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SID 5 Research Project Final Report

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Project identification

1. Defra Project code: PH0510

2. Project title:
   Development of an evidence based risk assessment for small hive beetle to provide input for the contingency plan

3. Contractor organisation(s):
   The Food and Environment Research Agency
   Sand Hutton
   York
   North Yorkshire
   YO41 1LZ

4. Total Defra project costs (agreed fixed price): £ 27,280.16

5. Project: start date ..... 01 November 2009

   end date ..... 31st March 2010

6. It is Defra's intention to publish this form.
Please confirm your agreement to do so.....**YES** ☒ **NO** ☐

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Defra recognises that in a small minority of cases there may be information, such as intellectual property or commercially confidential data, used in or generated by the research project, which should not be disclosed. In these cases, such information should be detailed in a separate annex (not to be published) so that the SID 5 can be placed in the public domain. Where it is impossible to complete the Final Report without including references to any sensitive or confidential data, the information should be included and section (b) completed. NB: only in exceptional circumstances will Defra expect contractors to give a "No" answer.
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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

The small hive beetle (SHB), *Aethina tumida*, is an invasive species that has become established in the USA and Australia, where it poses a significant threat to the beekeeping industry. In the past decade this species has been researched, primarily in the USA, and aspects of its biology, behaviour and methods for control have been investigated. This has increased knowledge of this species, which prior to its establishment in areas outside of sub-Saharan Africa, was very limited. Although legislation is in place to reduce the risk of importation of this species to the UK, there is a possibility that this species could enter countries within the EU, including the UK, where conditions for its establishment may be found. The potential risk that this species poses to bee health in the UK needs to be established using the most up-to-date information available. To this end a thorough review of the available literature was undertaken, with a particular emphasis on obtaining information related to the biology and control of this species. From this it will be determined whether (i) there are pathways through which SHB could enter the UK and (ii) if the beetle could establish in the UK. From the literature review eight separate pathways for the likely introduction of SHB were identified:

1. Movement of honey bees *Apis mellifera*: whole colonies (EU only), queens and packaged bees (EU and New Zealand only) for the purposes of trade.
2. Movement of alternative hosts e.g. bumble bees for pollination purposes.
3. Trade in hive products – in particular rendered beeswax and honey in drums post extraction from third country and EU origin and honeycomb and any other unprocessed wax products from the EU.
4. Soil or compost associated with plant trade from third countries. Soil imported from the EU and Mediterranean countries.
5. Fruit imports – in particular avocado, bananas, grapes, grapefruit, kei apples, mango, melons and pineapples.
6. Movement on beekeeping clothing / equipment.
7. Movement on freight containers and transport vehicles.
8. Natural spread of pest itself by flight, on its own or possibly in association with a host swarm. This pathway is only applicable for the scenario that *A. tumida* is present in neighbouring countries.

Although the routes of introduction to the countries where SHB has been found cannot be established conclusively, it would appear that various different pathways may have been responsible for the introductions. There is therefore a need to consider risk management options for all eight pathways identified.

A Pest Risk Analysis (PRA), based on the Great Britain (GB) Non-Native Organism Risk Assessment

Scheme (NNRAS), was used to determine the likelihood of SHB being introduced, establishing and spreading in the UK. This analysis identified that the most likely pathways for introduction, given existing legislation and practices, are the importation of honey bees (in particular illegal imports) and movement of beekeeping equipment. The PRA also incorporated a risk management section and this identified that although legislation and management practices are in place, these could be strengthened for some of the pathways.

The draft England and Wales contingency plan for exotic pests and diseases of honey bees was reviewed in conjunction with the findings from the PRA. The following conclusions were reached:

- The current recommendations for the size of the defined Statutory Infected Area (SIA) and the recommendations for measures for eradication are appropriate, based on current knowledge.

- The presence of feral bee colonies needs to be taken into account and management options for these, in the event of detection of the SHB, should be considered.

- Currently not all beekeepers are registered on the National Bee Unit (NBU) database, BeeBase. This increases the possibility that the SHB could enter undetected and that unregistered beekeepers will not be identified at the early stages of implementation of the contingency plan. This, in turn, could also impact on the effectiveness of movement restrictions that are put in place in the event of an incursion. The means to identify unregistered beekeepers in the Statutory Infection Area should be considered.

- If eradication of the SHB is not possible, control measures would need to be put in place to limit the spread of the SHB in the UK. As chemical control methods are limited at present, it is likely that an integrated pest management approach would be adopted. For this type of approach to succeed training is important. The NBU inspectorate and beekeeping associations are in a good position to provide such training and to establish best practice.

- Consideration should be given to the form that the integrated pest management approach would take at the earliest possible opportunity, preferably before any incursion, to give time for beekeepers to understand and perhaps put into practice elements of the approach. This could slow the spread of the SHB if it is introduced and this may make control more practicable.

Review of the literature also identified possible treatment measures to eradicate the SHB. Currently none of the chemical insecticides that could be used for treatment are registered for this use in the UK. However, it would be possible to import Checkmite +, which is used in the USA for SHB control, and contains the active ingredient coumaphos, via a Special Import Licence under the prescribing cascade. Alternative methods are being researched, including the use of biological control agents, (entomopathogenic fungi and nematodes), organic acids, lime and diatomaceous earths.

Conclusions

- Eight pathways have been identified for the introduction of the SHB.

- The PRA shows that in the event of entry the potential for establishment is likely with a low level of uncertainty, and that there is a high potential for spread. The overall impact of introduction was defined as moderate.

- Illegal importation of honey bees from countries where SHB is present represents the highest risk of SHB incursion to the UK.

- Movement of beekeeping equipment from countries where SHB is present to the UK poses a high risk as currently there is no legislation or management practice in place to limit or prevent movement.

- Legislation and inspection/monitoring schemes are in place for the pathways with which SHB is most closely associated. The greatest risk is from those imports from the EU, for which inspections are not currently made. These may be either legal imports from EU countries that are not routinely inspected because there is no requirement to inspect them, or imports that are not inspected because they are illegal.

- Research is needed to establish whether *Bombus terrestris* colonies can act as hosts for the SHB. If *B. terrestris* can act as a host, consideration should be given to increased monitoring, surveillance

and inspection of bumblebee colonies imported to the UK. The existing use of imported bumblebee colonies in semi-open or open systems would also need to be reviewed.

- Consideration should be given to the compulsory registration of beekeepers in the UK. This would ensure that the location of apiaries within an area is known, increasing the chances of rapid detection of SHB, and more accurate and effective imposition of movement restrictions in the event of an incursion. It would also ensure that information on SHB, and other exotic pests and diseases, is received by all beekeepers, and that beekeepers are aware of control options and movement restrictions at the earliest possible opportunity, should an incursion occur.

- There is a need to know which chemical, biological and/or integrated control measures are most effective against SHB so that these can be implemented as soon as possible after an incursion is detected. The option to seek approval for use of these methods at the earliest possible opportunity should be investigated, as an alternative to requesting emergency use of a non-registered product if the SHB is introduced.

- Increased awareness of the pest in the beekeeping sector, in inspectorates (Plant Health and Seed Inspectorate (PHSI) and Horticultural Marketing Inspectorate (HMI)), which are associated with imports of plant material and fruit, and with end users of bees and bee associated products would provide additional surveillance.

- Options for more effective field monitoring for the SHB should be studied, in particular the use of different trap types.

- There is a need to assess the status of feral honey bees to see whether these would need to be located and destroyed within the defined Statutory Infection Area, or to establish other control measures that could be utilised.

- An integrated pest management scheme for control of the SHB and established 'best practice' should be identified. Training of beekeepers and establishment of best practice, before SHB is suspected, would limit the spread and make control measures more practicable.

- Consider increasing the number of Exotic Pest Survey (EPS) inspections currently undertaken by the NBU, to increase the likelihood of detecting SHB quickly, in event of any incursion. Consideration should also be given to increasing the number of sentinel apiaries, and making the number of these in each beekeeping region representative of the relative intensity of beekeeping activity in the given area.

- A general awareness campaign should be considered to make travellers aware of the threat posed by SHB to bees (wild as well as managed).

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
   - the scientific objectives as set out in the contract;
   - the extent to which the objectives set out in the contract have been met;
   - details of methods used and the results obtained, including statistical analysis (if appropriate);
   - a discussion of the results and their reliability;
   - the main implications of the findings;
   - possible future work; and
   - any action resulting from the research (e.g. IP, Knowledge Transfer).

Introduction

Honey bees (*Apis mellifera*) make significant contributions to the national economy, not only as honey producers[1] but, more importantly, as the primary pollinators of a wide range of valuable commercial crops. Estimates for the value of agricultural/horticultural crops grown commercially in the UK that benefit from insect pollination vary, but are in the order of hundreds of millions of pounds each year[2], while the value of honey production in the UK fluctuates between £10 million and £35 million per annum. Their foraging activities also help to sustain the biodiversity of myriad natural and semi-natural (e.g. garden) ecosystems. For these reasons, it is vital to maintain robust, healthy honey bee stocks. At their worst, outbreaks of pests and diseases cause significant colony losses[3].

Increased globalisation, trade and movement of bees around the world, have amplified the risks facing bee health. Potential exists for major pest threats of the honey bee to reach Europe, including the UK[4]. Recent concern has focussed on the small hive beetle (SHB), *Aethina tumida* Murray (Coleoptera: Nitidulidae)[5]. The small hive beetle is a parasite and scavenger of honey bee colonies and is indigenous to sub-Saharan Africa[6]. More recently it has become an invasive species, which has caused serious damage to the apiculture industries in the USA and Australia[6,7]. From its first detection in Florida, it has spread to over 30 US States[8]. The economic damage it has caused in some US states is significant. In Florida, in 1998 alone, estimates of colony losses and economic damage from beetle infestations and honey contamination cost the industry $3 million, with over 30,000 colonies lost[6]. It has also been shown that the SHB will infest colonies of other bee species, including the bumblebee, *Bombus impatiens*[9,10,11]. Therefore, bumblebee colonies could serve as an alternative host for the SHB with potentially greater effects on the sustainability of pollinators.

Aethina tumida was intercepted in October 2004 in a consignment of queen bees imported into Portugal from Texas, USA[12]. This demonstrates that introduction to European countries is a real possibility. It is likely that if introduced to the UK, it would find favourable climatic conditions in many parts of the country and could have a dramatic effect on both honey production and pollination services. The SHB is a notifiable species within the European Community[13]. The major impact that this species has had in the USA has resulted in an increase in research on the biology, behaviour and control measures for the SHB. The most up-to-date knowledge of this species has been identified, reviewed and used to assess the level of risk that this species poses should it be introduced to the UK. The information has been used in a Pest Risk Analysis (PRA) to determine the likelihood of SHB entering, establishing and spreading in the UK; to evaluate the potential impact of introduction of this pest species and to examine the management options available to reduce the risks. The results of the PRA have been used to review and inform the existing draft contingency plan for exotic pests and diseases[14]. To ensure that management options are fully covered, the possible treatment methods to control this species have also been identified. This process has built on the pest risk assessment previously made for this species in 2004[15], by including the most up-to-date information available, the incorporation of risk management options and the identification of potential control measures.

Objectives

1. Obtain, review and analyse available information on the small hive beetle, with particular attention to the biology and behaviour of this species and possible control methods.
2. Identify possible pathways for entry of SHB.
3. Complete a Pest Risk Analysis to assess whether SHB is a high-risk threat to the UK beekeeping industry.
4. Review the contingency plan and develop recommendations for monitoring entry to the UK and possible control treatments.

Methods

Review of available literature and information on the SHB

Information on the SHB can be found within peer-reviewed scientific papers, conference proceedings, trade articles and on internet sites.

Searching for scientific literature was carried out on several hosts, using the following logic:

SMALL()HIVE()BEETLE? OR *AETHINA*()*TUMIDA*

On the Dialog host the following databases were searched:

File 50:CAB Abstracts 1972-2009/Nov W3 - (c) 2009 CAB International

File 155:MEDLINE(R) 1950-2009/Nov 17 - (c) format only 2009 Dialog

File 10:AGRICOLA 70-2009/Nov - (c) format only 2009 Dialog

File 203:AGRIS 1974-2009/Aug - Dist by NAL, Intl Copr. All rights reserved

File 24:CSA Life Sciences Abstracts 1966-2009/Dec - (c) 2009 CSA.

File 144:Pascal 1973-2009/Nov W3 - (c) 2009 INIST/CNRS

File 71:ELSEVIER BIOBASE 1994-2009/Nov W2 - (c) 2009 Elsevier B.V.

File 76:Environmental Sciences 1966-2009/Dec - (c) 2009 CSA.

File 292:GEOBASE(TM) 1980-2009/Nov W1 - (c) 2009 Elsevier B.V.

File 65:Inside Conferences 1993-2009/Nov 19 - (c) 2009 BLDSC all rts. reserv.

File 399:CA SEARCH(R) 1967-2009/UD=15121 - (c) 2009 American Chemical Society

using the basic logic:

S1 726 SMALL()HIVE()BEETLE? OR *AETHINA*() *TUMIDA*

S2 284 RD S1 (unique items)

Details of the databases and their coverage can be found at http://library.dialog.com/bluesheets/html/bln.html. 284 items were retrieved; titles for these were inspected and 132 items downloaded in full format from the CAB Abstracts database, and 34 items downloaded in full format from other databases.

In addition a similar search was carried out on other hosts / databases:
On the OVID host -
Biosis 1985- 80 items downloaded
Zoological Record – 62 items downloaded
On the Web of Knowledge host –
ISI Web of Science – 133 items downloaded

Grey literature and other databases with information on the SHB were examined online utilising popular web browsers using the search terms 'small hive beetle' and *'Aethina tumida*'. In addition key researchers in the USA and Australia were contacted for information on the status and spread of SHB in these countries.

Identification of pathways for entry of SHB
Based on previous pest risk assessments and on an understanding of the biology and behaviour of the SHB gained from the literature review, the most likely pathways for the entry of the SHB to the UK were identified. The likely pathways were based on two scenarios (1) The distribution of the SHB remains as currently known, or further establishment is only in countries outside the European Union (EU) (2) The SHB becomes established in an EU country.

Pest Risk Analysis (PRA)
A PRA was carried out based on the Great Britain (GB) Non-Native Organism Risk Assessment Scheme (NNRAS). This is an established system used by the GB Non-Native Species Secretariat (NNSS) to conduct risk assessments on a wide range of organisms which are not native to GB. The NNRAS is used to aid prioritisation of responses and for under pinning NNSS decision making. The NNRAS is based on a pest risk assessment scheme developed by the European and Mediterranean Plant Protection Organisation (EPPO) and is constantly under review and being updated. The current version is available in electronic format from the NNSS website (https://secure.fera.defra.gov.uk/nonnativespecies/home/index.cfm). The computerised version, NAPRA (Non-native Assisted Pest Risk Assessment), was developed in cooperation with EPPO.
The current version of NAPRA does not include a risk management section. However, a previous NNRAS containing risk management was developed in 2005 (UK non-native organism risk assessment scheme user manual, Version 3.3, Dated 28.2.2005). The NAPRA tool was used in this assessment to assess the risk from the small hive beetle to the UK. Management options were evaluated following the paper based handbook guidance from 2005. These two tools were used in preference to the EPPO risk analysis scheme used for plant health since the two tools consider broad elements of risk and hence are more suitable for use when assessing the risk from a bee pest.

Review of contingency plan
A review of the draft England and Wales contingency plan for exotic pests and diseases of honey bees was made in view of the findings from the literature review and the PRA. The draft contingency plan, dated October 2009, was understood to be the most current version of the draft document. In addition, the National Bee Unit (NBU), responsible for monitoring bee health in England and Wales, was consulted with regard to the current practices for inspections for exotic pests and contingency exercises.

Results
Review of available literature and information on the SHB
Records downloaded from the databases were reviewed and stored in a database using Reference Manager software. The information from the scientific literature and the 'grey' literature was compiled under various headings to provide a comprehensive review of current knowledge of the SHB. This review was used to inform the PRA and to provide information on possible control measures for the SHB.

Key points, with regard to the biology and behaviour of the SHB, which have particular relevance to contingency planning are as follows:

- The greatest threat is to weak colonies. This may be of particular relevance given the widely reported colony losses that have occurred in recent years, which may indicate increased prevalence of weak colonies.

- Adult beetles are strong fliers; flights in excess of 10 km are possible[16] . However, there is no information on the actual distance that can be covered within a given time period. This makes setting the size of the statutory infected area (SIA) difficult. Research carried out at the Food and Environment Research Agency (Fera) suggests that adult beetles are unable to fly at a temperature of 10°C (Fera, unpublished data). Therefore, temperature may affect the rate of spread of the SHB. The effects of other climatic factors, such as rainfall, have not been extensively researched.

- Wandering larvae can move up to 200 metres from hives to find a place for pupation[16] and can survive for up to 48 days without access to food and still develop into viable adults[17].

- Evidence from the USA suggests that if beetle numbers in colonies are low, the beetles do not tend to disperse over long distances[18].

- Data on infestation levels, particularly those resulting in an economic injury threshold, and the dispersal potential of SHB, is lacking[7,18].

- Treatment of all colonies within an apiary is important to prevent re-infestation[18].

- Although it is the larval stage that causes most damage to the hives, the SHB spends the greatest proportion of its time in the pupal stage within soil. This has implications when considering control options for the SHB.

- SHB can colonise feral bee colonies[9], which may act as a reservoir for re-infection of managed apiaries.

- Late identification of this species has been a factor that has prevented its eradication; in the USA it was not positively identified for two years after the first samples were collected[8] and in Australia it is believed to have been present for at least twelve months prior to identification[19,20].

- Adult SHB are vey strongly attracted to sources of food, such as honey processing areas and active apiaries. This means that in the event of an incursion, introduced adult beetles would be very effective at finding new breeding sites.

<u>Identification of pathways for entry of SHB</u>

The likely pathways for introduction were based on two scenarios:
(1) The distribution of the SHB remains as currently known, or further establishment is only in countries outside the EU.
(2) The SHB becomes established in an EU country.
Based on the literature and knowledge of the beekeeping industry and practices in the UK gained from staff in NBU, eight separate pathways for possible introduction of the SHB to the UK were identified:

1. Movement of honey bees *Apis mellifera*: whole colonies (EU only) queens and packaged bees (EU and New Zealand only) for the purposes of trade.
2. Movement of alternative hosts e.g. bumblebees for pollination purposes.
3. Trade in hive products – in particular rendered beeswax and honey in drums post extraction from third countries and EU origin and honeycomb and any other unprocessed wax products from the EU.
4. Soil or compost associated with plant trade from third countries. Soil imported from the EU and Mediterranean countries.
5. Fruit imports – in particular avocado, bananas, grapes, grapefruit, kei apples, mango, melons and pineapples.
6. Movement on beekeeping clothing / equipment.
7. Movement on freight containers and transport vehicles.
8. Natural spread of pest itself by flight, on its own or possibly in association with a host swarm. This pathway is only applicable for the scenario that *A. tumida* is present in neighbouring countries.

Although the routes of introduction to the countries where SHB has been found cannot be established conclusively, it would appear that various different pathways may have been responsible for the introductions. In the USA it is believed that SHB may have been introduced from South Africa on cargo ships[8]. Soil may have been the primary mode of introduction to Australia[20], whilst the importation of queen bees was the route by which

SHB entered Portugal[12]. Importation of beeswax[8] and natural spread[21] are the likely causes of introductions to Canada.

Pest Risk Analysis

The full PRA is shown in Appendix 1. A graphical summary of the likelihood and uncertainty level for the entry of *A. tumida* on each of the eight pathways identified is shown in Figures 1a and 1b. The following text describes the basis of the representation.

Each of the pathways identified was considered in turn. Each pathway was also considered from the point of view of the country of origin being a third country, where SHB is known to be established (Figure 1a), and from the point of view that the country of origin is within the EU in a hypothetical situation that SHB has established therein (Figure 1b). The entry section of the PRA contains eight main questions (questions 23 – 30 of the PRA) to identify the likelihood of entry. These are as follows:

23 - How likely is it that the organism is strongly associated with the pathway at the point(s) of origin?
24 - How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin?
25 - How likely is the organism to survive during transport or storage within the pathway?
26 - How likely is the organism to enter the Risk Assessment Area undetected?
27 - How likely is the organism to multiply/increase in prevalence during transport /storage?
28 - How likely is the organism to survive existing management practices within the pathway?
29 - How likely is the organism to arrive during the months of the year most appropriate for establishment?
30 - How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?

Each question within the scheme gives an answer in terms of the LIKELIHOOD of an event occurring. This is represented in the graphs by a score, the greater the score number the greater the likelihood of the event occurring i.e.
1 = Very Unlikely
2 = Unlikely
3 = Moderately Likely
4 = Likely
5 = Very Likely
Therefore the greater the height of a bar the greater the assessment of the likelihood of an event occurring.

The level of UNCERTAINTY in an answer is represented by the error bars on the graph. The uncertainty in an answer is due to the level of information available to make a judgement on the questions being asked. The greater the level of uncertainty the greater the height of the error bars in the graphical representation. Uncertainty was rated as either:
Low
Medium
High

Finally the colours of the bars in the charts have been used to represent clusters of questions which look at specific sections of the pathway. A key to this is given below:

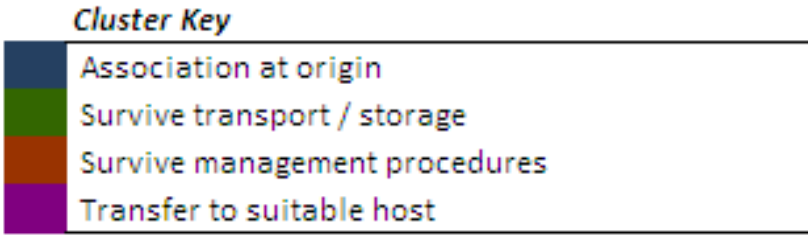


Figure 1a. Graphical representation of the likelihood (columns) and uncertainty (bars) associated with seven potential pathways for entry of the small hive beetle, *Aethina tumida*, into the UK from third countries where SHB is known to be established. (Ratings to questions in UK Non native risk assessment scheme (Q23 to 30) by Helen Anderson et al. (Defra project PH0510)
Charts from "Question Summary Template (Normal) 100326 d NNSS –SHB.xlsx" developed by Adrian Leach (Imperial College) from ideas and discussions within PRATIQUE.)

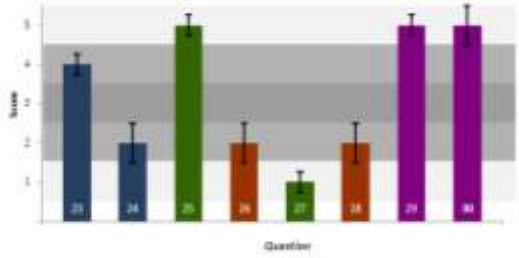
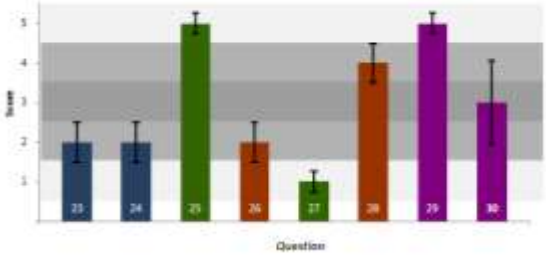
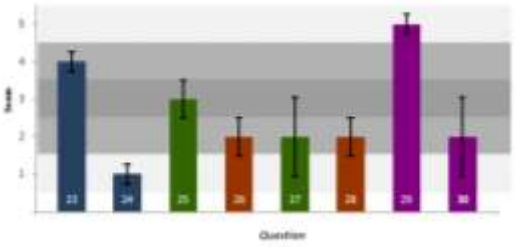
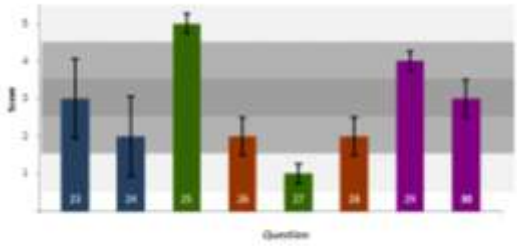
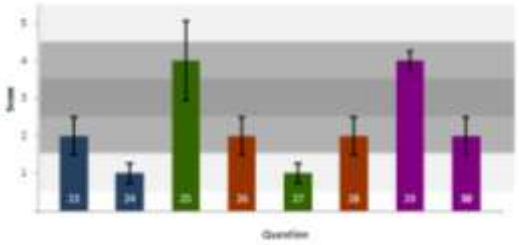
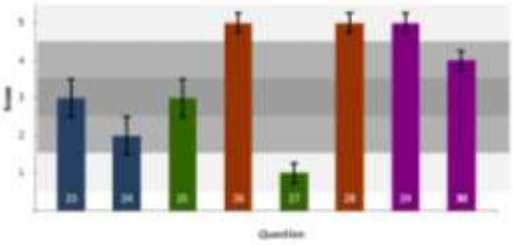
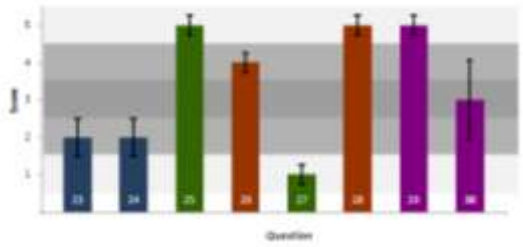
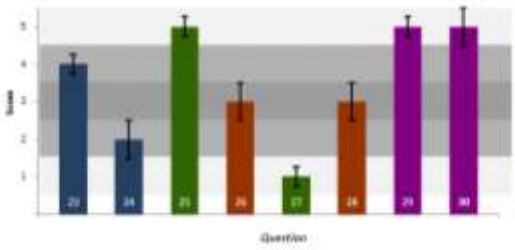
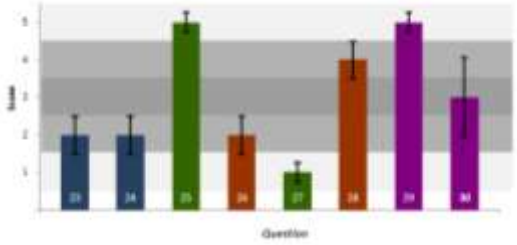
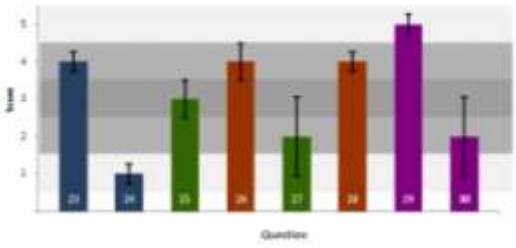
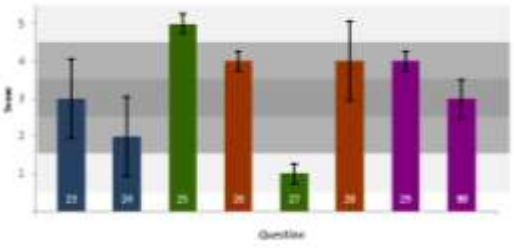
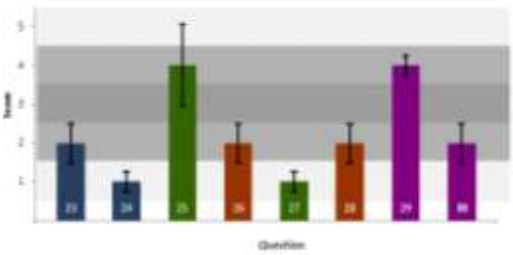
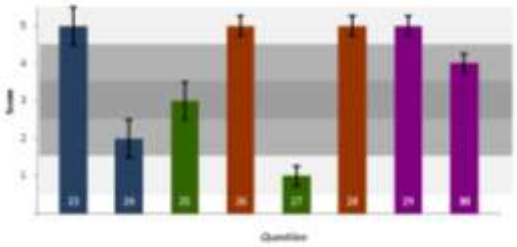
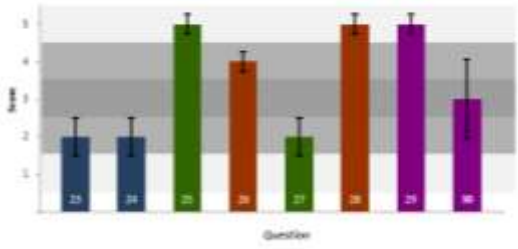
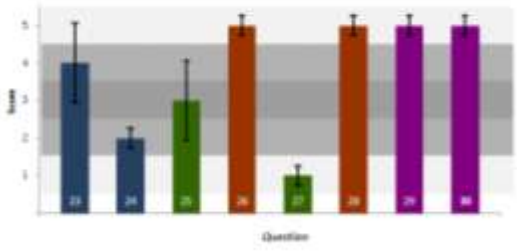
Pathway 1: Honey bees 	Pathway 2: Bumble bees 
Pathway 3: Hive products 	Pathway 4: Soil with plants for planting 
Pathway 5: Fruit imports 	Pathway 6: Beekeeping equipment and clothing 
Pathway 7: Freight containers & transport 	

Figure 1b. Graphical representation of the likelihood (columns) and uncertainty (bars) associated with eight potential pathways for entry of the small hive beetle, *Aethina tumida*, into the UK assuming that this species was present in an EU country. (Ratings to questions in UK Non native risk assessment scheme (Q23 to 30) by Helen Anderson et al. (Defra project PH0510). Charts from "Question Summary Template (Normal) 100326 d NNSS –SHB.xlsx" developed by Adrian Leach (Imperial College) from ideas and discussions within PRATIQUE.)

Pathway 1: Honey bees 	Pathway 2: Bumble bees 
Pathway 3: Hive products 	Pathway 4: Soil with plants for planting and soil from the EU and Mediterranean region 
Pathway 5: Fruit imports 	Pathway 6: Beekeeping equipment and clothing 
Pathway 7: Freight containers & transport 	Pathway 8: Natural spread 

The pathway likely to present the greatest risk of introduction was the movement and importation of honey bees. Although current legislation and management practices mitigate the risk from this pathway, a threat is posed by illegal trade that, by its nature, is not quantifiable and cannot be effectively managed. If SHB were to establish within countries in the EU this risk would be heightened. Under current legislation, imports into the UK from other EU countries could not be banned, but movement could only be of colonies outside of the 100 km exclusion zone that would be set up around infected colonies. A risk was also found for the movement of beekeeping equipment

from areas where SHB is present to the UK. Currently there is no legislation or management practice relating to the movement of this equipment.

The risk of establishment of the SHB in England and Wales was defined as likely, with a low level of uncertainty, although the extent to which successful establishment could occur (for example in more northerly regions) is not currently known. There is also a high potential for spread, due to the high mobility of adult beetles, which may be further assisted by human activity. Overall the potential impact of SHB introduction to the UK was defined as moderate, based on the direct effect it could have on apiaries and the potential indirect effect on pollination services. The economic impact in terms of reduction in the number of pollinators and a reduction in honey availability was defined as moderate, but the greatest economic impact is likely to be incurred from advice, publicity, certification schemes, increased surveillance, multi-fold increases in existing inspectorate, eradication costs and training should an incursion occur.

Potential control measures

Review of the literature permitted possible treatment measures to eradicate SHB to be identified. Currently none of the chemical insecticides that could be used for treatment are registered for this use in the UK. However, it would be possible to import Checkmite +, which is used in the USA for SHB control and contains the active ingredient coumaphos, via a Special Import Licence under the prescribing cascade. Alternative methods are being researched, including the use of biological control agents (entomopathogenic fungi and nematodes), organic acids, lime and diatomaceous earths. Biological control agents that are registered in the UK for other uses are currently being assessed for the ability to control the SHB, under a Defra funded project.

Other non-chemical control measures have been examined, for example, maintenance of strong colonies and use of good husbandry, boosting natural hygienic behaviour in honey bee colonies, the narrowing of hive entrances to restrict beetle access and mechanical control methods, such as using in-hive trapping tools and light traps.

If eradication of the SHB following introduction is not possible, control measures to prevent the spread of the pest would need to be considered. If in-hive control methods are used, these could act on the eggs, larvae (early instars) and adults and would target the most damaging stages. Although adult beetles are able to come and go from the hive, the eggs and early instar larvae are confined to the hive and therefore treatment could be targeted. However, the effect on the health of the bees and the potential for contamination of honey and other hive-associated products would need to be considered. Control measures that involve treating surrounding soil areas, would limit the harm to the bee colonies, but would target latter stages of SHB development after damage may have been caused. The area for treatment could be large and the effect of the treatment on other soil-dwelling fauna would also need to be considered. It is likely that for successful control an integrated pest management approach would be needed and best practice approaches would need to be adopted.

Review of contingency plan

The current draft of the England and Wales contingency plan for exotic pests and diseases of honey bees, dated October 2009, was reviewed. This is an operational document that details the response to an exotic pest and disease outbreak in the UK. Although the contingency plan is generic it focuses on the two notifiable pest species in the UK, the SHB and *Tropilaelaps* spp.. The potential pathways for introduction of the SHB as listed in section 2.4 of the contingency plan cover those identified in this project with the exception of importation of bumblebees and the currently hypothetical situation of natural spread should SHB be found in countries neighbouring GB.

If an exotic species is suspected, a statutory infected area (SIA) would be declared, which in the case of an incursion of the SHB, would extend to an initial area of at least 16 km around the suspect apiary or premises where the beetle has been found. Adult SHB are known to be strong fliers and are reported to fly distances of up to 10 km. The ability to fly is dependant on temperature. If infestation levels are low it is considered that less dispersal is likely to occur. Therefore, the radius for the SIA in the event of detection in an apiary would seem appropriate based on the available data, but would need to be reviewed if further information on the dispersal and spread of SHB becomes available.

The contingency plan also makes respective provisions in the event of an isolated outbreak, where eradication is considered practicable, and a widespread outbreak, which would utilise other control measures to minimise spread. If eradication is considered practicable all colonies in the affected apiary and the surrounding area that are infected or ‘are found to be exposed to infection’ will be destroyed. It is not clear what is meant by ‘found to be exposed to infection’. In the case of SHB, due to the high mobility of SHB adults and the difficulty in detecting their presence in low numbers, this could mean destruction of many colonies. Therefore, this statement within the contingency plan may require clarification with respect to SHB incursion. The plan also states that in the case of SHB infestation, soil surrounding hives that have been exposed to infestation (20 cm depth, 10-20 m from hives) will also be treated if an authorised treatment is available and it is practical to do so. Wandering larvae can crawl up to 200 m from the hive to find a suitable place for pupation[14]. However, it is likely that larvae will remain close to the hive if suitable pupation sites are available. Therefore, soil treatments within 20 m of infected colonies would seem practicable.

The contingency plan states that the NBU's existing beekeeper database, BeeBase, and Geographic Information Systems (GIS) will be used to collate information on beekeepers and apiary sites in the search area. However, any beekeepers who are not registered on BeeBase will not be identified at the early stages of implementation of the contingency plan. This will seriously impact on the likely effectiveness of movement restrictions that are put in place in the event of an incursion, and means that certain colonies that have been "exposed to infection" may go untreated. Currently, there is no consideration of the possible presence of feral bee colonies within the SIA and any measures that would be put in place to eradicate or control these colonies.

If eradication of the SHB is not possible, control measures would need to be put in place to limit the spread of the SHB in the UK. As chemical control methods are limited at present, it is likely that an integrated pest management approach would be adopted. For this type of approach to succeed, training of beekeepers and end-users of imported pollinator units is especially important. The NBU inspectorate and beekeeping associations are in a good position to provide such training and to establish best practice. Consideration should be given to the form that the integrated pest management approach would take at the earliest possible opportunity, preferably before any incursion, to give time for beekeepers to understand, and perhaps put into practice, elements of the approach. This could slow the spread of the SHB if it is introduced, and may make control more practicable.

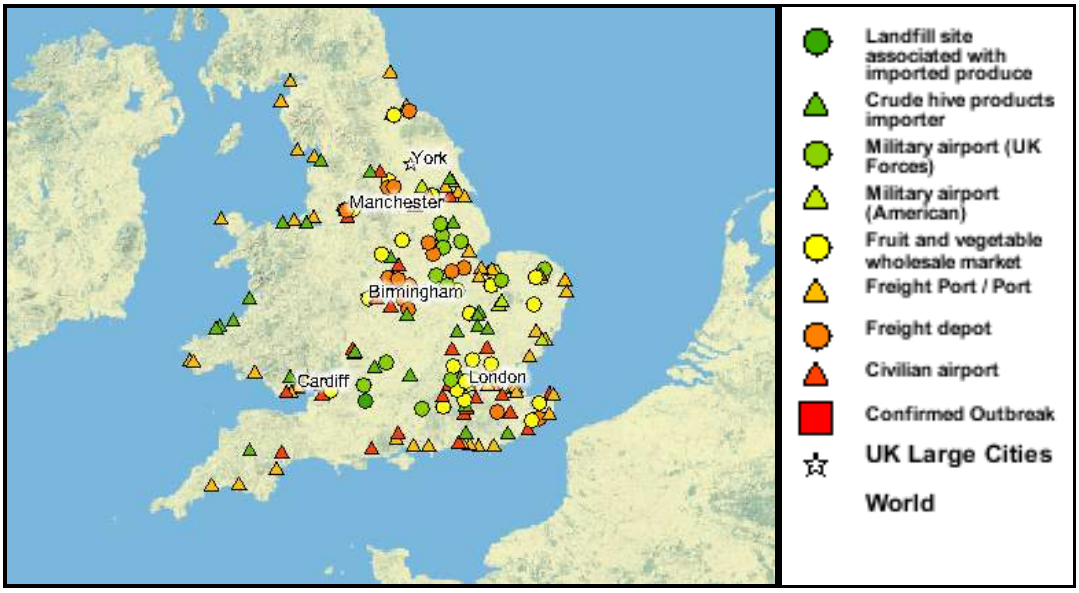
Current contingency practices within the NBU

Since 2003, the statutory inspections undertaken by the NBU have expanded to specifically monitor for exotic pests including the SHB and *Tropilaelaps* mites[22]. At risk apiaries (ARAs) have been identified by the NBU, which are defined by their proximity to potential points of incursion such as airports, freight ports, honey and wax importers etc. (Figure 2). NBU inspectors carry out surveillance for exotic pests through the exotic pest survey (EPS) inspection programme as part of its routine annual apiary inspection programme. Inspections of ARAs are prioritised by calculation of a risk score and in addition random apiaries are also selected for EPS inspections. In 2008 EPS inspections totalled 415 (7.2% of the annual total number of inspections carried out by bee inspectors) and in 2009 543 inspections (5.5% of the annual total number of inspections) for exotic pests were made.

Since 2007, the NBU has also carried out exercises to test the NBU contingency plan for exotic pest incursion. Five exercises were carried out in 2007, two in 2008 and four in 2009. These have simulated the report of a suspected finding of an exotic pest within a hive and contingency planning in line with the NBU standard operating procedure (NBU/153). Valuable lessons are learned from these exercises leading to a set of recommendations for improvement and changes to procedures, many of which have now been implemented (Ivor Flatman, NBU inspectorate, personal communication).

The NBU has recently designated a contingency officer, with responsibility for exotic pest surveillance and contingency planning in the event of an incursion by SHB, or *Tropilaelaps* mites. The NBU is also in the process of setting up sentinel apiaries that will be used to increase awareness of exotic pest threats. The aim is for 15 apiaries in each region to act as sentinel apiaries and that these will be in both 'at risk' and random areas to maximise the likelihood of early detection. Hives within the sentinel apiaries will be examined regularly for exotic pests using SHB traps and specific inspection procedures. Samples of hive debris will be tested twice in each season for the presence of SHB and *Tropilaelaps* mites. The setting up of sentinel apiaries marks an increase in the level of surveillance for exotic pests and provides a greater opportunity for early detection and for raising awareness.

Figure 2. Risk areas identified as potential incursion points for exotic pests such as the small hive beetle, *Aethina tumida*.



Conclusions and further work

- Eight pathways have been identified for the potential introduction of the SHB.
- The PRA shows that in the event of entry the potential for establishment is likely with a low level of uncertainty, and that there is a high potential for spread. The overall impact of introduction was defined as moderate.
- Illegal importation of honey bees from countries where SHB is present represents the highest risk of SHB incursion to the UK.
- Movement of beekeeping equipment from countries where SHB is present to the UK poses a high risk as currently there is no legislation or management practice in place to limit or prevent movement.
- Legislation and inspection/monitoring schemes are in place for the pathways with which SHB is most closely associated. The greatest risk is from those imports from the EU, for which inspections are not currently made. These may be either legal imports from EU countries that are not routinely inspected because there is no requirement to inspect them, or imports that are not inspected because they are illegal.
- Research is needed to establish whether *B. terrestris* colonies can act as hosts for the SHB. If *B. terrestris* can act as a host consideration should be given to increased monitoring, surveillance and inspection of bumblebee colonies imported to the UK. The existing use of imported bumblebee colonies in semi-open or open systems would also need to be reviewed.
- Consideration should be given to the compulsory registration of beekeepers in the UK. This would ensure that the location of apiaries within an area is known, increasing the chances of rapid detection of SHB, and more accurate and effective imposition of movement restrictions in the event of an incursion. It would also ensure that information on SHB, and other exotic pests and diseases, is received by all beekeepers, and that beekeepers are aware of control options and movement restrictions at the earliest possible opportunity, should an incursion occur.
- There is a need to know which chemical, biological and/or other integrated control measures are most effective against SHB so that these can be implemented as soon as possible after an incursion is detected. The option to seek approval for use of these methods at the earliest possible opportunity should be investigated, as an alternative to requesting emergency use of a non-registered product if the SHB is introduced.
- Increased awareness of the pest in the beekeeping sector, in inspectorates (Plant Health and Seeds Inspectorate and Horticultural Marketing Inspectorate) associated with imports of plant material and fruit and with end users of bees and bee associated products would provide additional surveillance.
- Options for more effective field monitoring for the SHB should be studied, in particular the use of different trap types.
- There is a need to assess the status of feral honey bees to see whether these would need to be located and destroyed within the defined Statutory Infection Area, or to establish other control measures that could be utilised.
- An integrated pest management scheme for control of the SHB, to establish best practice should be identified. Training of beekeepers and establishment of best practice before SHB is suspected would limit the spread and make control measures more practicable.
- Consider increasing the number of Exotic Pest Survey (EPS) inspections currently undertaken by the NBU, to increase the likelihood of detecting SHB quickly, in event of any incursion. Consideration should also be given to increasing the number of sentinel apiaries, and making the number of these in each beekeeping region representative of the relative intensity of beekeeping activity in the given area.
- A general awareness campaign should be considered to make travellers aware of the threat posed by SHB to bees (wild as well as managed).

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References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

The Pest Risk Analysis will be published as Annex 1 to this report.

The literature review will be used to prepare a review article on the current knowledge of the SHB for publication in a peer-reviewed journal, for example, Apidologie.