
**Project Number 289706**

**COLLABORATIVE PROJECT**
**AMIGA**

**Assessing and Monitoring the Impacts of Genetically modified plants on Agroecosystems**

# D2.2. Report on the current baseline conditions of different bio-geographic regions in Europe

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# Foreword

The current document includes a summary of available data on the beneficial arthropod fauna in maize and potato fields in Europe in preparation of establishing baselines for monitoring after field releases of transgenic maize and potato. According to the description of work, this deliverable is part of a task aimed at combining the analysis of published literature and field work to identify important ESs, develop methods to measure them, and assess their status. The first relevant part of this task was the analysis of existing scientific literature, which is discussed here. The data collected during surveys in commercial fields currently ongoing in the activities of AMIGA project in 9 European countries, and a specific review of existing monitoring methods will complete the effort of the project team to establish the current baseline conditions and ecosystem services in different bio-geographic European regions

## Summary

Information on sampling methods, time spans of collections and class and order distribution of arthropod predators and parasitoids in maize and potato crop according to their location in Europe have been extracted from of an European arthropod database. These extraction serve as a basis for developing a more generalized monitoring system in these two crops, which is required to deliver a more reliable risk assessment of the influence of genetically modified crops on beneficial arthropod fauna. The database contains records on altogether 3030 arthropod species and 1067 references. Some of these references include data for more than one crop and around half of them contain records of only one or two species per crop. In total, 14,762 records are available. A total of 2899 different species were found out of 13,836 records in crop fields and 529 species were found in field margins (926 records). The database contains 5499 records of 1679 species from maize and 2637 records of 793 species from potato. These records come from 31 countries, with the highest numbers from Germany. Fifteen methods have been used to collect these data, with pitfall traps being the most frequent. The most common predators include predatory beetles and spiders in both crops, with the share of beetles higher in maize than in potato. Parasitic Hymenoptera dominate the parasitoid guild in both crops. Sampling duration, composition by families and species, and methods summary provide useful guidelines about the methods to be tried for their potential as monitoring tools.

# 1. Introduction

## 1.1 The AMIGA project

Under the seventh framework programme “Food, Agriculture and Fisheries, Biotechnology” the project AMIGA (Assessing and Monitoring Impacts of Genetically Modified plants on Agro-ecosystems) has several major aims: it seeks to provide baseline data on biodiversity in agro-ecosystems in the EU and to translate regional protection goals into measurable assessment endpoints. Additionally suitable bioindicators for various European regions are to be defined and the knowledge on potential long term environmental effects of genetically modified plants (GMPs) should be improved. Also post market environmental monitoring, integrated pest management and economical aspects of GMPs are covered by AMIGA. Last but not least, the efficacy of the new EFSA Guidance Document for the Environmental Risk Assessment of GMPs will be tested.

Work Package 2 “Biogeographic regions and protection goals” of the AMIGA project aims to develop a selection matrix for identifying relevant biogeographical zones to be considered. Hereby, a case specific approach is chosen. Environmental protection goals and potential bioindicators are selected to characterize the receiving environment.

Task 2.2. “Baseline conditins and ecosystem services” serves to providing an overview about existing faunal species richness, with a special reference to species involved in providing useful ecosystem services in European maize and potato fields.

## 1.2. General background

Generally two genetically modified crops have been approved for the cultivation in Europe. This is the MON810 maize and the potato Amflora (EuropaBio, 2013). The MON810 maize is a transgenic variety designed to withstand crop loss due to insects, by an inserted gene that produces a harmful protein for insects eating of the maize. Main target is thereby the European corn borer and certain moths during storage of the maize. This gene is from Bacillus thuringiensis and therefore this corn plant is also randomly called Bt-corn (Hubert et al., 2008). Amflora, a genetically modified starch potato which only produces one particular type of starch, amylopectin, which optimizes the further processing to waxy potato starch (BASF, 2013). The Amiga (Assessing and Monitoring the Impacts of Genetically modified plants on Agro-ecosystems) project is a project by the European Union and aims to produce scientific data on the possible environmental and economic impacts of the cultivation of genetically modified plants that are relevant for the European environment. The Amiga project includes 22 partners from 15 European countries plus Argentina, studying the environmental impacts of genetically modified plants. A cornerstone of the project is to apply guidelines for the EFSA and standardized testing methods to help the European decision makers (AMIGA, 2013). EFSA commissioned a database of arthropod records from cultivated crops in Europe, with the purpose to deliver an overview of the arthropod fauna in arable crops across Europe, to support the environmental risk assessment of genetically modified crops in the European Union. This database has been developed out of scientific publications monitoring the arthropod fauna in arable land in Europe (Meissle et al., 2012). It is the aim of this document to extract the relevant and most important data for crop monitoring in Europe on beneficial arthropod fauna (predators and parasitoids) and thereby develop a basis for the development of a generalized monitoring of genetically modified maize and potato fields to examine their impact on the environment by monitoring their arthropod fauna.

# 2. Description of the database

## 2.1. Database structure

Species attributes and information on arthropod collections have been stored in a structured query language database. This database has been built up on an existing database for arthropod data of European maize fields by Knecht et al. (2010). A table with detailed information on every arthropod species is stored in the database with its scientific name, taxonomic family, order, class and subphylum. This taxonomy has been verified and checked by several European fauna databases. Also the functional group of each species was added to the database: herbivore, decomposer, predator, parasitoid, pollinator, planktivores or decomposers (including fungivores). Depending on the availability of such data, also the feeding guilds and habitat of the species were included in the database. Another table with detailed information of every collection of an arthropod species was developed. Studies of arthropod species in seven different crops have been included in the original database: maize, potato, beet, oilseed rape, rice, soybean and cotton. These studies have been either taken samples directly in the crop itself or in several types of field margins. These margins are classified as naturally occurring herbaceous margins, sown or planted margins, naturally regenerated margins, long-lasting woody margins or a combination of several of these margin types. The database also includes the method of sampling that was used for the collection as well as the duration of sampling and the taxonomic range covered by the study. Each study also refers to its reference with the name of the author, title, source and the year of publication. The abundance of each species for each collection was categorized in three classes: 'Unknown', 'low', for less than 1%, 'medium' for 1-5% and 'high' for more than 5% , calculated from the total number of individuals of the species compared to the total catch of the respective taxonomic order in the study. Out of this also mean (qualitative) abundances for each species in a crop have been calculated, using these three categories and referring on how many collections can be classified in the class of high, medium or low abundance. The resulting mean abundance is a number between 1 (low) and 3 (high) characterizing mean abundance of a certain species. Also geographical data, referring to the location of the collection, have been added to the database in form of geographical coordinates (longitude and latitude, coordinate system WGS 1984). The collections were also categorized into the European biogeographical regions.

The literature used for this database was retrieved from scientific literature systematically searched for the different crop and field margins and then filtered in a stepwise manner in ISI Web of Knowledge and the CAB Abstracts provided by OvidSP. After completion of the database several quality checks have been performed like checking species names or references for dublicates, checking geographical coordinates etc. (Meissle et al., 2012)

## 2.2. Crop type distribution in Europe and geographical zoning concept of the database

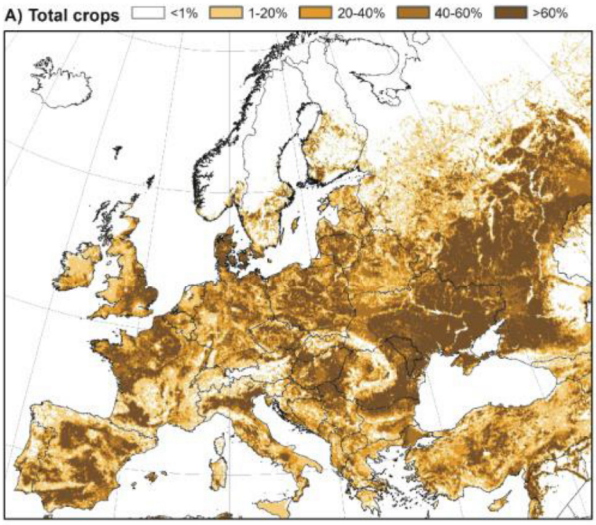


Figure 1: Total crop distribution Europe (Meissle et al, 2012)

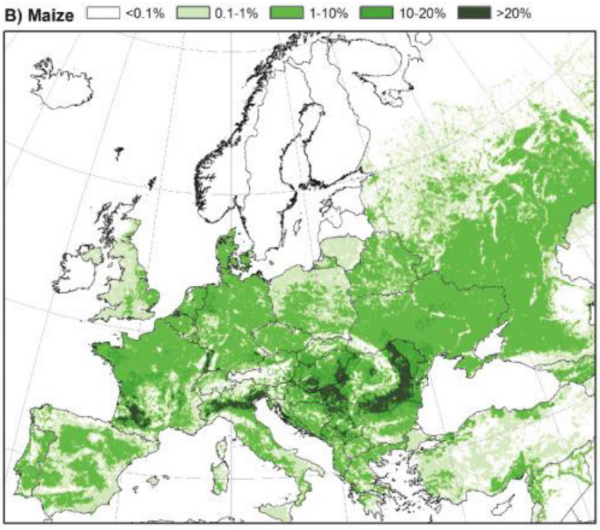


Figure 2: Maize cultivation Europe (Meissle et al., 2012)

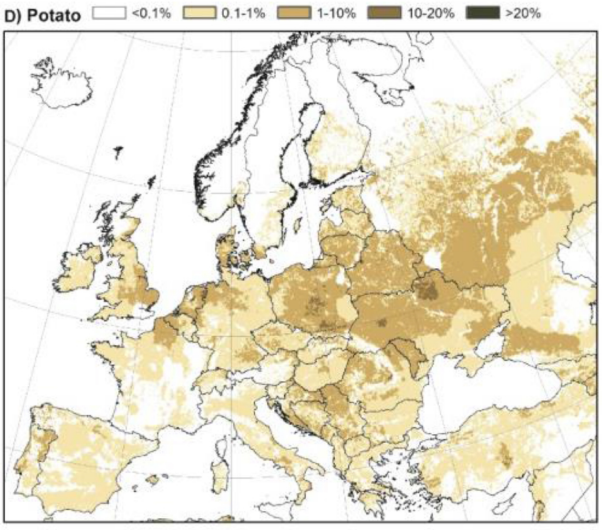


Figure 3: Potato cultivation Europe (Meissle et al., 2012)

Additionally to the database, crop maps have been created for Europe, based on the data of Monfreda et al. (2008). Figure 1 shows the distribution of the total arable land in Europe. Figure 2 the distribution of the cultivation of maize in Europe and figure 3 the areas where potato is cultivated. The percentage is referring to the harvested area of the crops as percentage of the total area. (Meissle et al., 2012)
These maps show the potential for GM-maize and GM-potato cultivation in Europe and the regions of most interest for this database analysis.

As there occur different arthropod species in different biogeographical regions more frequently, this developed European Arthropod Database allocated each species collection to a certain European biogeographical region. For this classification of biogeographical regions an existing zoning concept containing 10 zones was selected from Natura 2000 (European Environment Agency, 2013) of the European Commission (figure 4).

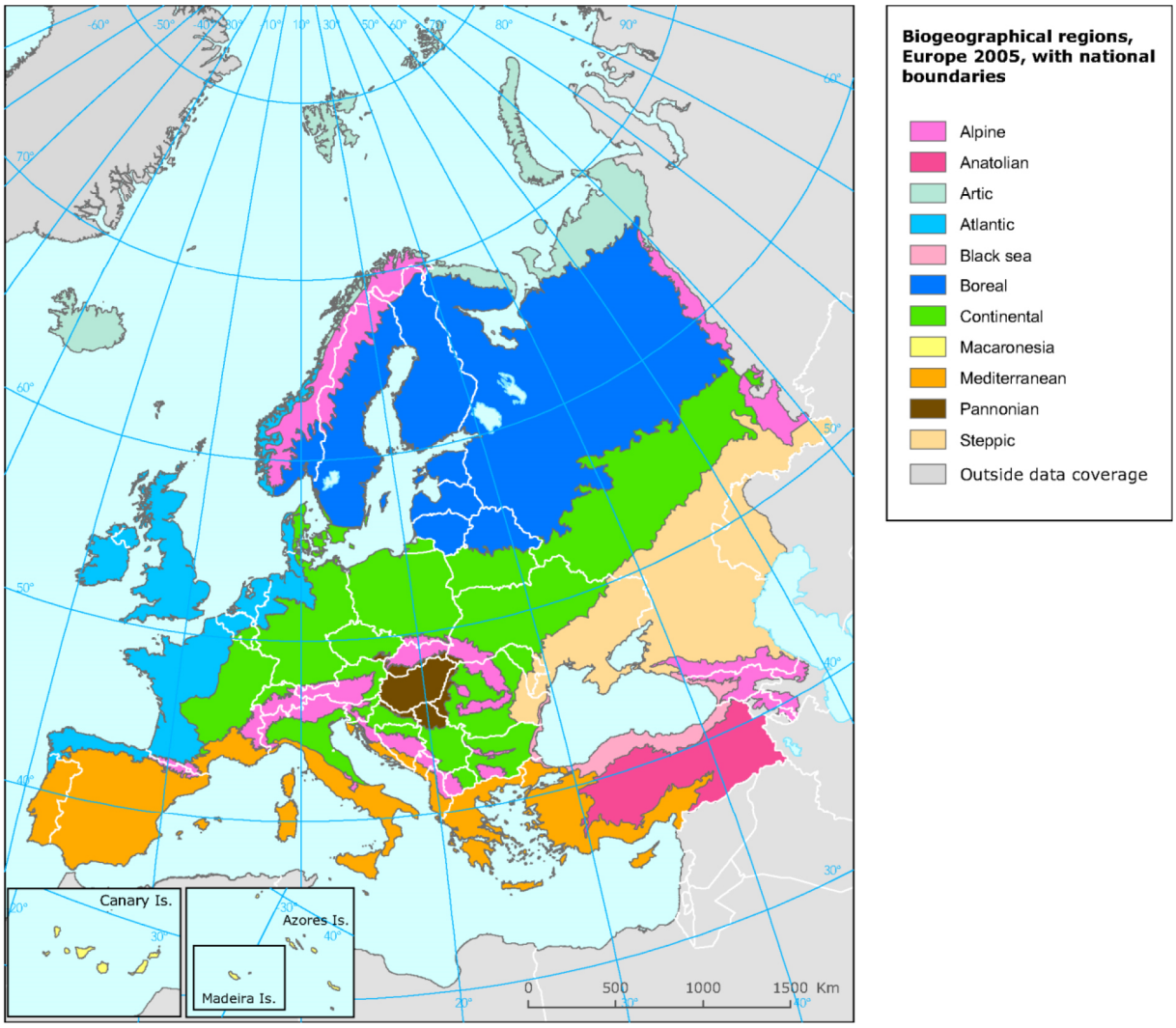


Figure 4: Biogeographical regions Europe (European Environment Agency , 2013)

Still some of these regions did not contain any or only a very few arthropod records for the recorded crop types for this database. The arctic region is excluded as it is considered that there are no field crops grown as well as the Anatolian region, as this region was not covered for the project are, considering the European continent. Additionally records from the Alpine regions were reassigned to bordering regions, as crops in the alpine areas are usually grown in the flat areas of valleys, which do not typically match alpine biogeography and climate. (Meissle et al., 2012) The choice of the regional characterizing according to the biogeographical area seems satisfying and suitable for such a database as it differs in the main climatic regions and environment types. Still some regions are on a very big scale like for example the boreal region and the continental region and it must be considered that small scale differences in climate and environment and therefore also in the appearance of fauna always take place under every regional classification. It would require a big effort to develop or convert the database to an even smaller regional scale than in this database classification.

## 3. Information extraction

### 3.1. General

The database contains records on altogether 3030 arthropod species and 1067 references. Some of these references include data for more than one crop and around half of them contain records of only one or two species per crop. In total 14,762 records are available. Two thousand, eight hundred and ninety-nine (2899) different species were found out of 13,836 records in crop fields and 529 species were found in field margins out of 926 records. The following information extraction and analysis of the database focuses on the records made in the crop field, as field margins might vary too much in their habitat characteristics to function as the basis of a generalized monitoring system. It occurs that many of the studies have been focusing on one or a few selected species rather than on a broad taxonomy. Figure 5 below shows the geographical distribution of the abundance of records from all crops, depending on the taxonomic range that was covered by the study.

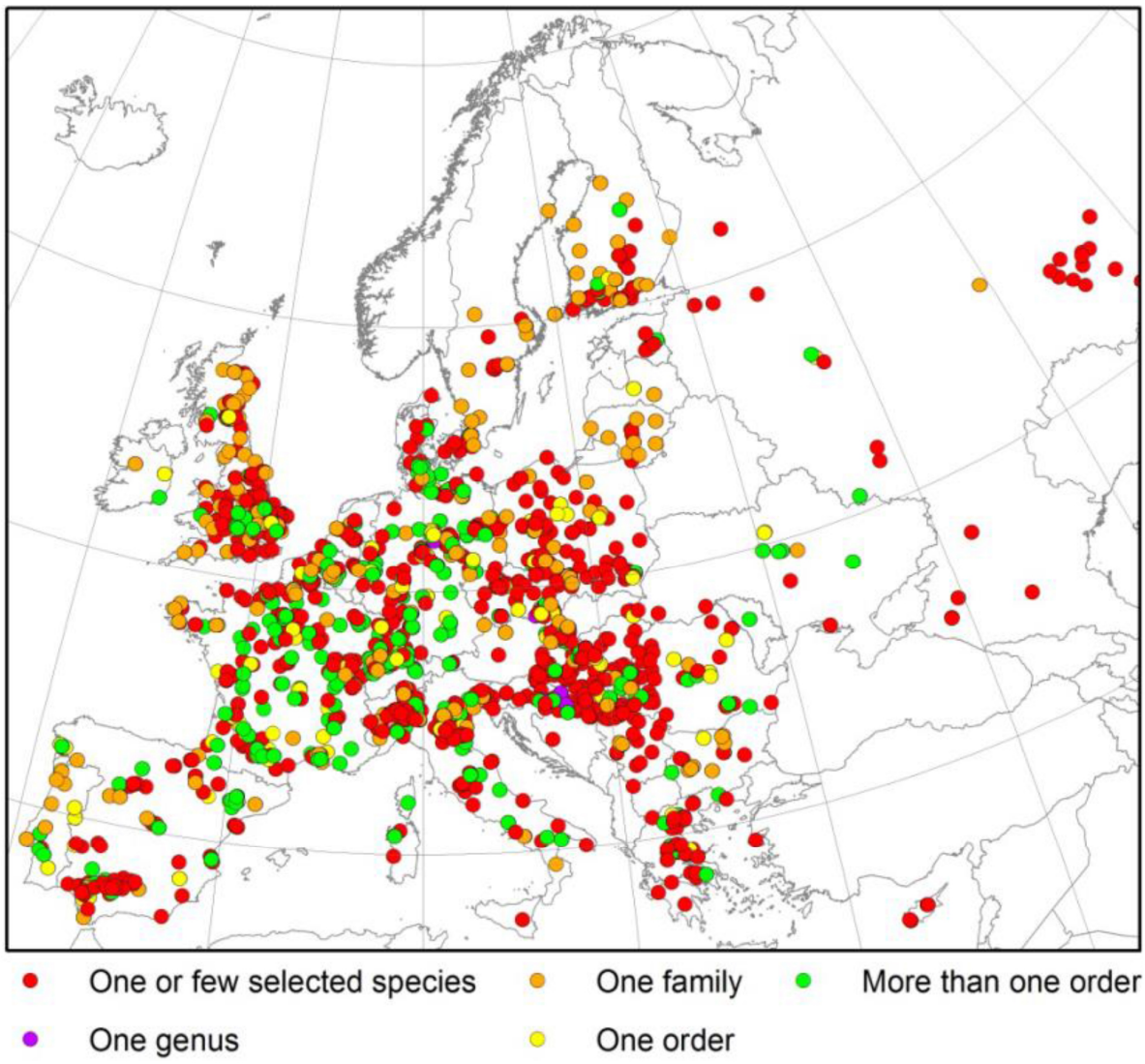


Figure 5: Geographical distribution of abundance of records (Meissle et al., 2012)

### 3.2. Records by crops, taxonomic resolution, methods and country

An overview of the number of species and records for each of the crops (Table 1) shows that most of the records indeed ceom from maize and potato.

**Table 1.** The number of records and identified arthropod species in major crops in Europe, 1915-2012

| Crop | Records | Species |
|---|---|---|
| Maize | 5499 | 1679 |
| Potato | 2637 | 793 |
| Beet | 2521 | 867 |
| Oilseed rape | 2342 | 689 |
| Rice | 429 | 232 |
| Soybean | 224 | 181 |
| Cotton | 184 | 71 |

The number of records depending on crop and country of record are illustrated in figure 6. The records are coming from 31 European countries, most of them from Germany with 3095 records, followed by the United Kingdom and Hungary which also have both more than 1000 records. More than 500 records are taken from Italy, France, Poland, Spain, Romania, Finland and the Czech Republic. Mainly due to missing translating capabilities or limited publications in the used literature databases only a few data is included from most Eastern European countries like Moldova or Ukraine.

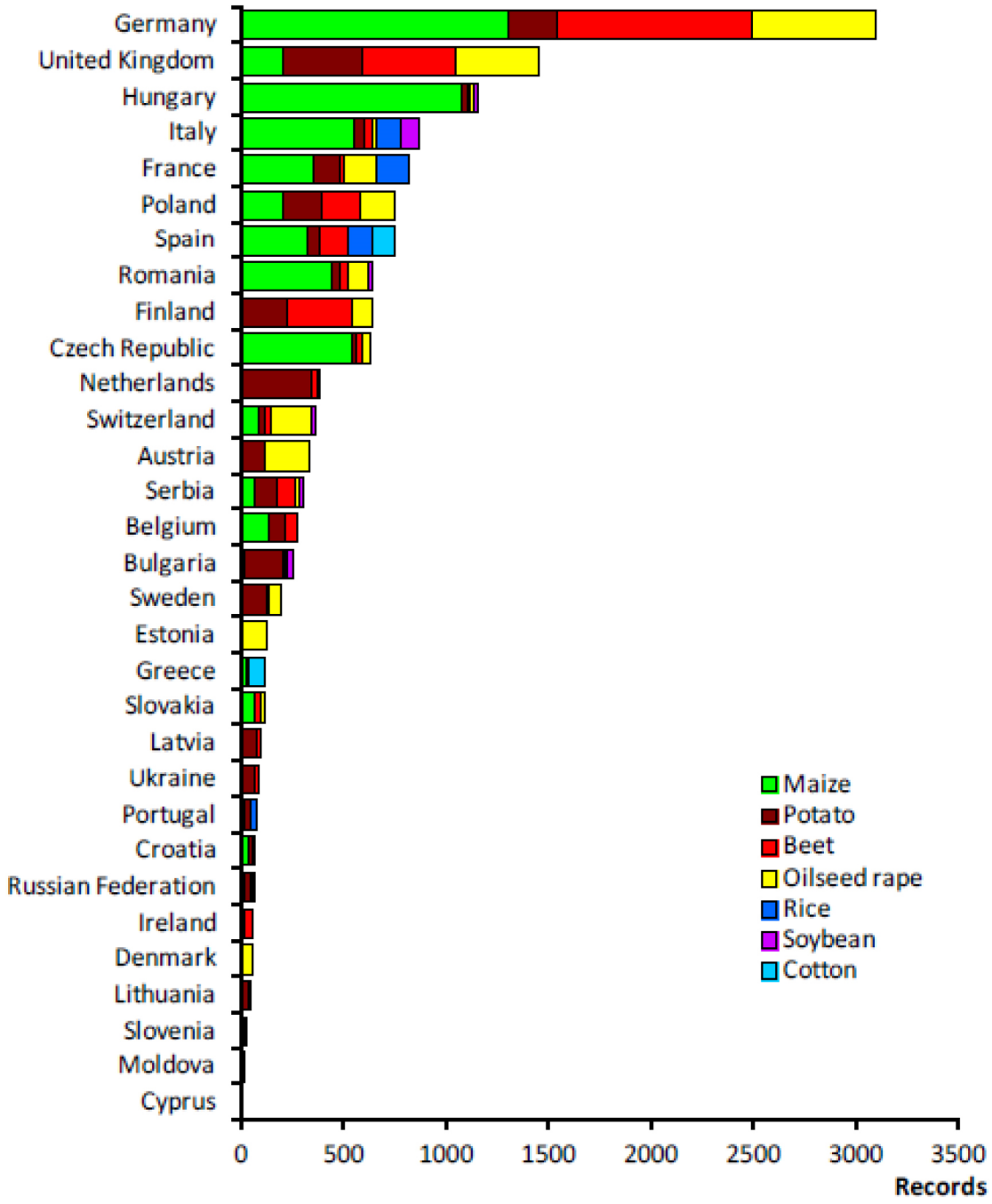


Figure 6: Records depending on crop and country (Meissle et al., 2012)

Fifteen categories have been made to analyze the distribution of the different sampling methods of the arthropod abundance records: pitfall trap, visual counts, pan trap, soil sample, plant removal, visual collection, emergence trap, light trap, sweep net, several methods, sticky trap, Malaise trap, aspirator, other, and unknown. However the database differantiates between pitfall trap, visual counts, pan trap, soil sample, plant removal, unknown, emergence trap, light trap, sweep net, several methods, sticky trap, malaise, aspirator, beat sheet, damage assessment, pheromone trap, water sampling and other. Based on the database categories, most of the records used pitfall trap as a sampling method with 4470 records (Figure 7). There are 1943 visual count records, 1004 records were made by pan traps and 1003 with soil samples. Sampling methods depend on the habitat of each arthropod species, as obviously below-ground arthropods are mainly collected with soil samples. Soil-surface arthropods are preferably collected with pitfall traps. Useful information can be provided by the database referring to the most common sampling methods for example for certain functional groups of arthropod species. Figure 7 illustrates the distribution of the different sampling methods in all crops based on the extracted data from the database.

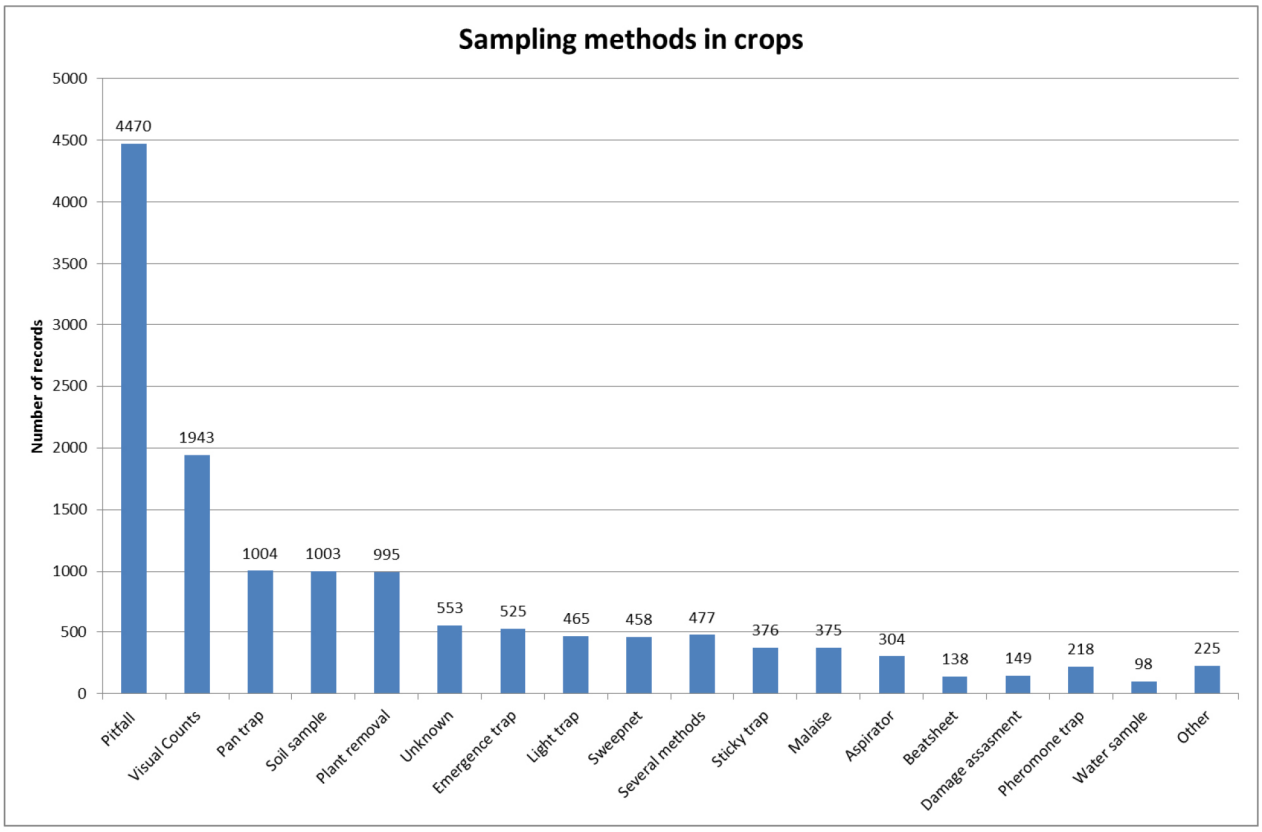


Figure 7: Distribution of sampling methods

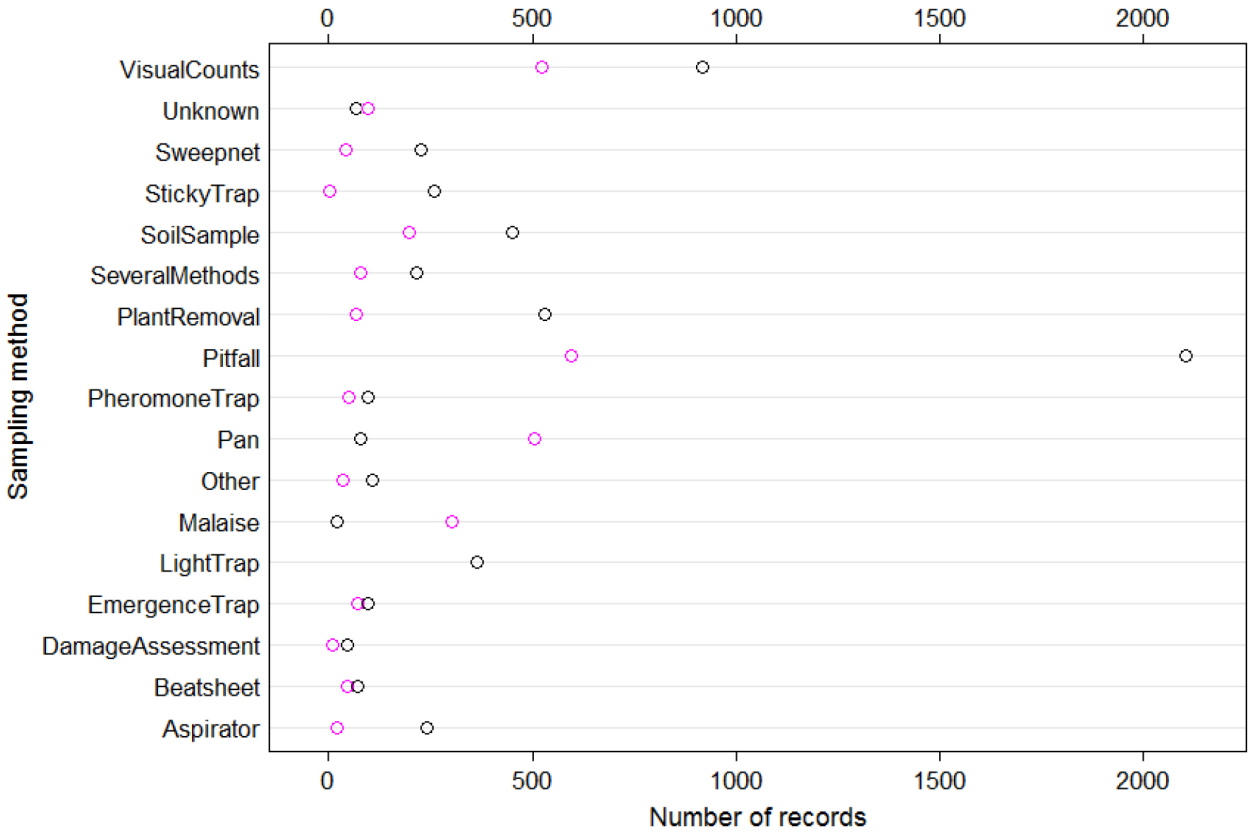


**Figure 8. The number of records for each sampling method used in maize (black circle) and potato (red circle) crop from 1925 till 2012 in Europe.**

Checking the methods used specifically for maize and ptoato surveys (Fig 8), a similar picture emerges. However, pitfall traps ahve been overhwelimngly used in maize (2000+ records).

**Table 2.** Published informations from 1925 to 2012 of the sampling methods used in seven different crops (cotton, maize, oilseed rape, potato, rice, soybean and sugar fodder beat) in Europe. Asp = aspirator; Bea= beatsheet; Dam = damage assessment; Em= emergence trap; Li= light trap; Mal = malaise; Oth = other; Phe = pheromone trap; Sev = several methods; Sti = sticky traps; Swe = sweepnet; Un = unknow; Wat = water sample

| Country | Sampling method | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aspirator | Beating | Damage assessment | Emergence trap | Light trap | Malaise trap | Other | Pheromon trap | Several methods | Sticky trap | Sweep netting | Unknown | Water pan trap |
| Austria | | | | X | | | | X | | X | | | |
| Belgium | | X | | | | X | X | | | | | X | |
| Bulgaria | X | X | X | | | | | X | X | | | X | |
| Croatia | | X | X | X | | | | X | X | X | | X | |
| Cyprus | | | | | | | | X | | | | | |
| Czech Rep. | X | | X | | | | X | | X | X | | X | |
| Denmark | | | | X | | X | | | | | | X | |
| Estonia | | X | X | | | | | | | | | | |
| Finland | | | X | X | | | | | X | X | X | X | |
| France | X | X | X | X | X | | X | X | X | X | X | X | X |
| Germany | X | X | X | X | X | X | X | X | X | X | X | X | |
| Greece | | | X | | X | | X | X | X | | X | X | |
| Hungary | | X | X | | X | | X | X | X | X | X | X | |
| Ireland | X | | | | | | | | | | | | |
| Italy | | | X | | X | X | X | X | X | X | X | X | X |
| Latvia | | | | | | | | | X | | | | |
| Lithuania | | | | | | | | X | | | | | |

| Country | Sampling method | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aspirator | Beating | Damage assessment | Emergence trap | Light trap | Malaise trap | Other | Pheromon trap | Several methods | Sticky trap | Sweep netting | Unknown | Water pan trap |
| Moldova | | | | | | | | | X | | | | |
| Netherlands | | | | X | | X | X | | | | | X | |
| Poland | | | X | | X | | X | X | X | | X | X | |
| Portugal | X | | | | | | X | X | | | | | |
| Romania | | | X | | | | | X | X | X | X | X | |
| Russia | | | | | | | | | | | X | X | |
| Serbia | | X | X | | X | | X | X | X | X | X | X | |
| Slovakia | | | X | | | | | | | X | X | X | |
| Slovenia | | | | | | | X | X | X | | | | |
| Spain | | X | X | | X | | X | X | X | | X | X | X |
| Sweden | X | X | X | X | | | | | X | X | X | X | |
| Switzerland | X | X | | | X | X | X | | X | X | X | X | |
| Ukraine | | | X | | X | | | X | X | | | X | |
| U.K. | X | X | X | X | | X | X | X | X | X | | X | |

### 3.3. Records by functional groups

Another important characteristic of the records is the distribution of the functional groups of arthropods that have been collected. Figure 9 shows that herbivores and predators are the most collected categories, followed by decomposers and parasitoids.

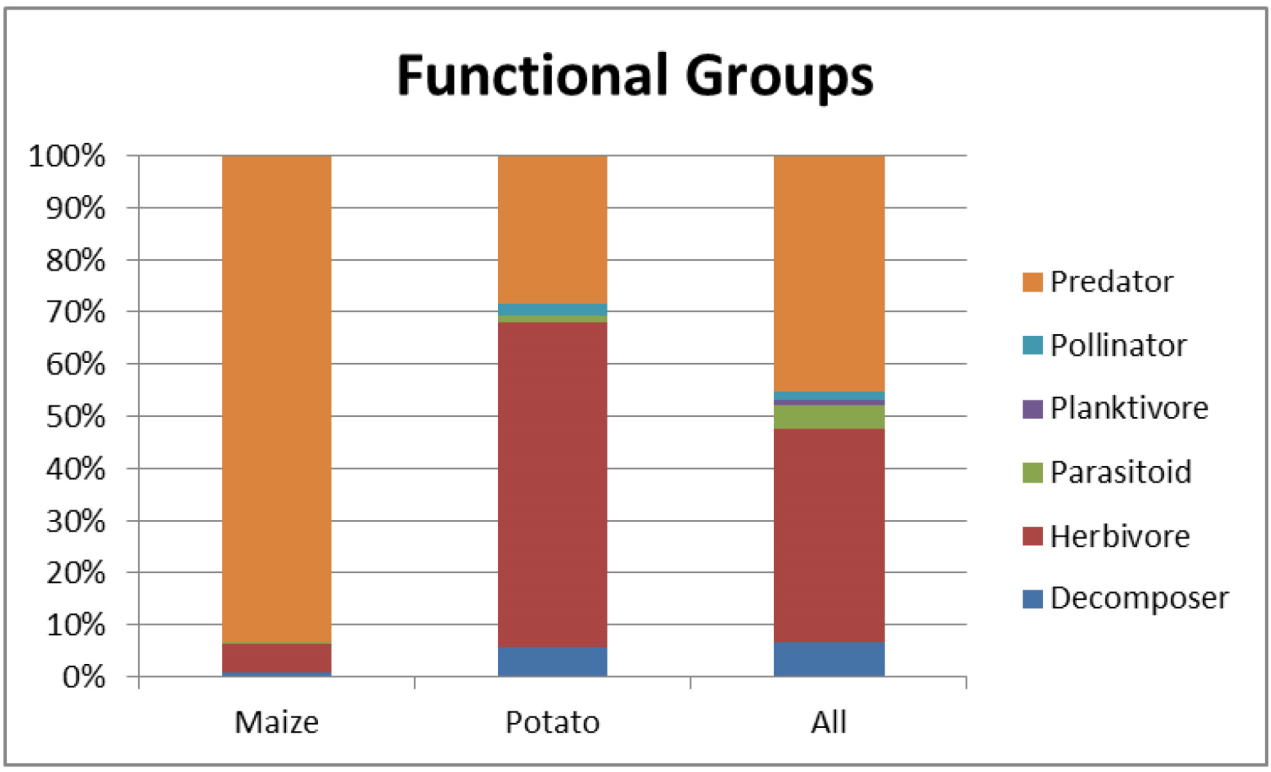


Figure 9: Functional groups depending on crop

### 3.3.1. Parasitoids and predators

Aim of this project is to focus on parasitoid and predator records of the database, as these two functional groups have beneficial functions as natural enemies of herbivores that damage the crop (Lövei & Arpaia, 2005). Figure 10 shows the distribution of the sampling methods of parasitoids and predators in all crops. The most common methods are marked and can be compared with each other.

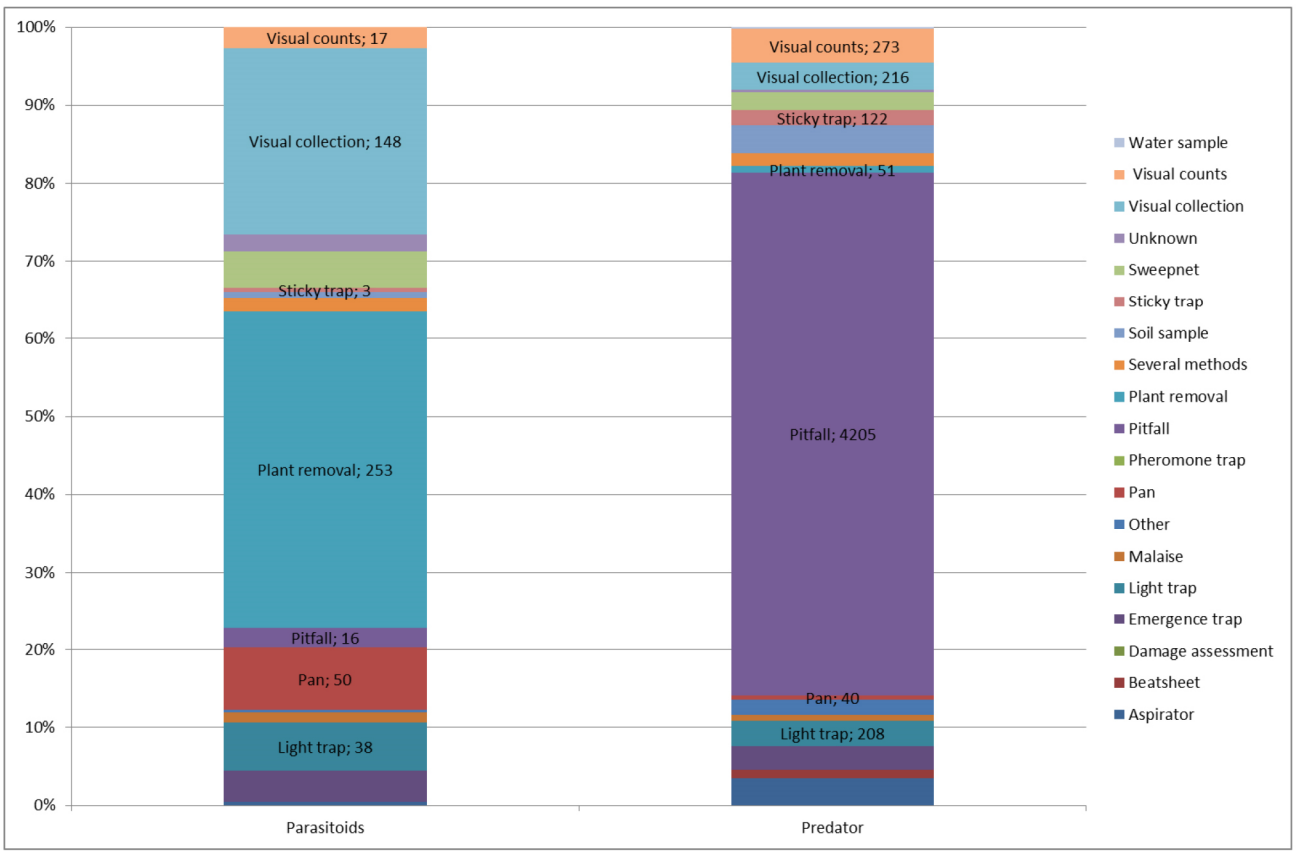


Figure 10: Sampling methods parasitoids and predators

*Maize*

Maize is cultivated over much of Europe. Studies on maize arthropods does not precisely reflect the importance of this crop for the region's agriculture. On figure 11, red circles stand for herbivore collections and green triangles for the collection of other functional groups against the background of the harvested area of maize based on Monfreda et al. (2008).

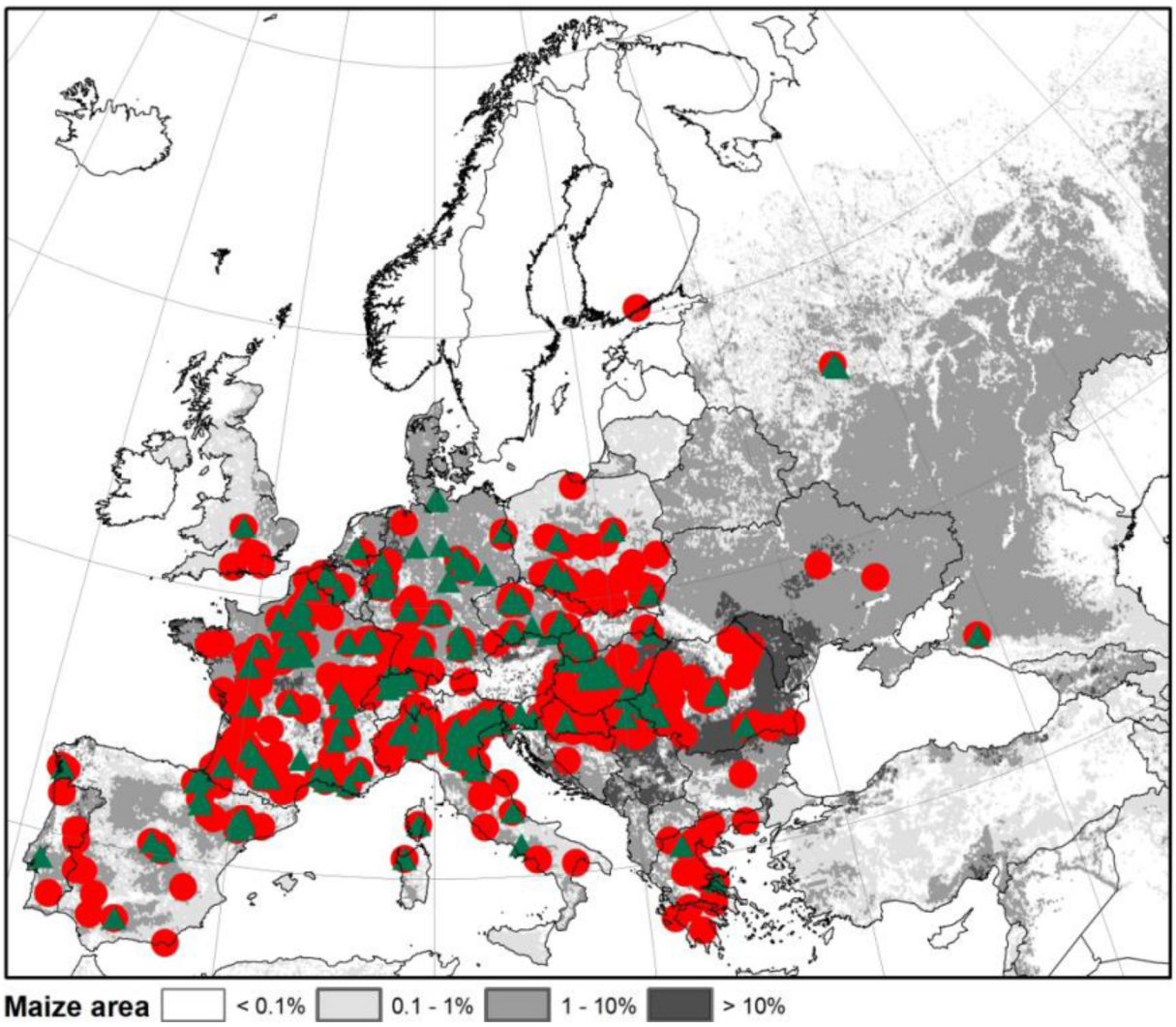


Figure 11: Geographical distribution records in maize, against a background of maize acreage in Europe.

The distribution of different orders and families of the arthropod species collected in the functional group of parasitoids and predators are displayed in table 2. Thereby the first number in the parentheses indicates the number of abundance records and the second number indicates the number of species within that group or taxon.

**Table 3.** The taxonolmic composition the predator and parasitoid guilds in European maize fields.

| Maize<br>Functional group | Orders | Families |
|---|---|---|
| Parasitoids (247, 107) | Hymenoptera (162, 87) | Braconidae (69, 33), Ichneumonidae (33, 20), Pteromalidae (18, 11), Trichogrammatidae (17, 4), Figitidae (8, 5), Mymaridae (6, 4), Eulophidae (5, 5), Encyrtidae (3, 2), Megaspilidae (2, 2), Scelionidae (1, 1) |
| | Diptera (75, 16) | Tachinidae (68, 9), Chloropidae (5, 5), Phoridae (2, 2) |
| | Coleoptera (10, 4) | Staphylinidae (10, 4) |
| Predators (3107, 876) | Coleoptera (1820, 438) | Carabidae (1369, 272), Staphylinidae (246, 133), Coccinellidae (193, 27), Cantharidae (8, 3), Monotomidae (2, 1), Histeridae (1, 1), Malachiidae (1, 1) |
| | Araneae (808, 246) | Linyphiidae (398, 94), Lycosidae (117, 34), Theridiidae (70, 20), Thomisidae (34, 11), Tetragnathidae (33, 4), Gnaphosidae (32, 19), Araneidae (28, 11), Salticidae (15, 11), Clubionidae (11, 6), Agelenidae (11, 5), Pisauridae (11, 1), Dictynidae (10, 6), Philodromidae (6, 5), Corinnidae (6, 2), Amaurobiidae (5, 3), Hahniidae (4, 2), Dysderidae (3, 3), Zoridae (3, 2), Zodariidae (3, 1), Anyphaenidae (3, 1), Mimetidae (2, 2), Liocranidae (1, 1), Pholcidae (1, 1), Uloboridae (1, 1) |
| | Diptera (116, 58) | Syrphidae (57, 14), Hybotidae (32, 23), Dolichopodidae (17, 13), Empididae (4, 4), Cecidomyiidae (4, 2), Microphoridae (1, 1), Sciomyzidae (1, 1) |
| | Neuroptera (110, 25) | Chrysopidae (67, 11), Hemerobiidae (42, 13), Osmylidae (1, 1) |
| | Hemiptera (103, 24) | Nabidae (55, 9), Anthocoridae (43, 10), Miridae (4, 4), Saldidae (1, 1) |
| | Acarina (66, 53) | Phytoseiidae (19, 13), Laelapidae (14, 11), Ascidae (8, 7), Parasitidae (6, 6), Macrochelidae (3, 3), Digamasellidae (3, 2), Eviphididae (3, 2), Galumnidae (2, 2), Veigaiidae (2, 2), Aceosejidae (2, 1), Halolaelapidae (1, 1), Rhodacaridae (1, 1), Scutacaridae (1, 1), Trombidiidae (1, 1) |
| | Hymenoptera (20, 10) | Formicidae (20, 10) |
| | Opiliones (17, 6) | Phalangiidae (15, 5), Trogulidae (2, 1) |
| | Dermaptera (16, 2) | Forficulidae (13, 1), Labiduridae (3, 1) |
| | Thysanoptera (13, 4) | Aeolothripidae (13, 4) |
| | Lithobiomorpha (11, 4) | Lithobiidae (9, 3), Henicopidae (2, 1) |
| | Geophilomorpha (4, 3) | Geophilidae (3, 2), Linotaeniidae (1, 1) |
| | Orthoptera (1, 1) | Tettigoniidae (1, 1) |
| | Pseudoscorpionida (1, 1) | Neobisiidae (1, 1) |
| | Scolopendromorpha (1, 1) | Cryptopidae (1, 1) |

The distribution of the main orders in the functional group of parasitoids and predators in maize are illustrated in figure 12. Most of the parasitoids are belonging to the order of Hymenoptera and most of the predators are belonging to the order of Coleoptera.

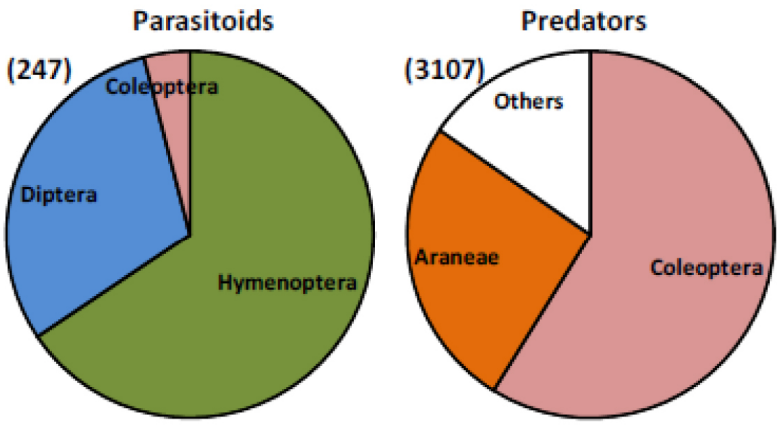


Figure 12. The taxonomic composition of the parasitoid and predatory guilds in European maize fields.

*Potato*

Focusing on the cultivation of potato in Europe the distribution of the arthropod records in potato is illustrated in figure 12. Red circles stand for herbivore collections and green triangles for the collection of other functional groups with the background of the harvested area of maize based on Monfreda et al. (2008).

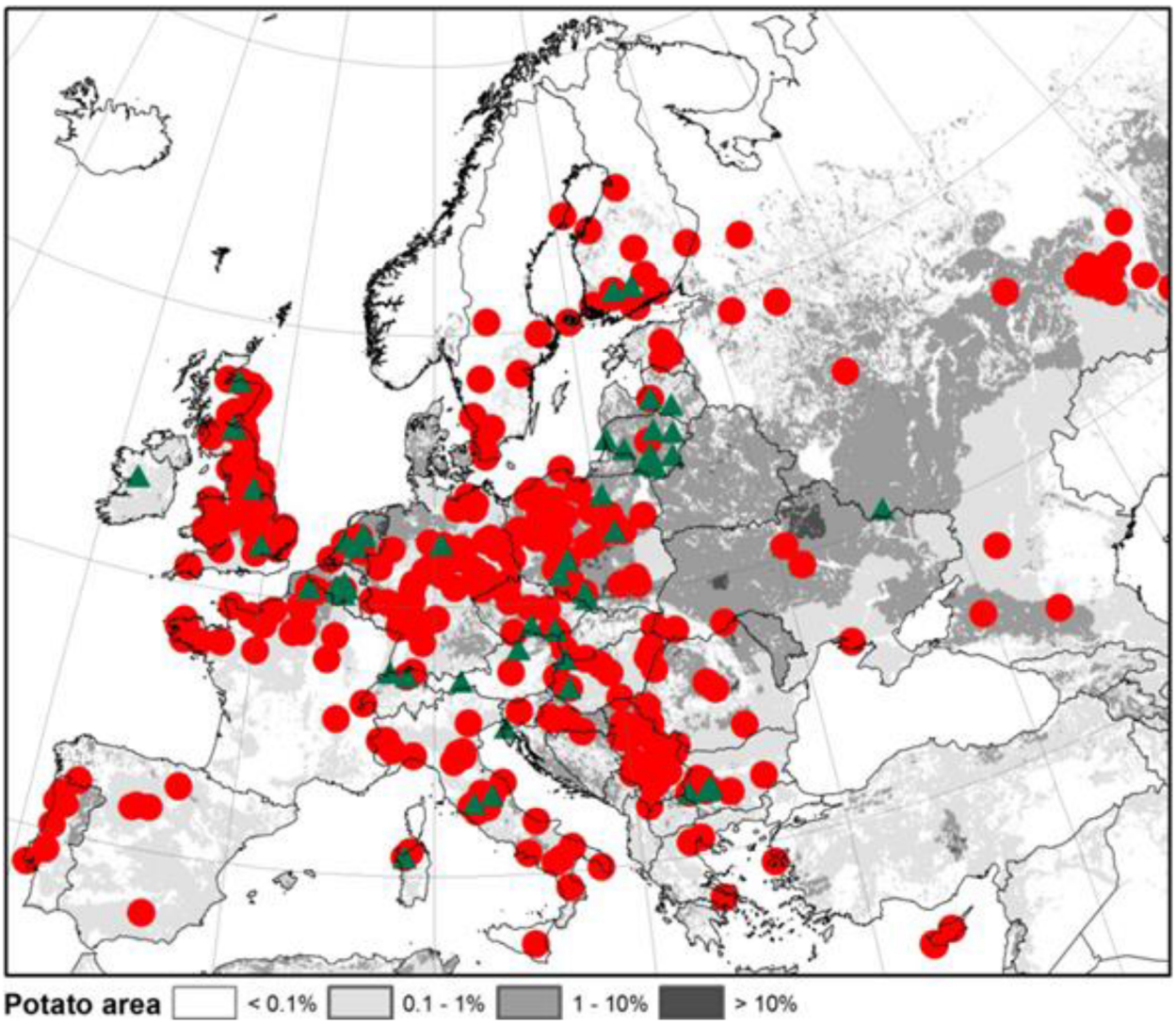


Figure 13. Geographical distribution records in potato, against a background of potato acreage in Europe.

The distribution of different orders and families of the arthropod species collected in the functional group of parasitoids and predators in potato are displayed in table 4. Thereby the first number in the parentheses indicates the number of abundance records and the second number indicates the number of species within that group or taxon.

**Table 4:** Potato, composition parasitoids and predators

| Potato | | |
|---|---|---|
| **Functional group** | **Orders** | **Families** |
| Parasitoids (29, 26) | Hymenoptera (25, 23) | Braconidae (15, 13), Figitidae (4, 4), Eulophidae (2, 2), Ichneumonidae (2, 2), Dryinidae (1, 1), Pteromalidae (1, 1) |
| | Coleoptera (3, 2) | Staphylinidae (3, 2) |
| | Diptera (1, 1) | Phoridae (1, 1) |
| Predators (753, 320) | Coleoptera (557, 171) | Carabidae (472, 123), Staphylinidae (43, 34), Coccinellidae (34, 8), Histeridae (5, 4), Cantharidae (3, 2) |
| | Araneae (117, 87) | Linyphiidae (27, 19), Lycosidae (27, 18), Gnaphosidae (24, 20), Salticidae (11, 10), Theridiidae (11, 5), Thomisidae (5, 4), Corinnidae (2, 2), Philodromidae (2, 2), Tetragnathidae (2, 1), Titanoecidae (2, 2), Araneidae (1, 1), Dysderidae (1, 1), Zodariidae (1, 1), Zoridae (1, 1) |
| | Diptera (45, 37) | Hybotidae (19, 19), Syrphidae (16, 8), Dolichopodidae (9, 9), Empididae (1, 1) |
| | Neuroptera (9, 4) | Chrysopidae (8, 3), Hemerobiidae (1, 1) |
| | Opiliones (9, 7) | Phalangiidae (9, 7) |
| | Hemiptera (8, 7) | Anthocoridae (4, 3), Nabidae (3, 3), Pentatomidae (1, 1) |
| | Acarina (7, 6) | Scutacaridae (2, 1), Veigaiidae (2, 2), Ascidae (1, 1), Eviphididae (1, 1), Laelapidae (1, 1), |
| | Orthoptera (1, 1) | Tettigonidae (1, 1) |

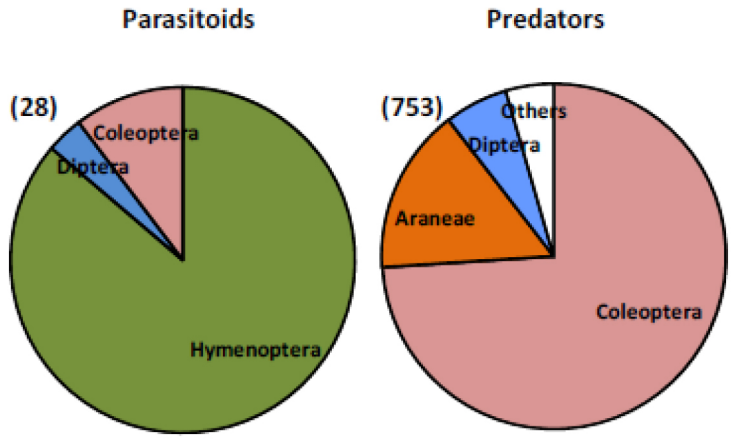


Figure 14: Potato, composition parasitoids and predators (Meissle et al., 2012)

The distribution of the main orders in the functional group of parasitoids and predators in maize are illustrated in figure 14. Also in maize fields most of the parasitoids are belonging to the order of Hymenoptera and most of the predators are belonging to the Coleoptera order.

# 4. Additional database analysis

The aim of an additional analysis of the database is to examine the parasitoid and predator fauna of the two crops maize and potato, examining the collected classes and orders, depending on the location in Europe. Additionally the most common sampling methods for monitoring parasitoid and predator fauna in maize and potato and the time span of researches wants to examined. Therefore the program Microsoft Access 2010 has been used with its function of using queries and filters to extract the wanted information. Only the predators and parasitoids with their adult habitat 'on above-ground plant parts' and 'on the soil surface' have been chosen for this analysis, as well as only the collections made directly in the crop and not the ones in neighbouring margins. The number of records of predators and parasitoids, the number of records in their different classes and orders have been examined for every geographical region of collection, to give an overview in which regions, which fauna orders are more or less common. Also the number of occurring species in the geographical area has been examined. This will provide a basis for developing a more standardized monitoring evaluation and developing a more standardized rules for fauna monitoring in maize and potato fields.

## 4.1. Maize

In maize there have been 3291 records found referring to the functional group of predators and parasitoids.

### 4.1.1. Predators

The number of records of predators in maize and the number of records of predators according to the class and order taxonomy of the found species are displayed in table 5. The amount of predator records in maize crop is 3044 including 828 different species. The continental region shows the highest amount of records followed by the Pannonian region and the Atlantic region, as these regions are the main maize growing regions in Europe. The most common orders found in nearly all regions are the Coleoptera belonging to the class of Insecta and the Araneae belonging to the class of Arachnida.

**Table 5:** Maize predators, regional.

| | | *Number of records* | *Number of species* | *Number of records* | | | |
|---|---|---|---|---|---|---|---|
| *Predators and parasitoids* | | 3291 | | | | | |
| *Predators* | | 3044 | 828 | | | | |
| | *Location* | | | | | | |
| | Continental | 1638 | 543 | | | | |
| | | | | *Class* | | | |
| | | | | Insecta | 1049 | | |
| | | | | | | *Order* | |
| | | | | | | Coleoptera | 949 |
| | | | | | | Dermaptera | 8 |
| | | | | | | Diptera | 30 |
| | | | | | | Hemiptera | 22 |
| | | | | | | Hymenoptera | 16 |
| | | | | | | Neuroptera | 18 |
| | | | | | | Orthoptera | 1 |
| | | | | | | Thysanoptera | 5 |
| | | | | Arachnida | 589 | | |
| | | | | | | *Order* | |
| | | | | | | Acarina | 10 |
| | | | | | | Araneae | 565 |
| | | | | | | Opiliones | 14 |
| | Atlantic | 534 | 282 | | | | |
| | | | | *Class* | | | |
| | | | | Insecta | 376 | | |
| | | | | | | *Order* | |
| | | | | | | Coleoptera | 284 |
| | | | | | | Dermaptera | 2 |
| | | | | | | Diptera | 60 |
| | | | | | | Hemiptera | 21 |
| | | | | | | Neuroptera | 6 |
| | | | | | | Thysanoptera | 3 |
| | | | | Arachnida | 158 | | |
| | | | | | | *Order* | |
| | | | | | | Araneae | 156 |
| | | | | | | Opiliones | 2 |
| | Boreal | 8 | 8 | | | | |
| | | | | *Class* | | | |
| | | | | Insecta | 8 | | |
| | | | | | | *Order* | |
| | | | | | | Coleoptera | 7 |
| | | | | | | Hemiptera | 1 |
| | Mediterranian | 151 | 82 | | | | |
| | | | | *Class* | | | |
| | | | | Arachnida | 22 | | |
| | | | | | | *Order* | |
| | | | | | | Acarina | 9 |
| | | | | | | Araneae | 12 |
| | | | | | | Opiliones | 1 |
| | | | | Insecta | 129 | | |
| | | | | | | *Order* | |
| | | | | | | Coleoptera | 95 |
| | | | | | | Dermaptera | 4 |
| | | | | | | Diptera | 5 |
| | | | | | | Hemiptera | 12 |
| | | | | | | Neuroptera | 9 |
| | | | | | | Thysanoptera | 4 |
| | Pannonian | 713 | 328 | | | | |
| | | | | *Class* | | | |
| | | | | Arachnida | 76 | | |
| | | | | | | *Order* | |
| | | | | | | Araneae | 75 |
| | | | | | | Pseudoscorpionida | 1 |
| | | | | Insecta | 637 | | |
| | | | | | | *Order* | |
| | | | | | | Coleoptera | 485 |
| | | | | | | Dermaptera | 2 |
| | | | | | | Diptera | 21 |
| | | | | | | Hemiptera | 47 |
| | | | | | | Hymenoptera | 4 |
| | | | | | | Neuroptera | 77 |
| | | | | | | Thysanoptera | 1 |

Most of the collections were made over a time span of more than a year or over the full crop season, which can be expected to deliver a reliable picture of the composition of fauna species in maize crop (figure 15).

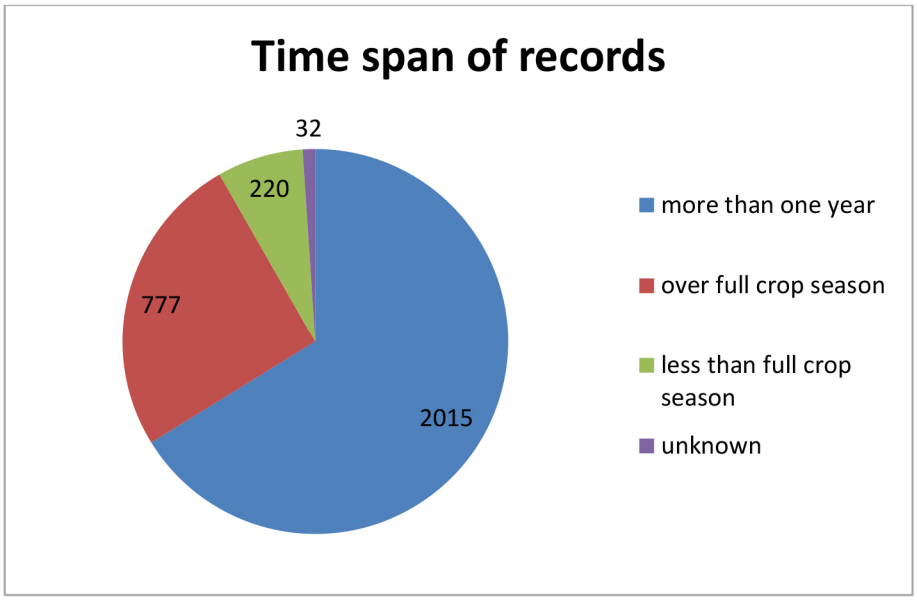


Figure 15: Maize predators, time span of records

The different methods of the sampling of the species collections are illustrated in figure 16. Most of the records are made using pitfalls or visual counts.

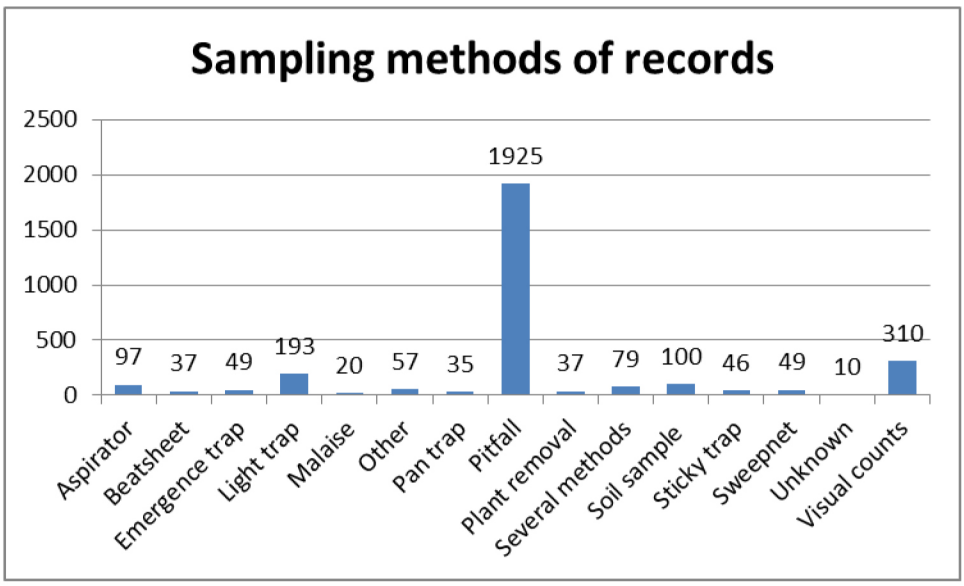


Figure 16: Maize predators, sampling methods

### 4.1.2. Parasitoids

The number of records of parasitoids in maize and the number of records of parasitoids according to the class and order taxonomy of the found species are displayed in table 6. The amount of parasitoid records in maize crop is 247 including 107 different species. The continental region shows the highest amount of records followed by the Pannonian region and the Atlantic region, as these regions are the main maize growing regions in Europe. The most common orders found in nearly all regions are the Hymenoptera and Diptera both belonging to the class of Insecta as also all other found orders in the functional group of parasitoids in maize.

**Table 6:** Maize parasitoids, regional.

| | *Number of records* | *Number of species* | *Number of records* | | |
|---|---|---|---|---|---|
| *Predators and parasitoids* | 3291 | | | | |
| *Parasitoids* | 247 | 107 | | | |
| *Location* | | | | | |
| Continental | 118 | 60 | | | |
| | | | *Class* | | |
| | | | Insecta | 118 | |
| | | | | *Order* | |
| | | | | Coleoptera | 7 |
| | | | | Diptera | 36 |
| | | | | Hymenoptera | 75 |
| Atlantic | 43 | 23 | *Class* | | |
| | | | Insecta | 43 | |
| | | | | *Order* | |
| | | | | Diptera | 25 |
| | | | | Hymenoptera | 18 |
| Steppic | 1 | 1 | *Class* | | |
| | | | Insecta | 1 | |
| | | | | *Order* | |
| | | | | Hymenoptera | 1 |
| Mediterranean | 30 | 21 | *Class* | | |
| | | | Insecta | 30 | |
| | | | | *Order* | |
| | | | | Coleoptera | 1 |
| | | | | Diptera | 11 |
| | | | | Hymenoptera | 18 |
| Pannonian | 55 | 36 | *Class* | | |
| | | | Insecta | 55 | |
| | | | | *Order* | |
| | | | | Coleoptera | 2 |
| | | | | Diptera | 3 |
| | | | | Hymenoptera | 50 |

Most of the collections were made over a time span of more than a year or over the full crop season, which can be expected to deliver a reliable picture of the composition of fauna species in maize crop (figure 17).

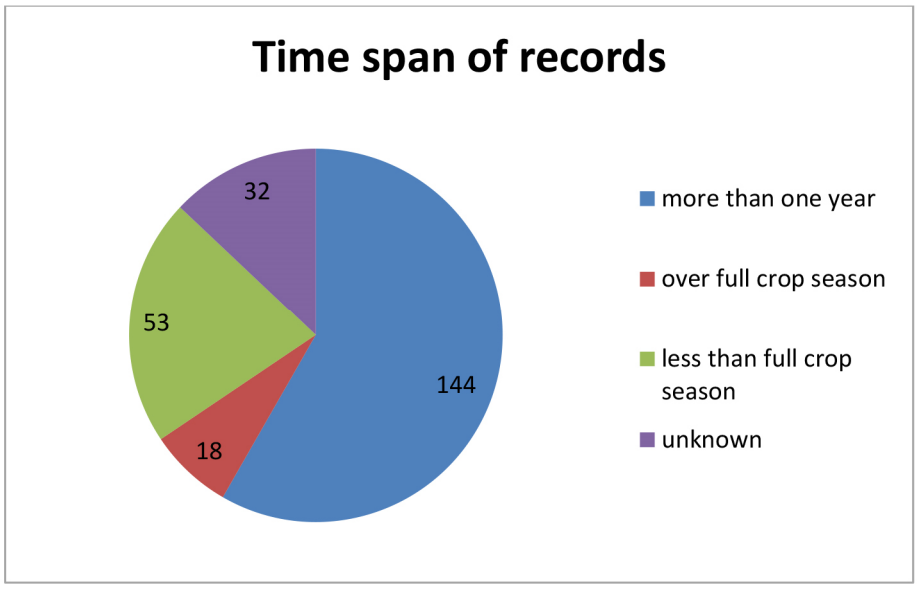


Figure 17: Maize parasitoids, time span of records

The different methods of the sampling of the species collections are illustrated in figure 18. Most of the records are made using plant removal or visual counts.

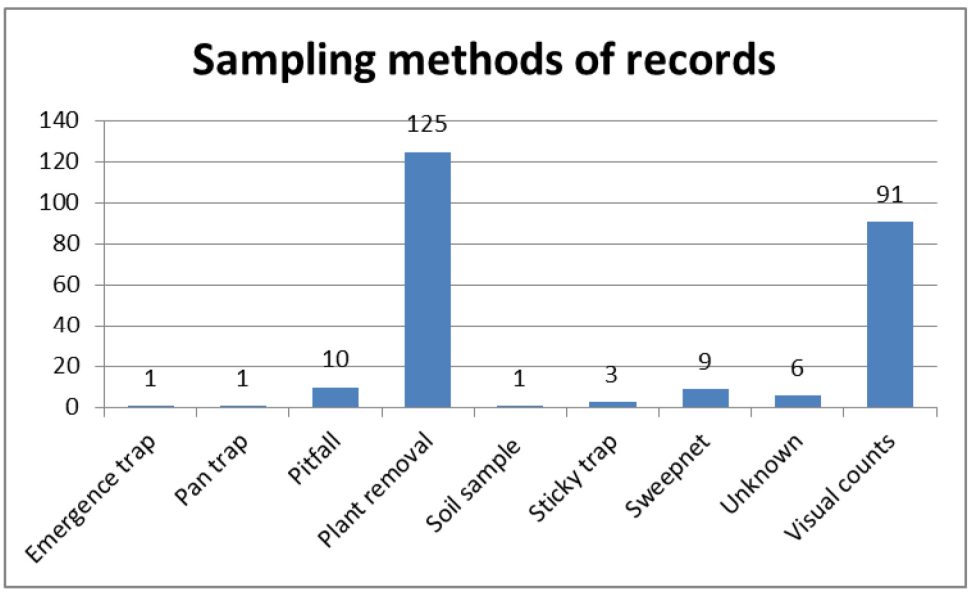


Figure 18: Maize parasitoids, sampling methods

## 4.2. Potato

### 4.2.1. Predators

The number of records of predators in potato and the number of records of predators according to the class and order taxonomy of the found species are displayed in table 7. The amount of predator records in potato crop is 746 including 314 different species.

The continental region shows the highest amount of records followed by the Atlantic region in Europe. The most common orders found in nearly all regions are the Coleoptera belonging to the class of Insecta. The order Araneae belonging to the class of Arachnida occurs in the continental region and the Pannonian region.

**Table 7:** Potato predators, regional.

| | *Number of records* | *Number of species* | *Number of records* | | | |
|---|---|---|---|---|---|---|
| *Predators and parasitoids* | 775 | | | | | |
| *Predators* | 746 | 314 | | | | |
| *Location* | | | | | | |
| Continental | 364 | 207 | | | | |
| | | | *Class* | | | |
| | | | Arachnida | 116 | | |
| | | | | | *Order* | |
| | | | | | Araneae | 114 |
| | | | | | Opiliones | 2 |
| | | | Insecta | 248 | | |
| | | | | | *Order* | |
| | | | | | Coleoptera | 246 |
| | | | | | Hemiptera | 1 |
| | | | | | Orthoptera | 1 |
| Atlantic | 205 | 114 | | | | |
| | | | *Class* | | | |
| | | | Arachnida | 7 | | |
| | | | | | *Order* | |
| | | | | | Opiliones | 7 |
| | | | Insecta | 198 | | |
| | | | | | *Order* | |
| | | | | | Coleoptera | 145 |
| | | | | | Diptera | 45 |
| | | | | | Neuroptera | 8 |
| Boreal | 161 | 78 | | | | |
| | | | *Class* | | | |
| | | | Insecta | 161 | | |
| | | | | | *Order* | |
| | | | | | Coleoptera | 157 |
| | | | | | Hemiptera | 4 |
| Pannonian | 16 | 14 | | | | |
| | | | *Class* | | | |
| | | | Arachnida | 3 | | |
| | | | | | *Order* | |
| | | | | | Araneae | 3 |
| | | | Insecta | 13 | | |
| | | | | | *Order* | |
| | | | | | Coleoptera | 9 |
| | | | | | Hemiptera | 3 |
| | | | | | Neuroptera | 1 |

Most of the collections were made over a time span of more than a year or over the full crop season, which can be expected to deliver a reliable picture of the composition of fauna species in maize crop (figure 19).

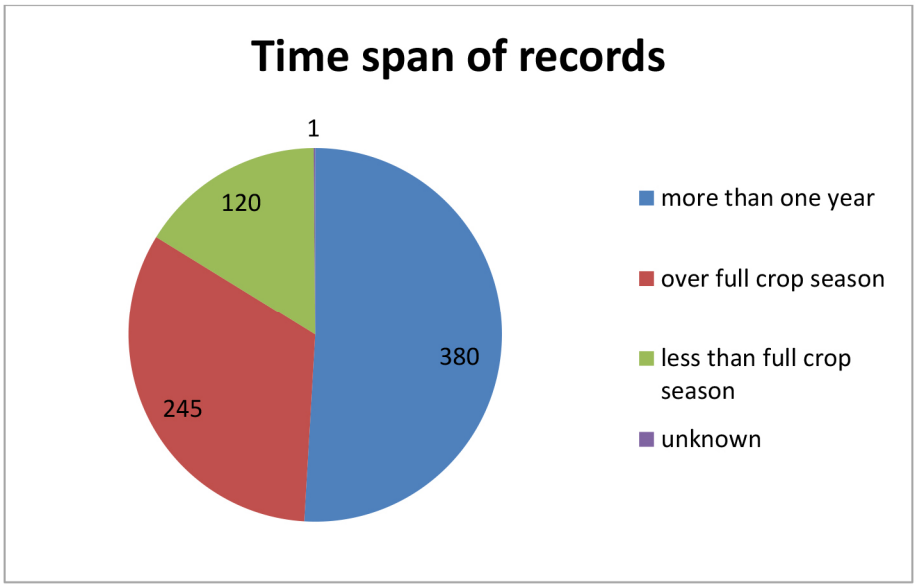


Figure 19: Potato predators, time span of records

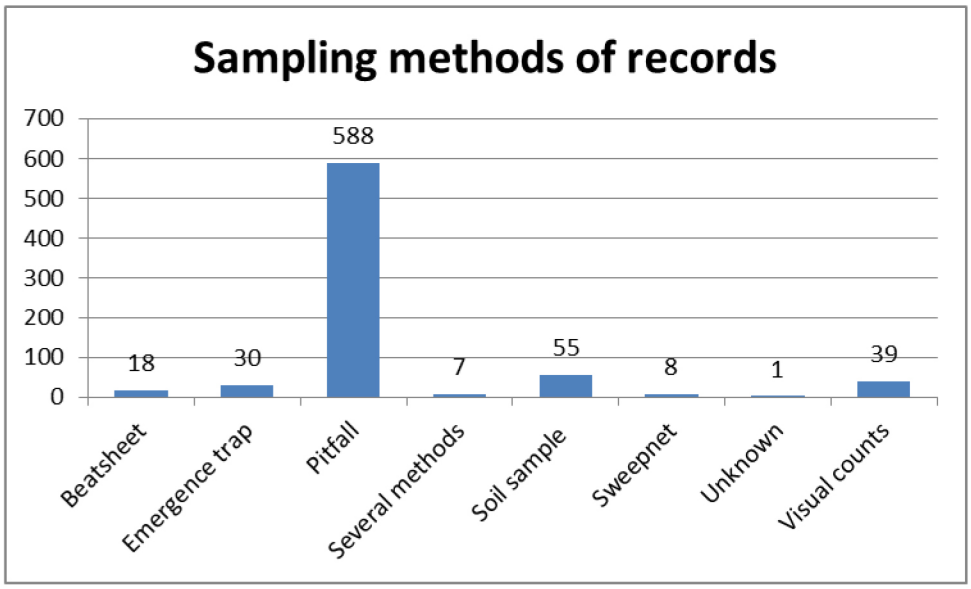


Figure 20: Potato predators, sampling methods

The different methods of the sampling of the species collections are illustrated in figure 20. Most of the records are made using pitfalls, soil samples or visual counts.

### 4.2.2. Parasitoids

The number of records of parasitoids in potato and the number of records of parasitoids according to the class and order taxonomy of the found species are displayed in table 8. The amount of parasitoid records in potato crop is 29 including 26 different species, which is a small amount of records to present a reliable picture of the parasitoids in potato. Records of parasitoids in potato crop are only made in three regions, continental, Atlantic and mediterranean, of which the Atlantic regions shows the highest amount of records collections. The most common order found in all regions is the Hymenoptera belonging to the class of Insecta as also all other found orders in the functional group of parasitoids in potato.

**Table 8:** Potato parasitoids, regional.

| | *Number of records* | *Number of species* | *Number of records* | | |
|---|---|---|---|---|---|
| *Predators and parasitoids* | 775 | | | | |
| *Parasitoids* | 29 | 26 | | | |
| *Location* | | | | | |
| Continental | 7 | 6 | | | |
| | | | *Class* | | |
| | | | Insecta | 7 | |
| | | | | *Order* | |
| | | | | Colepotera | 3 |
| | | | | Hymenoptera | 4 |
| Atlantic | 16 | 15 | | | |
| | | | *Class* | | |
| | | | Insecta | 16 | |
| | | | | *Order* | |
| | | | | Diptera | 1 |
| | | | | Hymenoptera | 15 |
| Mediterranean | 6 | 6 | | | |
| | | | *Class* | | |
| | | | Insecta | 6 | |
| | | | | *Order* | |
| | | | | Hymenoptera | 6 |

Most of the collections were made over a time span of more than a year or over the full crop season, which can be expected to deliver a reliable picture of the composition of fauna species in potato crop (figure 21).

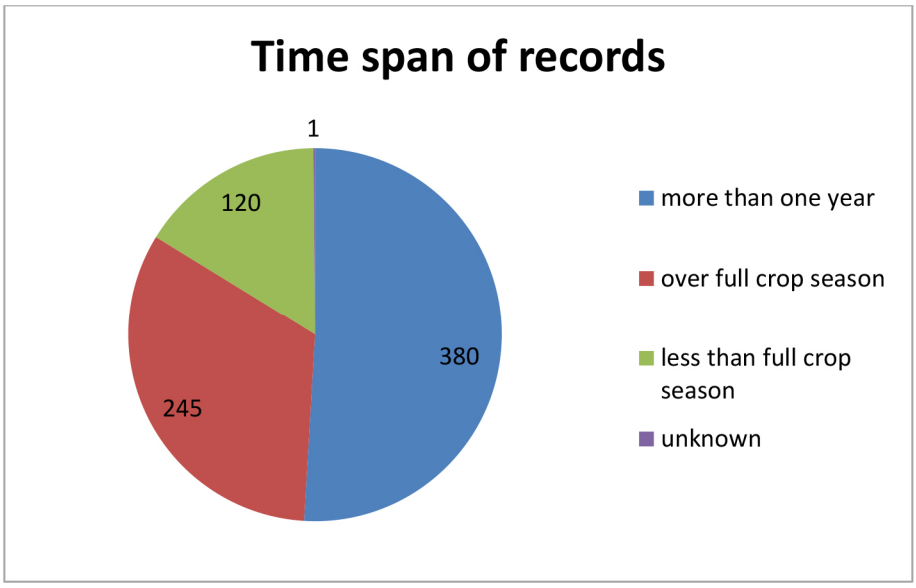


Figure 20: Potato parasitoids, time span of records

The different methods of the sampling of the species collections are illustrated in figure 21. Most of the records are made using pitfalls, soil samples or visual counts.

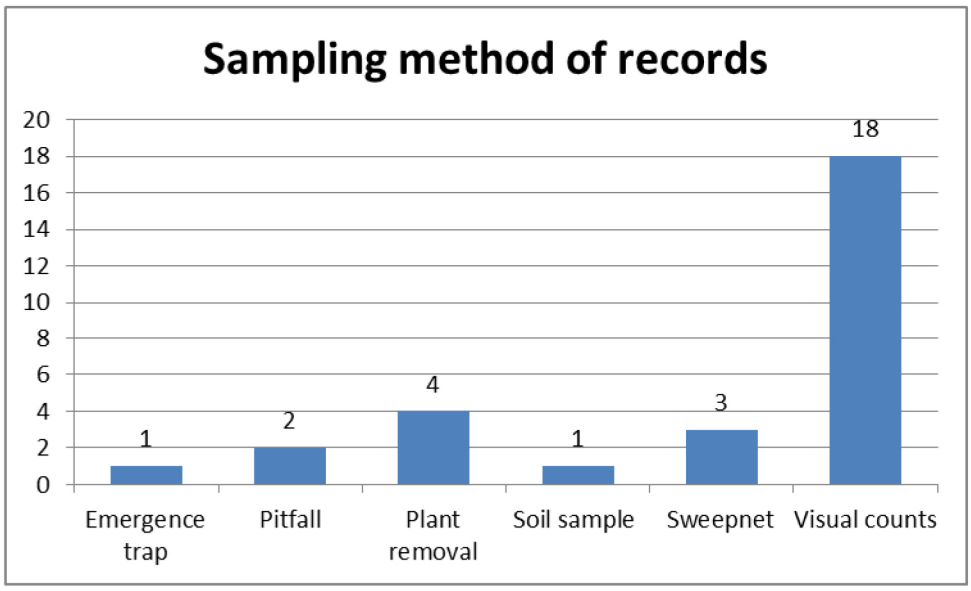


Figure 22: Potato parasitoids, sampling methods

## 5. Conclusions

In general it is not an easy task to generalize monitoring strategies for fauna, as many different sampling methods are used during different time spans in different regions in Europe. Still it is possible to see a certain monitoring pattern depending on the region and the functional group. The maize predator records are mainly made with pitfalls, most over a longer period than one year over the whole crop season. Also a high number of records provide these information which makes it reliable. It could be suggested to use the main sampling method of pitfalls for monitoring predators in genetically monitored maize over at least the whole crop season to get comparable results to the given records in conventional maize. Depending on the region one can see which classes and orders are the most common, which could be compared to the monitoring in genetically modified maize. In further analysis one could also break down to the family taxonomy and even the species level to develop a basis, to compare monitoring in genetically modified maize also on these levels. Also the predator collections in potato are mainly collected via pitfalls and over a longer period of time than a year or over the whole crop growing season. Also the amount of collections seems to show a reliable picture of the predator monitoring in potato crop. Parasitoids collections in maize and especially in potato show a much lower amount of records. Here it is hard to estimate if an overall conclusions should be made for general monitoring as the number of records might be too low to verify the result. For future genetically modified crop monitoring it will be important to take the different species abundance depending on the European region into account. Therefore it is very important to develop similar monitoring evaluations depending on the region, after having developed an overall more generalized monitoring guideline for fauna in genetically modified crops and also in conventional grown crops, so more reliable comparisons can be made. Due to the different conditions of regions, climate, crop management and sampling in fauna monitoring it can always be argued if the difference in fauna abundance and composition can finally be lead back to the fact that not a conventional crop, but a genetically modified crop is grown. Still using this database it is possible to develop a more similar and more comparable guideline for arthropod fauna monitoring in certain crops and regions. Using these generalized guidelines in the field, researches made due to these guidelines could be compared more easily and their results could be more helpful for decision makers about the growing of genetically modified crops in the European Union.

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