Sveriges lantbruksuniversitet
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Facing a new pest

- the case of the invasive fruit fly *Drosophila suzukii* in southern Sweden

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Department of Biosystems and Technology
Master´s thesis • 30 hec
Agroecology - Master's Programme
Alnarp 2017

Facing a new pest – the case of the invasive fruit fly *Drosophila suzukii* in southern Sweden

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Credits: 30
Level: Second cycle, A2E
Course title: Master's Thesis in Agricultural Science/Agroecology
Course code: EX0789
Programme/education: Agroecology - Master's Programme

Place of publication: Alnarp
Year of publication: 2017
Online publication: http://stud.epsilon.slu.se

Keywords: *Drosophila suzukii*, soft fruits and berries, Sweden, Skåne, Integrated Pest Management, SPLAT, *Hanseniaspora uvarum*, systems approach, Participatory Action Research

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Summary

In an increasingly globalized food system, pests move easily together with food products and can cause significant damage in their new ranges. The problem is aggravated by climate change, enabling pest survival in previously uninhabitable areas. The fruit fly *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) is a pest that has expanded its range to nearly global presence in the matter of a few years. Unlike most drosophilids, females of *D. suzukii* prefer to lay their eggs in fresh and ripening fruit, and this highly polyphagous fly has been very harmful to the soft fruit and berry industry globally.

D. suzukii was first found in Sweden in 2014. Since then, it has been found in several soft fruit and berry crops but has not yet caused any significant economical damage. A group collaborating to deal with the fly has been started, including the Swedish Board of Agriculture (JBV), the Swedish University of Agricultural Sciences (SLU) and HIR, an independent agricultural advisory service company. This thesis describes the current situation from the perspectives of these actors and the growers, and the interactions between them. The possibilities to and potential benefits of increasing grower participation in the further work were analyzed. Focus lay on growers in Skåne, the southernmost region in Sweden. One method being developed for *D. suzukii* management is attract-and-kill using the substance SPLAT (specialized pheromone and lure application technology). *D. suzukii* is closely associated with the yeast species *Hanseniaspora uvarum*, and it was tested if the attractiveness of SPLAT could be improved using this yeast.

A mixed methods approach was used, including semi-structured interviews, a growers' survey and laboratory experiments. The analysis of data was pragmatic, and conducted within the frame provided by systems thinking. The inquiry showed that the response to the arrival of *D. suzukii* in Sweden has been satisfactory for all involved. For Skåne growers, *D. suzukii* is still a largely intangible and therefore not prioritized pest. Still, the outreach on *D. suzukii* has had a positive effect on grower awareness and practice. Skåne growers emerged as a highly heterogeneous group, including in their perception of *D. suzukii* as a threat. Small- and medium size growers were suggested by the survey results to be the most concerned about *D. suzukii*. Therefore, these growers are proposed to be prioritized when increasing grower participation, with Participatory action research (PAR) as a suggested working mode. A grower reference group collaborating with JBV, SLU and HIR could be a suitable point of entry for a PAR process, which could adress both socio-economical and IPM aspects of *D. suzukii*. As *H. uvarum* showed potential to improve the attractiveness of SPLAT for *D. suzukii* females, trying out new SPLAT formulas with this yeast under field conditions could be one activity of a future PAR group.

Keywords: *Drosophila suzukii*, soft fruits and berries, Sweden, Skåne, Integrated Pest Management, SPLAT, *Hanseniaspora uvarum*, systems approach, Participatory Action Research

Foreword

Speaking of her choice to do action research, Mary Brydon-Miller (in Brydon-Miller *et al.*, 2003, p. 17) wrote that *”there are those who say that direct action is not, nor should be, the responsibility of social scientists”*. This is a statement of a frustration that I feel familiar with; I have often had the same feeling as a natural scientist. Having taken a bachelor’s degree in biology, a subject that I am deeply fascinated with, I found myself in a world of knowledge where reality was often very distant. There was no shortage of interesting findings or precise results, but my constant question was what it was all good for. I felt an urge to apply knowledge in practice to achieve real changes, and to broaden my perspective to include thoughts from other disciplines. Having a keen interest in insects, my attention was directed towards agriculture and how greater knowledge about insects can bring about sustainable practices of agroecosystems.

When I first started the agroecology program, my view was that the turn from theory to practice, for me, would only mean asking different, more ”applied” questions when conducting lab experiments, and perhaps to do field trials to a greater extent. How hard could it be? But as time progressed, I came to understand that the world of agriculture is so much richer and more complex than that. People’s thoughts, history, culture and politics are all essential parts of the social and ecological environment we create for ourselves, and there are no simple, constant or right answers to how we should live together with nature in the best way.

The process of breaking out of my hard-wired natural science positivism, strongly connected with a search for definite and complete answers, has not been without friction. In particular, I found it challenging that agroecology is not a singular and well-defined concept, but a multifaceted term that is constantly evolving. However, in the end I am very glad that I have started the journey of trying to understand reality from an agroecological perspective, and I look forward to developing my thinking in constant exchange with the developing concept of agroecology. In particular, learning about the perspective of constructivism, the principles of systems thinking and participatory action research has been very inspiring for me, and it has definitely had an effect on the way I think about the world. Ultimately, I think that these concepts express a lot of what life is supposed to be about – seeking to understand the whole, empathizing with other people’s views and taking action together to achieve positive change in the never-ending pursuit of sustainability.

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Abbreviations

CHAT	Cultural Historical Activity Theory
HIR	Hushållningssällskapets Individuella Rådgivning (Skåne), connected to the Rural Economy and Agricultural Societies
IPM	Integrated Pest Management
JBV	Jordbruksverket, the Swedish Board of Agriculture
LRF	Lantbrukarnas Riksförbund, the Federation of Swedish Farmers
PAR	Participatory Action Research
SEK	Swedish crowns
SLF	Stiftelsen Lantbruksforskning, Swedish Farmers' Foundation for Agricultural Research
SLU	Sveriges Lantbruksuniversitet, the Swedish University of Agricultural Sciences
SPLAT	Specialized Pheromone and Lure Application Technology
SWD	Spotted Wing Drosophila, *Drosophila suzukii*
SWOT	Strengths, Weaknesses, Opportunities and Threats
TT	Tillväxt Trädgård, Partnership Horticulture

Introduction

The importance of insects in agroecosystems cannot be overstated. Without the ecosystem services they provide, e.g. in the form of pollination and pest control, agriculture in its current form would not be possible (Gliessman, 2015). On the other hand, insects can be highly destructive when they act as pests by eating or otherwise damaging crop plants. Indeed, managing insect herbivory is one of the greatest challenges presented in agriculture (Gliessman, 2015). The current trend of global warming risks to increase problems with insect pests in agroecosystems worldwide by enabling them to expand their ranges. At the same time, an increasing global population creates ever higher demands on global food supplies (Yan *et al.*, 2017). In addition, the current global food trade means that pest range expansion is not restricted to active spread by the movement of the insects themselves, but can also take place through passive transport, with potentially disastrous results (FAO, 2015).

There are several different methods available to control insect pests in agroecosystems: biological control, mechanical/physical control, cultural control and chemical control. These methods were all, in general, equally used in the early 1900s (Vandermeer, 2011). However, after World War II, chemical pesticides surged in use and the goal of agroecosystem management became total eradication of pest insects. The problem was that the pesticides did not only kill the pest species, but also the beneficial insects – as soon as the farmers stopped spraying, the pests would therefore resurge because there were no natural enemies to control them. Other unwanted effects of pesticide use include the development of pesticide resistance and secondary pest outbreaks, where the target pest is replaced by another species that survived the spraying. All this created a pesticide dependency known as the ”pesticide treadmill”, where the farmers would have to use ever greater amounts of different pesticides or risk losing their crop altogether (Gliessman, 2015, Vandermeer, 1995). The failure of pesticides as a sustainable solution for pest management can be seen by the fact that crop losses due to pests has remained almost constant for the last 40-50 years, despite the increasing use of pesticides. At the same time, pesticides have had serious negative effects on the environment, including human health, and can add a heavy burden to farmers’ economy (Gliessman, 2015).

In response to the inability of pesticides to solve the problem of agricultural pests, the ideas of integrated pest management (IPM) emerged in the late 1970s. The basic principles of this approach are to 1) not use pesticides unless absolutely necessary, and 2) manage the agroecosystem so that it does not become necessary (Vandermeer, 1995). Methods within IPM can thus be seen as divided into those that are 1) responsive (the direct killing of pests, including biological control through mass release of its natural enemies) and those that are 2) prophylactic (the prevention of insects causing pests problems in the first place). The prophylactic measures include a diverse array of methods but can be roughly divided into those that enhance autonomous biological control and those that are in other ways discouraging destructive organisms through cultural control (Vandermeer, 2011). Examples of the latter include crop rotation and increasing crop plant diversity, removing suitable conditions for the pest (such as material enabling survival and reproduction),

employing physical barriers between the pest and the crop, and using chemical communication signals for trapping or other disruptions of pest insect behaviour (Vandermeer, 2011, Cini *et al.*, 2012). While not a part of the control itself, reliable monitoring is a crucial component of a well-functioning IPM system by enabling data to be collected about pest presence and abundance, to serve as a basis for management decisions taken. Modelling of population dynamics on a greater spatial and temporal scale is also an important part of understanding the pest species and how it can be managed (Cini *et al.*, 2012).

Drosophila suzukii from a global perspective

One example of a pest species where all lines of development and thought outlined above converge is the small fly *Drosophila suzukii* (Matsumura, 1931), a close relative of the vinegar fly *Drosophila melanogaster* that is often found flying around overripe fruit. In contrast to most drosophilids, however, *D. suzukii* prefer to lay their eggs in fresh, ripening fruit. This is made possible by the serrated ovipositor of *D. suzukii* females that enable them to pierce the skin of fresh fruit. The dark spots on the wings of male *D. suzukii* has earned the species the common name of spotted wing drosophila, SWD (Rota-Stabelli *et al.*, 2013).

Drosophila suzukii has emerged as a major threat to global production of soft fruits and berries in the last few years. The species has its origin in South East Asia, and was described for the first time in Japan in the early 1900s (Cini *et al.*, 2012). However, in 2008, the fly was simultaneously found for the first time in both North America (California) and Europe (Spain and Italy), and from there it has continued to spread (Rota-Stabelli *et al.*, 2013). By May 2015, the fly was widely dispersed in North and South America and Eurasia, with presence also in Northern Africa (Asplen *et al.*, 2015). The locations of the first outbreaks suggest that they were caused by transport of *D. suzukii* with imported fruit, and the fly's continuous long-distance spreading and propagation is likely achieved by the same means (Rota-Stabelli *et al.*, 2013, Manduric, 2017). The fly is helped in its range expansion by global warming, which allows it to survive in new areas, to be active for a longer time of the year and thereby also to have a larger number of generations per year (Quarles, 2015).

There are several reasons why *D. suzukii* is such a serious threat to fruit and berry production. First, the fly has almost no competitors for fresh fruit or natural enemies in its new range. It is able to survive in temperate climates and can overwinter also where temperatures go below zero (Rota-Stabelli *et al.*, 2013). However, the winter survival of the flies is weather dependent, and low temperatures during longer periods significantly decrease their viability unless they can find shelters (Manduric, 2017). Besides the passive spread of *D. suzukii* described above, it can also spread a long distance by flying. It has a high reproductive rate, both in terms of eggs laid per female and in terms of a short generation time (Rota-Stabelli *et al.*, 2013). Additionally, the fly has an extremely wide range of potential host plants; they can live on both wild and cultivated plants belonging to up to 19 families (Manduric, 2017). These include Rosaceae (e.g. strawberry, raspberry, cherry, apricot, peach and plum), Ericaceae (e.g. blueberries), Grossulariaceae (e.g. currants), Moraceae (e.g. figs) and Vitaceae (e.g. grapes) (Cini *et al.*, 2012). *Drosophila suzukii* damages fruit by feeding inside it during the larval stage, something that is often aggravated by secondary infections of the fruit with fungal spores or bacteria (Manduric, 2017). This

causes a faster deterioration of the fruit, shortening its shelf life (Cini *et al.*, 2012). The damage is often not detected until very late, just before or during harvest, and in some cases not until after distribution (Manduric, 2017). *Drosophila suzukii* has been able to cause damage in up to 100% of the crop on caneberries, strawberries and sweet cherries in northern Italy and France (Asplen *et al.*, 2015).

It is thus clear that *D. suzukii* is a serious challenge to the global fruit and berry industry, and the responses by researchers and growers in trying to find solutions have been intense and diverse. Efforts have been made to connect and integrate the theoretical and practical aspects of *D. suzukii* management already at an early stage, to mitigate the problem as effectively as possible. For example, in 2011, an international meeting was held in Trento, Italy, called *"Drosophila suzukii: new threat for European fruit production"*. The meeting gathered researchers, growers, and representatives from phytosanitary services from ten European countries, with the purpose of sharing current knowledge, identifying needs and trying to find strategies for the future. At this point, it was stated that efficient methods for monitoring and controlling the fly were not yet available, and that the knowledge of basic biological features of *D. suzukii* in Europe was insufficient. Additionally, it was stated that *"only an integrated and multidisciplinary approach can face the challenge of understanding and ultimately controlling this pest"* (Cini *et al.*, 2012). Among subsequent European efforts to counter *D. suzukii* can be mentioned the 2-year *"Droskii"* research project, uniting researchers from all over Europe in efforts to develop more efficient monitoring, evaluate susceptibility of different crops and varieties, develop environmentally friendly management methods and disseminate knowledge on a transnational level (Simoni *et al.*, 2013). There is also a 4-year EU project, *DROPSA*, with partners from Europe, Asia, New Zealand and North America, that targets *D. suzukii* and a few other fruit pathogens and *"will deliver a cost effective approach that can be widely implemented by the European fruit sector"* for these organisms by its end in December 2017 (DROPSA website). There are also numerous projects and initiatives to counter *D. suzukii* on a national level in several European countries (Asplen *et al.*, 2015). In the US, an extensive program called *"SWD*IPM"*, began to develop very soon after the first *D. suzukii* damage was discovered. The program addresses both social, economical and biological aspects, and includes researchers, authorities, advisors, growers and the public, as well as a diverse stakeholder advisory panel. Activities include informational meetings, research, creating a website for coordination and information dissemination, developing and disseminating educational material for growers and holding workshops on *D. suzukii* management, releasing newsletters, carrying out monitoring work, publishing articles, and regular evaluations to be able to report the impact of the program, as well as examinating how it can be improved (Dreves, 2011). In a review of the global situation from 2015, Asplen *et al.* confirm that research has indeed progressed rapidly in both Asia, North America and Europe in the 5 previous years, but also that there is still much to be done, both on basic *D. suzukii* biology and on applied methods for *D. suzukii* management. The importance of connecting research with outreach to manage the problem effectively is once again underlined (Asplen *et al.*, 2015).

One strong and common theme that emerges for all research efforts on *D. suzukii* is the importance of IPM. In the initial phase of the problem, there has been heavy reliance on pesticides to counter this pest in all geographic regions impacted (Asplen *et al.*, 2015, Haye *et al.*, 2016, Simoni *et al.*, 2013, Quarles, 2015, Rota-Stabelli *et al.*,

2013, van Timmeren & Isaacs, 2013). This is a cause for concern for several reasons. There is a risk of resistance development, especially considering the short *D. suzukii* generation time that allows for fast selection of resistant individuals, as well as possible negative effects on non-target organisms and the environment (Asplen *et al.*, 2015). The pesticides used against *D. suzukii*, that are often of broad-spectrum type, risk to disturb functioning IPM programs already in place (Haye *et al.*, 2016). They also pose a risk to consumers, as the growers are forced to spray very close to harvest (Rota-Stabelli *et al.*, 2013). Luckily, there are many methods currently being researched that can contribute to a more sustainable and less chemically-dependent IPM strategy for *D. suzukii* – some are already available, while others are being developed. Among cultural control methods, sanitation is one of the most important. These methods also include pruning to remove cool and humid habitats where the flies can develop, using mulches to reduce standing water, destroying winter habitats and preventing overwintered adults from moving up the trees, employing short harvest intervals, using coverage nets, and employing monitoring and mass trapping with baited traps. On the biological control side, both parasitoids, predators, nematodes and pathogens such as entomopathogenic fungi are possible control agents (Haye *et al.*, 2016). Quarles (2015) additionally names using early ripening cultivars, using repellents and potentially removing wild hosts around cultivations as proven or promising cultural methods. The release of sterile males, and use of endosymbiotic relationships between *D. suzukii* and bacteria are mentioned by Cini *et al.* (2012) in their outline for a future research agenda on *D. suzukii*, while they also call for wider perspectives to be employed, such as modelling *D. suzukii* occurrence and movement on a landscape/regional scale, and taking care to not repeatedly re-introduce the fly through long-distance passive transport.

One area of research that might contribute with solutions to the *D. suzukii* issue is that of the microbial associations of the fly. The microbial relations of *D. suzukii* can provide a tool to be used to improve monitoring but also management. For example, microbial cues can act as repellents, or as lures for the similar approaches of attract-and-kill (killing the insect at contact using a toxicant) and mass trapping (killing the insect by physical means, such as an adhesive or drowning solution) (Hamby & Becher, 2016). *Drosophila* species utilise yeasts as food – the nutritional content of yeast is important for fly survival and development – and species with different lifestyles are characterized by associations with distinct assemblages of yeast (Hamby & Becher, 2016). Interestingly, despite their strong preference for ripening fruit for oviposition, *D. suzukii* is still closely associated with yeasts in a way similar to other drosophilids. Among yeast species, *D. suzukii* appears to be closely associated with *Hanseniaspora uvarum*; this is the species that is most frequently cultured from wild-collected individuals, and the species that the flies have been shown to prefer in a multi-choice test of six different yeasts (Hamby & Becher, 2016). Therefore, *H. uvarum* holds promise as an attractant that might be used for efficient and species-specific monitoring and management.

Because of the intense and diverse research carried out on *D. suzukii*, there is hope that sustainable management methods, to be combined into locally adapted IPM programs, are within reach. Several authors mention the great advantage of having extensive knowledge of the close *D. suzukii* relative and widely used model organism *D. melanogaster*, that can help speed up the progress of *D. suzukii* research (Cini *et al.*, 2012, Haye *et al.*, 2016, Rota-Stabelli *et al.*, 2013). Asplen *et al.* (2015) finish on

a positive note in their global review of *D. suzukii*: according to them, the problem will probably fade in significance as growers gain more experience, knowledge and awareness of the fly, at the same time as the carrying capacity of wild habitats for *D. suzukii* will decrease when the ecosystem adjusts for the presence of the new species. However, it is underlined that significant efforts and resources will continue to be needed to tackle *D. suzukii*.

Drosophila suzukii in Sweden

Drosophila suzukii was found in Sweden for the first time in late August 2014 in the city of Lund, located in the southernmost region of Skåne. This was the first finding of the fly in the Nordic countries, but it was also found in Denmark later in the same year. The first Swedish finding was made in mixed shrubbery vegetation close to a grocery store handling imported fruit, but *D. suzukii* was also found in two Skåne berry plantations in early autumn 2014. In 2015 and 2016, monitoring work in southern Sweden was systematized and carried out on a bigger scale with standardized traps. In both 2015 and 2016, monitoring was carried out at 22 sites, commercial cultivations but also some home gardens. The crops monitored were raspberries, blackberries, blueberries, strawberries, elderberries, red currants, cherries, plums and grapes. In both years, *D. suzukii* eggs and/or larvae were found in all crops and plants monitored. In 2015, the fly was found all over Skåne but not in any other region, while in 2016, the fly was also found in three regions north of Skåne (Manduric, 2017).

Drosophila suzukii was found earlier in the season in 2016 than 2015 – first catch in week 29 (July 18-24) and week 32 (August 3-9), respectively. However, at the time of maximum captures in 2016, week 40 (October 3-9), most crops had already been harvested. The ability of *D. suzukii* to enter hibernation, its cold tolerance and its behaviour in the Swedish climate are still areas where many questions remain, even after analyzing the monitoring data from 2015 and 2016 (Manduric, 2017). It is important to remember that because the fly spreads with imported fruit, it is also possible to find it in places where the climate may not allow it to survive the winter – therefore, it still remains to be seen if the findings north of Skåne represent places where the fly has actually established (Sanja Manduric, JBV, pers. comm., 2017[1]).

The arrival of *D. suzukii* in Sweden was expected, considering how fast it has spread in the rest of Europe. Still, not much could be done to stop it; the fly is not regulated as there are not sufficient and feasible means available to prevent it from spreading. *Drosophila suzukii* has the potential to cause significant damage to the Swedish soft fruit and berry industry, which is of course even greater if wild berries are included. Losses can be of both economic, ecological and cultural nature. So far, however, damage caused by *D. suzukii* in Sweden has been very limited (Manduric, 2017).

The methods for *D. suzukii* prevention and control currently available and suggested to Swedish growers include monitoring, sanitary measures (such as removing material where the fly can reproduce), earlier and more frequent harvest, choosing more resistant and earlier ripening cultivars, increasing distance between fields with

[1] Interview at JBV's office, Alnarp, February 13, 2017.

crops of different ripening time to prevent migration between them, reducing moist environments and standing water, covering with nets, fast cooling after harvest, and use of the pesticide spinosad. Spinosad is one of very few chemical substances suitable for use against *D. suzukii* – to be eligible under Swedish conditions, a substance against *D. suzukii* must be possible to use several times per season, quickly degrade in nature and be as harmless as possible against beneficials. Spinosad has not been registered against *D. suzukii* in Sweden but has only been possible to use through yearly dispensation (Svensson *et al.*, 2017). This year's (2017) spinosad dispensation applies for cultivations of raspberries, blueberries, blackberries and currants on open ground and in tunnels, but not in greenhouses (JBV, 2017a). So far, there have been no differences in methods available to organic and conventional growers in Sweden (Sanja Manduric, JBV, pers. comm., 2017[2]).

In Sweden, JBV, SLU and HIR have joined forces to deal with the problem of *D. suzukii* together with growers. This collaboration will be extensively described below. In 2016, SLU, JBV and HIR started to jointly develop a new attract-and-kill method for *D. suzukii*, with a substance called specialized pheromone and lure application technology (SPLAT). The project continues in 2017 (Manduric, 2017). Initial trials with SPLAT have been made under field conditions in Sweden, leading to a reduction, albeit not significant, of infestation in raspberry (Svensson *et al.*, 2017).

Agroecology and Participatory Action Research, PAR

The issue of *D. suzukii*, in Sweden as well as worldwide, calls for a comprehensive structure for analysis and action on all administrative and geographical levels. To act as guidance, a framework for thinking and acting in the pursuit of sustainable agriculture is offered by agroecology. Agroecology takes its starting point in the agroecosystem, which is understood as a site of agricultural production (at farm level, or regional level) and its functioning as an ecosystem. To understand the agroecosystem, it is essential to understand the interconnections between its different parts and its complex sets of inputs and outputs. In an extended view, agroecology also takes into account the social systems in which the agroecosystem is embedded (Gliessman, 2015). As can be understood already from this short description, the definition of agroecology is not singular. While some define it only as an approach that aims to investigate agricultural issues from a natural science perspective, others embrace the complex realities of food systems as social-ecological systems (Méndez *et al.*, 2013). In addition to the wider or narrower range of scientific disciplines included under the umbrella of different agroecology definitions, the purpose of agroecology itself has also taken different forms; emphasis in different definitions have alternated between agroecology as a science, movement or practice (Wezel *et al.*, 2009).

The wider definition of agroecology, including both the social and ecological aspects of agriculture, is the one employed in this thesis. This approach is connected to a systemic philosophy of science. The underlying assumption of this philosophy is that everything is connected, impacts and is impacted by everything else. To gain

[2] Mail contact, April 24, 2017.

knowledge about the world, it is necessary to study systems as well as their parts, and therefore to engage people with different partial understandings to gain a more complete understanding of the system (Eksvärd *et al.*, 2014). When making a systemic description, systems thinking can be used as a tool – this will be further described below. In agriculture, production systems are interrelated with the biophysical and sociocultural environment, and taking only a partial view or trying to fit the system description within universal laws risks to overlook emergent properties of the system as a whole or missing out on important characteristics of a locality specific situation (Swiergiel, 2015). The systemic view as described here implies the necessity of investigating the world in a transdisciplinary way. Transdisciplinarity in agroecology means that different types of knowledge, both from different sources and on a wide variety of subjects, are integrated and valued in the process of agroecological research and action. Different kinds of knowledge include, for example, academic, local and experiential knowledge (Méndez *et al.*, 2013). The underlying motivation for taking a systemic, and thus transdisciplinary, approach in trying to understand agroecosystems can be seen as summarized by Eksvärd *et al.* (2014, p.18) when they say that *"how we as humans put value on things and processes have impact on what is possible of seeing, understanding, doing, and thinking as well as how to react"*. The greater the diversity of perspectives available through a transdisciplinary approach, the better our possibilities to gain a good understanding of and take appropriate action within an interconnected and complex food system.

To understand a complex situation in a systemic way, and to be able to make changes in pursuit of greater sustainability, structures are needed that enable the actors of the system to participate and take action, which are two other important aims of the wider definition of agroecology as stated by Méndez *et al.* (2013). One mode of working that provides both these things is Participatory Action Research (PAR). In PAR, those impacted by a problematic situation (practitioners, researchers, advisors and other stakeholders) together decide on relevant research questions, design research strategies, collect and analyze data, monitor the results and evaluate the outcome (Swiergiel, 2015). PAR does not have a fixed frame or working method, but is an approach that can be adjusted to every local situation where it is used (McGarvey, 2007). It is pluralistic and does not subscribe to any predetermined theories or methods of inquiry. Instead, these are defined by the need of the situation as interpreted by the PAR inquiry participants (Swiergiel, 2015). What differentiates PAR from other types of research is the view of knowledge, and the goal of the research process, which is reflected in the ”Participation” and ”Action” given in its name. ”Participation” means the strive to involve all stakeholders of a given problem situation and to democratize their influence, as indicated above. All types of knowledge that can be useful for finding solutions are taken into account. One fundamental attitude of PAR is therefore that everyone involved in the PAR process will learn from it; it is not building on a one-way flow of knowledge (McGarvey, 2007). ”Action” means that one goal of the process is to achieve a positive change for those involved, e.g. through finding a way to handle a problem. Theory and practice are closely connected in the PAR process, and PAR work creates a feedback channel between practitioners and researchers that can be used to improve the work of both

(McGarvey, 2007). In agriculture, one of the motivations for conducting research and development projects using a PAR approach is the experience of low farmer adoption rates of methods developed by the scientific community, or other unexpected problems, such as environmental or health problems, emerging as new technologies are adopted (Swiergiel, 2015). In other words, the PAR working mode stands a better chance to prevent problems that might otherwise be caused by insufficient consideration of the system as a whole.

The PAR process can be seen as divided into a series of phases. In phase 1, the work is started by building relations, making a preliminary analysis of the situation and mobilizing awareness. Phase 2 focuses on the identification of possibilities and limitations, and of the participants' existing knowledge, and establishes criteria for the subsequent choices of action. In the next phase (3), actions and experiments are planned, as well as how to evaluate their outcome. In phase 4, the actions, experiments and their evaluations are carried out, and in the final phase (5) the results and insights from the process itself are disseminated and presented (Eksvärd, 2003). To be able to move through a PAR process, it is important to have a facilitator that helps it forward. The role of the facilitator is not to determine the goal or the mode of working for the PAR group, but to use strategic communication to help the participants determine the goal and working mode themselves (Eksvärd, 2003).

Inherent to the PAR process is iterative learning, and one way to frame this is through Kolb's learning cycle (fig. 1). The cycle goes through the stages of having a concrete experience, reflecting on this experience, incorporating the experience into a theory through generalisation (abstract conceptualisation), and trying out the generalisation in other situations (active experimentation), leading again to a concrete experience (Eksvärd, 2003). Employing this cyclical working mode means that there is always close connection between thinking and action in PAR learning, at the same time as the subjectivity inherent in reflection is acknowledged as a part of the process. It also entails a flexibility and responsiveness of the research process, as previous learning is used when planning for new actions (Swiergiel, 2015). Learning takes place on both individual and group level, and can be seen as taking place several times within the PAR process. Indeed, the PAR process itself can be seen as a learning cycle, where the presentation phase leads on to a new search- or planning phase based on the experiences and reflections that has been made (Eksvärd, 2003).

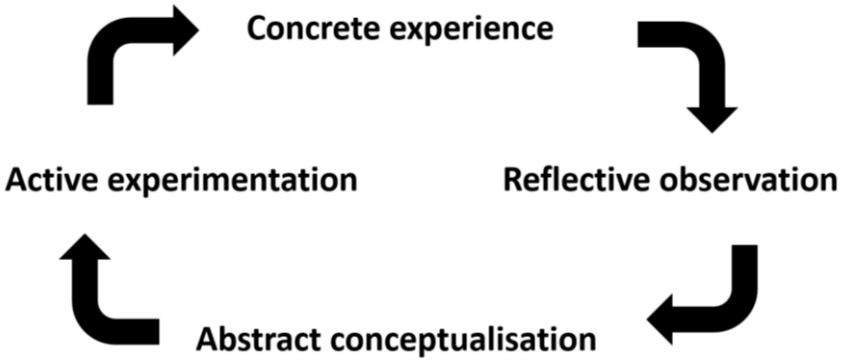


Figure 1. Kolb's learning cycle, after Eksvärd (2003).

The outcomes of a PAR process include new knowledge and experiences for those involved, as well as knowledge that can be disseminated to the wider public. New things are learned about the subject of investigation in itself, but also about how collaboration works, about the situation of other people and about oneself. By investigating reality with the explicit goal of making a positive change, PAR also reshapes the situation of its participants (Eksvärd, 2003). Several benefits emerge from the fact that knowledge is jointly generated by the PAR participants, and tried out in practice as a part of the research process. Findings are continuously cross-checked and their meaning negotiated by many kinds of stakeholders, and the knowledge base therefore becomes robust and learning efficient. As the systemic consequences of the implementation of natural science findings become evident, the research community is made aware of the effects of their choice of focus and proposed solutions, and the research process as a whole is democratized (Swiergiel, 2015). Despite all the potential positive outcomes and durable results of PAR work, it also faces challenges. Some of the main obstacles can be to find enough resources to give room for the full potential of a PAR project, especially as it is a working mode that requires time, at the same time as some of the outputs are of a nature that cannot be quantified and measured. Another challenge is to find permission and support from higher organisational levels (e.g. within a university or authority) to search for solutions through a PAR process, and to implement them (Eksvärd, 2003).

As has been said above, the broadest definitions of agroecology emphasize transdisciplinarity, participation and action, just as PAR does. This leads to the question of what the relationship actually is between these two terms. Indeed, Méndez *et al.* (2013) describe the principles of agroecology and PAR as converging. Overlapping goals include diversity of participants, empowerment of the stakeholders, sensitivity to local and systemic context, the joint definition of problems, and joint interpretation and implementation of research. PAR strives for an iterative learning process (Méndez *et al.*, 2013), and this connects well to the goal of agroecology: a well-adapted, resilient and sustainable food system. The connection between continuous learning and sustainability is made clear by Pretty (1995, p. 1249), in saying that *”as situations and conditions change, so must our constructions of sustainability also change. Sustainable agriculture is, therefore, not simply an imposed model or package. It must become a process for learning and perpetual novelty.”*

PAR, then, is seen as an important tool to achieve sustainability of food systems according to agroecological principles, and the approach has already been successfully used in agroecosystems around the world (Gliessman, 2015). In Sweden, several PAR projects in agriculture have taken place in recent years, spanning many different kinds of agricultural production and resulting in a rich and diverse collection of experiences. What all of the PAR projects have in common is that the needs of the practitioners have determined the research questions asked, and the stakeholder groups have then collaborated on a project to find solutions. To support the importance of this approach, one project on green manure that started as a more ”conventional” research project with a subsequent PAR ”add-on” showed that the fact that the farmers themselves were not involved in the initial formulation of questions became a weakness of the project, as the results from the study were limited in their relevance to the growers (Eksvärd, 2007). In several cases, groups of

growers in similar situations have been formed, and they have then been able to give their opinion on what problems to prioritize – for example within a group of organic tomato growers (Ögren *et al.*, 2008), organic vegetable growers (Hansson *et al.*, 2015), organic apple producers (Swiergiel, 2015), and cucumber growers (Rur, 2016). In many cases, the established PAR groups have decided to continue to work with new questions or projects after the end of the initial ones, showing that the goal of an iterative development process and long-term relationships within PAR has been reached, and that the work has been seen as worthwhile.

Objectives

Considering the damage that *D. suzukii* has caused to the fruit and berry industry worldwide, there is reason to be concerned about its recent arrival (and likely frequent re-introduction) in Sweden. At the same time, the situation is characterized by great uncertainty. More noticeable damage, but also ecosystem adjustments leading to lower carrying capacity of the pest, or that the fly will not be able to cause significant problems in the Swedish climate, are all possibilities close at hand. Adding to this is the rapid development of methods for *D. suzukii* monitoring and control, both in and outside Sweden. All these factors call for a close collaboration between researchers, authorities and growers to be able to respond quickly to changes of the situation and to be able to develop *D. suzukii* management strategies that are both sustainable and feasible for growers to use.

In this thesis, my objectives are therefore to provide a systemic description of the current situation concerning *D. suzukii* in Sweden, and to use this as a basis for analysis and suggestions of potential improvements in working structure and management methods to enable the affected stakeholders to respond to the situation in line with agroecological principles.

Research question and delimitation

The major research question for this thesis is:

Can PAR and IPM principles be further developed and integrated in the work against *Drosophila suzukii* in Sweden, with the goal of a sustainable and responsive management strategy?

The research question is broken down into three subqueries:

1. How are the stakeholders affected by *D. suzukii* in Sweden (SLU, HIR, JBV and growers) perceiving the problem, reasoning and acting?
2. Can PAR principles be employed in developing the collaboration between the stakeholders, and in that case how?
3. Can the efficacy of SPLAT as an attract-and-kill method for female *D. suzukii* be improved by adding *H. uvarum* yeast?

In this inquiry, I chose to limit myself to soft fruit and berry growers in Skåne because 1) they represent a large amount of all soft fruit and berries produced in Sweden (Persson, 2015), 2) the fly has been found in 3 places outside Skåne but it is still

uncertain whether these findings represent areas where the fly has established, 3) because the involved people from SLU, HIR and JBV all have their offices in Skåne, the geographic vicinity makes it easier for them to establish a participatory relationship with growers in this region.

Theoretical framework and research design

While aiming to analyse the possibilities for agroecological principles (PAR and IPM) to be further implemented and integrated in the Swedish work with *D. suzukii*, this thesis in itself can also be seen as written within the frame of agroecology, in the sense that a systemic description, including both economic, ecological and social factors has been made. The motivation for employing this perspective is no different from that of employing it as a part of PAR – the more perspectives are included, the more complete the description of the system and the more comprehensive the analysis made.

Creswell (2003) identifies three questions that need to be asked when designing research:

1. What knowledge claims are being made by the researcher?
2. What strategies of inquiry will inform the procedures?
3. What methods of data collection and analysis will be used? (Creswell, 2003, p. 5)

The knowledge claim made sets the limits for what can be learned within a study, by describing what kind of knowledge the researcher expects to gain from it. Knowledge claims are also called paradigms, and include positivism, constructivism and pragmatism (Creswell, 2003). These all have bearing on the work of this thesis.

The positivistic paradigm that has dominated scientific work for the last centuries builds on the assumption that there is an objective truth to be discovered, while the reductionism methodology associated with it assumes that the world can be understood by studying its parts separately (a mechanistic worldview) (Pretty, 1995). Positivism is concerned with testing pre-defined hypotheses about clearly defined causes and effects, with the aim of finding universal, underlying laws that explain how the world works (Creswell, 2003). This way of investigating the world has led to great advances within clearly delimited systems of low uncertainty. However, it is inadequate when dealing with complex and dynamic situations. For this kind of inquiries, the constructivist paradigm provides a better foundation for understanding. Within constructivism, the worldview (ontology), is relativist, meaning that there is no universal ”reality” but that every person holds their own reality, based on social context, local conditions and own experience (Guba & Lincoln, 1994). This also means that realities are not absolute even for the individual, but changes over time with new experiences. Because reality is dependent on experience within the constructivist paradigm, the view of knowledge (epistemology) is that it cannot be independent or ”objective” – it is shaped by the interaction between the investigator and the object of investigation (Guba & Lincoln, 1994). Findings of a constructivist inquiry are thus not something that lay hidden at the outset for the inquirer to find, but something that is created in the investigation process. For the constructivist inquiry process, *”the final aim is to distill a consensus construction that is more informed and sophisticated than any of the predecessor constructions”* (Guba & Lincoln, 1994, p.

111). Important to note when contrasting the positivist and constructivist paradigms is that both allow for qualitative and quantitative methods to be used (Guba & Lincoln, 1994).

The current work draws on both the positivist and the constructivist paradigms in its inquiry, while all results have been merged into a constructivist analysis. Therefore, it can be said that the overall knowledge claim of this study is pragmatic. Pragmatism puts focus on the research problem and its solution instead of any particular philosophy or method, and thus lets the researcher use all methods that can contribute to understanding the problem (Creswell, 2003). According to Creswell (2003, p. 11), pragmatic *"knowledge claims arise out of actions, situations, and consequences rather than antecedent conditions"*. What is important within a pragmatic paradigm is that the research done achieves its purpose, and it is valued against the difference it makes rather than if it has given a "true" description of reality. The purpose can be described as using the results to bring about positive consequences in the value system of interest to the researcher (Mertens, 2015).

The systemic philosophy of agroecology implies a way of interpreting reality, and a tool to use in describing the world in a systemic way is provided by systems thinking. Systems are defined as complex wholes made up of related parts, and can be of any nature or scope – in its broadest sense, then, everything is a system (Cabrera *et al.*, 2008). The basic principles of all systems thinking is the critical practice of 1) drawing boundaries around distinct concepts, 2) finding relationships between concepts, 3) defining systems made up of concepts and 4) considering what perspective the system is seen from (Cabrera *et al.*, 2008). Systems thinking helps its practitioner to see and predict cycles, counterintuitive effects and unintended consequences in a system of interest (Ison, 2008), making it a useful tool when proposing changes for a complex situation.

Because of the properties of systems thinking described above it is an important tool for understanding agriculture, that is by nature characterized by vast complexity. The understanding gained can in turn be used to help move food systems towards a more sustainable state, and systems thinking has been widely adopted in the study of agriculture in recent years (Bland & Bell, 2007). However, system thinking faces two challenges: that of drawing boundaries and that of accommodating for change (Bland & Bell, 2007). The boundary challenge stems from the fact that no matter how we try, we cannot describe reality in its entirety, and for the sake of any useful analysis it is not even desirable to strive for this. All boundaries that inevitably need to be drawn within systems thinking are therefore artificial and subjective – they reflect the interests of the observer (e.g. researcher) and the specific narrative that the researcher wants to tell about this area of interest. This puts the researcher in a position where the validity of the systems analysis, based on the subjective boundaries drawn, can always be questioned. The second challenge, accommodating change, has manifested itself by the fact that many systems analyses only show a snapshot that, no matter how inclusive and complex, does not account for the possibility of new connections or that elements of the system may appear or disappear (Bland & Bell, 2007). Faced with the insufficiency of a mechanistic worldview on the one hand, seeing an agricultural system as separate and distinct parts with defined interactions, and the difficulty of analysis when applying a full systems thinking approach on the other hand, where the connections

are endless, Bland & Bell (2007) want to provide the agricultural analyst with a third option, in the form of holon thinking. Holons are presented as an ontological model, a way to think about the world. They are neither wholes nor parts, but can take on both roles depending on the purpose of analysis, and the same goes for the ”parts” that constitute them. In that sense, nothing can ever be seen as only whole or part. The interacting parts of a holon are bounded by a common intentionality, meaning that they strive for a common goal. The key activity of holons is to constantly seek configurations of all the contexts that they exist in that allow them to pursue their intention. The contexts provide the driver for the holon's intention, and the holon might have more or less capacity to change its different contexts. The seeking of configurations means that holons are in a constant state of unpredictable, but directed, change. It is important to remember that holon thinking still gives no guarantee for the accuracy of analysis – the researcher may still overlook important intentions or contexts of holons, and the outcome of holon analysis will always be a subjective narrative. To reduce the risks of an unbalanced or incomplete holon analysis, the aim should be to try to understand the holon in the ways that it is understood by the parts constituting it (Bland & Bell, 2007). In this study, the holon concept was used as a tool for reflecting on and analyzing the different entities and their intentions such as they emerged during the course of the work.

With the knowledge claim and the tools used for describing reality in place, the next question is that of the strategy of inquiry. The pragmatic knowledge claim is connected to mixed methods research (Creswell, 2003), which is the chosen strategy of inquiry, or methodology. The current study includes both experiments and a survey (quantitative) and semi-structured interviews (qualitative) which will be further described in the methods section below. In this case the benefits gained from the mixed methods approach, in the categories provided by Bryman (2006), were that 1) the different methods complemented one another and gave a fuller picture of the situation, 2) the different methods answered different research questions, 3) the methods were applied in a sequential way and could therefore inform one another over time as the research process developed, and 4) that one method (the survey) facilitated the sampling of respondents of another method (the semi-structured grower interviews).

Methods

A brief list of the methods used in this thesis is provided below. They will all be described in detail further down.

- Three semi-structured interviews with one representative each from SLU, HIR and JBV
- A survey for commercial growers of soft fruits and berries in Skåne
- Semi-structured follow-up interviews with five growers
- Laboratory experiments on the attractiveness of different combinations of the attract-and-kill formula SPLAT and *Hanseniaspora uvarum* yeast for *Drosophila suzukii* females
- Literature and secondary data studies

The collection of material for this thesis began with semistructured interviews with representatives of the *D. suzukii* working group: SLU, HIR and JBV. In the words of Bernard (2006), *"a semistructured interview is open ended, but follows a general script and covers a list of topics"*. The purpose of the interviews were:

1) to gain an overview of the structure, development, content and aims of the *D. suzukii* work from different perspectives
2) to gain an understanding of how the different institutions see their own role in the *D. suzukii* work
3) to gain an understanding of how the different institutions view the collaboration and roles of the other actors within the *D. suzukii* working group
4) to gain different perspectives on how the *D. suzukii* work has succeeded thus far, and if there were any ideas for how it can be further developed

Two participatory visualization tools were used: the respondents were asked to draw a mindmap of the actors involved in the *D. suzukii* work and the connections between them, and to draw a timeline with important events in the history of the *D. suzukii* work. The interviews strived for a conversational atmosphere. Follow-up or clarifying questions outside the interview guide where asked when needed, and the interview guide was slightly altered from the first interview to the last, with gained experience and the emergence of new topics. However, the outline stayed the same. See Appendix 1 for interview guide.

The interviews were made in the offices of the respective institutions, during January and February 2017, and lasted between 70 and 90 Minutes. All respondents gave their permission to record the interviews. The interviews were held in Swedish (the first language of the author) or English, depending on the preference of the respondent.

The respondents were:

- **SLU:** Paul G. Becher, associate professor and researcher in chemical ecology at the Department of Plant Protection Biology.
- **HIR:** Victoria Tönnberg, soft fruit adviser.
- **JBV:** Sanja Manduric, responsible for plant protection issues concerning fruits and berries at the Plant Protection Central (Växtskyddscentralen), Alnarp.

In parallel with the interviews, information was collected both on the global and Swedish situation concerning *D. suzukii*, current efforts of research and outreach, soft fruit and berry cultivation in Skåne and Sweden and the theoretical foundations of PAR and IPM. Collecting secondary data has been an integrated part of the process throughout this work, and the sources have been diverse: from scientific articles to books, reports, official statistics, web pages, theses and encyclopaedias.

A survey for growers of soft fruits and berries in Skåne was developed using Google Forms – digitally available by link, but also printed in paper form for the growers that preferred this. An outline of the survey was proposed at a meeting with representatives from SLU, JBV and HIR that I participated in (at SLU, Alnarp, 13 February 2017), and its content was discussed. Feedback was received from SLU,

HIR and JBV in the following days, and after adjustments had been made, the survey was also pre-tested together with one of the growers.

The link to the survey, together with a descriptive text, was published on the official website for the Swedish *D. suzukii* working group, www.drosophila-suzukii.se, on the 27th of February. On the 28th of February, I shortly presented my Master's project and the survey at a course on plant protection and cultivation for berry growers and advisors organised by JBV and HIR in Kristianstad, Skåne. The survey was handed out in paper form to the growers present, and some answers were collected.

The survey was spread further by several different means:

- Sent out through the growers' association LRF together with a personal letter to around 80 berry growers in Skåne.
- Sent to growers of cherries and plums in Skåne connected to the growers' association Äppelriket – the mail addresses to 17 growers were obtained, and personal mails were sent to these.
- The phone number to as many additional growers of soft fruits and berries in Skåne as possible were collected by the author, and a total of around 50 suitable growers were contacted by phone. Because the mail addresses of the LRF growers were not known, there may have been overlap between the two means of contact.
- The survey was promoted in a regular information letter for berry growers sent out by HIR, both in digital and paper form (HIR Bärbrev nr. 2, 9th of March 2017). The berry letter reaches around 25 growers in Skåne.
- Additionally, the agricultural newspaper ATL (Lantbrukets Affärstidning) published a short interview with the author about the survey in their digital version (Eborn, 2017).

The purpose of the survey was to try to grasp the general view of *D. suzukii* among soft fruit and berry growers in Skåne, to be able to see different patterns of views and situations within this heterogeneous group and also to sow the seed of future participation of growers in the *D. suzukii* work. Questions asked related to the fly itself, to the *D. suzukii* working group and to the growers' own involvement, and were alternately closed and open-ended. The survey was divided into four parts:

1) basic information about the respondent's cultivation of soft fruits and berries
2) perception of *D. suzukii* and what is done about it
3) what kind of information the grower receives/needs and how new information should be made available
4) the growers' view of participation in the *D. suzukii* work.

See Appendix 2 for a complete list of survey questions.

At the end of the survey, which was anonymous, the growers had the opportunity to fill in their contact information if they would agree to a follow-up interview, if they would consider to participate in future activities with the *D. suzukii* working group, or both. In total, 37 growers answered the survey, and out of these 15 agreed to a follow-up interview. Among these, 5 growers were chosen with the intention to include as different growers as possible concerning cultivation conditions. The

growers were contacted and semistructured interviews were subsequently held on location at the different farms during April 2017, lasting between 30 and 60 minutes. The approach was the same as for the interviews with SLU, HIR and JBV. Interviewing was done in Swedish and all growers agreed to having the interview recorded. The questions asked were informed by previous knowledge and experiences gained in the Master's work, and aimed to find a deeper and more nuanced understanding beyond the survey answers. The interviews were divided into the following themes:

1) understanding the context and structure of the specific farm, and the role of soft fruit/berry cultivation within that context
2) the direct and indirect effects that the arrival of *D. suzukii* in Skåne has had at the farm
3) the reasoning behind actions taken and not taken against the fly
4) perception of the work done in Sweden to counter *D. suzukii*, own ideas for improvement and the view of the role of the growers.

See Appendix 3 for the interview guide.

During the course of the work, one issue that all kinds of actors (SLU, JBV, HIR and growers) expressed interest in was the development of the attract-and-kill substance SPLAT. Therefore, laboratory experiments were conducted on the potential improvement of SPLAT attractiveness for *D. suzukii* females using *Hanseniaspora uvarum* yeast as a part of this work. The methods, results and analysis of these trials will be further presented in its own section below.

Qualitative and quantitative analysis

All interviews were transcribed, and the transcripts read and reflected on. The survey results were visualized by making graphs in Excel. With the theoretical framework of systems thinking in mind, the definition of concepts, relationships between them and different perspectives within the system were sought, with holon thinking as a complementary tool for reflection on boundaries, intentionalities and change. To find themes was facilitated by the structuring of the original interviews and the survey, where questions had been organized into broad categories, but new themes that emerged during the interviews were also accounted for. Throughout the analysis of the growers' situation and perspective, the qualitative (interview) and quantitative (survey) data were used to complement each other in making interpretations. In the words of Schutt (2012), *"qualitative data can provide information about the quality of (…) quantitative survey measures, as well as offer some insight into the meaning of particular fixed responses"*.

As made clear by Kvale (1997), a researcher working with qualitative material always chooses a certain perspective in the analysis, that determines what aspects of the material are examined, and a theoretical framework, that determines the interpretations made. Seeing the material through the given lens, the researcher goes beyond what is said to develop structures and relations that are not immediately evident in a text. One important point is therefore to be open about one's

assumptions, to make the interpretations made in research available for control by others. There will always be alternative views and interpretations of the collected data, but the central criterion for qualitative research is that a reader taking the same perspective as the researcher should be able to see what the researcher saw, whether agreeing or not (Kvale, 1997).

To complement the survey data, an approximate calculation was made on 95% confidence intervals for the whole population (all soft fruit and berry growers in Skåne) for every given number of positive answers among the survey respondents. The total number of soft fruit and berry growers in Skåne was estimated to 140, based on official statistics from JBV (Persson, 2015). The program used to calculate the confidence intervals was made using RStudio Version 1.0.136 (RStudio Team, 2017). See Appendix 4 for the program and full table of confidence intervals.

Context

Sweden and Skåne

The location of Sweden in Europe, and the location of the region of Skåne in Sweden, can be seen in fig. 2. More than half of Sweden is covered by forest, and only about 7% of the area is agricultural land (UI, 2016b). Of the around 10 million inhabitants, 86% live in cities, and the southern third of the country is home to around 85% of the total population (UI, 2016a). Sweden is ranked among the top ten countries in the world when it comes to access to education, life expectancy and standard of living (UI, 2016d).

The importance of agriculture in Sweden as a source of employment and rural development has declined since World War II (Swiergiel, 2015). Today, the agriculture is highly mechanized and is only employing around 1% of the work force (UI, 2016c). Small- and medium scale farms have increasingly given way to large-scale production in the years since 1944 (Swiergiel, 2015). The total number of farms in the country has been reduced by more than half in the last 40 years, but there has been no decline in production (UI, 2016c).

Figure 2. Location of Sweden in Europe (red arrow) and Skåne in Sweden (red marking). Pictures from Google Maps.

Skåne is the southernmost region in Sweden. Its climate is distinctly maritime, with mild winters and warm summers (average temperature in January is 0 to -2 °C and in July 16 to 17 °C). The annual precipitation varies between 500 and 750 mm depending on location. The Skåne landscape is characterized by fertile plains, and is relatively flat: only ¼ of its area is situated more than 100 m above sea level, and the highest point is 212 m above sea level (Behrens, ND).

Skåne covers 10 969 km^2 and has around 1 300 000 inhabitants. The infrastructure is highly developed, and the most important harbours for trade with the European continent (Helsingborg, Malmö, Trelleborg and Ystad) are located here. Skåne is the most important region for agriculture in Sweden, with the country's highest yields per areal unit for almost all crops. Horticultural production is economically important, and Skåne is the region in Sweden with the most greenhouse cultivation area. Despite the relative importance of agriculture, only 2,2% of the work force in the region is employed in the agricultural and forestry sector together (von Konow & Erlandsson, ND).

Fruit and berry production in Sweden and Skåne

It is clear that open ground production of berries in Sweden is affected by the general trend for Swedish agriculture, towards fewer and larger farms. From 1999 to 2014, the total production area has been relatively constant, keeping around 3 000 ha (2 665-3 358 ha), but the number of enterprises has declined sharply from 949 to 581 in the same period. For greenhouse berry production, the total area has declined some (from 88 925 m^2 in 2005 to 64 870 m^2 in 2014 with some fluctuation) but the number of enterprises stayed fairly constant (rising from 27 to 33 in the same period, also with some fluctuation). Cherries and plums (henceforth collectively known as

soft fruits), have also experienced a sharp decline in the number of producers: cherries from 73 producers in 1999 to 36 in 2014 (with fluctuation), plums from 148 to 73 producers in the same period. In this case, however, the declining number of enterprises has been accompanied by a decline in production area (195 to 40 ha for cherries, 101 to 42 ha for plums with fluctuation in the same years) (Persson, 2015).

In the open ground production of fruit and berries in Sweden, strawberries is the most economically important crop, followed by apples and raspberries. The production value of strawberries was 540 million SEK (Swedish crowns) in 2015, constituting 89% of the total berry production value (608 million SEK). Total value for open ground cultivated soft fruits and berries in 2015 was 618 million SEK. In comparison, greenhouse cultivation of berries is not economically significant; there is no exact data available for only berries in greenhouse, but their value amount to less than 27 million SEK (2015) (Persson, 2016).

Skåne is the most important region for soft fruit and berry production in Sweden. According to data from 2014, the region has 40% of the total open ground area for berry production and 52% of the total open ground area for soft fruit production. When it comes to greenhouse berry production, Skåne has 66% of the total production area. The harvest amounts to 8 200 tonnes (49% of Sweden total) for open ground berry production, 216 tonnes (76%) for greenhouse berry production, 123 tonnes (61%) for cherries and 190 tonnes (75%) for plums. The number of producers is 136 (23% of Sweden total) for open ground berry production, 8 (24%) for greenhouse berry production, 15 (42%) for cherries and 37 (51%) for plums (Persson, 2015). It should be kept in mind that producers may fall under several of these categories. It should also be noted that the percentage of growers in Skåne is consistently lower than the percentage of produced amounts in comparison to the Sweden total for these crops. This indicates that large-scale production of soft fruits and berries is more common in Skåne than in other parts of Sweden.

The institutions: SLU, JBV and HIR

SLU is a university with the stated goal of developing knowledge about the biological resources and how they can be managed and used by society in a sustainable way. This is done through research, education and environmental analysis (SLU, 2017). The southernmost branch of SLU is located in Alnarp, Skåne, and the SLU people currently involved in the *D. suzukii* work are all at least partly stationed here. Most of them belong to the Department of Plant Protection Biology, that has the long-term goal of contributing to increased and sustainable production within agriculture, horticulture and forestry, with IPM as an important area of research (SLU, 2016).

JBV is a state authority with expertise and management responsibilities regarding agriculture, fishery and rural development. JBV promotes and supports agricultural activities and help them to develop towards ecological, economical and social sustainability (JBV, 2017b). The unit within JBV directly involved in the *D. suzukii* work is the Plant protection central (Växtskyddscentralen) in Alnarp, which is one of several such centrals which provide advice on plant protection issues (weeds and pests) and monitor the situation for these issues (JBV, 2016).

HIR is an independent agricultural consulting company owned to at least 60% by the Rural Economy and Agricultural Society in Skåne (Hushållningssällskapet Skåne) (Hushållningssällskapet, NDb). The Rural Economy and Agricultural Society in Skåne, in turn, is one of 17 independent societies present throughout Sweden. Their activities span from driving agricultural high schools, trial farms, research programs and development projects, to offering advisory services for agricultural production and rural development. The goals are to contribute to good health among consumers, knowledge development, a sustainable society, and good business conditions for agricultural enterprises (Hushållningssällskapet, NDa).

Results and analysis

It became clear during the working process that SLU, HIR and JBV are seen by themselves and the growers as distinct actors, and they will be described individually concerning their *D. suzukii* work. It also became clear that SLU, HIR and JBV see themselves as a group, and that they act as a group in their relation to the growers. Therefore, the resulting sub-system of SLU, HIR and JBV will be described in its own section. The growers and their farms constitute another, and very diverse, part of the system. While growers are seen as one concept, the aim of this analysis is to reflect and acknowledge the great diversity within this group, and to give room for different perspectives, situations and experiences that were expressed. While describing the growers, the analysis simultaneously explores the connections and interactions between them and SLU, HIR and JBV. The analysis in its entirety builds up a description of the situation of all actors affected by *D. suzukii*, and concludes with a section on the implications for the possibilities of increasing grower participation in the work with *D. suzukii* according to PAR principles.

The structure of this section, looking first at the perspectives of SLU, HIR and JBV and not that of the growers, is worth a reflection. To this point in the development of the *D. suzukii* issue in Sweden, the initiatives for action have come from researchers, authorities and advisors. The growers have a complex relationship to this still largely intangible pest, and they have not yet had much time to develop their own experiential knowledge base. As the actions taken emanate from SLU, HIR, JBV and their collaboration, it is easier to understand the growers' situation if this perspective is described first. However, this does not imply any kind of desirable hierarchy, presumptions about future relationships and initiatives, or that one view of reality should be given precedence over another.

The role and actions of SLU

At SLU, the main focus of the *D. suzukii* work lies on collecting knowledge through experiments carried out within the frame of conventional natural science. However, several people, projects and activities at different points on the scale between theory and practice are part of the *D. suzukii* work at this institution.

The history of *D. suzukii* work at SLU began with its close relative *Drosophila melanogaster*, which is a very common model organism in science. Extensive research had been done on *D. melanogaster* before *D. suzukii* arrived, and the

background knowledge created in this way was crucial for the decision to start working with *D. suzukii*. In 2011 an application was made to start a project called ”From model to pest”, directly connecting the potential use of knowledge on *D. melanogaster* to monitoring and control of *D. suzukii*. At this time, *D. suzukii* was already a problem in Southern Europe, and the idea to start working with it most likely came from a SLU researcher who had heard about it during a visit in Northern Italy. The practical research on the fly started in 2012, when a quarantine lab was ready to use for experiments. Building the quarantine lab was a precaution taken to guarantee that *D. suzukii* would not spread from SLU at a time when the fly had not yet been found in Sweden. In 2012, the first monitoring efforts in Sweden were carried out by SLU, but the fly was not found. The monitoring work was continued in 2013 with the help of JBV, but as there were no resources set aside for this work at SLU, the monitoring was taken over altogether by JBV in 2014.

At SLU, the work with *D. suzukii* revolves around projects. At the time of the interview, there were several ongoing projects dealing with *D. suzukii* from different points of view. The projects are strongly connected to one another and are to some extent overlapping, and so they should not be seen as separate entities from a knowledge perspective. What is important about the projects in themselves, however, is that they are units of work that have received funding, and this is something that the SLU research is completely dependent on. The researchers have experienced that funding for *D. suzukii* research was not available for them when they wanted to start working with the issue, but has only become available once the fly developed into a bigger problem.

One main research topic at SLU is that of how microbial semiochemicals (chemical compounds with a role in communication) can be used for manipulating *D. suzukii* behaviour, and thus be used in making monitoring and control more efficient and species-specific. In particular, the researchers have found a strong association between *D. suzukii* and the yeast *Hanseniaspora uvarum* that they are hoping to use in application. The researchers are also looking into pheromones and entomopathogens as potential ways of improving *D. suzukii* management. Even if all research on *D. suzukii* at SLU aims for producing results that can be applied, it is one project in particular where they have become involved in trying out their ideas on a model farm and where they are in direct contact with JBV and HIR in doing the work. This project is called the SLF project (funded by the Swedish Farmers’ Foundation for Agricultural Research). It is mainly about improving monitoring through the development of highly attractive lures for *D. suzukii* but has also included trying out the attract-and-kill formula SPLAT. Coworkers at SLU have also been highly involved in more straightforward outreach work: compiling available information on *D. suzukii* within the TT-project (funded by Partnership Horticulture, and the berry section of the growers’ association LRF) resulting in a guide for growers and advisors and a protocol for measures at farm level, as well as starting and administrating the website www.drosophila-suzukii.se, and being active partners in the field excursions on *D. suzukii* that have been organized. Besides this work, SLU is continuously providing HIR and JBV with relevant information.

The researchers at SLU are not only connected to JBV and HIR in their work with *D. suzukii*, but have a wider network of research colleagues for example at institutions in Italy, USA and Denmark. Additionally, they follow the development continuously through information from papers and conferences. During the interview, the core of the work on *D. suzukii* at SLU was described as understanding the fly's behaviour and ecology on a basic level – to see it as an insect rather than a pest. Building onto this knowledge, the researchers want to provide applicable experimental results, leading in the end to an environmentally sustainable control strategy for *D. suzukii* that growers can use.

The role and actions of JBV

The role of JBV in the work with *D. suzukii* in Sweden is broad. One main responsibility is to carry out the monitoring and to provide risk status reports. JBV started helping SLU with monitoring in 2013, but it was only made on a small scale until it became standardized with specific traps and expanded to more locations in 2015. Other tasks of JBV include keeping track of the development of both threats and solutions in other countries, informing growers of risks and management strategies, initiating new research projects, and discussing strategies for applying for permission to use pesticides with growers' associations, as well as with the manufacturers of pesticides themselves. JBV spreads information through their homepage, fact sheets and courses, and have been active partners in organizing the field excursions. They also keep the advisors informed, and have an ongoing knowledge exchange with SLU.

When it comes to collaborations with SLU and HIR, JBV has been involved both in writing the guide within the TT project and in the SPLAT trials. In these trials, JBV provided data on *D. suzukii* occurrence, collected through monitoring traps, while the SLU researchers collected information on berry infestation. Additionally, JBV have an ongoing cooperation with other advisors in mid-Sweden that help carrying out monitoring there to see how far the fly has spread.

Since JBV is an authority that has the assignment of monitoring, it is not dependant on project funding for this activity. *Drosophila suzukii* has been given more attention than other pests since its arrival in Sweden, as the problem is new and much information is needed to learn about its behaviour. However, it is only one out of many pests that JBV monitors. In 2016, official monitoring of *D. suzukii* was made by JBV at 16 farms in Skåne, and 22 places in total.

What JBV wants to achieve within the *D. suzukii* work is to gain an overview of the situation, both nationally and internationally, on all topics relevant for pest management with the overarching goal to *"keep one step ahead of the fly"*. This means that their interest spans from biology (population size, phenology, damages etc.) to management methods and policies. They then disseminate this information to the public, advisors and growers to enable them to act as rational as possible given the current knowledge level. Because of their "helicopter perspective", they also have the role of driving the development forward by strategical communication work, trying

to couple emergent needs and possibilities with suitable actors. What they do not do, however, is to immerse in the situation at individual farms.

The role and actions of HIR

Of the actors in the *D. suzukii* working group, HIR has the most contact with the growers. They give advice to the growers on how to best run their agricultural businesses – here, *D. suzukii* comes in as one of many aspects of production planning and management that HIR give advice on. The advisors are continually educating themselves and collecting information (including from SLU and JBV) in order to be able to present available solutions to the growers in a balanced way. Advice is given through personal visits to the farms, but HIR also regularly sends out a ”berry letter”, summarizing current information relevant to berry growers. The letter reaches growers all over Sweden, around 200 in total. HIR have also been actively involved in arranging the *D. suzukii* field excursions, as well as other courses for growers where the fly has been discussed. In addition to information, HIR have recently started to offer the growers *D. suzukii* monitoring services, to lower the threshold for them in investigating *D. suzukii* presence at their farms.

When it comes to collaborations with SLU and JBV, HIR have been partners in both the TT project and the SLF project. In the TT project, HIR had a significant role in contributing with the writing of the guide and protocol, and when starting the SPLAT trials they were present to facilitate the communication between the researchers and the growers. The economical means available to HIR consists of their earnings from selling advisory services, and funding for specific projects, such as the TT project, where they have the possibility to look deeper into a specific topic. The projects are important for the self-education of the advisors and the information dissemination they are able to make, but also for evening out the income over the year as the growing season, where advice is relevant, is quite short. At the time of the interview, the TT project was about to end, and HIR did not have any new projects on *D. suzukii* planned for 2017, but would only be able to work with the issue as a part of their advisory service. Project funding was described as difficult to get, but it was also pointed out that it is not self-evident what would be a suitable project for HIR to start at the moment. The guide and protocol have only just been released, and the effect they will have still remains to be seen.

In summary, HIR takes the perspective of the individual farm, and their overall goal is to provide benefits to the growers from a business point of view, with solutions to the problem of *D. suzukii* as one part. Their close relationship with growers and advisory role means that they are able to influence the growers in their actual on-site management. Because of their position, they can also act as intermediaries between SLU and JBV on the one hand and the growers on the other, conveying information in both directions and help in pointing the direction of new research efforts. In this way, they help drive the development of solutions forward, to the benefit of the growers – but it is also in the interest of HIR themselves to have solutions to offer, as they depend on growers being willing to pay for their advice.

The roles of SLU, HIR and JBV have been summarized in fig. 3.

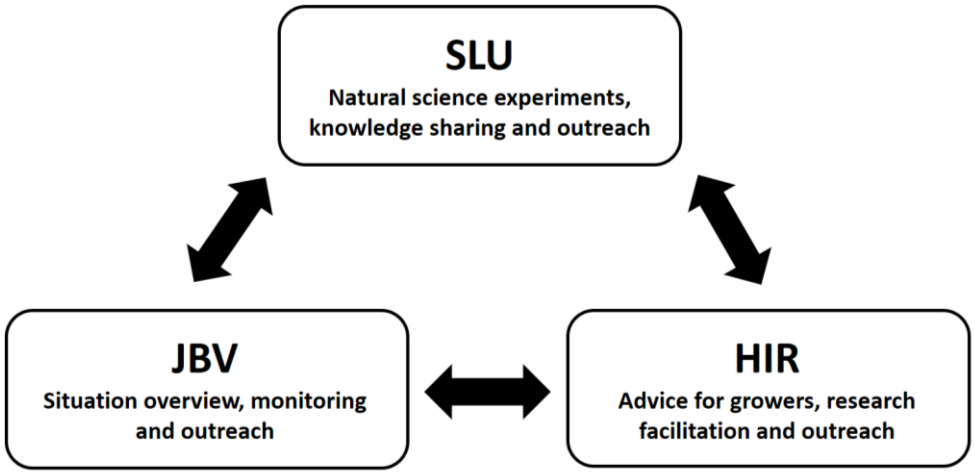


Figure 3. Simplified description of the roles of SLU, HIR and JBV in the work against D. suzukii *in Sweden.*

The working group as a whole

The collaboration between SLU, JBV and HIR on *D. suzukii* has taken multiple forms over the years since SLU applied for their first *D. suzukii* project ”From model to pest” in 2011. The role and involvement of SLU, HIR and JBV in the different projects have naturally varied depending on project purpose and the possibilities of each actor. During the interviews, however, it became clear that these actors see themselves as a group. Important instances of collaboration that emerged during the interviews are briefly described below, and a timeline with important events for the *D. suzukii* working group is shown in fig. 4.

- **The TT project.** The purpose of this project was to write a guide for *D. suzukii* that would be useful for growers and advisors. Therefore the guide focuses on practical aspects that can be of use for farm management of the fly. It includes information about the basic biology of *D. suzukii*, how to find and monitor the fly, and how to prevent damage. At the end of the guide is a protocol that growers can go through to see what measures are relevant at their particular farm. The overall goal with the guide and protocol is to reduce spread and establishment of *D. suzukii* in Swedish cultivations of soft fruits and berries (HIR, 2016). The project also provided an opportunity for SLU, JBV and HIR to develop a common view of this complex problem, where there are no given answers. The TT project ended in the beginning of 2017, and the final version of the guide and protocol were released in February this year.

- **The SLF project.** The main topic of this project is monitoring, i.e. how to make traps more efficient and specific by using odours (Stiftelsen Lantbruksforskning, ND) – in particular, how to exploit the strong association between *D. suzukii* and *Hanseniaspora uvarum* yeast for this purpose. However, this project has also developed to include the attract-and-kill method SPLAT. The SLF project includes lab experiments as well as field trials. The project is planned to end in 2017, but there is a hope of getting funding for prolonging the project.

- **The homepage www.drosophila-suzukii.se.** On the site itself, it can be read that *"The aim of this website is to provide up-to-date information on SWD in Sweden, and to establish communication between growers, advisors and researchers"*. SLU are responsible for the page, but the aim is to collect all available information about *D. suzukii* in Sweden in one place. On the page, there is information about the research being done, biology and identification of *D. suzukii*, available methods for monitoring and management, updated information about *D. suzukii* occurrence in Sweden and a calendar of events related to the fly that the growers can participate in, as well as other relevant news updates. There is also a form that the growers can use to get in contact with the working group, and contact information to all people involved from SLU, HIR and JBV. The site is currently in English, but there will also be a Swedish version in the near future.

- **The field excursions.** These excursions have been held during 2016 at three farms around Skåne where the fly has been found. Organizers have been HIR, SLU, JBV and the growers' association LRF, and the financial means have come from TT. The purpose of the excursions has been to provide a forum for information dissemination and presentation of new projects, and because they have been held at different times in the growing season they have also been able to reflect the seasonal development of *D. suzukii* in the field (Hushållningssällskapet, 2016). The excursions have given opportunities for dialogue and discussion between growers, researchers and advisors. Besides SLU, JBV and HIR, speakers at these meetings have also included experts from Switzerland and the US, and retailers of material that can be used in managing the fly, such as traps and protective nets (Hushållningssällskapet, 2016).

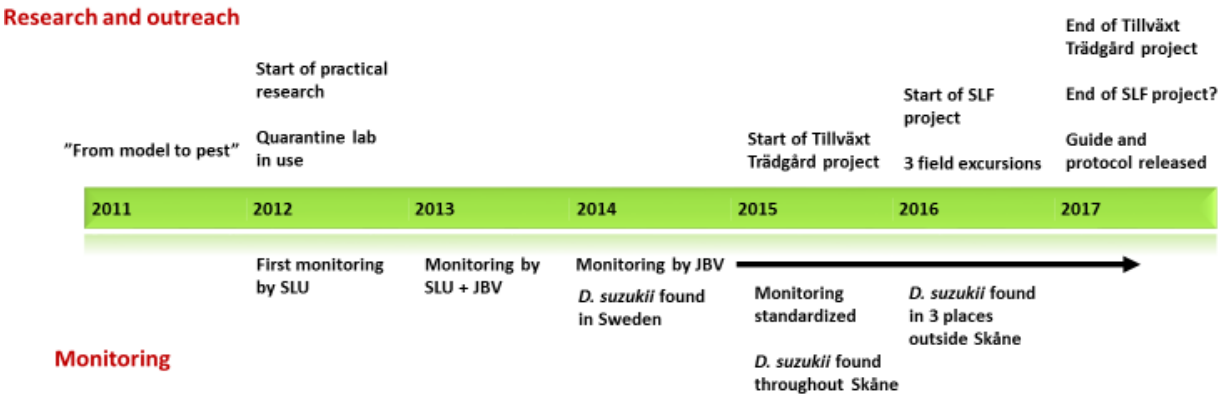


Figure 4. Timeline with important events for the D. suzukii *working group.*

The collaboration within the working group has thus had very concrete outputs and has been framed here in clearly defined projects and activities. In reality, however, the working structure is more complex and organic. SLU, HIR and JBV keep in

regular contact via telephone and mail, and occasionally through meetings for planning and updating – their offices are geographically close to one another – but there is no formal structure underlying the collaboration beyond the agreements on how to divide the work within specific projects. The collaboration as a whole is instead characterized by a pragmatic, flexible and responsive approach, almost taking the form of a network, where the different actors contribute with different knowledge, resources and mandate depending on the specific situation. Much of the work done on *D. suzukii* is restricted to only one of the institutions, with the others providing support as discussion partners but not being directly involved. The different actors naturally have different interests in their work with *D. suzukii* – however, they all share the common intention of finding and implementing sustainable solutions to *D. suzukii* in Sweden. All actors interviewed expressed that they were very happy with the collaboration, and that it had benefitted the *D. suzukii* work significantly both in scope and content. Together, they have been able to achieve more than they would have done on their own – both in collecting knowledge and in spreading it through their combined channels. Another important reason for collaborating mentioned by HIR is to bring the different actors together in forming a common and coherent message to the growers on *D. suzukii*, to avoid confusion.

It is not very clear exactly when the collaboration on *D. suzukii* started or who took the initiative. Rather, it has developed gradually, and intensified in the last years. During the interviews, it was mentioned several times how the different projects and activities have been interlocked, one leading to another, in this process. It is also worth pointing out that several of the people involved in the *D. suzukii* group has worked for more than one of SLU, HIR and JBV, and therefore have good insight into the workings of other institutions through own experience.

In total, the working group consists of seven people from SLU, HIR and JBV (those mentioned as co-workers on www.drosophila-suzukii.se). The small group size means that all people involved can have relatively close contact – something that has enabled the informal structure of collaboration. So far, this has worked well, but it was mentioned during the interviews that more formal guidelines might be an option worth discussing, and that it might be more effective in some cases to have common plans and priorities already from the beginning and not shape the collaboration as the work progresses. It was also said, however, that the informal mode of working could be an advantage, as it allows the actors more freedom, hopefully leading to more motivation and commitment. Another issue was how much time to spend on coordination and discussion. It emerged during the interviews that more time for meetings is something that the actors would like to see – even if there is also a strong awareness that time is a limiting factor. Different perspectives emerged on whether the group in itself is sufficiently big for the task given. Here, the view that more manpower would be desirable was expressed, but also that the size of the group is actually reasonable considering that the soft fruit and berry industry in Sweden is not as large as elsewhere, and that the group members still cover the most important competences. JBV mentioned that they think it could be a good idea to start a reference group with growers to complement the working group. In their view, this could provide a better connection of SLU, HIR and JBV to conditions and

challenges faced by the growers, and create a forum for discussing the growers' concerns and needs when planning the *D. suzukii* work.

Resources in the form of time and money are limited for the *D. suzukii* working group, and highly dependent on available funding. This makes it difficult to make long-term plans, as it is never certain that applications for new projects will receive funding. In addtion, uncertainty of how serious the *D. suzukii* problem will be in Sweden, as well as what solutions will emerge from the intensive research in Sweden and elsewhere, mean that the *D. suzukii* working group will have to be prepared for many possible future scenarios. Because of the free structure of collaboration between SLU, HIR and JBV, however, there is room to accommodate for change and respond to new conditions.

Results from the grower survey

In total, 37 growers of soft fruits and berries in Skåne answered the survey. Out of these, 35 had open ground cultivation area and 5 had greenhouse cultivation area. As noted earlier, it is not possible to say exactly how many open ground growers of soft fruit and berries there are in Skåne, as some growers fall under more than one of the categories of open ground berry growers, cherry growers and plum growers available in the official statistics. For the greenhouse growers, however, it is possible to say that 5 out of the reported 8 enterprises in Skåne (2014) answered the survey (Persson, 2015).

General information about the growers

In fig. 5, the number of commercial growers of each soft fruit and berry crop among the survey respondents are presented. The numbers are compared with the total number of growers for that crop in Skåne (2014) (Persson, 2015). As can be seen, the survey results were more representative for some crops than for others. Worth to note is that the proportion of currant growers answering the survey, compared to Skåne total, will be overestimated as the official statistics only accounted for blackcurrants. For blueberries and blackberries, there were no official statistics available for Skåne, and so no comparison could be made. In the survey, the growers had an ”Other” option where they could fill in soft fruits and berries that they grow commercially and that were not included among the alternatives. Here, 2 respondents reported growing gooseberries and 2 respondents reported growing seabuckthorn. In total, there were 21 growers of ”other berries” in Skåne in 2014 (Persson, 2015). The growers of blueberries, blackberries, gooseberries and seabuckthorn should thus be seen as a part of this broad category, even if no precise comparison can be made.

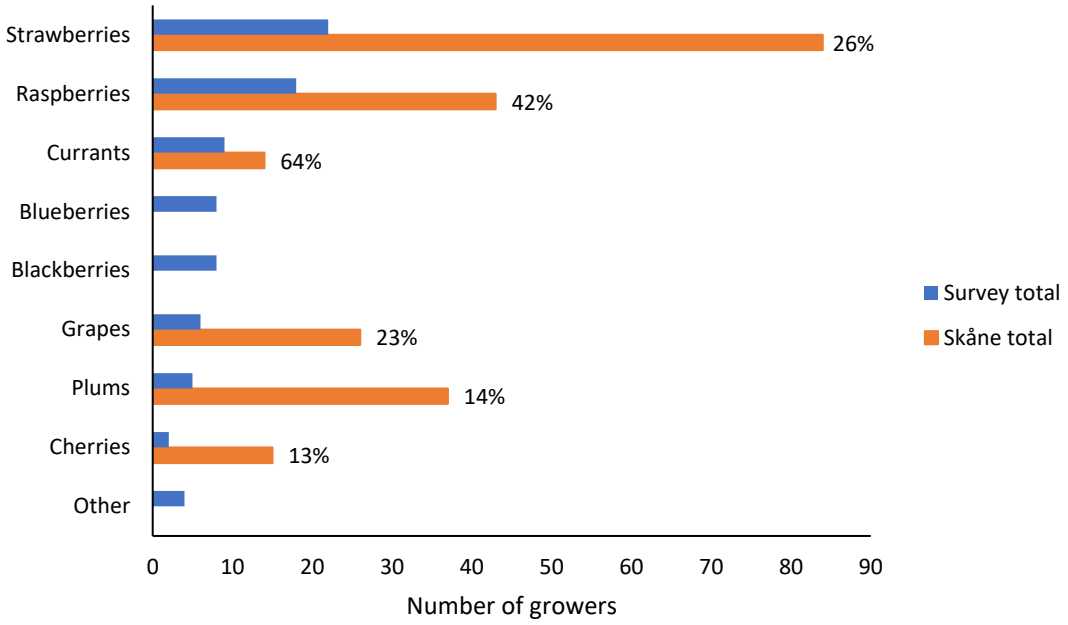


Figure 5. Number of growers answering the survey shown by crop, and the total number of growers for these crops in Skåne. The % indicates the proportion of all Skåne growers that answered the survey for each crop.

The respondents were asked which one(s) of their commercially grown soft fruit and berry crops were their main crop(s) in this category. It was possible to mark several alternatives. The results are shown in fig. 6, together with the total number of commercial growers for each crop among the survey respondents. As can be seen, some crops were commonly the main soft fruit and berry crop for its growers, while others were not.

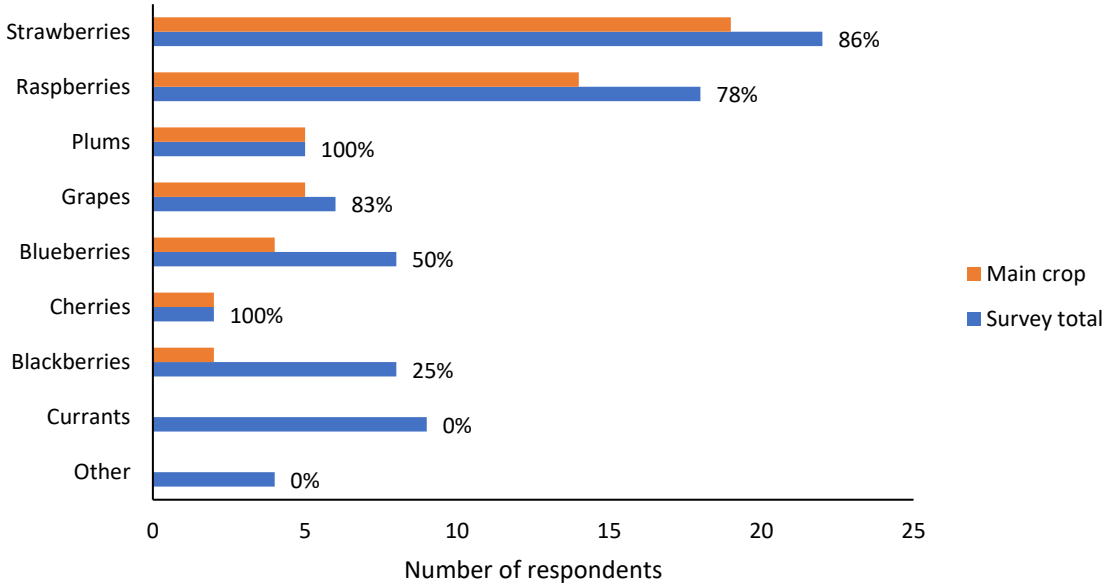


Figure 6. Main soft fruit and berry crops, and the total number of growers for each crop among the survey respondents. The % indicates the proportion of respondents marking "main crop" for each crop.

The respondents were also asked when they started to harvest their earliest soft fruit and berry crop, and when they had finished harvesting the last one. The results are seen in fig. 7.

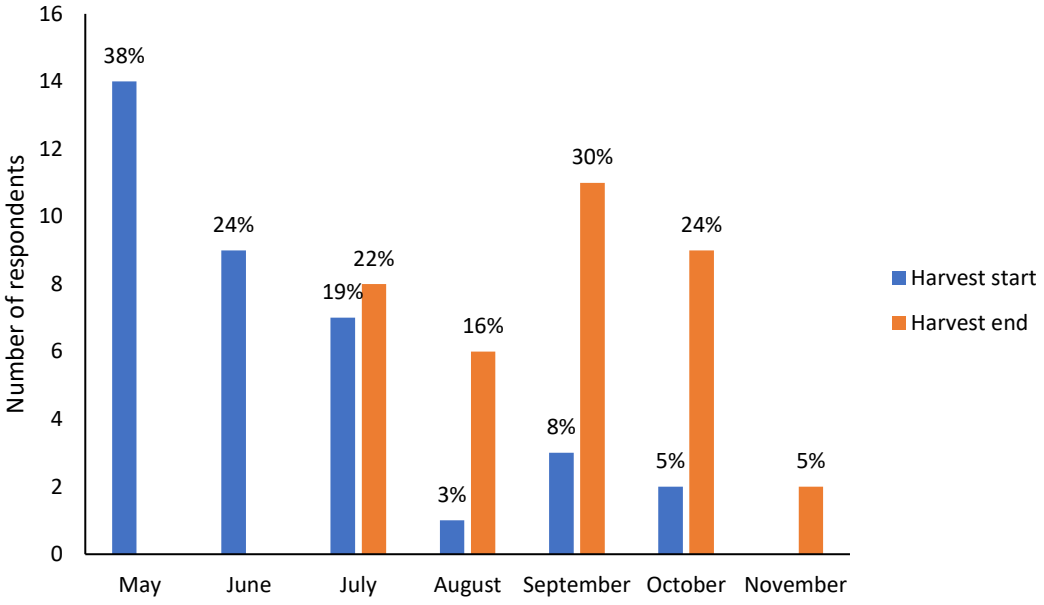


Figure 7. Harvest start and end months of respondents, with % indicating the proportion of all respondents.

In fig. 8 and 9, the cumulative open ground and greenhouse cultivation area for soft fruits and berries of the respondents are shown, with each colour field indicating one individual farm. With a mean of 15 ha and a median of 1,3 ha, the open ground area shows an unequal distribution among the respondents; a few large producers holds a majority of the area while the majority of growers have a comparatively small growing area. For the greenhouse growers, the mean and median area was the same, 1800 m^2. The total open ground area of the respondents, 525 ha, represented 43% of the Skåne total for soft fruits and berries, while the greenhouse area, 9000 m^2, represented 21% (Persson, 2015).

When it comes to growing area, it is worth noting that there were no lower limits for single crops to be counted in the official statistics. However, to be included, the horticultural cultivation needed to be at least 0,25 ha in its entirety. For greenhouse cultivation, the minimal area was 200 m^2 (Jörgen Persson, JBV, pers. comm, 2017[3], Persson, 2015). Two cultivations slightly below this limit are included in the current presentation of results (both with an open ground area of 0,2 ha).

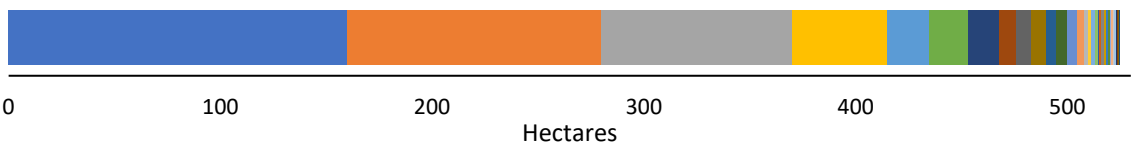


Figure 8. Cumulative growing area of respondents (open ground). Each colour field represents one farm.

[3] Mail contact, April 25, 2017.

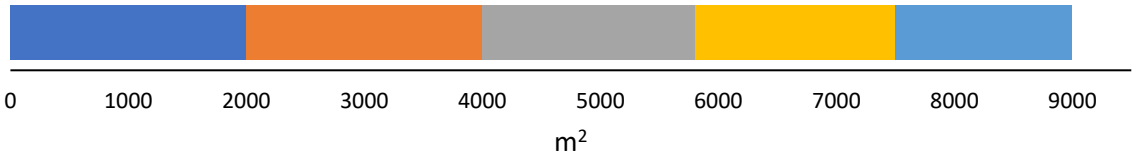


Figure 9. Cumulative growing area of respondents (greenhouse). Each colour field represents one farm.

Perception and actions towards D. suzukii

The respondents were asked if they perceive *D. suzukii* as a threat to their cultivation. They were then asked to mark their answer on a scale from 1 to 5, 1 meaning ”not at all” and 5 meaning ”very strongly”. The results can be seen in fig. 10, together with error bars showing the confidence intervals for the population as a whole. As can be seen, the answers are quite evenly spread across the scale, meaning there was no consistent perception of the risk with *D. suzukii* among the respondents as a group. With the confidence intervals taken into account, it cannot be said that the number of respondents for any answer (1-5) differed significantly from any other.

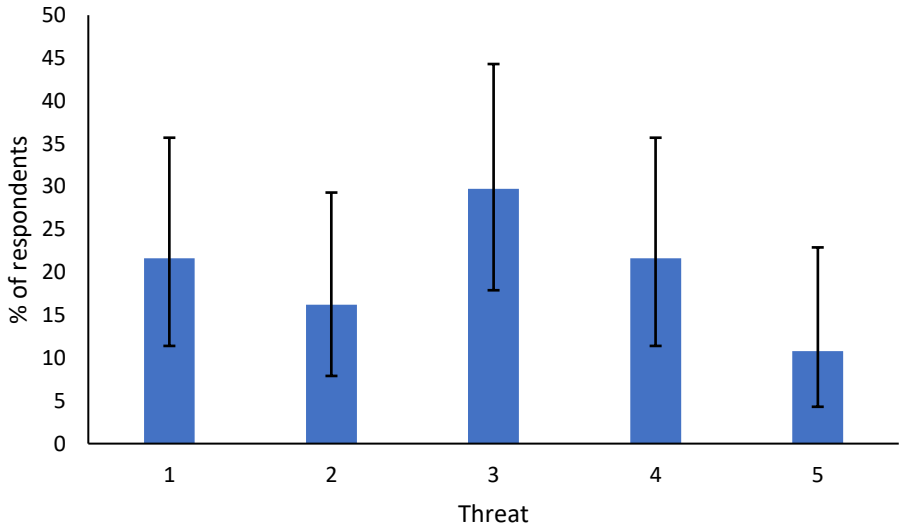


Figure 10. Perceived threat of D. suzukii *among respondents, 1 meaning no threat at all and 5 meaning very strong threat.*

The next question was whether *D. suzukii* presence had been investigated at the farms of the respondents, and if it had been found. A majority of the respondents (25) had not investigated *D. suzukii* presence, 10 had investigated it, and 2 respondents did not know whether an investigation had been made or not. Out of the 10 farms where an investigation had been made, the fly had been found at 6 (fig. 11). The majority-minority relationship between those who have not and have investigated *D. suzukii* presence holds true for the population as a whole with the confidence interval taken into account: 25 out of 37 respondents yields an interval of 53-80% for the whole population, while 10 yields an interval of 16-41%.

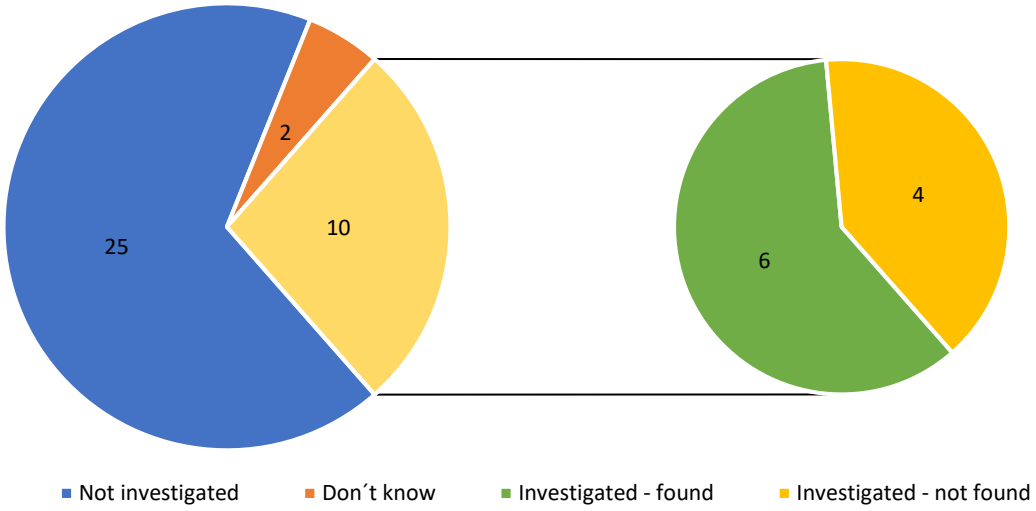


Figure 11. Investigated and actual presence of D. suzukii *among the respondents, with numbers indicating number of respondents.*

The measures taken by the respondents against *D. suzukii* in 2016, and measures planned to be taken in 2017, can be seen in fig. 12. Besides the alternatives seen in the figure, there was an open ”Other” category, but no respondents filled in any additional measures here. Additionally, two of the measures given as alternatives in the survey were not taken by anyone, and are not shown in the figure: increasing the distance between cultivating fields with different ripening times, and mass trapping. At the time of collecting the survey answers, it was not yet known if dispensation for use of spinosad would be given for 2017, and if so for which crops. Therefore, the spinosad alternative for 2017 was written as ”Pest control with spinosad (given dispensation)”. As can be seen, the general trend among the respondents was for more measures to be taken in 2017 than in 2016: the number of respondents taking no measures at all has decreased between these seasons, while most measures are increasing in use.

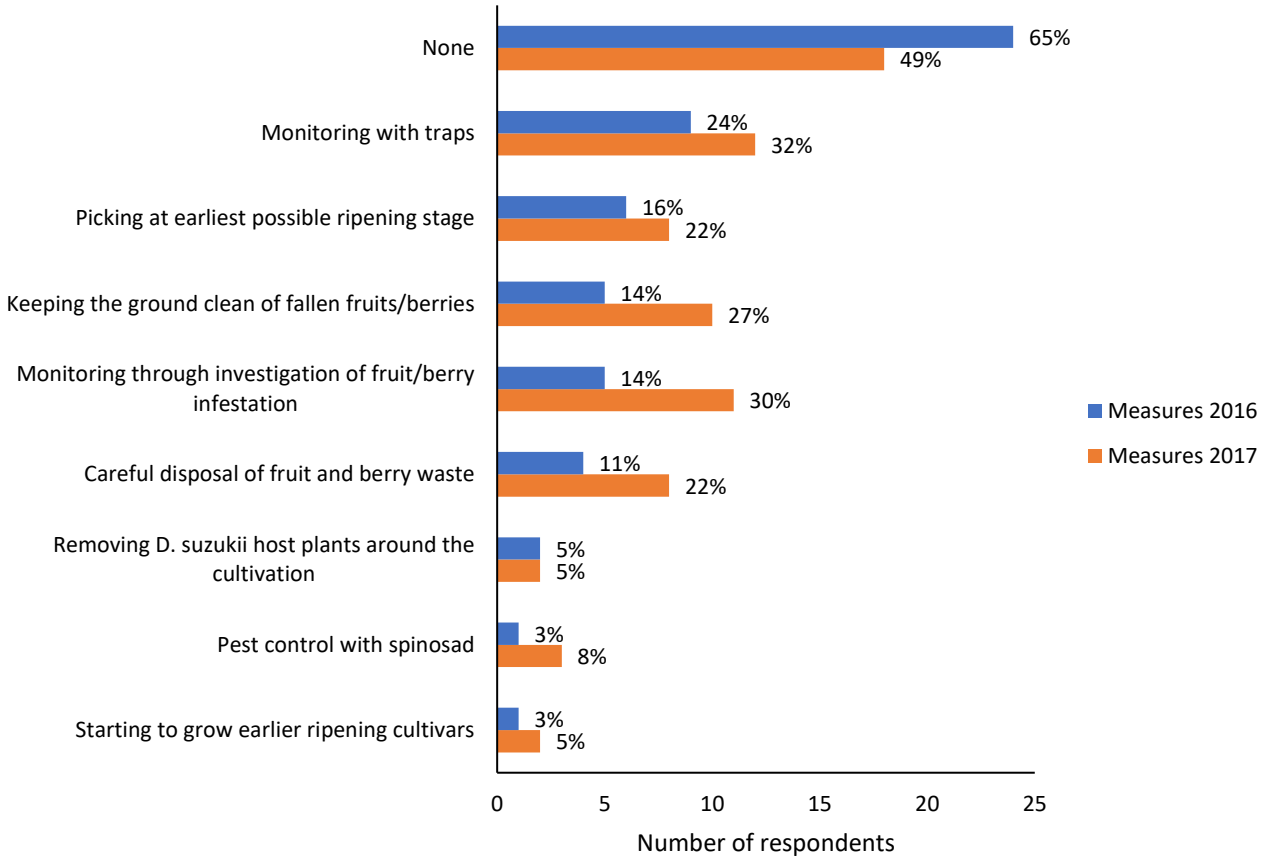


Figure 12. Measures taken by respondents against D. suzukii *2016 and planned to be taken 2017. The % indicates the proportion of all respondents.*

Information about D. suzukii *and its availability*

Fig. 13 shows where the survey respondents get information about *D. suzukii* from. An open ”Other” alternative was provided, but no respondents filled in anything here. Fact sheets and newsletters from independent sources (advisors and authorities) were by far the most common information source, but all alternatives given in the survey were chosen by at least 2 respondents. Only one respondent did not have any information source on *D. suzukii*.

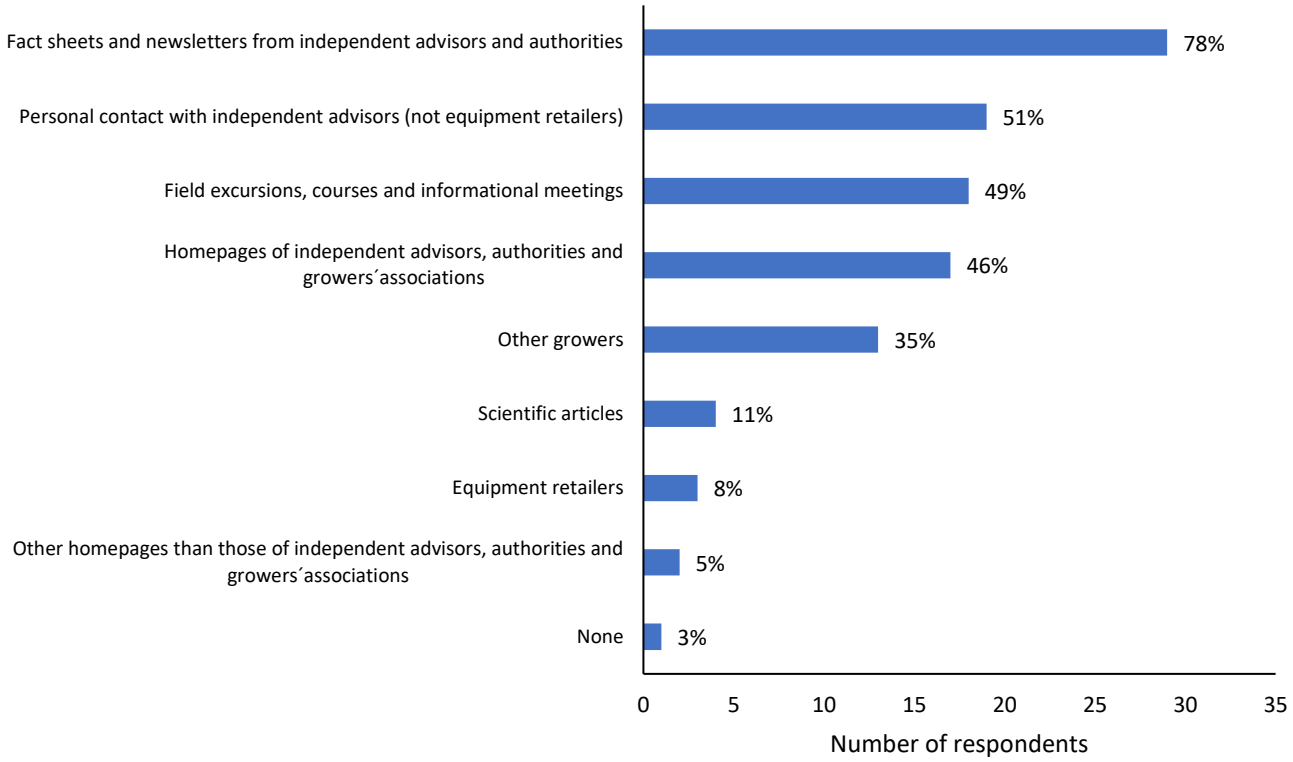


Figure 13. Where the respondents get information about D. suzukii *from. The % indicates the proportion of all respondents.*

The respondents were also asked how they prefer to get new and updated information about *D. suzukii*, and the results are shown in fig. 14. It was possible to mark several alternatives. The alternatives were restricted to communication means available to SLU, HIR and JBV for reasons that will be described below. Again, there was an open ”Other” alternative where no respondent filled in any additional requests. As can be seen, all given alternatives were preferred by a relatively large part of the respondents.

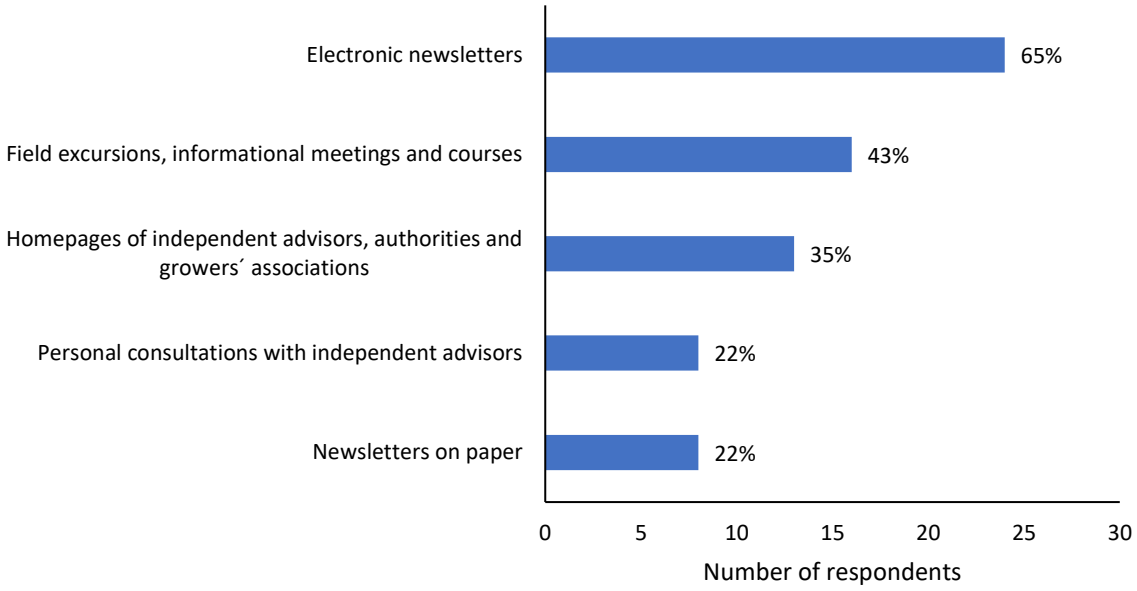


Figure 14. How the respondents prefer to get new information about D. suzukii*.*
The % indicates the proportion of all respondents.

The proportion of respondents that knew about/did not know about the official homepage of the Swedish *D. suzukii* working group, www.drosophila-suzukii.se, is seen in fig. 15. The confidence interval for the groups were 45-73% for ”has not heard” and 27-55% for ”has heard”, giving quite a lot of room for error that should be considered when interpreting these numbers in relation to the whole population.

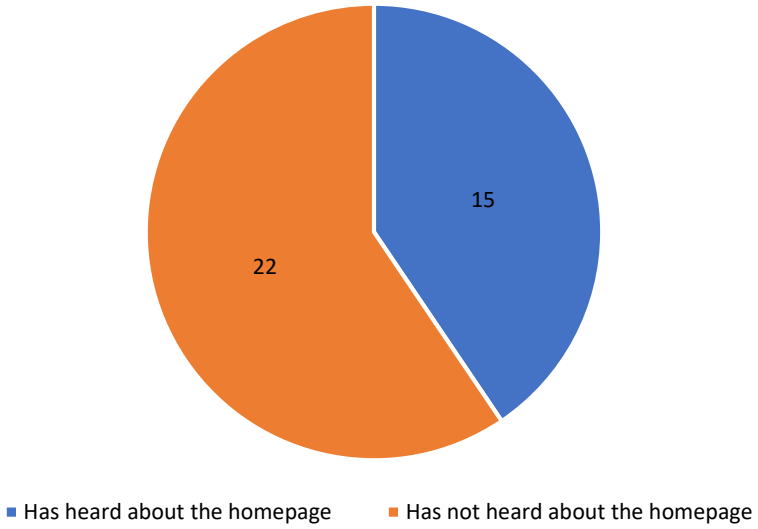


Figure 15. The number of respondents that had heard about, and not heard about, the homepage www.drosophila-suzukii.se.

Grower participation in the work with D. suzukii

In the final part of the survey, the attitudes of growers towards participation in the national *D. suzukii* work was examined. The question whose results are shown in fig. 16 began with an explanation of what different forms grower participation can take in

the national *D. suzukii* work; that it can entail anything from well restricted tasks, such as contributing with monitoring, to engaging in a dialogue with the group working on *D. suzukii* in Sweden (SLU, HIR, JBV). The respondents were then asked if they would consider participating in the national *D. suzukii* work at any level. Out of the 37 respondents, 29 (78%) said ”yes” or ”maybe”. Even taking the confidence interval into account, the proportion answering ”no” was in minority (11-36%).

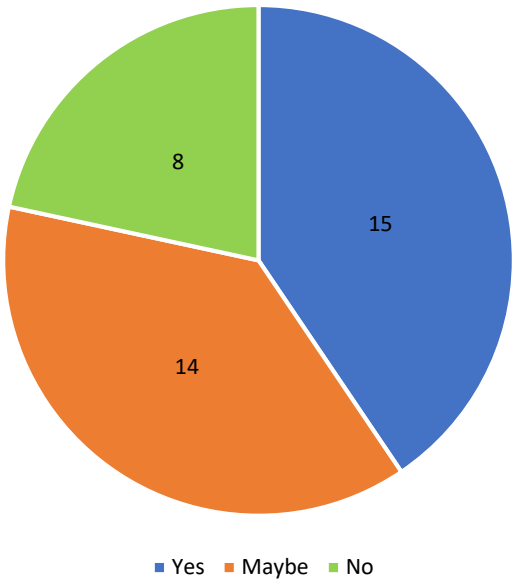


Figure 16. The respondents' answers to whether they would consider participating in the national work with D. suzukii*, with numbers indicating number of respondents.*

The growers that answered ”yes” to the previous question were then asked what kind of activities they would consider to participate in. It was possible to mark more than one alternative, and to write own suggestions under an ”Other” alternative. Besides all respondents answering ”yes”, 4 respondents that answered ”maybe” to the previous question also filled in this question – all these results are showed in fig. 17. The only suggestion other than the given alternatives is presented along with Farm #5, who gave the suggestion, below.

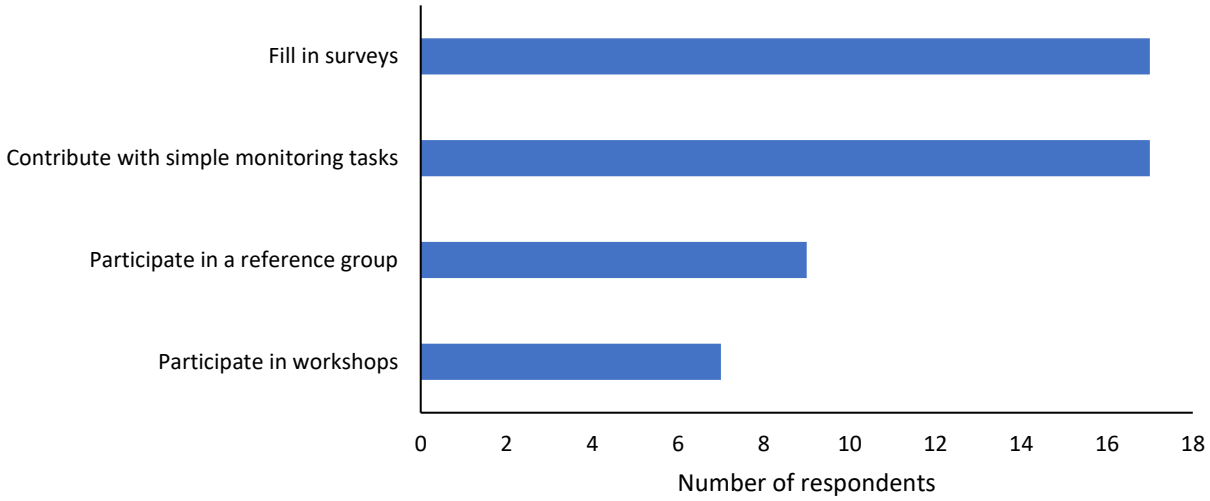


Figure 17. The number of respondents that would consider participating in different activities of the national D. suzukii *work.*

Lastly, the respondents were asked if they think that it is important that growers in general participate in the national *D. suzukii* work. The answers were given on a scale from 1 to 5 where 1 meant ”not at all” and 5 meant ”very important”, and the results are shown in fig. 18. As can be seen, the respondents generally agreed that this participation is very important – however, the respondents’ interpretation of ”participation” and ”national work” will be critically discussed below.

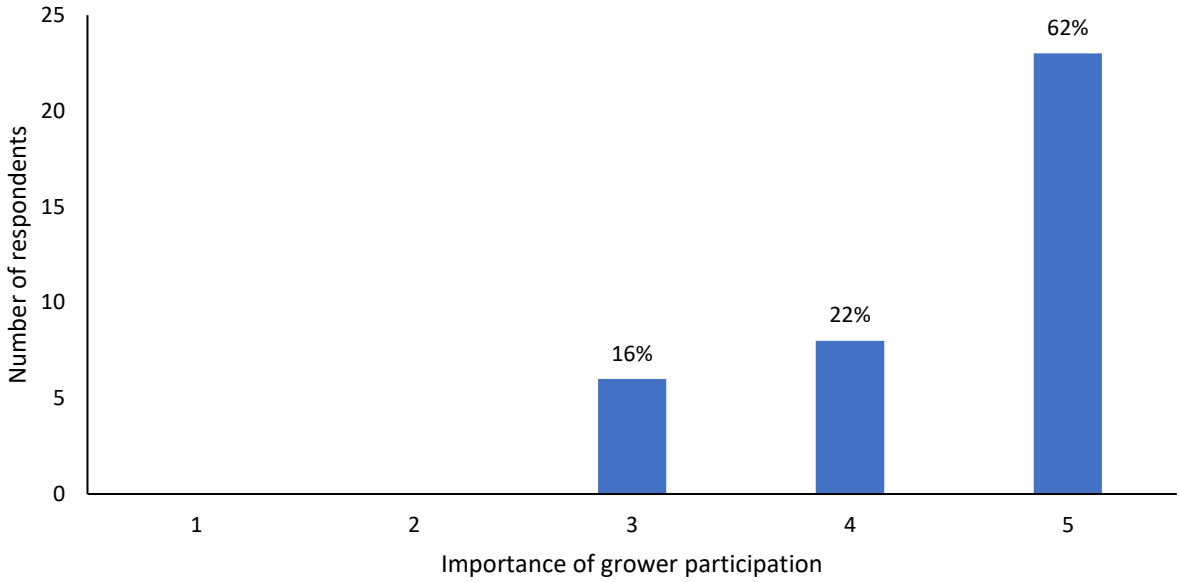


Figure 18. Perceived importance among respondents of general grower participation in the national D. suzukii *work, 1 meaning not important at all and 5 meaning very important. The % indicates the proportion of all respondents.*

In addition to the quantitative data that has been presented here, the survey also gathered information through a few open-ended free-text questions. The results of these are incorporated in the further description and analysis of the growers below.

Introduction to the interviewed growers

The 5 growers that were interviewed for this thesis will be briefly described here.

Farm #1
This farm is growing berries on 3 hectares of land: raspberries, blackberries, blueberries, currants, and from the 2017 season also strawberries. Raspberries is the main crop. Harvest starts in June and ends in September. The farm includes 19 hectares in its entirety, but the main share of the remaining 16 hectares is leased to other farmers – currently autumn wheat is grown on this land.

The grower experiences the threat from *D. suzukii* as a 4 out of 5, and *D. suzukii* has been found on the farm. Active measures have been taken against *D. suzukii* in the 2016 season: monitoring with traps and through investigation of berry infestation, picking at earliest possible ripening stage, keeping the ground clean of fallen berries and careful disposal of berry waste. For the 2017 season, the growers are planning to keep up these measures, and additionally to start growing earlier ripening cultivars and to use spinosad, provided that this is allowed for their cultivation. The growers on this farm get information about *D. suzukii* from personal contact with independent advisors, fact sheets/newsletters from independent advisors and authorities, and homepages of independent advisors, authorities and growers' associations.

The growers are already actively involved in the national work on *D. suzukii* – for example by letting their farm be used for SPLAT field trials - and they are positive about participating in all the activities proposed in the survey. Additionally, they think that general grower participation in the *D. suzukii* work is very important (5 out of 5).

Farm #2
This farm is growing wine grapes on an area of 0,3 hectares. Harvest starts and ends in October. The farm includes an additional area of 3,3 hectares that is partly leased to other farmers and used for growing cereals. They also have a small meadow where hay is taken.

The grower on this farm is not perceiving *D. suzukii* as a threat (1 out of 5). The grower has looked for *D. suzukii* through investigation of grape infestation (2016), but has not found it. As a preventive measure, the grower has removed *D. suzukii* host plants (elderberry) around the cultivation in the 2016 season. Monitoring through investigation of grape infestation and removal of elderberry plants is planned to continue in the 2017 season. The grower gets information about *D. suzukii* from other growers, the webpages of independent advisors, authorities and growers' associations, and scientific articles.

This farm is not involved in the national work on *D. suzukii*, but the grower is positive about participating "*in any or some of the proposed activities, where I can be of use*". This grower is also rating the importance of general grower participation in the national work with *D. suzukii* as 5 out of 5.

Farm #3
This farm is dominated by the cultivation of apples and pears, but also grows plums.

The total fruit growing area is 45-50 hectares, with a plum cultivation of 1 hectare. It is not entirely sure when the plum harvest begins and ends, as the grower also took the apples and pears into account when answering the question about harvest time in the survey. However, the growers reported during the interview that the plums start the season, and therefore it is likely that the plum harvest takes place in their reported month of beginning harvest, August.

The growers do not perceive *D. suzukii* as a threat (1 out of 5). Presence of *D. suzukii* has not been investigated. No measures were taken against *D. suzukii* in 2016, and none are planned for the 2017 season. The growers get information about *D. suzukii* from personal contact with independent advisors and from fact sheets/newsletters of independent advisors and authorities.

Asked about whether they would consider to participate in the national work with *D. suzukii*, the growers answered ”maybe”, adding that they ”*still don't know how seriously we have to take this*”. Importance of general grower participation in the national work with *D. suzukii* was rated 5 out of 5.

Farm #4

This farm has greenhouse cultivation only. Raspberries, blackberries, blueberries and currants are grown on a total of 2000 m^2, but the farm also grows tomatoes (their main crop) and haricots verts. Among the berry crops, the main crops are raspberries and blueberries. Harvest of berry crops begins in May and ends in August.

The grower experiences the threat from *D. suzukii* as a 4 out of 5, and *D. suzukii* has been found on the farm. During the 2016 season, monitoring with traps was carried out, and this is planned to continue in the 2017 season together with investigation of berry infestation. The grower gets information about *D. suzukii* from personal contact with independent advisors, fact sheets/newsletters of independent advisors and authorities, and equipment retailers.

This grower also answered ”maybe” to if they would consider participating in the national work with *D. suzukii*, adding that they ”*have good advisors*”. Importance of general grower participation in the national work with *D. suzukii* was rated 5 out of 5.

Farm #5

This farm has large scale berry cultivation: 120 hectares of land and an additional 1500 m^2 of greenhouse cultivation. The berries grown are strawberries and raspberries, with strawberries as the main berry crop. Early ripening raspberries are grown in the greenhouse, while both strawberries and raspberries are grown on open ground. Harvest begins in May and ends in September. The enterprise consists of 5 farms and is highly diversified with both agriculture and forestry activities, as well as forestry machine services.

The threat of *D. suzukii* is perceived as a 3 out of 5. The fly has been found in the open ground cultivation but not in the greenhouse. In 2016, measures taken against *D. suzukii* were monitoring with traps and through investigation of berry infestation, and removing *D. suzukii* host plants around the cultivation. For the 2017 season, these measures are planned to continue, together with keeping the ground clean from fallen berries, careful disposal of berry waste and using spinosad, if this is

allowed. The growers get information about *D. suzukii* from personal contact with independent advisors, fact sheets/newsletters from independent advisors and authorities, and the homepages of independent advisors, authorities and growers' associations.

This farm is also actively involved in the national work with *D. suzukii*. Of the activities proposed in the survey, they would consider contributing with simple monitoring tasks and filling in surveys. They also added *"field excursion"* as something they were interested in, however it is not clear if this means that they want to host or attend a field excursion. Importance of general grower participation in the work with *D. suzukii* is ranked 5 out of 5.

The current situation of the growers

From the interviews, the heterogeneity of soft fruit and berry growers in Skåne became evident. Every grower would have their own story to tell about their current situation and perception of *D. suzukii*, and so the interviews made for this study are in no way exhaustive. This must be kept in mind while reading the following description and analysis.

The historical connections of the growers to their farms and to soft fruit and berry production varied highly. Farm #1 has been owned by the same family for seven generations. The couple running the farm have both had other jobs until recently, but then decided to make their main living out of their farm. Farm #5 is also a family business that has been run for several generations, with berry production already from its beginning in the 1930s. Farm #3 and Farm #4 are both one-generation companies, where soft fruit and berry production constitute a smaller part of the income. For Farm #3, plums has been a part of the production on and off during the whole history of the company, while berries have become a part of the production later on for Farm #4. The growers at Farm #2 have no historical connection to their farming land, and have had long careers outside farming in another part of Sweden. They recently started the cultivation in connection to their retirement.

The cultivation of soft fruits and berries means different things to the different growers. All the interviewed growers were commercial, however, and so they all gained an income from growing. One reason for growing berries that recurred in several of the interviews is that they are high-value crops, thus giving a relatively high income per areal unit. For Farm #1, this means that they can make a living out of their farm land. The farm has historically been growing large-scale crops such as sugarbeets, cereals and rape, but having this kind of cultivation on a farm of their size is no longer economically viable. For Farm #4, starting to grow berries was connected to declining profitability of their greenhouse tomato production, and the choice of growing grapes at Farm #2 was also made because they can, despite the small growing area, *"perhaps still give a small profit at some point"*. Farm #5, despite having a highly diversified enterprise, report getting the largest part of their income from strawberries. On the other hand, the growers at Farm #3 reported that *"it has been a bit difficult to find varieties that have a cultivation value"* for plums. In the case of plums, the small scale cultivation, according to the growers, is a necessity because

of the high work intensity of such a cultivation and because plums need to be consumed soon after picking.

Another thing that the interviewed growers had in common was that their cultivations enabled them to have a lifestyle they wanted, and to turn their ideals into practice. For some, living as a farmer was connected to historical ties, to a specific farm or the farming practice itself, or to both. For others, the idea of becoming a farmer had been a childhood dream or was sparked by a lifelong interest in biology. Pride in the product and in growing in an environmentally conscious way were also important themes that emerged. None of the interviewed growers were organically certified but several of them emphasized their deep engagement in an environmentally friendly production – as an important part of personal philosophy, but also for adding market value.

Yet another common feature of all growers was that they were vertically integrated, e.g. refining their own products, selling through a farm shop or café. Several of them come into contact with the consumers of their products in this way, while they were all also selling through wholesalers. One reason for growing soft fruits and berries that emerged was that these crops increase the diversity of production – something that helps spreading the risks and also makes the farms more attractive to the market, e.g. by increasing visibility of the brand, prolonging the growing season and enabling the farms to meet the demands of their customers. Berries have been a good base for an integrated business concept for some growers, as they are attractive for the customers, both in fresh and refined form, and also for self-picking. Two of the interviewed growers described the berry production as the *”engine”* or the *”heart”* of their diversified businesses, making possible other parts of their enterprise.

All growers were asked during the interviews if their customers had expressed any concern about *D. suzukii*, but none had experienced such questions, neither from wholesalers nor from direct consumers. According to the grower at Farm #1:

”The prognosis work is one step ahead. And the buyers, they will not care about this at all until things start to crawl in the berry boxes. Not one bit. Our biggest wholesale customer, I’ve brought it up with them and told them ’we are doing this and this, stopping growing autumn raspberries, we are trying to avoid this and that’, ’Ok’. Not very interested. That’s the producer’s headache. ’Just make sure we get good and healthy berries’”.

In this case, the grower has tried to discuss *D. suzukii* with the wholesaler, before the problem has manifested itself, and sought understanding for the preventive measures they take. In the grower’s experience this was not well received by the wholesaler, who was only interested in the final product and did not want to engage with the issue or the grower’s situation. None of the other growers interviewed mentioned that they had tried to approach their customers about *D. suzukii*.

Overall, the growers’ dependence on and ties to their farm, as well as the importance of soft fruits and berries as a part of the farm enterprise, differ widely. This is important to keep in mind in the further discussion about how *D. suzukii* should be

handled and how the growers could become more involved. In the words of the grower at Farm #4:

”I have a small ’throwaway’ cultivation so it doesn’t mean much to me, but there are many who have strawberries, and raspberries and blueberries and cherries. It’s disastrous in a cherry cultivation as far as I understand.”

Practical experiences that the growers have of *D. suzukii*

In total, 6 of the 37 survey respondents (16%) had found *D. suzukii* in their cultivation. However, this should be viewed in the light of the fact that only 10 respondents had investigated the presence of *D. suzukii*, meaning that it has been found in 60% of these cases. It should therefore be expected that *D. suzukii* is underrecorded in relation to its presence at soft fruit and berry farms in Skåne, alternatively that growers are not aware that it has been recorded. Important to keep in mind is that *D. suzukii* was found in 14 out of 16 Skåne farms that were officially monitored in 2016 (Manduric, 2017).

Of the five growers interviewed, three had found *D. suzukii* at their farm, all of them late in the season, through checking berries for infestation and/or through monitoring with traps. One of the growers reported finding *D. suzukii* in a box of overripe 2nd class berries, but not in any of the berries going for sale. All three growers have been able to sell their berries as usual. According to one of them:

*“If JBV had not been so observant and made controls, I wouldn’t know it yet. Because it (*D. suzukii*) has not had any direct effect yet. Because we have no damages.”*

Common for all three growers with personal experience of *D. suzukii* is that the fly has not marked its presence in any significant way - the growers would not have noticed it if they had not been made aware of it. The nature of *D. suzukii* infestation is such that the grower does not see the damage in the berries being handled, and it is thus still possible for a grower to say that they *“have no damages”* even when they know the fly is there. In contrast, another grower interviewed said that *“the damages are there”* in the berries, even if this grower also confirmed the elusive nature of this pest. At their farm, they educate the personnel in finding different kinds of quality problems in the berries being packed, e.g. different kinds of insects, but they have had a hard time finding a good method for detecting *D. suzukii* as the larvae are very small in size.

As mentioned previously, *D. suzukii* damage has been very limited in Sweden so far (Manduric, 2017), but this is clearly also dependent on what is meant by the term “damage”, as showed by the different definitions by the different growers. Manduric (2017) appears to use the term for signifying “economical damage”, as the same article reports that *D. suzukii* was indeed found in all crops monitored in 2015 and 2016. Important to note here is also that despite that there are no significant economical damages for growers with *D. suzukii* in Sweden, the survey respondents who had found the fly are not ignoring the problem: all but one are planning measures for the 2017 season.

Interactions between the growers and the *D. suzukii* working group

Independent advisors and authorities were the most important source of information for the survey respondents, through their fact sheets and newsletters, personal advisory services, field excursions, meetings and courses, and homepages (this alternative also included the homepages of growers' associations). The fact sheets and newsletters were the most common source, and most respondents were using them. However, it is of course not possible to know the relative importance of different information sources to the individual grower. During personal advice and group meetings, there is opportunity for dialogue between growers and SLU, JBV and HIR, in contrast to the one-way information flow of fact sheets, newsletters and homepages (even though the homepage www.drosophila-suzukii.se aims to become a platform for dialogue in the future).

As a natural consequence of their task, HIR are the working group actors most frequently in contact with the growers, and convey information from both SLU and JBV to them. The grower at Farm #4 describes how he has an advisor from HIR coming every second week, that she investigates the current situation and gives suggestions of what to do, that they then discuss together. On the other hand, HIR is not the only advisory service available to the growers. For example, the growers at Farm #3 have two other independent advisors who had not talked to them about *D. suzukii*. It is important to note, then, that all respondents with personal advice are not in connection with HIR, and that not all advisors have *D. suzukii* on their agenda. It is also important to remember that only around half of the respondents had any personal advice at all on *D. suzukii* (37-66% of the whole population with confidence interval taken into account).

According to HIR, the level of contact with advisors is influenced by the interest and engagement of the individual grower. As said by the grower at Farm #4, using advisory services is also an economical question for the growers, requiring a cultivation of a certain size. After further reasoning, however, the grower said that this is something that everyone can afford in some form, especially considering the costs for not having someone keep track of cultivation pests. According to him, self-administered control is never enough, as growers have neither the time nor the detailed knowledge required. However, the differences in economic means and interest between growers (in addition to limited manpower at HIR) likely means that personal advice will never be a way to reach all growers. Additionally, the survey data showed that it was more common to have personal advice on *D. suzukii* if the respondent had a big cultivation area of soft fruits and berries than if the area was relatively small (fig. 19).

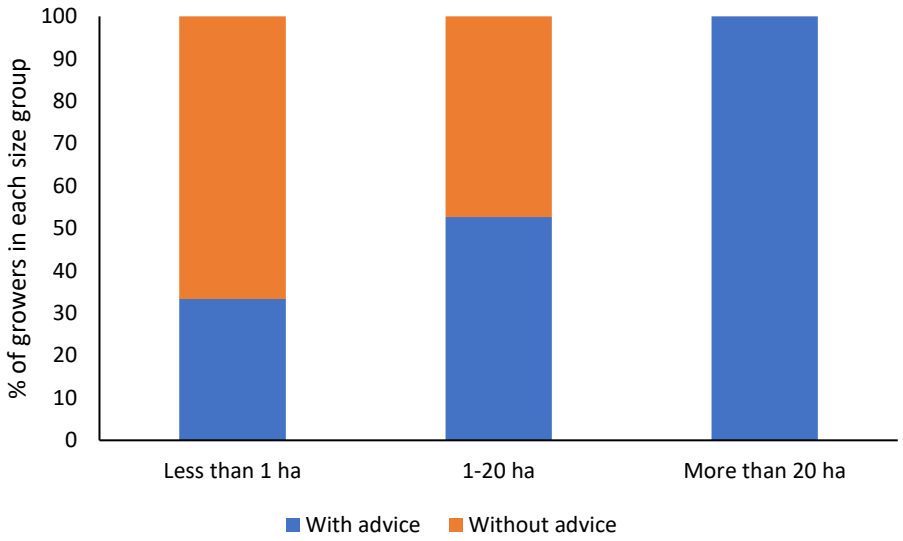


Figure 19. The proportion of growers of different size groups receiving personal advice on D. suzukii*. Ha indicates hectares of open ground cultivation.*

The direct grower contact is more limited for JBV and SLU. Both JBV and SLU have participated in the field excursions and have had the chance to talk to growers there. The contact information of everyone in the working group is also available on www.drosophila-suzukii.se, enabling the growers to get in touch. JBV regularly meet growers in the field when checking the monitoring traps, and these are occasions when growers get a chance to ask questions about *D. suzukii*. JBV is also an active participant in courses and meetings outside the field excursions.

The interviewed growers were highly variable in their interaction with SLU, HIR and JBV. At the time of the interview, the grower at Farm #2 had not been in personal contact with the *D. suzukii* working group, and he did not have any advisory services. He had heard about *D. suzukii* from JBV at the time of its arrival in Sweden, but had not followed the development since then very actively. The situation for the growers at Farm #3 was somewhat similar. In general, they were very interested in the ecological balance at their farm, especially for insect pests and natural enemies. Because of this, they had been involved in other projects with SLU, for example with pheromones for mating disruption. However, they had not been in personal contact with the *D. suzukii* working group. They were aware that there had been a meeting (one of the field excursions) on a farm nearby, with information directed at them as well, but they had not been there because they had been busy at the time. The growers had marked in the survey that they were receiving information from fact sheets, and when asked about this one of them said:

”There came something then, I think, around the time when there was this meeting (the field excursion)*, but it was like I said (…), there were so many other problems that were real at that time, so we thought ’no, we’ll wait, because at least it’s not a problem right now’. (…) And you think, ’that is something that they can read then, the ones that have seen a fly like that, at that time’”.*

This statement connects the growers’ practical experience of *D. suzukii* and their view of need for information. It is supposed in this quote that information about the fly

is only relevant for those who have found it at their farms. It shows that even when information collection and distribution works well, its usage ultimately depends on grower interest. The quote also indicates that the information sources used by the growers need to be seen in a critical and realistic light, concerning how actively and fully the growers are using the sources that they have marked in the survey.

Farm #1 and Farm #5 are very actively in contact with the *D. suzukii* working group. JBV has monitored *D. suzukii* with traps at both of these farms, and at Farm #1 this was combined with SPLAT field trials, as mentioned above. Both farms have also hosted field excursions. Farm #1 is an important interface between SLU and growers in general, as it is a place where they can try out their research results in practice. It is also a suitable place for more collaborative work as it is geographically close to HIR, SLU and JBV, and in addition SLU has done monitoring there previously. At Farm #1, all the actors affected by *D. suzukii* have come together, jointly invested manpower and exchanged knowledge to get the most out of the collaboration on SPLAT. SLU contributed with the natural science part and designed the experiment, but for this to work, they needed to sit down and talk to the growers to learn about the management and what the season looks like – for example, at which time their different raspberry varieties are ripening. The practical work was very rewarding, but a challenge for SLU as it was *"not easy to take the step to the field and do something practical and having a tool in our hands"*, and the outcome for the growers could, of course, not be guaranteed. HIR played an important role in establishing understanding between the different perspectives of the growers and the researchers, by being present at the planning meetings before the field trials. The monitoring done by JBV in the farm helped provide a baseline for the presence of *D. suzukii* at different times of the season that the data on SPLAT efficiency (level of berry infestation) could be compared to. The growers at Farm #1 have seen the research and monitoring done at their farm as an advantage for them, and they have warmly welcomed SLU, HIR and JBV to do their work there. For them it is very important to contribute to the development of management methods for *D. suzukii*.

Farm #5 has also made the cultivation available to JBV and SLU, and they have a close contact with HIR for advice, while they also have other independent advisors. Additionally, they welcome visitors in all forms (e.g. at the field excursion). In 2016, the farm had Riga traps (ready-made single-use traps) put up in and around the cultivation, and they also did their own berry checks throughout the summer months, investigating infestation by putting berries in sugar solution. Berry checks have also been done by HIR. It is not entirely clear how the monitoring work has been divided in this case and how much of the trap setup and checks that the growers had to do themselves (and how much of the monitoring was done for the growers' own information and how much for the official recordings of JBV). However, during my visit, the grower expressed that the responsibility for the practical monitoring work had been too heavy for them in 2016 – both because of the amount of work and the competence needed. One possible reason for why the growers were given more responsibility at this farm is that it is located considerably further away from JBV, HIR and SLU than for example Farm #1.

During the interviews, the growers were asked about their overall view of the work currently being done to manage *D. suzukii* in Sweden. On a general level, they had all been reached by information about the presence of *D. suzukii* in Sweden, and understood that the problem was given attention. They were all very positive about the issue being addressed vigorously and proactively at an early stage, and agreed that the work with *D. suzukii* should proceed as quickly as possible. Beyond awareness of the work being done, the growers diverged greatly in how much own experience and knowledge they had, which affected how much they wanted and could say about the work more specifically.

The information flow was something that all growers had experience of. According to one grower at Farm #3, *D. suzukii* had been much talked about a few years ago, but overall it had *"not been made a big thing"*, and it is not something that fruit growers discuss among themselves yet. This is similar to the experience of the grower at Farm #2, who also had not discussed it to any greater extent with his colleagues. In neither of these cases, however, the growers expressed that there had been a lack of information available. Rather, they were aware that there was more information to be found if they had looked for it. The grower at Farm #4 said that he had received the information he needs – he has read about it in newsletters from JBV, but also mentioned specialist press as an important source. At the same time, he also emphasized how much he relies on his advisors for keeping up with the information on *D. suzukii*. The latter applies to Farm #1 and Farm #5 as well. In contrast to the view of the grower at Farm #3, the grower at Farm #5 said that *"not many insects are given as much attention as* D. suzukii*"*, from an information point of view. Because of their own strong involvement with *D. suzukii*, however, it might be difficult for Farm #1 and Farm #5 to say how the information flow has worked for growers in general.

The growers at Farm #5 and Farm #1, based on their experience, had elaborate views of the work being done on *D. suzukii*. Both think that the field trials with SPLAT are very important, and the grower at Farm #1 said that even though it did not give impressive results during 2016, they feel confident in the researchers and will continue to give access to as much of their cultivation as they need for new trials. Both growers are however also emphasizing the need of having a last resort method, to take when there is an infestation despite all preventive measures taken. In view of this, the grower at Farm #1 called for measures to be developed on the whole spectrum, from monitoring to prevention and chemical control.

In many aspects, the grower at Farm #1 had a positive view of the work being done on *D. suzukii* in Sweden:

"I would like to say, to mention what is good, that I'm impressed that, from SLU to JBV and also within the advice, so much work is being done. (…) It's the third or fourth year that we are talking about this, third at the least. And so far we have not seen infestation in the field, and still they are so active and so far ahead, it's hopeful and impressive."

However, the grower also thinks there is room for improvement. During the interview, the question was raised of how the efforts should be divided between collecting theoretical knowledge and developing practical methods for management of *D.*

suzukii. His view of this issue was clearly not one-sided. He expressed deep understanding and respect for the need to collect information about the occurrence, lifecycle and behaviour of the fly in Sweden, but said that he wanted to feel a clearer connection between this knowledge collection and the development of practical measures against the fly. As an example, he called for more concrete information about the practical aspects of *D. suzukii* management at growers' meetings. The grower at Farm #5, on the other hand, thought that the balance between theory and practice has worked well so far. Something that he commented on, however, was the need for proposed measures to be realistic. He said it was not possible for them to follow all recommendations on how to prevent *D. suzukii* overwintering, as this would mean that they would have to stop keeping their houses warm in the winter and that they would need to cut down the forest surrounding the farm.

Actions taken, not taken or planned to be taken by the growers against *D. suzukii*, and the reasoning behind decision making

As the survey showed, much is happening on the farm level when it comes to managing *D. suzukii*. Among the respondents there was a noticeable difference only between 2016 and 2017 – 6 growers more than last year plan to take some kind of measures, meaning that 19 plan to take measures, while 18 do not. More or less all measures are increasing in use from 2016 to 2017, notably for better cultivation hygiene and for checking berry infestation. The question is what underlies this increase. As noted above, it is not an increase in actual economical damage. Neither is it only the awareness of *D. suzukii* presence at the farms – it has been found at 6 farms while 19 growers are planning to take measures. Many growers, then, are doing "preventive" work (although the fly might already be present at their farms), which means that they are aware of the problem and have knowledge of measures available without own personal experience – this knowledge must come from external sources. As noted above, the most important information sources on *D. suzukii* for the growers are SLU, JBV and HIR. For the growers that are aware of the presence of *D. suzukii* at their farms, it is also possible to start building own personal experience, even though this process has not yet been given much time. The grower at Farm #5 described how previous experiences influence their thinking, e.g. that the discovery of berry infestation last season by HIR would have called for some kind of treatment if they had known it earlier, and that they will be doing even more rigorous controls this season.

One important issue from HIR's perspective is to encourage the growers to make an active choice of taking or not taking any measures against *D. suzukii*. It is not yet clear if all growers irrespective of harvest time actually need to take measures, but still it is important that the growers who are not taking any measures have a good motivation for doing so. To look into this question, a graph was made of the information sources of the growers who have planned/not planned to take any measures in 2017 (fig. 20). The groups were similar when it comes to using fact sheets and newsletters, which does not necessarily mean taking an active stance, but they were also similar in how much personal advice they had. The interviewed growers who have personal advice all described how this is very important for them

in deciding what measures to take (even if the choice of action is always ultimately up to the growers). According to the grower at Farm #4:

"So she, she works at HIR, she's taking care of that part, do that work, 'you get the information, you check how it looks when you come here every second week, and then we discuss the measures', and then she gives suggestions. Because she has a much broader knowledge about it, she follows it much more. I mean, I have eight cultures here that I have to keep up-to-date with."

For the growers that have personal advice and are not planning measures, then, the most likely seems to be that the advisors (HIR or otherwise) have not recommended them to do so.

The respondents planning/not planning to take measures 2017 differed more when it comes to the information sources of field excursions, courses, meetings, homepages and other growers. Common for these is that they are more active ways of seeking information than having a newsletter sent, or an advisor that comes regularly. However, it is hard to say what is the cause and effect for more active information intake for these growers – if they are planning measures because they have informed themselves or if they are seeking out information because they are already active and want to learn more.

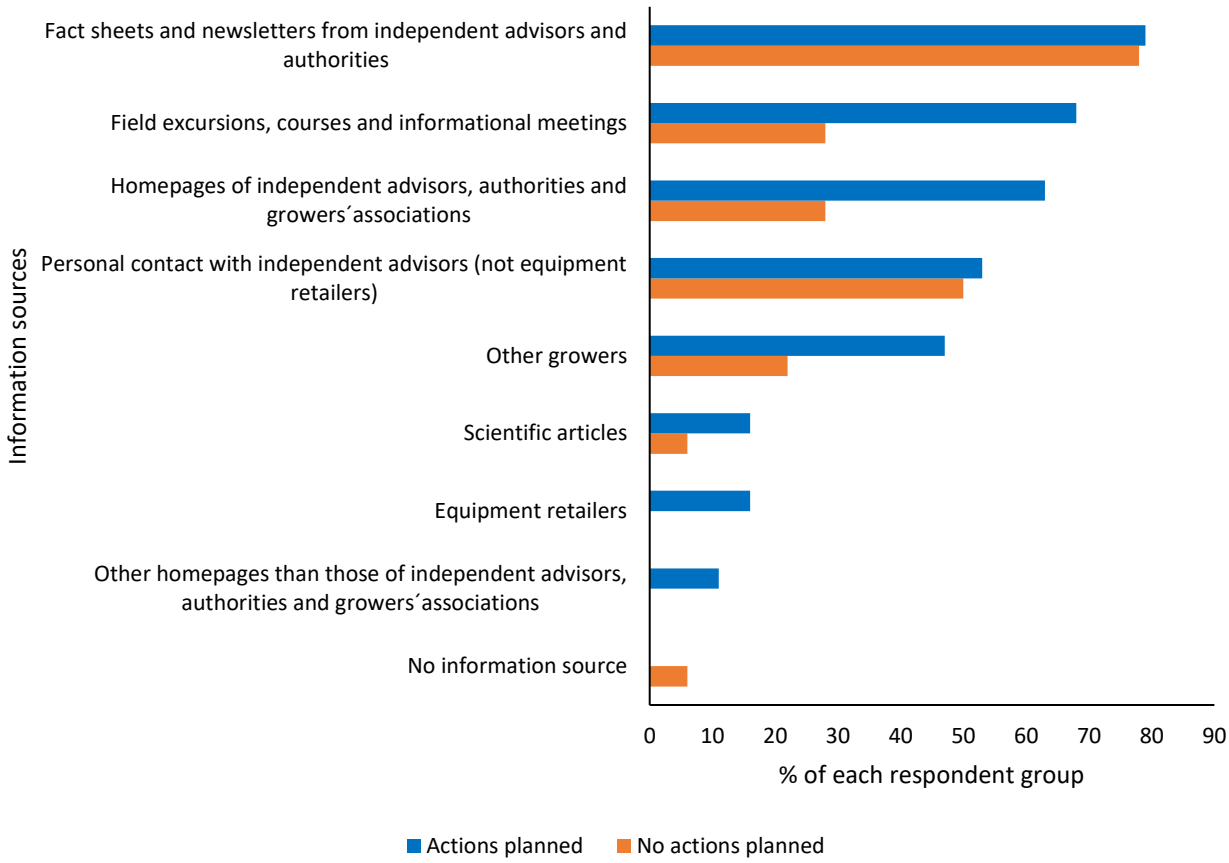


Figure 20. Information sources on D. suzukii *used by the respondents, divided by the growers who are planning and not planning any measures against the fly for the 2017 season.*

One aspect that emerged during the current work was that some measures recommended against *D. suzukii* are already in use for other reasons, and so the growers may not think of them as directly connected to *D. suzukii*. For example, one grower marked in the survey both ”no measures planned” and ”picking at earliest possible ripening stage” for 2017. Another measure that does not target *D. suzukii* specifically but will have played a role in that the growers are not yet experiencing economic damage is the cooling of berries after harvest. For example, the growers at Farm #5 cool all their berries shortly after picking – *”raspberries are so sensitive, they need to be cooled right away for the sake of preservation”*. Growers might also have routines similar to those recommended against *D. suzukii* in place for the management of other pests. For example, the growers at Farm #3 describe how they already have traps for other insects in their cultivation, and how putting up *D. suzukii* traps would not be a burden for them.

Connected to the above is the statement of the grower at Farm #5 – that the measures proposed must be realistic and feasible for the grower - and this depends on the context of every individual farm. For example, the grower at Farm #2 has been cutting down elderberry bushes around the vineyard, which was not a big effort as they only have 2 or 3 bushes. The grower at Farm #1, on the other hand, is aware that there are plenty of elderberry around their cultivation, but it is not feasible for them to take them down. What is considered feasible is also connected to how serious the problem is perceived to be. All growers interviewed who had found *D. suzukii* at their farms were willing to make considerable investments to mitigate the problem, e.g. to work harder on cultivation hygiene. They also strongly expressed that they want to take measures that are in line with their environmental philosophies, as far as it is possible, with chemical control as a last resort. Preventive measures are perceived as very important and an absolute first-hand choice. On the other hand, one of the growers at Farm #3, where the fly has not yet been found, said that they will not make any big efforts as long as the problem stays on the current level of uncertainty for them.

Finally, one aspect that emerged during the interviews was that measures not taken can be the result of a still existing knowledge gap between the *D. suzukii* working group and the growers. The growers at Farm #3 were interested and willing to put up traps, but assumed that such traps were not easily available. The grower at Farm #2 said that they were *”willing to follow the given recommendations”*, if such recommendations were to be presented. This can be seen as a contradiction, given that both these growers knew that there was more information available, but that they had not been looking for it. However, in these cases there was a clear ”interview effect” - my interest in their view of *D. suzukii* had brought this problem to the surface where they had previously not had the time and motivation to look into it, and the issue had not actively been brought up with them.

The growers’ preferred sources of information about *D. suzukii*, requested information and approach to new knowledge

The survey showed that all but one of the respondents were informing themselves about *D. suzukii*, meaning that they are, in general, building their knowledge. This is

happening in parallel with the *D. suzukii* working group building their knowledge, as they are regularly reporting to the growers about their latest findings. In the survey, the growers were also asked how they prefer to get new and updated information, and if there was anything in particular that they wanted more information about concerning *D. suzukii*. The alternatives given in the former question were limited to the communication means available to JBV, HIR and SLU, in order to make the survey answers as relevant as possible for them and because of their special responsibility for the question. Electronic newsletters are the most preferred means of information for the growers, but all means were preferred by a relatively large part of the respondents. Digital information might not be available or easily accessible for everyone – 8 respondents preferred getting information through paper newsletters (2 respondents only marked this option).

The answers to the open question of what the growers wanted more information about can be summarized as follows, with some answers given by more than one grower:

- Where the fly has occurred
- Methods for prevention in general
- Methods for control (both in organic and conventional cultivations)
- Activities on the national level
- Information about traps
- Locally relevant measures
- If berries can be safely traded with other growers
- Attraction of *D. suzukii* to different crops – why some are more attractive than others
- How to discover the fly in the field
- Which crops the fly has been found in

Much of the information sought for by the respondents is already available in the recently released guide and on the homepage of the working group. Concerning the question of whether it is safe to trade berries with other growers, it emerged during the HIR interview that some growers have a cooperation where they help selling each other's berries, in order to have a big enough volume to be interesting to the customers.

During the interviews, the concrete knowledge of the growers about *D. suzukii* as such was not discussed to any greater extent, as this was not one of the goals of the interview and might have strained the conversation. Much of the knowledge was instead expressed through the growers' descriptions of the actions they were taking against the fly. At several occasions during our visits, the growers took the chance to ask my supervisor and I questions about *D. suzukii*, and were clearly eager to learn more. Another theme that emerged in connection to the subject of knowledge was, again, the responsibility of the advisors in keeping track of the latest findings and making sure that they are put into practice. The grower at Farm #4 described how the fact that he has an advisor affects his acquiring of knowledge:

"I mean that if I don't have problems, I have a good advisor who is moving in this sphere of knowledge collection, I might not readily invest a lot of work in immersing myself, 'how long is the time from egg to hatching, and temperatures' and all those things. I don't do that then."

At least some of the knowledge of *D. suzukii*, then, might be outsourced to advisors for growers who have them. Several growers said that the knowledge conveyed should, in turn, be generated by JBV and SLU – one grower termed these actors the *"knowledge builders"*.

The growers' risk perception and management concerning *D. suzukii*

The survey respondents as a group were heterogeneous in their perception of *D. suzukii* as a threat. The question is, then, if growers with similar perception of *D. suzukii* also share similar features of their cultivation. To investigate this, the growers were divided into "low threat" (1 and 2), "medium threat" (3) and "high threat" (4 and 5) and compared concerning their growing area, their main crops, their harvest time and if they are cultivating in greenhouse or only on freeland (fig. 21-24). Of course, these categorizations are coarse, and they do not show how the different factors interact. Instead, they should be seen as attempts to discover overall patterns in the reasoning of the growers.

The size of the cultivation in itself does not seem to be correlated with how big a threat *D. suzukii* is perceived to be (i.e. growers of bigger-scale cultivations being more worried) (fig. 21). This is a case where interaction of factors will have had an impact – not only the size of the cultivation, but also what is the main crop on that land, is of course important for the threat perception. All the respondents with more than 20 ha growing area had strawberries as a main crop and, as can be seen below, growers of strawberries in general are not perceiving *D. suzukii* as a big threat. As noted above, the large-scale growers were all also receiving personal advice on *D. suzukii*. The most worried growers are found in the medium- and small-scale cultivations, who are more heterogeneous when it comes to main crops, and who are receiving less personal advice on *D. suzukii*.

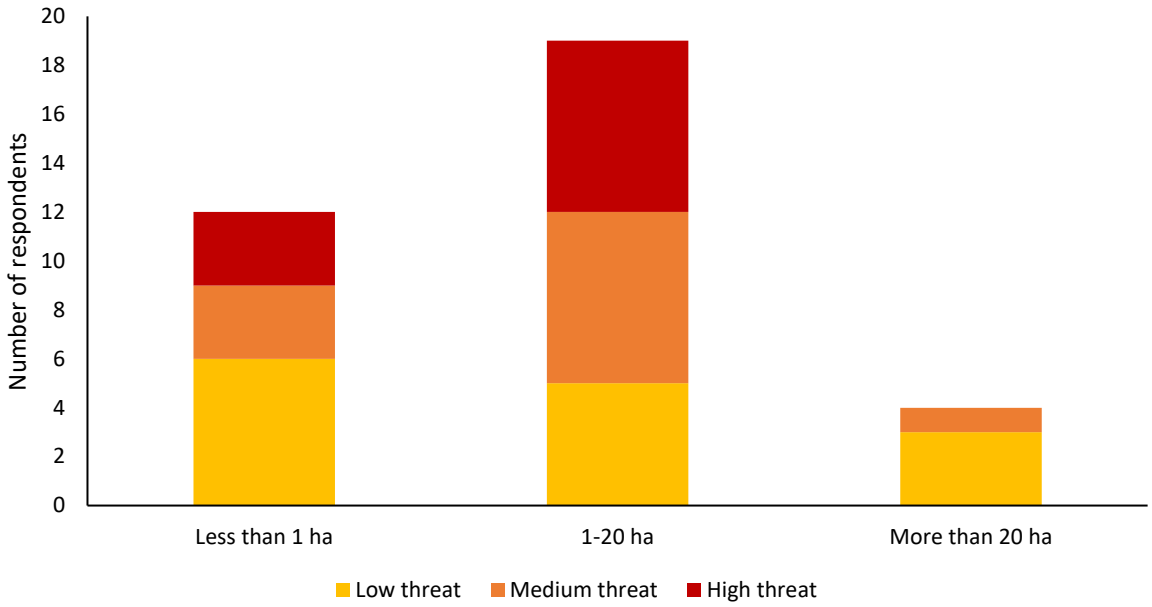


Figure 21. Perceived D. suzukii *threat of respondents, divided by open ground cultivation area size groups.*

One factor that seems to be important in itself for the threat perception is the main crop of the growers (fig. 22). Important to remember is that *D. suzukii* has been found in all crops in fig. 22 in the official monitoring (Manduric, 2017). Among the respondents, there was a clear difference between the two most common main crops, strawberries and raspberries, with growers of raspberries perceiving *D. suzukii* as a big threat to a greater extent than strawberry growers.

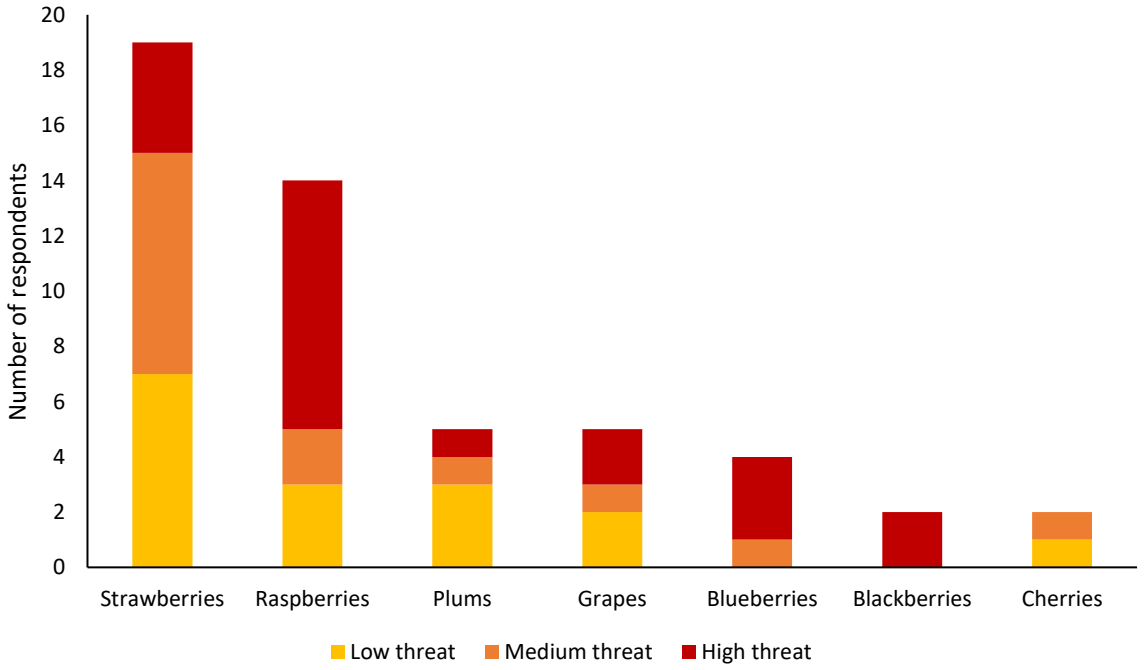


Figure 22. Perceived D. suzukii *threat of respondents, divided by their main crops.*

Drosophila suzukii is known to increase in number as the season progresses, but this was not clearly reflected in the worries of the growers in relation to their last month of

harvest (fig. 23). It should be said here that it is still uncertain which parts of the season will be impacted by *D. suzukii* in Sweden. It should also be remembered that last month of harvest is a measure that lacks some accuracy, as it does not tell how large part of each grower's harvest that is taking place in this month.

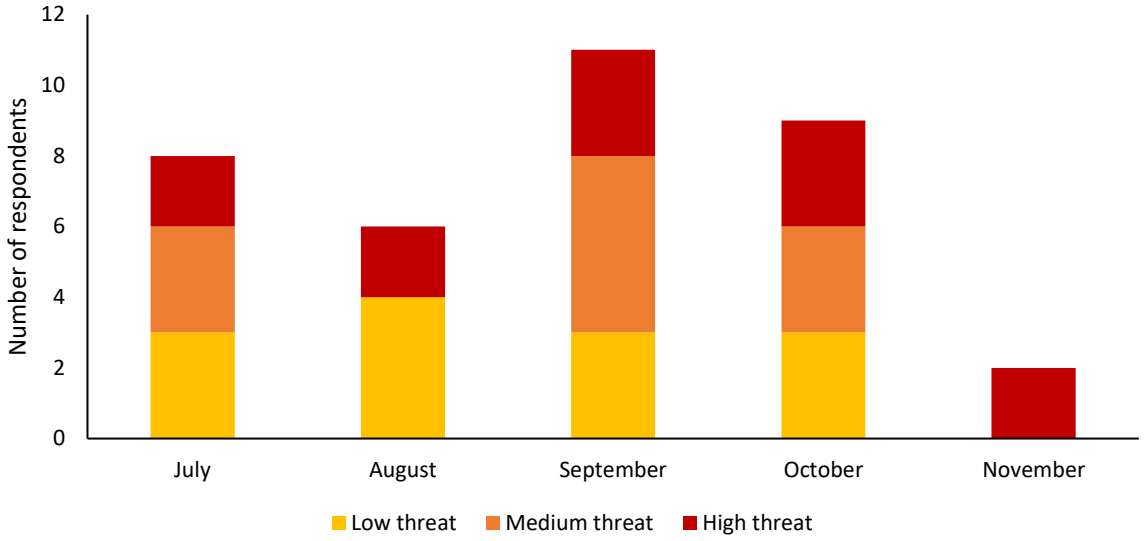


Figure 23. Perceived D. suzukii *threat of respondents, divided by their last month of harvest.*

It was noted in the survey data that growers with greenhouse cultivation (5 in total) were perceiving *D. suzukii* as a big threat (fig. 24). Three of these grower also had open land cultivation (120, 1 and 0,5 hectares, respectively). During the interview with the grower at Farm #4, he talked about both pros and cons of growing in greenhouse in regard to *D. suzukii*. On the one hand, some pests do not cause problems in greenhouses because the production is earlier than on open ground. On the other hand, the greenhouse can also allow the pests to overwinter and become active earlier. It is easier to keep pests out when cultivating in a greenhouse – but those that enter can become a bigger problem than outside. Yet another aspect is that it might be easier to get biological control methods to work under greenhouse conditions, if such methods become available for *D. suzukii*. In the recently released guide, it is confirmed that the fly can have more generations per season in greenhouse cultivations than on open ground, and that egg-laying can take place during a longer period of time each season (Svensson *et al.*, 2017). Additionally, the pesticide spinosad was not permitted for use in greenhouses during the 2017 season.

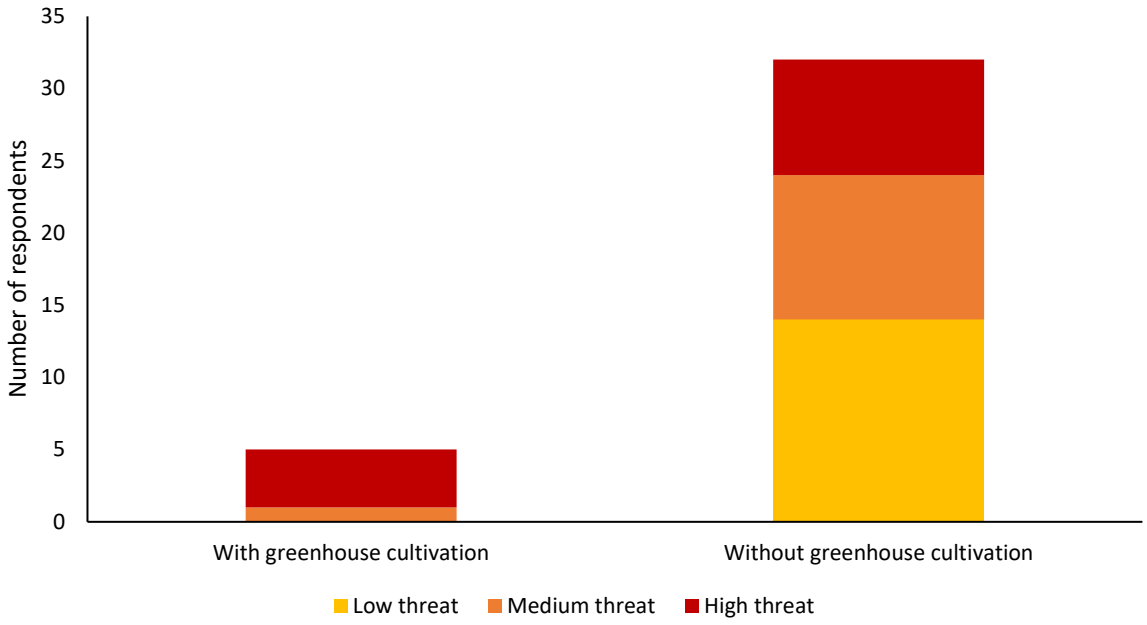


Figure 24. Perceived D. suzukii *threat of respondents, divided by those who did and did not have greenhouse cultivation.*

The previous correlations have all been about potential causes of worry, but from the survey data it might also be possible to say something about the effects. In some cases, it is hard to determine what is the cause and what is the effect. For example, growers who have investigated *D. suzukii* presence appear to perceive the fly as a bigger threat than those who have not investigated it (fig. 25) – it might be that the growers have investigated it because of their worries, or it could be that the investigation itself has given them cause for worry. Since 7 out of 10 growers who have investigated presence have had personal advice on *D. suzukii*, it seems that the latter is the most common – that the growers become worried because *D. suzukii* is investigated at their farm, after recommendations from the advisors. In line with this, one of the growers at Farm #3 said during the interview that she believed that growers in general *"choose not to see it before you have seen it. (…) You want to be prepared but in some way you're still hoping"*. When asked about if they were worried or had any thoughts of changing the plans at their farm, she said:

"Not right now. No. But it can strike like lightning. If you had come next spring, we might have been really worried. You cannot know. If you're asking now we say no. But if we were to find something here, then we would be worried."

The other growers interviewed all believed *D. suzukii* could become a bigger problem in the future, but they were also hopeful about the management methods under development.

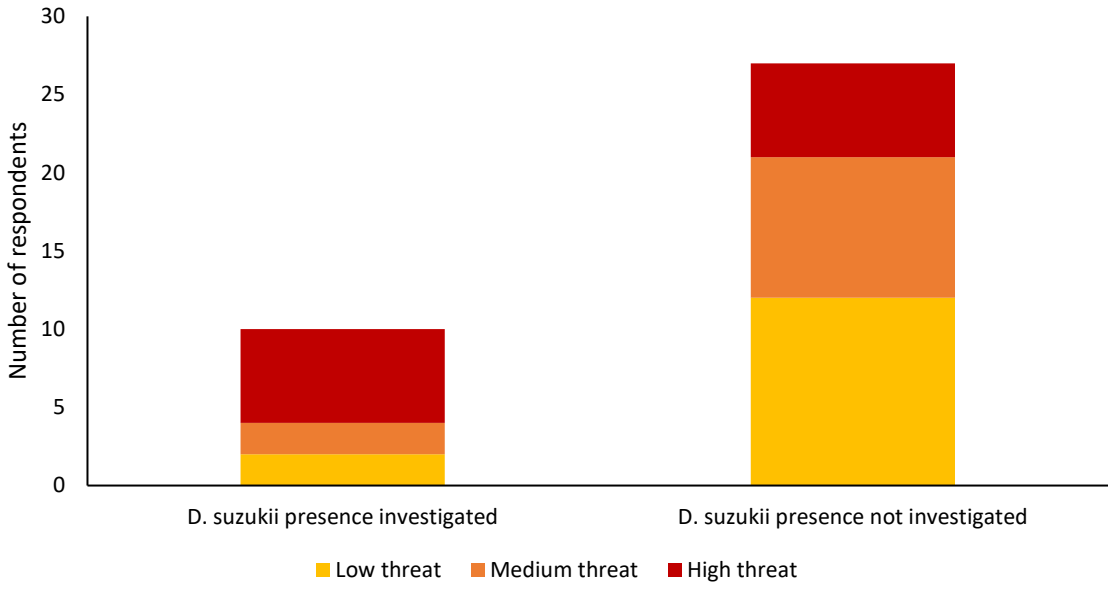


Figure 25. Perceived D. suzukii *threat of respondents, divided by those who had and had not investigated* D. suzukii *presence.*

The perception of *D. suzukii* as a threat has a clear positive influence on actions planned to be taken in 2017 (fig. 26) – naturally, most growers who are perceiving *D. suzukii* as a threat are planning actions, and vice versa. It should be remembered, however, that growers who are not perceiving the fly as a threat – and not planning actions – might have good reasons for their stance.

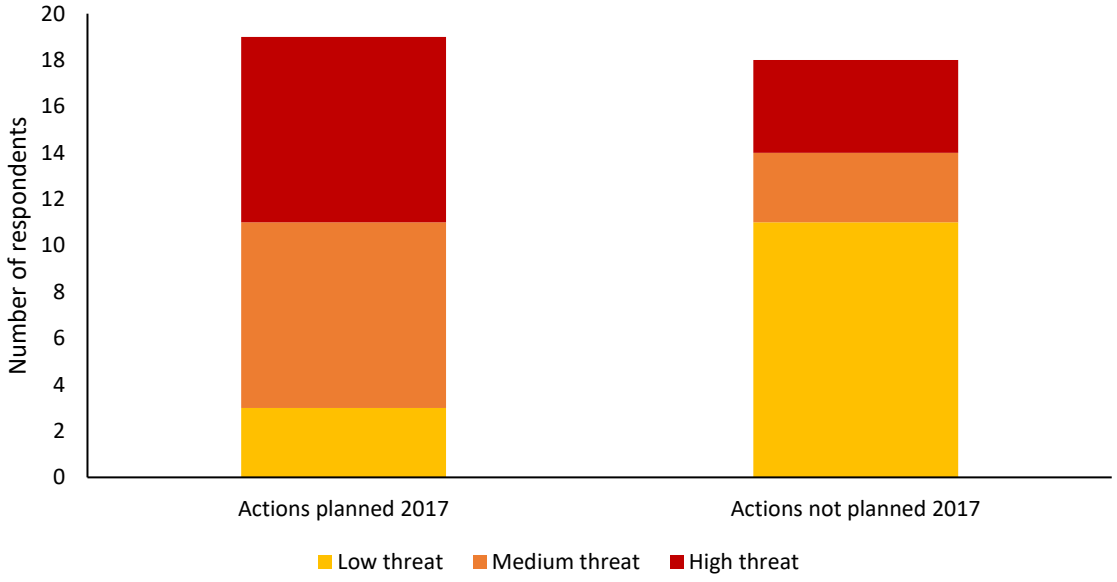


Figure 26. Perceived D. suzukii *threat of respondents, divided by those who had and did not have actions planned against the fly in the 2017 season.*

In the interviews, one view which was expressed by the growers several times was that *D. suzukii* is not an exceptional threat to soft fruit and berry cultivation. According to the grower at Farm #1:

”There is a lot you can worry about in a business like this. This is one part that you can immerse yourself in of course, if you want, but we don’t do that. If there is any change that we have to deal with, we will do that then.”

Two other growers explicitly compared *D. suzukii* to other pests, saying that the fly does not have a bigger impact than any other insect, and that it might even be less grave than mildew since *D. suzukii* does not affect the viability of the plant itself. This is in line with the statement by JBV that *D. suzukii* is *”just another pest”*. At the same time, several growers were also referring to the extensive damage caused by the fly in southern Europe as something that increases their concern with this particular pest. The size of the matter, however, also means that the problem is given much attention and that there are many people working on solutions.

A SWOT summary (Strengths, Weaknesses, Opportunities and Threats) has been made based on statements by the growers during the interviews (table 1). The strengths and weaknesses in this case are properties of the actors directly involved with *D. suzukii* in Sweden that affect their ability to deal with the fly, while the opportunities and threats are such factors emanating from outside this system.

Table 1. Strengths, weaknesses, opportunities and threats of the Swedish D. suzukii *situation mentioned during the grower interviews.*

Strengths	**Weaknesses**
High activity of researchers, authorities and advisors to deal with the issue	Current lack of concrete measures Takes a long time to get new pesticides approved
Opportunities	**Threats**
Vulnerable cultivations in Sweden are further apart than in other countries – might hinder spread of the fly Colder climate than in southern Europe might make the problem less grave Knowledge is available from other countries with more experience of *D. suzukii*	The growing season is shorter in Sweden than in southern Europe – reduced opportunities to advance harvest to avoid *D. suzukii* Climate change may provide better conditions in Sweden for the fly to become established *Drosophila suzukii* will likely keep spreading from other countries into Sweden

Growers’ views of collaboration with research and extension seen in the light of previous experience

Some perspectives of the growers on collaborating with research and authorities, both on *D. suzukii* and in other contexts, emerged from the interviews. The extensive

collaboration between Farm #1 and Farm #5 on the one hand, and JBV, SLU and HIR on the other, was described above from the perspective of these actors alone. However, the grower at Farm #1 also brought up how the collaboration has affected their farm in a wider sense. They have experienced how their cultivation has become particularly associated with *D. suzukii*, because of their engagement in the issue, and that this might have led to the general perception that their farm is more affected by *D. suzukii* than others. For example, their farm often comes into focus at growers' meetings, as they openly speak about the issue together with people from the *D. suzukii* working group.

One of the growers at Farm #3 described another experience, with authorities outside the *D. suzukii* working group, that had affected their view of authorities in general. The growers had been visited by authorities during the fruit packing process, and had been given directions that had not been perceived by them as relevant or necessary – rather, they had felt diminished and treated as less knowledgeable than they were. According to the grower:

"Bureaucrats are the kind of people who are interested in many things that are self-evident. If not irrelevant then self-evident for regular people. What is bad with bureaucrats sometimes is that they want to take responsibility and thought from those they are in contact with."

Growers' views of their own role in the *D. suzukii* work

The question of how the growers see their own responsibility in relation to *D. suzukii* emerged as a complex issue. However, a dynamic give-and-take relationship with researchers and authorities emerged as something to strive for. The survey respondents thought it was important for growers in general to participate in the national work with *D. suzukii*, and were prepared to participate themselves. For example, nine growers would consider participating in a reference group, something that JBV were also interested in. All four proposed activities for grower participation were of interest to a relatively large number of growers.

The survey included an open-ended question where the growers could comment on their answer (yes/no/maybe) to whether they would consider participating in the national *D. suzukii* work. In summary, those that answered "yes" gave the following explanations (some given by more than one grower):

- They are willing to help with what they can
- They see it as an incentive to become more rigorous with monitoring, and a chance to learn from the experience of other growers
- They are already involved in other collaborations with SLU and JBV
- They think that grower engagement is necessary, and that it is important that everyone contributes with experience
- They are interested in the biological interaction between the fly and its environment

For the ones that answered ”maybe”, a few different reasons emerged:

- Having been involved in monitoring before, and calling for compensation for this work
- Being uncertain of having enough knowledge
- Having a cultivation that might be too small
- Having good advisors
- Not having the main responsibility for the farm anymore
- Depending on how much time it requires
- Depending on what kind of work is being asked for
- Being uncertain about the gravity of the problem

The four growers who gave a comment on their ”no” answer all gave ”lack of time” as their explanation. Interesting to note is that none of the growers perceiving *D. suzukii* as a high threat answered ”no” to considering participating in the national work – again, showing the connection between what is considered feasible work and perceived threat, and in addition that this applies not only for on-farm work but also for work dealing with the fly on national level.

Something that emerged partly from the survey answers, but became even more clear during the interviews, was that some growers did not interpreted the term ”national work” in the way that I intended – which was work done for collecting knowledge to be used in a wider context than the individual farm. This can for example be seen in the answers ”having good advisors” and ”uncertainty of the gravity of the problem”, that were referring to the respondents’ own farms. When asked during the interviews about the role of growers in general in the work with *D. suzukii*, the first thing mentioned by the growers – who had all ranked the importance of grower participation as 5 out of 5 - was the responsibility of every grower to take care of one’s own cultivation; making rigorous controls and taking feasible and relevant measures according to the current knowledge level. Two growers mentioned especially the economical responsibility of every individual grower as the foundation for other responsibilities. Several interviewees then returned later to the issue of informing the growers and waking their interest as a prerequisite for the practical work. When it comes to how the information should reach the growers, the interviewees mentioned homepages of growers’ associations, growers’ meetings with invited experts on *D. suzukii,* newsletters of growers’ associations, and personal contact with advisors. Asked about what the content should be of such communication, the grower at Farm #5 answered:

”You ask the question. Inform that there is a problem. Put forward a suggestion of what needs to be done, measures against the fly. Everything from available measures to the need for more money for research, and then you would have to present a concrete suggestion of how much resources are needed.”

This leads on to another emergent theme of the growers’ role in regard to *D. suzukii* – that of actively advocating for work to be done on the issue, and to facilitate the direction of sufficient resources to this work. Two interviewees mentioned that it is important for the growers to keep up the communication with JBV on *D. suzukii*, to let

them know that the issue is important for them so that the work pace is not slowing down. One grower mentioned that it is not only important to turn to the working group actors, but also to raise the issue in public to make sure resources are directed towards HIR, JBV and SLU – for example, the growers could write debate articles together with SLU where they argue for more resources for *D. suzukii* research from the point of view of economical interest. A third way of advocating that was mentioned was for the growers' associations to mobilise their members in favour of *D. suzukii* work. According to one of the growers, who was a member of the growers' association LRF, there are considerable research funding to be obtained through this organisation if its grower members find the problem a priority.

The last theme of grower participation was that of taking part in the research itself. The general view was that the growers should try to be of help to research if they can. One grower thought it was more or less a responsibility of growers to help the development move forward, while others said that it is something that growers should do if they want knowledge to develop concerning their crop, and that it is something that needs to be decided on by the individual grower. In summary, the role of the growers as expressed by the interviewees can be said to be communicating their perception of the problem, provide support to research and contribute to the knowledge base of *D. suzukii* in Sweden. What was not perceived as the role of the growers, however, was to be driving forces in research, provide structure to, coordinate and have an overview of the *D. suzukii* work, and distribute information – this is seen as the responsibility of research and authorities, while one grower also suggested LRF as a suitable central point of coordination.

Analysis of the prospects for further integration of grower participation in the *D. suzukii* work

To analyze the prospects for PAR to be further integrated in the *D. suzukii* work in Sweden requires a systemic view. The situation as a whole emerges as very complex, with many different forces at play at different levels, both in the biological and socio-economical realms. The issue of *D. suzukii* is clearly one of the whole food system, and growers of soft fruits and berries in Skåne are affected by factors far beyond their reach – for example pesticide policies in other countries, EU trade agreements, globalization of food trade and climate change. On a national level, they are affected by the general trend in Swedish agriculture mentioned above, with small-scale giving way to large-scale production and lower profitability of agricultural products. These are all factors where neither of the actors included in this work (SLU, HIR, JBV and growers) have the ability to bring about significant change, at the same time as they impact the possibilities to conduct PAR work and to succeed in dealing with *D. suzukii*. These limitations would need to be taken into account at the outset of a PAR process and be openly articulated and discussed, to build trust and understanding between the participants and to avoid false or unrealistic expectations. As one goal of PAR is to bring about change in structures underlying unsustainable situations, a long-term goal of a future PAR group on *D. suzukii* might be to advocate for policy change on national level. For this purpose, it might become necessary and

desirable to involve a wider group of stakeholders, for example through joining forces with similar working groups in other European countries.

While the biological aspects of *D. suzukii* in Sweden – its ability to survive, activity period, reproductive rate and ability to cause damage, etc. – are still poorly understood, the socio-economical context of the stakeholders affected by *D. suzukii* in Sweden is better known, even if conditions are highly dynamic. A central question is what possibilities, driving forces and needs the growers have in relation to *D. suzukii*. According to Bland & Bell (2007, p. 280), farms are good examples of holons because *"their humans plan and act to maintain them as a source of livelihood, necessarily in contexts as diverse and shifting as climate, life histories, trade rules, subsidies, personal spirituality and public perceptions of agricultural practices"*. A complementary view for the specific case of soft fruit and berry growers in Skåne was given during the HIR interview: *"Their* (the growers) *goal, you can have very different goals with your enterprise. Run it because you enjoy it, to earn money and so on, but they want to run their enterprises. They want to cultivate and sell berries."* As noted in the description of the current situation of the growers, and also indicated by the HIR statement, the strength of the intentionality to run an enterprise differs between farms. The main point, however, is that the highest priority for a farm is to maintain itself. This came across several times during the grower interviews – the cultivations are in constant change and adapt to new situations to be able to persist. There seems to be a pragmatic view where problems are given attention in proportion to the threat they are perceived to pose to the farm, whether it is declining profitability of a specific crop, a pest or a disease. The connection between perceived threat of *D. suzukii* and actions planned against it can be seen as a consequence of this pragmatism. For several reasons, then, the growers that should be prioritized for involvement in PAR work are those that perceive *D. suzukii* as a big threat to their cultivation. Firstly, because they likely have good reason for their perception, secondly, because they are highly motivated, as seen by the connection between willingness to participate in the national *D. suzukii* work and threat perception. As said during the JBV interview, *"… the growers who are most engaged, they willingly participate in reference groups. They are interested, they want to know more, they want to learn, they set aside time because they think they get a lot in return".* From the survey results, small- and medium size cultivations emerged as the most vulnerable. Small- and medium size growers both perceive *D. suzukii* as the biggest threat and have the least access to personal advice. One explanation of the vulnerability of small-scale berry growers might be that berries are high-value crops, enabling economic survival of relatively small farms. As in Farm #1, and to some extent Farm #4, growers might have turned to berries as a last resort with declining profitability of more traditional agricultural and horticultural crops.

Even if the most concerned growers are suggested here to be prioritized for PAR, efforts should continue in trying to reach all growers with information and, as said by HIR, encourage them to take an active stance. As more growers inform themselves about the fly, and as the damage potential of *D. suzukii* becomes more clear, the base of growers interested in participation might broaden. Growers of soft fruits and berries in Skåne are a very heterogenuous group, and suitable solutions for growers in different situations will likely differ greatly. Therefore it might be a good idea to

separate the PAR into several groups in such a situation. If such groups were formed, they should be coordinated so that results and ideas can be shared to the benefit of all. The heterogeneity of the growers also implies a need for abundant communication between them as a basis for successful PAR work, regardless of the chosen working structure. Communication would create better understanding and solidarity between growers of different crops and scales, and hopefully also facilitate the mobilization of resources for further *D. suzukii* work.

For HIR, JBV and SLU as institutions, *D. suzukii* does not pose an immediate threat as they all have other activities to rely on, but if growers would cease their soft fruit and berry cultivation due to the fly it would be a significant loss also for them. By initiating the collaboration on *D. suzukii*, they have shown that this issue is important both for them and for their funders, and helping growers to persist is a fundamental mission of all three institutions. While the holons of SLU, HIR and JBV will persist for the foreseeable future, what is most uncertain is the proliferation of the holon constituting their collaboration on *D. suzukii*, as described during the interviews with these actors. The future of this working structure will depend on the development of the problem as well as emergence of solutions. This is a hindering factor in planning for a PAR process that will inevitably span a longer period of time.

One challenge of the *D. suzukii* work is how to motivate it from an economic perspective if it were to be conducted according to the recommendations given here. As noted above, strawberries are by far the most economically important soft fruit and berry crop in Sweden, and strawberry growers among the survey respondents did not generally perceive *D. suzukii* as a big treat. All survey respondents only growing strawberries finished their harvest early in the season – July or August. Even though *D. suzukii* has also been found in strawberries in the official monitoring, the fly is probably not seen as able to cause significant damage as its activity period mostly does not overlap with the strawberry season. However, this might change over time, as the fly has been seen to appear earlier in the season between 2015 and 2016. It is thus possible that the interests of growers of different crops can find common ground, at least in an initial phase. Development of the attract-and-kill method SPLAT (see experiment below) could constitute such an example. Further, working with smaller-scale growers could be motivated with arguments such as the benefits for rural development and sustaining a living countryside. The arguments for PAR could be drawn from positive experiences of earlier PAR projects, and these should also be used as a source of inspiration and advice for how to go about the process.

As a whole, many aspects speak in favour of the feasibility and desirability of PAR in dealing with *D. suzukii* in Skåne. Considering the short time since the arrival of the fly in Sweden, work has progressed rapidly and already found a good structure. A working group with the needed competences has come together and been able to carry out joint projects that have been both purposeful and diverse. Basic and applied research has been carried out alongside outreach activities, and communication with growers has been addressed already at an early stage. The positive results of the outreach are seen by the noticeable difference in measures taken by growers in 2016 and 2017. Field trials at Farm #1 are already running, and both HIR and JBV are in contact with a large network of growers around Skåne. There is a general positive

attitude towards the *D. suzukii* work, both at SLU, JBV, HIR and among growers. There also seems to be a good coherence in the way the growers' situation is described by themselves and by the actors closest to them, JBV and HIR. The researchers, advisors and authorities all express how their actions are directed towards helping the growers, and there is a pragmatic and explorative attitude towards the growers' situation and needs. Very encouraging is that there is interest at JBV in starting a grower reference group and that this is matched by an interest among growers in participating in such a group. Overall, the results from the participation section in the survey gave very hopeful results, even though some answers will have to be written off as misinterpretations. A large share of respondents were willing to become more engaged in participatory and knowledge-building activities, and also thought that grower participation in general was very important. Lastly, the infrastructure and overall material conditions (e.g. most growers having internet access) also greatly facilitates grower participation in this case. Skåne covers a relatively small area and all farms are easily accessible by car, making personal meetings feasible.

Despite all positive factors, there are also some that speak against or would need to change in order for PAR to work well. Several of these have been described above, such as uncertainty of how serious the *D. suzukii* problem will be, what solutions will emerge and how much time and money will be available. Lack of time emerged as a limiting factor of all actors. To do PAR work it would likely be needed to start a new project with its own resources. It is important to remember that while the time available for PAR work can be extended for researchers, advisors and authorities by starting a project, for the growers this work always needs to be compatible with their regular work and other engagements. As was seen in the survey answers, however, the perception of having the time to become more engaged seems to be connected to threat perception. One factor that has multiple effects on the ability to conduct PAR in this case is the novelty of the problem. This might mean that the thinking surrounding the problem and working structure is more flexible and open to new ideas than if the actors already had many years of experience of the fly and had had the time to establish ”truths” about it. In the best case, this might mean a more open atmosphere for innovation and experimentation, an openness to knowledge from a diversity of sources and a chance to approach the *D. suzukii* issue from a sustainability perspective already from the beginning. On the other hand, it can also bring some uncertainty to the actors involved, and worries about being inadequate in engaging with the issue. As was seen from the survey responses, while some growers were willing to participate in the *D. suzukii* work *because* they want to learn more, others were worried about having insufficient knowledge to do so. The actors of SLU, HIR and JBV are also in the process of building their own knowledge base, and are still developing their view of *D. suzukii*. For any PAR to work, it is important to acknowledge that everybody has things to learn from the process. In this case, SLU, HIR and JBV as well as growers have to accept that research, authorities and advisors do not have all the answers, and neither is it desirable for SLU, HIR and JBV to develop such answers without the growers' involvement. Having growers as co-researchers may make SLU, JBV and HIR feel unsure about their roles at first, but in the end all actors could benefit from an expansion and redefinition of their roles. As

said by Eksvärd *et al.* (2014, p. 19), working according to a systemic perspective requires not only learning new patterns of thinking *"but also an unlearning of some behaviours, knowledge and pre-assumptions"*. For example, during the interviews with SLU, HIR and JBV, it emerged that these actors all define SLU as the only actor contributing with research. This view will naturally be challenged when an interdisciplinary PAR approach is applied.

With the expressed interest of JBV and growers in mind, it seems that starting a grower reference group could be a good way to initiate a PAR process in this case. The term "reference group" in itself does not give away much about its nature or its approach to participation. The goals of participation can differ widely and is often determined by its initiating actors. It can range from 1) instrumental rationality, where the goals are pre-set and participation is conducted to manipulate others in order to reach these goals, to 2) strategic rationality, where the goals are also pre-determined but in a covert way, and other people are seen as strategic actors that need to be outwitted to reach these goals, and finally 3) communicative rationality, where goals and plans of different actors are negotiated and coordinated, so that actions can be taken through agreement, commitment and shared understanding (Groot & Maarleveld, 2000). In the best case, a reference group can accommodate for this third definition, and it is important for SLU, HIR and JBV to be self-aware when taking the initiative for participation so that the foundation is laid for a true communicative rationality. In view of the approach of these actors as described above, there seems to be good conditions for taking such a perspective.

A reference group started on the foundation of communicative rationality will automatically form a PAR group similar to other PAR efforts in Swedish agriculture, where researchers, advisors, authorities and growers are seen as one group and work together in iterative cycles (e.g. Swiergiel, 2015, Hansson *et al.*, 2015, Ögren *et al.*, 2008). Starting this kind of work will likely entail a need for more defined structures of collaboration than has been necessary thus far, which should be discussed among all participants at the beginning of the work. An interesting actor to mention here is LRF, that was brought up both by growers, JBV and HIR as an important point of coordination for the *D. suzukii* work, as a mean to reach and inform growers and as a potential source of funding. Indeed, LRF has already been involved both in funding the guide and in organizing the field excursions, as well as helped reaching growers for the current study. LRF is a network comprised of growers, with different sections for different kinds of crops, and one section specifically for berry growers. It might be a good idea to engage representatives from this section, that can act as a bridge between berry growers in general and the PAR group. Other growers' associations, such as Äppelriket (including members growing cherries and plums) and Föreningen Svenskt Vin (for growers of grapes), could also be valuable to include in the PAR work. It should also be kept in mind, however, that not all growers are members of any growers' association.

It is a basic assumption here that the work of a possible PAR group would focus on *D. suzukii*, meaning that it is essential to engage participants that are genuinely interested in the issue, but the work itself can take many directions and is something that should be collectively decided by the group. On the research side, the PAR

might mean a negotiation that shifts the balance between basic and applied research, between prophylactic and responsive methods, or between monitoring and control in one or the other direction, and in accordance with the needs of the situation. Additionally, the group might take on tasks of advocacy, reaching out to both growers and the wider public as described above, to increase awareness and mobilize resources for the work. In this way, even if it might initially be an additional cost to start a PAR project on *D. suzukii*, it is possible that the group will be able to generate resources to the *D. suzukii* work over time. As the PAR group would work in a responsive manner, it should be able to scale up or down its activities as the situation concerning *D. suzukii* in Sweden becomes more clear.

On a final note, when planning a PAR process on *D. suzukii*, it is important to take into account the views of the growers of their role in this work. Some general guidelines for PAR work that emerged during the grower interviews are:

- The growers need to feel that participation does not mean that authorities and research are trying to escape responsibility.
- The growers need to be given tasks that they feel they can handle, both when it comes to resources and knowledge.
- The other actors must listen to the needs of the growers, have a strong connection to field conditions, and help propose concrete and realistic measures.
- The growers want their knowledge to be acknowledged, used and respected, but they also want understanding for their limits of knowledge.

Combining the highly attractive yeast *Hanseniaspora uvarum* with the attract-and-kill technology SPLAT to enhance its efficacy for *Drosophila suzukii* females

SPLAT (manufactured by ISCA Technologies, California, USA) is a substance intended to be used in attract-and-kill management of *Drosophila suzukii.* The idea is that a mixture of a carrying material, an attractant and the pesticide spinosad will attract the flies, that they will eat from it and die (Svensson *et al.*, 2017). In the interviews with SLU, HIR, JBV and growers, SPLAT emerged as something that everyone was greatly interested in and hoped could be used in the near future. During the HIR interview, when asked what would be the best possible future scenario for them, it was said that:

”The best thing would be if SPLAT is fantastic. Fantastic used in the right way. We know when it works and when it doesn’t work. And additionally if we can use it within reasonable time.”

JBV agreed that it would be a big step forward to test and enhance SPLAT efficiency. However, it was underlined, as also implied by HIR, that it has to be approved and registered in Sweden before it can be used, and that the manufacturer holding the license has to give approval. However, JBV has decided to work with SPLAT because they think it has a good chance of getting approved. On a side note, there

are direct contacts between SLU and the SPLAT manufacturer, something that likely has been decisive in choosing to invest in this method, and that might also facilitate further discussions between the manufacturer and the Swedish *D. suzukii* group.

As mentioned above, field trials with SPLAT have been conducted at Farm #1 in the 2016 season. These initial trials gave a reduction, albeit not significant, of infestation in raspberry (Svensson *et al.*, 2017), and the project continues in 2017 (Manduric, 2017). While the first trial was made with a type of SPLAT being developed for commercial use in the US (containing spinosad and an attractant mimicking raspberry), the research efforts of the SLU Alnarp team are directed towards improving *D. suzukii* management by exploiting the association between the fly and *Hanseniaspora uvarum* yeast. By incorporating *H. uvarum* into both traps and SPLAT, efficacy and species specificity of these methods can hopefully be enhanced. As this thesis is being written, continuous experiments have been made at SLU Alnarp to test *D. suzukii* attraction to *H. uvarum* under different conditions, and the current laboratory experiment should thus be seen as a small part of a much bigger ongoing research effort.

Drosophila suzukii females have the potential to cause crop damage by laying their eggs inside fresh and ripening soft fruits and berries. Therefore, the females should be the main target of pest control. In a study by Mori *et al.* (2016) virgin and newly mated females were compared in their attraction to blueberries (a potential oviposition site) and *H. uvarum* yeast. A clear shift in behaviour of *D. suzukii* females after mating was discovered: mated females were more attracted to both blueberry and yeast odours than virgins in a wind tunnel test. Additionally, mated females increased their consumption of *H. uvarum* compared to virgins in a capillary feeding experiment, and adding yeast to spinosad was shown to give a higher mortality of mated females in an arena containing cherries and cherry leaves, as compared to spinosad alone (Mori *et al.*, 2016). Mori *et al.* (2016) argue that the intake of yeast likely supplies nutrients to the developing eggs of *D. suzukii* females. However, as shown in a study by the author (Mühlhäuser, unpublished), the time passed since mating also influences female behaviour. In this study, eggs laid per female increased significantly during the first day after mating, while feeding on blueberry juice and *H. uvarum* suspension increased significantly in the second day, showing a sequential preference for oviposition and feeding when mated females were given the opportunity to do both in a combined feeding and oviposition setup.

Because of the shift in behaviour of *D. suzukii* females after mating, virgin and mated females can be expected to differ in their attraction to SPLAT containing odour cues indicating feeding (yeast) or oviposition (fruit) sites. Both mated and virgin flies are desirable targets in attract-and-kill management. The risk of oviposition is lowered if females can be targeted already as virgins, but it is also important to attract mated females before they have caused any damage. Therefore, the current experiment examines the relative attraction of *D. suzukii* females to different combinations of SPLAT and *H. uvarum* yeast, with the aim of showing how the current SPLAT commercial formula can be improved both for virgin and mated females.

The research question was:

Can the efficacy of SPLAT as an attract-and-kill method for female *D. suzukii* be improved by adding *H. uvarum* yeast?

The overarching question was divided into the following subqueries:

- What mixture of commercial SPLAT, blank SPLAT and *H. uvarum* yeast is most attractive to newly mated and virgin females, respectively?
- Are there any differences in preference or choice rate between newly mated and virgin females when given different combinations of commercial SPLAT, blank SPLAT and *H. uvarum* mixtures?
- What are the implications for application in the field?

Material and methods

Flies, yeast and SPLAT

The flies in the study came from a laboratory colony of *Drosophila suzukii* established from wild individuals caught in Italy (San Michele all'Adige) in 2011. The flies were kept on standard Bloomington diet at 22-24°C, 35-60% RH under a 12:12 hours Light:Dark cycle. Virgins were collected on the day of adult emergence, anaesthetized with CO_2 and sorted by sex. Male and female flies were subsequently held separately under the same conditions as described above, until they were used for experiments at 4-5 days old.

Hanseniaspora uvarum (CBS 2570) suspensions were grown in liquid minimal medium (Merico *et al.*, 2007) and incubated at 25°C in a shaking incubator (65 rev/min) for 3-6 days before use.

Two types of SPLAT were used in this study: the type currently under development for commercialization (SPLAT-Commercial), containing an artificial raspberry odour and the insecticide spinosad (active ingredient 0,5%, Spinosyn A and Spinosyn B), and a "blank" type (SPLAT-Blank), that did not contain any attractants or insecticides but that was in all other respects identical to the commercial type.

The mixtures of SPLAT and *H. uvarum* tested were made by measuring 2 ml each of SPLAT and *H. uvarum* suspension with a disposable plastic 3 ml pipette, and mixing the liquids together in a 13 ml plastic tube.

Attraction setup

Controlled matings of females were conducted as described in Mori *et al.* (2016): males and females of the same age were released into a plastic vial at the beginning of the photophase, around 9.00 am. Mating pairs were then transferred in copula to individual vials, until mating ceased.

Female flies were released into arenas where their attraction was tested (fig. 27). Between 4 and 11 of either virgin or mated females were released into each arena. The arenas consisted of colourless, round plastic boxes (height: 6 cm, diameter: 11,5 cm) with mesh lids, that had been cleaned with ethanol before use. Two colourless

glass vials (32*11,6 mm), each containing 0,5 ml of a solution of interest, were placed in each arena together with two cotton balls soaked in distilled water to give the females a water source. A pipette tip (2-200 µl) with the tip cut off was placed upside-down in each glass vial to trap the flies that entered. In one of the setups (5 virgins, testing SPLAT-Commercial and SPLAT-Commercial+yeast), bigger glass vials were used (45*14,75 mm), but this setup was otherwise identical to the others.

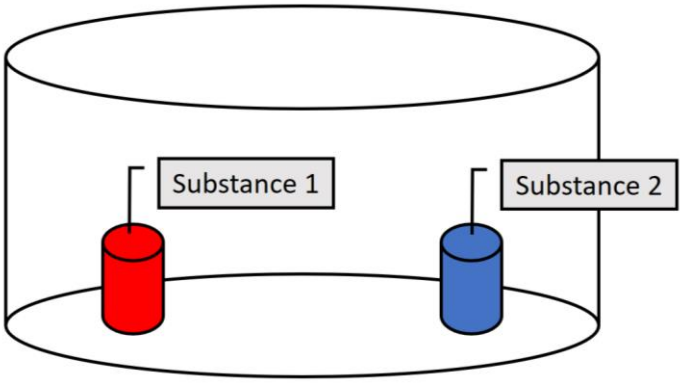


Figure 27. Experimental setup for testing the relative attraction to different mixtures of SPLAT and H. uvarum *for mated and virgin* D. suzukii *females. Simplified picture.*

The arenas were kept under the same conditions as the rearing described above, and were covered with plastic wrap to maintain humidity. After 24 hours, the number of flies in each glass vial and outside both vials were counted for each arena. The different combinations tested were: SPLAT-Commercial and SPLAT-Blank, SPLAT-Commercial and SPLAT-Blank+yeast, SPLAT-Commercial and SPLAT-Commercial+yeast, and SPLAT-Blank+yeast and SPLAT-Commercial+yeast. A total of 20 virgin and 20 mated female flies were tested for each combination.

Statistics

The substance preferences in the different setups were tested for mated and virgin females separately, using a binomial test and assuming equal likelihood of choosing either option (Minitab's 1 Proportion test) (LoPresti, 2014).

Potential differences in choice rate (counting the total of females choosing any substance as one category) between mated and virgin females in the different setups were tested using Fisher´s exact test, assuming a test difference of zero (Minitab's 2 Proportions test) (Mori *et al.*, 2016).

All statistics were calculated using Minitab® 18 (Minitab, 2017). See Appendix 5 for a complete list of p-values.

Results

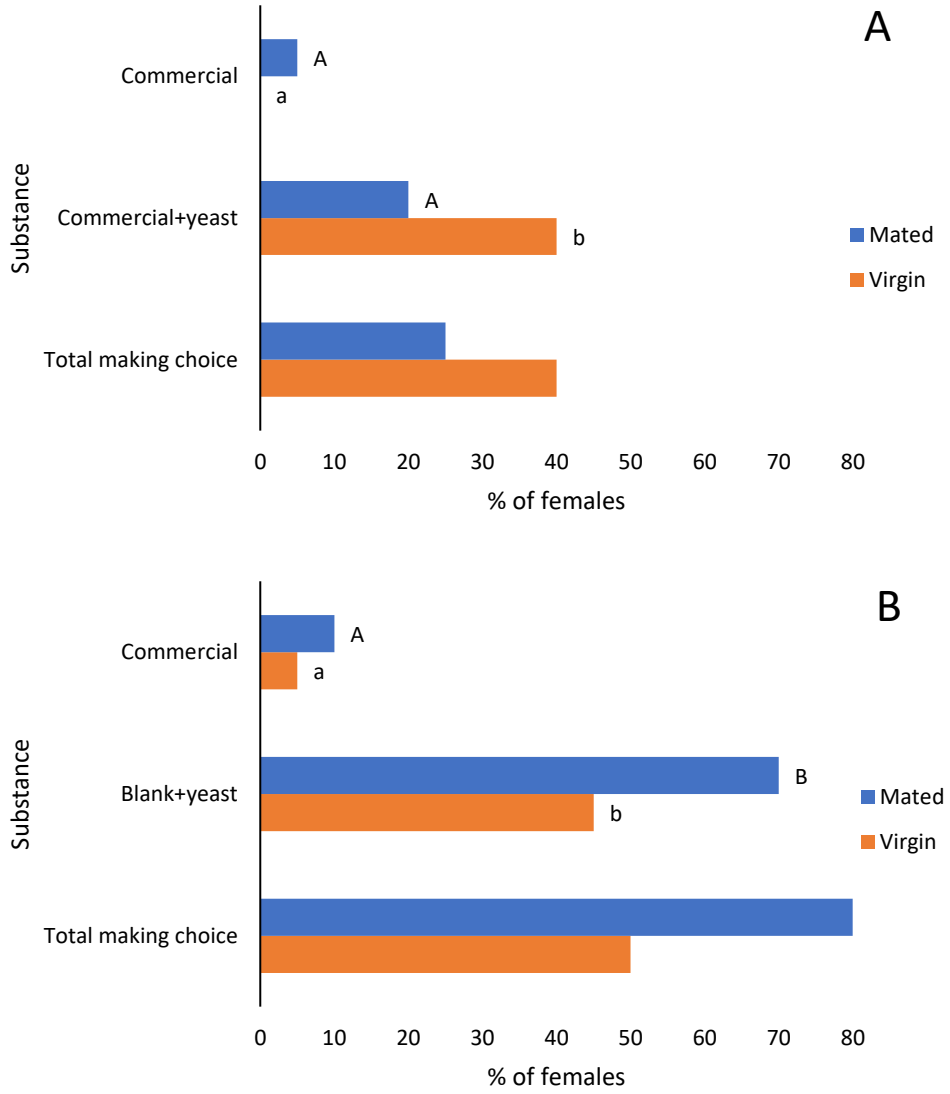
By adding *H. uvarum* yeast to SPLAT-Commercial, it became significantly more attractive to virgin *D. suzukii* females (p = 0,008), but the increase in attraction was not significant for mated females (fig. 28A).

In contrast, when comparing SPLAT-Commercial and SPLAT-Blank+yeast, both mated and virgin females were significantly more attracted to the latter (p = 0,004 for mated females and p = 0,021 for virgins) (fig. 28B).

In the trial with SPLAT-Commercial+yeast and SPLAT-Blank+yeast, mated females were significantly more attracted to SPLAT-Blank+yeast (p = 0,022), while the difference was not significant for virgins (fig. 28C).

Finally, SPLAT-Commercial and SPLAT-Blank were compared. SPLAT-Blank was significantly more attractive for virgins (p = 0,008) but not for mated females (fig. 28D).

There were no significant differences between the proportion of mated and virgin females making a choice in any of the tested combinations.



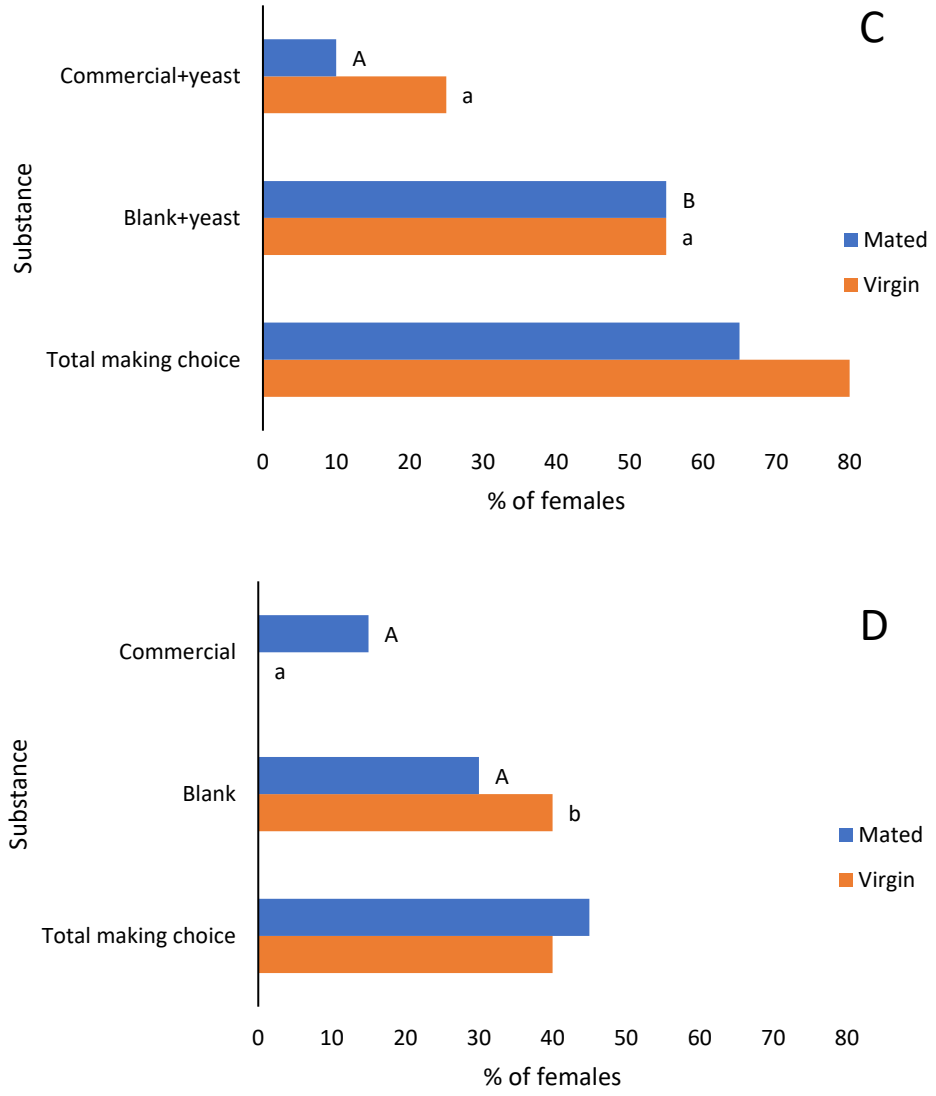


Figure 28. The choices of mated and virgin D. suzukii *females in setups where two different substances were provided (combinations of SPLAT-Commercial, SPLAT-Blank and* Hanseniaspora uvarum *yeast). Different uppercase and lowercase letters indicate a significant preference for one of the given substances, for mated and virgin females respectively.*

Discussion

The SPLAT experiment

The SPLAT experiment results showed a clear hierarchy in attraction between the different substances tested, and similar preferences regardless of the mating status of the *D. suzukii* females (however not always significant). The SPLAT-Blank and *H. uvarum* blend appears to be the most attractive for both mated and virgin females (even if virgins were not significantly more attracted to this blend than to SPLAT-Commercial and yeast, there was a positive trend). Virgins seem to respond better to SPLAT-Commercial with added yeast than mated females do, but there was also a trend for mated females to prefer SPLAT-Commercial with added yeast over SPLAT-Commercial alone. In all combinations tested, SPLAT-Commercial was the least

attractive substance; SPLAT-Blank was even significantly preferred over SPLAT-Commercial for virgins, despite its only attractive feature being its reddish, berry-like colour. Taken together, the results indicate that several factors, chemical as well as visual, affect *D. suzukii* attraction. No significant differences could be shown between the proportions of mated and virgin females making a choice in the combinations tested – something that might have changed with a bigger number of replicates. The biggest difference in absolute numbers was found in the comparison between SPLAT-Commercial and SPLAT-Blank+yeast – the strong attraction of mated females to SPLAT-Blank+yeast in this setup is in line with the increased post-mating yeast attraction and feeding found by Mori *et al.* (2016). It is hard to determine the reason for the low attraction to SPLAT-Commercial, as this substance differs from SPLAT-Blank both by containing a raspberry odour and spinosad. It is also hard to say why virgin females respond better to SPLAT-Commercial with yeast than mated females, and further experiments would be needed to separate the impacts of raspberry odour, yeast odour, spinosad presence, and combinations of these. In an earlier study, honeybees have been shown to avoid food sources containing a spinosad-based toxic bait (Cabrera-Marín *et al.*, 2015). This is something to keep in mind when it comes to SPLAT-Blank+yeast – this combination may not be as attractive for *D. suzukii* when spinosad is added.

The results from this experiment should be seen in light of the fact that 1) the attractiveness of different odours under laboratory conditions may not reflect their attractiveness in the field, and 2) that also a relatively weak attraction may be enough for control in the field. In the case of *D. suzukii*, this is seen by the fact that SPLAT-Commercial did reduce infestation in raspberries, even if not significant, during the field trials in 2016 (Svensson *et al.*, 2017). When moving out to the field, there will be numerous factors affecting the efficiency of an attract-and-kill formula, such as the odour released by the crop itself, other background odours, wind and rain, and temperature variation. These are not accounting for the different conditions affecting fly physiology and behaviour, that may contribute with another list of potentially affecting factors. The importance of testing attract-and-kill methods in the field is underlined by the results from a study by Hampton *et al.* (2014) who showed that mass trapping of *D. suzukii* can actually have a negative impact on crops in vicinity to the traps. In a trial in blueberry cultivation, more flies were attracted because of the traps and increased infestation in the berries nearby.

From the point of view of environmental sustainability and consumer safety, there are several advantages to using attract-and-kill as a pest management strategy. Crop contamination and the amount of pesticide needed is reduced in comparison to cover spraying, species-specific lures can make the insecticide unattractive to natural enemies and pollinators, and the fact that also relatively ineffective pesticides can be used due to the enhanced pest attraction and feeding of an attract-and-kill formula makes a broader range of pesticides available, thereby reducing resistance problems (Mori *et al.*, 2016). However, there is reason to be careful when using *H. uvarum* as the attractant in attract-and-kill formulations because of its potential impact on non-target organisms. Mori *et al.* (2016) write that *H. uvarum* is attractive for many drosphilids other than *D. suzukii*, however most of these are only interested in fruit of later ripening stages. Of greater concern is perhaps the results from a study by

Andreadis *et al.* (2015), who tested the attractiveness of a range of yeasts in an organic apple orchard in Alnarp; the five yeast species tested trapped in total 93 different arthropod species, belonging to 15 different orders.

This study has shown that *H. uvarum* holds potential to improve SPLAT. SPLAT-Blank with *H. uvarum* was the most attractive substance for both mated and virgin females among the combinations tested, and its attraction will hopefully not be significantly decreased by addition of an insecticide. However, the use of fresh fruit cues should not be ruled out either, as oviposition has earlier been shown to be the priority for newly mated females. Rather, investigations should be made on why the current commercial raspberry odour is weakly attractive – if it is weak on its own or in combination with spinosad, and how attractive it is in comparison to other odours when tried under field conditions.

A systemic perspective

The description of the situation concerning *D. suzukii* in Sweden provided here has just scratched the surface of the complexity of reality, both from a natural and social science perspective. A systemic view, connecting the situation of soft fruit and berry growers in Skåne with global trends, and global research efforts with locally suitable solutions, has emerged as a necessity to deal with the problem. In many ways, PAR seems like a highly advisable, if not necessary, working mode to successfully deal with *D. suzukii* in Sweden. Considering the damage potential of *D. suzukii* in a wide range of fruit and berry crops, its capability of dispersal and reproduction and its unpredictable behaviour in the Swedish climate, a close collaboration between heterogeneous actors on a landscape scale is vital. Researchers, authorities and advisors need to be able to follow the development closely and respond rapidly, and growers need to give feedback to these actors on what works for them, both from a socio-economic and ecological perspective. Innovation, transdisciplinarity and an open attitude to different realities are clearly highly desirable at this point.

At first glance, it might seem that a PAR approach would make the situation harder to overview and to handle, as it would invite the stakeholders to take a systemic view and take their own initiatives. However, as PAR is rooted in pragmatism, it might actually lessen the overall work needed as it continuously directs efforts in the most purposeful direction, and avoids ”false solutions” that are not feasible or desirable from a systemic perspective. In other words, the actors of a PAR collaboration help each other to find and define the contexts that are relevant to work with to achieve positive change in an endlessly complex reality. In the current work, a number of actors with potential impacts on the development of the *D. suzukii* issue were not analyzed, or just briefly mentioned. These include fruit and berry retailers and consumers, developers and retailers of plant protection material, media, other authorities (such as Kemikalieinspektionen, who approves new plant protection substances), and advisors other than HIR. The actors that have been described, on the other hand, are those that have been given, and taken on, a formal responsibility of working with *D. suzukii*, with the aim of finding sustainable solutions for growers. The other actors mentioned all have a role to play in the *D. suzukii* work, but they have not been as close to the problem in its initial phase and do not have any formal

obligations. Further, their roles and relevance will likely differ as the situation develops. Therefore, the exploration of who should be involved in the collaboration and in what way should be a continuous task of the PAR working group.

As much as PAR could have a positive effect on the socio-economical relevance of the *D. suzukii* work, it could also benefit the development of IPM. The measures proposed in the newly released guide (Svensson *et al.*, 2017) are intended to be parts of an IPM program for *D. suzukii*, and it would be highly valuable to learn under what circumstances the different measures are feasible and efficient and in what combinations. For example, field trials using different measures could be running simultaneously at several farms as a part of PAR. It would also be valuable to learn what the growers are already doing in their cultivations – if they already have routines identical or similar to those recommended against *D. suzukii* for other reasons, this will of course lower the threshold to direct them also against *D. suzukii*. The IPM inquiry includes SPLAT; as was said during the HIR interview, to be able to use SPLAT, it has to be known when it does and does not work. As has been explained above, the development of SPLAT could be a good entry point in initiating PAR, as it is a method of interest for all actors involved, and can potentially be used by growers of several different crops and scales. PAR could also give the opportunity to involve actors that turn out to be important in dealing with the fly from a landscape point of view. *Drosophila suzukii* is highly polyphagous and mobile, and therefore its presence is not limited to soft fruit and berry cultivations. In the hygiene section of the guide (Svensson *et al.*, 2017), it is mentioned that waste of other fruits, such as apples and pears, can contribute to fly survival and reproduction, raising the question of whether apple and pear growers should also become involved. Backyard fruit growers have been engaged in the *D. suzukii* work in the US (Dreves, 2011) – perhaps the Swedish *D. suzukii* work would benefit from a similar outreach campaign to non-commercial growers.

It emerged during the collection of material for this thesis that the information dissemination to all soft fruit and berry growers in Skåne needs to continue. There is currently a gap between the information held by SLU, JBV and HIR and the knowledge level of growers in general; the short time passed since the detection of the fly in Sweden and current lack of interest from growers emerged as important reasons for this, even though the outreach efforts made so far have had good effect. In my contact with growers, one important reason for disinterest was the belief that *D. suzukii* could not become a problem in their type of crop or cultivation, a view that in many cases can be upheld because of the current insignificance of the pest. As mentioned by the grower at Farm #1, such conceptions of other growers might add a burden to those who choose to openly engage with the issue. Therefore, when reaching out to growers in the future, it should be underlined that the fly has been found all over Skåne, that it can affect a wide range of crops and that it can appear in many types of cultivations, both open ground and greenhouse. As mentioned above, the growers should also be encouraged to discuss the *D. suzukii* issue between themselves. It is important to create an open atmosphere around the problem, to lower the threshold for growers to look into the issue and to avoid a polarization between those who are engaged and those who do not perceive themselves as having a problem.

According to Eksvärd's (2003) description, the initial steps of a PAR process have already been taken by SLU, HIR and JBV, and the current work has hopefully brought it even further. JBV, HIR and SLU all have extensive networks that they are developing, have made a joint and continuously updated analysis of the situation, and are mobilizing awareness. These features of the initial PAR phase can also be seen as parts of the current work; during the interviews, growers have been directly encouraged to reflect on *D. suzukii* and their relation to the *D. suzukii* working group, while SLU, HIR and JBV have also been encouraged to reflect on their internal and grower relations. The survey may have raised the awareness among its recipients even for those who did not answer it, and given the chance of reflection for those who did. Growers who wanted to become more active were given the opportunity to provide their contact information in the survey. This resulted in a list of growers that the *D. suzukii* working group can contact, together with basic information about the farm and the type of activities that the grower is interested in. The current work has hopefully also covered a large part of the second phase of PAR: identifying possibilities, limitations and the existing knowledge of participants, and analyzing possible criteria for subsequent choices of action. One of the conclusions that can be drawn from this work is that it is not possible to conduct research in a socio-ecological system without changing it – my study can not be seen as a passive recording but should be seen as an intervention, raising new thoughts and, when finding it was desirable, advocating for PAR. However, as I am not a stakeholder, the results presented here should only serve as guidance. The final choices of principles and actions should be taken by the stakeholders themselves - the belief that sustainable change can only be achieved in a system when its stakeholders are acting out of own conviction and knowledge is one of the core PAR principles.

There are of course several reasons to be cautious when interpreting the results from this study. Because of the limited time, only relatively few interviews could be made - this is problematic not least because of the heterogeneity of soft fruit and berry growers in Skåne. Further studies would benefit from including several more growers' voices, and one suggestion would be to use convergent interviewing. With this technique, the interview is kept as open-ended as possible, and the respondents define what they think is important about a specific topic. Respondents are sought that are as different from each other as possible, and as different opinions emerge, they are tested through more direct questions in later interviews. The aim is to see under which conditions there is agreement, and to seek explanation for disagreements. The interviewing continues in cycles until no more new information is added by new respondents (Dick, 1998). The idea of this technique is to exhaust a population for all their different opinions on a specific subject, and seek to explain them. Convergent interviewing was employed in this study to some extent, as the interviewed growers were chosen to be as different as possible, but the results would have been even more reliable if the technique had been fully implemented. Similarly, the results from the survey have to be interpreted with their limitations in mind. The answers represented some crops better than others, and it will also have to be assumed that the least interested growers were not answering the survey to the same extent as those who were already interested. Given more time, even more answers would have been sought to increase the sample size. Some of the

weaknesses of self-administered questionnaires are pointed out by Bernard (2006): the researcher has no control over the interpretation of questions, and there is no guarantee that the survey is filled in by the person that the researcher intended. Both these factors had a clear effect in this case. Even though the survey was pretested with one of the growers, the questions were clearly not unambiguous to the respondents, as could be seen in the interpretations of ”participation” and ”national work”. There were also some factors that I missed out on at the beginning, and that were only added later on, such as the question of greenhouse cultivation. Some questions were perhaps unclearly worded to the respondents, and changed in their formulation as this became evident – this concerned questions of crops, growing area and harvest time. On the issue of who responded to the survey, I depended on other actors to send it to relevant growers within Skåne, and for respondents to not answer it if they did not belong to the target group. Indeed, some answers had to be removed because they were given by growers outside Skåne – for all growers giving their contact information, the geographical location was checked. When calling up potential respondents, a wide range of factors affecting their motivation to inform themselves about *D. suzukii* and take measures against it emerged that were not feasible to include in the survey. Some growers had just started their cultivation or were expanding, while others were just about to stop growing or to retire, some were depending on the cultivation for their income while others had alternative income sources or a more diversified production. Another dimension that was not addressed in this study is the different power, roles, knowledge and opinions of the people at each farm. To define ”the grower” is not a straightforward question. As was said during the HIR interview, about participants at the field excursions: *”all are not growers, some are owners, others are tractor drivers, others do the spraying”*. These are all levels of complexity that will have to be left to subsequent studies to explore.

Another idea of a tool to be used in further studies of *D. suzukii* in Sweden is cultural historical activity theory (CHAT). Swiergiel (2015) used this method to find the historical and systemic root causes of the pest problems experienced by organic apple growers in Sweden, and to analyze if solutions found through PAR work were sustainable from this perspective. Such an inquiry would clearly benefit the understanding of the situation also for soft fruit and berry growers in Skåne, and help point the direction forward from a systemic perspective. It would inevitably go much deeper than the problem of *D. suzukii*, towards the terms of existence for these growers, and thereby for example the underlying causes for small-scale growers giving way to large-scale cultivations and the rapid decline of plum and cherry production. The question if the solution of the *D. suzukii* problem, and other pest problems, is enough to make the farms sustainable would be asked. Further, it would be evaluated if SPLAT can be a part of a sustainable solution, i.e. if it would remediate tensions in the system, or if it would create new ones in the ecological, economical or social realm.

Conclusion

The fruit fly *Drosophila suzukii* has spread rapidly across the world in the matter of a few years, and caused great damage to fruit and berry cultivations globally. There is therefore reason to be concerned about its arrival in Sweden, even if it has not yet caused any significant economical damage. Starting in 2011, research has been made on *D. suzukii* at SLU, Alnarp, and the work has intensified since the fly was first detected in Sweden in 2014. Authorities (JBV), researchers (SLU) and advisors (HIR) have reacted rapidly, vigorously and collaboratively, started to build knowledge about the fly's behaviour under Swedish conditions, investigated possible solutions for Swedish growers and communicated them through a range of outreach activities that have had a good effect on the awareness and actions of the growers. The current situation is characterized by unpredictability, both concerning *D. suzukii* damage potential and on the side of research, where intensive activity both in Sweden and abroad means that solutions may develop rapidly. Soft fruit and berry growers in Skåne (the southernmost, and currently most affected region in Sweden) constitute a heterogeneous group, something that affects their perception of *D. suzukii*. The growers differ for example in crop types, harvest time, cultivation size, economic dependence, age and aspirations. Since berries are high-value crops, enabling the survival of relatively small farms, the fact that small- and medium size growers among survey respondents in this study see *D. suzukii* as a bigger threat than large-scale growers, at the same time as having less personal advice, should be taken seriously. The closing down of small-scale berry farms has the potential of draining rural communities, and small-scale growers should be prioritized if and when the *D. suzukii* working group decides to develop a closer collaboration with the growers. It is also desirable for growers to have more communication about *D. suzukii* among themselves. Overall, growers were positive about becoming more active in the national *D. suzukii* work and thought it was important for growers in general to participate.

With the complexity of the current situation in mind, PAR is suggested as a suitable working mode. This framework for democratized, iterative and action-oriented research would allow the actors to continuously direct their efforts in the most purposeful direction. While being suitable for addressing the socio-economic aspects of *D. suzukii*, PAR would also be useful in co-developing locally adapted IPM programs together with growers. One example of an IPM method that would benefit from participatory field trials is attract-and-kill using the substance SPLAT. As has been shown in this study, the SPLAT formula can be improved in its attraction to *D. suzukii* females by adding *Hanseniaspora uvarum* yeast, but the species specificity and effectiveness of new SPLAT formulas including this yeast still remain to be proven under field conditions.

Acknowledgements

I would like to thank everyone who has made this work possible. My supervisors, Joelle Lechelt and Anna Hofny-Collins, for their great support, encouragement and invaluable guidance throughout the whole process. Sanja Manduric, Paul Becher, Victoria Tönnberg and the five growers who all took the time to talk to me and to share their thoughts on *D. suzukii*. All growers who filled in the survey, and all those who helped me develop, spread and promote it. Jan-Eric Englund who generously took the time to discuss the survey results with me, and helped me with the statistics. And finally, to all those who have given feedback, expressed their interest and support along the way. It has been a privilege and a pleasure to work together with all of you!

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Appendices

Appendix 1. Guide used for the interviews with SLU, HIR and JBV.

General work structure

- Can you, in your own words, give a short description of the *D. suzukii* work?
- How and when did the *D. suzukii* work start? Who took the initiative?
- What are the goals? Why? Who was involved in determining the goals and structure of the *D. suzukii* work?
- Are there any underlying principles that guide the work?
- What actors are/have been involved? How are the different actors connected? (Mindmap)
- What are the important events that have taken place within the *D. suzukii* work? (Timeline)
- Do you know how the work will continue? What are the plans for the time ahead?

The actor as part of the *D. suzukii* work

- What is the role of SLU/HIR/JBV in the *D. suzukii* work? What are your areas of responsibility?
- What do you see as the most important question/area of focus for SLU/HIR/JBV at this point in time, within this work?
- Do you communicate with the other actors? On what topics? How do you communicate?
- What do you (SLU/HIR/JBV) hope to achieve within the *D. suzukii* work?

The other actors

- What roles do the other actors have? What do they work on?
- Do you consult/support/advise one another on your respective topics of expertise? How?
- Do you think that the actors are in balance when it comes to influence and competence? Can everyone contribute in a good way?

The *D. suzukii* work as a whole, successes and failures, future direction

- How do you think that it has worked thus far?
- What are the strengths and weaknesses of the work? Opportunities and threats?
- Do you have any ideas of how to make it work even better in the future?
- Any other thoughts/things I have missed?

Appendix 2. Questions of the growers' survey.

General information about the growers

- How big is your cultivation area for soft fruits and berries (hectares)? Apples and pears do not belong to this category. Any greenhouse cultivation area is given separately.
  (Open text question.)
- Which soft fruit and berry crops do you grow commercially? Mark all that apply.
  (Multi-choice question. Alternatives: Raspberries, Strawberries, Blackberries, Blueberries, Grapes, Currants, Cherries, Plums, Other.)
- Which one(s) of these is/are the main soft fruit and berry crop(s) in your cultivation? Mark all that apply.
  (Multi-choice question. Alternatives: Raspberries, Strawberries, Blackberries, Blueberries, Grapes, Currants, Cherries, Plums, Other.)
- When in the season do you start to harvest the earliest of the above mentioned crops (estimation)?
  (Date question.)
- When in the season have you finished harvesting the last of the above mentioned crops (estimation)?
  (Date question.)

How is *D. suzukii* perceived and what is being done about it?

- Do you perceive *D. suzukii* as a threat to your cultivation?
  (Ranking question with the scale 1 to 5, 1=not at all, 5=very strongly.)
- Has *D. suzukii* presence been investigated in your cultivation?
  (Single-choice question. Alternatives: Yes, No, Don't know.)
- Has *D. suzukii* been found in your cultivation?
  (Single-choice question. Alternatives: Yes, No, Don't know.)
- What measures were taken against *D. suzukii* in your cultivation in the last season (2016)? Mark all that apply.
  (Multi-choice question. Alternatives: None, Monitoring with traps, Monitoring through investigation of berry infestation, Picking in the earliest possible ripening stage, Keeping the ground clean of fallen fruits and berries, Removing *D. suzukii* host plants around the cultivation, Careful disposal of fruit and berry waste, Starting to grow earlier ripening cultivars, Increasing the distance between fields of different ripening times, Mass trapping, Pest control with spinosad, Other.)
- Are measures against D. suzukii planned in your cultivation for the coming season (2017), and in that case which ones? Mark all that apply.
  (Multi-choice question. Alternatives: No measures planned, Monitoring with traps, Monitoring through investigation of berry infestation, Picking in the earliest possible ripening stage, Keeping the ground clean of fallen fruits and berries, Removing *D. suzukii* host plants around the cultivation, Careful disposal of fruit and berry waste, Starting to grow earlier ripening cultivars, Increasing the distance between fields of different ripening times, Mass trapping, Pest control with spinosad (given dispensation), Other.)

What kind of information is needed and how should it be made available?

- Where do you get information about *D. suzukii* from? Mark all that apply.
  (Multi-choice question. Alternatives: Other growers, Personal contact with independent advisors (not retailers of material), Fact sheets and newsletters from independent advisors and authorities, Retailers of material, Homepages of independent advisors, authorities and growers' associations, Homepages other than those of independent advisors, authorities and growers' associations, Scientific articles, Field excursions, courses and informational meetings, None, Other.)
- Is there anything in particular that you would like more information about concerning *D. suzukii*?
  (Open text question.)
- How do you prefer to get new and updated information about *D. suzukii*? Mark all that apply.
  (Multi-choice question. Alternatives: Through the homepages of independent advisors, authorities and growers' associations, Through digital newsletters, Through paper newsletters, Through field excursions, informational meetings and courses, Through personal meetings with independent advisors, Other.)
- Do you know about the homepage www.drosophila-suzukii.se?
  (Single-choice question. Alternatives: Yes, No, Don't know.)

Grower participation in the *D. suzukii* work

- Participating in the national *D. suzukii* work as a grower can entail anything from limited contributions, like helping with monitoring tasks, to engaging in a dialogue with the Swedish *D. suzukii* working group (SLU, HIR, JBV). Would you consider participating in the national *D. suzukii* work at any level?
  (Single-choice question. Alternatives: Yes, No, Maybe.)
- Give a short explanation to your answer above (yes, no, maybe).
  (Open text question.)
- If you answered Yes above: what kinds of activities would you consider participating in? Mark all that apply.
  (Multi-choice question. Alternatives: Contribute with simple monitoring tasks, Fill in surveys, Participate in workshops, Participate in a reference group, Other.)
- Do you think that it is important for growers in general to participate in the national *D. suzukii* work?
  (Ranking question with the scale 1 to 5, 1=not at all, 5=very important.)

Thank you for your answer!

- If you are willing to give a follow-up interview (for the same Master's work as the survey), please fill in your contact information below.
  (Open text question)
- If you are interested in participating in activities, please fill in your contact information below to enable contact if and when such activities are arranged (outside the Master's work).
  (Open text question.)

Appendix 3. Guide used for the interviews with the growers.

Overview of the specific farm

- How come you grow soft fruits and berries?
- How important is this cultivation in relation to other activities on and outside the farm? Both from an economical and other perspectives.

What impact has *D. suzukii* had on the farm?

- In what way has your farm been affected by the establishment of *D. suzukii* in Skåne?
  Direct but also indirect effects.

How come the grower has acted the way that he/she has?

- How are you reasoning when deciding what measures to take and not to take against *D. suzukii*?
- What factors are being considered, and how are they weighed?
- Who is involved in making the decision of which measures to take?

View of the work being done against *D. suzukii*

- What is your view of the work being done to manage *D. suzukii* in Sweden?
- What is working good/not so good?
- Have you benefitted from the work, and in that case in what way?
- Who do you consider to be involved in the work against *D. suzukii* in Sweden?
- How do you see the role of the growers in this work?
- How do you think the work should best be carried out to find solutions?
- Other thoughts or things I have missed?

Appendix 4. Program used to calculate confidence intervals for the entire population of soft fruit and berry growers in Skåne given the survey results, and a full table of those confidence intervals.

RStudio, version 1.0.136

```
# p. is for population, s. is for sample

p.size <- 140
s.size <- 37

# This is the confidence level for the confidence interval.
conf.level <- 0.95

# This pvalue is only a help in the calculations.

pvalue <- matrix(0,s.size+1,p.size+1)

for (s.yes in 0:s.size){
  for (p.yes in s.yes:p.size){
    pvalue[s.yes+1,p.yes+1] <-
      min(1,
          2*min(phyper(s.yes,p.yes,p.size-
p.yes,s.size,lower.tail=TRUE),
                phyper(s.yes-1,p.yes,p.size-
p.yes,s.size,lower.tail=FALSE)))
  }
}

# This is also only as a help
bound <- matrix(NA,s.size+1,p.size+1)

for (r in 1:(s.size+1)){
  for (c in 1:(p.size+1)){
    if (pvalue[r,c] >= 1-conf.level) {bound[r,c] <- c}
  }
}

conf.int <- matrix(NA,s.size+1,2)
for (observed in (1:(s.size+1))){
  conf.int[observed,1] <- (min(bound[observed,],na.rm=TRUE)-
1)/p.size
  conf.int[observed,2] <- (max(bound[observed,],na.rm=TRUE)-
1)/p.size
}

conf.int
```

No. of yes in the sample	Percent in the sample	Lower limit	Upper limit
0	0%	0.000	0.079
1	3%	0.007	0.121
2	5%	0.014	0.164
3	8%	0.029	0.200
4	11%	0.043	0.229
5	14%	0.057	0.264
6	16%	0.079	0.293
7	19%	0.093	0.329
8	22%	0.114	0.357
9	24%	0.136	0.386
10	27%	0.157	0.414
11	30%	0.179	0.443
12	32%	0.200	0.471
13	35%	0.221	0.500
14	38%	0.250	0.529
15	41%	0.271	0.550
16	43%	0.293	0.579
17	46%	0.321	0.607
18	49%	0.343	0.629
19	51%	0.371	0.657
20	54%	0.393	0.679
21	57%	0.421	0.707
22	59%	0.450	0.729
23	62%	0.471	0.750
24	65%	0.500	0.779
25	68%	0.529	0.800
26	70%	0.557	0.821
27	73%	0.586	0.843
28	76%	0.614	0.864
29	78%	0.643	0.886
30	81%	0.671	0.907
31	84%	0.707	0.921
32	86%	0.736	0.943
33	89%	0.771	0.957
34	92%	0.800	0.971
35	95%	0.836	0.986
36	97%	0.879	0.993
37	100%	0.921	1.000

Appendix 5. All p-values for statistical tests made in connection to the SPLAT experiment.

Testing substance preference for every setup and mating status separately, 1 Proportion test:

	Substances tested			
Mating status	C and B	C and B+Y	C and C+Y	B+Y and C+Y
Mated	0,508	**0,004**	0,375	**0,022**
Virgin	**0,008**	**0,021**	**0,008**	0,210

Testing differences in choice rate between mated and virgin females in the different setups, 2 Proportions test:

Substances tested			
C and B	C and B+Y	C and C+Y	B+Y and C+Y
1,000	0,096	0,501	0,480

Appendix 6. Fact sheet for soft fruit and berry growers in Skåne.

Drosophila suzukii – hur hanterar man bäst en skadegörare ny för Sverige?

Faktablad skrivet av Emilia Mühlhäuser, som del av en masteruppsats inom programmet Agroecology, SLU, Alnarp, 2017.

Vad är det för en fluga?

Drosophila suzukii, som inte har något svenskt namn, är en fluga nära besläktad med bananflugan som ofta kan ses surra kring övermogen frukt i fruktfatet. Till skillnad från bananflugan så är *D. suzukii* intresserad av färska och mogna frukter och bär, där honan lägger sina ägg. När äggen sedan kläcks orsakar larverna skada genom att äta inuti frukten. Samtidigt blir frukten också mer mottaglig för andra infektioner.

Flugan har sitt ursprung i Asien och har spridit sig över världen på bara några år, till stor del med hjälp av importerade frukter och bär. Den hittades i Europa och Nordamerika för första gången 2008, och har orsakat stora skador. I frukt- och bärodlingar i Italien och Frankrike har flugan angripit upp till 100% av skörden.

Hanar av *D. suzukii* känns igen på sina mörka vingfläckar, medan honan lättast känns igen på sin sågtandade äggläggare.

Drosophila suzukii-hane med mörka vingfläckar.

Honans sågtandade äggläggare. Bägge bilder: Joelle Lechelt.

Äggläggningshål med utstickande äggfilament i blåbär, och skador i hallon några dagar efter plockning. Foto: Joelle Lechelt och Birgitta Svensson.

Vad gör *Drosophila suzukii* i Sverige?

D. suzukii hittades för första gången i Sverige 2014, och flugan har nu etablerat sig över hela Skåne. Den har även hittats längre norrut (i Halland, Småland och Östergötland), men det är osäkert om detta rör sig om enstaka fynd.

Flugan kan använda ett mycket stort antal växter som värdväxter, både vilda och odlade. I Sverige har flugan hittats i hallon, björnbär, blåbär, jordgubbar, fläder, röda vinbär, körsbär, plommon och vindruvor.

Flugan är aktiv relativt sent under odlingssäsongen. År 2016 gjordes det första fyndet sent i juli, men flugorna var som flest i oktober. Än så länge har flugan inte orsakat några betydande skador i Sverige.

Vad är på gång för att hantera den?

Stora ansträngningar görs i Sverige för att lära sig mer om hur *D. suzukii* beter sig i vårt klimat, och för att ta fram metoder som kan användas för att förebygga och minimera skador på gårdsnivå.

Det pågår ett nära samarbete mellan Sveriges Lantbruksuniversitet (SLU), Jordbruksverket (JBV) och Hushållningssällskapets Individuella Rådgivning Skåne (HIR).

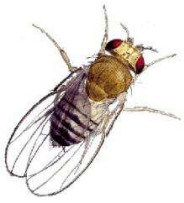
SLU ägnar sig åt att lära sig mer om flugans biologi, och använda kunskapen till att utveckla metoder att hantera den. Övervakning och attract-and-kill är två huvudfokus.

JBV övervakar flugans förekomst, håller sig uppdaterade om situationen i andra länder, jobbar på att hitta och presentera de lösningar som finns och att föreslå nya forskningsprojekt, och håller odlarna informerade.

HIR ägnar sig åt rådgivning på gårdsnivå vad gäller *D. suzukii*, samlar och sprider information om flugan.

Samarbetet har resulterat i fältförsök med SPLAT (se bredvid), och tre fältvandringar under 2016 på exempelgårdar där flugan hittats.

Vidare har man skrivit en **guide, ”Guide till fruktflugan *Drosophila suzukii*”**, med fakta om flugan, rekommenderade åtgärder och ett riskprotokoll, och startat **hemsidan** www.drosophila-suzukii.se, där all aktuell information om flugan finns samlad.



SPLAT i hallonbuske. Foto: Joelle Lechelt.

Ny metod under utveckling – SPLAT och jäst

SPLAT (Specialized Pheromone and Lure Application Technology) är en substans som kan användas för att bekämpa *D. suzukii* enligt principen attract-and-kill. SPLAT sprutas på nederdelen av t. ex. en hallonbuske, och genom att den innehåller både ett växtskyddsmedel och ett lockämne så kommer flugorna till substansen, äter av den och dör. Inledande fältförsök med SPLAT har gjorts i Sverige och gett positiva resultat. Försöken fortsätter under 2017.

D. suzukii är nära förknippad med jästarten *Hanseniaspora uvarum*. Honorna, som är de som kan orsaka skada, äter jäst för att få näring till äggens utveckling. Ett experiment gjordes därför för att se om SPLAT, som för närvarande använder hallondoft som attraktionsämne, kan bli mer attraktivt för honor genom att lägga till jäst. Resultaten visade att honorna var mer attraherade av SPLAT med jäst än av SPLAT med hallondoft. Jäst skulle alltså kunna användas för att förbättra SPLAT-metoden, och göra den både mer effektiv och artspecifik. Fältförsök återstår dock för att se om effektiviteten är lika bra under odlingsförhållanden.

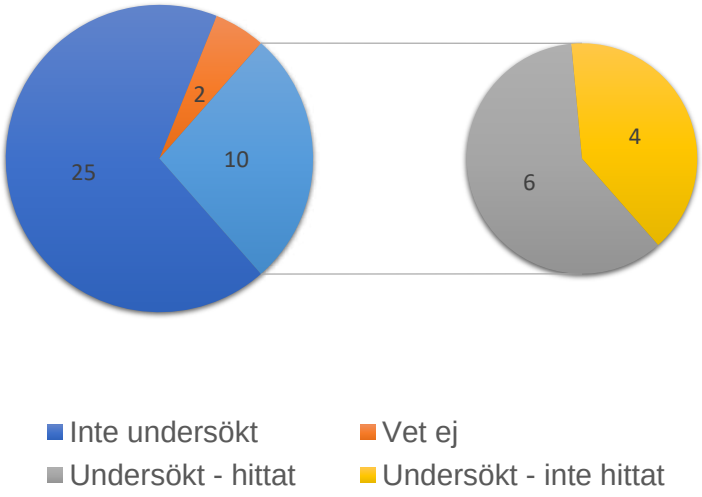
Vad säger odlarna?

Odlarnas perspektiv på *D. suzukii* undersöktes med en enkät som besvarades av 37 odlare av tunnskaliga frukter (körsbär och plommon) och bär i Skåne. Fem intervjuer med odlare gjordes för att komplettera enkätdatan.

De skånska odlarna är sinsemellan mycket olika – både vad gäller odlingens storlek, grödor och ekonomiskt beroende av odlingen. Mindre odlare kan försörja sig på sina odlingar tack vare att bär ger hög avkastning per ytenhet. Jordgubbar var den vanligaste huvudgrödan bland de som svarade på enkäten (19 odlare) följt av hallon (14 odlare). Övriga grödor var plommon, vindruvor, blåbär, körsbär, björnbär och vinbär.

Oron för *D. suzukii* var jämnt spridd bland de svarande, från inte alls till stark. Många odlare har ännu inte undersökt förekomst av *D. suzukii*, men de som letar hittar den ofta.

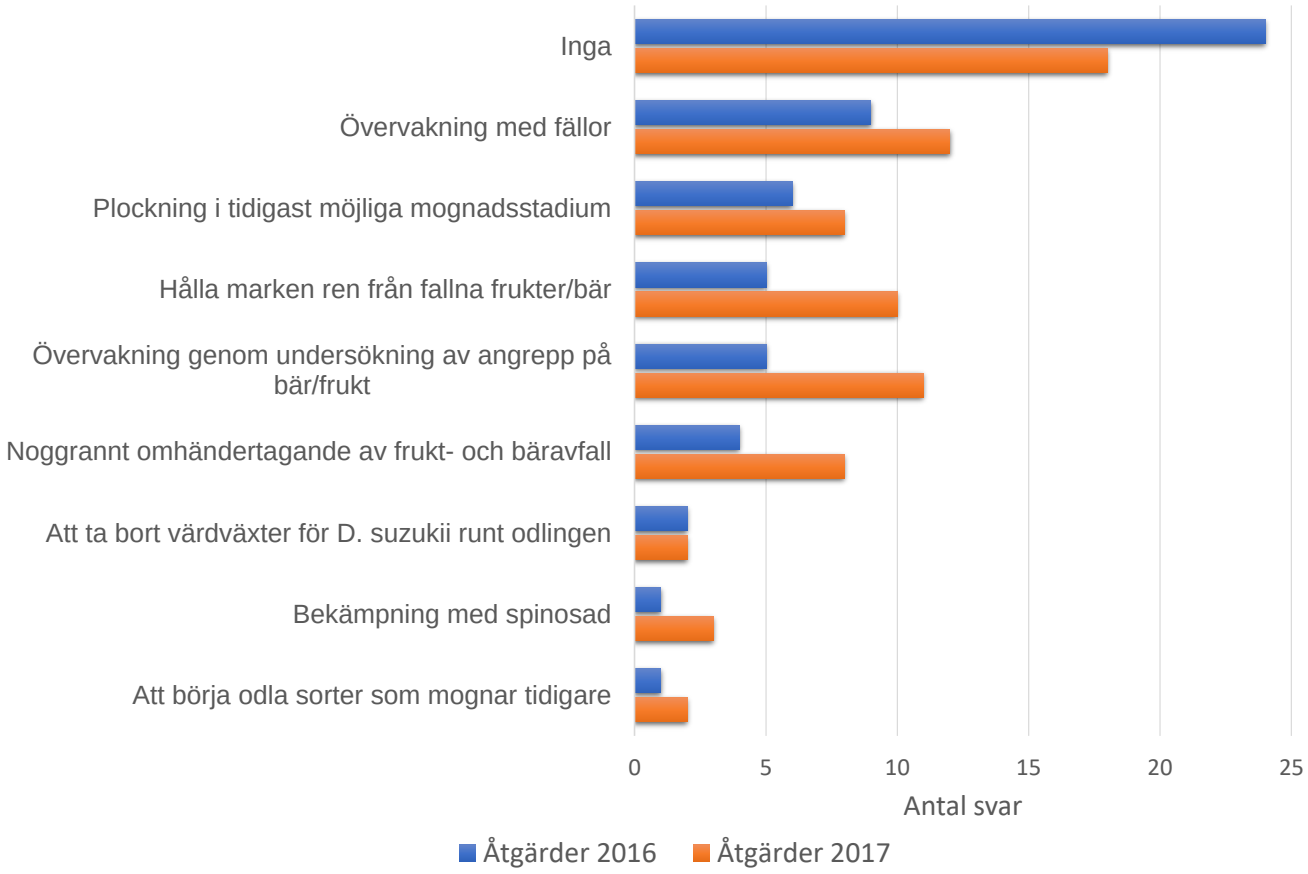
Förekomst av *D. suzukii* (antal svar)



Alla utom en av de svarande odlarna informerade sig om *D. suzukii*, genom faktablad, nyhetsbrev, personlig rådgivning, hemsidor, möten, andra odlare, artiklar och försäljare av material.

Många åtgärder mot *D. suzukii* ökar i användning, och färre bland de svarande hade inga åtgärder alls planerade 2017, jämfört med 2016.

Åtgärder mot *D. suzukii*



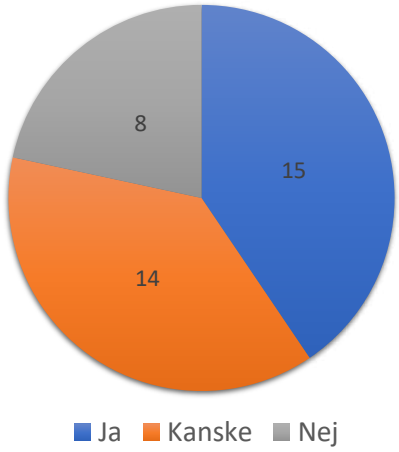
Hur kan arbetet fortsätta?

Eftersom *D. suzukii* nyligen kommit till Sverige är det svårt att veta hur situationen kommer att utveckla sig. Många olika parter är berörda, och mycket samarbete mellan dem pågår redan.

Odlarna som svarade på enkäten var positiva till att bli engagerade i det nationella arbetet mot flugan, d.v.s. arbete som ger kunskap som kan användas även utanför gården. De svarande kunde tänka sig att fylla i enkäter, hjälpa till med övervakning, delta i en referensgrupp och i workshops. Dessutom tyckte de allra flesta som svarade att det är mycket viktigt att odlare i allmänhet engagerar sig i sådant arbete.

Ett alternativ för det fortsatta arbetet är deltagardriven forskning. Detta innebär att alla berörda parter är delaktiga i att bestämma vad man ska forska om, att samla in och tolka resultaten. På detta sätt kan man samla in flera olika sorters kunskap och prova den direkt i praktiken. För odlarnas del skulle sådant arbete t.ex. kunna ta sin början genom bildandet av en referensgrupp, som samarbetar med SLU, HIR och JBV.

Skulle du kunna tänka dig att delta i det nationella arbetet mot *D. suzukii*? (antal svar)



Tycker du att det är viktigt, generellt sett, att odlare deltar i det nationella arbetet med *D. suzukii*? (antal svar)