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DEVELOPMENT OF COLONY COLLAPSE DISORDER IN HONEYBEES
IN SCHLESWIG-HOLSTEIN AND ITS RELATION TO THE BEEKEEPING METHODS

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Abstract

Keywords: Honeybees, Colony Collapse Disorder, Ecosystem services, Beekeeping methods

Honeybees have important functions in terrestrial ecosystems and for biodiversity through their pollination services. We also benefit from bee products such as honey and beeswax, which are used in a variety of industries, including bakery, pharmaceuticals, cosmetics, water-proof polishes and candle making. Consequently, the increased number of honeybee losses, known as Colony Collapse Disorder (CCD), will cause severe damage to ecosystems and our economy. Therefore, it has concerned many scientists and ecologists in recent years and affected many farmers and beekeepers.

Although researchers have tried to determine the main causes of CCD in honeybees throughout the globe in the past decade, we still do not have sufficient knowledge of the actual factors that cause and increase death rates in honeybee colonies. On the other hand, most of the research being done in Germany on this issue is mainly focussed in the southern parts of the country. However, the weather conditions in the northern German coastal areas with often strong winds and relatively few sunny days for the honeybees to collect pollen or nectar differ significantly from those in southern Germany.

Several research articles suggest the use of pesticides as one of the potential causes of bee mortality. Others also focus on pathogens and varroa destructor. However, due to the rise in the number of CCDs occurring worldwide, it seems less realistic to consider only one factor as the main cause. Therefore, an overview of all potential causes of death in honeybee colonies is provided and a combination of (synergistic) factors is identified as a means to weaken the bees' immune system.

Hence, this dissertation focuses on the development of CCD in honeybees in Schleswig-Holstein, its main causes and its possible relation to beekeeping methods.

The main questions asked in this dissertation are therefore:

- Why are honeybees disappearing more often today than in the past?
- How severe is the loss of the bee population in Northern Germany?
- Is the crisis of bee mortality related to beekeeping methods?
- Is there a way to decrease the losses?

For this matter, the following research project is based on firstly, a comparative study of the development of all the potential causes of CCD in bees in Schleswig-Holstein, including the background history of beekeeping in the region. Secondly, an evaluation and analysis of qualitative questionnaires will help to discuss the progress and the estimated causes of CCD in this area.

For this research project, up-to-date data from local beekeepers are needed to analyze the recent development of colony collapse disorder in honeybees in the region. Furthermore, common local beekeeping methods and management trends could be easily patterned using a questionnaire. Finally, specific problems, requests, wishes and needs of beekeepers could be identified.

Therefore, with the help of a several new and old local beekeepers from the region, a questionnaire with 21 questions was designed to add their field of interest. This survey is divided into two parts: in the first part, general questions about beekeepers, such as number of beehives and their equipment, and the second part, technical questions about deeper beekeeping methods, bee losses, issues and requests that include different perspectives on the topic. However, they are primarily focused on the main research hypothesis, beekeeping methods and bee losses.

Finally, some methods and factors will be suggested to reduce or cut the losses of honeybees and to improve the general situation of honeybees in natural and man-made ecosystems.

Despite the growing loss of honeybee colonies in recent decades, there is hope to put an end to this issue by understanding the main causes of this phenomenon at the local scale and eliminating these factors by improving the beekeeping and management methods and maintaining biological pest-control targets.

Zusammenfassung

Honigbienen haben wichtige Funktionen in terrestrischen Ökosystem. Ein bedeutender Teil der biologischen Vielfalt hängt von der Fremdbestäubung ab. Auch Menschen profitieren von Bienenprodukten wie Honig und Bienenwachs, die in Industriebranchen wie Backwaren, Pharmazeutika, Kosmetika, wasserfeste Polituren und Kerzenherstellung weit verbreitet sind. Infolgedessen kann die erhöhte Zahl von Verlusten an Bienenvölkern, bekannt als Colony Collapse Disorder (CCD), schwere Schäden an den Ökosystemen und unserer Wirtschaft verursachen. Deshalb befassten sich in den letzten Jahren viele Wissenschaftler und Ökologen sowie Landwirte und Imker mit CCD.

Obwohl Forscher in den letzten zehn Jahren versucht haben, die Hauptursachen für CCD bei Honigbienen auf der ganzen Welt zu ermitteln, sind uns die tatsächlichen Faktoren, die zum Tod von Honigbienenvölkern führen und die die Sterblichkeitsraten in diesen Völkern erhöhen, nach wie vor unbekannt. Andererseits konzentrieren sich die meisten Forschungen, die in Deutschland zu diesem Thema durchgeführt werden, hauptsächlich auf den Süden. Die variablen Wetterbedingungen in den norddeutschen Küstengebieten mit starken Winden stellen jedoch eine andere Situation für die Imkerei dar, mit relativ wenigen windarmen Sonnentagen für die Honigbienen zum Sammeln von Pollen oder Nektar.

Mehrere wissenschaftliche Publikationen weisen auf den Einsatz von Pestiziden als eine der potenziellen Todesursachen von Bienen hin. Andere befassen sich auch mit Krankheitserregern und Varroamilben. Aufgrund des weltweiten Anstiegs der Zahl der auftretenden CCDs ist es nicht sinnvoll, nur einen Faktor isoliert als Hauptursache zu betrachten. Daher wird ein Überblick über alle potenziellen Todesursachen von Honigbienenvölkern gegeben und eine Kombination von (Synergismus-)Faktoren als bedeutendste Ursache der Schwächung des Immunsystems der Bienen vorgeschlagen.

Diese Dissertation konzentriert sich auf die Entwicklung von CCD bei Honigbienen in Schleswig-Holstein, ihre Hauptursachen und eine mögliche Korrelation mit den Imkereimethoden.

Die wichtigsten Forschungsfragen, die in dieser Dissertation gestellt werden, sind:

- Warum verschwinden Honigbienen heute öfter als früher?
- Wie stark ist der Verlust an Bienenpopulationen in Norddeutschland?
- Hängt die Bienenverlust-Krise mit den Imkerei-Methoden zusammen?
- Gibt es eine Möglichkeit, die Zahl der Bienenvölker zu senken?

Zu diesem Thema wird sich das folgende Forschungsprojekt zunächst auf eine vergleichende forschungsbasierte Studie über die Entwicklung aller potenziellen Ursachen von CCD bei Bienen in Schleswig-Holstein stützen, wobei auch die Geschichte der Bienenzucht in der Region untersucht wird. Zweitens helfen eine Auswertung und Analyse qualitativer Fragebögen, den Fortschritt und die geschätzten Ursachen von CCD in diesem Bereich zu diskutieren.

Für dieses Forschungsprojekt werden aktuelle Daten von den lokalen Imkern benötigt, um die jüngste Entwicklung der Bienensterbensstörung bei Honigbienen in der Region zu analysieren. Darüber hinaus könnten die üblichen lokalen Imkermethoden und Managementtrends mit Hilfe eines Fragebogens leicht nachgebildet werden. Und schließlich könnten spezifische Probleme, Wünsche und Bedürfnisse der Imker ermittelt werden.

Deshalb wurde mit Hilfe mehrerer neuer und alter lokaler Imker ein Fragebogen mit 21 Fragen entworfen, um ihr Interessengebiet zu untersuchen. Diese Umfrage gliedert sich in zwei Teile: Der erste Teil umfasst allgemeine Fragen über die Imker, wie z.B. die Anzahl der Bienen und ihre Ausrüstung. Der zweite Teil beinhaltet technische Fragen u.a. zu den Imkereimethoden, Bienenverlusten, zu Fragen und Wünschen, die verschiedenen Perspektiven in Bezug auf das Thema beinhalten. In erster Linie sind sie auf die Hauptforschungshypothese zu den Imkereimethoden und Bienenverlusten ausgerichtet.

Schließlich werden einige Methoden und Faktoren vorgeschlagen, um die Verluste an Honigbienen zu reduzieren oder zu verringern und die allgemeine Situation der Honigbienen in den natürlichen und von Menschen geschaffenen Ökosystemen zu verbessern.

Trotz der wachsenden Verlusten an Honigbienenvölkern in den letzten Jahrzehnten besteht die Hoffnung, diesem Problem ein Ende zu bereiten, indem man die Hauptursachen dieses Phänomens auf lokaler Ebene versteht und diese Faktoren durch die Verbesserung der Imker- und Managementmethoden und die Beibehaltung biologischer Schädlingsbekämpfungsziele eliminiert.

Chapter 1: Introduction

Honeybees play an important role in land use, agriculture, ecosystems and biodiversity due to their ability to pollinate. The production of many cultivated plants such as apples, strawberries, corn, oranges, almonds, Alfa-alfa, avocados, cucumber, blueberries, citrus, carrots, cotton and cherries depends on cross-pollination (Johnson, 2010; Sass, 2011). It is estimated that globally 90% of natural flora and at least 30% of the crops depend on bees for their pollination service (Sass, 2011). Humans benefit from bees' products such as honey and beeswax, which are widely used in industries such as lubricants, cleaners, food processing, beauty products, pharmaceuticals and pastries. Consequently, the increased number of honeybee losses, known as Colony Collapse Disorder (CCD) will cause severe damage to the ecosystems and the economy. Therefore, it has concerned many scientists and ecologists as well as farmers and beekeepers in the past years.

Colony Collapse Disorder (CCD), which began in 2006, is characterized by the rapid or sudden disappearance of adult worker bees, leaving the queen, brood and food stores but lacking damaging effects of *Varroa* mite or *Nosema* microsporidians (Williams, 2010).

Although researchers have been trying to determine the main causes of CCD in honeybees throughout the globe in the past decade, yet the actual factors leading to and increasing the rates of death in specific honeybee colonies remain to be widely unknown. On the other hand, most of the research completed in Germany regarding this issue mainly focus on the southern parts of the country. However, the weather conditions in the northern coastal areas, with high rates of precipitation and strong winds, make up a different situation for beekeeping.

Therefore, this dissertation focuses on the development of CCD in honeybees in Schleswig-Holstein, its main causes and its potential correlation with the beekeeping methods.

For this purpose, the following research project will be based on firstly, a comparative research-based study of the development of all the potential causes of CCD in bees in Schleswig-Holstein. Secondly, a logical assessment and analysis of qualitative questionnaires helps to indicate the progress and the estimated causes of CCD in the region. Finally, some methods and changes in factors will be suggested to reduce or cut the losses of honeybees and to improve the general situation for honeybees in in semi-natural ecosystems and in ecosystems strongly influenced by humans.

Several research articles suggest the use of pesticides as one of the potential causes of devastation in the bee population and weakening the bees' immune systems (Lu, 2012 and 2014; Ratnieks, 2010; Williams, 2015). Other scientists also focus on pathogens and Varroa mites (Frazier, 2011; Genersch, 2010; Martin, 2012; Johnson, 2010). However, due to a global rise in the number of CCDs occurring, considering only one factor as the main cause could be unrealistic. Therefore, an overview of all possible causes of death in honeybee colonies is given, and a combination of (synergism) factors is proposed as an explanation for the weakening of the immune system of bees.

Despite the growing rates in loss of the honeybee colonies in the recent decades, there is hope of putting an end to this issue by understanding the main causes of this phenomenon, on a local scale, and eliminating those factors by improving the beekeeping and management methods and maintaining biological pest-control targets.

1.1. Are honeybees disappearing in northern Germany?

The problem of bees vanishing applies to honeybees and to wild bee species (Rundlöf, 2015; Woodcock, 2016). For the first time in history, 7 wild bee species were listed in the endangered species list in 2016 (Zukowski, 2016). Wild bees have been suffering from anthropogenic harmful chemicals and pesticides the same way managed bees do and it has caused several wild pollinator species to join the red list of endangered species.

Are honeybees dying off in Germany, and in particular in northern part of the country as well? This is a key question this research will answer.

Studies show that honeybees and wild bees have a lower rate of overwintering and reproduction if exposed to neonicotinoid pesticides (e.g. Woodcock, 2017). The impacts of pesticide exposure in domestic and wild bees depend on the intrinsic sensitivity of single bee species as well as their specific life cycle, nesting activity and foraging behavior (Arene, 2014).

Furthermore, managed bee colonies could be saved through management actions such as queen replacement, adding to bee frames and removing sick bees or mite-affected cells. In other words, as long as there are educated apiculturists, there will be honeybees; additionally, unlike honeybees, wild bees could not be temporarily moved during spraying periods. Therefore, wild pollinators are further in danger of extinction and population losses.

What makes bees particularly important for the ecosystem they live in and for us is the role they play in pollinating crops and natural flora species, besides the fact that they produce honey and wax for our food, medical and industrial purposes. Hence, they affect the natural environment, our agriculture, forestry, economy, industry and food directly and indirectly.

Consequently, the increased number of honeybee losses, known as Colony Collapse Disorder (CCD), has concerned many scientists and ecologists as well as farmers and beekeepers.

In spite of the increased number of researches done on the colony collapse disorder phenomenon, the number of CCDs occurring throughout the USA and Europe has further increased recently (Zukowski, 2016). Experts suggest habitat loss, invasive species, pesticides and wildfires as possible causes of bee loss in the recent years in the USA (Zukowski, 2016), but what exactly results in a massive number of CCDs occurring around the world remains a mystery. Several research papers suggest pesticides, in particular neonicotinoid pesticides, cause the massive death of bees (Lu, 2014; Williams, 2015; Woodcock, 2017). However, the real reason behind the destruction of the colonies in different regions remains unknown.

1.2. Statement of the problem

The phenomenon of sudden death or disappearance of honeybees has always been happening throughout the history of beekeeping (Johnson, 2010); however, the fact that the number of honeybee deaths has been increased rapidly in several regions around the world in the past years makes it far from a natural accident. Many researchers suppose Varroa mites, diseases, pesticides and genetically modified crops are the reason for this.

This research project will investigate, why and how many death records have been occurring in Schleswig-Holstein, on local and regional scales.

Moreover, the honeybee losses have several consequences on many essential crops and natural plant species by a shortage of pollination. Among the plants pollinated by bees, there are many fruit trees, nuts, forage and field crops and vegetables such as apples, strawberries, rapeseed, corn and sugar beet, which are commonly produced in Schleswig-Holstein. Therefore, fewer bees may lead into fewer crops and less wax, honey and other bee-related products. That is the reason why many researchers have shown their concerns regarding this matter and many others are trying to find out what the main causes could be (Ellis, 2007, Johnson, 2010).

Therefore, this study tries to discuss a general and broad range of potential causes of this issue, determining the local problem with improved precision including input from individual beekeepers in the region and furthermore, some solutions and ways to mitigate this problem will be suggested.

1.3. Significance of the study

One may ask why we need to protect honeybees. The answers could be:

- According to environmental ethics bee species, the same as any other species have the right to live and be protected. Most major religions including Christianity, Islam and Buddhism insist on respecting nature and animals and plants (Primack, 2012);
- The more diverse an ecosystem, the healthier it will be. Ecosystem health is a consequence of healthy components and functions in an ecosystem;
- A part of conservation includes species conservation and the other part which should not be neglected is habitat conservation. Habitat loss is often one of the main reasons leading the species to extinction;
- Population reduction in honeybees will result in a population reduction in many natural and agricultural plants as well as forests, due to the pollination roles they play for floral plants; which will cause the whole local ecosystem to collapse in time;
- Since honeybees affect the economy through crop pollination, honey and beeswax production, a decrease in their numbers will have direct regional and global economic consequences.

1.4. Questions, objectives and methodology

Honeybee populations have been decreasing throughout the world in the past decade, which concerns namely the economy due to their pollination ability and effectiveness on the crops and natural flora.

The purpose of this research is to find the answers to the following questions:

- Why are honeybees disappearing today more often than in the past?
- What causes bees to suddenly disappear or die?

- What impacts does the colony collapse disorder have on us and other parts of the ecosystem?
- How severe is the loss of the bee population in the northern part of Germany?
- Is the bee loss crisis related to the beekeeping methods?
- Is there a way to decrease its rate?

To answer these questions, the history of colony collapse disorder and its rate in the past years will be investigated.

Then, a broad range of possible reasons for the disappearance or death of honeybees will be discussed.

Furthermore, a local analysis of honeybee population losses, causes of loss and other issues in Schleswig-Holstein, types of beekeeping and main beekeeping products will be discussed. Finally, suggestions and recommendations will be offered to reduce the rate of CCD. For this purpose, a questionnaire has been designed, containing 21 questions regarding beekeeping methods, types of beekeeping, main problems and causes of bee population losses in recent years in the region. Based on the answers of this questionnaire by over 100 local beekeepers, an analysis of current issues in beekeeping and possible solutions will be discussed.

For this purpose, the following research project will be based on firstly, a comparative research-based study of all the potential causes of CCD in bees and analyzing the possible effects of it. Secondly, a questionnaire-based study on the beekeeping methods and bee population losses and issues will be done. Finally, a logical assessment of what methods and factors will be able to reduce or cut the losses of honeybees and to improve the general situation for honeybees in ecosystems.



Figure 1.1. A bee frame - Photo by Samar Shafiei

What most studies lack is an integrated study on natural, environmental and human-made causes. These ideas mostly neglect any beekeeping mismanagement factors related to the issue. Local research is scarce in the northern part of Germany and most of the conducted research focuses on Alpine and southern German regions. What the following research proposes is a combination of factors causing or increasing the death rates in honeybees in Schleswig-Holstein, from which mismanagement, nutrition, parasites and diseases, pesticides, global warming, mono-cultural fields and natural habitat loss could all be probable causes.

In addition, the mutual interactions and benefits of bees in the ecosystem will be discussed. The role they play in the ecosystem and the benefits they have for humans will also be analyzed.

Researchers mostly focus on the causes of CCD, but also what effects this phenomenon has on the environment, on human lives and the economy. Effects on the aforementioned have been neglected. In other words, these areas have a high potential for future research. Regarding the literature review, please refer to Chapter 2.

Therefore, the following research project aims at combining an interdisciplinary study on the possible causes of CCD in honeybees and the potential impacts of this condition on the natural environment, including the human population. This investigation mainly focuses on the colony collapse disorder in Schleswig-Holstein and its relation to beekeeping methods in the region.

Finally, some suggestions and recommendations will be presented to decrease the number of honeybee losses and to improve the general situation of farmlands with some beekeeping methods for a better health in honeybees.



Figure 1.2. A honeybee in the field, collecting pollen and nectar from Rubus - Photo by Samar Shafiei

1.5. Limitations and scope

What mainly limits the possibility of exactly measuring the factors causing CCD in honeybees is the fact that this problem is indeed an interdisciplinary issue caused by many different local, regional and global factors.

Many regions have their own subspecies of honeybees, and also its own environment, land use systems, issues and causes for CCD: as an instance, one region might suffer from mismanagement, while the other beehive suffers from lack of nutrition. In one part of the world, a specific type of pesticide might be used, while in another locality, a specific type of parasite might affect the CCD. Many local beekeepers report bee population losses, but do not know the exact reasons behind the issue. It will therefore be difficult, if not impossible, to consistently generalize one or more of the reasons behind all CCDs in the world.

The economic aspects of the losses resulted by the CCD are quantitative. On the other hand, the ecological effects of honeybee loss are actually much more complicated. Because an ecosystem is a complex system of many different biotic and abiotic components working together, the loss of a key member of this system, bees, with their important role of helping with the pollination for many plant species, will be more complicated to assess accurately.

Some other potential problems one may face regarding the CCD research are:

- Some farmers might be rather conventional and fixed in their old ways and resistant to new data, hence using the same chemicals over and over again;
- It could be that while working with questionnaires, some people are biased by media and filling out the questionnaires incorrectly;
- It is possible that many apiculturists are buying honeybee colonies from the same sources and thus spreading the disorder around the country;
- Some colonies observed might be unsuccessful due to natural or other reasons, thus misleading the CCD results. Also, some farmers have problems with pollution from coal refineries and others from livestock waste improperly taken care of.

Nevertheless, a rather close-to-reality estimation of all the environmental and ecological impacts' assessment of CCD should be done, and a list compiled to suggest what will be lost in case that the growing trend of honeybee CCD does not stop. In this way, legislators and anyone responsible for this matter will have a clearer vision in mind to plan methods of reducing the number of untimely honeybee deaths.

Moreover, what can be determined from more research are integrated, comparative statements on various already-known parameters and causes of CCD to find similar patterns in CCDs occurring in different regions and continents. Further studies might lead us to a potential combination of reasons and various factors behind this global issue. The best way would be to look at each region individually to determine their specific potential problems.

1.6. Structure of the dissertation

These questions will be answered in the current research project and for this purpose, we will firstly look at the currently available research papers and books on this subject; Secondly, the data which was collected from the local beekeepers will be compared to the up-to-date international research status.

The questionnaire, the statistical data and the extrapolations from the data may give the beekeepers a greater idea of why this phenomenon is occurring. This research aims to determine why bee colonies are disappearing, as well as finding solutions for these regional and global issues causing CCD.

The dissertation consists of seven main parts:

- Chapter 1 will be an introduction to the CCD problem, the significance of this study, the main questions and methodology, the milestones of the research and the hypothesis;
- Chapter 2 will include the literature review, possible causes of CCD in the bees, describing briefly what has been done so far by other researchers and what questions have not been answered yet and the general status of the research on an international scale;
- Chapter 3 will be related to the reasoning behind Schleswig-Holstein being chosen as a local region for this study, agricultural structures in the region, and finally the history of beekeeping in northern Germany will be discussed;
- Chapter 4 will be dedicated to methodology and the way this project has been constructed. Which methods of research have been selected and the reason for their selection, will be discussed;
- Chapter 5 will discuss the questionnaire, which will indicate how many beekeepers have answered the questions and why these questions have been chosen. Furthermore, for each question, a graph of the collected data will be displayed;
- Chapter 6 will be about interpretations of each answer and also general interpretations which will explain what results have been reached out of this research project and which new information has been achieved. Furthermore, potential effects of CCD will be described;
- Chapter 7 will be dedicated to conclusion and recommendations for decreasing the rate of CCD as well as finding new ways to improve the current situation of honeybees and beekeeping. Finally, some a new outlook for future research will be introduced.

Chapter 2: Literature review

2.1. Introduction

Why do honeybee colonies disappear? Why have the death rates in Honeybees increased in the recent decades? What causes the bees-colonies to die and how could we stop this problem? What are the main problems among beekeepers in the region? Are the recent bee losses related to the beekeeping methods?

Bees play a vital role in ecosystems and agriculture by pollinating the natural flora and the crops (Heid, M. 2015). They are also important for humans since their honey and wax have many industrial and medicinal uses. Therefore, they affect the global economy and human lives both directly and indirectly. Their losses will have a great impact on both the economy and the planet just as well.

The phenomenon of sudden death or disappearance of honeybee colonies which is called Colony Collapse Disorder (CCD), has been occurring since the beginning of beekeeping in ancient times (Johnson, 2010); However the rates have been rapidly increasing in the past few years, to the point that in some regions around the world, an estimated 90% of the population loss has been reported (Zukowski, 2016).

Hence, many ecologists and environmentalists are concerned, and their warnings have caused many farmers and politicians to act.

2.2. Potential causes of CCD in honeybees

Researchers (Goulson, 2015; Picó, 2019; Williams, 2015; Woodcock, 2017) suggest a number of potential causes, which are listed below:

- Pesticides;
- Parasites;
- Pathogens;
- Fungicides.

Additionally, other potential causes of death to the bee colonies include:

- Malnutrition;
- Beekeeping practices and mismanagement;
- Monoculture and lack of biodiversity in agricultural fields;

- Antibiotics;
- Genetically modified crops;
- Global warming;
- Electromagnetic radiation;
- A combination of several the above-mentioned factors.

Main cited causes	Additional potential causes
Pesticides	Global warming
Diseases	Low biodiversity
Parasites	Land use and habitat loss
Malnutrition	Agriculture (monoculture)
Viruses and other pathogens	Beekeeping mismanagement
	Pests and mites
	Stress due to location change
	Genetics and queen source
	Genetically modified crops
	Chemicals (agriculture, beehive or environment)
	Predators
	Cool brood
	New and unknown pathogens
	Weakened immune system by a combination of factor (synergism)

Table 2.1. Potential causes of CCD in honeybees

Ever since the sudden growth in honeybee deaths in 2006, a number of different possibilities have been suggested regarding the potential causes of CCD increase in the honeybees; many of them which refer to a particular region and may not be generalized as a global issue (Johnson, 2010; Lu, 2012; Ratnieks, 2010). On the other hand, no research combines a variety of possible causes of CCD in bees to provide a better understanding of this recent global phenomenon.

2.2.1. Pesticides

Pesticides and in particular, neonicotinoids adversely affect the health of bee colonies and honeybee populations, by declining the colony population over winter and in general exposing the bees to other diseases (Lu, 2012 and 2014; Ratnieks, 2010; Siefert, 2020; Tomé, 2020; Williams, 2015).

Following the growth of agriculture and hence, increased application of chemical pesticides for both agricultural and beekeeping purposes, the number of honeybees suffering from the chemical reaction of pesticides on their health has increased dramatically. Crop pollination indeed exposes the pollinator to the harmful chemicals and pesticides used on the farmlands (Pettis, 2013).

Chemical pesticides which are being used in agriculture, harm not only the insects considered as pest for our crops, but also kill other insects that are beneficial for us and our crops, such as honeybees. Specifically, neonicotinoids are being widely used mainly for the reason that they harm insects but are not extremely dangerous for us humans and other mammals and they can also be used for seed treatments (Oliver, 2012).

Therefore, management practices and laws are needed to provide protection for the honeybees. Some shifts in practice could change the results such as: limiting and prohibiting the use of these harmful pesticides, replacing them with less toxic chemical or natural means of pesticides and altering the time and amount of pesticide application, spraying the plants only after the sunset.

The current international research papers mostly focus on pesticides and in particular neonicotinoids as one of the main reasons behind the rapid population decrease in the past several decades. Neonicotinoid pesticides cause chemical reactions and bindings on bees' biological organs and cause the bee populations to slowly drop down (Dengler, 2017).

As an example, Nancy Ostiguy et al. in a recent study, from the U.S., named *Honeybee exposure to pesticides: A four-year nationwide study* (2015), mention that insecticides were found far more frequently than fungicides or herbicides in the gathered samples of pollen and wax comb, and that a third of the found pesticides were found in pollen.

B.A. Woodcock et al. (2017) have worked on the impacts of neonicotinoid pesticides on bees in *Country-specific effects of neonicotinoid pesticides on honeybees and wild bees*. In their field experiments across Hungary, Germany and United Kingdom, they compared neonicotinoid-treated fields of oilseed rape with the nontreated version and explored their effects on three species of bees. The results indicated that in most cases, reproduction was negatively correlated with neonicotinoid residues. The findings show that neonicotinoids cause a reduced capacity of bee species to establish new populations in the year following exposure.

Furthermore, B.A. Woodcock (2016), Maria Arena (2014) and Maj Rundlöf (2015) have mentioned in their studies that neonicotinoid pesticides negatively affect wild bee species; which is a reason why not only honeybee species are affected and threatened by the chemical pesticides, but also wild pollinators in the ecosystem.

Sébastien C. Kessler et al. in their study *Bees prefer foods containing neonicotinoid pesticides* which was published in Nature in 2015, demonstrate that not only honeybees do not avoid flowers which were contaminated by the most common neonicotinoids (IMD, TMX, CLO), but also prefer them over the noncontaminated plants.

In *Neonicotinoid Pesticides Severely Affect Honeybee Queens*, a paper by Geoffrey R. Williams et al. (2015), the authors discuss the importance of queen health on colony survival, and they specifically focus on the impacts of exposure to neonicotinoid pesticides on the queen bees. Despite being the first research working on queen bees' exposure to neonicotinoids in the field, it does not take a combination of potential causes to honeybee CCD into consideration.

Chensheng Lu and his team have worked on *Sub-lethal exposure to neonicotinoids impaired honeybee's winterization before proceeding to colony collapse disorder" (2014)* which suggests that exposing the honeybee colonies neonicotinoid insecticides throughout the winter months may lead to colony collapse disorder. This study gives us the opportunity to compare the seasonal factors in death of honeybees; however, it only considers one parameter as a means of increasing the ratio of CCD and ignores other possible factors.

Jeffery S. Pettis et al. (2013) discuss pesticides and their potential effects on honeybees and causing CCD in their study *Crop Pollination Exposes Honeybees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen Nosema ceranae*. It describes the interaction between pollination and the risk of exposure of honeybees to pesticides and hence a decline in colony health; an insight into the relation between agricultural fields and honeybees is also given. On the other hand, it solely focuses on the pesticides and overlooks the other possible threats to the colony disorders.

In their other research project, Chensheng Lu et al. (2012) have studied and analyzed the further effects of neonicotinoid pesticides on a smaller scale in their paper called *In situ replication of honeybee colony collapse disorder*. This in-situ study mainly focuses on the impacts of neonicotinoid pesticides on honeybee colonies by replacing the insecticide to decrease the mortality of honeybees. It neglects any other biological or ecological aspects to determine other possible causes of CCD.

Another study done by Devillers and Decourtye which focuses on the *ecotoxicity of neonicotinoid insecticides to bees* (2010) reviews the available data on the degree of toxicity of neonicotinoids on bees which are among the most important pollinators. The research suggests that nitro-substitute compounds appear the most toxic to bees; versus cyano-substituted neonicotinoids seem to cause a much lower toxicity.

Francis L. W. Ratnieks and Norman L. Carreck (2010) have also worked on the reason behind the population drop of honeybees in *Clarity on Honeybee Collapse*. This article suggests a wide range of possibilities to explain the reasons for the recent CCD has increased in number. However, the potential harmful factors remain in theory and do not fully support a practical proof.

Reed M. Johnson et al. (2010) in their study *Pesticides and honeybee toxicity-USA*, review the impacts of both agricultural pesticides and the other chemicals and pesticides used by the beekeepers to suppress pests and mites in their beehives. Their research examines pesticides applied to crops, in apiculture and also the chemical residues in hive products. They discuss the role that chemicals may play in colony collapse disorder and other colony problems. They add that even though no single pesticide has been shown to cause colony collapse disorder, the additive and synergistic effects of multiple pesticide exposures may contribute to declining honeybee health.

Nicola Cicero et al. (2016) in their research project *Monitoring of neonicotinoid pesticides in beekeeping* determine the concentrations of neonicotinoid insecticides in honeybees, honeycomb and honey samples, collected in the blooming period from different areas in Italy in order to carry out an evaluation of bees products' safety and an overview of neonicotinoid contamination in beekeeping. The results showed only the presence of clothianidin in bee samples and an absence of residue in all honey samples, which as a result do not represent a risk for bees' vitality and safety.

Mickaël Henry et al. (2012) in *A common pesticide decreases foraging success and survival in honeybees* suggest that exposure of honeybees to neonicotinoid pesticides causes high mortality rates due to homing failure at levels that could put a colony at risk of collapse. In their study, the researchers simulated exposure events on free-ranging foragers labeled with a radio-frequency identification tag, which suggests that homing is impaired by thiamethoxam intoxication. Their experiments offer new insights into the consequences of common neonicotinoid pesticides used worldwide, since it had been thought that neonicotinoid pesticides were nonlethal to honeybees.

Moreover, Paul Siefert (2020) in *Chronic within-hive video recordings detect altered nursing behaviour and retarded larval development of neonicotinoid treated honeybees* observes beehives using a video technique over a long-term period. He and his team record a sublethal effect on worker bees, in particular at the larval stage, with a reduced feeding visits and duration which was a result of introducing honeybee colonies to clothianidin and thiacloprid which are neonicotinoid pesticides used in agriculture.

2.2.2. Parasites and diseases

Among the different potential causes increasing the rates of CCD, diseases and maladies (viral, fungal, bacterial etc.) have been numerously reported by beekeepers and researcher. As an example, the viral gut disease pathogen *Nosema ceranae* has been reported to be one of the main causes of death in honeybees (Pettis, 2013).

On the other hand, there is a potential risk of undiscovered viruses and bacteria that cause sudden death in bees in cases where there is no other explanation of a whole colony death.

Another common factor affecting the bee populations would be parasites and pests (Frazier, 2011; Genersch, 2010; Martin, 2012; Johnson, 2010) such as Varroa mites (Pohl, 2008; Engelsdorp, 2009). A beehive affected by pests and parasites will most probably die off, due to the fact that a colony's survival and reproduction is dependent on the health of each individual in order to play their roles in the honeybee colony.

A relatively large number of studies have been conducted on the topic of diseases and parasites related to honeybees as one of the main potential factors causing CCD in honeybee colonies. One of the causes of these diseases could be mismanagement by the beekeeper; factors such as amount of sunshine, food, Varroa, usage of pesticides, monocultured fields, locating the beehives in the shadow and other general issues.

As an example, Dave Goulson, a British biologist who specializes in Bumble bees, has a number of books and papers on the topic of the declining in bee population and parasites. In his research titled *Bee declines driven by combined stress from parasites, pesticides, and lack of flowers (2015)*, he suggests that a combination of stress factors seem to have a synergetic impact on impairing the bees' immune system, and by removing either of these potential factors, modern research may get one step closer to declining the bee population losses.

In another research conducted by Dave Goulson et al. called *Mitigating the anthropogenic spread of bee parasites to protect wild pollinators (2015)*, the authors mention a concern that the anthropogenic movement of bees species for crop pollination purposes has led to the accidental introduction of bee parasites to countries and regions where they do not naturally occur, exposing native bees to parasites against which they may have little or no resistance. Therefore, he proposes a few mitigation strategies to reduce the risks.

The relationship between managed bees and the prevalence of parasites in bumblebees (2014), another research study conducted by Graystock and Dave Goulson, discusses the impact of managed honeybee colonies on wild bee species such as bumble bees' health against parasites and other environmental health risks.

Maryann Frazier (2011) introduces the typical diseases, parasites, pests, disorders and predators related to the honeybees, in her *Field guidebook about honeybees and their maladies*. This e-book helps to categorize the possible causes of CCD related to different diseases and health issues of honeybees (Viral, Fungal and Parasite pathogens) due to improper management methods.

Report on the National Stakeholders Conference on Honeybee Health: USDA (2012) discusses the current knowledge of bee biology, nutrition, pathogens, pests and pesticides, genetics and breeding and relations of bee-health to Colony Collapse Disorder. This report gives an overview on the current state of knowledge. However, it does not conduct a broad research on ways to prevent and decrease the pathological harms on the honeybees but can be of help in terms of malnutrition and pathogens to analyze some potentials causing CCD in honeybees.

On the other hand, the FAO (Food and Agriculture Organization) report titled *Honeybee diseases and pests: a practical guide: Agricultural and food engineering (2006)* discusses a variety of pests, microbial or parasitic diseases, as well as insects and vertebrates harming the common honeybee species. It is a practical guide for beekeepers, but the report neglects the potential environmental factors affecting the bee colonies and their health.

Elke Genersch (2010), in her study *Honeybee pathology: current threats to honeybees and beekeeping*, also focuses on health issues and diseases that might be causing the current threat to beekeeping. This study mainly suggests pesticides and some pathogens as the potential causes of the colony collapse disorder.

Parasites are one the most common causes of diseases in honeybees. Therefore, it is necessary to analyze what main viruses and parasites could be causing CCD in honeybees.

Stephen J. Martin et al. (2012) suggest viruses and other pathogens as the main cause of CCD. The study, *Global Honeybee Viral Landscape Altered by a Parasitic Mite*, focuses on emerging diseases among honeybees caused by viruses as a threat to honeybee population. It suggests viral diseases and pathogens are among the key factors causing CCD.

2.2.3. Malnutrition

Malnutrition is one of the main causes of weakened immune system and diseases, which could lead to CCD in honeybees. Therefore, it could be one of the leading factors to be taken into account for beekeepers and farmers.

Lack of nutrition directly affects the bee populations (Naug, 2009). Malnutrition could be a consequence of management practices, shortage of honey throughout the winter, monocultured fields which do not provide a variety of flowers for honeybees and in general a misuse of land and therefore, destruction of natural ecosystems for bees. Also, overcrowding and contaminated water supplies might be other factors increasing the risk of death in the bees.

Dhruba Naug (2009) has an article related to shortage of nutrition in honeybees and its potential relation to the CCD: *Nutritional stress due to habitat loss may explain recent honeybee colony collapse*. It suggests the potential of lack in open land and therefore lack of nutrition could lead to colony collapse disorder in honeybees in the United States. It, however, only focuses on nutrition and land use and does not take other factors into consideration.

Gloria DeGrandi-Hoffman and Yanping Chen (2015) in *Nutrition, immunity and viral infections in honeybees*, discuss how honeybees decrease the risk of diseases by a combination of social immunity and individual immunity and the relation between the effectiveness of these immunity strategies and the nutritional state of the colony.

Cédric Alaux et al. (2010) in their research *Diet effects on honeybee immunocompetence*, compare mono-floral pollen versus poly-floral pollen and diet diversity and their impacts on enhancing the individual and social immunity. They realized that mono-floral diet causes no increases in enhancing the immunity levels in bees; However, diet diversity increases the Immunocompetence in honeybees.

Honeybee Exposure to Pesticides: A Four-Year Nationwide Study by et al. (2019), is a research conducted in the U.S.A. on the degree of pesticide exposure in honeybees. It compares the existing harmful chemicals in beeswax and the presence of pesticides in the collected pollen. The results show that insecticides were detected more frequently than fungicides or herbicides and one third of the detected pesticides were found only in pollen.

2.2.4. Beekeeping methods and mismanagement

Managed beehives are directly affected by the management methods applied by their beekeepers. Therefore, some mismanagement methods could result in fatal impacts for honeybees. Instances are, locating the beehive in the shadow or wind and blocking the sight and orientation of bees, harvesting too much honey resulting in lack of nutrition in winter, using chemical pesticides for Varroa etc, relocating the bee colonies often for rent in order to provide pollination services and checking on the bees too often on cold days which might lead to cool brood (Oldroyd, 2007).

Beekeeping influences the honeybee population and health. By studying the beekeeping methods in the past and comparing them, the modern styles can help experts in the field understand the potential mismanagement that is causing the recent sudden death or disappearance of honeybees.

T. Minor's publication *Experienced Beekeeper (1804)* is an American historical book and one of the oldest available printed books on the topic of beekeeping. It explains the common issues related to beekeeping; such as feeding the honeybees, natural enemies of the honeybees, beehives throughout the winter, honey distraction and so on. It is important to compare the beekeeping methods and management in the past and current times in order to determine key factors leading to the possible mismanagement and disease of honeybees.

Additionally, Caroline B. Thompson (1918) in her research paper on *Dual queens in a colony of honeybees* focuses on the possibility and reasons behind the dual existence of Queens in a honey colony, which was published by the American Association for the Advancement of Science. It is useful to compare what differences it makes in terms of honeybee management in the past century versus the management nowadays to keep two queens in a singular bee colony and if it is in some ways helping the colony to reduce the potential bee losses.

Emerson Chamb (2016) in his edited book entitled *Beekeeping and bee conservation, advances in research*, presents current issues in the field of bees in multiple contexts and ties together experiments conducted by some of the world's most renowned researchers. He finally adds his objective point of view and results of his own research in this area, which is a useful book for both beginners and advanced researcher in the beekeeping subject.

2.2.5. Other potential causes of CCD

- Global warming

Global warming results in a raise in temperature and hence an earlier than expected blooming of some flowers, while the honeybees are still hibernating (Sass, 2011). Therefore, as the winter comes to an end and the honeybees resume searching for nectar from various flowers, the blooming season has already passed and there will not be enough flowers for the bees.

- Biodiversity

Lack of biodiversity has been a result of ecosystem destruction for urban and agricultural uses. Since there will be less flora species to provide nectar and habitat for honeybees, a lack of biodiversity will cause an increased death in bee colonies. Health of an ecosystem equals with the health of its components and functions such as trophic cycles and the higher the diversity of an ecosystem, the healthier it will be.

- Land use and habitat loss

It is clear that by cutting down the trees and turning natural ecosystems into managed lands such as agricultural fields, industrial and urbanized areas, natural inhabitants such as honeybees lose their habitats and homes and hence their populations decrease.

- Agriculture

Agriculture and in particular monoculture, has severe impacts on honeybees. It not only increases the chances of poisoning the bees by agricultural chemicals and pesticides, but also by limiting the food options for bees, it raises the risk of lack of nutrition at some periods of time when there is not enough flower from that particular plant species. Also, by decreasing the biodiversity, the probability of infections and diseases or pests increases.

- Pests and mites

Pests and mites, in particular Varroa mite, is a very common cause of death in honeybee colonies (Martin, 2012). The management methods are the key to reduce the impacts of pests and to increase the risks of infecting the healthy bee colonies. It is important to fight against the pests using biological pesticides.

- Stress due to location change

Many farmers, especially in the US, rent their beehives in order to offer pollination services to farmers and decrease the number of crops. However, this practice and frequent change of location throughout the year might cause unwanted stress for the bees and weaken their immune systems (Sass, 2011).

- Genetics and queen source

How strong a bee colony's immune system is and how healthy and long living they are factors dependent on the genetics of the colony and mostly the Queen cell. Each race or sub-racial bee might be specifically sensitive to a particular pathogen. Therefore, choosing a strong and healthy queen plays a vital role on having a healthy and sustainable bee colony.

- Genetically modified crops

Another possibility for a sudden increase in CCDs occurring in the recent years might be the increased use of genetically modified crops (Ellis, 2007; Oldroyd, 2007). As these modified crops are a food source for honeybees, more research needs to be done on their potential side-effects on honeybees and other pollinators.

- Agricultural insecticides and chemicals

As the agricultural fields grow in size due to population growth and the natural habitats for honeybees change their places with man-made crop fields, it is important for farmers to use biological and environmentally friendly sources of pesticides and insecticides and avoid using harmful chemicals that kill not only pests and insects but also bees and other pollinators. There are a number of insecticides and agricultural pesticides which have been banned in many countries but are still being used in the USA (Sass, 2011).

On the other hand, management practices which should be done and monitored by both beekeepers and farmers include spraying the pesticides only after sunset when bees return to their hives. So far, chemicals have been reported as one of the most common causes of death in the bees.

- Predators

Honeybees, like any other part of the ecosystem, have their own natural predators. Mice or other small rodents which tend to eat the honeybees. If the number of predators overrate the number of preys, or in other words, if there is not enough food for rodents, more bees will be killed and consumed as their food. (Personal observations).

- Cool brood

Honeybees provide and maintain the same temperature conditions for their brood nests and in the beehive, throughout the year and keep it around 34.5 Degrees C (Oldroyd, 2007). However, if there are fluctuations within the temperature due to frequent opening the hive in winter or other similar cases in which does not allow the adult bees to maintain the required temperature for their brood, it might affect the colony health.

- New pathogens

In addition to the traditional pests and diseases causing death to the honeybees, there might be a number of new and undiscovered pathogens that have raised the number of CCDs in the past recent years. As an instance, Israeli Acute Paralysis Virus and a new sub-species of *Nosema* (*Nosema ceranae*) have been discovered recently (Ellis, 2007).

- Weakened immune system by a combination of factors (synergism)

Many cases of CCD might be a result of not just one factor, but a combination of several factors such as *Varroa*, stress, diseases and other factors which in theory weaken the immune system in bees and therefore, cause collapses in the bee colony. Since the number of honeybee deaths have been raised in different regions in the world, with different environmental conditions and pathogens, it is very likely that a synergism between several minimal factors could be causing the deaths, which makes the research in this area more complex.

2.2.6. Colony Collapse Disorder

In the following section, some relevant works have been named and discussed which have been chosen among research, books and online resources related to CCD in honeybees:

Jamie Ellis (2007), in his research published by Florida University press titled *Colony Collapse Disorder in Honeybees* gives a brief introduction to colony collapse disorder and names some potential causes. It also describes the effects of CCD on the general public, but it does not relate the issue in an ecological scale and does not provide any environmental impact assessment of the CCD. Nor does it mention the ecological importance of honeybees, and thus neglects to mention the consequences of CCD on the ecosystem.

Stéphane Kluser et al. (2010), in their research published as UNEP Emerging Issues: *Global Honeybee Colony Disorder and Other Threats to Insect Pollinators*, mainly focus on pollination and pollinators, pollinator populations and the driving forces of the pollinator population instabilities.

Renée Johnson (2010), in *Honeybee Colony Collapse Disorder*, describes the extent and symptoms of CCD, importance of pollination and explains how CCD differs from the past bee colony losses. It also suggests some potential causes of CCD such as pesticides and parasites, however, this research does not correlate the issue to further ecological aspects.

A CCD Steering Committee study conducted by Kevin Hackett and a group of agricultural experts (2007) entitled *Colony Collapse Disorder Action Plan* aims to determine the possible causes of CCD and to research gaps and priorities related to the issue. Furthermore, it suggests and tries some prevention methods to decrease this phenomenon. While this study fails to make an ecological link between the causing factors and an environmental impact assessment of the problem. They further on, in their “*Colony Collapse Disorder Annual Progress Report from CCD committee*” (2012) inform the reader about the current status of CCD in the USA as of 2012. This report also describes the effects of CCD on crops. But does not focus on suggesting ideas to solve or prevent the problem.

Myrna E. Watanabe (2008) has also written an article called *Colony Collapse Disorder, Many Suspects, No Smoking Gun*. This article published by the Oxford University Press, discusses the possible explanations for the honeybee losses. It confirms the lack of evidence to directly come to a conclusion as to which factors play a vital role in causing this issue and hence suggests further research on the CCD subject.

Furthermore, Dennis van Engelsdorp et al. (2009), in their paper: *Colony Collapse Disorder, A Descriptive Study*, compare the potential factors impacting the honeybee colonies and their losses in the U.S.A. from the past decade. This research primarily focuses on pesticides and pathogen analysis.

The article called: *What’s Killing American Honeybees* by Benjamin P. Oldroyd (2007) describes the colony collapse disorder phenomenon and suggests a number of possible factors causing or increasing CCD. However, it does not provide any specific evidence to back up the main and most important causes and impacts of CCD.

Among researches related to Colony Collapse Disorder, some authors refer to electromagnetic fields and EMF radiation as potential causes of CCD and death in the bees (Cammaerts, 2017; Kumar, 2018; Wyszowska, 2019).

Some other research papers refer to the possible causes and effects of Colony Collapse Disorder and offer potential solutions regarding this issue (Gupta, 2019; Lu, 2020; Rucker, 2019; Stanimirović, 2019).

2.2.7. Honeybee biology

What are honeybees? Which functions do they have in ecosystems?

Honeybees or *Apis mellifera* are the honey producing species of the Apidae family. Depending on the amount of honey or wax they produce, there are different species and sub-species.

A beehive consists of three types of bees: Queen-bees, drones and worker bees. Each group has a certain type and number of tasks in the beehive; For example, laying eggs, mating and producing honey respectively.

As one of the main pollinators in the ecosystem, honeybees play a crucial role for both natural and agricultural fields. They not only produce honey, nectar and beeswax, but also, they pollinate many flora species, including fruit trees, flowers and crops. This pollination results in not only benefiting the natural floral ecosystem, and the consequently fauna species using the plants, but also it directly and indirectly benefits the economy for human beings via honey and wax production, as well as crop pollination.



Figure 2.1. Honeybees, collecting nectar in Lavender field - Photo by Samar Shafiei

Among many papers, reports, research and books regarding the topic of honeybees, some of the few relevant works are cited below:

David Stone (2005) describes the bee anatomy, bee stages, killer bees, bee parasites, competitors and finally bee products. As the title "*An Introduction to Bee Biology*" indicates, it is a useful resource to grasp a basic-levelled knowledge of bee biology. In order to understand how specific pests, diseases or pesticides affect the honeybees, it is important to study the biology of honeybees, and hence this book helps identify the reasons for some pesticides affecting the bees and why other types of pesticides do not.

Furthermore, Albert W. Needham (2010) focuses on general and important information related to honeybees and in particular, beekeeping skills. Additionally, it informs the reader how to install bee-packages, the benefits of beekeeping and honey, beekeeping throughout winter and how to treat African bee strings. It is a practical source for hobby beekeepers, and it is relevant to this research study, as it helps to relate different management methods to the potential causes of CCD. However, it does not mention the main threats and difficulties related to honeybees.

Ved Parkash Sharma and Neelima R. Kumar (2010), in their study titled *Changes in honeybee behavior and biology under the influence of cell phone radiations* carried out an experiment on 4 bee colonies to determine the impacts of cell phone frequencies on honeybees. The results exhibit a significantly higher strength in the control colony, compared to the those treated. Comb frames, brood, number of eggs laid by the queen, number of returning bees and also the rate of bees leaving the hive were all significantly higher in the control bee colony than the ones treated by mobile phone radiation frequencies.

R.F.A. Moritz and his colleagues (2000), in their research project called *Pheromonal contest between honeybee workers*, represent how queenless honeybee workers develop into reproductive individuals termed pseudoqueens. They remain morphologically worker bees, but physiologically act and function as a queen bee thanks to pheromones similar to those of real queen bees. A strong intracolony selection decides from many, which few workers turn into pseudoqueens.

Van Engelsdorp (2017), in his research titled *Colony Collapse Disorder (CCD) and bee age impact honeybee pathophysiology*, discusses how bees' age potentially affect the pathophysiology of honeybees, making them more vulnerable to CCD.

2.2.8. Honeybees in Ecosystem

Understanding how honeybees and their loss affect the ecosystem and global agriculture will help experts and beekeepers to invest more effort in conservation of honeybees in society. It will also inform politicians about the importance in preserving the natural order of bees in the ecosystem.

On the other hand, the only way to fully understand all the possible causes of CCD and the potential effects that the bees' loss has, is an integrated study of all the relevant factors in the ecosystem. Hence, a detailed study of the ecological impact assessment of CCD in honeybees will be required.

What roles the honeybees play in an ecosystem and how they affect their surroundings have been collected in Paul Rhoades' article *The Importance of Bees in Natural and Agricultural Ecosystems* (2013). This article discusses the important ecological impacts that the honeybees have on an ecosystem, such as pollination, and compares it with the other pollinators and their interactions. It does not focus on the impacts that humans have on honeybees nor does it mention the causes of recent losses in honeybee colonies.

Randolf Menzel (1985), in *Learning in Honeybees in an Ecological and Behavioural Context*, explains the ecological and behavioral characteristics of honeybees, such as how they orient in the space, color learning etc. This study clarifies and is helpful in comparing the ecological connections of honeybees in the 80s and comparing them to the present time, helping experts to understand how certain beekeeping methods might affect the bee colonies.

It, however, mainly explains the honeybee behavior as an individual species and does not discuss the interactions with other pollinators or generally the surrounding ecosystem.

Vivian M. Butz Huryn (1997), in *Ecological Impacts of Introduced Honeybees*, analyses the potential impacts that introduced honeybees could have on the wild ecosystems. It suggests minor competition between the honeybees and the other wild species of pollinators. It also mentions the possibility of decreasing some floral species which do not get pollinated by the honeybees. However, it solely bases the study on potential minor effects and assumptions; it does not show any practical evidence of honeybees being introduced to an ecosystem and how that affects the abundance of local wild pollinator species.



Figure 2.2. Honeybees on a bee frame - Photo by Samar Shafiei

2.3. Conclusion

Following the increase of honeybee colony losses in the past decade, many researchers have been trying to find out the potential causes of colony collapse disorder.

Although a number of publications related to the CCD topic have already been done, still the main causes of this phenomenon and reasons why it has increased in the past years remain mysterious. Despite the various attempts to discover the main and most important factors causing and/or resulting in an increase in CCD, the real causes and also impacts of CCD on the ecosystem are yet to be discovered.

Most of the research conducted on this issue in Germany focuses on the southern parts of the country. However, the intensive weather conditions in the northern coastal areas, with high rates of precipitation and strong winds, make up a relatively different situation for beekeeping with fewer sunny days for the honeybees to collect pollen or nectar. No study so far has collected data on the recent changes in bee population in the area.

The majority of publications related to the potential causes of CCD focus on pathogens, viral diseases or pests and the use of pesticides. There have been several researches on the possible effects of pesticides on honeybee colony populations, but none certainly concludes that diseases and pesticides are the true cause of colony collapse disorder in honeybees or the reason it has recently increased. So far, there are only assumptions to many possible reasons resulting in CCD or its increase.

Additionally, most of the articles and books regarding the ecological impacts of honey bee introduction and generally what ecological functions the honeybees have in the ecosystems, are rather old and lack recent changes in the environment due to the fact that although the main functions of ecosystems remain the same, the environment changes through time.

Furthermore, there are not adequate publications covering both ecological and human-caused impacts and causes related to CCD in honeybees. In most cases, mismanagement factors have been overseen.

Therefore, further research is recommended on not only the ecological functions and importance of honeybees but also its relations to the potential causes of CCD and what consequences they will have on our environment and economy.

The current available research on this topic lacks a general overview of ecological impacts and causes of CCD and what it exactly means to humans and the economy as well as the nature surrounding them. They also lack an overview on the interdisciplinary issue and only focus on a main reason causing the bee mortalities. However, the current CCD problem seems to be more complex than only one or two reasons. Therefore, it is important to look at a combination of factors that might be causing bee population losses and step by step, target these factors.

Another point, which is ignored mostly in the current research papers, is the importance of beekeeping methods and management trends. They usually overlook the role a beekeeper plays and only focus on the surrounding environment. However, in order to keep the bee colonies healthy and strong, it is necessary to manage the beehives correctly. Therefore, this research project firstly, looks at the potential causes of CCD and secondly looks at its relationship to the beekeeping methods in the region.

Category Author Year	Beekeeping	Diseases and parasites	Nutrition	Pesticides	CCD	Honeybee biology	Ecology of bees
	T. Minor (1804)	Maryann Frazier (2011)	Dhruba Navg (2009)	Geoffrey R. Williams (2015)	Jamie Ellis (2007)	David Stone (2005)	Paul Rhoades (2013)
	Caroline B Thompson (1918)	Elke Genersch (2010)	Gloria DeGrandi-Hoffman (2015)	Jeffrey S. Petting (2013)	Stephane Kluser (2010)	Albert Needham (2010)	Randolf Menzel (1985)
	Emerson Chamb (2016)	Stephen Martin (2012)	Cédric Alaux (2010)	Francis L. W. Ratnieks (2010)	Renee Johnson (2010)	Ved Parkash Sharma (2010)	Vivian M. Butz Huvyn (1997)
		Dave Goulson (2014) & (2015)	Nancy Ostiguy (2019)	Chensheng Lu et al (2012) & (2014)	Myrna E. Watanabe (2008)	R.F.A Moritz (2000)	
				Nancy Ostiguy (2015)	Dennis Van Engelsdorp (2009)	Dennis Van Engelsdorp (2017)	
				B.A. Woodcock (2017)	Benjamin P. Oldroyd (2007)		
				Mickaël Henry (2012)	Santhosh Kumar (2018)		
				Nicola Cicero (2016)	Chenseng Lu (2020)		
				Reed M. Johnson (2010)	Marie-Claire Cammaerts (2017)		

				Hudson Tomé (2020)	Joanna Wyszkowska (2019)		
				Picó Yolanda (2019)	Zoran Stanimirović (2019)		
				Siefert (2020)	Randal R. Rucker (2019)		
					Deepali Gupta (2019)		

Table 2.2. Literature review categorized by topic

Chapter 3: Land use and beekeeping in Schleswig-Holstein

3.1. Why Schleswig-Holstein?

There are over 3,000 beekeepers registered in the Schleswig-Holstein and Hamburg region who are working as either hobby-beekeeper or as professional beekeepers. However, most of the research done on this issue in Germany mainly focuses on the southern parts of the country. One should bear in mind that the intensive weather conditions in the northern coastal areas, with high rates of precipitation and strong winds, create a relatively different situation for beekeeping with fewer sunny days for the honeybees to collect pollen or nectar. And the relatively mono-cultured structure of agriculture in the northern areas, might have an impact on the increased rates of CCD. Furthermore, studying the causes of bee population losses on a local basis is crucial in determining the specific causes of CCD.

Therefore, this thesis focuses on collecting current data from regional beekeepers in Schleswig-Holstein and partially from Hamburg. The data regarding beekeeping methods, devices, problems and bee population losses will be analyzed and the current issues, potential causes and the suggested solutions will be provided.

3.2. Agricultural structures

In Schleswig-Holstein cereals, specifically wheat, corn and rapeseed are the most common agricultural products. Average harvest rates of cereals in Schleswig-Holstein are noticeably higher than the German statistics.

Land-use		Germany	Schleswig-Holstein
Total area	ha	35.757.963	1.580.420
Agricultural area	ha	16.658.928	990.403
Agricultural area % in the total area	%	47	63
Evergreen area	ha	4.694.469	327.805
Arable land	ha	11.763.002	655.803
Total cereals	ha	6.325.023	303.721
Wheat	ha	3.201.699	188.694
Winter rapeseed	ha	1.322.681	92.817
Sugar beets	ha	334.485	7.061

Potatoes	ha	242.519	5.418
Silage corn	ha	2.137.607	165.217
Harvest results¹			
Total cereals	dt/ha	71,8	82,1
Wheat	dt/ha	76,4	89,1
Sugar beets	dt/ha	762,3	756,0
Winter rapeseed	dt/ha	34,6	31,4
Vegetables / Fruits			
Outdoor vegetables	ha	120.930	6.044
Cabbage	ha	9.224	3.199
Asparagus	ha	22.274	400
Fruit area	ha	49.934	628
Apples	ha	33.981	476
Outdoor strawberries	ha	13.337	824

Table 3.1. Agriculture in Schleswig-Holstein compared to Germany, 2016. Source: https://www.schleswig-holstein.de/DE/Schwerpunkte/Agrarstatistik/ZahlenFakten/agrarstruktur_Dossier.html?cms_notFirst=true&cms_doid=9bf68374-4554-4a5e-a147-a1d9235448ea (Last accessed on 05.07.2020)

3.3. Beekeeping in Schleswig-Holstein

Landesverband Schleswig-Holsteinischer und Hamburger Imker e.V. (LV), The Country's Association of Beekeepers in Schleswig-Holstein and Hamburg, owns 77 local associations, 11 breeder's rings and 16 district associations. As a result, it supports more than 3,000 beekeepers with approx. 25,0000 bee colonies and, as a member of the German Beekeepers' Association, represents their interests. It receives state and EU funding from the support program for improving the production and marketing conditions for beekeeping products in Schleswig-Holstein.

Some important questions and answers regarding the topic of apiculture in Schleswig-Holstein are listed below (Source: personal communication LV in Schleswig-Holstein):

¹ dt = decitonne

- How many beekeepers are active in Schleswig-Holstein?

3,378 (status 01.01.2019)

- Which types of honey are most produced in the region?

Typically, spring harvest and summer harvest are common in the region: the first extraction after Rapeseed harvest, the second extraction after Linden harvest. More information regarding other types of honey could be found on chart 5.13.

- Which types of beekeeping are the most common in Schleswig-Holstein?

The results of the questionnaire in this study show that over 90% are hobby beekeepers in Schleswig-Holstein. The Country's Association of Beekeepers in Schleswig-Holstein and Hamburg states 99% of the beekeepers registered in the club are leisure-time beekeepers. (LV archive, Last, 2019)

- How is the relationship between agriculture and beekeeping in the region?

LV strives for a good relationship and good communication between the ministry of agriculture in the region and the beekeepers' association.

- What is the rate of bee losses? And what is done against it?

10% to 20% losses per year. Beekeepers' educational courses provide the beekeepers with the latest updates on ways to fight against pests, Varroa destructor and general beekeeping methods to improve the health of the bee colonies.

Additionally, beekeepers' insurance with low annual rates, provided by the LV, makes sure the financial impacts of bee losses are minimized and provides a degree of safety and support to both hobby and professional apiculturists in the region.

- How do beekeepers educate themselves in the region?

Educational courses which are organized by the LV in Bad Segeberg and taught by Jörg Pardey. The center of beekeepers' school is located in Celle. There are several courses offered every year and the fees are relatively low.

- What types of financial support exist in Schleswig-Holstein?

48,600 € per year which includes 50% support from the EU and the other 50% from federal state resources.



Figure 3.1. The LV in Schleswig-Holstein, Bad Segeberg – Photo by Samar Shafiei

3.4. History of beekeeping

3.4.1. Beginning of beekeeping

The name of honeybee, *Apis mellifera*, was chosen by Linné in 1758 and means “the honey-bearing bee” (Thomeier, 2006).

The first discovered bees are related to enclosed animals in amber stones dating back to approximately 50 million years ago. They resemble present-day bees and probably already lived in colonies at that time. The oldest depiction discovered so far is roughly 12,000 years old, found in a cave painting near Valencia in Spain. It shows a woman on a rope ladder with a basket and a bee smoker surrounded by bees. At that time, it was already commonly practiced harvesting honey (Thomeier, 2006).

How and when humans started eating honey is unknown. It could be that humans had already found abandoned honeycombs during Paleolithic. It is also conceivable that they observed animals taking honey from the bee colonies and imitated them. Honey was the only real sweet substance that people knew at that time as there was no other sugar then; exceptions were occasional fruits, which were often eaten unripe (Thomeier, 2006).

The fact that bees were something special in many cultures can be seen from many historical monuments. As an example, the symbol for rulers in Egypt was the bee (3000 B.C.).

The city of Ephesus issued silver coins with a bee in the 6th century B.C. The bees were a symbol for fertility and reproduction. The church also used bees; the pope's coat of arms of Urban VIII. (1640) pictures three bees.

Beekeeping in central Europe started in bees' habitat, the forest. Thus, the first beekeepers in Germany were "forest beekeepers" and were called "Zeidler" in German language, which comes from Slavic "Zidaln" and means "cutting down the honeycombs". As a last name, Zeidler is nowadays more common in eastern parts of Germany. The first laws regarding forest beekeeping in Lower Saxony are known to be approximately 1,000 years old (Thomaier, 2006).

People found a radical remedy against the strict rules and the insufficient honey harvest. They sawed the hives from the trees and resettled the bee colonies. This way, block hives and beekeepers were developed (Thomaier, 2006).

3.4.2. Beehives

Today's beekeeping in Germany is mainly carried out in hives with frames. (An exception is the heath beekeepers (Heideimker), who continue to use straw baskets.) The inventor of the movable honeycombs was the priest Johannes Dzierzon from Karlsmarkt in Silesia. Nowadays, beehives are built of wood, or as of recently, pressed from polystyrene (Thomaier, 2006). Polystyrene hives last much longer than the wooden ones, are lighter in weight and the watercolor used on them to protect them against UV does not leave traces in the honey or wax. Colonies in polystyrene hives remain warmer throughout the winter, they build up about three weeks before the other colonies in wooden hives and they start flying earlier in the day. As a result, bee colonies in polystyrene hives produce about 25% more honey than in wooden hives (<http://www.beehivesupplies.co.uk/PDF/Polystyrene%20Beehives%20Key%20Facts.pdf>). The most common hive used in northern Germany was developed in Segeberg and is called "Segeberger Beute".





Figure 3.2. Some traditional beehives - Photos by Samar Shafiei, from the beekeeping school in Segeberg

3.4.3. Bee species in Germany

Originally, the dark European bees (*Apis mellifera mellifera*) were native to the region. Their habitat began from north of the Alps and stretched north to Scandinavia and even east to the Urals. South of the Alps is the distribution area of the Carniolan bees (*Apis mellifera carnica*). In contrast to the dark bees, which are also called "forest bee" in Eastern Europe the "Carnica" is called "mountain bee." The triumph of the Carnica in Germany began around 1860. In comparison with the dark bee they were just as vital, very swarming, but clearly calmer and more peaceful (Thomaier, 2006).

3.4.4. History of beekeeping in Schleswig-Holstein

Human beings and bees have a long history of interactions. Honey robbing has been ongoing for a long time before the beginning of actively keeping bees for the purpose of honey extraction (Kritsky, 2017). In northern Germany, similar to the rest of central Europe, honey and wax were among the major trade commodities in early middle ages (Kritsky, 2017). Therefore, forest beekeeping, which has evolved from honey hunting from wild nests in natural tree cavities, developed in central and eastern European woodlands, including Germany during the middle ages (Kritsky, 2017). Ever since, beekeeping has been established in the region and the bee products have been used throughout the history of mankind industrialization. Around 150 years ago, LV in Schleswig-Holstein was established (Figure 3.3 illustrates the first newsletter from the Country's Association of Beekeeping in Schleswig-Holstein, dated back to 1872).

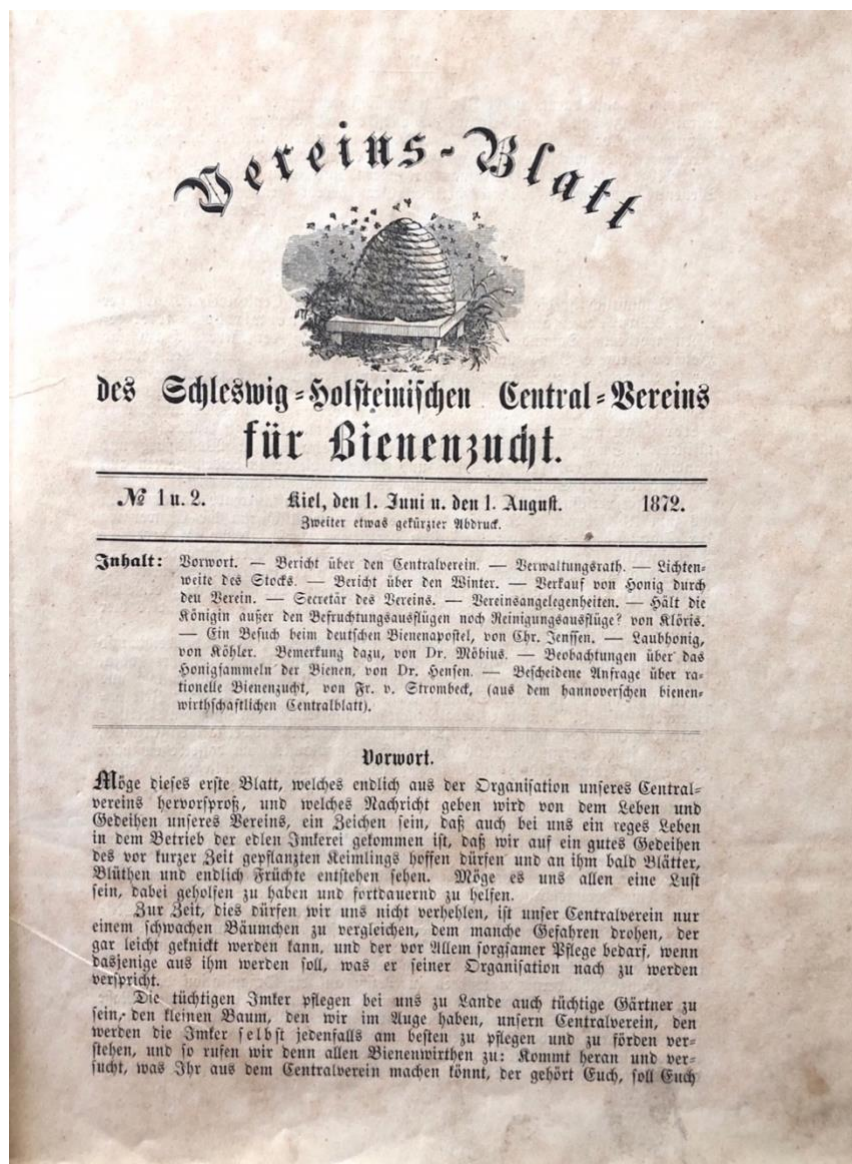


Figure 3.3. First newsletter of the LV in Schleswig-Holstein, 1872 - Photo by Samar Shafiei

The data collected from the archive of LV in Schleswig-Holstein indicates a general decrease in the number of beekeepers, which are members of this association, in the past 95 years. As seen on table 3.2, the association had 5,895 members and 65,863 bee colonies in 1924, which has dramatically reduced to 3,378 members and 28,847 bee colonies in 2019. During 1977 and 1981, 10 clubs based in Hamburg have left the association in Schleswig-Holstein and started their own association in Hamburg. Nevertheless, the number of beekeepers has been declining for several decades until 2011. Since 2011, the number of new beekeepers and bee colonies have been increasing. This could be due to a rise in awareness of the public in bees' importance and more interest in preserving the environment and the bees.

Year	Members	Colonies	Harvested honey in kg	Members' growth	Members' growth rate %	Colonies per beekeeper
1924	5,895	65,863		5895		11
1925	5,477	63,654		-418	-7.09	12
1926	5,004	60,524		-473	-8.64	12
1927	4,602	59,344		-402	-8.03	13
1928	4,154	52,666		-448	-9.73	13
1929	3,633	48,453		-521	-12.54	13
1930	3,758	59,312		125	3.44	16
1931	3,109	56,580		-649	-17.27	18
1932	3,225	38,115		116	3.73	12
1933	3,270	40,615		45	1.40	12
1934	4,812	57,265		1542	47.16	12
1935	4,520	55,041		-292	-6.07	12
1936	5,233	65,473		713	15.77	13
1937	5,659	75,332		426	8.14	13
1938	6,144	82,529		485	8.57	13
1939	6,339	90,322		195	3.17	14
1940	7,666	100,969		1327	20.93	13
1941	7,826	95,441		160	2.09	12
1942	8,271	95,130		445	5.69	12
1943	8,732	100,863		461	5.57	12
1944	8,816	100,627		84	0.96	11
1945	8,067	95,604		-749	-8.50	12
1946	9,664	87,008		1597	19.80	9
1947	9,760	83,756		96	0.99	9
1948	10,171	90,208		411	4.21	9
1949	10,414	100,084		243	2.39	10
1950	10,249	112,849		-165	-1.58	11
1951	10,169	121,165		-80	-0.78	12
1952	9,435	112,906		-734	-7.22	12
1953	8,450	76,710		-985	-10.44	9
1954	7,883	88,085		-567	-6.71	11
1955	7,079	75,647		-804	-10.20	11
1956	6,502	67,627		-577	-8.15	10
1957	6,368	69,750		-134	-2.06	11
1958	6,364	71,622		-4	-0.06	11
1959	6,296	72,078		-68	-1.07	11
1960	6,248	71,343		-48	-0.76	11

1961	6,087	70,140		-161	-2.58	12
1962	5,872	66,096		-215	-3.53	11
1963	5,699	66,669		-173	-2.95	12
1964	5,560	65,325		-139	-2.44	12
1965	5,405	62,656		-155	-2.79	12
1966	5,193	58,383		-212	-3.92	11
1967	4,889	54,494		-304	-5.85	11
1968	4,632	54,894		-257	-5.26	12
1969	4,426	53,993		-206	-4.45	12
1970	4,181	48,655		-245	-5.54	12
1971	3,950	45,000		-231	-5.52	11
1972	3,798	44,126		-152	-3.85	12
1973	3,662	42,769		-136	-3.58	12
1974	3,524	40,390		-138	-3.77	11
1975	3,483	39,275		-41	-1.16	11
1976	3,419	37,034		-64	-1.84	11
1977	3,321	37,116		-98	-2.87	11
1978	3,147	35,578		-174	-5.24	11
1979	3,137	34,140		-10	-0.32	11
1980	2,977	32,295	695,400	-160	-5.10	11
1981	3,013	32,169		36	1.21	11
1982	2,834	30,117		-179	-5.94	11
1983	3,002	30,930		168	5.93	10
1984	3,209	34,499		207	6.90	11
1985	3,306	35,476		97	3.02	11
1986	3,338	34,770		32	0.97	10
1987	3,397	35,685		59	1.77	11
1988	3,417	36,227		20	0.59	11
1989	3,439	36,042		22	0.64	10
1990	3,483	36,105	772,100	44	1.28	10
1991	3,374	35,254		-109	-3.13	10
1992	3,352	34,297		-22	-0.65	10
1993	3,310	33,317		-42	-1.25	10
1994	3,251	31,784	1,754,476	-59	-1.78	10
1995	3,188	30,191	1,234,812	-63	-1.94	9
1996	3,101	28,331	745,000	-87	-2.73	9
1997	3,037	26,667	760,000	-64	-2.06	9
1998	2,962	25,969	577,920	-75	-2.47	9
1999	2,944	25,800		-18	-0.61	9
2000	2,920	25,589	1,072,179	-24	-0.82	9

2001	2,828	25,175	755,250	-92	-3.15	9
2002	2,792	24,656	862,960	-36	-1.27	9
2003	2,698	23,439	369,840	-94	-3.37	9
2004	2,606	22,845	731,197	-92	-3.41	9
2005	2,506	22,875	1,128,528	-100	-3.84	9
2006	2,626	23,432	1,150,324	120	4.79	9
2007	2,471	23,127	716,937	-155	-5.90	9
2008	2,447	21,114	879,340	-24	-0.97	9
2009	2,435	20,823	859,990	-12	-0.49	9
2010	2,536	21,202	1,020,297	101	4.15	8
2011	2,534	21,176	823,746	-2	-0.08	8
2012	2,650	20,941	747,594	116	4.58	8
2013	2,724	20,886	622,403	74	2.79	8
2014	2,736	21,216	842,750	12	0.44	8
2015	2,953	22,093	799,000	217	7.93	7
2016	2,980	23,986	923,460	27	0.91	8
2017	3,097	25,904	878,146	117	3.93	8
2018	3,218	27,029	1,262,254	121	3.91	8
2019	3,378	28,847	894,257	160	4.97	9

Table 3.2. Number of members and colonies recorded in the states' association of beekeepers in Schleswig-Holstein throughout the history
Source: Archive of LV in Schleswig-Holstein

The LV in Schleswig-Holstein has been actively publishing monthly newsletters regarding beekeeping in the region since June 1872. Their archived data, containing every month's issues of beekeeping newsletter ever since the first publication, are available at the library of the association in Bad Segeberg.

As an instance, the following text is a part of a report from the first published newsletter in June 1872:

“Reports on the winter:

Wintering stand Association Oldenburg: 200 hives

Of which succumbed in winter: 10 hives

Queenless: 9 hives

Wintering stock: 181 sticks

Among them only 9 weak colonies”

Some more impressions from the newsletter’s archive could be seen at the end of this chapter.

Currently, the new version of the newsletter is called “Bienenzucht” and has been edited by Hans-Joachim Tödter since 2002.

Postverlagsort: Heide (Holst.)



Fachschrift der Landesfachgruppe Imker Schleswig-Holstein
Druck u. Verlag: Westholsteinische Verlagsanstalt Boyens & Co., Heide i. Holst.

Nr. 10

Januar 1943

46. Jahrg.

Unter dem wärmenden Strohdach dämmern unsere Bienen einem neuen Frühling entgegen



Bienenstand des Imkerkameraden W. Molt in Kofel über Eternförde

Malz. W. Molt



Nordwestdeutsche Bienenzeitung

GEMEINSCHAFTSZEITSCHRIFT AUS
 Der Niedersächsischen Imker-, Imker aus Thüringen-, Sachsen-Anhaltische Bienenzeitung,
 Schleswig-holsteinische Bienenzeitung-, Unf'Immen' und Westfälische Bienenzeitung

1. Jahrgang
Erscheint am 1. jeden Monats in Heide in Holstein
April 1943

Der Krieg erfaßt alle und alles

Von Kichhoffel, Geschäftsführender Präsident der Reichsfachgruppe Imker

Unter dieser Überschrift betonte ich schon im Sommer vorigen Jahres die Notwendigkeit auch für die Bienenwirtschaft und die Imker, sich im gesamten Lebensbereich auf den totalen Krieg einzustellen. Mit dieser Nummer erhält nun jeder Imker mit geringen Abnahmen nicht mehr seine altgewohnte Zeitschrift, sondern das Blatt, das auf Grund des totalen Kriegereinsatzes für mehrere Blätter erscheint. Von den 2500 perlektionspflichtigen Zeitschriften bleiben rund 1500, aber zusammengefaßt und meist mit Einschränkung des Umfangs und der Erscheinungshäufigkeit. Die dadurch freiwerdenden Kräfte und Rohstoffe werden in unmittelbarem Dienst des Krieges gestellt.

Diese Vereinfachungsmaßnahmen während des Krieges müssen recht verstanden werden, um sie so zu tragen und zu gestalten, daß sie unserem Einsatz zum deutschen Siege im Fühlen, Denken und täglichen Tun nicht hemmen, sondern stärken. Die Bienenwirtschaft ist dabei in Würdigung aller sachlichen Gegebenheiten besonders vorsichtig und entgegenkommend behandelt worden. Während eine Wirtschaftsgruppe in der Regel nur eine Zeitschrift behalten darf, sind uns Imkern 8 Zeitschriften zuerkannt worden: Der Deutsche Imkerführer als das Hauptblatt für die Führung, 6 Gebietszeitschriften für die zweckmäßigste Umwertung aller Leitungsmaßnahmen in gebietliche Anweisungen und Hilfen und daher in Form, Inhalt, Mitarbeitererschaft und Leserschaft je einem großen Gebiete besonders verbunden, und eine gebietsfreie Zeitschrift, die sachlich und zeitlich besonders herauszustellenden Arbeiten zu dienen hat.

Blüte und Biene und damit Voben, Wetter, Weide und Biene gehören eng zusammen. Was in der rheinischen Ebene gut ist, kann im Nordosten des Reiches untragbar sein. Diese Erkenntnis begründet die jetzige Regelung. Sie ist, soweit Leser sie auch von ihrer liegewardenen Zeitschrift trennt, im Hinblick auf die Gesamtlage doch so, daß wir Imker dankbar sein müssen. Mit allen Schriftleitern, Mitarbeitern und Lesern der Zeitschriften, vor allem auch die Verbandsführung mit allen ihren Gliederungen, wollen nun helfen, daß durch die kriegsnotwendige Zusammenfassung keine Leistungsenkung, daß aus der Beschränkung keine Verschärfung wird, sondern daß das bienenwirtschaftliche Zeitschriftenwesen auch in Zukunft seiner Aufgabe, der Leistungssteigerung, gerecht wird. Diese aber ist notwendiger denn je. Die immer rächer wachsende Erkenntnis der innigen Beziehung von Biene und Blüte machen aus unseren 400 000 Bienenständen immer mehr Verstäubungsstätten wichtiger Nutzpflanzen zur Sicherung von Samen und Frucht, und damit von Fett, Fleisch und anderen hochwertigsten Nahrungsmitteln. Hier zu helfen, von der so notwendigen Bewanderung des Kapses bis hin zur weiteren Durchführung dieser Erkenntnis im täglichen Tun des Pflanzendanes ist neben der stetigen Verbesserung der Betriebsweise und der erfolgreichen Abwehr und Bekämpfung der Krankheiten und Schädlinge der Biene und ihrer Erzeugnisse die Hauptaufgabe unserer Zeitschriften auch im Kriegsgewande.

Wenn wir das recht erkennen und danach handeln, so dienen wir dem deutschen Siege, der dann Raum geben wird auch für Gestaltung und Entfaltung des bienenwirtschaftlichen Zeitschriftenwesens.

An unsere Leser! Mit der vorliegenden Nummer erhalten unsere Leser die neue Gebietszeitschrift für die Landesfachgruppen Mecklenburg, Niederachsen, Sachsen-Anhalt, Schleswig-Holstein, Thüringen und Westfalen. Wir werden uns bemühen, alle Wünsche unserer Leser, soweit das möglich ist, zu erfüllen. Da die bewährten Mitarbeiter der bisherigen Landesfachgruppen-Zeitschriften sich zum großen Teil schon zur Mitarbeit bereitwillig haben, finden unsere Leser altvertraute Namen auch in der neuen „Nordwestdeutschen Bienenzeitung“ wieder. Hinzu kommen weitere Mitarbeiter, deren Namen allen deutschen Imkern bekannt sind, so daß wir hoffen, unsern Lesern eine Zeitschrift bieten zu können, deren Inhalt allen gefallen wird.

Gemeinschaftsverlag und Schriftleitung.

Figure 3.4. The beekeepers' association in Schleswig-Holstein newsletter from the time of WWII (1943) Source: Archive of the beekeeping school in Segeberg



Figure 3.5. Some more examples of the newsletter

Die Landesverbands-Vorsitzenden



Detlef Breiholz (1864-1929)

- seit 1920 Leiter des Schleswig-Holsteinischen Imkerbundes
- seit 1921 Leiter des Preußischen Imkerbundes
- seit 1922 Präsident des Deutschen Imkerbundes
- 25 Jahre Schriftleiter der Bienenzeitung für Schleswig-Holstein
- Wegbereiter für qualifizierte Schulung der Imker. Dies führte zur Gründung der Schleswig-Holsteinischen Imkerschule, der ältesten in Deutschland.
- Mit Prof. Dr. Koch Gründer des Forschungsausschusses des DIB
- Mit Wahl/Neumünster der Wegbereiter des Einheitsglases des DIB

Reproduktion Horst Rodig



Hermann Preim

Landesverbands-Vorsitzender von 1930 - 1956



Tesmar von Bonin

Landesverbands-Vorsitzender von 1981 - 1988



Irmgard Tietgen

Landesverbands-Vorsitzende von 1988 - 1993



Hans-Sönke Hansen

Landesverbands-Vorsitzender seit 1993

Figure 3.6. Presidents of the LV in Schleswig-Holstein

Source: The LV in Schleswig-Holstein, Anke Last (2017)

Chapter 4: Methodology

For the purpose of this dissertation, a questionnaire, containing 21 questions was designed with the help of a several new and old local beekeepers, to add their field of interest (please refer to chapter 5 for the specific questions). This survey is divided into two parts: general questions about the beekeepers, such as number of bees and their equipment for the first part, and the second part includes technical questions regarding deeper beekeeping methods, bee-losses, issues and requests. These questions include a variety of perspectives related to the topic, but primarily focuses on the main research hypothesis, beekeeping methods and bee-losses.

4.1. Why Questionnaires?

The ultimate reason for questionnaires being chosen as a means of collecting data for this thesis, is that it is a useful method to investigate patterns and frequencies, user needs, expectations, perspectives, priorities and preferences; moreover, these surveys are easy and practical to use.

For the matter of this research project, up-to-date data is needed from the local beekeepers to analyze the recent development of colony collapse disorder in honeybees in the region. Furthermore, the common local beekeeping methods and management trends could be easily patterned using a questionnaire. And finally, specific problems, requests, wishes and needs the beekeepers have could be determined.

Therefore, recent information should be collected from the individuals who report their bee population losses. Only this way could the current status of honeybee population loss on a local basis be determined. So far, no survey or paper has covered this type of information in the region, and is the information needed for this project is not available anywhere else in books or research papers.

4.1.1. Advantages of questionnaires:

Like any other method, using questionnaires as a means of collecting data has both pros and cons. Here is a suggested list of potential reasons why questionnaires are a good way to collect and later process data in the research field:

The main advantages of questionnaires are: (<http://www.evalued.bcu.ac.uk/tutorial/4a.htm>)

- They are relatively easy and straightforward to analyze;
- They are familiar to authorities;
- A large sample of the given population can be contacted at relatively low cost;
- They are simple to administer;
- The format is familiar to most respondents;
- They are usually simple and quick for the respondent to complete;
- Information is collected in a standardized way;
- They can be used for sensitive topics which users may feel uncomfortable speaking to an interviewer about;
- Respondents have time to think about their answers; they are not usually required to reply immediately;
- They are suitable for evaluating trends, frequent patterns and requests.

4.1.2. Disadvantages of questionnaires

On the other hand, some negative points about working with questionnaires are as follows: (<http://www.evalued.bcu.ac.uk/tutorial/4a.htm>)

- If a particular question is forgotten, you cannot usually go back to anonymous respondents;
- It could be at times difficult to obtain a sufficient number of responses;
- People with an interest in the subject may be more likely to respond, hence the samples are selective;
- Questionnaires may appear impersonal;
- Questions may be incorrectly completed, misunderstood or not answered honestly;

- Respondents' answers to the questions are their personal ideas and the answers are subjective;
- They are not suitable to investigate long, complex issues;
- Questionnaires are not suitable for all types of respondents, e.g. visually impaired people;
- They may require follow up research to investigate issues in greater depth and identify ways to solve problems highlighted;

4.2. Designing the questionnaire

The first step in determining which questions should be asked in the questionnaire was to find out what information is required to answer the key questions in this research project.

In order to design the questionnaire, a list of relevant keywords and questions regarding the thesis theme have been prepared, and with the help of a couple of beekeepers, the list of questions has been compiled. The questions related to the topic of this project were intended to address current topics and issues including common beekeeping methods, management trends in the region, types of beekeeping, beekeeping equipment, main issues and problems faced by the farmers, bee losses in the recent years and the reasoning behind these losses, how the beekeepers resolve these issues, if and how they feed the bees, how apiculturists fight Varroa and what requests and wishes they have.

Altogether, a total of 21 questions were selected covering the aforementioned topics to obtain a common idea of colony collapse disorder trends in Schleswig-Holstein, and how this issue is related to the beekeeping methods. These questions are categorized in two groups:

- A. General questions related to the beekeeping equipment, methods and types of beekeeping.
- B. Technical questions regarding the bee population losses, fighting Varroa, feeding the bees, trends of bee losses and other specific issues pertaining to beekeeping methods.

The questionnaire was designed in a way to be easily understood by both beekeepers and readers with only a basic overview of beekeeping. Please refer to chapter 5 for the list of questions, why each question was relevant to our topic and for results.

4.3. Collecting data

The methods of data collection, for this research project were electronic and personally administrated. The common benefits of using online or electronic methods include low cost, high speed, respect for the environment, ability to build a rapport with the respondents and low staff-time required. However, not all beekeepers have access to internet. Therefore, in order to have a broader range of responses, some of the data was obtained in person. This method had its own advantages, such as higher response rate, detailed questions and ability to elaborate on necessary topics. Personally, meeting the farmers, also allowed for the building of an individual rapport with respondents, and just as well allowed access to a larger group of audience. (<http://www.evalued.bcu.ac.uk/tutorial/4a.htm>)



Figure 4.1. Weekly market in Kiel Exerzierplatz - Photo by Samar Shafiei

The first step after designing the questionnaire, was determining the audience for the questionnaire and searching for some local organizations dedicated to the beekeeping, such as beekeeping clubs.

An online version was sent to a group of clubs and beekeeping schools via email. Afterwards, I took part at a couple of workshops and events such as “Kielerhonig- workshop” about bee-products, German beekeeping day event, Nord life sciences conference, Environmental toxicology courses from UKSH as well as several others pertaining to the topic. Afterward, I familiarized myself with the local honey providers in the weekly market, followed by participating in a series of monthly get-togethers of regional beekeepers and got the chance to personally interact with many beekeepers with varying degrees of experience and expertise. Finally, I participated in the *Beekeeper Day in Schleswig-Holstein and Hamburg*, which was a massive event, held by the local beekeeping clubs and the Segeberger Beekeeping School. There, I got the chance to distribute the questionnaires among over a hundred local beekeepers.



Figure 4.2. Beekeeper’s Day in Schleswig-Holstein - Photo by Samar Shafiei

At the aforementioned summit in Neumünster, I introduced my work and heard feedbacks from a total of 105 beekeepers. After analyzing the questionnaires and responses, 97 questionnaires were chosen, since they had answered every question. This dissertation is based on the comparison and analysis of these 97 questionnaires.



Figure 4.3. Beekeeper's day in Schleswig-Holstein - Photo by Samar Shafiei

The questionnaires were firstly distributed personally among local beekeepers in weekly markets. Then, several questionnaires were sent online via email to a group of beekeepers from regional beekeeper clubs in different towns in Schleswig-Holstein. Then, I participated personally in several of their monthly meeting events in Kiel and Neumünster and got the opportunity to speak with the beekeepers in person, and I distributed more copies of the questionnaire personally. I also met a couple of local beekeepers on a regular basis to discuss the thesis and the questions more often, and to collect some more information on their greatest concerns, as well as beekeeping and management methods. They also helped me find other ways to contact more beekeepers in the region.

Afterwards, I took part in the annual meeting of beekeepers in Schleswig-Holstein and Hamburg called *The Beekeeper Day*, where I personally distributed the greatest number of questionnaires. Finally, after reading through the answered questionnaires, 97 questionnaires which had clear and completed answers were selected to work on.

The next step after collecting data from the regional beekeepers, was to categorize the data and conduct an analysis using a Microsoft Excel. For this matter I also improved my abilities with Excel through participating in a weekly course on Excel, and also on data management.

As the next step, quantitative responses of each question were analyzed using graphs. Afterwards, the graphs were assessed, and categorized questions and answers were then interpreted. Please refer to chapter 5 for answers and graphs and chapter 6 for the interpretation.



Figure 4.4. Nord Life Sciences Conference in Kiel, 2017

Furthermore, in order to collect some data regarding the trends of bee losses and beekeeping history in the region, I made a trip to Bad Segeberg, where the head of the beekeeping school is located, and I observed their archive collected from the last several decades. Other data regarding the agricultural structures in the region were collected with the help of the environmental ministry in Kiel. Through these methods, a broad vision into regional structures and history of beekeeping was obtained, to compare with the recent data collected from the questionnaires.

Finally, after studying the common reasons of untimely deaths in the bees around the world, a comparative study on the beekeeping methods and its relation to the honeybee losses in Schleswig-Holstein, in particular Colony Collapse Disorder, was put together to determine the main reason behind CCD in the region, compared to the increasing international rates of bee-colony losses.

And at the end, possible solutions and methods of improvement in order to decrease the number of bee-losses have been suggested.



Figure 4.5. Traditional beehives vs. modern standard ones on the left

A photo from the German beekeeping day in Bremerhaven - Photo by Samar Shafiei

Chapter 5: Answers and results of the questionnaire

5.1. Questionnaire

The questionnaire, which was used in this research to ask the relevant questions from the beekeepers in Schleswig-Holstein is presented below.

Beekeeping in Schleswig-Holstein and CCD development

A. General questions

Age: Sex: Location of the beehives: Education:

1. Why are you interested in beekeeping?
2. How many beehives do you own?
3. How long have you been keeping bees?
4. Have you noticed any major changes in bee populations recently?
5. What are the main problems you are facing in the recent years?
6. Do you keep bees as a hobby or as a job?
7. Are your hives stationary or mobile? If mobile, how often and how far do you move them?
8. What kind of hives (size and frames) do you have?

B. Technical questions

9. Are the queens purchased locally or from abroad?
10. Do you re-queen your hives? If so, how often?
11. What race of bees do you keep?
12. Do you treat for Varroa destructor? If so, how?
13. What kind of honey do you produce?
14. What are the main causes of loss you have been experiencing?
15. What percentage of stock loss have you had per year?
2010: 2011: 2012: 2013: 2014: 2015: 2016: 2017:
16. How do you supplement feed, if you do so?
17. Do you ever lease your bees for pollination? If so, what crops?
18. Do you also harvest other products? If so, other products?
19. What do you expect in the future development of beekeeping? (personal or general expectations)
20. Do you suggest any changes of land use to improve the situation of beekeeping?
21. Do you have any requests or suggestions?

5.2. Distributing the questionnaires

For the purpose of this research, questionnaires consisting of 21 questions were distributed to beekeepers in Schleswig-Holstein and were completed by 97 participants. The beekeepers were drawn co-selected and requested to participate in this research on different occasions including the weekly markets in Kiel, monthly meetings of beekeepers' club in Kiel, annual summit of Schleswig-Holstein and Hamburg beekeepers, and also via online as well as personal contacts through the local beekeepers in the region. After collecting information and gathering the required data, Microsoft Excel has been selected as the means of processing our data and producing tables, charts and graphs. Finally using a statistical analysis, the collected data has been analyzed in order to proceed with the research project and draw conclusions from the resulting data. Meanwhile, the collected information was briefly compared with the existing historical information in the region and the literature review of similar studies within Germany, Europe and worldwide. Finally, in addition to the analysis of results, some suggestions and possible solutions for the existing issues have been provided to improve the situation of beekeeping in the region.

5.3. Answers

A. General questions

1. Why are you interested in beekeeping?

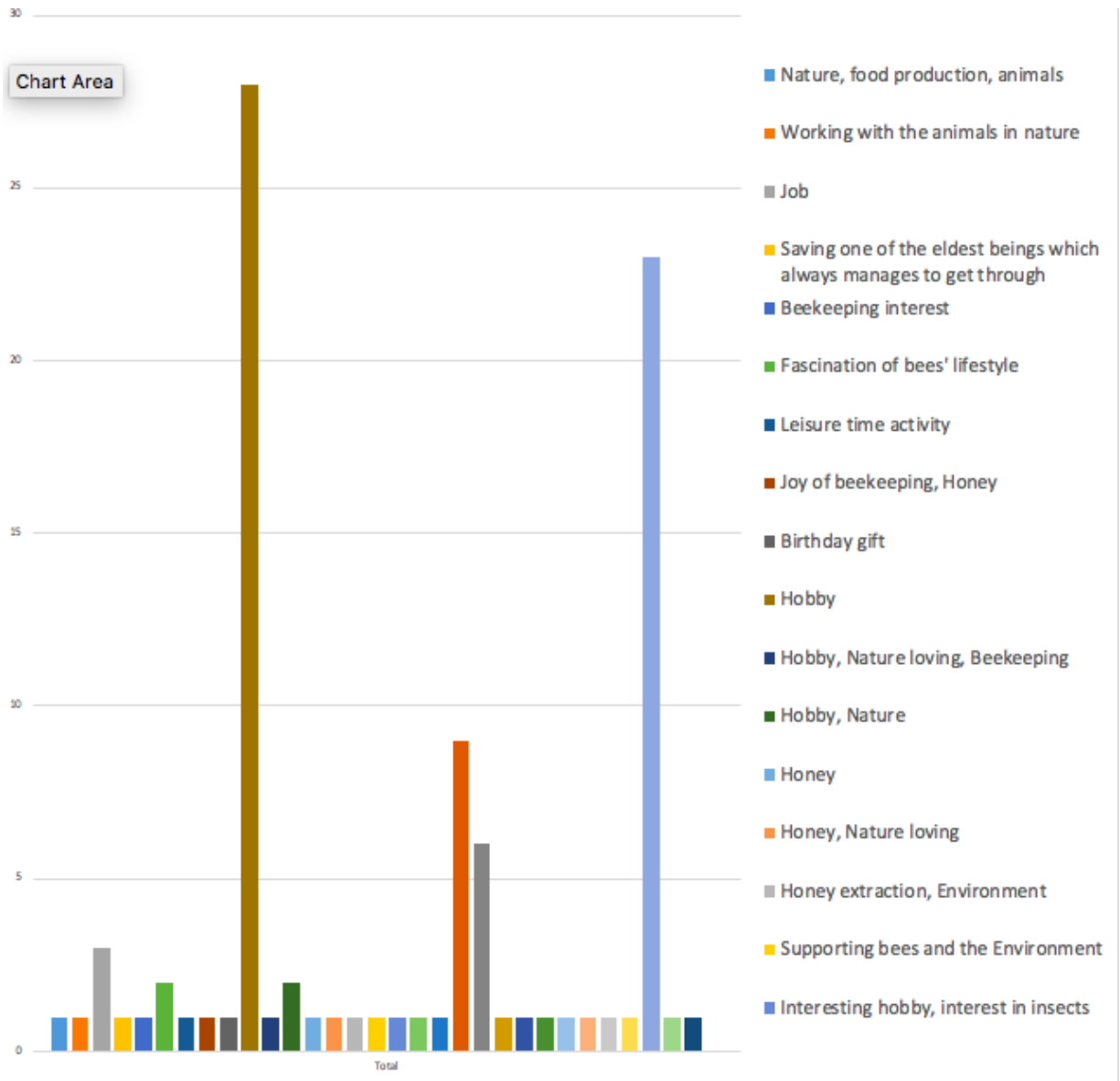


Chart 5.1. Reasons behind beekeepers' interest in beekeeping in Schleswig-Holstein

Most beekeepers in Schleswig-Holstein are interested in beekeeping as a hobby and leisure time activity (over 81%), followed by the second largest group which are concerned about the environment and nature. For these reasons, they have chosen beekeeping as a voluntary activity to support sustainability and the bees and hence protect agriculture and the ecosystems. Around 10% of beekeepers do so to follow their parents' footsteps and keep the family tradition. Only about 9% consider beekeeping as the main source of income.

Compared to the EU, where around 76.4% of beekeepers are "hobby beekeepers", the number of local nonprofessional beekeepers in the northern region of Schleswig-Holstein is slightly higher (Chauzat, 2013).

2. How many beehives do you own?

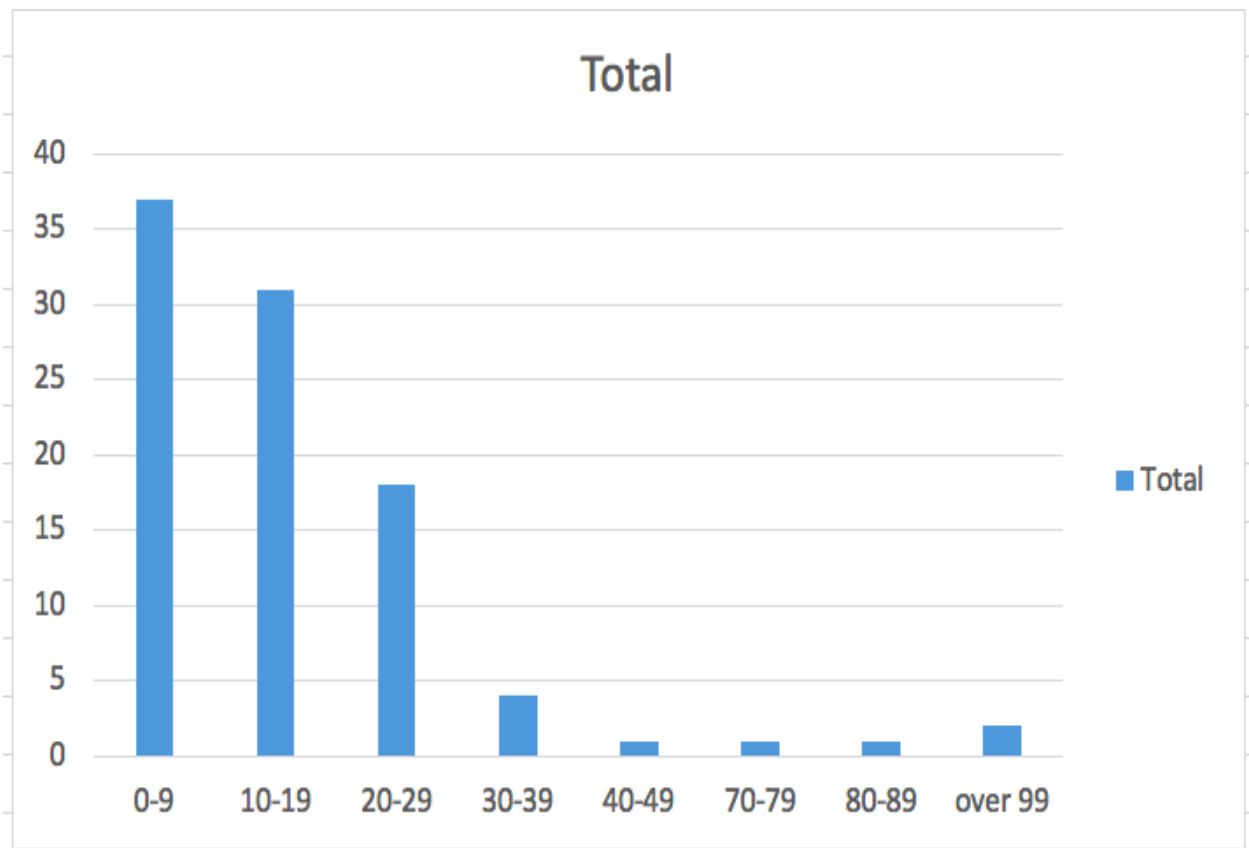


Chart 5.2. Number of beehives owned by beekeepers in Schleswig-Holstein

The majority of beekeepers (67%) possess less than 20 beehives. About 18% own between 20 and 30 beehives and only 2% manage over 100 beehives.

The European average number of bee-colonies per beekeeper is 22.4 colonies which is considerably higher than the northern German statistics (Chauzat, 2013).

This differential could be due to the fact that majority of apiculturists in the region are hobby beekeepers who look at this activity as a leisure time practice. They are mostly seniors and pensioners who love spending their spare time in the nature and therefore, choose to look after a few bee colonies, rather than taking care of many beehives. They also do not feel the security to invest in many hives, since they are not sure about the financial outcome.

3. How long have you been keeping bees?

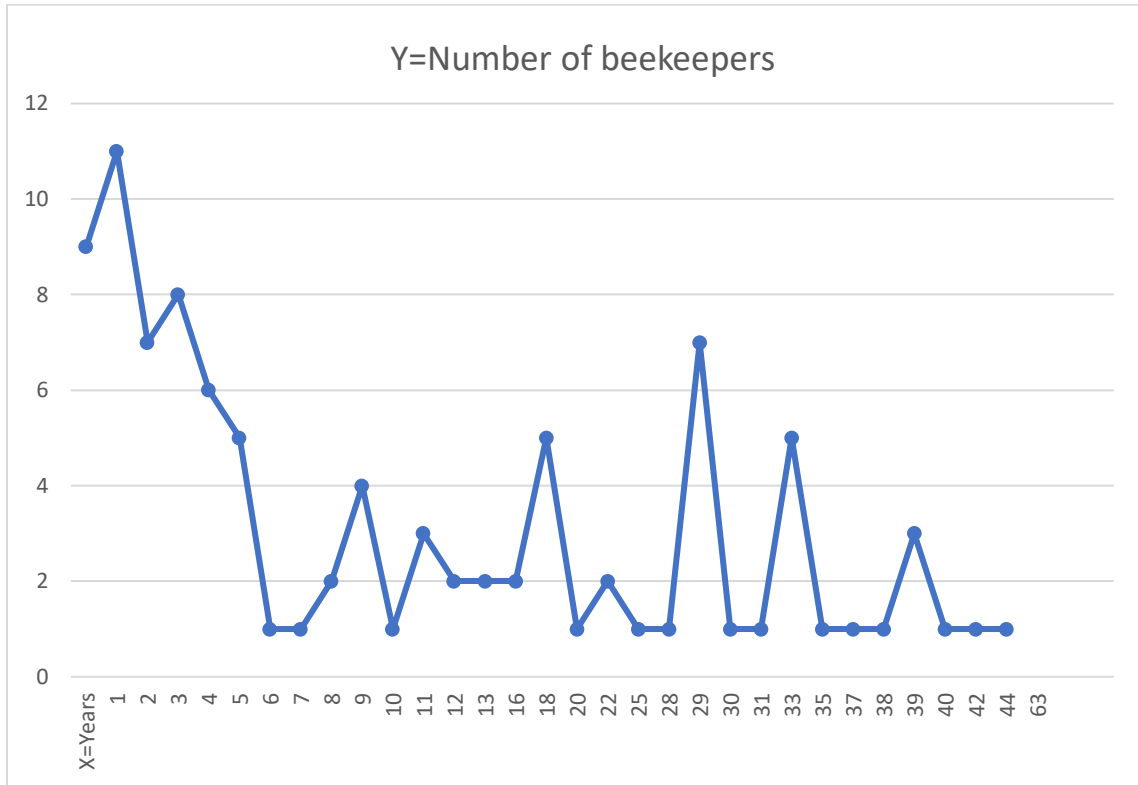


Chart 5.3. Count of beekeeping years by individual beekeepers in Schleswig-Holstein

About 40% of beekeepers have been practicing beekeeping for 5 years or less. The rate decreases to ca. 13% for those who have between 5-10 years of experience. 16% have gathered 10 to 20 years of experience and 22% have been beekeeping for over 30 years.

This information shows us that in the recent years, more people have become aware of the importance of the bees in the ecosystem and generally for the environment. Fortunately, the media and researchers have drawn more attention towards the problem of CCD and how the consequences could affect human lives both directly and indirectly. Thus, there is a new wave of young people who exhibit interest in beekeeping as a free time hobby. As the number of years which an individual beekeeper has been practicing keeping bee colonies increase, the statistics naturally drop. In past decades mostly elderly have been keeping bees and in the recent years, their generation will have aged and decreased in population.

4. Have you noticed any major changes in bee populations recently?

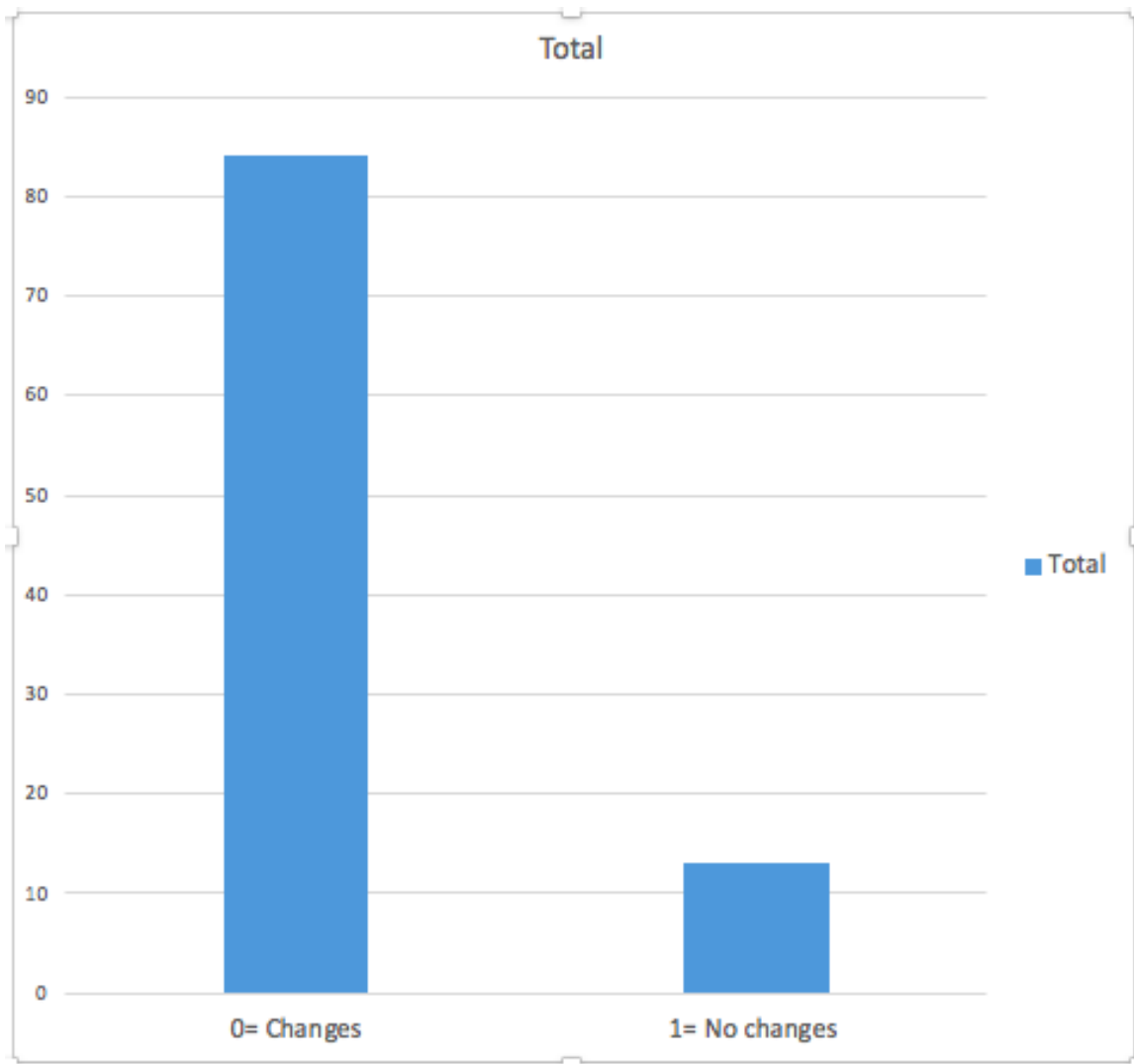


Chart 5.4. Changes in bee populations in Schleswig-Holstein

The majority of beekeepers (more than 88%) have recognized changes in the bee populations in the recent years.

5. What are the main problems you are facing in the recent years?

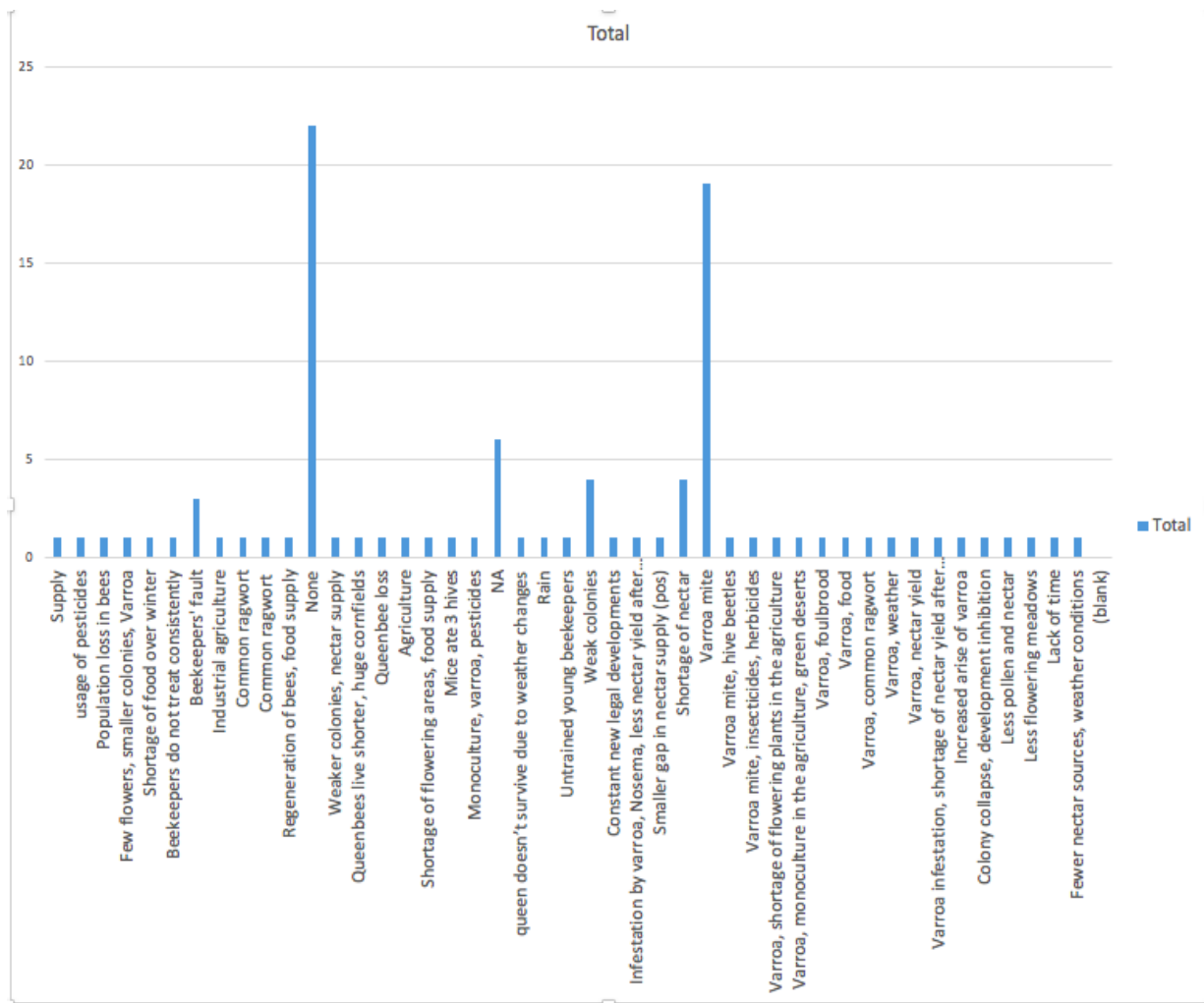


Chart 5.5. Main problems of beekeepers in Schleswig-Holstein

The majority of beekeepers in the region have declared the Varroa mite as the main issue in the recent years, followed by weakened bee-colonies and beekeeping mistakes. As a comparison, main causes of colony mortality reported by European beekeepers in 2010, include diseases, Varroa, poisoning and general problems (Chauzat, 2013).

It could be due to the fact that the media has been informing people about the Varroa and chemicals on one hand, and biasing people on the other hand, that these could be the only reasons why bees have been disappearing around the world. The truth is, however, that also other factors such as mismanagement, monoculture, global warming and other ecological factors could be in charge of the mass bee losses.

6. Do you keep bees as a hobby or as a job?

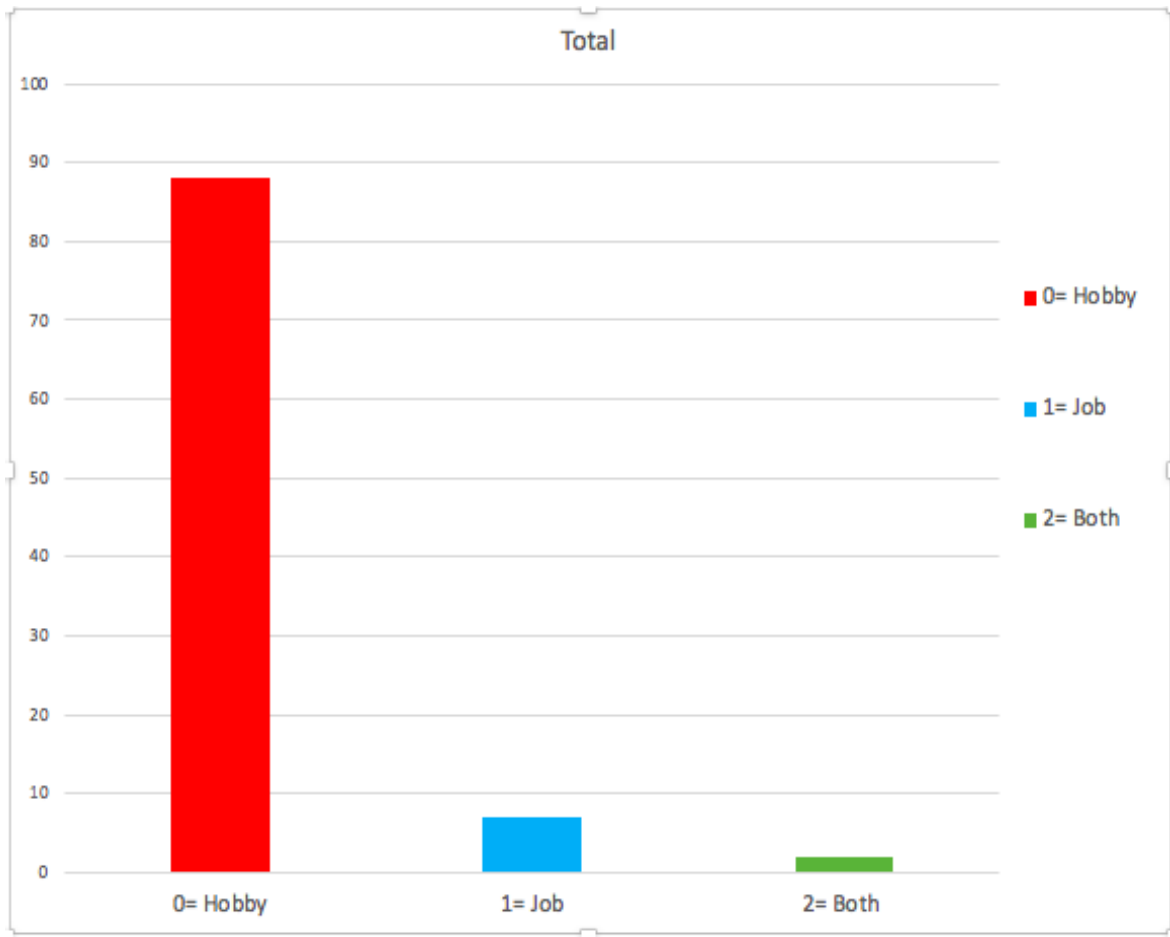


Chart 5.6. types of beekeeping in Schleswig-Holstein

Most beekeepers in Schleswig-Holstein consider beekeeping as a hobby, and only about 10% live from the profits as a main job.

The European numbers according to the 2010 statistics are 90.7% non-professional versus 9.3% professional (Chauzat, 2013).

7. Are your hives stationary or mobile? If mobile, how often and how far do you move them?

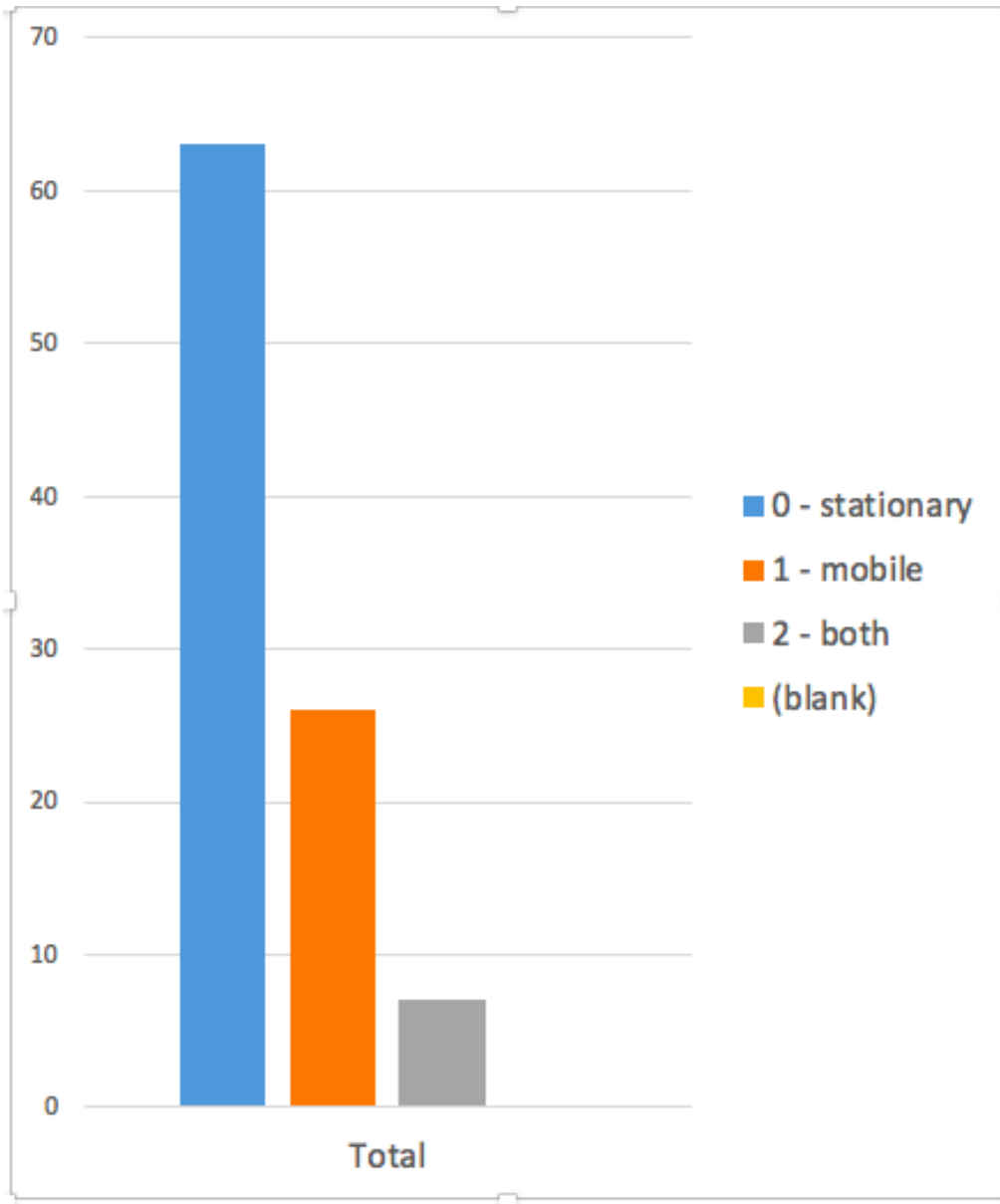


Chart 5.7. Stationary or mobile beehives owned by beekeepers in Schleswig-Holstein

A lot of beekeepers seem to prefer stationary beehives over portable ones. Over 65% possess only stationary beehives. 27% mobile and 8% own both types of beehives for beekeeping purposes.

8. What kind of hives (size and frames) do you have?

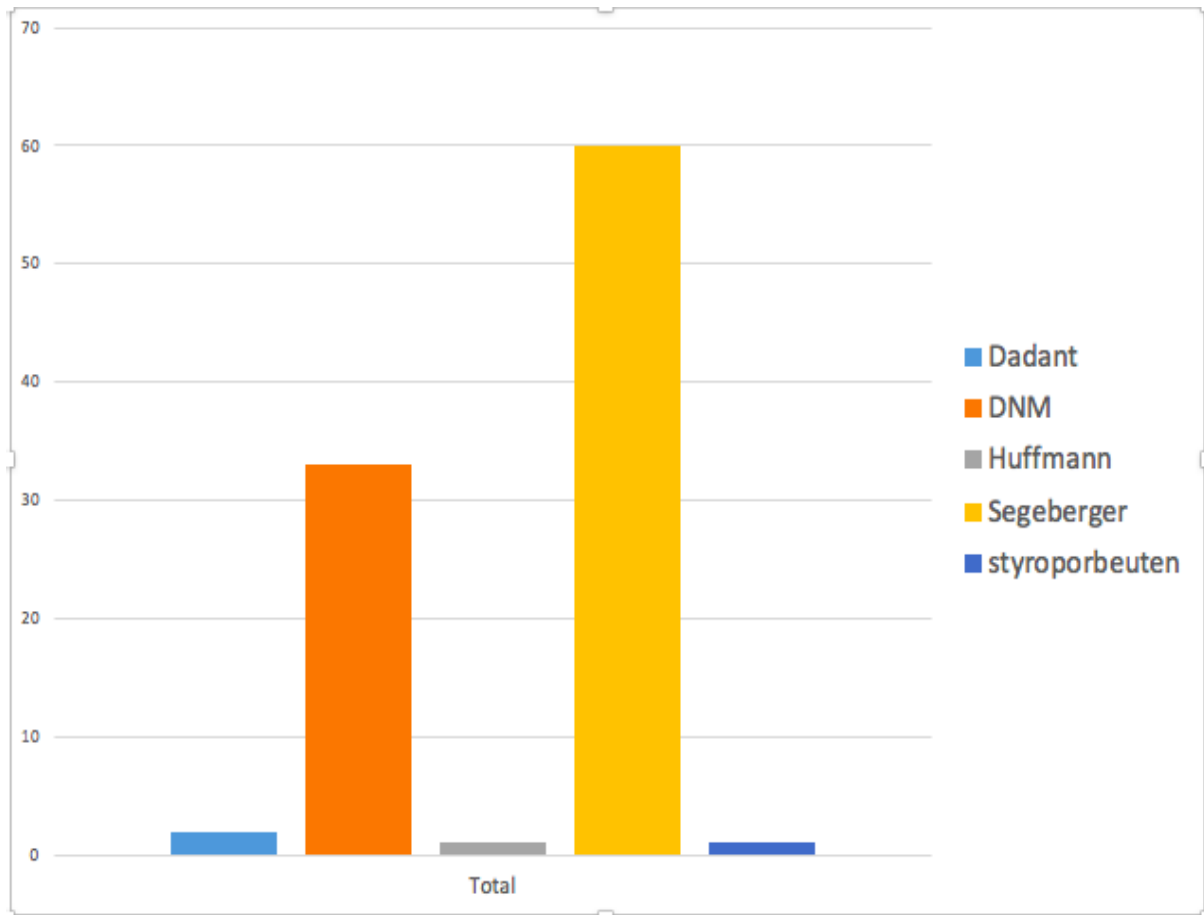


Chart 5.8. Types of beehives owned by beekeepers in Schleswig-Holstein

As seen on the graph, most beekeepers possess Segeberger or DNM (Deutschnormalmaß) hives.

B. Technical questions

9. Are the queens purchased locally or from abroad?

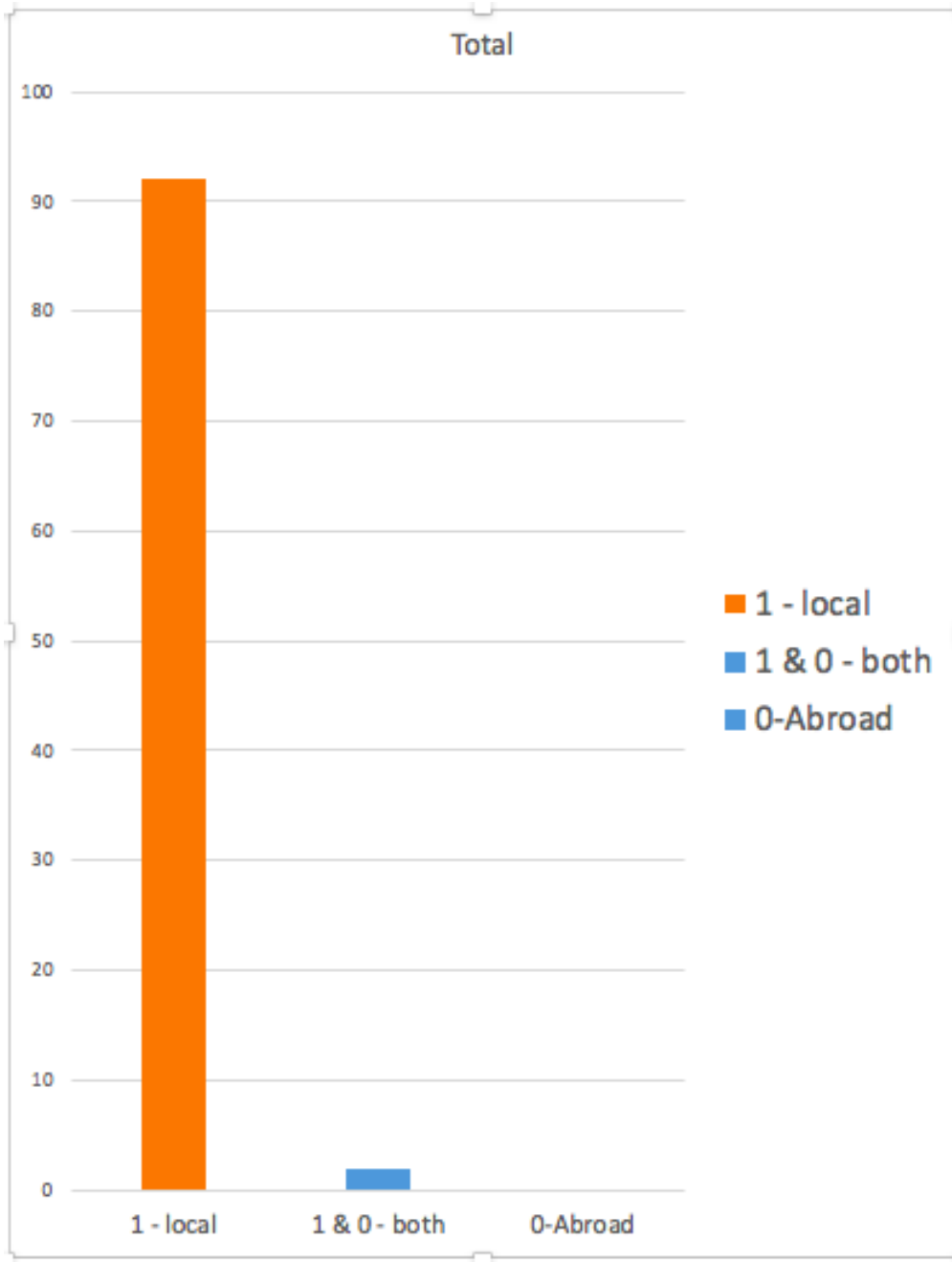


Chart 5.9. Sources of queen bee purchases in Schleswig-Holstein

Almost all Schleswig-Holsteiner beekeepers purchased their queen bees from local sources, whereas only two individuals have a mixture of both local and foreign queen bees.

10. Do you re-queen your hives? If so, how often?

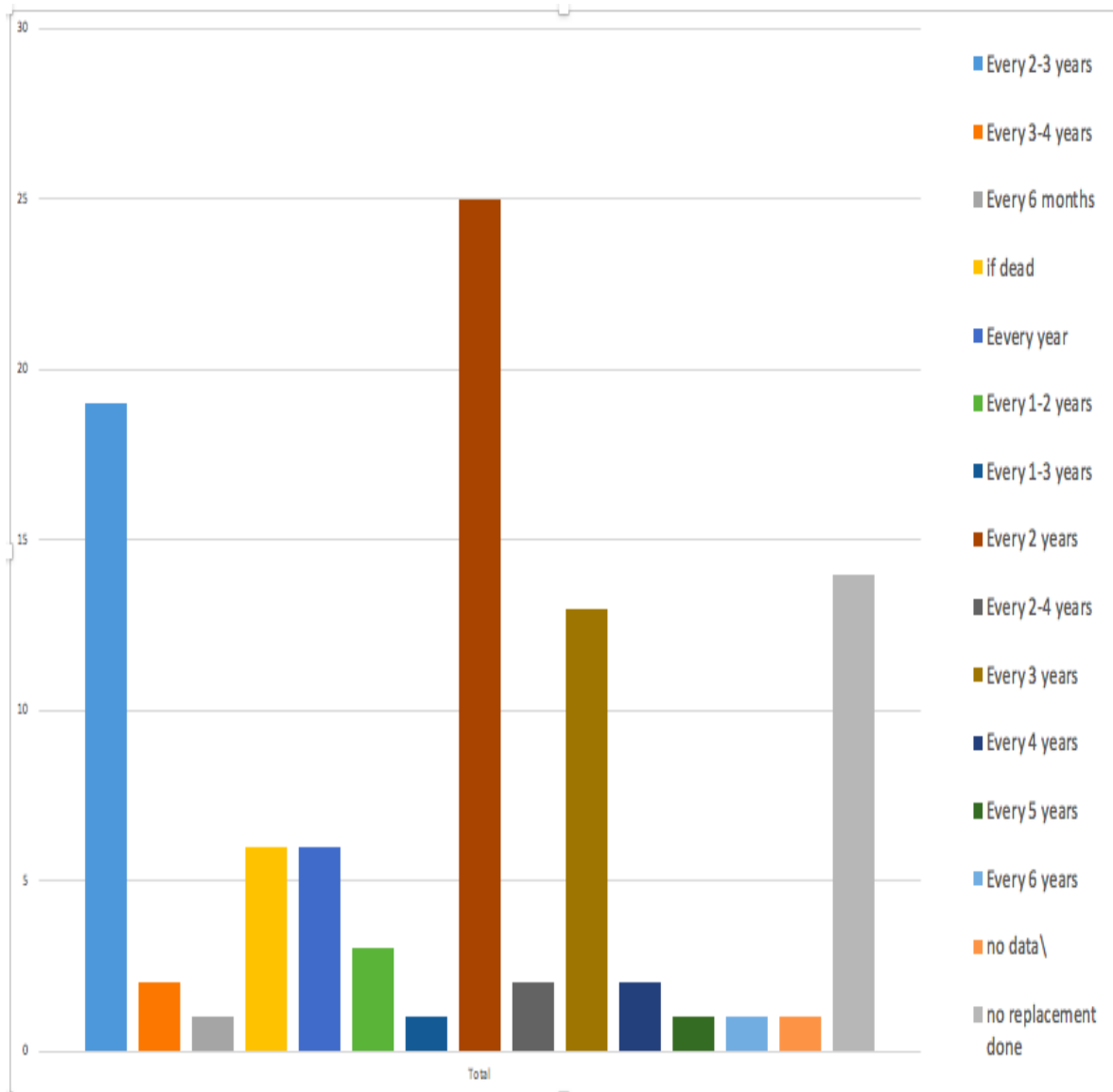


Chart 5.10. Frequency of queen bee replacements in Schleswig-Holstein

Quite a large number of beekeepers practice re-queening their beehives, with only 15% who do not do so. 7% replace the queen only in case of death of the current queen and about 65% tend to change the queen-bees every 2 to 3 years.

11. What race of bees do you keep?

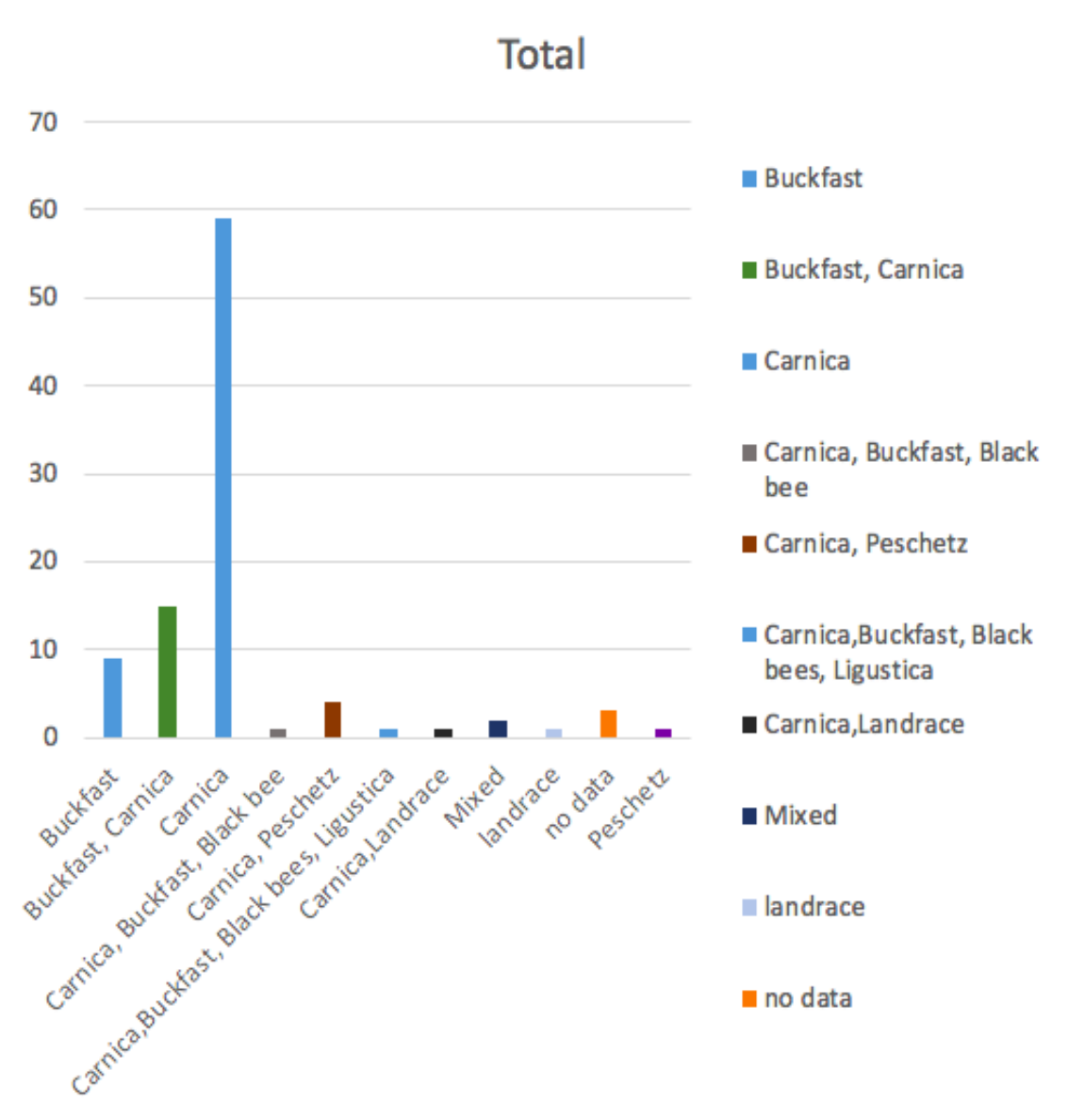


Chart 5.11. Honeybee races mostly kept in Schleswig-Holstein

Most beekeepers in Schleswig-Holstein keep Carnica as the main race of bee. This group makes up around 70% in total. Other races of bee which are also being kept in the region consist of Buckfast, Peschetz, Black bees and Lingustica (Goldbees).

12. Do you treat for Varroa destructor? If so, how?

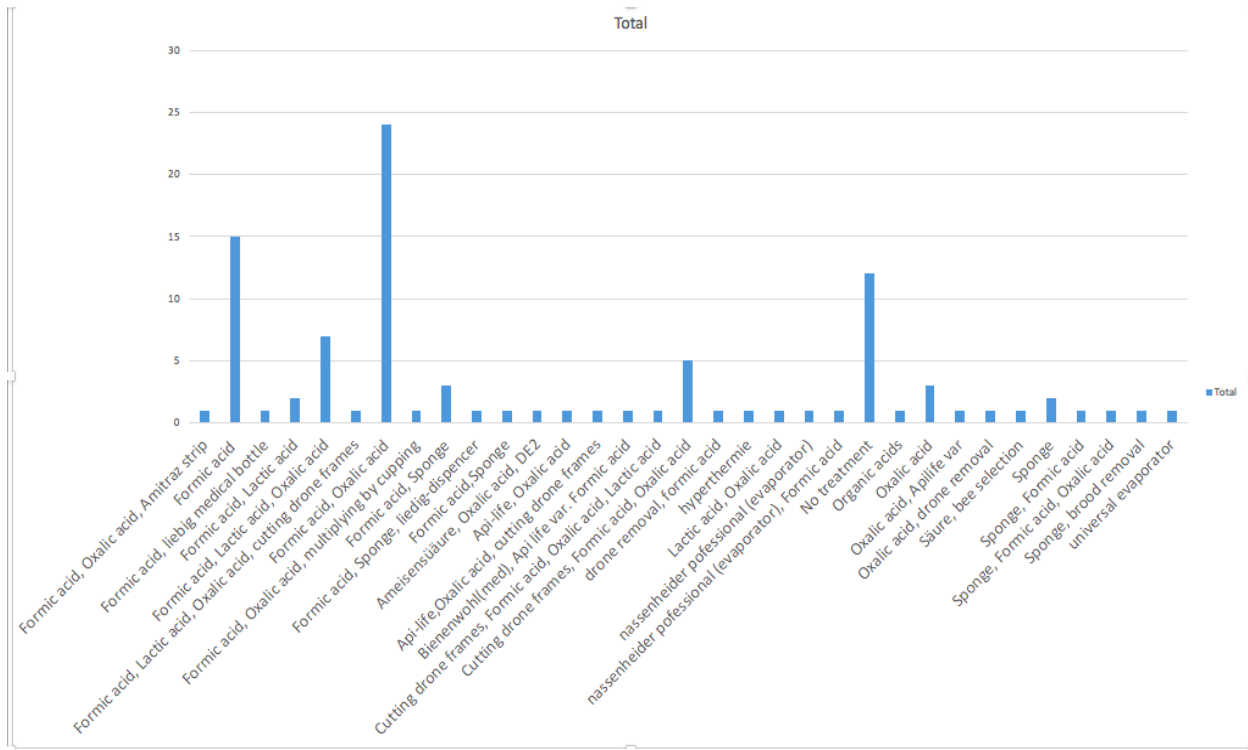


Chart 5.12. Fighting Varroa mite by beekeepers in Schleswig-Holstein

Formic acid, Oxalic acid and Lactic acid are the main substances used in the region by the beekeepers, against Varroa mites. Drone removal and hyperthermia are the other alternative means of Varroa treatment. Only 15% of beekeepers do not treat for Varroa destructor.

Using these acids are among the most common traditional treatments against the Varroa mite. However, most beekeepers in the region report Varroa mites as the number one reason for their bee population losses. Therefore, the question remains to be answered if and how well the above-mentioned methods are effective. Additionally, other chemical-free methods, such as heat treatment and drone frame removal, are gaining more and more interest among the apiculturists, which is a sign of a decrease in credibility for conventional methods.

13. What kind of honey do you produce?

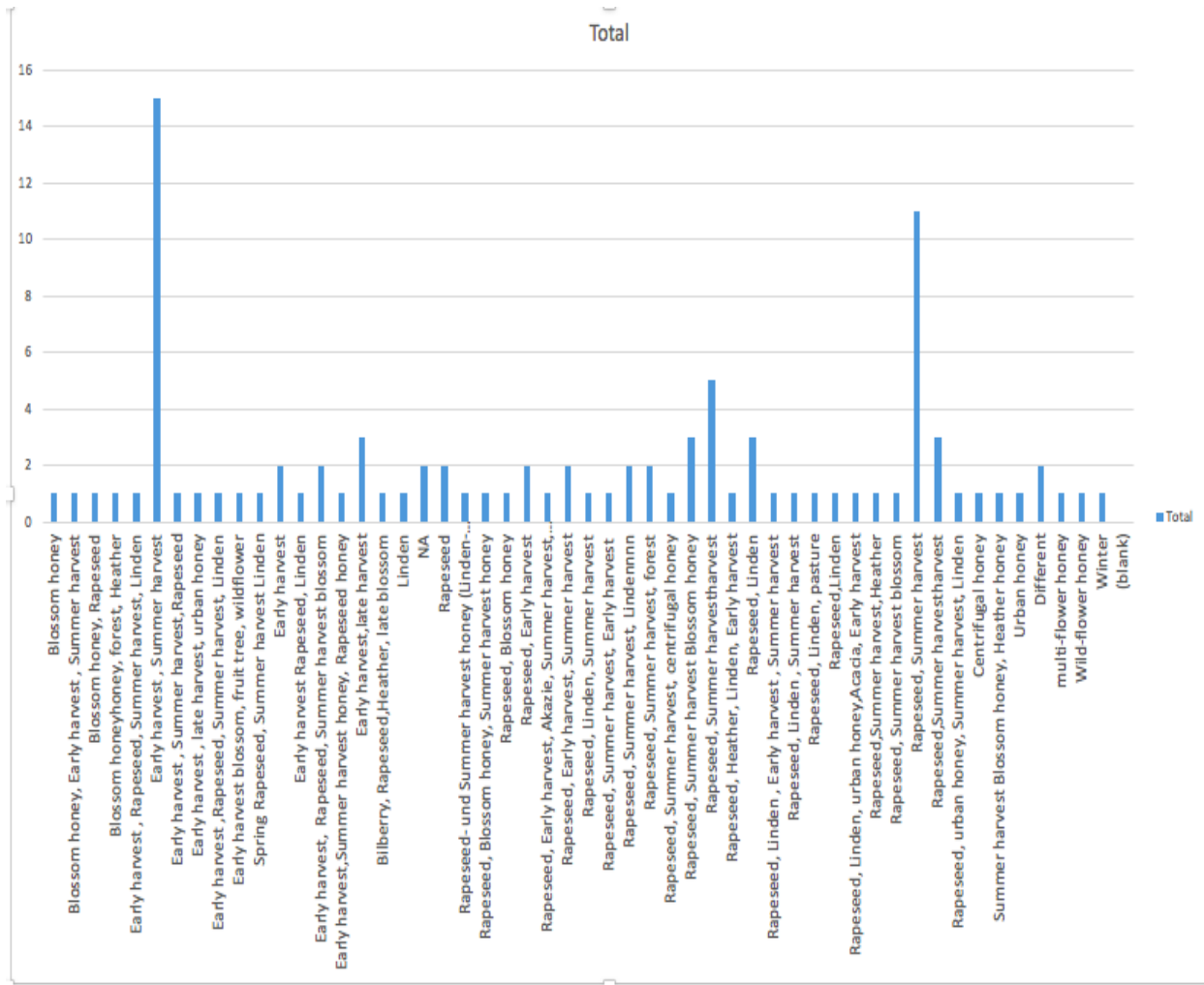


Chart 5.13. Types of honey produced in Schleswig-Holstein

Spring and summer honey are the most common types of honey produced by the beekeepers in Schleswig-Holstein, followed by Rapeseed honey and linden honey.

14. What are the main causes of loss you have been experiencing?

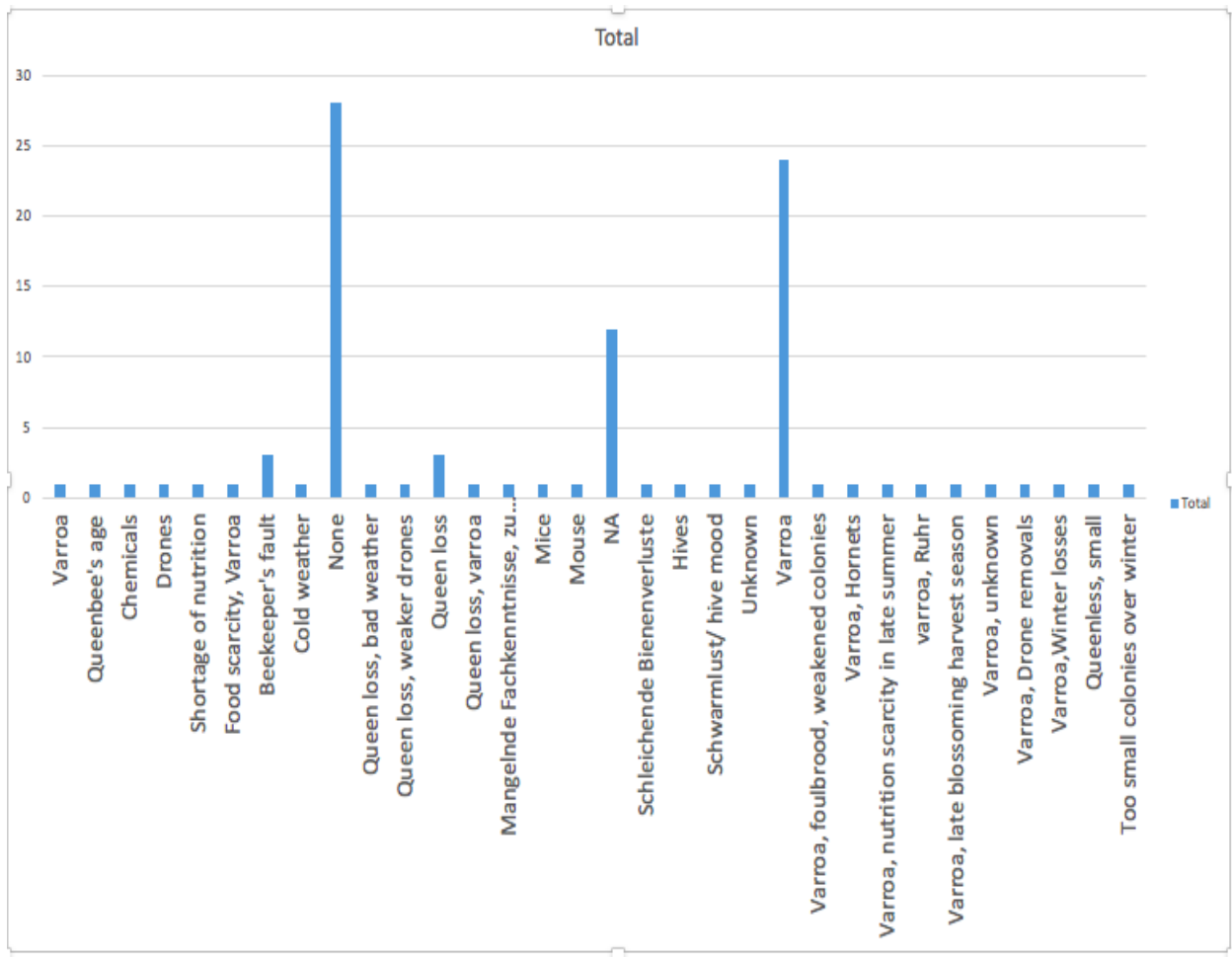


Chart 5.14. Main causes of bee losses experienced by beekeepers in Schleswig-Holstein

Varroa mite has been mentioned by the greatest number of beekeepers as the main reason behind the bee population loss. Other common reasons are cold weather, not enough food, old queen bees, beekeeper mistakes and bad weather. In Europe, in 2010, the main causes of loss by beekeepers have been reported respectively, unknown diseases, Varroa, general problems, poisoning, American foulbrood, queen weakness and starvation (Chauzat, 2013). According to the laboratories, in 2010, the main causes of colony mortality have been diseases, Varroa, American foulbrood and Nosemosis (Chauzat, 2013).

15. What percentage of stock loss have you had per year?

Most beekeepers in the region seem to have mostly lost their bees in 2017 than the years prior to this.

16. How do you supplement feed, if you do so?

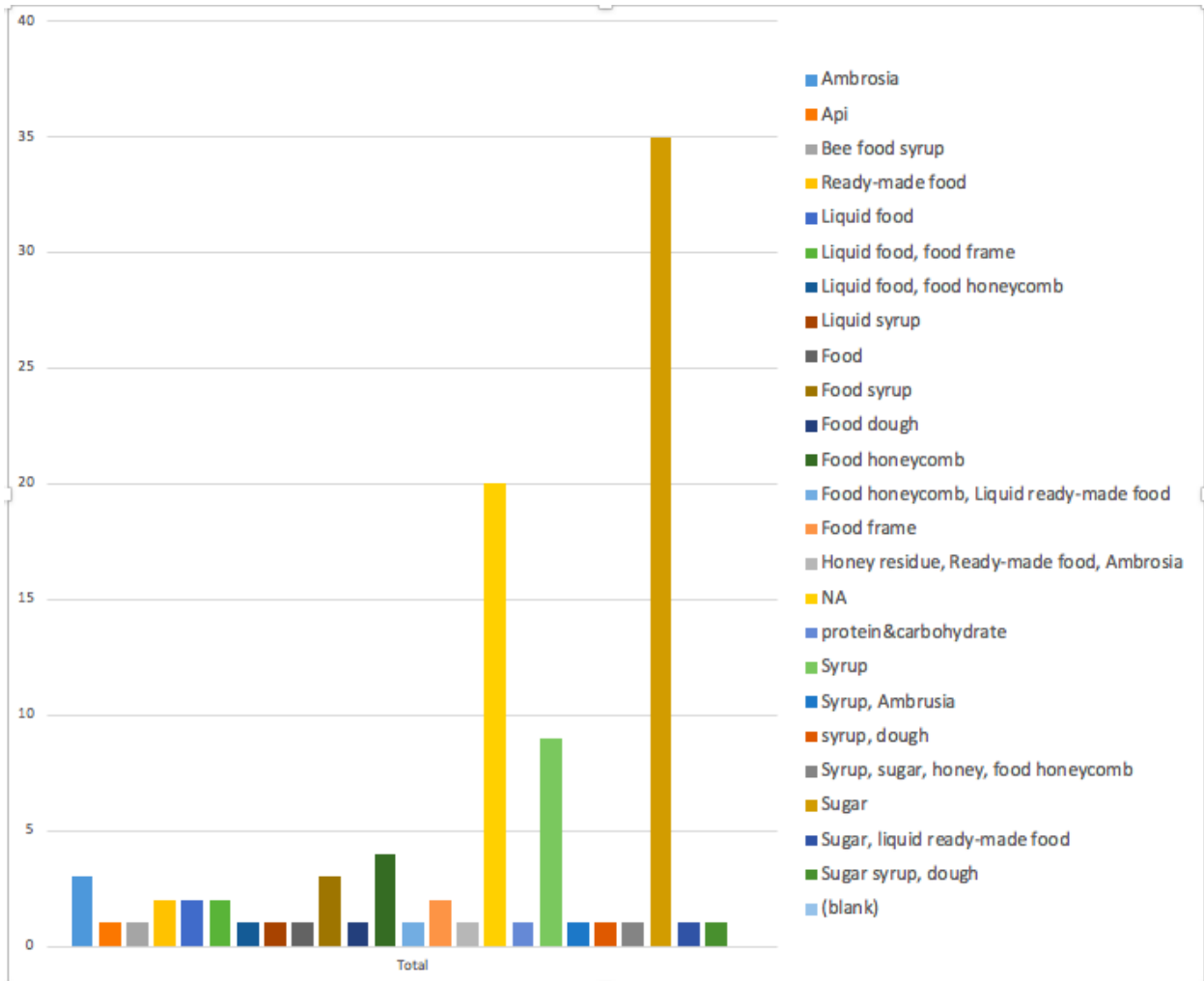


Chart 5.15. Types of food supplements used by Schleswig-Holstein beekeepers

Most beekeepers feed their bees with sugar syrup. The liquid form of sugar is preferred among beekeepers and the bees. It is usually necessary to feed the bee colonies when there is no honey left in the hive, for instance in early spring. The act of feeding the colonies should be repeated until the bees do not take any sugar anymore, since there is enough nectar flow.

17. Do you ever lease your bees for pollination? If so, for which crops?

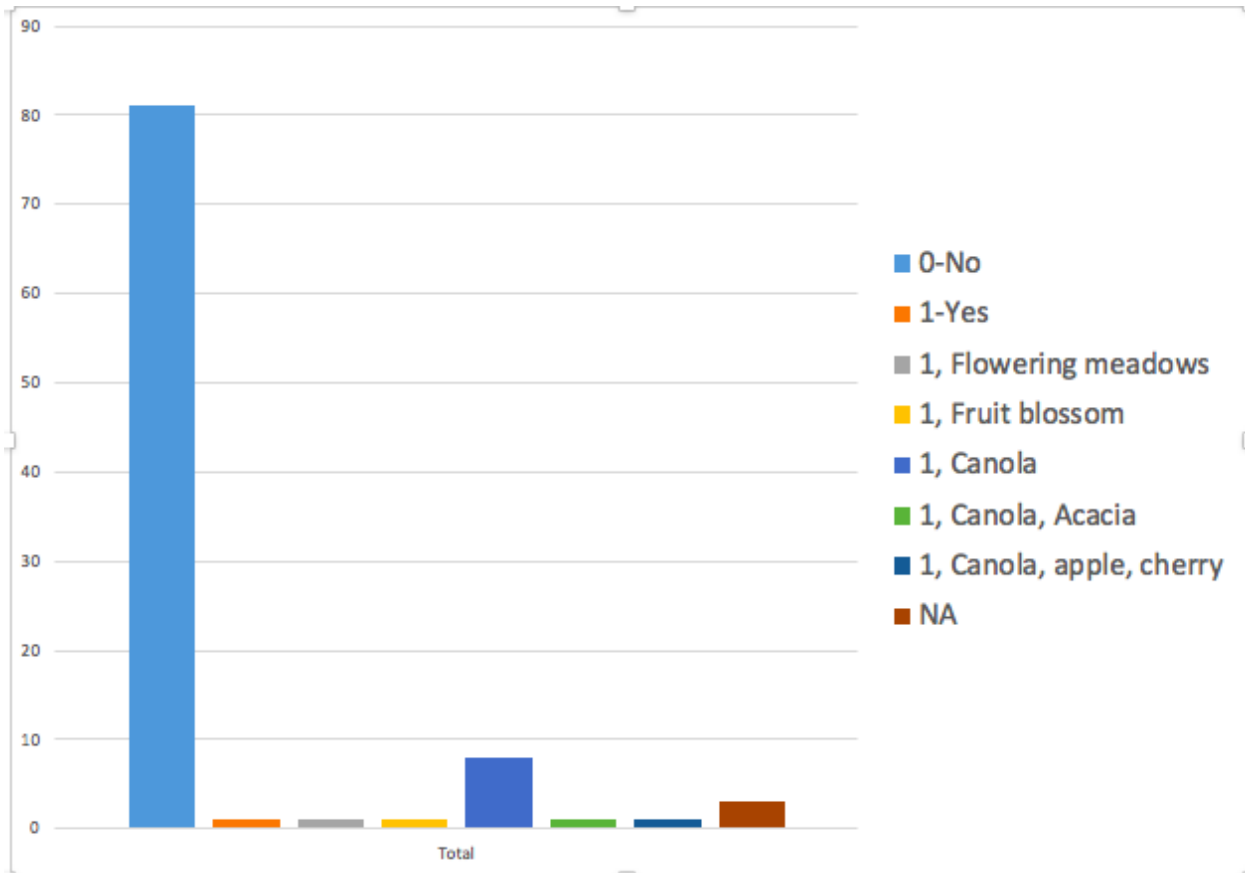


Chart 5.16. Renting bee colonies for pollination in Schleswig-Holstein

Most beekeepers in the region do not lease their bees for agricultural purposes. (over 82%). The rest who do so, mainly use bees for their private gardens and fields of rapeseed, cherries and Acacia. In North America it is quite common to lease bee colonies for the purpose of pollination. The average rate of renting a bee colony on farmers was 64.40 USD in 2009 season (Caron, 2009).

18. Do you also harvest other products? If so, which other products?

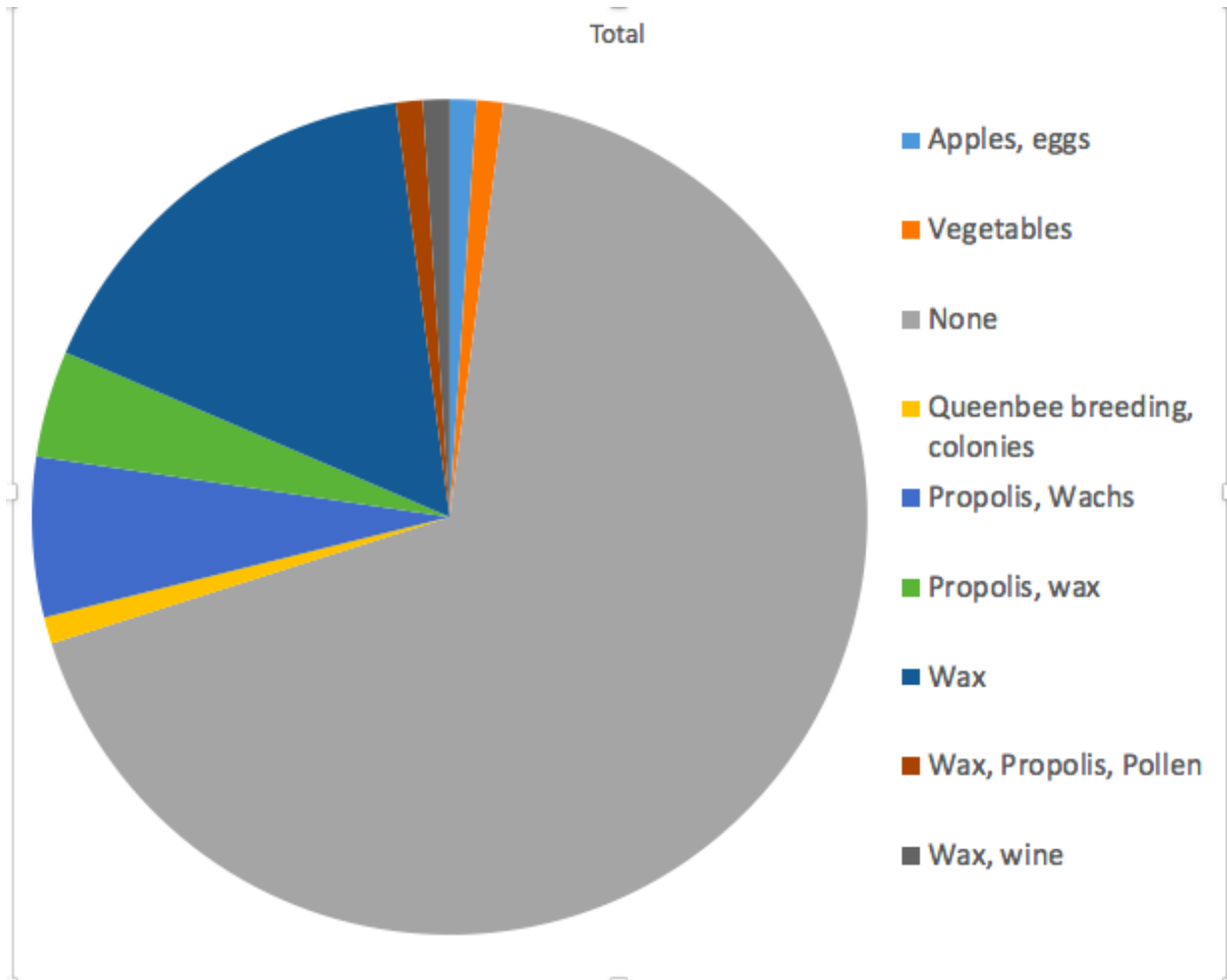


Chart 5.17. Harvesting by-products by beekeepers in Schleswig-Holstein

Wax and propolis are the most common biproducts of honey by beekeepers. A few others also use bees for pollen, and for the pollination of their vegetables and fruit gardens.

After Honey, pollen, royal jelly, swarm and Queen production are among the popular European bee productions (Chauzat, 2013).

19. What do you expect in the future development of beekeeping? (personal or general expectations)

More Flowers, less chemicals and more support for beekeeping are among the top requests.

20. Do you suggest any changes of land use to improve the situation of beekeeping?

Most beekeepers desire more flowers, floral stripes, bee-friendly gardens in the city, less monoculture, reduced usage of pesticides, herbicides and insecticides, and increasing ecological and bio-agriculture, more attention and support from the government, more research on the subject and encouraging young beekeepers to enter the profession for the future.

21. Do you have any requests or suggestions?

Less pesticides, illegalizing the use of harmful chemicals in the agriculture, financial support from the local governments, more flowers and greater diversity have been among the most requested ideas from the beekeepers.

Chapter 6: Interpretation of answers

6.1. Interpretation of individual answers



Figure 6.1. A honeybee frame - Photo by Samar Shafiei

In the previous chapter, answers of each question were mentioned based on the graphs and results of the questionnaire. In this chapter, personal interpretations, analysis and the potential reasoning to the graph results will be discussed.

6.1.1. Q1: Why are you interested in beekeeping? Q6: Do you keep bees as a hobby or as a job?

Over 91% of the beekeepers keep bees as a hobby and only roughly 9% are professional beekeepers for a living. This explains how most beekeepers in Schleswig-Holstein tend to look at beekeeping as a leisure activity rather than as a career. Choosing a hobby instead of a career could be due to the lack of insurance and security of income through bees, as well as the high probability of losing the bee-colonies via diseases and other problems. However, the majority of beekeepers are on average seniors who choose beekeeping as a post-retirement activity which is nature-related and relatively low-maintenance.

6.1.2. Q2: How many beehives do you own?

In Schleswig-Holstein approximately 67% own less than 20 beehives. This number is, compared to the average European rates of 22,4 Colonies per beekeeper, at a lower level. This occurrence might be due to the fact that most beekeepers in the northern part of Germany are beekeeping during their free time as a hobby. Therefore, they do not feel the urge to increase the number of their hives in order to gain more income from their products. This activity is looked at as a non-official means of living and a way to pass time in nature, rather than as an unstable source of income.

6.1.3. Q3: How long have you been keeping bees?

About 40% of the beekeepers in the researched area have been practicing beekeeping for 5 years or less. This could indicate that in the past couple of years, due to the increased advertisements and news around bees and its relation to biodiversity and sustainability, more people have been interested in beekeeping as a hobby to support the bees, and also to improve agriculture from pollination.

6.1.4. Q4: Have you noticed any major changes in bee populations recently? Q 15: What percentage of stock loss have you had per year?

Over 88% of the beekeepers have noticed changes in their bee-colonies in recent years. The greatest number of bee losses have been reported in 2017 from local beekeepers. This could be related to several factors such as modifications in agricultural methods including more monoculture, mass production of agricultural products and also an increase in the use of pesticides, GMOs and likely even climate change.

6.1.5. Q5. What are the main problems you are facing in the recent years? Q14: What are the main causes of loss you have been experiencing?

Varroa mite has been reported as the main cause of death to the bee colonies in Schleswig-Holstein by the participants of this research. One other issue that has been recognized is a lack of food. In the EU, diseases, Varroa and poisoning have been mentioned as the most common causes of population loss in bee colonies. Varroa destructor is one of the multiple factors contributing to the higher number of bee losses around the world. Varroosis, the disease caused by this parasite, has been seen more commonly in the bees in recent years and therefore, it has become one of the biggest concerns of beekeepers around the world as well as the targeted area. It might be due to the increase of monoculture in the northern Germany that many beekeepers consider lack of food as another factor. On the other hand, in other EU countries, poisoning caused by pesticides have been mentioned as one of the most important reasons of death in the bees. It could be related to the lack of practical policies against the use of neonicotinoids and other harmful chemicals and insecticides.

6.1.6. Q7: Are your hives stationary or mobile? If mobile, how often and how far do you move them? Q8: What kind of hives (size and frames) do you have? Q17: Do you ever lease your bees for pollination? If so, what crops?

More than 65% of beekeepers in the region prefer stationary beehives over mobile ones, since they do not commonly practice leasing their bees for pollination. They keep their bees in the same region throughout the year, regardless of annual weather conditions and crop or flower related statistics. Less than 18% of the beekeepers in the region have announced that they consider using their bee-colonies for pollination services. However, they mostly use their bees for private fields and gardens. This practice is much more common in some other countries, which leads to more crop production and less bee population losses caused by lack of food. Nevertheless, stress factors such as change of location may weaken the bee's immune system. Multiple location changes might need to be questioned and studied more accurately. According to the graphs, the majority of beekeepers own Segeberger German standard beehives (DNM).

6.1.7. Q9: Are the queens purchased locally or from abroad? Q10: Do you re-queen your hives? If so, how often? Q11: What race of bees do you keep?

Apart from two individuals, all other beekeepers in the region purchase their queen bees locally. Most of them replace their queen bees every two to three years and Carnica is the number one kept bee race among the local beekeepers. Ease of access, less transportation risks and costs could be a factor for beekeepers to consider mainly local bee subspecies. On the other hand, trading queen bees from other local fellow beekeepers during the monthly meetings seem to be a traditional common practice among the beekeepers in the region.

6.1.8. Q12: Do you treat for Varroa destructor? If so, how?

Although over 85% of the beekeepers use treatments against Varroa mite, this destructor remains the primary listed reason of population losses in the bees. Formic acid, Oxalic acid and Lactic acid are mostly used against Varroa and since these treatments have not practically been proved to be effective against bee population losses, other new methods such as hyperthermia and drone removal are gaining more attention among the beekeepers.

Formic acid, used in two common forms of gel (Bee Var formulation) and paper wick (Liebig-dispenser), have been tested against Varroa destructor and the results show that the gel form produced an interruption in the brood reared, whereas the Liebig-dispenser hives had a higher adult mortality rate (Satta, 2005). Formic acid can be traced in both honey and wax; therefore, it is recommended to carry out the formic acid treatment shortly after the end of honey flow (Hansen, 2016).

Lactic acid, which is usually used with a water spray, should be applied at least 8 weeks prior to harvesting honey in order to minimize the existence of chemical residue in the honey. It is important to carry out this treatment when there is no brood in the colony, so in early spring or late autumn (Hansen, 2016)

Oxalic acid, which is an odorless white solid can be used in either crystal form (sublimation) or a water solution. Studies show a variation of 39-90% based on the time of usage, colonies with or without brood and the dosage of solution (Charlie Vanden Heuvel, 2018)

Drone removal must be used as a supplement to other methods. Since the Varroa mite prefers drone brood cells, removing those sealed drone broods can minimize the spread of Varroa destructor in the colony (Hansen, 2016).

Heat treatment of sealed broods or hyperthermia can effectively treat against Varroa mites, provided that the treatment is carried out at least twice during the presence of brood and each time three to four hours at 44 degrees C (Hansen, 2016).

Other possible methods, such as Queen caging and creation of Nuclei, can be combined with other methods to reach a better efficiency in fighting against the Varroa destructor (Hansen, 2016).

6.1.9. Q13: What kind of honey do you produce? Q18: Do you also harvest other products? If so, other products?

The most harvested types of honey in the region have been respectively spring and summer honey types, followed by Rapeseed and Linden honey. This is clearly a result of mono-agriculture and in other words, lack of biodiversity in the flora of northern Germany which leads to a low variety of harvested honey product. After honey, wax and propolis are other common bee products of the beekeepers. However, since beekeeping is mainly practiced as a hobby in the region, rather than a profession, a smaller number of beehives are being kept and therefore, less variety of bee products in total are being harvested, compared to the European average.

6.1.10. Q16: How do you supplement feed, if you do so?

Sugar syrup is the most common food supplement for honeybees. It is unfortunately a result of shortage in sufficient natural food, which is diverse flowering plants throughout the collecting seasons. Therefore, beekeepers need to provide extra food for their colonies in order to help them survive. Nonetheless, in the long run, this might weaken a bee's immune system, since it is lacking natural nutrition diversity and richness (Hoffman, 2015).

Viruses and generally pathogens could spread rapidly in bees and other social insect colonies. Honeybees decrease the risk of infection outbreaks by a combination of social immunity behaviors and individual immune function. Nutritional state of the colony has a positive relationship to the effectiveness of social and individual immunity. Varroa mites for instance, reduce the nutrient levels, suppress individual immune function (Hoffman, 2015). Therefore, less nutritional diversity causes a decrease in the overall social and individual immunity of honeybees.

6.1.11. Q19: What do you expect in the future development of beekeeping? (personal or general expectations) Q20: Do you suggest any changes of land use to improve the situation of beekeeping? Q21: Do you have any requests or suggestions?

More Flowers and less usage of chemicals are the main requests of beekeepers in the region. Encouraging young beekeepers to partake in the hobby, and conducting more scientific research in this area, are believed to be the only ways to sustainably improve the future of this industry. These suggestions are among other common requests, which indicate how environmentally aware and concerned they are. The crucial role that governments and general politics play in reducing monoculture and use of harmful chemicals cannot be overlooked. Therefore, more support from the government is what most apiculturists expect.

They also hope to see more flower strips. The more flowering plants are being planted by the farmers, and also by urban individuals in private gardens, the more nutritional diversity exists and due to these new plants, the bees are healthier.

6.2. General interpretation

6.2.1. General answers

As the results show, the majority of beekeepers in Schleswig-Holstein keep bees as a free-time activity. In fact, most beekeepers choose beekeeping as a post-retirement activity which is relatively low maintenance. It is not only beneficial for the beekeepers to keep bees and harvest honey and other bee-related products, but also it is very soothing to spend time in the nature. Only very few beekeepers own over one-hundred beehives and consider the income a means of living. This disparity might be due to lack of income security in this industry. Among the beekeepers in the region, quite a few have also mentioned “inheriting ancestors’ occupation or hobby”.

Beekeepers mostly mentioned protecting the environment and nature and promoting sustainability as their reasoning for beekeeping. They enjoy spending time in nature and view beekeeping as a leisurely activity. Therefore, they do not look bee farming as a means of income, and they do not harvest many different products from their hives. Honey is the number one, and in most cases the only, financial benefit of beekeeping for the beekeepers in Schleswig-Holstein; which is different from the European beekeepers’ average, as they produce many other products such as industrial wax, propolis and medical products.

Leasing bee-colonies for the purpose of increasing agricultural products, has not become common in the region. Most beekeepers who use bees for this purpose, use them for their private gardens and fields. They increase their agricultural harvest through bees, as a side benefit rather than a goal. Most beehives owned in the region are, as a result of this locational restriction, stationary. Although, the benefit of growing bee-colonies for the agriculture is well-known, owning mobile hives and moving them from time to time, could be a factor weakening the bees' immune systems. Since the majority of local beekeepers keep bees solely for the purpose of spending their free-time in the nature and as a hobby which also protects the nature, they do not consider leasing their bee-colonies as a way to increase their income. They mostly own a small number of bee-colonies to start with, namely under 20 beehives.

Additionally, unexpected costs such as insurance, damages from wildlife, such as mice, dogs and birds or vandalism and the general risks of losing bee colonies add to their concerns of renting their beehives.

Fortunately, in the recent years, due to the expansion of awareness about bees' importance in the ecosystem and pollination, and the increasing death reports, more and more young people show interest in keeping bees as a hobby. This renewed interest leads to not only a shift in beekeeping methods by gaining information through modern educational courses, but also helps to promote more support from the individuals and the government to support bees.

6.2.2. Main problems beekeepers are facing

The increase in human population in the recent decades has caused an enormous increase in agricultural products. Hence an extraordinary amount of pesticides and other chemicals have been used by farmers in order to increase their harvests. This has led to the untimely deaths of many useful insects including bees. A common series of insecticides, which cause bee losses through damaging bees' navigation capability, are neonicotinoids. This could be one of the main reasons why an increase in the number of bee-losses has been seen in the past decade. Spraying the plants only in the late afternoon and evening is vital in reducing the bee and other important pollinating insect poisonings. GMOs as another trend in mass production could also be harmful on bees, however more detailed research and data on this area are lacking.

Monoculture, in the previous years, has not only damaged the natural flora of the area and turned a self-sufficient and complex ecosystem into a man-made and managed field, to produce mostly rapeseed and corn, but has also caused a shortage of available blooming plants and flowers throughout the foraging seasons for bees. As a result, food-shortage for the bees and a lack of diversity throughout the year, has forced the beekeepers to sugar-feed their bee-colonies, which might weaken the bees' immune system. Planting blooming and bee-friendly plants by urban and rural gardeners and houses can help the bees find a variety of food options during different seasons.

Another common problem spread among the bee-colonies, is Varroa destructor. In fact, Varroa mite has been reported the most by the beekeepers and is considered to be the number one common issue among the beekeepers, causing death to the bees in Schleswig-Holstein. This parasite attacks the body of bees and forages their body-fat which weakens the bees' immune system and eventually kills them. Despite using several treatment methods, Varroa remains one of the main causes behind bee population losses.

Most number of losses in the region have occurred in 2017. Amongst those, Varroa has been mentioned as the main reason, as well as the lack of food and weakened broods.



Figure 6.2. Beehive in an urban area, Kiel – Photo by Samar Shafiei

6.2.3. Fighting Varroa destructor

Among the different methods fighting Varroa mite, Formic acid, Oxalic acid and Lactic acid are used the most by the keepers. Formic acid can kill the mites in all different life stages; therefore, it is the most popular chemical used against the mites. It is usually used in late summer to prevent the mites throughout the winter (Lampe, 2015). Some other methods used for this purpose, which are gaining more popularity in the recent years, are drone removal and hyperthermia.

Oxalic acid commonly exists in many fruits and vegetables consumed by humans, such as beets, spinach, poppy seeds, can be used in either solution form or as sublimation, which consists of solid crystals turning into gas. The solution form cannot be kept longer than a week at room temperature and in case it changes color, it will be toxic to the bees (Venden Heuvel, 2018). This method is very popular amongst the beekeepers, as it is relatively easy to use. This acid, taken in either form, attaches to the sticky feet of Varroa mites and enters the blood circulation of the body within hours and kills the mites (Papežíková, 2017).

Lactic acid is the least harmful organic chemical among the acids used against Varroa. This compound, however, kills effectively only the adult mites and does not work on the brood cells (Crushman, 2002). Therefore, it is commonly used along with other chemicals, such as formic acid, in order to get rid of mites in all different stages.

The phenomenon in some Western bee colonies called Varroa Sensitive Hygiene, in which worker bees recognize when a cell is contaminated by Varroa mites and remove the broods from the cell to prevent the growth of the parasite, interests researchers to breed Varroa-resistant honeybees (Insect Sleuths, Beenow 2015, issue 1).

Some beekeepers might be interested in not using chemicals in their beehives to produce organic honey. However, using no treatment against mites means increasing the varroa population through your bee colonies and spreading this parasite in the region while infecting other beehives. Therefore, it is wiser to do some research and pick the best method for mite removal in every bee-colony.

Among the non-chemical ways of fighting the Varroa destructor, drone removal is a common and easy way to kill the mites. Varroa destructors lay their eggs preferably in the drone cells, as the chances of survival in the male body is almost twice higher than in the worker bees. Therefore, inserting a drone-sized frame as a bait trap in the center of the hive, and captivating the mites by removing the frame no later than July will help fight the mites (Using drone brood removal as a Varroa control, APHA, National Agri-Food Innovation Campus, 2014).

This method has been used by about 10% of the beekeepers in the region. The reason its gaining popularity, is the fact that it is completely chemical-free and suitable for organic honey producers. On the other hand, since it does not removal 100% of the mites. Some might remain in the worker cells. it is not as common as using the acids. Additionally, if the brood frame is not removed punctually, the mites will increase in population quite rapidly. Another negative effect of usage of this method is that the drone broods are also removed along with the mites.

Hyperthermia is a relatively new method used against Varroa mites. It kills both adult and broods of Varroa using heat and reduces the chemical residues in the honey. By heating up the beehive to 42 °C, for at least 12 minutes, the majority of mites will be dead depending on the length of treatment. This method can be efficient destroying up to 100% of the mites if used long enough and does not harm the bees but in cases of treatment over two hours, dead larvae have been found in the brood cells (Goras, 2015).

All in all, there are different options for destroying mites and a combination of a few of them, regarding the time of the year and degrees of contamination. Furthermore, in order to reduce the amount of chemicals in the beehive, combining a non-chemical method together with partially adding an acid, might be worth taking into consideration.

6.3. Potential impacts of CCD in honeybees

Honeybees play a vital role in the natural ecosystem and in agriculture. They are not only an inevitable part of the ecosystem as a species, but also help pollinate many natural and cultivated floral species. Therefore, besides the value of adding to the biodiversity and health of an ecosystem, bees actively provide support in the re-growth and reproduction of several plant species in forests, rangelands and agricultural fields. Due to this shortage, a drastic loss in the honeybees' population will result in direct impacts on the flora of the ecosystem they live in.

From an economic perspective, there are several important services and products obtained from bees. Honeybees produce honey which is broadly used in medicine and pharmacy, food and pastries, wine, cosmetics and health products. Beeswax is another natural product taken from the honeybees. It is widely used in industry, pharmaceutical products, cosmetics, candles and many other products. Thus, losing bees equals with losing these natural products.

Additionally, a very common ecological service provided by the bees, is renting out the beehives to the farmers for pollination services. Without the bees, crops would not yield as they should, and agriculture and forestry will face serious damage.

6.3.1. Ecological impacts

The effects of a drastic decrease in the population of honeybees will be first and foremost on their surrounding environment and natural ecosystem. As a part of the ecosystem, every species plays a role in keeping the ecosystem vital and adding to the biodiversity which helps to keep the ecosystem healthy. Therefore, honeybees are important for ecosystem conservation and stability, genetic diversity and ecological relationships. From an environmental and ethical point of view, every species has the right to live and is worth conservation efforts (Primack, 2012).

Furthermore, due to the pollination service, many plant species rely on the honeybees and thus they are vital for the floral diversity, reproduction and the genetic variation in the plants. Without the pollinators, the flora and eventually some main functions in the ecosystem such as trophic cycles will collapse.

Honeybees strongly influence terrestrial ecosystems, including tropical forests, savannah woodlands, rangelands, mangrove and deciduous forests (Bradbear, 2009). Eliminating bees in the ecosystem will result in the losses of many plant and animal species. Other animals relate to bees in different ways such as eating the brood or the adult bees, eating honey, wax or pollen, parasite relationship or living within the hive (Bradbear, 2009).

In both natural and cultivated croplands, bees are among the main pollinators and many floral species, seeds, nuts, berries and fruits are dependent on them (Bradbear, 2009). Due to this fact, pollination is the most important role of honeybees.

Cross-pollination is the act of transferring the pollen from male parts of the plant to the female parts of it, which can be done by birds, wind, bats and in most cases by bees. Despite the variance in pollinators, over 80% of the flowering plants depend on the solely bees for pollination (Bradbear, 2009).

Honeybees are attracted to flowers because of nectar or pollen as food; their hairy body attaches the pollen to them, and as bee visits thousands of flowers in a single day, many plants will come in contact with the pollen.

On average, a European honeybee visits up to 1,000 flowers in a single trip and makes up to 14 trips a day. A colony which consists of around 25,000 bees can pollinate over 250 million flowers (Bradbear, 2009).

Additionally, biodiversity of forests and open landscapes and bees are interdependent. If there are no bees, there will be no flowering plants and vice versa.

Deforestation, monoculture, global warming and other causes of CCD around the world have been affecting the honeybee populations and this has resulted in loss of plant species.

6.3.2. Economic impacts

As for natural environments, also cultivated lands rely on the bees for pollination. Without the bees, many species such as apples, oranges, nuts, limes, onions, carrots, almonds, blueberries, cherries, cucumbers, cantaloupes, avocados, broccoli, cranberries, Alfa-alfa will not be produced (Sass, 2011).

In the United States of America, the crops relying on honeybees for pollination are worth over \$15 billion per year and the loss of bees in the recent years has caused over \$5.7 billion of annual loss (Sass, 2011).

Therefore, many farmers are obliged to rent beehives during the blooming season in order to help with the pollination of their crops. Pollination helps improve both quality and quantity of the crops. As the bee populations decrease, the need for renting honeybees from beekeepers has been rising. Pollination is the most important ecological service by the honeybees. In Western Europe, the value of pollination by bees is estimated to be 30-40 times the value of honey and beeswax production (Bradbear, 2009).

Thus, the increased rates of CCD in the past years have been affecting the farmers the most; and everyone is affected by the rise of crop production costs.

Other than the pollination work, bees produce honey which is one of the main reasons for beekeeping in both rural and urban areas. Honey is used for food production, as sweetener in pastries and cookies, in medicine and pharmaceutical products such as cough medicine and allergy medicine, in creams and shampoos and other cosmetics. This product is known to have many health benefits. A decrease in honeybee colonies directly affects the honey production rates and will raise the price of products which contain honey as a main ingredient.

Beeswax, another product of honeybees has several uses in the industry: around 40% of beeswax production is used for cosmetics such as creams and soaps; 30% is used by pharmaceutical companies for ointments, 20% for candle making and the other 20% for industrial purposes (Bradbear, 2009) such as lubricants, wax for models and casting, archers' bow, in jewellery and dentistry for casting, in production of polish, threads, crayons, CDs and many other products.

Other trades from the honeybee products include propolis, royal jelly and bee venom, which are also commonly used in producing cosmetics such as lip balms, creams and also edible capsules. (Bradbear, 2009)

Values	Potential adverse effects
Terrestrial (Land) values	<ul style="list-style-type: none"> - Reduction or damage to indigenous biodiversity (Plant pollination) - Clearance, disturbance or destruction of vegetation or natural area - Damage to wildlife or habitat - Introduction of new or existing threats to indigenous ecosystem e.g. Pests or weeds - Weakening the natural and cultivated ecosystem health
Economic values	<ul style="list-style-type: none"> - Decrease in crop production for food, medicine and industry - Decrease in Honey production - Decrease in beeswax and other products - Raising the costs of agricultural products - Raising the costs of industrial products
Landscape values	<ul style="list-style-type: none"> - Loss of floral species - Destruction of natural and cultivated landscapes - Deforestation
Recreation values	<ul style="list-style-type: none"> - Loss of flowering plants - Loss of trees - Destruction of natural ecosystems such as parks - Beekeeping as hobby
Other	<ul style="list-style-type: none"> - Increasing unemployment - Decreasing rural livelihood - Religious and environmental ethics of species conservation

Table 6.1. Environmental impact assessment of CCD in honeybees

Chapter 7: Conclusions

Honeybee populations have been facing a decline throughout the world in the last decade. Germany has been suffering from CCD in the bees as well as the rest of the world; It has been recorded that there were 115,000 beekeepers active in Germany in 2016 (Bundesanstalt für Landwirtschaft und Ernährung). Pollination increases both the yield and quality of our crops. About one third of the world's agricultural crop production depends on pollination. The pollination value of a bee colony is between 800 and 900 euros. According to estimates by the University of Hohenheim, the economic value of pollination is 70 to 100 billion euros worldwide and about 2.5 billion euros in Germany (Bundesanstalt für Landwirtschaft und Ernährung).

In addition to the classic pollination plants such as fruit trees and berries, the pollination of wild plants, which are the food of many wild animals, must also be taken into account. Therefore, bees also contribute to the diversity of nature (Bundesanstalt für Landwirtschaft und Ernährung).

however, most studies on the bees have been carried out in the alpine regions and southern parts of the country. On the other hand, the special weather conditions in northern coastal areas and the different structure, provides northern part of Germany a different condition. Therefore, it is important to carry out research on a local basis to find out the core of issue in the region. So far, there has been no paper covering the issue of CCD in bees in Schleswig-Holstein, focusing on the up-to-date data from beekeepers and their problems regarding bee population losses.

Additionally, researchers mostly focus on one or two potential environmental causes of CCD and overlook the role that the beekeeping practices plays. They also neglect the importance of integrated studies on the synergism of different causing factors for the bee population losses.

This thesis aims to be an initiative in firstly, collecting data from local apiculturists on how the current situation regarding the bee population decreases and the beekeeping methods is, furthermore, analyzing the data and finding out what potentially causes the issues in the region. Finally, by discovering the scale and causing factors of the problem, suggestions to minimize the CCD in honeybees are provided.

7.1. Outlook

“Bees have been declared to be the most important living being on earth” according to The Science Times, based on their role of pollinating over 70% of the agriculture around the world. Nevertheless, in the recent years about 90 per cent of bee species have disappeared, making them part of the red list of endangered species (Chardynne Joy H. Concio, Jul 09. 2019, sciencetimes.com). It is estimated that 90 per cent of natural flora across the world depend on honeybees for cross-pollination (Sass, 2011).

Honeybee populations have been facing a dramatic decline around the world in the past decades and northern Germany has not been an exception in this case. In the recent years, the majority of local beekeepers have reported a large number of bee losses and it concerns not only the beekeeping industry, but also it threatens many farmers, ecologists and the economy.

The main causes of CCD are potentially one or a combination of the following factors (For more information please refer to section 2.2):

- Disease;
- Pests and mites;
- Viruses;
- Parasites;
- Microbial or fungal pathogens;
- Chemicals and pesticides, insecticides and in particular neonicotinoids;
- Malnutrition;
- Mismanagement practices and beekeeping methods;
- Monoculture;
- Changes in land-use and habitat loss;
- Global warming;
- Stress due to location change;
- Genetically modified crops;
- Genetics and queen source;
- Predators;
- Cool brood;
- New and unknown pathogens;
- Exhaustion due to long distances of searching for food;
- Mobile phones;
- Urban growth;
- Synergism and weakened immune system due to stress factors.

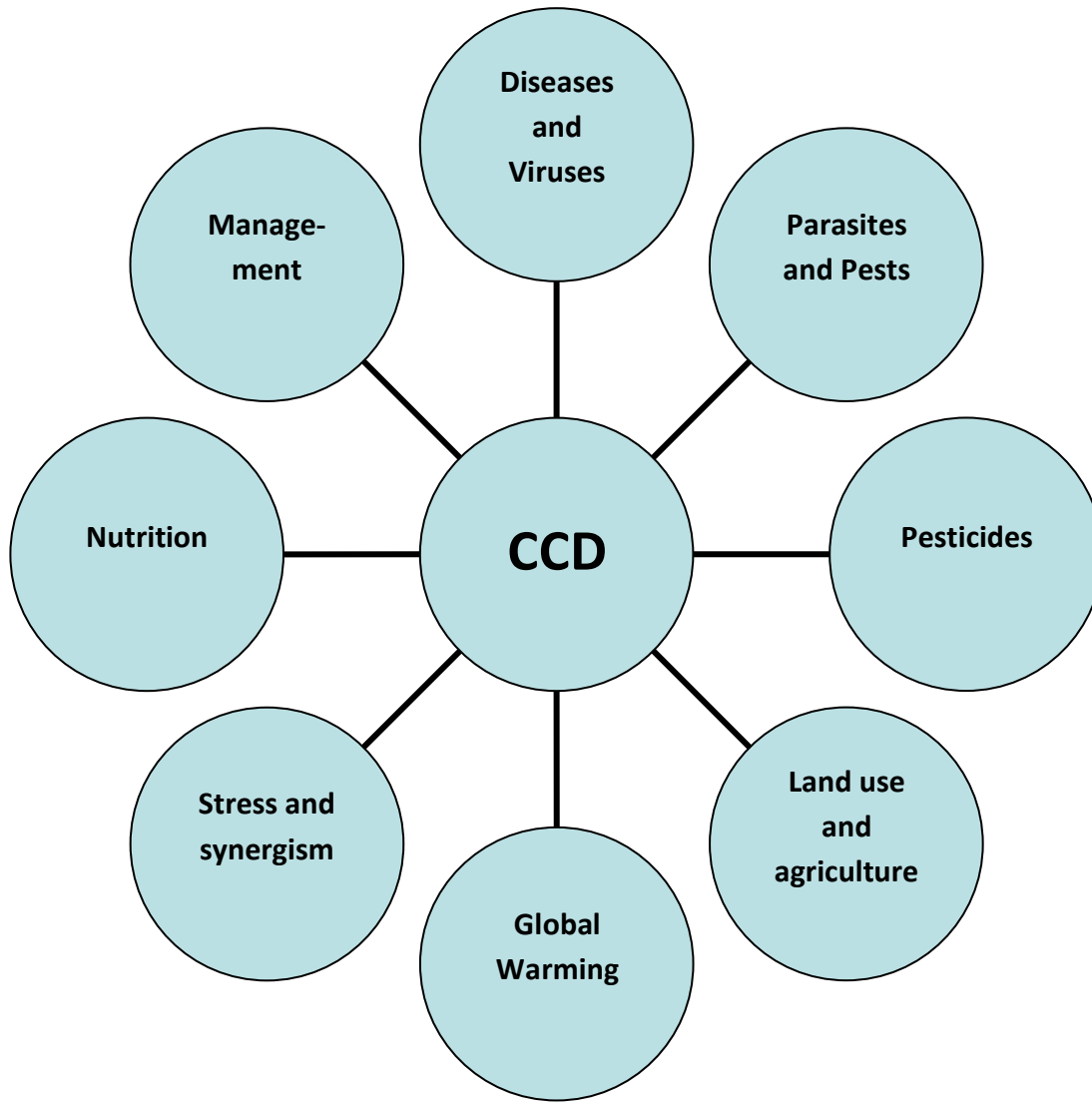


Figure 7.1. Common causes of CCD in honeybees

Most beekeepers in the region have mentioned Varroa mite as one of the main bee-population loss factors in their beehives; however, other factors could play an important role in causing an increase in the CCD numbers, such as an increase in use of chemicals by both farmers and beekeepers, mites and pathogens, global warming and generally climate change, mono-culture and lack of nutrition, lack of food diversity, mismanagement and beekeeping methods. Some scientists also suggest mobile phones, pollution, and anthropogenic displacement, exponential urbanization and industrialization as potential causes of increased bee mortality. Scientists suspect, pushing bees to travel longer distances to find pollen, might be killing them through exhaustion.

Change in land use and monoculture in the region, together with global warming have led to shortage of nutrition for the bees throughout the year. Growing urban areas and converting the structure of natural habitats into buildings and roads have made bees move several kilometers in order to find flowers, and there are unfortunately only very few types of flowering plants available for the bees; therefore, exhaustion as a result of searching for food and lack of nutritional diversity have caused more stress on the bees and hence it has weakened their immune systems. Adding more and more sugar to feed the bees might also affect their weakened health and therefore make bees more susceptible to pathogens, mites and pests. Nevertheless, beekeeping methods continue to play an important role in preserving and strengthening the bee-colonies.

Since many floral species and crops are dependent on honeybees for pollination, as the rates of deaths in honeybees increase, the concerns regarding crop-cross production by farmers and economic and ecological consequences arise.

Therefore, the higher rates of deaths in honeybee colonies will affect the natural ecosystems by affecting the quality of flora in woodlands, rangelands and farmlands and it will also aggravate the health of ecosystem and biodiversity.

The decreased number of bees will not only affect the economy and agriculture but will also have a direct and indirect impact on ecosystems and food production, as well as on honey and beeswax and all related industrial and medical products. Therefore, it is necessary to take the required steps in order to find solutions and solve the problems to reduce the number of death rates in the bees.

7.2. Recommendations and solutions

The common suggestions and requests that beekeepers in Schleswig-Holstein have mentioned are as listed below:

7.2.1. The beekeepers are demanding more

- Flower strips in agricultural fields and green spaces in the city;
- Planting more blooming plants which are bee-friendly;
- Diversity of flora for foraging in the later months of the year;
- Roadside-flowers and flower boxes to increase green areas in urban districts;
- Clover meadows;
- Bio and organic products;

- Sustainability measures in gardening and agriculture which ensure a stable future for the pollinators;
- Local plants instead of ever-green plants;
- Younger beekeepers for the future generations;
- Courses and seminars for beekeepers;
- Research on the topic to find solutions for the current issues regarding beekeeping;
- Competition for beekeeping through increasing the number of beekeepers;
- Attention towards this topic in the society and politics;
- EU support, financially and educationally;
- Governmental support;
- New rules and laws against the use of chemicals;
- Lobbying among beekeepers;
- Free areas from pesticides/ herbicides to ensure the production of bio honey and improve the health of bees.

7.2.2. The beekeepers are demanding less

- Monoculture to avoid food shortage for the bees;
- Corn production which are overly replacing the natural meadows;
- Grain fields and grass meadows which do not benefit the bees;
- Glyphosate which harms many insects including the pollinators;
- Chemical herbicides, pesticides and insecticides;
- Spraying plants with weed killers;
- Honey import from overseas.

Some other suggestions that could help to reduce the CCD rates and minimize bee deaths are as follows:

7.2.3. Requirements beekeepers should meet

- Improving beekeeping management methods by informing oneself about ways to improve pest-control and feeding techniques;
- Learning up-to-date methods of sustainable beekeeping and fighting against pests;
- Taking courses for a better understanding of beekeeping methods;
- Using ecologically friendly methods of fighting mites instead of using chemicals in apiculture; beekeepers could apply organic methods and pesticides against the bugs and pests within the beehive;

- Alternative methods against Varroa such as drone removal and heat therapy which are chemical-free ways to remove and kill the mites;
- Improving beekeeping practices such as placing the beehives in the direction of sunlight for orientation;
- Avoiding checking on bees and opening the hives too often to decrease the amount of stress and cooling down the broods;
- Keeping enough honey in the hives for fall and winter to ensure avoiding shortage of food throughout the year;
- Avoiding long distance transportations while renting the bees for pollination to minimize the stress on bees. Long distance movements might also weaken the bees' immune systems and make them more prone to pathogens;
- Choosing locally native, indigenous and healthy races of bees which are familiar with the local ecosystems. Carnica and Buckfast are the most common bee races in the region;
- Placing the hives away from pollution sources such as noise pollution, electromagnetic radiations, radioactivity or chemicals which could be harmful for the bee colonies;
- Keeping the hives away from the wind to avoid temperature decrease;
- Ensuring the safety of the beehives against predators such as mice and other mammals by placing them on a higher level than the ground;
- Feeding the bees with healthy food and clean water to ensure the health and strong immune systems in the colonies;
- Removing the sick bees from rest of the beehive to avoid spreading the viruses and bacteria;
- Avoiding overfeeding the bees with sugar in order to avoid weakening of their immune system due to lack of nutritious food;
- Avoiding frequent smoking of the bees to minimize the stress factor;
- Not checking on bees in Winter or on rainy and cold days to keep the beehives warm and dry;
- Choosing the right size of beehives for the number of bees to avoid lack of space for the colonies and extra space for the pests;
- Choosing strong and healthy bees and good genes for the queen to reproduce healthy bees;
- Avoiding extra stress on the bees by making noise or opening the hives on bad weather;
- Applying IPM methods to control and avoid Varroa; IPM stands for Integrated Pest Management which is an ecosystem-based strategy focusing on long-term prevention of pests and their damages using a combination of methods such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties (UCANR.EDU);

- Avoiding a mixture of dead colonies with healthy ones in a hive to minimize the risk of spreading diseases;
- Treating mites and other pathogens in the beehives to avoid infecting the neighboring colonies;
- Not using a dead colony`s equipment for healthy bees to keep the pathogens away from the other colonies;
- Eliminating stress on the bees by a combination of factors (synergism).

7.2.4. Requirements farmers should meet

- Replacing neonicotinoids with less harmful pesticides (See table 7.1). Farmers could use less harmful pesticides which are bee-friendly and substitute the neonicotinoids;
- Cutting down on the use of chemical pesticides, herbicides and insecticides and using more natural methods;
- Using organic materials and natural methods such as traps, using predators for pests or weed, hand picking and using pesticides during non-blooming seasons (www.offthegridnews.com). Using natural predators and pesticides for weed and pests. For a list of less harmful pesticides, see table 7.1;
- Using pesticides only after sunset, since the bees forage during the day; Management methods such as which season and what time during the day are important factors in absorbing the chemicals by bees. Therefore, using the chemicals during non-blooming seasons and after sunset will decrease the bee deaths since bees collect nectar during daytime. Farmers should be educated and possibly encouraged by the governments by subsidizing the more bee-friendly methods and materials. Also, application of local and EU laws against harmful chemicals such as nicotinoids should be taken into account;
- Avoiding monoculture and increasing the flowering plants` diversity for a stable and nutritious food source for the bees and a stronger immune system for them; Farmers and in general gardeners should be encouraged to plant different crops and flowers which bloom during different months throughout the year so that the bees find enough food. Additionally, feeding on different sources of food will decrease the chances of weakened immune system by malnutrition and also transition of pathogens through food source;
- Planting bee-friendly plants and good nectar sources such as red clover, foxglove, bee balm and joe-pye weed (Kaplan, 2010);
- Reassuring the existence of flowering plants throughout the foraging seasons to avoid malnutrition in bees;
- Avoiding genetically modified agriculture and promoting bio-products; More research is required to prove the harmlessness of the modified crops for the pollinators and especially for the bees;

- Alternating crops to provide enough food during different seasons; Education regarding the issue and enforcement practices should be applied by the governments.

7.2.5. Requirements the governments and local authorities should meet

- Protecting the local and indigenous races of bees, which are relatively familiar with and or resistant to the local pests;
- Preserving biodiversity by conserving the fauna and flora species as well as habitats;
- Protecting natural woodlands, meadows and rangelands to provide pollinators with a variety of options to forage on;
- Avoiding desertification, urban development and deforestation to preserve the biodiversity for the pollinators;
- Rewarding and subsidizing farmers who practice bee-friendly actions such as leaving habitat for bees and using bee-friendly methods and less harmful chemicals in agriculture;
- Promoting flower boxes, roadside flower strips and bee-friendly green spaces in the city;
- An example of using the urban space for bee-friendly flowers is Netherlands which has covered hundreds of bus-stops with plants as a gift for bees (<https://www.independent.co.uk/news/world/europe/bus-stop-plants-green-roof-bees-holland-utrecht-a8997581.html>);
- Providing education and awareness to people, farmers, beekeepers, pupils, politicians and law makers regarding the issue;
- Supporting beekeepers and bee protection by application of laws and financially.

7.2.6. Requirements the public and researchers should meet

- Doing more research on causes of CCD on a local scale;
- Finding out ways to decrease the rates of death in bees;
- Educating beekeepers and providing courses for improving beekeeping methods;
- Bee-friendly gardens and flower boxes;
- Using less chemicals and more organic products;
- Using edible papers for bees which avoids bee exhaustion from searching long distances for food (<https://beesavingpaper.com>, Last accessed on 05.07.2020);

Non-toxic	Bacillus thuringiensis	Garlic	Kaolin clay	Corn gluten	Gibberellic acid		
Moderately toxic	Boric acid	Neem	Ryania	Adjuvants	Horticultural vinegar	Copper	Sulfur, lime sulfur
Highly toxic	Diatomaceous earth	Insecticidal soap or oil	Pyrethrins	Rotenone	Sabadilla	Spinosad	Copper sulfate

Table 7.1. List of pesticides and degrees of toxicity for bees

Source: <https://www.offthegridnews.com/survival-gardening-2/7-top-methods-for-bee-friendly-pest-control/> (Last seen on 05.07.2020)

In spite of the growing rates of death in bees and extinction of some bee species around the world, through increasing awareness and attention towards the problem and doing more research on local scales in order to find ways and cut down on CCD in bees, there is still hope to save these multifunctional and extremely precious species in the ecosystems.

Hence, more research is required to determine the causes of individual dead colonies in the region to gain a more exact overview. Additionally, an environmental assessment of the relationships between agricultural sector and the wild and managed pollinators could help us determine a closer estimation of the ecological and economic impacts of CCD in northern Germany.



Figure 7.2. Pollinators in the garden - Photo by Samar Shafiei

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Appendix: Definition of Terms

American foulbrood An extremely contagious disease of bees that affects them in the larval (worm) stage of development; caused by the bacteria *Bacillus larvae*.

Apiculture Beekeeping.

Apis mellifera A species of honeybee originated from Europe

Beehive A box with removable frames for housing bees

Beekeeper A person who keeps bees mainly for honey production

Beeswax A substance secreted by bees and it is used in industry, medicine and cosmetic products

Brood Young developing bees found in their cells in the egg, larval, and pupa stages of development.

Castes The different kinds of adult bees in a colony: workers, drone, and queen.

CCD Colony Collapse Disorder, a phenomenon which happens when a bee colony suddenly disappears or dies off, sometimes just leaving a queen and a few bees left in a hive

Cell A single compartment in a honeycomb in which brood is reared or food is stored.

Clarification The removal of foreign particles from liquid honey or wax by the straining, filtering, or settling process.

Colony A group of bees including the Queen, Drones and worker bees which form a family in a beehive and divide their duties among the members

Domestic Bees living in a manmade hive, Vs a natural hive

Drone A group of male bees in a colony with the only responsibility of fertilizing the Queen

European foulbrood An infectious disease affecting honeybees in the larval (worm) stage of development; caused by the bacteria *Streptococcus pluton*.

Extracted honey Liquid honey.

Frame Four strips of wood joined at the end to form a rectangular device for holding honeycomb.

Honey flow A time when nectar is plentiful, and bees produce and store surplus honey.

Honeycomb The mass of six-sided cells of wax built by honeybees in which they rear their young and store their food.

Larva The grublike or wormlike immature form of the honeybee in its second stage of metamorphosis.

Metamorphosis The series of changes in form through which an insect passes; egg to larva to pupa to adult.

Movable frame A frame of comb that can be easily removed from the hive. It is constructed to maintain a proper bee space, which prevents the bees from attaching comb or fastening it too securely with propolis.

Nectar A sweet liquid secreted by plants, usually in their flowers, and converted into honey by bees.

Nosema An infectious disease of the adult honeybee that infects the mid-gut, or stomach. It is caused by a protozoan parasite. Symptoms of this disease closely resemble those of dysentery.

Pesticide A general name for materials used to kill undesirable insects, plants, rodents, or other pests.

Pollen Dust-like grains formed in the flowers of plants in which the male elements are produced. Honeybees use pollen as a protein food for their young.

Propolis A kind of glue or resin collected by the bees for use in closing up cracks, anchoring hive parts, etc. It is also called bee glue.

Queen A fully developed female bee, responsible for laying eggs

Sealed brood Brood, mostly in the pupa stage, that has been capped or sealed in cells by the bees with a somewhat porous capping of wax.

Smoker A device that burns slow-burning fuels to generate smoke for the purpose of keeping the bees calm while working in their hive.

Swarm A large group of worker bees, drones, and a queen that leaves the mother colony to establish a new colony.

Worker bees A group of female bees in a colony, who are in charge of all the daily routine tasks

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Schiffdorf, 10.06.2020, _____

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