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PERSEUS*

Plant health surveys for the EU territory: an analysis of data quality and methodologies and the resulting uncertainties for pest risk assessment

Gritta Schrader et al.

*Perseus, first of the mythic heroes was famed for slaying beasts, such as the snake-haired Medusa and the deceptively beautiful Gorgon. In our context, the foes are the organisms that impact on plant health that require "slaying" through diligence brought about by adequate surveying methodologies.

Objectives of the project

1. Review the methodologies of specific surveys for quarantine pests listed in the annexes of Directive 2000/29/EC: 298 species

2. Identify the strengths and limitations of methodologies

3. analyse the uncertainties for pest risk assessment and for evaluation of management options

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The project

Work Package 1	Work Package 2	Work Package 3	Work Package 4	Work Package 5	Work Package 6
FERA	FERA	JKI	INRA	FERA	FERA
Systematic review of literature	**Inventory of specific surveys**	**Review of methodol-ogies**	**Case studies**	Reporting	Manage-ment

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WP 1: Systematic literature review

Species list (Annexes I and II of Directive 2000/29/EC)

1) Detection
2) Delimitation
3) Monitoring
4) Commodity surveys

Search protocol according to EFSA guidelines

But: There is no available quantitative data on the effectiveness of surveys in detecting, delimiting, monitoring pest populations or inspecting commodities to formulate such questions

→ Difficult to run a true systematic review

TRADITIONAL REVIEW

DATABASE OF THE CASES and data analysis

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WP 1: Systematic literature review

1) Detection:

- devices/techniques for detecting/monitoring plant pests
- Methods (e.g. trap type, attractant, molecular identification technique)
- not field application
- “Which is the best trap for a defined species?”
- not: how many traps are needed

2) Delimitation:

- application of methods described in 1) to delimit population of established organism in PRA area
- how to implement delimitation survey under real field conditions

3) Monitoring:

- field application of methods described in 1) for monitoring population density of established plant pest
- information on how to implement a monitoring survey (e.g. trap density, sampling effort, spatial distribution of the traps, frequency of checks).

4) Commodity:

- potential commodities associated with introduction of plant pest and methods to detect pest in commodity

WP 1: Systematic literature review

Strategy element	Examples
1. Focused, explicit search terms	*"Diabrotica virgifera"* / "Western corn rootworm" (pest); "*Zea mays*" / maize (host)
2. Pre-defined eligibility criteria	1 genus name AND species name 2 AND surve* or monitor* or detect* or find* or trap* or delimit* or commodit* or inspect*
3. Predefined search protocol	Search BIOSIS 1985–2011, CAB 1973–2011, Ovid MEDLINE 1996–2011, Zoological record 1993–2011
4. Quality assessment tool	Qualitative assessment based on eligible survey characteristics
5. Full reporting of results	Results tabulated, all aspects of search described
6. Synthesis	Description of data, quantitative wherever possible

WP 1: Results

- **58,811** publication items analysed,
- **16,561** retained for analysis,
- **226** were added,
- **5,115** were cited and reported as full references in the summaries
- All taxonomic groups well represented, except mites
- **Detection:** methods available for most species (16 excluded: 8 fungi, 5 insects, 1 phytoplasma, 2 viruses),differ greatly among taxonomic groups
- **Delimitation:** methods available for 67 species out of 283, mainly ground surveys (visual inspection and application of the detection methods)
- **Monitoring:** methods available for 195 species out of 283, different frequencies among groups
- **Commodity:** pathways available for 140 species out of 283, evenly distributed among groups. Mainly: trade of whole plants, fruit and seed, soil, wood
- **Summaries** for each species, the best available methods and major gaps

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Anoplophora glabripennis (Motschulsky)

Taxa: Insecta: Coleoptera: Cerambycidae
EU: subject to emergency measures under Commission Decision 1999/355.
EPPO A1 list: No. 296

Organism

The host range of *A. glabripennis* is splitted according to the develomental stages of larvae (development to maturity) and adults (maturation feeding).
The major hosts of *A. glabripennis* in China are species and hybrids of section Aegeiros of the genus Populus: *P. nigra*, *P. deltoides*, *P. x canadensis* and the Chinese hybrid *P. dakhuanensis*. Some poplars of the other sections of the genus (Alba and Tacamahaca) are also attacked. Salix spp. (*S. babylonica*, *S. matsudana*) are also major hosts. Various other woody plants have also been recorded as hosts in China: *Acer*, *Alnus*, *Malus*, *Morus*, *Platanus*, *Prunus*, *Pyrus*, *Robinia*, *Rosa*, *Sophora* and *Ulmus*. Within the urban outbreak areas in North America, *A. glabripennis* has mainly been found on Acer spp. (*A. negundo*, *A. platanoides*, *A. pseudoplatanus*, *A. rubrum*, *A. saccharinum* and *A. saccharum*) and on *Aesculus hippocastanum*. However, it has also been found on a range of other hardwood species: *Betula*, *Fraxinus*, *Liriodendron tulipifera*, *Morus alba*, *Populus*, *Robinia pseudacacia*, *Salix* and *Ulmus*.

The species is indigenous to China, but also reported from Korea Democratic People's Republic, Korea Republic and Taiwan as well as from North America: USA (New York city and Illinois).
According to climate and feeding conditions the development of a generation takes between one and two years. Thus, there can be one or two overlapping generations per year. Adults emerge between May and October and live for about a month. The adults usually remain on the tree from which they emerged, or fly short distances to nearby trees, and feed there on leaves, petioles and young bark. The eggs are laid one by one under the bark, in oviposition slits chewed out by the female. The larva feeds in the cambial layer of bark in the branches and trunk and later enters the woody tissues. Pupation takes place in chambers in the heartwood, accompanied by presence of characteristic wood “shavings” that are packed into the chamber. Adults emerge from circular holes, 10 mm across, above the sites where the eggs were laid (EPPO DATA SHEETS ON QUARANTINE PESTS).

1. Detection
As the detection is commonly done together with *A. chinensis* methods used are similar basing on the typical symptoms of the species. Nevertheless, as visual inspection and manual destruction of samples is time consuming and expensive, two new approaches, also used in *A. chinensis* detection and different from the distruction of trees, by olfactory and acoustic means are introduced. The first to notice is the employment of snuffle dogs reported by Hoyer-Tomiczek and Sauseng (2009). A more detailed description of the method is provided in the summary for *A. chinensis*.
The second metod is a acoustic technology, which has potential for reducing costs and hazards of tree inspection.
The development of practical methods for acoustic detection requires the solution of technical problems involving transmission of resonant frequencies in wood and high background noise levels in the urban environments where most infestations have occurred. A study was conducted to characterize sounds from larvae of different ages in cambium, sapwood, and heartwood of bolts from three host tree species (Mankin et al., 2008).

In China field trapping experiments with baited *A. glabripennis* male-produced pheromone in the summers of 2007 and 2008 were conducted according to Nehme et al. (2010).

To confirm the assumption of larvae belonging to the species A. glabripennis they were sent to laboratories for DNA-analysis.
DNA markers were identified for the molecular detection of the Asian long-horned beetle (ALB), *Anoplophora glabripennis* (Mot.), based on sequence characterized amplified regions (SCARs) derived from random amplified polymorphic DNA (RAPD) fragments (Kethidi et al., 2003).

2. Monitoring
The type of monitoring carried out mainly aims at the delimitation of the plant health pest.
Mostly visual inspections for the presence of holes, sawdust and oviposition scars in host trees, and by collecting adults and other stages is done (see *A. chinensis* summary).
In the USA a model of spatial establishment patterns was developed. Delimiting hot spots for invasions (i.e., areas where establishment is likely) within urban areas would facilitate monitoring efforts. We used a propagule pressure framework to delimit establishment hot spots of a hypothetical generalist EFI in six U.S. urban areas: Chicago, Detroit, Houston, Los Angeles-Long Beach-Santa Ana, New York-Newark, and Seattle. Using a lattice of 5-km-diameter cells for each urban area, we used the input data (urban tree cover and propagule pressure) to model establishment and Moran's I to delimit hot spots. We used urban population size and the area of commercial-industrial land use as indicators of propagule pressure in the model (Colunga-Garcia et al., 2010).

WP 2: Inventory of specific surveys

Inventory of surveys across the EU

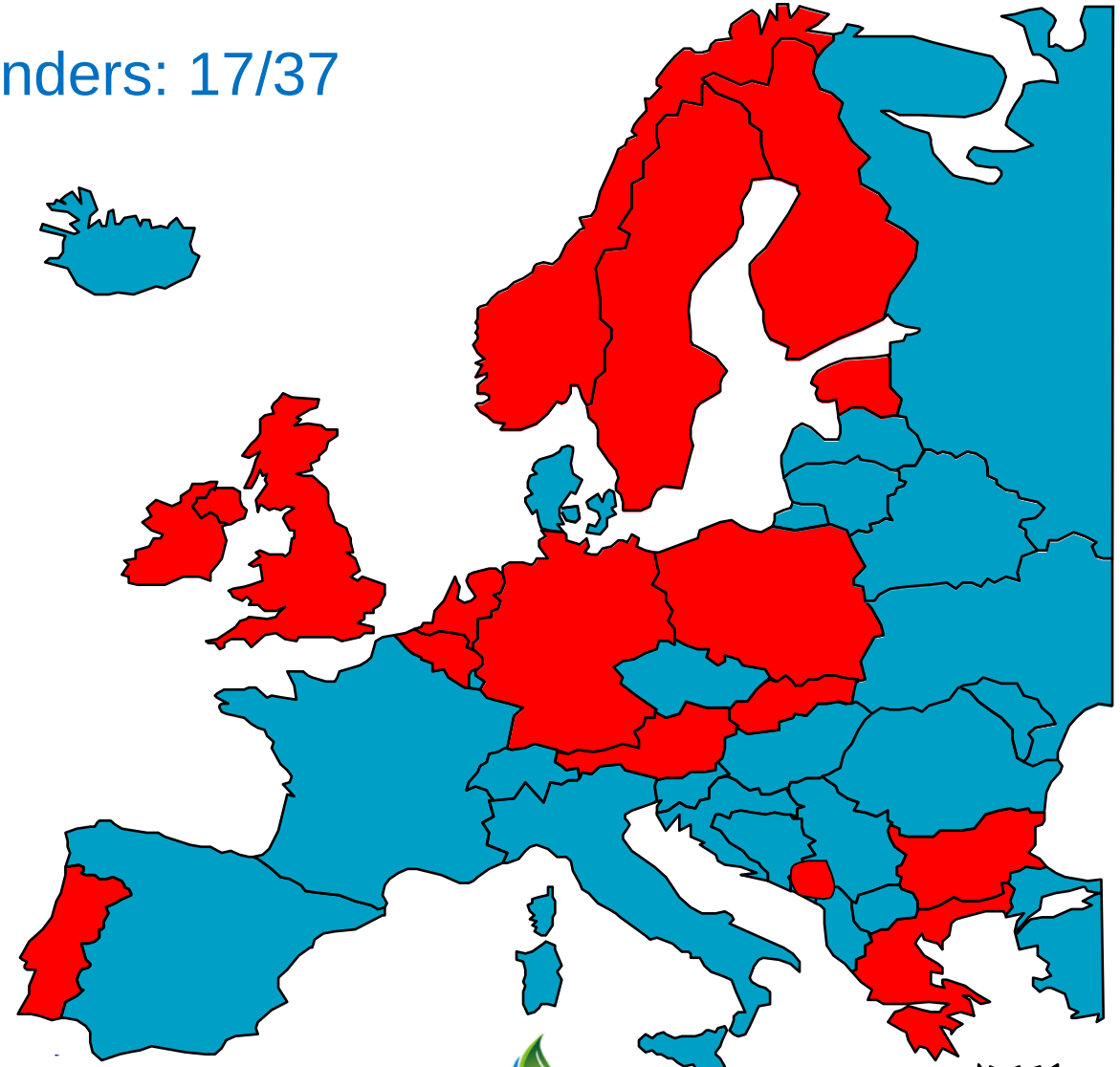
Questionnaires developed and sent to EU and accession countries

<u>Questionnaire 1. Simple</u>
-Which species do you survey for?
-Who is the responsible person (and full contact details)?

<u>Questionnaire 2. More detail for 25 selected species</u>
-Details of methodologies for each species asked for via point-contacts

WP2: Questionnaire 1

Responders: 17/37



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WP2 Species surveyed in 17 countries

Agrilus planipennis	1
Anplophora chinensis	**13**
Anoplophora glabripennis	5
Anoplophora malaisiaca	1
Anthonomus grandis	1
Aphelenochoides besseyi	2
Apple proliferation	6
Apricot chlorotic leafroll	1
Beet necrotic yellow vein virus	4
Bemisia tabaci	**10**
Bursaphelenchus xylophilus	**15**
Cephalcia lariciphila	1
Ceratocystis fimbriata	2
Ciborinia fimbriata	2
Citrus tristeza virus	3
Clavibacter michiganensis	**16**
Cryphonectria parasitica	2
Curtobactrium flaccumfaciens	2
***Diabrotica virgifera* etc**	**13**
Epichoristodes acerbella	1
Erwinia amylovora	**14**
Eotetranychus orientalis	1
Gibberella circinata	**12**
Gilpinia hercyniae	2
Globodera pallida	**14**
Globodera rostochiensis	**14**
Glomerella gossypii	1
Gonipterus scutellatus	2
Grapevine FD	3
Gremmeniella abietina	1
Guignardia citricarpa	1
Heliothis armigera	2
Hypoxylon mammatum	1
Ips species	3
Leptinotarsa decemlineata	6
Liriomyza species	7
Meloidogynes species	4
Monilinia fructicola	3
Opogona sacchari	1
Paysandisia archon	1
Pear decline mycoplasm	4
Pepino mosaic virus	**15**
Phytophthora fragariae	*3*
Phytophthora ramorum	***16***
Plasmopara halstedii	1
Plum pox virus	8
Potato spindle tuber viroid	**16**
Potato stolbur mycoplasm	2
Pseudomonas solanacearum	**14**
Pseudomonas syringae	1
Puccinia horiana	2
Rhagoletis species	1
Rhynchophorus ferrugineus	**12**
Spodoptera littoralis	1
Synchytrium endobioticum	8
Thrips palmi	6
Thrips indica	1
Tomato spotted wilt virus	5
Tomato yellow leaf curl virus	1
Toxoptera citricida	2
Xanthomonas species	5
Xylella species	1

Arthropods (total 24, more than 10 countries: 4)

Nematodes (5, 3)

Pathogens (33, 7)

Total: 62, 14

WP2 Questionnaire 2 on 25 species

1. **What is the survey's purpose?**
2. **To what quality?**
3. **What is the sampling frame?**
4. **How many locations / times do you survey?**
5. **At the survey location**
6. **Recording and reporting results**
7. **How are survey results analysed to gain the information that meets the purpose of the survey?**

WP2 Questionnaire 2 on 25 species

	Species	Countries where surveyed	No.
1	Anoplophora chinensis	GR, DE, PL, AT, BE, EE, FI, IE, ME, SK, UK, MT,NL SE,PT	15
2	Anoplophora glabripennis	BE, EE, FI, UK, NL, SE	6
3	Apple proliferation	NO, PL, AT, BG, EE, SK, NL,	7
4	Bemisia tabaci	PL, BG, EE, FI,IE, ME, SK, UK, NL, SE, PT	11
5	Bursaphelenchus xylophilus	NO, GR, DE, PL, AT, BE, BG, EE, FI, IE, ME, SK, UK, MT, NL, SE	16
6	Clavibacter michiganesis ssp. sepedonicus (spp. michiganensis)*	NO, GR, DE, PL, AT, BE, BG, EE, IE, ME, SK, UK, MT, SE, PT (PL, BG, FI, IE, UK, NL)	15 (6)
7	Diabrotica virgifera virgifera/zeae	GR, DE, PL, AT, BE, BG, EE, IE, ME, SK, UK, NL, SE, PT	14
8	Ditylenchus destructor/dipsaci	PL, BG, IE, SK, NL	5
9	Drycosmus kuriphilus	GR, DE, PL, AT, BE, IE, ME, SK, UK, NL, SE, PT	12
10	Erwinia amylovora	NO, GR, PL, AT, BE, BG, EE, FI, IE, SK, UK, MT, NL, SE, PT	15
11	Giberella circinata	GR, DE, PL, AT, BE, BG, EE,ME, SK, UK, MT, NL, SE	13
12	Globodera pallida / rostochiensis	NO, GR, DE, PL, AT, BE, BG, EE, IE, ME, SK, UK, MT, NL, SE	15
13	Leptinotarsa decemlineata	FI, IE, UK, MT, NL, SE, PT	7
14	Liriomyza species	PL, BG, EE, FI, IE, ME, SK, NL	8
15	Melodigyne chitwoodi / fallax	PL, BG, IE, ME, NL	5
16	Pepino mosaic virus	GR, DE, PL, AT, BE, BG, EE, FI, IE, ME, SK,UK, MT, NL, SE, PT	16
17	Phytophthera ramorum	NO, GR, DE, PL, AT, BE, BG, EE, FI, IE, ME, SK, UK, MT, NL, SE, PT	17
18	Plum pox virus	NO, PL, BG, EE, IE, SK, MT, NL, PT	9
19	Potato spindle tuber viroid	NO, GR, DE, PL, AT, BE, BG, EE, FI, IE, ME, SK, UK, MT, NL, SE, PT	17
20	Pseudomonas solanacearum	NO, GR, DE, PL, AT, BE, BG, EE, IE, ME, SK, UK, MT, NL, SE, PT	16
21	Rhynchophorus ferrugineus	GR, DE, PL, AT, BE, IE, ME, SK, UK, MT,NL, SE, PT	13
22	Synchytrium endobioticum	GR, PL, BE, EE, IE, ME, SK, UK, NL	9
23	Thrips palmi	PL, BG, EE, FI, SK, MT, NL	7
24	Tomato spotted wilt virus	EE, FI, ME, MT, SE	5
25	Xanthomonas fragariae/campestris	PL, BG, EE, FI, IE, NL	6

WP2 Results

- Excel database with information from all returns and links to relevant documents
- Separate database with information retrieved from CIRCA Europhyt database
- Returns were highly variable, but provided a useful starting point
- Results used within WP3

Work Package 3: Review of Methodologies

- Comprehensive review of methodologies used based on outputs from WP1 and WP2
- Analysis of the strengths and limitations of the survey types
- Where possible, quantitative descriptions of the uncertainties are provided

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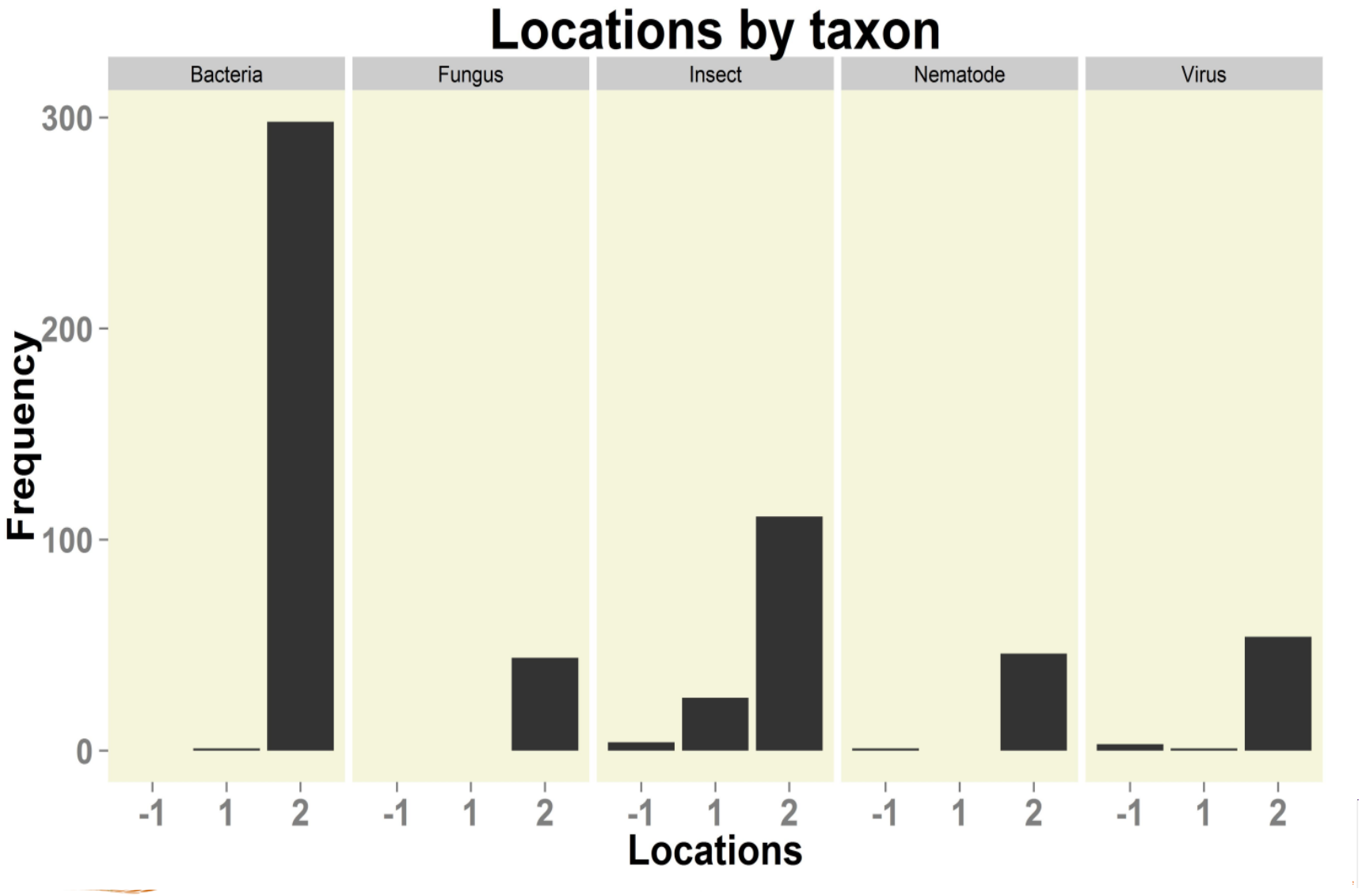
WP 3 Survey types and number of countries

Survey type	Organism	Taxonomy	Countries
Delimiting/Detection	Anoplophora chinensis	Insect	26
	Anoplophora glabripennis	Insect	5
	Dendroctonus micans	Insect	3
	Diabrotica virgifera virgifera	Insect	17
Detection	Cephalcia lariciphila	Insect	2
	Clavibacter michiganensis spp. michiganensis	Bacterium	2
	Clavibacter michiganensis ssp. sepedonicus	Bacterium	27
	Dryocosmus kuriphilus	Insect	28
	Gibberella circinata	Fungus	5
	Globodera pallida and rostochiensis	Nematode	11
	Gonipterus scutellatus	Insect	1
	Hypoxylon mammatum	Fungus	1
	Ips spp.	Insect	5
	Leptinotarsa decemlineata	Insect	9
	Liriomyza bryoniae	Insect	5
	Meloidogyne spp.	Nematode	3
	Phytophthora ramorum	Fungus	27
	Rhynchophorus ferrugineus	Insect	6
	Sternochetus mangiferae	Insect	1
Detection/Monitoring	Beet necrotic yellow vein virus	Virus	8
	Citrus tristeza virus (European and non-European isolates)	Virus	4
	Erwinia amylovora	Bacterium	21
	Pepino mosaic virus	Virus	27
	Plum pox virus	Virus	10

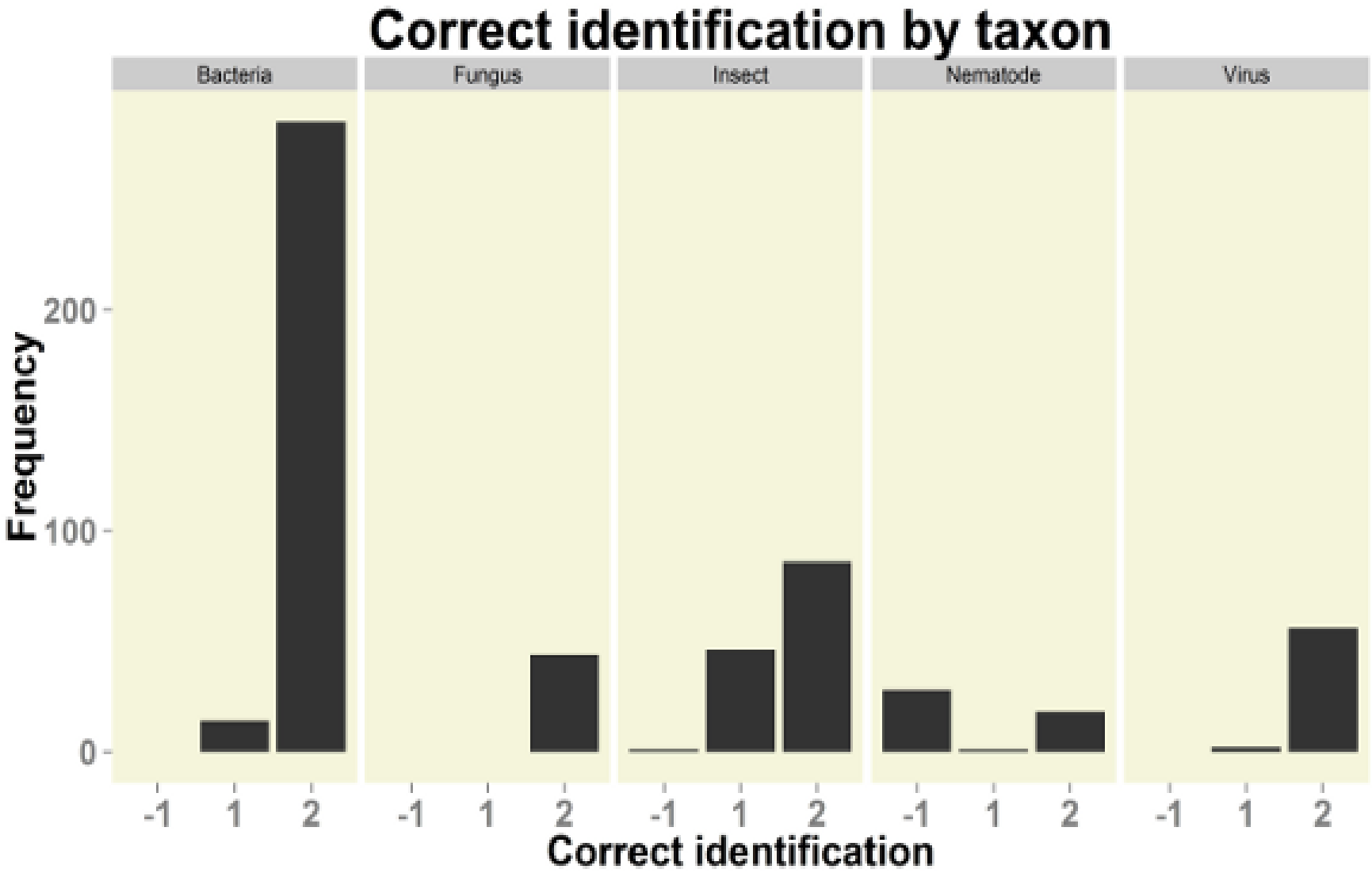
WP3 Key areas examined

- Sampling procedures
- Identification procedures
- Scoring system for the evaluation of data
  - -2 done badly
  - -1 not enough information reported to judge
  - 0 not relevant,
  - 1 partially OK,
  - 2 fully OK

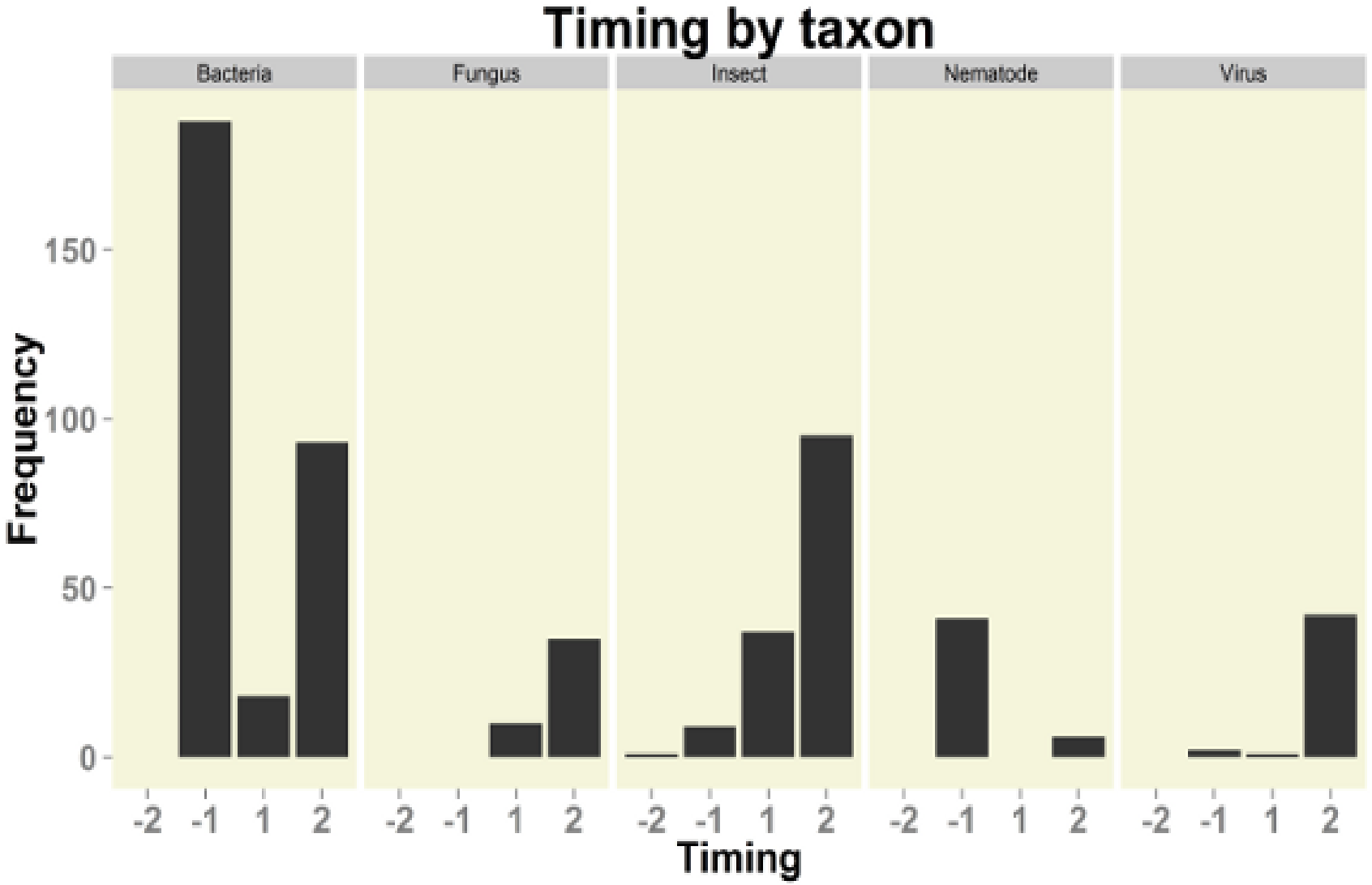
WP3 Location



WP3 Identification methods



WP3 Timing


Timing by taxon
Bacteria
Fungus
Insect
Nematode
Virus
Frequency
150
100
50
0
-2
-1
1
2
Timing

WP3 Strengths and limitations

Strengths

- Surveys are planned and conducted over extended time periods – flexibility
- Wide area covered – both area-oriented and risk-oriented
- Diagnostic protocols are closely followed

Limitation

- Transparency regarding choice of area to be surveyed
  - Increases uncertainty!

Work Package 4: Case studies

Pseudomonas solanacearum
Bursaphelenchus xylophilus
Anoplophora glabripennis
Bemisia tabaci
Diabrotica virgifera
Pepino mosaic virus
Phytophthora ramorum
Clavibacter michiganensis
Erwinia amylovora
Globodera pallida
Potato spindle tuber viroid
Rynchophorous ferrugineus
Thrips palmi
Drycosmus kuriphilus
Giberella circinata
Plum pox virus
Agrilus planipennis
Epitrix

1. Good (i.e. detailed) datasheets produced

2. Widely surveyed for across Europe

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WP4 Inputs required from survey

- Purpose of survey
- Description of sampling target (population represented by the survey)
- Sampling frame (population from which samples can be taken)
- Number of locations sampled
- Effective total number of plants sampled, or total area surveyed
- Method of testing / diagnosis; rules for interpreting results from multiple test methods
- Estimated false positive rate associated with testing or diagnosis
- Estimated false negative rate associated with testing or diagnosis

WP4 Questions regarding uncertainty

- Are hosts for the disease /pest known and identifiable?
- Are symptoms of the disease / infestation known and identifiable?
- Are infected or infested plants always symptomatic? Are pests visible?
- Are the areas of risk known *and accessible?* (Where hosts occur etc)
- Does the time of year affect the outcome of the survey?
- Does the frequency of the survey affect the outcome?
- What is the performance of the test method? (if used)
- What is the performance of surveying equipment? (Traps etc) (if used)
- Can prevailing weather effect survey?
- Potential dependencies between the above factors.
- Are there differences between the survey protocol and the details of how the survey is carried out in the field?
- Areas inspected

WP4 Results

- often difficult to derive reliable estimates for survey performance
- where surveys were undertaken in well defined areas or targets with methods with known performance, an estimate of performance could be made (e.g. potato cyst nematode)
- surveys for pests and pathogens ‘in the wild’ more difficult to characterise (sample size, or number of plants surveyed not always reported, e.g. *Phytophthora ramorum*)
- framework for collection of data to examine quantitative information provided for specific surveys
- methods can be complex and dependant on many different variables, maybe necessary to obtain further information in some areas to prevent over-simplification
- data needed for quantitative assessment is not in general available, but models have shown how this data could be used, if made more generally available

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Project conclusions

- Survey methods for the majority of species are poorly documented (in particular sampling methods)
- Typically (though not always) positives are reported without number of plants or area examined
- Diagnostic tests are well described
- Research disproportionate for some species
- No common reporting procedure
- Key information for quantitative assessment of uncertainty not reported/available

Project outputs

- Review of the literature for surveying regulated pests, individual surveying sheets
- Database including all references
- Detailed databases
- Case Studies
- Identification of the strengths and weaknesses associated with surveying regulated pests
- Recommendations

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Project recommendations

- A structure for the reporting of survey results should be developed
- Consideration should be given to emerging pests
- A central repository of methods used and data collected should be considered
- Pest risk assessments should be reviewed and updated in light of new published diagnostic procedures and the introduction or removal of available control methods

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