important pest species, such as spider mites (Trombidiformes: Tetranychidae) and aphids (Hemiptera: Aphididae), were low in abundance (Appendix A–D).

There were some differences between the two regions (Viken and Hardanger) included in our study (Fig. 1). The variation explained by only grouping the sites according to region was about 30%).

Anthocorid bugs, which are among the most important predators in fruit orchards, were seemingly more common in Hardanger compared with Viken (Figs 1 and 2). However, in Viken, other "beneficials" were more abundant than in Hardanger, such as lacewings and spiders (Fig. 1). The predatory phytoseiid mites were also more abundant in Viken compared with Hardanger, while the opposite pattern was found for tydeid mites (Fig. 3). However, this observed trend was not significant (LR = 1.46, d.f. = 1, $p = 0.227$).

In the pheromone traps, a total of 1,640 moths were sampled, of which 422 were identified as codling moth and 1,108 as fruitlet-mining tortrix moth. The codling moth was not recorded in Hardanger, while the latter species was common in both regions (Fig. 4). There was a positive relationship between the numbers caught of the two species in the Viken orchards in 2016, but this was not significant for both years combined (LR = 0.81, d.f. = 1, $p = 0.368$). Furthermore, the numbers of tortricid larvae (also called leaf rollers) found in the beating funnel samples were higher in Viken compared with Hardanger (Fig. 5), although not significantly higher (LR = 1.46, d.f. = 1, $p = 0.227$).

### 3.2 Pesticide treatments, IPM level and crop damage by arthropod pests at harvest

The use of broad-spectrum pesticides (thiacloprid) was higher after flowering than before flowering in both regions, and higher in Viken than Hardanger (Fig. 6). Most of the growers did not use any insecticides in spring before the apple flowering period, nor did they apply any broad-spectrum insecticides. Indeed, 53–70% of the growers were assigned a high IPM level, depending on the year (Supporting Information, Table S1). The mean number of insecticide sprays in the 30 orchards was $0.8 \pm 0.07$ sprays per year per orchard, and the maximum number of 3 sprays annually. Furthermore, the broad spectrum acaricide spirodiclofen was used $0.06 \pm 0.02$ times per year per orchard.

Skin damage identified as 'early damage by lepidopteran larvae', i.e., damage on fruitlets younger than about 8 weeks,[19] was the most common arthropod damage, ranging from 0 to 23% of apples affected per orchard. The early skin damage caused by lepidopterans was on average 9.2% and 7.8% of assessed fruits in 2016 and 2017, respectively in Viken, while the corresponding numbers in Hardanger were 8.4% and 7.4% (LR < 0.01, d.f. = 1, $p = 1.00$). The difference in damage between years where significant (LR = 3.83, d.f. = 1, $p = 0.050$). There was a tendency (LR = 3.31, d.


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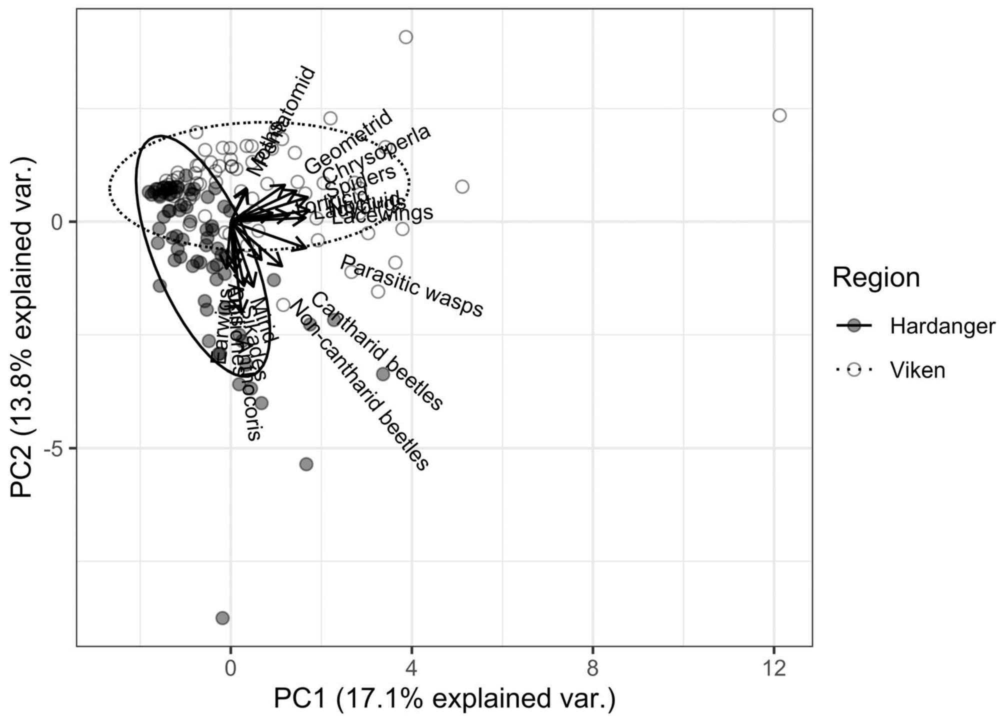


**Figure 1.** Principal component (PC) analysis of all arthropods in both regions across three years of beating funnel sampling. The first two PCs explain 30.9% of the total variability of the multivariate data matrix. The first PC gives more weight to beetles, parasitic wasps, lacewings, tortricid and geometrid moths and spiders, whereas earwigs, leafhoppers, anthocorids, stinkbugs and other moths have weight close to zero. The second PC separates observations from the Viken region (eastern Norway) vs. the Hardanger region (western Norway).

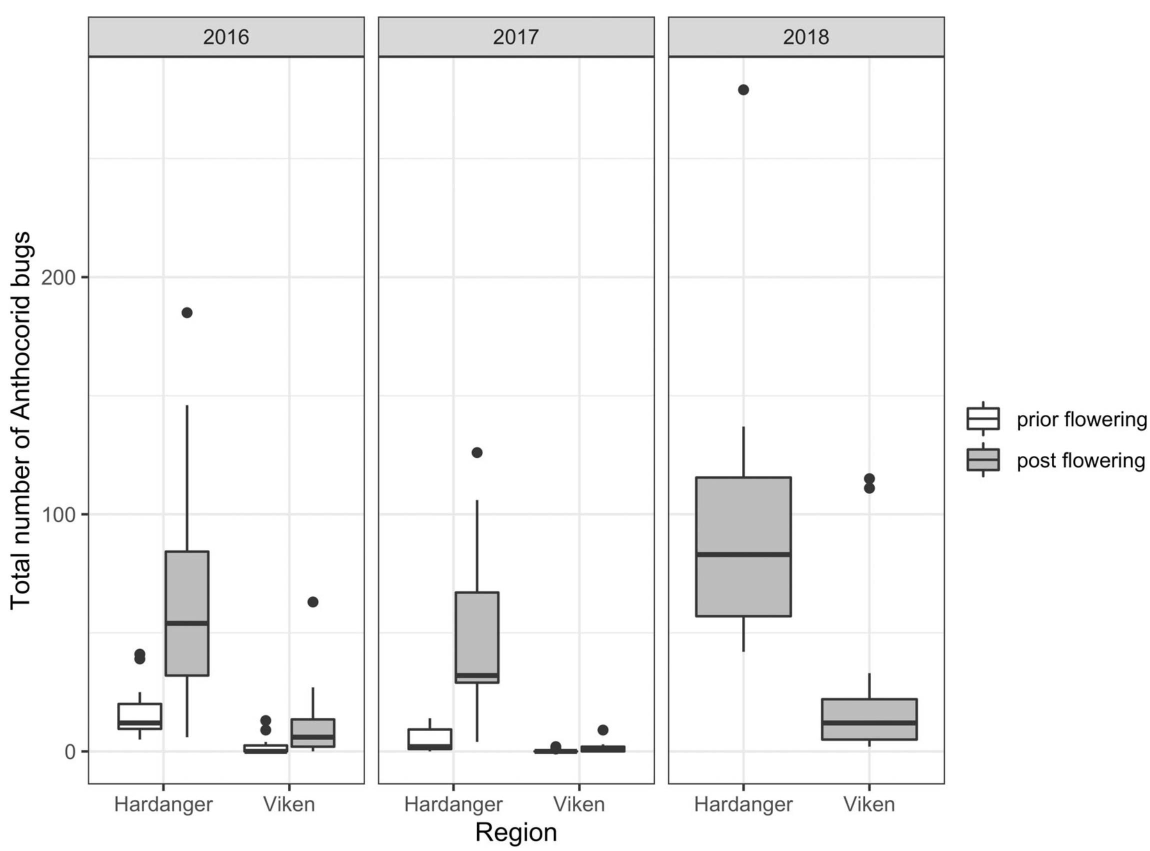


**Figure 2.** Box plots of anthocorid bugs found in beating funnel samples in 30 Norwegian apple orchards, region and time of sampling shown separately.


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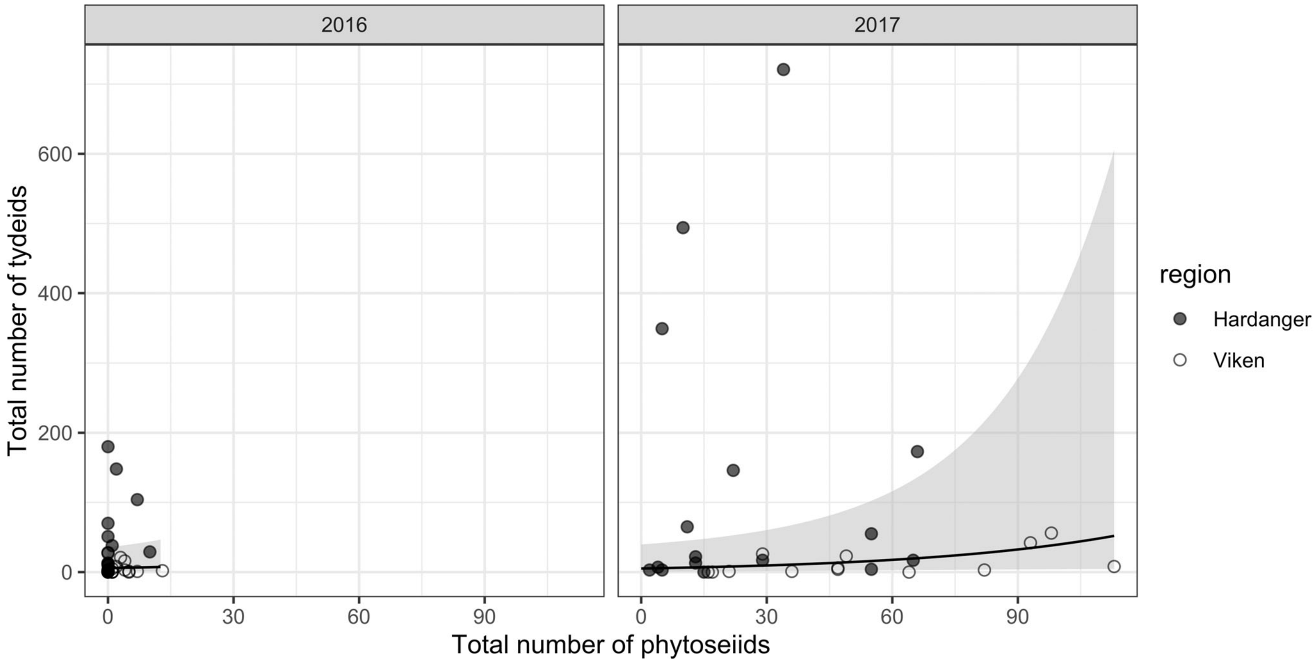


**Figure 3.** Phytoseiid and tydeid mites found in leaf samples from 30 Norwegian apple orchards post flowering. The black curves represent the predicted values obtained from the Poisson GLMM, and the shaded areas the 95% confidence intervals for the true mean total number of mites.

f. = 1, $p = 0.069$) towards more early damage when higher numbers of Lepidoptera larvae were found in the beating funnel samples taken before apple blossom (Fig. 5). However, only the number of tortricid larvae was significantly (LR = 8.49, d.f. = 1, $p = 0.004$) correlated with damage identified as early Lepidoptera damage.

The other types of arthropod damage had a relatively low frequency. The codling moth damage in Viken, where the species was present, was 0.6 and 1.5% on average, in 2016 and 2017, respectively. Damage due to fruitlet mining tortrix moth was also low; approximately 0.5% on average in both regions. Aphid damage also occurred: The rosy apple aphid *Dysaphis plantagenea* (Passerini) (Hemiptera: Aphididae) caused the main damage (up to 3% on average in 2017) in Viken, while no damage of this species was found in Hardanger. Damage due to the green apple aphid *Aphis pomi* De Geer (Hemiptera: Aphididae) was recorded in Hardanger (0–23%, 3% average damage in 2016), but not in

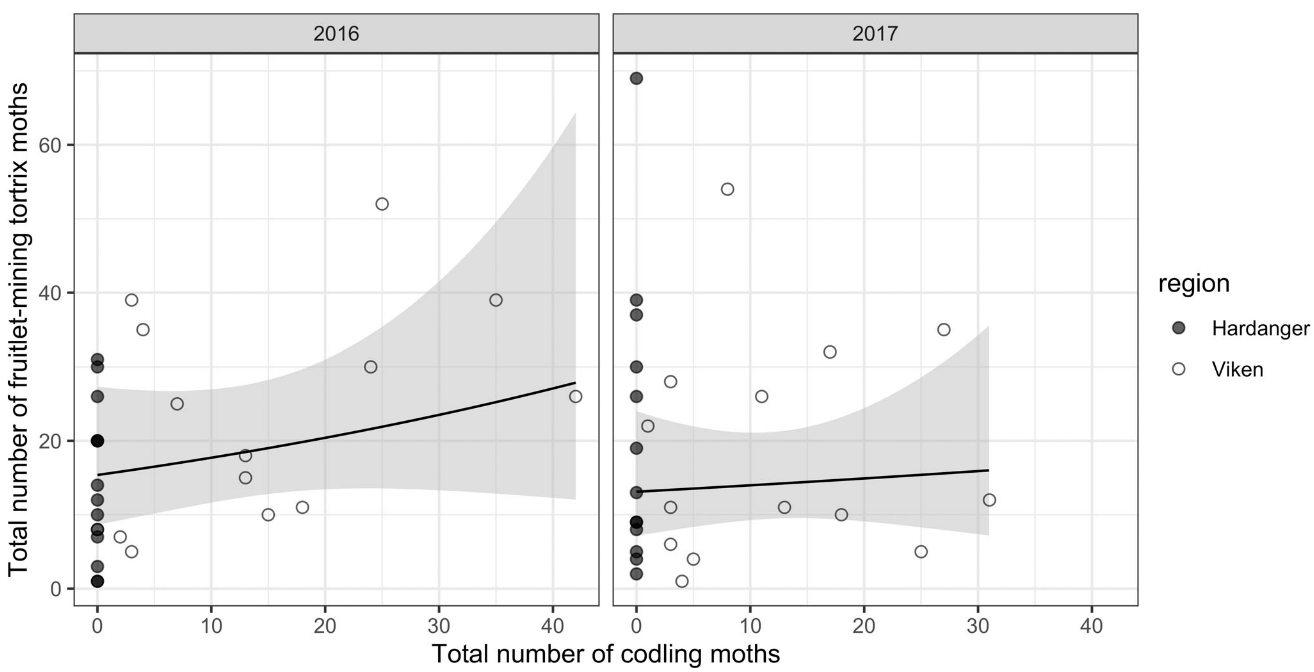


**Figure 4.** Codling moth (*Cydia pomonella*) and fruitlet-mining tortrix moth (*Pammene rhediella*) caught in pheromone traps in May and June. The black curves represent the predicted values obtained from the Poisson GLMM, and the shaded areas the 95% confidence intervals for the true mean total number of fruitlet-mining tortrix moths.


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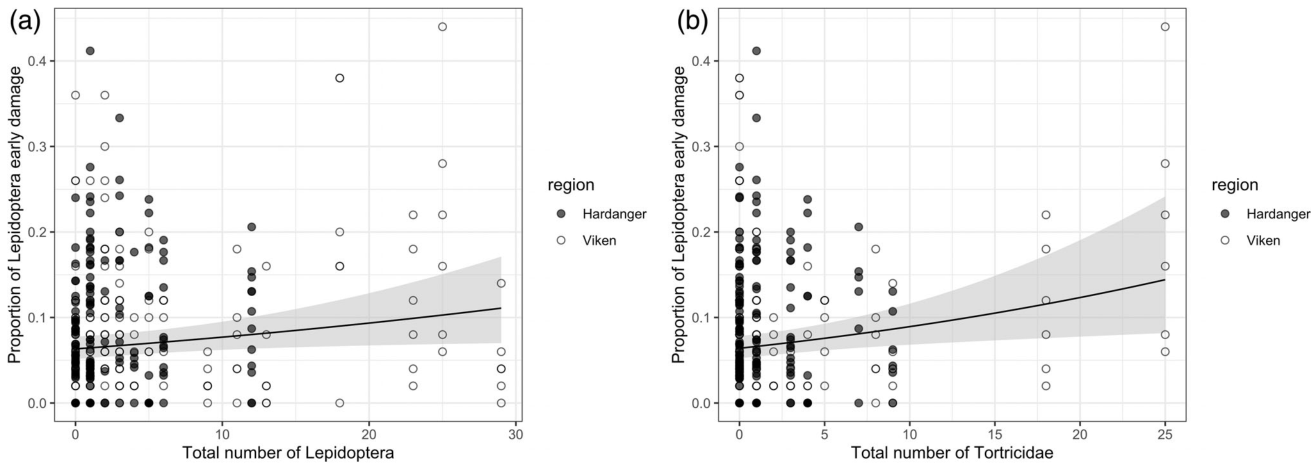


**Figure 5.** Relationship between proportion apples with early damage of Lepidoptera (made ca. 0-8 weeks after blossom) and: a) number of total lepidopteran larvae or b) only tortricid larvae found in beating funnel samples before blossom in the same orchard (N=30 orchards and 2 years). The curves are the predicted proportions of Lepidoptera early damage obtained from the binomial GLMM and the shaded areas are the 95% confidence intervals for the true mean proportion of Lepidoptera early damage.

Viken. Capsid bugs caused up to 12% damage in one orchard in Hardanger and 2% on average in the region; in comparison the damage caused by capsids in Viken were less than 1% on average.

We did not find any significant effects of IPM level (low or high) on damage by arthropod pests (LR = 0.14, d.f. = 1, $p = 0.711$, Fig. 7). Nor did we find significant differences between IPM level and early (GLMM, Df = 1, $p = 0.3008$) and late Lepidoptera (GLMM, d.f. = 1, $p = 0.2360$) damage, respectively. The pre-flowering application of the insecticides, indoxacarb and thiacloprid, had no effects on early lepidopteran damage (LR = 1.39, d.f. = 1, $p = 0.2387$; and LR = 0.02, d.f. = 1, $p = 0.8944$, respectively) and only minor effects as post-flowering applications on late lepidopteran damage (LR = 3.12, d.f. = 1, $p = 0.0771$; and LR = 3.27, d.f. = 1, $p = 0.0707$, respectively).

### 3.3 Non-target effects of insecticide and acaricide treatments

Orchards with the high level of IPM had significantly more spiders than orchards with the low level (LR = 7.59, d.f. = 1, $p = 0.0058$), and there was a similar trend for anthocorid bugs (LR = 2.71, d.f. = 1, $p = 0.0997$). However, the IPM level had no significant effect on lacewings (LR = 0.31, d.f. = 1, $p = 0.5807$) nor parasitic wasps (LR = 1.86, d.f. = 1, $p = 0.1723$). Furthermore, there were no significant effects of the number of insecticide treatments applied through the season on any of these important groups of beneficials. Regarding phytoseiid mites, there was no effect of IPM level (LR = 0.11, d.f. = 1, $p = 0.7398$) nor the application of the acaricide spirodiclofen (LR = 0.14, d.f. = 1, $p = 0.7088$).

## 4 DISCUSSION

In this study, made in a Nordic climate with a low level of pesticide use, the number of insecticide sprays or a simple categorization of IPM level into high and low did not predict the level of fruit damage by insects nor the abundance of important pests or most beneficial groups in an apple orchard. A take-home message is that growers with a more prudent pesticide use, i.e., a higher level of

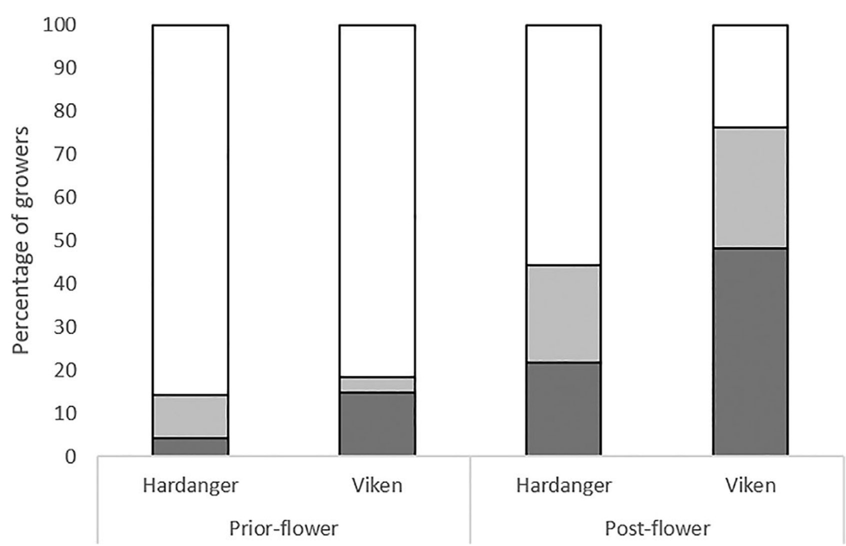


**Figure 6.** Insecticide use as percentages of 30 surveyed apple orchards prior and post-flowering. White = no insecticides, light grey = narrow-spectrum insecticides and dark grey = broad-spectrum insecticides.


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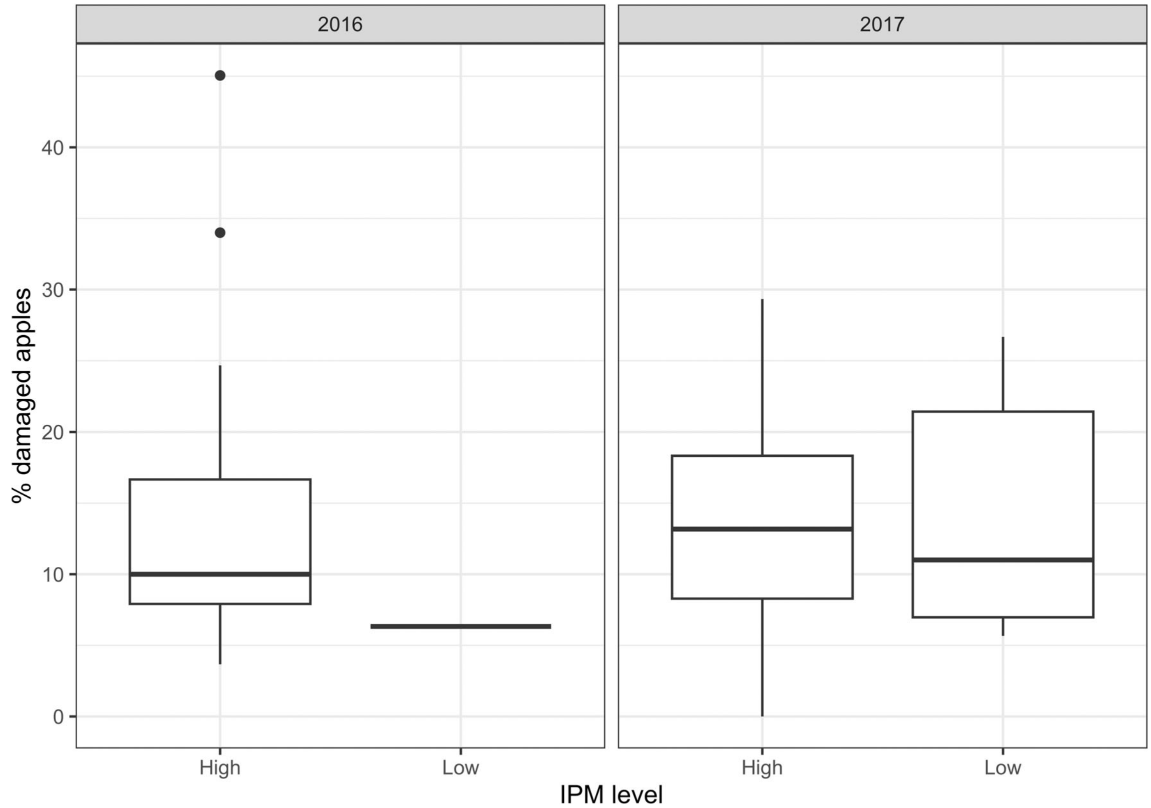


**Figure 7.** Box plots of apple damage by arthropod pests and IPM levels in 2016 and 2017.

IPM, did not experience significantly higher percentages of damaged fruits due to pests than those with the lower level.

The lack of relationships between pesticide use, arthropod abundance and fruit damage found in our study can have many causes, both methodological and biological, but is also to be expected if most growers only spray when they observe a high abundance of a pest in their orchard—i.e., following the main principles of IPM. The criteria we used to assign IPM level were based on whether a monitoring or pest risk assessment had been carried out according to the grower's diary, together with the use of narrow-spectrum insecticides if available. Such scoring of a complex strategy like IPM is difficult to do, and moreover, the data used for its calculation will typically have monitoring errors as well as natural faunistic variation, requiring large data sets to search for patterns. In our study the faunistic variation among the 30 orchards was relatively high and the pesticide use low, 0.8 and 0.06 times per season for insecticides and acaricides, respectively, which is similar to numbers reported from the 1970s and onwards.[25] In comparison, five insecticide applications were used in UK orchards in the period of our study,[26] and further south this number may more than double.[27,28] The difference reflects the cooler climate in Norway, with a lower pest diversity and abundance, but probably also the relatively low apple acreage (approximately 1600 ha), the focus on IPM in apple production from early on, and a relatively strict national legislation for pesticide use.

The most frequent type of insect fruit damage found in the study, and thus likely to be the main unresolved pest problem in both regions studied, was the skin damage by caterpillars on 3–9% of the apple harvest each year. Another type of lepidopteran damage, and one of the most important ones in apple globally, is the fruit boring made by codling moth. In our study this damage was low, and in agreement with other studies[29] it was not found in Hardanger.[29] Its presence in Viken could be one of the reasons for the tendency of more sprays there. The most important fruit borer in Norwegian apple orchards is the apple fruit moth, which had a small attack in some localities in 2016, and a major attack in 2018. The former led to the use of a broad-spectrum pesticide (thiacloprid) post flowering by growers with a risk of an attack, the latter was not part of the study (no data collected after early July 2018).

The damage to apples was only assessed at harvest, thus any damage early in the season leading to fruitlets falling prematurely off the trees was not investigated. Based on the catches from pheromone traps in our study the fruitlet mining tortrix is currently more abundant than codling moth in Norwegian apple orchards and may thus cause more damage than reflected in our study on fruits at harvest time, especially in years with a low fruit set. In a study on distribution and abundance of selected tortricids, including the two regions in the present study, both fruitlets and apples at harvest were investigated for larval damage.[30] Skin damage was the most important insect damage on both fruit stages, but damage by the fruitlet mining tortrix moth on fruitlets were also significant in some orchards.

Regarding the lack of relationships between pesticide use and abundance of beneficial non-targets, this is a complex issue as predators can be affected both by the pesticide use directly as well as indirectly through effects on prey abundance. Other studies have shown negative effects of pesticides on several groups of natural enemies in apple orchards,[31–33] but in our study there was no significant relation between number of sprays and the abundance of any group of natural enemies. Spiders were the only group with a significantly lower abundance in orchards with a low IPM-level than in those with a high level. Spiders are



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polyphagous predators feeding on a range of different prey including pest insects and mites.[7] Their importance in conservation biological control of especially smaller insect pests such as aphids, thrips, psyllids as well as lepidopteran larvae (e.g., tortricids) have been documented.[34,35] In a 3-year Czech study with weekly collection of spiders in four types of apple pest management – conventional, integrated, biological, untreated—the IPM plots had the highest abundance in two of the three years.[36] Two of the insecticides used by the growers in our study (thiacloprid and indoxacarb) significantly reduced the spider abundance in the Czech study.

The most abundant group of non-targets in our beating samples was anthocorid bugs. This is in accordance with previous studies emphasizing genera such as *Anthocoris* and *Orius*.[37,38] Being among the most important predators in European fruit orchards, *Anthocoris nemorum* (L.) (Hemiptera: Anthocoridae) is widespread and common in all fruit regions of Norway and feeds on a number of different arthropods including common pests such as aphids and psyllids.[39] It is also active early in the season and is thus important to prevent the potential build-up of pest insects such as aphids during the season.[40] A recent study showed that anthocorids predate on psyllids in Hardanger from spring and onwards,[41] and they are also the most common natural enemies in Swedish apple orchards and important in suppressing aphid pests such as the rosy apple aphid.[42] Predatory bugs are often present at lower numbers in conventional orchards compared with organic orchards.[40] In the present study, anthocorids tended to be more abundant in Hardanger than in the Viken region, and also in orchards with a high level of IPM.

In the leaf samples, which collected mites and other small arthropods that are difficult to capture with the beating funnel method, the two most abundant groups were tydeid and phytoseiid mites. Tydeids have diverse food habits, including predation of rust mites and mycophagy.[43] Their main ecological function in the orchards we studied is thus unclear, but their abundance and positive association with phytoseiids indicate that they could be significant as prey for phytoseiids and other small predators.[44] Phytoseiids in apple orchards are important natural enemies of phytophagous mites such as spider mites and rust mites. They are commonly used in augmentative biological control in other crops and a pesticide-resistant strain of one species has previously been released into apple orchards in Norway.[14] However, such releases must take into account the risk of spreading foreign biotypes if brought from abroad, and of plant pathogens if a substrate (twigs or felt strips) is used in the release.[14,45] Conserving and facilitating the phytoseiids naturally present should therefore be given priority. In a perennial crop system like apple orchards, natural enemies can build up in numbers over time, as opposed to annual systems where spill-over of natural enemies from field edges, hedgerows or similar will be the main source of beneficials.[7] In Norwegian fruit orchards, anthocorid bugs, lacewings, ladybirds, parasitic wasps, predatory mites and spiders are all regarded as important natural enemies of pest insects and mites.[13] All these groups are important in conservation biological control, and mass production and augmentation is often difficult and costly.[46]

Some striking differences in abundance of the different insect groups were found in the two different regions. While anthocorids were more abundant in western Norway, the highest numbers of other groups of “beneficials” such as lacewings and spiders were found in Viken. Moreover, there were also differences between years, where higher numbers of most insect groups were generally found in 2018, which was a particularly warm summer with average temperatures 3–5 °C above normal temperatures in May, June and July in both study areas.

Some arthropod groups were not sampled by the methods used in our study, for example edaphic guilds, which may include important natural enemies of fruit pests,[47] or groups hiding during daytime, e.g., earwigs. Furthermore, sampling was restricted to early and mid-season (early May to early July), meaning that arthropods active later in the season would be underestimated.[48] In addition, some arthropod groups (e.g., predatory flies and parasitic wasps) were probably underestimated since other sampling methods like suction methods have proven to be more effective for these species.[49]

Our study shows that improved control of lepidopterous pests in Norwegian orchards should be given priority. At present, no synthetic pesticides are registered for control of these pests in Norway following the ban of indoxacarb, and mating disruption by semiochemicals and microbiological control of larvae are used on dispensation. These methods have been successfully used in other countries for years.[50,51] However, for the fruitlet mining tortrix moth, or the most important pest species of all, the apple fruit moth, no such alternatives to pesticides are available. In years with a significant attack of the apple fruit moth, which currently happens every second year, the Norwegian apple production is totally dependent on a dispensation for the pesticide chlorantraniliprole. This also affects other caterpillars present post flowering, implying that the much-needed development of a specific control method for the apple fruit moth, for example based on semiochemicals,[52] may lead to increased problems with some other Lepidoptera.

The recent EU ban of neonicotinoid insecticides and current goal of a 50% reduction in pesticide use and risk by 2030, including a proposal of adopting legally binding crop-specific IPM rules,[53] urgently call for a more profound understanding and use of IPM in food production. Improved IPM strategies rely on an increased availability of biopesticides and other alternatives to chemical control, but also on better monitoring and forecasting models, as alternative control measures often require accurate timing.[54] Preventive measures, including conservation biological control (e.g., flower strips, volatiles), will probably be more important in future IPM compared with previous decades of IPM practices. The success and profitability of all these tools will depend on the local arthropod fauna, and as we have shown this fauna may vary considerably among orchards in the same region. Any legally binding IPM rules for apple should take such variability into account.

## ACKNOWLEDGEMENTS

We thank the reviewers for valuable comments for improving the manuscript. We also thank the agricultural advisors Sigrid Mogan, Jan Ove Nes, and the late Kristin Kvamm-Lichtenfeld for participating in the various registrations in the orchards. We also thank Henrik Antzee-Hyllseth for help with sorting and identification of insects and mites and Marta Bosque Fajardo for preparing the appendices. Finally, we thank all the fruit growers involved in this project, allowing us to use their orchards and IPM diaries. The study was part of the IPM project “SMARTCROP”, which was funded by the Research Council of Norway (project no. 244526).

## DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article


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## SUPPORTING INFORMATION

Supporting information may be found in the online version of this article.

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# APPENDIX A

**Arthropod species/genera/groups found using the beating funnel method (3 beatings × 33 branches) in both areas (eastern and western Norway) in 2016**

| Year | time 1/2 | East/ west | Grower-NR | Anthocoris adult | Anthocoris nymph | Mirid adult | Mirid nymph | Pentatomid adult | Pentatomid nymph | Tortricid larvae | Geometrid larvae | Noctuid larvae | Psyllid adult | Cantharid beetles | Other beetles | Opiliones | Spiders | Anystis mites | Earwigs | Ants | Leafhopper adult | Leafhopper nymph | Parasittic wasps | Aphids with parasitoids | Ladybirds Adult | Ladybirds Larvae | Tineidae moths | Lacewings Adult | Lacewings Larvae |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2016 | 1 | West | 16 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 48 | 0 | 2 | 0 | 7 | * not reg. | 0 | 7 | 2 | 0 | 1 | 2 | 0 | 0 | 3 | 1 | 0 |
| 2016 | 1 | West | 17 | 16 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 0 | 43 | 0 | 0 | 0 | 5 | * not reg. | 0 | 2 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 2016 | 1 | West | 18 | 11 | 1 | 1 | 0 | 0 | 0 | 7 | 5 | 0 | 39 | 0 | 7 | 0 | 19 | * not reg. | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 1 | West | 19 | 9 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 150 | 0 | 0 | 0 | 5 | * not reg. | 0 | 23 | 3 | 0 | 0 | 2 | 1 | 0 | 2 | 0 | 0 |
| 2016 | 1 | West | 20 | 18 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 249 | 0 | 0 | 0 | 4 | * not reg. | 0 | 11 | 23 | 0 | 1 | 0 | 2 | 0 | 5 | 1 | 0 |
| 2016 | 1 | West | 21 | 22 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 8 | 0 | 2 | 0 | 3 | * not reg. | 0 | 24 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 1 | West | 22 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 16 | 0 | 1 | 0 | 6 | * not reg. | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 1 | West | 23 | 5 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 151 | 0 | 0 | 0 | 12 | * not reg. | 0 | 2 | 8 | 0 | 2 | 0 | 2 | 0 | 1 | 0 | 0 |
| 2016 | 1 | West | 24 | 12 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 79 | 0 | 7 | 0 | 5 | * not reg. | 0 | 10 | 4 | 0 | 2 | 0 | 3 | 0 | 1 | 3 | 0 |
| 2016 | 1 | West | 25 | 39 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 23 | 0 | 4 | 0 | 12 | * not reg. | 0 | 7 | 16 | 0 | 1 | 0 | 4 | 0 | 4 | 2 | 0 |
| 2016 | 1 | West | 26 | 22 | 3 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 15 | 0 | 0 | 0 | 7 | * not reg. | 1 | 0 | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 1 | West | 27 | 11 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 110 | 0 | 0 | 0 | 4 | * not reg. | 0 | 23 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 2016 | 1 | West | 28 | 41 | 0 | 2 | 0 | 0 | 0 | 9 | 2 | 1 | 183 | 0 | 2 | 0 | 8 | * not reg. | 0 | 23 | 23 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2016 | 1 | West | 29 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 51 | 0 | 0 | 0 | 5 | * not reg. | 0 | 2 | 37 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 |
| 2016 | 1 | West | 30 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 7 | * not reg. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 2016 | 2 | West | 16 | 1 | 145 | 20 | 8 | 0 | 0 | 0 | 0 | 5 | 32 | 0 | 1 | 0 | 8 | <50 | 0 | 0 | 4 | 0 | 2 | 0 | 0 | 1 | 2 | 0 | 17 |
| 2016 | 2 | West | 17 | 2 | 63 | 2 | 1 | 0 | 0 | 1 | 1 | 1 | 17 | 0 | 0 | 0 | 2 | <50 | 0 | 15 | 3 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2016 | 2 | West | 18 | 0 | 90 | 2 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 4 | 0 | 13 | <100 | 0 | 11 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 2 | West | 19 | 1 | 95 | 4 | 1 | 0 | 0 | 0 | 0 | 3 | 56 | 1 | 2 | 1 | 3 | <50 | 0 | 69 | 0 | 0 | 3 | 0 | 0 | 1 | 2 | 0 | 0 |
| 2016 | 2 | West | 20 | 10 | 175 | 0 | 7 | 0 | 0 | 1 | 0 | 1 | 11 | 2 | 4 | 0 | 3 | <50 | 1 | 7 | 5 | 0 | 2 | 0 | 0 | 1 | 1 | 1 | 0 |
| 2016 | 2 | West | 21 | 0 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 1 | 0 | 0 | 2 | 2 | 4 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2016 | 2 | West | 22 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 1 | 0 | 0 | 5 | 28 | 0 | 12 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2016 | 2 | West | 23 | 0 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 6 | <50 | 0 | 6 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 2016 | 2 | West | 25 | 2 | 52 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 6 | 0 | 10 | <50 | 0 | 3 | 2 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 |
| 2016 | 2 | West | 26 | 2 | 33 | 22 | 10 | 0 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 0 | 8 | 7 | 0 | 5 | 6 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 2 | West | 27 | 2 | 18 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 5 | <50 | 0 | 63 | 1 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2016 | 2 | West | 28 | 3 | 51 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 5 | 0 | 2 | 0 | 1 | 4 | 0 | 21 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 2 | West | 29 | 4 | 63 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | <50 | 0 | 23 | 1 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2016 | 2 | West | 30 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 1 | East | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 5 | 0 | 1 | 0 | 21 | * not reg. | 0 | 2 | 6 | 0 | 1 | 0 | 3 | 0 | 4 | 0 | 0 |
| 2016 | 1 | East | 10 | 12 | 1 | 5 | 0 | 0 | 0 | 1 | 1 | 0 | 6 | 0 | 2 | 0 | 11 | * not reg. | 0 | 6 | 2 | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 0 |
| 2016 | 1 | East | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 6 | * not reg. | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 1 | 0 |
| 2016 | 1 | East | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 6 | 0 | 16 | 0 | 0 | 0 | 4 | * not reg. | 0 | 3 | 1 | 0 | 0 | 0 | 6 | 0 | 3 | 0 | 0 |
| 2016 | 1 | East | 9 | 2 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 6 | 0 | 1 | 0 | 17 | * not reg. | 0 | 1 | 2 | 0 | 0 | 0 | 4 | 0 | 1 | 1 | 0 |
| 2016 | 1 | East | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 51 | 0 | 1 | 0 | 27 | * not reg. | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 1 | 0 |
| 2016 | 1 | East | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 15 | * not reg. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 1 | East | 14 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 18 | 0 | 6 | 0 | 0 | 0 | 9 | * not reg. | 0 | 8 | 1 | 0 | 0 | 0 | 6 | 0 | 5 | 0 | 0 |
| 2016 | 1 | East | 8 | 4 | 0 | 1 | 0 | 0 | 0 | 5 | 1 | 0 | 3 | 0 | 1 | 0 | 22 | * not reg. | 0 | 1 | 3 | 0 | 0 | 0 | 1 | 0 | 5 | 0 | 0 |
| 2016 | 1 | East | 12 | 2 | 0 | 0 | 0 | 1 | 0 | 18 | 5 | 0 | 7 | 0 | 8 | 0 | 39 | * not reg. | 0 | 0 | 7 | 0 | 0 | 0 | 2,5 | 0 | 4 | 1 | 0 |
| 2016 | 1 | East | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 9 | 0 | 1 | 0 | 0 | 0 | 21 | * not reg. | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| 2016 | 1 | East | 2 | 0 | 0 | 2 | 0 | 0 | 1 | 9 | 20 | 0 | 2 | 0 | 1 | 0 | 15 | * not reg. | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 5 | 5 | 0 |
| 2016 | 1 | East | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 1 | 0 | 1 | 0 | 8 | * not reg. | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 1 | East | 6 | 9 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 4 | 0 | 3 | 0 | 15 | * not reg. | 0 | 0 | 10 | 0 | 2 | 0 | 1 | 0 | 11 | 0 | 0 |
| 2016 | 1 | East | 11 | 0 | 0 | 1 | 0 | 0 | 0 | 8 | 3 | 0 | 19 | 0 | 1 | 0 | 16 | * not reg. | 0 | 0 | 2 | 0 | 1 | 9 | 2 | 0 | 7 | 0 | 0 |
| 2016 | 2 | East | 13 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 83 | 0 | 10 | 0 | 10 | 0 | 0 | 4 | 2 | 1 | 3 | 0 | 0 | 0 | 12 | 0 | 8 |
| 2016 | 2 | East | 10 | 2 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 0 | 8 | 2 | 0 | 1 | 0 | 0 | 2 | 3 | 1 | 0 | 2 | 0 | 0 |
| 2016 | 2 | East | 5 | 1 | 5 | 20 | 12 | 0 | 0 | 1 | 1 | 0 | 30 | 0 | 5 | 0 | 7 | 14 | 0 | 7 | 1 | 0 | 1 | 1 | 0 | 0 | 4 | 0 | 5 |
| 2016 | 2 | East | 15 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 103 | 0 | 0 | 1 | 13 | 0 | 0 | 3 | 1 | 0 | 5 | 0 | 1 | 0 | 4 | 3 | 6 |
| 2016 | 2 | East | 9 | 0 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 0 | 5 | 9 | 0 | 21 | 1 | 0 | 3 | 0 | 0 | 0 | 2 | 1 | 3 |
| 2016 | 2 | East | 7 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 8 | 0 | 2 | 1 | 12 | 11 | 0 | 7 | 2 | 0 | 2 | 0 | 1 | 0 | 2 | 1 | 12 |
| 2016 | 2 | East | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 2 | 0 | 17 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 |
| 2016 | 2 | East | 14 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 20 | 0 | 4 | 0 | 13 | 0 | 1 | 22 | 2 | 5 | 3 | 0 | 0 | 0 | 10 | 0 | 14 |
| 2016 | 2 | East | 8 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 5 | 0 | 22 | 0 | 28 | 2 | 0 | 1 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 6 |
| 2016 | 2 | East | 12 | 3 | 21 | 45 | 4 | 0 | 0 | 1 | 0 | 0 | 26 | 2 | 12 | 1 | 29 | 0 | 0 | 0 | 1 | 4 | 1 | 0 | 0 | 0 | 2 | 0 | 9 |
| 2016 | 2 | East | 3 | 0 | 0 | 8 | 3 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 5 | 1 | 15 | 0 | 0 | 6 | 1 | 1 | 4 | 0 | 0 | 0 | 2 | 1 | 10 |
| 2016 | 2 | East | 2 | 1 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 9 | 1 | 1 | 0 | 0 | 0 | 4 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 9 |
| 2016 | 2 | East | 1 | 1 | 4 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 4 | 0 | 9 | 0 | 0 | 15 | 2 | 0 | 2 | 0 | 0 | 0 | 3 | 0 | 2 |
| 2016 | 2 | East | 6 | 3 | 60 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 7 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 1 | 0 | 2 |
| 2016 | 2 | East | 11 | 1 | 10 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 3 | 0 | 7 | 2 | 0 | 4 | 1 | 0 | 3 | 0 | 1 | 0 | 4 | 0 | 1 |

# APPENDIX B

**Arthropod species/genera/groups found using the beating funnel method (3 beatings × 33 branches) in both areas (eastern and western Norway) in 2017**

| Year | time 1/2 | East/ west | Grower-NR | Anthocoris Adult | Anthocoris Nymph | Mirid Adult | Mirid Nymph | Pentatomid Adult | Pentatomid Nymph | Tortricid larvae | Geometri larvae | Noctuid larvae | Psyllid Adult | Cantharid beetles | Other beetles | Opiliones | Spiders | Anystis mites | Earwigs | Ants | Sikades Adult | Sikades Nymph | Parasittic wasps | Aphids with parasitoids | Ladybirds Adult | Ladybirds Larvae | Tineidae moths | Lacewings Adult | Lacewings Larvae |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | 1 | West | 25 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 432 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 1 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 104 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 21 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 105 | 0 | 0 | 0 | 12 | 0 | 0 | 1 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 281 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 0 | 0 | 14 | 0 | 0 | 4 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 24 | 12 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 236 | 0 | 0 | 0 | 5 | 0 | 0 | 3 | 2 | 0 | 0 | * not reg. | 0 | 0 | 0 | 2 | 0 |
| 2017 | 1 | West | 27 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 173 | 0 | 0 | 0 | 10 | 0 | 0 | 1 | 1 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 26 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 126 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 17 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 197 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 20 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 417 | 0 | 0 | 0 | 12 | 0 | 0 | 6 | 0 | 0 | 1 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 19 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 530 | 0 | 0 | 0 | 14 | 0 | 0 | 2 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 18 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 246 | 0 | 0 | 0 | 27 | 0 | 0 | 3 | 1 | 0 | 1 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | West | 23 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 355 | 0 | 3 | 0 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 2 | West | 17 | 0 | 20 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 1 | 0 | 3 | many | 0 | 1 | 7 | 0 | 11 | * not reg. | 0 | 0 | 0 | 1 | 0 |
| 2017 | 2 | West | 26 | 3 | 27 | 10 | 95 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 5 | many | 0 | 10 | 7 | 0 | 7 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 2 | West | 18 | 2 | 124 | 0 | 3 | 0 | 0 | 3 | 2 | 1 | 5 | 2 | 44 | 0 | 17 | many | 0 | 12 | 14 | 0 | 18 | * not reg. | 0 | 1 | 0 | 1 | 0 |
| 2017 | 2 | West | 22 | 1 | 31 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 0 | 2 | 2 | 0 | many | 0 | 11 | 6 | 0 | 4 | * not reg. | 0 | 3 | 0 | 0 | 0 |
| 2017 | 2 | West | 23 | 20 | 34 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 13 | 0 | 11 | many | 0 | 1 | 4 | 0 | 5 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 2 | West | 21 | 1 | 22 | 0 | 1 | 0 | 0 | 5 | 1 | 0 | 4 | 0 | 7 | 0 | 7 | many | 0 | 3 | 8 | 0 | 7 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 2 | West | 25 | 20 | 56 | 0 | 6 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 19 | 0 | 6 | many | 0 | 2 | 1 | 0 | 7 | * not reg. | 0 | 0 | 1 | 0 | 0 |
| 2017 | 2 | West | 24 | 33 | 47 | 5 | 6 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 12 | 0 | 4 | many | 0 | 1 | 3 | 0 | 2 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 2 | West | 20 | 8 | 50 | 3 | 15 | 0 | 0 | 2 | 1 | 0 | 14 | 0 | 11 | 0 | 6 | many | 0 | 15 | 9 | 0 | 5 | * not reg. | 0 | 0 | 0 | 1 | 1 |
| 2017 | 2 | West | 28 | 3 | 38 | 0 | 6 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 6 | 0 | 5 | some | 0 | 19 | 26 | 0 | 5 | * not reg. | 0 | 0 | 1 | 0 | 0 |
| 2017 | 2 | West | 27 | 4 | 24 | 1 | 0 | 0 | 0 | 2 | 1 | 0 | 5 | 0 | 7 | 0 | 1 | some | 0 | 17 | 2 | 0 | 3 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 2 | West | 30 | 1 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 3 | some | 0 | 0 | 1 | 0 | 1 | * not reg. | 0 | 0 | 0 | 0 | 1 |
| 2017 | 2 | West | 16 | 4 | 26 | 1 | 2 | 0 | 0 | 1 | 0 | 2 | 69 | 0 | 1 | 0 | 0 | some | 0 | 4 | 0 | 0 | 9 | * not reg. | 0 | 0 | 0 | 1 | 2 |
| 2017 | 2 | West | 29 | 0 | 106 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 42 | 0 | 5 | 0 | 2 | many | 0 | 4 | 1 | 0 | 4 | * not reg. | 0 | 1 | 0 | 0 | 0 |
| 2017 | 2 | West | 19 | 4 | 28 | 1 | 10 | 0 | 0 | 1 | 0 | 0 | 33 | 1 | 6 | 0 | 5 | many | 0 | 14 | 1 | 0 | 8 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | East | 15 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 59 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 1 | 0 | 0 |
| 2017 | 1 | East | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 31 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 2 | 0 | 0 |
| 2017 | 1 | East | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 45 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 1 | 0 | 1 | * not reg. | 0 | 0 | 1 | 0 | 0 |
| 2017 | 1 | East | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 3 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | East | 5 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 2 | * not reg. | 0 | 0 | 0 | 1 | 0 |
| 2017 | 1 | East | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | East | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 13 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 1 | 0 | 0 |
| 2017 | 1 | East | 11 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 20 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | East | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 1 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | East | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 22 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 2 | 0 | 0 |
| 2017 | 1 | East | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | East | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | East | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 12 | 0 | 0 | 0 | 7 | 0 | 0 | 1 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 1 | East | 12 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 2 | East | 15 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 2 | 2 | 0 | 2 | 0 | 12 | 0 | 0 | 0 | 7 | 0 | 0 | * not reg. | 1 | 0 | 0 | 0 | 0 |
| 2017 | 2 | East | 14 | 1 | 0 | 3 | 2 | 0 | 0 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 12 | 1 | 0 | 2 | * not reg. | 0 | 0 | 3 | 0 | 0 |
| 2017 | 2 | East | 6 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 8 | 5 | 3 | 0 | 4 | 0 | 24 | tilstede | 0 | 3 | 6 | 0 | 0 | * not reg. | 1 | 0 | 2 | 1 | 0 |
| 2017 | 2 | East | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 2 | 0 | 2 | 0 | 12 | 0 | 0 | 0 | 12 | 0 | 6 | * not reg. | 0 | 0 | 1 | 0 | 0 |
| 2017 | 2 | East | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 12 | 6 | 1 | 0 | 2 | 0 | 25 | 0 | 0 | 5 | 9 | 0 | 22 | * not reg. | 0 | 0 | 1 | 0 | 0 |
| 2017 | 2 | East | 7 | 2 | 0 | 2 | 0 | 0 | 0 | 5 | 3 | 22 | 7 | 0 | 7 | 0 | 31 | 0 | 0 | 0 | 16 | 0 | 3 | * not reg. | 0 | 0 | 5 | 2 | 0 |
| 2017 | 2 | East | 13 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 7 | 1 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 3 | 6 | 0 | 0 | * not reg. | 2 | 0 | 0 | 0 | 0 |
| 2017 | 2 | East | 12 | 0 | 0 | 3 | 22 | 0 | 0 | 4 | 10 | 1 | 4 | 0 | 5 | 0 | 35 | 0 | 0 | 2 | 8 | 0 | 9 | * not reg. | 3 | 0 | 3 | 0 | 0 |
| 2017 | 2 | East | 9 | 1 | 0 | 4 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 22 | 0 | 0 | 15 | 5 | 0 | 2 | * not reg. | 0 | 0 | 2 | 1 | 0 |
| 2017 | 2 | East | 5 | 1 | 0 | 0 | 5 | 0 | 2 | 2 | 1 | 1 | 1 | 0 | 3 | 0 | 8 | 0 | 0 | 0 | 4 | 0 | 1 | * not reg. | 0 | 0 | 1 | 0 | 1 |
| 2017 | 2 | East | 11 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 20 | 3 | 7 | 0 | 3 | 0 | 15 | 0 | 0 | 0 | 8 | 0 | 5 | * not reg. | 0 | 0 | 4 | 0 | 0 |
| 2017 | 2 | East | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 8 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 9 | 3 | 0 | 5 | * not reg. | 0 | 0 | 0 | 0 | 0 |
| 2017 | 2 | East | 8 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 3 | 0 | 41 | 0 | 0 | 0 | 4 | 0 | 5 | * not reg. | 2 | 0 | 1 | 1 | 0 |
| 2017 | 2 | East | 10 | 8 | 1 | 14 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 0 | 9 | 0 | 19 | 0 | 0 | 12 | 17 | 0 | 2 | * not reg. | 0 | 0 | 8 | 1 | 0 |




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# APPENDIX C

**Arthropod species/genera/groups found using the beating funnel method (3 beatings × 33 branches) in both areas (eastern and western Norway) in 2018**

| Year | Reg. time 1/2 | East / West | Grower-NR | Anthocoris adult | Anthocoris nymph | Mirid adult | Mirid nymph | Pentatomid adult | Pentatomid nymph | Tortricid larvae | Geometrid larvae | Noctuid larvae | Psyllid Adult | Cantharid beetles | Other beetles | Opiliones | Spiders | Anystis mites | Earwigs | Ants | Leafhopper adult | Leafhopper nymph | Parasittic wasps | Aphids with parasitoids | Ladybirds adult | Ladybirds larvae | Tineidae moths | Lacewings adult | Lacewings larvae |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2018 | 2 | East | 15 | 0 | 14 | 1 | 6 | 0 | 0 | 2 | 1 | 0 | 153 | 5 | * not reg. | 0 | 15 | 2 | 0 | 0 | 12 | 0 | 10 | 0 | 0 | 0 | 0 | 1 | 0 |
| 2018 | 2 | East | 14 | 0 | 15 | 0 | 0 | 0 | 0 | 7 | 19 | 9 | 25 | 0 | * not reg. | 0 | 15 | 1 | 0 | 66 | 1 | 0 | 10 | 1 | 0 | 0 | 0 | 1 | 0 |
| 2018 | 2 | East | 7 | 2 | 10 | 4 | 3 | 0 | 0 | 0 | 1 | 0 | 15 | 3 | * not reg. | 0 | 31 | 7 | 0 | 52 | 0 | 0 | 4 | 1 | 1 | 0 | 0 | 0 | 0 |
| 2018 | 2 | East | 9 | 3 | 30 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | * not reg. | 0 | 43 | 74 | 0 | 2 | 4 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2018 | 2 | East | 5 | 6 | 16 | 15 | 113 | 0 | 0 | 14 | 4 | 8 | 1401 | 1 | * not reg. | 0 | 15 | 10 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 4 | 1 | 1 | 0 |
| 2018 | 2 | East | 2 | 2 | 1 | 4 | 0 | 0 | 0 | 7 | 0 | 1 | 12 | 0 | * not reg. | 0 | 19 | 5 | 0 | 0 | 4 | 0 | 11 | 0 | 1 | 0 | 1 | 0 | 0 |
| 2018 | 2 | East | 8 | 1 | 8 | 5 | 1 | 0 | 0 | 2 | 2 | 0 | 14 | 3 | * not reg. | 0 | 42 | 2 | 0 | 6 | 5 | 0 | 4 | 0 | 0 | 1 | 2 | 0 | 0 |
| 2018 | 2 | East | 10 | 0 | 115 | 1 | 2 | 0 | 0 | 31 | 11 | 4 | 24 | 0 | * not reg. | 0 | 24 | 13 | 0 | 4 | 7 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2018 | 2 | East | 13 | 0 | 5 | 0 | 2 | 0 | 0 | 12 | 3 | 8 | 18 | 6 | * not reg. | 0 | 25 | 1 | 0 | 0 | 3 | 0 | 3 | 1 | 0 | 0 | 1 | 3 | 0 |
| 2018 | 2 | East | 3 | 0 | 2 | 2 | 3 | 0 | 0 | 2 | 4 | 0 | 4 | 1 | * not reg. | 0 | 68 | 19 | 0 | 21 | 1 | 0 | 15 | 3 | 0 | 0 | 0 | 2 | 0 |
| 2018 | 2 | East | 11 | 0 | 8 | 1 | 3 | 0 | 1 | 2 | 11 | 29 | 6 | 1 | * not reg. | 0 | 57 | 9 | 0 | 2 | 15 | 0 | 22 | 0 | 3 | 9 | 1 | 0 | 0 |
| 2018 | 2 | East | 6 | 5 | 106 | 1 | 0 | 0 | 0 | 3 | 3 | 6 | 29 | 2 | * not reg. | 0 | 55 | 3 | 0 | 2 | 5 | 0 | 3 | 0 | 1 | 3 | 2 | 2 | 0 |
| 2018 | 2 | East | 4 | 0 | 4 | 0 | 5 | 0 | 0 | 2 | 1 | 9 | 30 | 1 | * not reg. | 0 | 29 | 1 | 0 | 6 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2018 | 2 | West | 21 | 0 | 59 | 0 | 4 | 0 | 0 | 6 | 0 | 0 | 0 | 1 | * not reg. | 0 | 14 | 5 | 0 | 1 | 1 | 20 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2018 | 2 | West | 28 | 1 | 41 | 1 | 12 | 0 | 0 | 1 | 0 | 3 | 5 | 1 | * not reg. | 0 | 3 | 19 | 0 | 63 | 19 | 102 | 3 | 0 | 0 | 0 | 1 | 2 | 0 |
| 2018 | 2 | West | 27 | 35 | 244 | 35 | 6 | 0 | 0 | 3 | 0 | 0 | 21 | 0 | * not reg. | 2 | 5 | 21 | 1 | 84 | 5 | 42 | 4 | 0 | 0 | 0 | 0 | 0 | 17 |
| 2018 | 2 | West | 30 | 2 | 40 | 0 | 8 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | * not reg. | 0 | 0 | 16 | 0 | 2 | 4 | 6 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2018 | 2 | West | 18 | 5 | 117 | 5 | 22 | 0 | 0 | 3 | 0 | 3 | 1 | 1 | * not reg. | 0 | 61 | 62 | 0 | 7 | 2 | 43 | 6 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2018 | 2 | West | 31 | 17 | 78 | 5 | 12 | 0 | 0 | 4 | 1 | 0 | 8 | 0 | * not reg. | 0 | 1 | 15 | 1 | 3 | 8 | 29 | 1 | 1 | 0 | 4 | 0 | 0 | 0 |
| 2018 | 2 | West | 32 | 1 | 54 | 23 | 81 | 0 | 0 | 1 | 4 | 0 | 1 | 2 | * not reg. | 0 | 9 | 36 | 0 | 1 | 23 | 219 | 9 | 1 | 0 | 1 | 0 | 1 | 0 |
| 2018 | 2 | West | 23 | 20 | 89 | 2 | 14 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | * not reg. | 0 | 20 | 28 | 0 | 0 | 6 | 89 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 2018 | 2 | West | 25 | 5 | 71 | 4 | 55 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | * not reg. | 0 | 13 | 20 | 0 | 1 | 0 | 74 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2018 | 2 | West | 29 | 15 | 68 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 3 | 1 | * not reg. | 0 | 3 | 44 | 0 | 7 | 16 | 216 | 11 | 0 | 0 | 1 | 0 | 0 | 0 |
| 2018 | 2 | West | 22 | 3 | 94 | 5 | 37 | 0 | 0 | 1 | 5 | 0 | 2 | 0 | * not reg. | 0 | 5 | 41 | 0 | 13 | 4 | 54 | 3 | 5 | 0 | 2 | 0 | 0 | 0 |
| 2018 | 2 | West | 19 | 10 | 72 | 2 | 8 | 0 | 0 | 0 | 0 | 0 | 81 | 0 | * not reg. | 0 | 11 | 28 | 0 | 10 | 0 | 11 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2018 | 2 | West | 24 | 4 | 42 | 28 | 40 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | * not reg. | 0 | 8 | 10 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2018 | 2 | West | 20 | 24 | 102 | 57 | 22 | 0 | 0 | 0 | 0 | 1 | 2 | 4 | * not reg. | 0 | 10 | 21 | 0 | 1 | 4 | 47 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2018 | 2 | West | 17 | 7 | 130 | 4 | 19 | 0 | 0 | 2 | 2 | 0 | 38 | 1 | * not reg. | 0 | 8 | 46 | 0 | 8 | 6 | 25 | 5 | 11 | 1 | 9 | 0 | 0 | 0 |

# APPENDIX D

**Arthropod species/genera/groups found using the leaf washing method in both areas (eastern and western Norway) in 2016 and 2017**

| Year | Grower nr. | Sampling date | No of leaves | Spider mites adult/ nymph | Spidermites larvae | Phytoseiid mites adult/ nymph | Phytoseiid mites larvae | Thrips adult | Thrips larvae | Psyllids adult | Psyllids nymph | Leafhopper adult | Leafhopper nymph | Anthocoris adult | Anthocoris nymph | Aphids adult | Aphids larvae | European red mites adult | European red mites larvae | Bryobia adult/ nymph | Bryobia larvae | Gall-mites | Tydeids | Other mites | Spiders | Ladybirds | Parasittic wasps | Gall-midges larvae | Leaf sucker "crawler" | Lacewings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2016 | 13 | 23.06.2016 | 47 | 0 | 0 | 45 | 0 | 23 | 14 | 1 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | not | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 9 | 23.06.2016 | 50 | 0 | 0 | 16 | 1 | 8 | 157 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 64 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 14 | 23.06.2016 | 51 | 0 | 0 | 137 | 4 | 2 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 44 | 2 | 3 | 9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 12 | ? | 50 | 0 | 0 | 115 | 5 | 18 | 87 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 2016 | 5 | 20.06.2016 | 50 | 0 | 0 | 185 | 13 | 3 | 24 | 0 | 0 | 0 | 4 | 0 | 1 | 0 | 0 | 4 | 3 | 0 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2016 | 15 | 23.06.2016 | 50 | 0 | 0 | 64 | 5 | 39 | 75 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| 2016 | 2 | 20.06.2016 | 49 | 0 | 0 | 79 | 7 | 32 | 43 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 1 | 1 | 30 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 9* | 0 |
| 2016 | 7 | 20.06.2016 | 50 | 7 | 6 | 98 | 4 | 24 | 44 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 3 | 3 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2016 | 21 | 14.07.2016 | 50 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 1 | 0 | 0 | 1 | 13 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2016 | 1 | 20.06.2016 | 49 | 0 | 0 | 18 | 1 | 1 | 99 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 11 | ? | 50 | 0 | 0 | 15 | 1 | 16 | 22 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 112 | 61 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2016 | 8 | 23.06.2016 | 50 | 0 | 0 | 10 | 1 | 78 | 30 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 14 | 24 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 4 | 20.06.2016 | 50 | 0 | 0 | 84 | 3 | 25 | 25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 13 | 1 | 21 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| 2016 | 7 | 15.07.2016 | 50 | 0 | 0 | 23 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 6 | 22.06.2016 | 50 | 0 | 0 | 14 | 0 | 20 | 109 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 6 | 3 | 3 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2016 | 10 | 23.06.2016 | 50 | 0 | 0 | 18 | 2 | 2 | 7 | 0 | 2 | 0 | 2 | 0 | 0 | 1 | 33 | 0 | 0 | 0 | 0 | 4 | 8 | 22 | 0 | 0 | 0 | 0 | 1 | 0 |
| 2016 | 18 | 15.06.2016 | 50 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 4 | 32 | 0 | 0 | 2 | 180 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 27 | 16.06.2016 | 50 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 11 | 0 | 6 | 0 | 0 | 0 | 0 | 6 | 8 | 0 | 0 | 1 | 70 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 25 | 14.06.2016 | 49 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 4 | 0 | 2 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 26 | 15.06.2016 | 50 | 0 | 0 | 20 | 7 | 0 | 0 | 0 | 2* | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 16 | 15.06.2016 | 50 | 0 | 0 | 35 | 10 | 0 | 0 | 1 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 24 | June | 50 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 4 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 28 | 16.06.2016 | 50 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 23 | 14.06.2016 | 50 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 73 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 19 | 16.06.2016 | 50 | 0 | 0 | 28 | 2 | 0 | 0 | 0 | 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 148 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 20 | 16.06.2016 | 50 | 0 | 0 | 16 | 1 | 0 | 0 | 0 | 17 | 0 | 7 | 0 | 0 | 0 | 0 | 2 | 5 | 0 | 0 | 2 | 38 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 3 | 20.06.2016 | 50 | 0 | 0 | 19 | 0 | 29 | 71 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2016 | 30 | 15.06.2016 | 50 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2016 | 29 | 15.06.2016 | 50 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 22 | 15.06.2016 | 50 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 12 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2017 | 18 | 29.06.2017 | 50 | 0 | 0 | 11 | 3 | 0 | 1 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 65 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 27 | 29.06.2017 | 50 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 349 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 30 | 29.06.2017 | 50 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 29 | 29.06.2017 | 49 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 4 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 20 | 29.06.2017 | 51 | 0 | 0 | 29 | 3 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 24 | 27.06.2017 | 49 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 2017 | 22 | 29.06.2017 | 50 | 0 | 0 | 66 | 7 | 0 | 1 | 0 | 1 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 173 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 19 | 29.06.2017 | 50 | 0 | 0 | 65 | 3 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 16 | 29.06.2017 | 50 | 0 | 0 | 55 | 6 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 23 | 27.06.2017 | 50 | 0 | 0 | 22 | 1 | 0 | 0 | 0 | 1 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 146 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 28 | 29.06.2017 | 50 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 25 | 27.06.2017 | 50 | 0 | 0 | 55 | 2 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 21 | 27.06.2017 | 50 | 0 | 0 | 13 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 2017 | 26 | 29.06.2017 | 50 | 0 | 0 | 10 | 2 | 0 | 0 | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 494 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2017 | 17 | 29.06.2017 | 50 | 0 | 0 | 34 | 2 | 0 | 0 | 0 | 2 | 0 | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 721 | 0 | 0 | 0 | 0 | 4 | 0 | 0 |
| 2017 | 8 | 04.07.2017 | 50 | 0 | 0 | 16 | 5 | 21 | 37 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 119 | 21 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| 2017 | 10 | 04.07.2017 | 50 | 0 | 0 | 47 | 5 | 4 | 2 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 17 | 0 | 0 | 0 | 0 | 3 | 0 |
| 2017 | 12 | 03.07.2017 | 50 | 0 | 0 | 17 | 2 | 4 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 6 | 03.07.2017 | 50 | 0 | 0 | 29 | 2 | 25 | 7 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 26 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 19 | 04.07.2017 | 50 | 0 | 0 | 15 | 0 | 3 | 6 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 1 | 0 |
| 2017 | 2 | 03.07.2017 | 50 | 0 | 0 | 21 | 1 | 5 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 5 | 03.07.2017 | 50 | 0 | 0 | 64 | 3 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 2017 | 3 | 03.07.2017 | 51 | 0 | 0 | 36 | 1 | 5 | 38 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 7 | 04.07.2017 | 50 | 0 | 0 | 82 | 3 | 1 | 5 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 2 | 0 | 0 | 42 | 23 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 2017 | 15 | 03.07.2017 | 50 | 0 | 0 | 47 | 5 | 4 | 9 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 14 | 03.07.2017 | 50 | 0 | 0 | 113 | 1 | 1 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 21 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 13 | 03.07.2017 | 50 | 0 | 0 | 98 | 2 | 7 | 43 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 9 | 0 | 56 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 2017 | 11 | 03.07.2017 | 50 | 0 | 0 | 93 | 4 | 13 | 165 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 2 | 0 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 4 | 03.07.2017 | 50 | 0 | 0 | 49 | 0 | 15 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 1 | 0 | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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