Appendix 1. Pest Risk Analysis (PRA) for the small hive beetle, *Aethina tumida* (Murray) (Coleoptera: Nitidulidae)

Guideline on Pest Risk Assessment

Decision-support scheme for quarantine pests Version N°3

PEST RISK ASSESSMENT FOR: *Aethina tumida* (Murray) – Small Hive Beetle

Stage 1: Initiation

Authors: Helen Anderson, Andy Cuthbertson, Gay Marris, Maureen Wakefield

1 - What is the principal reason for performing the Risk Assessment? (Include any other reasons as comments)	Risk Assessment initiated by the identification of a harmful or potentially harmful organism that is non-native or not ordinarily resident in the risk assessment area.	The main reasons for the initiation of this risk assessment are: - **To better understand the threat and potential impact on UK bee health by** *Aethina tumida* **establishing in the UK** - **To provide evidence for updating the existing contingency plan.**
2 - What is the Risk Assessment Area?	The UK is the area considered under risk	
3 - What is the name of the organism? **This will appear as a heading** (Other names used for the organism can be entered in the comments box)	*Aethina tumida* (Murray)	Common name: The small hive beetle or SHB Coleoptera, Nitidulidae
4 - What is the status of any earlier Risk Assessment?	Assessment partly valid	

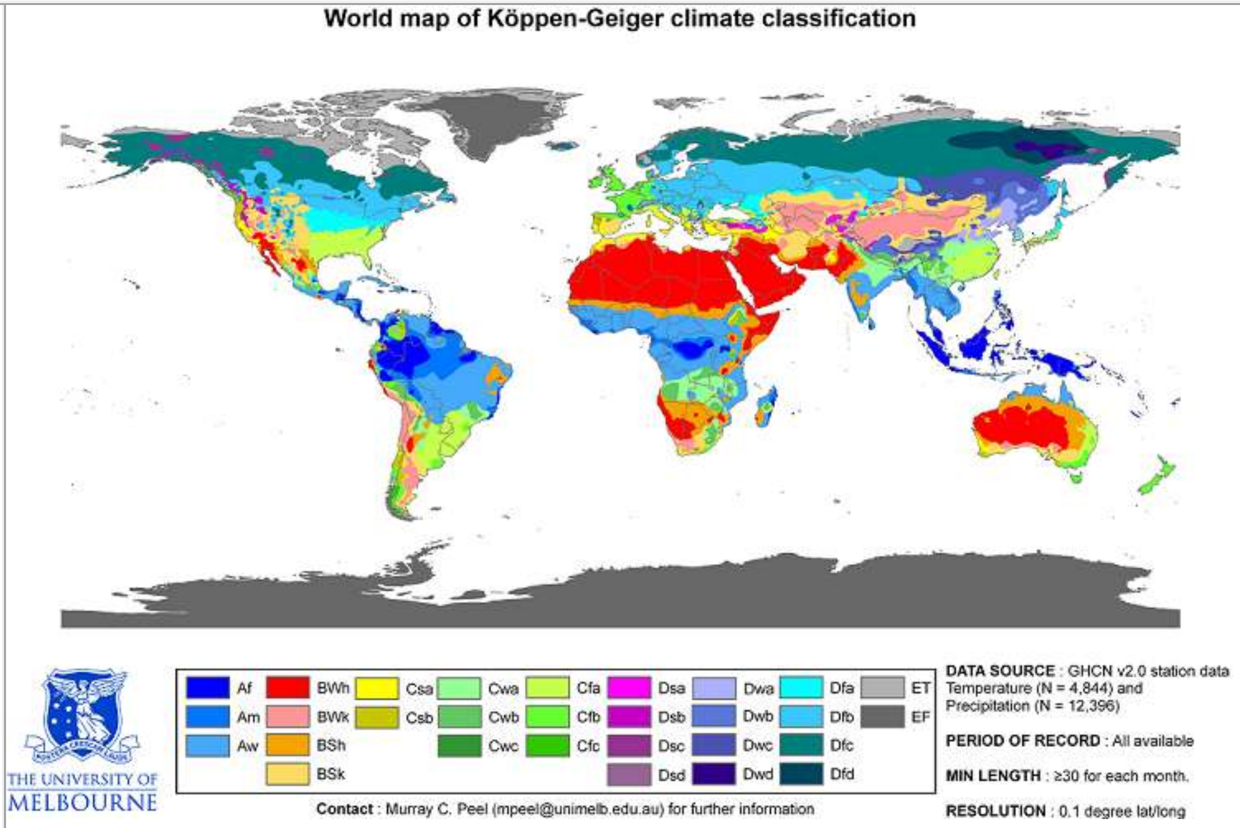
5 - Give details of any earlier Risk Assessment(s)	MAF Biosecurity, 2002 MAF Biosecurity, 2003 MAF Biosecurity New Zealand, 2004 SFVO (2004) OIE (2009) Brown, M.A. (2004)	The small hive beetle is a pest of concern to beekeepers around the world and as such a number of risk assessments in various formats have been carried out. Biosecurity New Zealand, the Biosecurity Authority of the Ministry of Agriculture and Forestry, has produced three import risk analyses which include the risks posed by *A. tumida*: 1. Honey bee hive products and used equipment (MAF Biosecurity, 2002); 2. Honey bee (*Apis mellifera*) genetic material (MAF Biosecurity, 2003) and 3. Honey bee products (MAF Biosecurity New Zealand, 2004). The Swiss Federal Veterinary Office (SFVO) completed a risk analysis for *A. tumida* in 2004 (SFVO, 2004) with import recommendations and The World Organisation for Animal Health (OIE) has a chapter on the small hive beetle in its Terrestrial Animal Health Code (2009), including import recommendations. From the UK perspective, an earlier Pest Risk Assessment exists in the UK non-native organism risk assessment format (Brown, 2004). This PRA aims to provide an up to date risk assessment for the UK, that takes into account recent research findings and includes a pest risk management section.

Stage 2a: Organism Risk Assessment

Authors: Helen Anderson, Andy Cuthbertson, Gay Marris, Maureen Wakefield

6 - If you are sure that the organism clearly presents a risk, or that in any case a full Risk Assessment is required, you can omit this section and proceed directly to the Section B.		Continue with Organism Screening to provide further background.
7 - What is the taxonomic group of the organism?		Class: Insect Order: Coleoptera Family: Nitidulidae
8 - What is the taxonomic status of the organism?		Single taxonomic entity
9 - If not a single taxonomic entity, please give details?	N/A	
10 - Is the organism in its present range known to be invasive?	Yes, the organism is considered to be invasive.	*Aethina tumida* is native to sub-Saharan Africa, where it is usually only a minor pest, being most damaging in weak, stressed colonies and recently abandoned honey bee nests, rather than strong colonies (Neumann & Elzen, 2004). During the past decade the small hive beetle has been introduced into (entered and established in) several countries around the world: Australia (Animal Health Australia, 2003; Neumann & Elzen, 2004), Egypt (Mostafa & Williams, 2000), Jamaica (Brown, 2005) and the USA (Elzen *et al*., 1999a; Fore, 1999; Neumann & Elzen, 2004). The beetles are known to be harmful pests of European honey bee subspecies and even strong colonies can be taken over and killed (Neumann & Elzen, 2004).
12 - What is the current distribution status of the organism with respect to the Risk Assessment Area?	Not present	

13 - Are there conditions present in the Risk Assessment Area that would enable the organism to survive and reproduce? Comment on any special conditions required by the species?	Yes / possible	European honey bees (*Apis mellifera* L.) are known hosts of *A. tumida* and are present in the UK. The known number of managed colonies in England and Wales is around 110,000. These belong to beekeepers who are registered on BeeBase, which is the National Bee Unit's (NBUs) online database for England and Wales. Several thousand more colonies are found in Scotland and Northern Ireland. However, the exact number of active beekeepers in the UK is unknown as there is no legal requirement to register on BeeBase (NBU, 2010). Colonies of feral bees are also believed to be present across the UK, although their incidence and distribution is currently unknown (Thompson *et al*., 2010). *Aethina tumida* has been shown to invade colonies of the bumble bee *Bombus impatiens*, both in the field and in glasshouse studies (Spiewok & Neumann, 2006; Hoffmann *et al*., 2008). Alternative bumble bee hosts (*B. terrestris*), have been successfully infested with small hive beetle under experimental conditions (OIE, 2009), but infestation has not been demonstrated in wild populations. The UK has a number of bumble bee species, although not *B. impatiens*, which the small hive beetle can use as a host. The UK also has other indigenous bee species which may be potential hosts. Small hive beetle may use fruits as an alternative food source, and the complete lifecycle has been demonstrated on fruit in the laboratory (Ellis *et al*., 2002). The level of reproduction and feeding on fruit has not been studied in the wild (Neumann & Elzen, 2004).
14 - Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of the Risk Assessment Area or sufficiently similar for the organism to survive and thrive?	Yes / possible	Yes, populations of *A. tumida* have been found breeding in North America, including in maritime climates found in north eastern states of USA (See question16). The UK has a maritime climate.

		 Fig. 1. World map of Köppen-Geiger climate classification
15 - Could the organism establish under protected conditions (such as glasshouses, aquaculture facilities, terraria, zoological gardens) in the Risk Assessment Area?	Yes / possible	*Aethina tumida* has been shown to invade colonies of bumble bees in glasshouses (Hoffman *et al*., 2008) in the USA – and conditions in the UK glasshouses are not dissimilar, although the species used in the USA study (*B. impatiens*) is not present in the UK.

<table>
<tr>
<td>16 - Has the organism established viable (reproducing) populations anywhere outside of its native range?</td>
<td>Yes</td>
<td>Aethina tumida is native to sub-Saharan Africa: possibly all the African countries where it is known other than Egypt.
<table>
<tr><th colspan="2">Table 1: Distribution of Aethina tumida</th></tr>
<tr><td>North America:</td><td>Canada: currently nine outbreaks recorded in Quebec, close to the USA border (WAHID, 2010); Mexico: several outbreaks since 2007, with the most recent described as continuing (WAHID, 2010); USA: Alabama, Arkansas, California, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Jersey, New York, North Carolina, North Dakota, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, Vermont, Virginia, West Virginia, Wisconsin (Neumann & Elzen, 2004; Neumann & Ellis, 2008)</td></tr>
<tr><td>Central America:</td><td>Reported in Jamaica (Brown, 2005).</td></tr>
<tr><td>South America:</td><td>No confirmed records</td></tr>
<tr><td>Europe:</td><td>Intercepted only in Portugal (Murilhas, 2005).</td></tr>
<tr><td>Africa:</td><td>Presence in sub-Saharan Africa, with known reports in: Angola, Botswana, Cameroon, Central African Republic, Congo, Democratic Republic of Congo, Ethiopia, Eritrea, Ghana, Guinea Bissau, Kenya, Lesotho, Malawi, Mozambique, Namibia, Nigeria, Senegal, South Africa, Southern Sudan, Swaziland, Tanzania, Uganda, Zambia, Zimbabwe (Neumann & Elzen, 2004; Neumann & Ellis, 2008). Recently detected in Egypt (Mostafa & Williams, 2000), where the population is assumed to be an introduction.</td></tr>
<tr><td>Asia:</td><td>No confirmed records</td></tr>
<tr><td>Oceania:</td><td>Australia: New South Wales, Queensland, Victoria and Western Australia (Somerville, 2003; Annand, 2008)</td></tr>
</table>
In the USA the small hive beetle was first identified in Florida in 1998 (Hood, 2000). However, the earliest collected specimens were found in South Carolina in 1996 (Hood 2000). By the end of 1999 small hive beetle was present in 12 states (Hood, 2000), extending to 25 states in 2002 (Evans et al., 2003) and to 29 states in March 2003 (Neumann & Elzen, 2004).</td>
</tr>
</table>

		In Australia, presence of small hive beetle was confirmed in October 2002 (Fletcher and Cook, 2002). Extensive inspection and surveillance followed, resulting in confirmations of the presence of small hive beetle in 103 apiaries in four regions of New South Wales, including 13 feral colonies. As a result it was decided that the small hive beetle was not eradicable, and it was declared endemic (Somerville, 2003). The small hive beetle subsequently spread to Queensland, Victoria and the Kimberley area of Western Australia (Annand, 2008). There are reports of its spread through to Tully in northern Queensland where it is considered that it could be a more serious pest due to the rapid rate of reproduction under warm, humid conditions (Leemon & McMahon, 2009). In 2000, the presence of *A. tumida* in Egypt was reported (Mostafa & Williams, 2000). In a recent survey, there were no findings of small hive beetle in 1239 inspected colonies in 11 districts throughout Egypt, and it was concluded that small hive beetle is not well established in Egypt (Hassan & Neumann, 2008). In 2004 the presence of *A. tumida* was reported in Jamaica and a control programme initiated (Brown, 2005). There have been outbreaks of small hive beetle in Canada in 2002 (Manitoba), 2006 (Alberta and Manitoba), 2008 (Quebec) and 2009 (Quebec) (Clay, 2006; Neumann & Ellis, 2008; WAHID, 2010). In 2008 both adult and larval stages were found, suggesting for the first time the beetle was able to reproduce in Canada, but subsequent inspections of the first outbreaks in Quebec have suggested that the pest did not overwinter, although it is possible that the numbers surviving were very low (Giovenazzo & Boucher, 2010). The outbreaks in Quebec appear to be genetically linked with populations from the USA, and all have been found close to the USA border. The earlier outbreak in Alberta has been linked with Australian populations of small hive beetle (WAHID, 2010). *Aethina tumida* has been found in Mexico in 2007 (Coahuila), 2008 (Guanajuto and Coahuila) and 2009 (Coahuila). The earlier incursions are believed to have been eradicated, but the 2009 finding is described as ‘continuing’ and further updates are expected (WAHID, 2010). To date, the only known European interception was in 2004, when small hive beetle larvae were found in a consignment of queen bees imported into Portugal from Texas (Murilhas, 2005). The colonies into which the queen bees had been introduced were destroyed.

17 - Can the organism spread rapidly by natural means or by human assistance?	Yes / possible	Adult small hive beetles are strong fliers and are capable of flying several kilometres (in excess of ten) (Somerville, 2003) which aids in their natural spread. Rapid spread is possible through human assistance. In the USA it is not clear whether single or multiple introductions occurred (Evans *et al*., 2000; 2003), but the rapid spread is likely to be as a result of movement of infested colonies, queen bees, packaged bees and beekeeping equipment, and also migratory beekeeping (Delaplane, 1998). The assumption is that movement of the pest is also possible in trade of fruit, soil and compost with plants; anything that the beetle can survive in as adults, larvae, pupae or eggs.
18 - Could the organism as such, or acting as a vector, cause economic, environmental or social harm in the Risk Assessment Area?	Yes / possible	In its native range, *A. tumida* exist as both scavengers and symbionts in colonies of African subspecies of western honey bees (*Apis mellifera* L.) (Lundie, 1940; Neumann & Elzen, 2004). The beetle is a colony scavenger, feeding on pollen, honey and bee brood. In extreme circumstances, the beetle may act as a superorganismic parasite that destroys weakened or diseased colonies, but this scenario is the exception rather than the rule (Ellis & Hepburn, 2006). In the USA and Australia there are mixed reports as to the degree of damage caused by small hive beetle in managed colonies. Damage is mainly caused by the larvae, which feed on honey, pollen and brood. The excrement from the larvae can cause the honey to ferment, rendering it unfit for human consumption. In hives with very heavy infestations, where larval feeding is extensive, the bees may abscond (Hood, 2000; Neumann & Elzen, 2004). *A. tumida* has had a greater impact on European honey bee colonies than on African subspecies. European honey bees appear more susceptible, suffering greater damage from beetle infestations, and colonies collapse more often (Elzen, *et al*., 1999b, 2000). A recent survey of beekeepers in Queensland has shown that the small hive beetle is causing more extensive damage than originally thought. The survey showed that more than 3000 hives had been lost to the small hive beetle across the state. The cost, including clean up, control and restoration was more than $400 per hive (Mulherin, 2009). The greatest impact in the USA has been in Florida. In 1998, 30,000 colonies were lost, with total damages worth 3 million dollars (Ellis *et al*., 2002).
19 - If answers to questions in	Necessary to proceed	Yes. *A. tumida* is a pest which has been known to establish outside its native area with significant impact

this section were 'yes' (even if some were only possibilities), then a full assessment is likely to be necessary. If some answers were 'no' then consider whether this negates the need for a full assessment or not. Please give an appraisal of whether it is necessary to proceed with a full assessment and briefly give the key reasons in the comment box.	with full assessment	on managed European honey bees in these areas.

Stage 2b: Pathways

Authors: Helen Anderson, Andy Cuthbertson, Gay Marris, Maureen Wakefield

20 - How many pathways are relevant to the potential entry of this organism?	Many	We will consider the possibilities of entry from areas of current distribution and the hypothetical situation if the pest was present in the EU.
21 - Please list the broad pathways through which the organism could be carried (one per line).		1. Movement of honey bees: queens and packaged bees (workers) for the purposes of trade. From the EU only this also includes the movement of whole colonies. 2. Movement of alternative hosts e.g. bumble bees for pollination purposes. 3. Trade in hive products – specifically rendered beeswax and honey post extraction in drums from both 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 other than Mediterranean countries. Soil from the EU and Mediterranean countries. 5. Fruit imports – in particular avocado, bananas, grapes, grapefruit, kei apples, mango, melons and pineapples – Small hive beetle may oviposit on fruit. 6. Movement on beekeeping clothing / equipment 7. Movement on freight containers and transport vehicles themselves 8. Natural spread of pest itself by flight, on its own or possibly in association with a host swarm. Neither of these is possible from third countries so this pathway is relevant only for the scenario that *A. tumida* is present in the EU.
22 - Please select the pathway:	**1.**	**Movement of honey bees: queens and packaged bees (workers) for the purposes of trade. From the EU only this also includes the movement of whole colonies.**
PATHWAY 1.		

23 - How likely is it that the organism is strongly associated with the pathway at the point(s) of origin?	Likely Low level of uncertainty	**Third countries**: Point of origin is assumed to be a country where infestation is known to be present (sub-Saharan Africa, Australia, Egypt, Jamaica and USA). Honey bees are most likely to be imported to the PRA area during the UK spring / summer months. The lifecycle of the small hive beetle is such that the stages associated with hives are eggs, larvae or adults. It is unlikely that eggs would be associated with adult bees in transport. Pupae would also not be associated as pupation takes place in the soil, outside the colony. **EU member states**: Again, bees are unlikely to be moved from this region during the winter. The risk of association with the pathway is stronger in the summer and the active beekeeping season. Honey bee imports typically occur between March and September (NBU, pers. comm.).
24 - How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin?	Unlikely Medium level of uncertainty	Large numbers of adults or larvae are unlikely as these would be noticed in consignments. It is unlikely that eggs would be associated with adult bees (queens or workers). Legal trade volumes from both third countries and the EU are documented. However, it is important to note that the level of illicit trade entering the UK is unknown and by its nature not monitored (NBU, pers. comm.). **Volume of trade from third countries**: In 2009, a total of 5222 honey bee queens were imported into England and Wales from third countries: Hawaii – 4182 New Zealand – 740 Australia – 300 (Information from BeeBase, 2010). **Volume of trade from the EU**: Table 1 shows imports from the EU into England and Wales. **Table 1.** Honey bees: Queens or nucleus colonies imported from the EU into England/Wales in 2009 (Information from BeeBase, 2010)).

Country of origin	No. of consignments imported	Batched no. of queens	Batched no. of nucleus
Austria	1	8	0
Cyprus	21	725	0
Germany	10	113	0
Denmark	4	48	0

France	1	0	10
Greece	29	2175	2
Italy	3	375	0
Poland	3	128	0
Slovenia	12	2034	0
Total	**84**	**5606**	**12**

25 - How likely is the organism to survive during transport or storage within the pathway?	Very Likely Low level of uncertainty	If honey bees can survive transport or storage, so can the small hive beetles. *A. tumida* can survive some time without food or water (Cuthbertson *et al*., 2008; Pettis & Shimanuki, 2000; Ellis *et al*., 2002). Larvae can survive for up to 48 days (Cuthbertson *et al*., 2008). Solid sugar based food, known as candy or fondant, is usually provided to sustain the honey bees themselves during transport (NBU, pers. comm.).
26 - How likely is the organism to enter the Risk Assessment Area undetected?	Unlikely from third countries Medium level of uncertainty. Moderately Likely from the EU Medium level of uncertainty	Note that the authoritative legal position for the importation of bees into the UK can be found in the appropriate national legislation which is available at: http://www.opsi.gov.uk/stat.htm and the European Commission legislation may be found at: http://eur-lex.europa.EU/RECH_menu.do?ihmlang=en It is also summarised in the NBU Standard Operating Procedure (SOP NBU/084) (Brown, 2006a). **Third country imports:** Honey bees may be imported into the EU from third countries provided that the three notifiable pests of bees in the EU, including *A. tumida*, are confirmed as notifiable throughout the exporting country. Only Argentina, Australia, New Zealand and the US State of Hawaii currently meet these requirements, and of these only Australia has *A. tumida*. Imports of honey bees from third countries are further restricted to consignments of queens and no more than 20 attendant workers, the exception to this being for New Zealand. Packaged honey bees may be imported from New Zealand under a derogation of the Commission Decision 2006/855/EC. To import honey bees from other third countries, checks have to be made that they are able to comply with the requirements of the EC health certificate. Eligible third countries include the following which are known to have small hive beetle: Botswana, Ethiopia, Kenya, Namibia, South Africa, Swaziland and Zimbabwe (Bee Health Policy, 2009). Imports from these countries are equally restricted to queen bees and no more than 20 attendant workers. All honey bees imported directly into England from a third country must enter through one of two designated Border Inspection Posts (BIPs) – Heathrow and Gatwick airports – where they are inspected by Veterinary Officers. As well as being accompanied by an appropriate health certificate the import should be notified in advance via the TRACES (Trade Control and Expert System) (See Brown, 2006a for more information on TRACES) and the NBU should also be notified of the import. All third country imports should be examined (Bee Health Policy, 2009; NBU, 2010).

		Upon receipt of queen honey bees from a third country the queens must be transferred to a new queen cage before they are introduced to any local colonies. The queen cages, attendant worker bees and other material accompanying queen bees from a third country should be sent to the NBU within 5 days for examinations for small hive beetle. Queen honey bees from third countries must come from a breeding apiary which is supervised and controlled by the competent authority and the hives must have been inspected immediately prior to dispatch and show no clinical signs or suspicions of pests affecting bees. In addition if *A. tumida* is known to be present in the exporting country imported honey bees must come from an area of at least 100km radius where this pest is absent. They and the packaging must have undergone a detailed examination to ensure that no life stage of the small hive beetle is present. The packaging material and cages and all accompanying products should be new and all precautions should be taken that they have not been in contact with diseased bees (Bee Health Policy, 2009). The legislation for the control of honey bees imported to the EU from third countries is very thorough. However, it is not always followed to the letter. The NBU does have evidence that there have been occasions when the legal requirements have not been fully followed; for example queen bees imported from Australia without the packaging being sent to the NBU for examination (NBU, pers. comm.). This is a concern, as the interception of the small hive beetle in Portugal was made in the packaging accompanying a third country import. There is also a concern that the queen honey bees themselves are not physically examined in the UK before being introduced to local colonies. This is because targeted methods of pest and disease screening in the laboratory are, necessarily, destructive. While adult beetles and larvae are likely to be noticed attached to a queen bee, there is a possibility that eggs could go unnoticed, though the likelihood of this is believed to be low (NBU, pers. comm.). **Imports from the EU**: Consignments of honey bees from other EU member states must be accompanied by an original health certificate (Annex E part 2, Council Directive 92/65/EEC) – the electronic paperwork of which is held on the TRACE system. Importers must also give 24 hours written notice to the Animal Health Office responsible for the region where their consignment is destined to arrive. This letter, copied to the NBU gives details of the planned date and arrival time and details of the final destination. NBU inspectors have the power to check the paperwork and have a requirement to look at the paperwork of 50% of consignments. 10% of these must be subject to physical checks, however there is no border inspection point for the checks of EU imports. The checks may not be at the point of entry at all, but at the final destination. The physical checks may therefore involve checking an imported nucleus or full sized colony for pests and diseases and possibly checking the colonies into which imported queens have been introduced (Brown, M., 2006b; Bee Health Policy, 2009; NBU, 2010).

		Should the small hive beetle be confirmed as present in an EU Member State, EC legislation doesn't permit the UK to ban imports. However, imported honey bees must come from an area of at least 100km radius which is not subject to any restrictions associated with suspicion or confirmed occurrence of the small hive beetle and they and the packaging must have undergone a detailed examination to ensure no life stage of the pest is present (Bee Health Policy, 2009; NBU, 2010). Current legislation limits the chance of the pest entering undetected, but does not rule it out. The main areas of concern are that not all consignments are physically checked in the UK and that those checks which are made may be done at the final destination of the consignment and not the point of entry. There is additional uncertainty over the detection of the small hive beetle due to the possibility of illicit trade entering the UK without any documentation and no notification of the authorities. Volume of this trade is unknown, but is likely to be larger from the EU than third countries due to the ease of transport.
27 - How likely is the organism to multiply/increase in prevalence during transport /storage?	Very Unlikely Low level of uncertainty	Adults could potentially mate and lay eggs, but not complete a lifecycle. Time in transport or storage cannot be long, as this limits the survival of the honey bee commodity itself, regardless of area of origin.
28 - How likely is the organism to survive existing management practices within the pathway?	Unlikely from third countries Medium level of uncertainty Moderately Likely from the EU Medium level of uncertainty.	There are no treatments made to the commodity which are likely to affect the small hive beetles ability to survive. However, due to inspection (discussed in Question 26 above) small hive beetle should be picked up in official trade from third countries. If *A.tumida* were present in the EU: it is possible current inspections may miss an infestation of small hive beetle, particularly with only 10% of imports being physically inspected, and some of these inspections only occurring once the honey bees have reached their destination. The uncertainty surrounding survival during management methods is due to illicit trade, which by its nature will not be managed.

29 - How likely is the organism to arrive during the months of the year most appropriate for establishment?	Very Likely Low level of uncertainty	Honey bee imports typically occur between April and September, regardless of whether the imports are of EU or third country origin (NBU, pers. comm.). These six months cover the key beekeeping months of the year in the UK. These dates are based on imports that are notified to the NBU directly or through TRACES, but even unofficial imports are unlikely during the UK winter season as spring / summer would be when conditions are appropriate for bee establishment. If bees can establish successfully, then small hive beetle will also be able to.
30 - How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	Very Likely Medium level of uncertainty	Being transported with honey bees the small hive beetle would enter the PRA area already associated with suitable hosts. Imports from third countries are subject to conditions that queen honey bees must be transferred to new cages before being introduced to local colonies, and that the cages and any attendant worker bees from third country origin should be sent to the NBU for examination for small hive beetle and other pests within five days (Bee Health Policy, 2009). This would restrict the possibility of transfer to a suitable host hive, however there are occasions when the legal requirements are not fully followed which increases the risk of transfer to a host. Honey bees and colonies imported from the EU may be introduced to new colonies or established in their final homes before checks are made on the health of the bees and not all imports are officially checked (see 26). This provides a much more open pathway for the small hive beetle to transfer to a suitable host hive. None of the controls are effective if honey bees are imported illegally.
31 - Do other pathways need to be considered?	Yes	
22 - Please select the pathway:	**2.**	**Movement of alternative hosts e.g. bumble bees for pollination purposes. *Bombus terrestris* is the species imported for this purpose by the UK. This is not known to be a natural host for small hive beetle – though it has been found in association with other Bombus species (*B. impatiens*)**
PATHWAY 2.		
23 - How likely is it that the organism is strongly associated with the pathway at	Unlikely Medium Level of Uncertainty	**Third countries**: Point of origin is assumed to be a country where infestation is known to be present (sub-Saharan Africa, Australia, Egypt, Jamaica and USA). Bumble bees are potential alternative hosts and imported to the UK for pollination purposes. They are more likely to be imported all year round than honey bees. However, they are required to have been bred in controlled environments within a recognised establishment and the species imported to

the point(s) of origin?		the UK (*B. terrestris*) is not a known natural host for the small hive beetle. Specifically the subspecies imported for commercial use are: *Bombus terrestris terrestris* (B.t.t.) and *Bombus terrestris dalmatinus* (B.t.d.). The UK native subspecies is *Bombus terrestris audax* (B.t.a.) There has been debate over whether non-native subspecies should be imported into the UK where they could potentially be released into the wild and consideration has been given to the use of commercially produced B.t.a. (CABI *et al*., 2005). There has been no known investigation into whether any of these subspecies may be better potential hosts than the others. The lifecycle of the small hive beetle is such that the stages associated with hives are eggs, larvae or adults. Pupae would not be associated as pupation takes place in the soil, outside the colony. **EU member states**: the situation would be the same as with third country origin. The potential for association increases if the system is abused and bumble bees are illegally bred and exported. The likelihood of this is unclear.
24 - How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin?	Unlikely Medium level of uncertainty	Large numbers of adults, larvae or eggs are unlikely as they would be noticed in consignments. Smaller numbers, especially of eggs, may go undetected. Currently all commercial imports of bumble bees into the UK originate in the EU. In a typical year an estimated 60, 000 units (boxes of bumble bees) enter the UK from the EU. The horticultural industry is reliant upon this supply of pollinators, and it is believed that almost 100% of tomatoes grown under glass in the UK are pollinated by imported bumble bees (NBU, 2010). What is uncertain is the volume of illicit trade which may be entering the UK and whether any of this may be from the higher risk third countries where small hive beetle is known to be established.
25 - How likely is the organism to survive during transport or storage within the pathway?	Very Likely Low level of uncertainty	If bumble bees can survive transport or storage, so can the small hive beetles. *A. tumida* can survive some time without food or water (Cuthbertson *et al*., 2008, 2010; Pettis & Shimanuki, 2000; Ellis *et al*., 2002). Larvae can survive for up to 48 days (Cuthbertson *et al*., 2008). Solid sugar based food, known as candy and fondant, and sugar syrup are usually provided to sustain the bumble bees themselves during transport (NBU, Pers. comm.).
26 - How likely is the organism to enter the Risk Assessment Area undetected?	Unlikely Medium level of uncertainty.	Note that the authoritative legal position for the importation of bees into the UK can be found in the appropriate national legislation which is available at: http://www.opsi.gov.uk/stat.htm and the European Commission legislation may be found at: http://eur-lex.europa.EU/RECH_menu.do?ihmlang=en

		Third country imports: Bumble bees may be imported into the EU from third countries provided that the three notifiable pests of bees in the EU, including *A. tumida*, are confirmed as notifiable throughout the exporting country. Only Argentina, Australia, New Zealand and the US State of Hawaii currently meet these requirements and of these only Australia has *A. tumida*. To import bumble bees from other third countries checks have to be made that they are able to comply with the requirements of the EC health certificate. Eligible third countries include the following which are known to have small hive beetle: Botswana, Ethiopia, Kenya, Namibia, South Africa, Swaziland and Zimbabwe (BeeBase, 2010). In the case of bumble bees, imports from eligible third countries of packages or single colonies with a maximum of 200 adult bees per container are permitted if they are bred under environmentally controlled conditions within recognised establishments. Imports of queen bumble bees from eligible third countries are restricted to consignments of queens and no more than 20 attendant workers. Bumble bees from third countries must come from a breeding apiary which is supervised and controlled by the competent authority. Colonies must have been inspected immediately prior to dispatch, and show no clinical signs or suspicions of pests affecting bees. In addition, if *A. tumida* is known to be present in the exporting country, imported bees must come from an area of at least 100km radius where this pest is absent. As well as being accompanied by a health certificate and notified on the TRACE system, they and the packaging must have undergone a detailed examination to ensure that no life stage of the small hive beetle is present. The packaging material, cages and all accompanying products should be new and all precautions should be taken that they have not been in contact with diseased bees (Bee Health Policy, 2009). As with honey bees, imports of bumble bees from third countries would be required to enter the UK through one of the two designated Border Inspection Posts, and as well as being accompanied by an appropriate health certificate the import should be notified in advance via the TRACE system. The NBU would be aware of any imports through this system, though they are not obliged to act on this information and no inspections are made on imported bumble bees for any pests. The NBU is not aware of any third country imports of bumble bees to the UK. **Imports from the EU**: Consignments of bumble bees from other EU member states must be accompanied by an original health certificate (Annex E part 2, Council Directive 92/65/EEC) – the electronic paperwork of which is held on the TRACE system. The NBU is aware of imports entering the UK through this system, but is not obliged to act on this information and no inspections are made on imported bumble bees for any pests. Should the small hive beetle be confirmed as present in an EU Member State, EC legislation doesn't permit the UK to ban imports. However, imported bumble bees must come from an area of at least 100km radius which is not

		subject to any restrictions associated with suspicion or confirmed occurrence of the small hive beetle, and they and the packaging must have undergone a detailed examination to ensure no life stage of the pest is present (Bee Health Policy, 2009; NBU, 2010). Current legislation would limit the chance of the pest entering undetected through this pathway, but not rule it out. Legal imports of bumble bees for pollination come from specific commercial companies who must screen bees for pests and diseases. This is typically achieved by taking regular small samples of bees for dissection, and by visual inspection of colonies during production, but it is unclear whether these regimes would provide sufficiently robust levels of detection if the small hive beetle were to become established in an EU member state (NBU, 2010). There is also concern that currently there is no obligation for checks to be made on the bumble bees entering the UK from the EU. There is additional uncertainty over the detection of the small hive beetle due to the possibility of illicit trade entering the UK without any documentation, and no notification of the authorities. Volume of this trade is unknown, but is likely to be larger from the EU than third countries due to the ease of transport.
27 - How likely is the organism to multiply/increase in prevalence during transport /storage?	Very Unlikely Low level of uncertainty	Adults could potentially mate and lay eggs, but not complete a lifecycle. Time in transport or storage cannot be long, as this limits the survival of the bumble bees themselves, regardless of area of origin.
28 - How likely is the organism to survive existing management practices within the pathway?	Likely Medium level of uncertainty	There are no treatments made to the commodity which are likely to affect the small hive beetles ability to survive. There do not appear to be any obligations for bumble bee consignments from third countries or the EU to be checked for small hive beetle. Containers transporting colonies of bumble bees received from third countries must be destroyed either immediately, or at the end of the lifespan of the imported colony, along with all material which accompanied the bees (Bee Health Policy, 2009) – but there do not appear to be any checks that this is carried out by the end receiver of the bumble bees. The NBU is aware of bumble bee nests just being thrown away on compost heaps and not properly disposed of (NBU, pers. comm.).
29 - How likely is the organism to arrive during the months of the year most appropriate for	Very Likely Low level of uncertainty	Bumble bees are imported for pollination all year round, regardless of whether the imports are of EU or third country origin (NBU, 2010).

establishment?		
30 - How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	Moderately Likely High level of uncertainty	*Bombus terrestris* is the species imported to the UK for pollination. This is not known to be a host for small hive beetle – although the pest has been found in association with other Bombus species (*B. impatiens*). Most commercially produced bumble bees are used in green houses, on crops such as tomatoes and strawberries, which would restrict the small hive beetles ability to find suitable hosts if the bumble bees in the consignment were not suitable. However, bumble bees are increasingly used commercially to enhance pollination in open sided polytunnels or out of doors on fruit crops. The nature of these systems would allow the escape of the small hive beetle into the environment and increase the possibility of it finding suitable hosts (NBU, 2010). It is unclear if known host species of bumble bees (*B. impatiens*) are brought into the UK illegally.
31 - Do other pathways need to be considered?	Yes	
22 - Please select the pathway:	**3.**	**Trade in hive products – specifically rendered beeswax and honey post extraction in drums from both third country and EU origin and honeycomb and any other unprocessed wax products from the EU. Honey bee semen, honey bee venom, honey packaged in jars, refined beeswax, propolis, royal jelly and pollen are excluded from this risk assessment due to the process of extraction and preparation and, in some cases, the end use of human consumption eliminating the risk of association with these commodities.**
PATHWAY 3.		
23 - How likely is it that the organism is strongly associated with the pathway at the point(s) of origin?	Likely Low level of uncertainty	It is known that *A. tumida* are strongly attracted to honey houses (packing facilities) (Lundie, 1940; Schmolke, 1974). Honey itself is not very attractive to the beetles, but the beeswax cappings and other hive material which may be associated with honey awaiting extraction are. In Texas, USA, 500 pallets of honey on combs waiting to be extracted were found to be infested with beetle larvae. In another instance, cappings left on the settling tank on top of the honey during the process of extraction have been known to attract the small hive beetle. Once honey extraction has begun, small hive beetles can therefore be a major concern to exposed hive product (Somerville, 2003). The first confirmed case of small hive beetle in Canada (Manitoba) in 2002 was at a wax rendering plant – the beetles being brought into country in beeswax cappings (unprocessed beeswax) from Texas, USA (Dixon & Lafreniere, 2002; Hood, 2004).

		All the evidence suggests that any honey or wax related product left lying around prior to or post processing is vulnerable to infestation. Due to the preheating and processing of honey prior to bottling, honey in jars for direct sale is not considered a risk. Honey in drums may become infested after extraction by beetles laying eggs around the lids, or even inside the container before sealing. Small hive beetles around the lids pose the greatest risk, although larvae can apparently survive in extracted honey for more than a week, provided they can swim to the surface (MAF Biosecurity New Zealand, 2004). The importation of unprocessed beeswax in the form of honeycomb (a product which contains both honey and beeswax) is completely banned from third countries (DEFRA, 2007). Illegal imports of honeycomb are not considered likely due to the difficulties with importing this product (NBU, pers. comm.). The import of this product is not banned from the EU and given the association which has been found in the USA this product must be considered a risk from the EU, if small hive beetle was present. Beeswax for technical use must be refined or rendered before import from third countries and be accompanied by a commercial document. There is no definition of rendering for beeswax but OVS note 07/98 states that beeswax that has been melted and set in blocks would meet the requirements of Commission Regulation 829/2007 (2007) (DEFRA, 2007). Rendered beeswax has not been filtered for contaminants. Refined beeswax is filtered. Rendered beeswax is the crudest state of beeswax which may be legally imported into the UK from outside the EU. With a known association between small hive beetles and rendering plants, it is the post processing contamination of this product which is considered the greatest risk. There are no restrictions on the UK import of wax products from within the EU and whether these would always have been rendered is unclear.
24 - How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin?	Very Unlikely Low uncertainty	Large numbers would be noticed within the products prior to transport. However there is a risk that despite detection of the pest an exporter may send the products anyway.
25 - How likely is the organism to survive during	Moderately Likely	Good conditions – in terms of food – potentially exist with all the hive products discussed in 23. There are reports that small hive beetles can survive without water for up to 9 days (Pettis & Shimanuki, 2000; Ellis *et al.* 2002). They are known to be able to survive at a range of temperatures, but extremes of tolerance are not known. Larvae may

transport or storage within the pathway?	Medium level of uncertainty	survive in extracted honey for more than a week provided they can swim to the surface (MAF Biosecurity New Zealand, 2004). Length of time spent on the pathway is unknown, and this adds a level of uncertainty as the stages likely to be associated with either product are adults, eggs and larvae. If the duration of the pathway is long enough for the small hive beetle to need to pupate this may limit its survival as pupation takes place in soil. Travel time from the EU (if the small hive beetle were present) is likely to be less than from third countries.
26 - How likely is the organism to enter the Risk Assessment Area undetected?	Unlikely from third countries Medium level of uncertainty Likely from the EU Medium level of uncertainty.	The detection of the small hive beetle within an imported hive product will be dependent on the lifestage – eggs and larvae may be harder to detect than adults. **Third country imports**: Council Directive 97/78/EC requires that all consignments of animal products from third countries imported into the European Community receive a documentary, identity and physical check under the responsibility of the Official Veterinary Surgeon (OVS) before being cleared for free circulation in the Community. The list of products that require veterinary checks is laid down in Commission Decision 2007/275 (DEFRA, 2009). Honey is classed as a Category II commodity which means that 100% of consignments have documentary and identity checks and physical checks are carried out on not less than 50% of consignments. Propolis is also checked as honey (DEFRA, 2009). Other apiculture products are classed as Category III, which means that 100% of consignments have documentary and identity checks. Physical checks are made on not less than 1% and not more than 10% of consignments (DEFRA, 2009). Apiculture products includes pollen. Commission regulation 829/2007 amended the by-products legislation to also require beeswax for technical use to be checked on entry (DEFRA, 2009). Beeswax for technical use must be refined or rendered prior to importation. The importation of unprocessed beeswax in the form of honeycomb is completely banned by Commission regulation 829/2007 (DEFRA, 2007). **EU imports:** Products from other EU countries do not require checks (DEFRA, 2009). Additional uncertainty lies in the unknown factor of illicit trade in regulated products – and if such a trade exists.
27 - How likely is the organism to multiply/increase in	Unlikely High level of	Very little information to support an answer here, in particular length of time during transport is unknown.

prevalence during transport /storage?	certainty	
28 - How likely is the organism to survive existing management practices within the pathway?	Unlikely from third countries Moderate level of uncertainty Likely from the EU Low level of uncertainty	There are no known management practices currently applied to this pathway, other than the inspections on third country imports discussed in 26. There are no known management practices in place on the pathway from EU Member States. The OIE has recommendations that for the importation of honey bee collected pollen and honeycomb, that the products should either be from a country or zone free from *A. tumida* infestation and contain no live bees or brood, or contain no live bees or brood and have been thoroughly cleaned and treated to ensure destruction of *A. tumida*. The treatment recommended is that the product be subject to a temperature of -12°C or lower in the core of the product for at least 24 hours (OIE, 2009). It is not known if this could be potentially implemented should an outbreak of small hive beetle occur in the EU. It is unclear if there is illicit trade in any of the regulated products.
29 - How likely is the organism to arrive during the months of the year most appropriate for establishment?	Very Likely Low level of uncertainty	Potentially there is year round trade in honey and beeswax into the UK from countries where small hive beetle is known to be present (Eurostat, 2010: data on the imports of natural honey and rendered beeswax from third countries).
30 - How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	Unlikely High level of uncertainty	There is little information on what happens to the honey and beeswax commodities once they enter the UK, which leads to the uncertainty on the likelihood of transfer to a suitable host. Most wax entering the UK goes to British Wax, which are now the only wax refiners in the UK. Approximately 130-150 tonnes are imported per year as rendered (melted, but not cleaned) blocks. The wax is used to make a range of refined products for many industries, including cosmetics (British Wax, pers. comm.). How long the potentially infested imported wax sits around before processing is unknown, but it is unlikely to be all processed immediately. If stored in a warehouse the small hive beetle is unlikely to be able to transfer to suitable hosts, but whether it may find a way outside is unknown. If wax is stored outside prior to processing then transfer is more likely. Drums of honey may also potentially be left prior to processing.

		There is no information on the movement of honeycomb or potentially unrendered wax which may be brought in from the EU.
31 - Do other pathways need to be considered?	Yes	
22 - Please select the pathway:	**4.**	**Soil or compost associated with plant trade from third countries. Soil from the EU and Mediterranean countries.** **Other plant material is excluded as a pathway as data suggests that less than 2% of small hive beetle will survive on blooming pot plants, with no reproduction recorded, suggesting that flowers are unlikely to serve as alternative food and breeding substrate (Buchholz *et al.*, 2008).**
PATHWAY 4.		
23 - How likely is it that the organism is strongly associated with the pathway at the point(s) of origin?	Moderately Likely High level of uncertainty	Pupation occurs in the soil, in 80% of cases at a depth of no more than 10cm (Pettis & Shimanuki, 2000; Frake & Tubbs, 2009). Beetles tend to pupate close to the hive, however they are known to travel some distances to find a sandy substrate in which to pupate (Pettis & Shimanuki, 2000). Larvae are capable of crawling over 200m in search of suitable pupation substrate (Somerville, 2003). Soil may have been the primary mode of introduction of this pest to Australia (White, 2004). Plant imports are likely to come from nurseries not associated with bee hives. It is possible that some fruit trees, e.g. specialist varieties, may come from orchards that use managed pollinators – but such numbers are likely to be very small. Soil imports from countries other than continental Europe (with the exception of Turkey, Belarus, Moldavia, Russia and the Ukraine) and the Mediterranean countries of Egypt, Israel, Libya, Morocco and Tunisia respectively, are prohibited by all member states. Soil imports from within the EU and from the named Mediterranean countries, are permitted (Plant Health Directive 2000/29/EC, 2009). Imports of soil from Egypt would be of most current concern as the small hive beetle is known to be present here. How likely the small hive beetle is to be associated with such imports is unknown.
24 - How likely is it that large numbers of the organism will travel along this	Unlikely High level of uncertainty	How much soil is imported with plants may depend on the size of the plant – what is essential to sustain the vitality of the plants may vary. How much soil is imported from the EU and the named Mediterranean countries (see 23) is unknown.

pathway from the point(s) of origin?		
25 - How likely is the organism to survive during transport or storage within the pathway?	Very Likely Low level of uncertainty	Small hive beetle will stay within the soil for between 15 – 60 days (Steadman, 2006).
26 - How likely is the organism to enter the Risk Assessment Area undetected?	Unlikely from third countries (except named Mediterranean countries) Medium level of uncertainty Likely from the EU and named Mediterranean countries Low level of uncertainty	Current legislation makes this pathway easier to discuss in terms of EU and Mediterranean countries and other third countries **Third country imports**: Soil and growing media containing soil is prohibited from third countries outside continental Europe, other than from Egypt, Israel, Libya, Morocco and Tunisia (Plant Health Directive 2000/29/EC, 2009). The exception to this is soil intended to sustain the vitality of the plants. In these cases there is a requirement for documentation that the growing medium is free from insects and harmful nematodes and have been subjected to appropriate examination, heat treatment or fumigation and that appropriate measures have been taken to ensure it has been maintained free from harmful organisms (Plant Health Directive 2000/29/EC, 2009). Plant material from third countries will be inspected on entry into the UK, although it is not possible to inspect every plant. **EU and Mediterranean imports:** There are no such restrictions on the movement of soil within the EU or from Egypt, Israel, Libya, Morocco and Tunisia.
27 - How likely is the organism to multiply/increase in prevalence during transport /storage?	Very Unlikely Low level of uncertainty	Not the appropriate life stage being transported for multiplication.
28 - How likely is the organism to survive existing management practices within the pathway?	Unlikely from third countries (except named Mediterranean countries) Medium level of	**Third country imports:** Freedom from this pest will not be specified on the documentation coming in with the plants. Inspections could potentially pick it up, but there is no guarantee, soil associated with plants can be difficult to inspect. However where heat treatment or fumigation is used this is likely to kill the pest. **EU imports:**

	uncertainty Likely from the EU and named Mediterranean countries Low level of uncertainty	There are no such restrictions on the movement of soil within the EU or from Egypt, Israel, Libya, Morocco and Tunisia.
29 - How likely is the organism to arrive during the months of the year most appropriate for establishment?	Likely Low level of uncertainty	Could arrive at any time of year. Plants may be planted out, or potted up on nurseries and kept under cover. Soil may potentially be brought in at any time.
30 - How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	Moderately Likely Medium level of uncertainty	Depends to some extent on the type of plants which have been imported and where they will be planted – in nurseries or outside, or if the planting will be in areas where bee pollinators are regularly used, such as some glasshouses, or orchards. However when the beetle emerges it will be able to fly some distance to find a host. Transfer is therefore more likely if the plants are planted outside and the beetles are not confined on emergence. For imports of soil itself transfer to a suitable host would depend on how soon the soil was used outside. If stored for some time this may limit the small hive beetles ability to transfer to a suitable host.
31 - Do other pathways need to be considered?	Yes	
22 - Please select the pathway:	**5.**	**Fruit imports – in particular kei apples (Ellis, 2002), banana, avocado, melon, pineapple, mango, grapes, grapefruit (Eischen *et al*., 1999; Buchholz *et al*., 2008).**
PATHWAY 5.		
23 - How likely is it that the organism is strongly associated with the pathway at	Unlikely Medium level of uncertainty	The small hive beetle is most likely to be associated with rotting fruit. Oviposition could occur and larvae could potentially be inside the fruit. Laboratory studies have shown *A. tumida* to be associated with and reproduce on some types of fruit, but it is unclear how much this occurs in the field. There has been some evidence of adults feeding on fruit (Buchholz *et al*., 2008) and over 500 beetles were observed in one cantaloupe melon (Eischen *et al.*, 1999).

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?	Very Unlikely Low level of uncertainty	Large numbers are not expected to be associated with this pathway as heavily infested, rotting fruit would be noticed and rejected. Known fruit hosts are imported regularly from countries where *A. tumida* is known (Eurostat, 2010).
25 - How likely is the organism to survive during transport or storage within the pathway?	Likely High level of uncertainty	Larvae inside fruit are likely to be quite well protected. May also be other pests on the fruit to supplement their diet e.g. fruit flies.
26 - How likely is the organism to enter the Risk Assessment Area undetected?	Unlikely Medium level of uncertainty	Rotting and damaged fruit is likely to be removed from consignments, at port of origin or on entry into the UK. Not clear what would happen to the fruit if detected on entry – assume destruction.
27 - How likely is the organism to multiply/increase in prevalence during transport /storage?	Very Unlikely Low level of uncertainty	Not the appropriate life stage being transported for multiplication – eggs and larvae most likely stages to be associated.
28 - How likely is the organism to survive existing management practices within the pathway?	Unlikely Moderate level of uncertainty	Fruit being imported may be chilled during transport. In the short term it is hypothesized that this probably would not harm any small hive beetle eggs or larvae associated with the commodity, but further research on temperature extremes at which different lifestages can survive would be valuable. Ripening chemicals or insecticides applied may affect the survival, but it is unknown how often and on what fruit commodities these would be used. PHSI Inspections may also pick up damaged / infested fruit – though this is less likely if the fruit came from the EU, either cleared elsewhere or if the pest was present in the EU.
29 - How likely is the organism to arrive during the months of the year	Likely Low level of uncertainty	Could potentially arrive all year round- known fruit hosts are imported to the UK throughout the year from countries known to have small hive beetle (re-Fresh Directory, 2009; Eurostat, 2010).

most appropriate for establishment?		
30 - How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	Unlikely Medium level of uncertainty	The life stage being imported with the fruit is likely to be larvae. These will need to find somewhere to pupate for the lifecycle to continue. If rotting fruit found at entry or commercially is destroyed there is little possibility of this. Rejected fruit which is thrown onto landfill or rotting fruit thrown into garden compost is most likely to provide a situation in which the beetle is then able to pupate. The adult could then emerge and potentially find suitable hosts. Whether infested fruit, given that it is apparently rotting to start with, would make it this far down the pathway is unclear.
31 - Do other pathways need to be considered?	Yes	
22 - Please select the pathway:	**6.**	**Carried inadvertently on beekeeping clothing / equipment** - such as PPE (Personal Protective Equipment) e.g. veils and suits, footwear, gloves; wooden hives, plastic hives, hive tools, smoker etc. Also included may be vehicles / machinery used by beekeepers and then brought into the UK.
PATHWAY 6.		
23 - How likely is it that the organism is strongly associated with the pathway at the point(s) of origin?	Moderately Likely from third countries Medium level of uncertainty Very Likely from the EU Medium level of uncertainty	Any beekeeping equipment used in an area where small hive beetles are known to be present could potentially be contaminated with the pest. The greatest risk of association is with hives themselves, which if not cleaned properly could harbour large numbers of eggs or even larvae and adults. It is thought unlikely that wooden hives would be entering the UK from third countries which have the small hive beetle (NBU, pers. comm.) due to the practicalities of transporting such large items by air. For clothing the greatest risk of association is probably that of an adult beetle, or infested debris from cleaning hives, trapped within the folds of the clothing (NBU, pers comm.). Vehicles / machinery used in an area where the small hive beetle is present may potentially carry the pest as a hitchhiker or in soil attached to the vehicle / machinery. Vehicles used by beekeepers themselves in close association with the hives and then brought into the UK would pose the greatest risk. The likelihood of this from third countries is believed to be low, but much higher if the pest is present in the EU.
24 - How likely is it that large numbers of the organism will	Unlikely Medium level of	Large numbers of small hive beetles inadvertently associated with equipment, clothing or machinery would be noticed. The greatest risk would be of numbers of eggs associated with hives.

travel along this pathway from the point(s) of origin?	uncertainty	It is unknown how large the volume of trade in hive equipment and protective clothing into the UK is, but it is known that beekeepers (including members of the NBU) go over to other EU Member States to work and would take their own equipment, clothing and vehicles with them and back (NBU, pers. comm.).
25 - How likely is the organism to survive during transport or storage within the pathway?	Moderately Likely Medium level of uncertainty	This would be highly dependent on the length of time the equipment, clothing or machinery was in transit or in storage and the life stage associated with it. Also whether there is anything on which the small hive beetle may be able to feed associated with the commodity, such as remaining pollen, honey or wax, which would affect the likelihood of survival. Eggs hatch after 3- 6 days (Lundie, 1940). Wandering larvae have been shown to survive for up to 48 days without feeding (Cuthbertson *et al.*, 2008), but in order to pupate the small hive beetle needs access to the soil. Pupae may be inadvertently picked up in soil by vehicles or machinery, but it is unclear whether they would be able to survive for long. Adults may survive for up to nine days without food or water (Ellis *et al*., 2002).
26 - How likely is the organism to enter the Risk Assessment Area undetected?	Very Likely Low level of uncertainty	There is no regulation on the movement of hive equipment or personal protective clothing into the UK, from third countries or the EU. No checks on such commodities are therefore made. Detection of hitchhikers on vehicles or machinery is also unlikely.
27 - How likely is the organism to multiply/increase in prevalence during transport /storage?	Very Unlikely Low level of uncertainty	The small hive beetle would be unable to complete its lifecycle on this pathway.
28 - How likely is the organism to survive existing management practices within the pathway?	Very Likely Low level of uncertainty	There are no existing management practices on this pathway. The OIE recommends that used beekeeping equipment should either come from a country or zone free from *A. tumida* infestation and contain no live honey bees or brood or contain no live honey bees or brood and have been thoroughly cleaned and treated to ensure the destruction of *A. tumida*. Also that all precautions should have been taken to avoid contamination. None of these recommendations are currently implemented.
29 - How likely is the organism to arrive during the months of the year most appropriate for establishment?	Very Likely Low level of uncertainty	Imports / movements could potentially occur at any time of year.
30 - How likely is the organism to be	Likely	Transfer to suitable host is likely as the beekeeping equipment will be used near bee hives or bee stores where equipment is kept overwinter and in which adults and possibly larvae would be able to survive for a period, due to

able to transfer from the pathway to a suitable habitat or host?	Low level of uncertainty	the presence of potential food sources (NBU, pers. comm.). Hitchhikers on vehicles or machinery could potentially leave the carrier at any stage.
31 - Do other pathways need to be considered?	Yes	
22 - Please select the pathway:	**7.**	**Freight containers and transport vehicles themselves.**
PATHWAY 7.		
23 - How likely is it that the organism is strongly associated with the pathway at the point(s) of origin?	Unlikely Medium level of uncertainty	Potential with this pathway is for association as a hitchhiker. Hood (2000), reported that the small hive beetle may have arrived in the USA aboard ships carrying common commodities from Africa. A factsheet produced by the North Carolina State University (Tarpy, 2007) states that there have been records of African honey bees hitchhiking as swarms on ships and bee swarms have also occasionally been picked up on ships arriving in the UK (NBU, pers. comm.). It is possible, therefore, that small hive beetle could also be associated with hosts transported by freight.
24 - How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin?	Unlikely Medium level of uncertainty	It is considered unlikely that large numbers of the organism will travel along this pathway, but there is no information on this.
25 - How likely is the organism to survive during transport or storage within the pathway?	Very Likely Low level of uncertainty	Adults beetles have been shown to survive for up to 9 days without food or water (Ellis, *et al*., 2002). Wandering larvae have been shown to survive for at least 48 days without food and water (Cuthbertson *et al*., 2008). In addition Nitidulid beetles are scavengers and *A. tumida* may be able to adapt to food sources on-board, although, if the beetles are travelling in association with a swarm of host they may have adequate food available. Transport from the EU is likely to be more rapid than from third countries which would increase the chance of survival.
26 - How likely is the organism to enter	Likely	Freight containers and the vehicle transporting them are not checked for hitchhikers of this beetle. Swarms of bees “stowing away” may be more easily detectable and have been destroyed in the past (Tarpy, 2007).

the Risk Assessment Area undetected?	Low level of uncertainty	
27 - How likely is the organism to multiply/increase in prevalence during transport /storage?	Very Unlikely unless travelling with hosts Low level of uncertainty Unlikely even with hosts Moderate level of uncertainty	In most cases no suitable hosts for small hive beetle reproduction will be present. Where suitable hosts may be found, reproduction may not be possible due to a lack of suitable areas to lay eggs and for larvae to develop. Reproduction will also be constrained by the time period of transport – by plane or train multiplication will be less likely than if transporting by ship.
28 - How likely is the organism to survive existing management practices within the pathway?	Very Likely Low level of uncertainty	There are no known consistently used management practices on this pathway. Some containers may be fumigated during transport, depending on the consignment, but there is no data on this.
29 - How likely is the organism to arrive during the months of the year most appropriate for establishment?	Very Likely Low level of uncertainty	Could potentially arrive at any time of year, depending on origin.
30 - How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	Moderately likely High level of uncertainty	Transfer to a suitable host would depend on the commodities and their destination. The small hive beetle could potentially fly off a ship or plane on landing and find a suitable host bee colony. If travelling with a swarm could leave the pathway with suitable hosts.
31 - Do other pathways need to be considered?	Yes	

22 - Please select the pathway:	**8.**	**Natural spread of pest itself by flight, on its own or possibly in association with a host swarm. Neither of these is possible from third countries so this pathway is for the scenario that *A. tumida* is present in the EU.**
PATHWAY 8.		
23 - How likely is it that the organism is strongly associated with the pathway at the point(s) of origin?	Likely High level of uncertainty	**If *A.tumida* were present in the EU:** In particular if present in a country just across the English Channel or North Sea, it is possible that the small hive beetle could be associated with a bee swarm which came across to the UK and possible that with appropriate weather conditions and the help from crossing shipping *A. tumida* itself could fly over. There have been reports of sightings of small hive beetles flying along behind swarms (Lundie, 1940; Ellis *et al.*, 2003). It is unknown whether there are any records of European honey bees crossing from continental Europe to the UK.
24 - How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin?	Unlikely Low level of uncertainty	**If *A.tumida* were present in the EU:** It is unlikely that *Apis mellifera* (European honey bee) swarms would cross the channel to the UK in a single flight. However there are reports of certain honey bee species forming swarms on ships and hitchhiking to countries outside their normal range (Tarpy, 2007). It is also uncertain how far the small hive beetle itself could fly without some aid from crossing shipping.
25 - How likely is the organism to survive during transport or storage within the pathway?	Moderately Likely High level of uncertainty	**If *A.tumida* were present in the EU:** There is no data on the likelihood of the small hive beetle surviving the flight and completing the journey.
26 - How likely is the organism to enter the Risk Assessment Area undetected?	Very Likely Low level of uncertainty	**If *A.tumida* were present in the EU:** Flying overhead – even if with a swarm of bees - the small hive beetle would probably not be detected.
27 - How likely is the organism to multiply/increase in prevalence during transport /storage?	Very Unlikely Low level of uncertainty	**If *A.tumida* were present in the EU:** More likely to decrease – due to individuals dying on the journey.
28 - How likely is the organism to survive existing	Very Likely Low level of	**If *A.tumida* were present in the EU:** No suitable management of this pathway

management practices within the pathway?	uncertainty	
29 - How likely is the organism to arrive during the months of the year most appropriate for establishment?	Very Likely Low level of uncertainty	**If *A.tumida* were present in the EU:** When bees and beetles are flying in other areas of the EU (especially the most risky area of north western EU) it will also be the bee season in the UK.
30 - How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	Very Likely Low level of uncertainty	**If *A.tumida* were present in the EU:** Beetles are able to detect the presence of hives over distance of several km (Wenning, 2001). If associated with a swarm the beetles are already with suitable hosts.
31 - Do other pathways need to be considered?	NO	
END LEVEL		
32 - Please estimate the overall likelihood of entry into the Risk Assessment Area for this organism (please comment on the key issues that lead to this conclusion).	Moderately Likely to enter – High uncertainty from third countries Likely to enter – Moderate uncertainty if established in EU.	1. **Movement of honey bees: queens and packaged (worker) bees for the purposes of trade** - Likely to be associated with pathway – but the pathway is already regulated for EU and third country imports. Risk is through illegal imports or legislation not being followed. Imports from the EU are less thoroughly checked and this poses a greater risk. 2. **Movement of alternative hosts e.g. bumble bees for pollination purposes** - Unlikely to be associated with pathway – pathway is already regulated and the species being moved are not known hosts. However, while imports must have a health certificate, inspections are not made on bumble bees entering the UK in the same way as for honey bees. There is additional risk through illegal imports, especially if alternative known host species were imported. 3. **Trade in hive products – specifically rendered beeswax and honey post extraction in drums from both third country and EU origin and honeycomb and any other unprocessed wax products from the EU** – Association with such products is likely, although survival is less certain. All consignments from third countries require documentary and a proportion of physical checks. Consignments from the EU are a greater

		risk as no checks are performed. 4. **Soil or compost associated with plant trade from third countries and the EU. Soil from the EU and Mediterranean countries** – regulated pathway and therefore low chance of association from third countries outside the Mediterranean. No restrictions on EU or Mediterranean imports. Illicit trade and soil from Egypt pose the greatest risk. 5. **Fruit imports – in particular avocado, bananas, grapes, grapefruit, kei apples, mango, melons and pineapples** – weak association with pathway. Association in the field not proven. PHSI inspections may pick up the larvae within fruit entering EU. If the pest was present within the EU infected fruit would be less likely to be picked up by official inspection. 6. **Movement on beekeeping clothing / equipment** – There is high uncertainty as to trade or transport of beekeeping equipment from third countries, but association of the pest is possible. Of much greater risk is the movement of equipment from the EU. 7. **Freight containers and transport vehicles themselves** – weak association, but evidence suggests this is how the pest reached the USA and there may be the possibility of association with host swarms during transport. Therefore feasible pathway though very little information on it. Likely to be a higher risk if present in EU due to rapid train and ferry links. 8. **Natural spread of pest itself by flight, on its own or possibly in association with a host swarm** – relevant only if present in EU – very unlikely but could happen. Insufficient information on flight capability, both of European honey bee and the small hive beetle.
ESTABLISHMENT		
33 - How likely is it that the climatic conditions that would affect establishment in the Risk Assessment Area are similar to those in the area of the organism's current distribution?	Likely Medium level of uncertainty	The development of the small hive beetle is known to be affected by temperature (Schmolke, 1974). At 34°C, de Guzman & Frake (2007) observed a total development time of 23 days. At a range of 18–25°C the length of developmental cycle has been reported to be 41.32 ± 1.34 days (Mürrle & Neumann, 2004) and at 17–24°C, 49 ± 0.11 days (Neumann *et al.*, 2001). Finally, Lundie (1940) described development periods of about 80 days at unreported temperatures. Cuthbertson *et al*. (2008) observed viable adult emergence after 84 days in temperatures ranging from 20-30°C. This confirms that changes in temperature can make significant impacts on small hive beetle abundance, with development being slower at lower temperatures (de Guzman & Frake, 2007). Therefore, the evidence suggests that temperature does affect the development of the small hive beetle, with lower temperatures indicating that development will be slower. In Canada it has been shown that they can reproduce, but there is no evidence that they have been able to overwinter. It is speculated

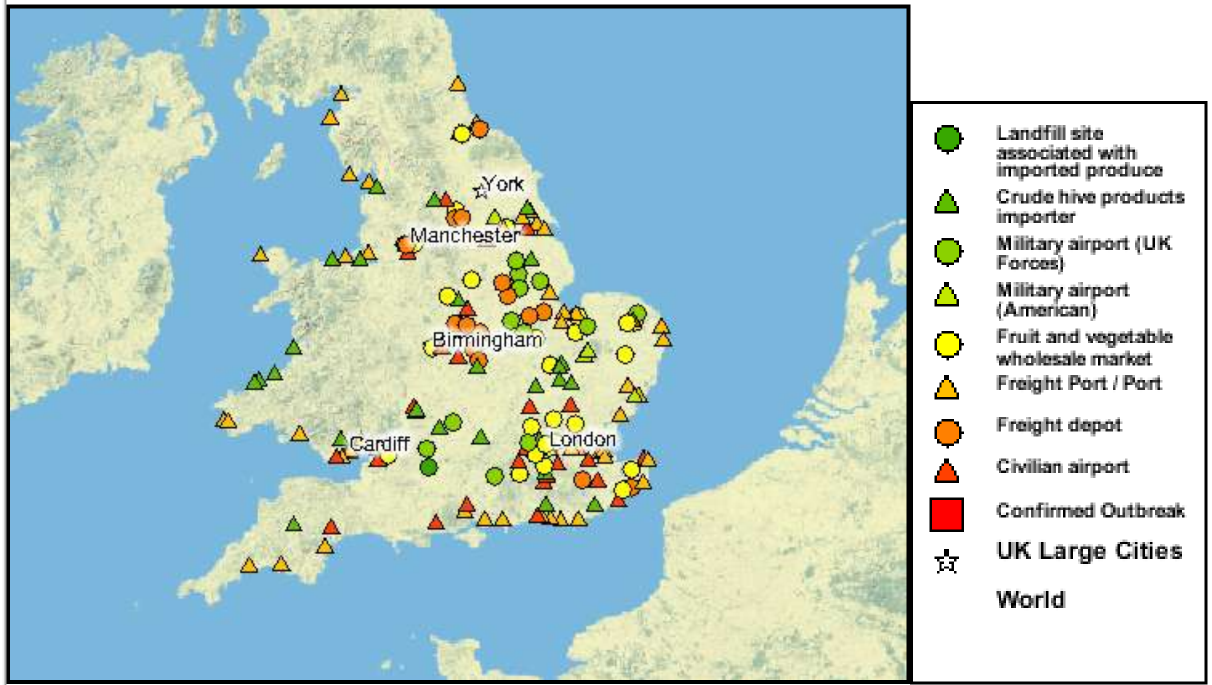
		that this may be due to temperatures in the soil. However the extremes for survival are unknown. The evidence suggests that temperatures within the UK would be suitable for establishment of this pest in England and Wales, particularly the further south, but may be less suitable for establishment further north and into Scotland. It is important to consider the climate outside the hive and also that within the hive – bee hives are designed to maintain relatively constant temperatures within the colony and bees regulate the temperature themselves. A high mortality of small hive beetles in the winter is likely unless they can get within the bee cluster (Schäfer *et al.*, 2010).
34 - How likely are other abiotic factors that would affect establishment in the Risk Assessment Area and in the area of current distribution to be similar?	Likely Low level of uncertainty	Small hive beetles spend >75% of their developmental time in the soil (de Guzman & Frake, 2007). Therefore, environmental factors such as soil type, soil moisture, soil density, field slope, drainage, rainfall, temperature greatly affect their biology (Frake & Tubbs, 2009). Young pupae are mostly affected by soil moisture rather than soil type, which appears to have little effect on pupation survivability (Ellis, 2004). Frake and Tubbs (2009) found more beetles to survive in areas that were predominantly silty clay and silty clay loam compared to most sandy loam and loam soil areas. Dryer soils would seem to impede pupation success rates, however, Frake and Tubbs (2009) concluded that beetle pupation could occur in any soil type. Ellis (2004) concluded that pupation rates ranged from 92–98% in various soil types provided the soil was moist. This implies that beetle pest problems can be expected regardless of soil type in areas where soil moisture remains high during the year. Therefore, soil moisture appears to be a major limiting factor in beetle reproduction thus population build-up. This may partly explain why small hive beetles are not a major problem in honey bee colonies in sub-Saharan Africa, as much of Africa (except equatorial Africa) is semi-arid to arid (Ellis, 2004) It may also help explain why in Australia it is the coastal areas, rather than the dry interiors, where beetle populations do the most damage. The dryer soil conditions would be expected to have a negative effect on beetle pupation rates (Ellis, 2004). Frake and Tubbs (2009) also observed that the majority of beetles reproduce in the first 10 cm of soil (mostly under the surface), only a few at 20cm and none at 30cm. These observations on soil depth agree with those of Pettis and Shimanuki (2000) and Schmolke (1974) indicating that most beetles pupate at <10cm or below the soil surface. This preference of the uppermost layer for beetle pupation was probably due to the presence of decaying litter or loose organic materials that are easy for larvae to burrow into as well as adults to emerge from (Frake & Tubbs, 2009). Soil density was found to affect pupation rates also with high density soils having a negative effect on pupation rates (Schmolke, 1974). Possible affect of soil temperature on pupation success has not been investigated. Pupae are vulnerable to adverse weather conditions, soil

		borne fungal infection, nematodes and soil cultivation. Egg hatching viability is affected by the relative humidity within the hive or colony (Somerville, 2003, Stedman, 2006). All the evidence suggests soil moisture may affect establishment, but conditions in the UK would not be expected to be dissimilar from other areas of the world where pest has established.
35 - How many species or suitable habitats vital for the survival, development and multiplication of the organism species are present in the Risk Assessment Area? Please specify in the comment box the species or habitats.	Few Low level of uncertainty	There are over 220 species of bee in Britain with varied biologies and habitats. By far the most numerous are *Apis mellifera* the European honey bee. In England and Wales there are in excess of 20, 000 registered beekeepers who together manage around 110,000 colonies (NBU, 2010) and it is estimated there may be many more who are not registered on BeeBase (NBU, pers. comm.). Thousands more managed colonies are found in Scotland (est. 20,000; NBU, pers. comm.) and Northern Ireland and colonies of feral bees are also believed to be present across the UK (Thompson *et al*., 2010). Bumble bees and solitary bees are also present in the UK and these may or may not be alternative hosts. The only proven alternative host is *B. impatiens* which is not present in the UK. However there is evidence that the small hive beetle may infest *Bombus spp.* (Stanghellini *et al.*, 2000; Ambrose *et al*., 2000; Hoffman *et al*., 2008). OIE, 2009 states that small hive beetle may also parasitise *B. terrestris* under experimental conditions. It is unknown if the beetle would develop on rotting fruit found in the UK. The UK does not grow known fruit preferences.
36 - How widespread are the species or suitable habitats necessary for the survival, development and multiplication of the organism in the Risk Assessment Area?	Widepread Low level of uncertainty	80% of managed *Apis mellifera* are found in England, the rest being in Wales, Northern Ireland and Scotland (NBU, 2010). *Bombus spp*. may be found all over the UK (Edwards & Jenner, 2009).
37 - If the organism requires another species for critical	None other than bee hosts mentioned	

stages in its life cycle then how likely is the organism to become associated with such species in the Risk Assessment Area?		
38 - How likely is it that establishment will occur despite competition from existing species in the Risk Assessment Area?	Very Likely Low level of uncertainty	No known competitors
39 - How likely is it that establishment will occur despite predators, parasites or pathogens already present in the Risk Assessment Area?	Likely Medium level of uncertainty	There are no known natural predators, other than possibly birds eating larvae moving across the ground to pupate. Small hive beetles are vulnerable to soil borne fungal infections and nematodes (Ellis *et al*. 2004; Ellis *et al.*, 2010). *Aspergillus niger* is a soil borne fungi widely found in the UK which has been documented to infect the small hive beetle pupal stage when the larvae have burrowed into soil for pupation (Richards *et al*., 2005; PHIW, 2010). Cabanillas and Elzen (2006) investigated the susceptibility of wandering larvae to commercially available entomopathogenic nematodes and found larvae to be susceptible to *Steinernema carpocapsae, S. riobrave* and *Heterorhabiditis megidis*. *Steinernema spp.* are commonly found in Britain, including in the colder soils of northern and upland areas, although it has not been found documented whether either of the two species known to affect the small hive beetle have been found (Gwynn & Richardson, 1996). *Heterorhabiditis megidis* is present in the UK (Ansari, *et al.*, 2008). The presence of entomopathogenic fungi and nematodes in the UK suggests that the small hive beetle may be affected by parasites or pathogens present in the soil, but how great an effect this would have on establishment is unclear.
40 - How likely are management practices in the Risk Assessment Area to favour establishment?	Likely Low level of uncertainty	How beekeepers keep their bees in the UK is unregulated. Most beekeepers are “hobbyist”, with one or two hives, rather than commercial scale beekeepers and the culture of beekeeping is fairly informal (NBU, pers. comm.). Informal exchange of beekeeping tools between beekeepers will facilitate the spread of pests like the small hive beetle and individual husbandry practices (poor hive hygiene) could favour establishment. Beekeepers not registered on BeeBase (and there is no obligation to be) will not be included in existing bee health surveillance programmes, posing a risk that small hive beetle could establish undetected. Additionally unregistered beekeepers may not have access to training materials to alert

		them to the danger of this pest if they did detect it.
41 - How likely is it that existing control or management measures will fail to prevent establishment of the organism?	Likely Low level of uncertainty	The National Bee Unit conduct exotic pest surveys – although these will only be on registered apiaries. **Existing Surveillance for *A. tumida* in the UK** The current Apiary Inspection Programme undertaken by the NBU for England and Wales includes an element of Exotic Pest Surveillance (EPS), specifically designed to monitor for the arrival of exotic threats, such as *A. tumida*, and *Tropilaelaps* mites. EPS focuses on “at risk apiaries” (ARAs), which are located at sites considered to be particularly vulnerable to exotic pest incursion. Search patterns and prioritisation for routine surveillance of ARAs for SHB are coordinated by the Regional Bee Inspectors, each of whom has overall responsibility for one of the eight areas located across England and Wales. ARAs are identified by BeeBase and the GIS system, and include apiaries that satisfy one or more of the following criteria: Apiaries within 5km of seaports Apiaries within 5km of airports, including military airfields Apiaries within 5km of freight depots Apiaries within 5km of container and cargo yards Apiaries owned by queen importers

Fig. 2: The map below illustrates the distribution of ARAs in England and Wales



Individual routine inspection of honey bee colonies for *A. tumida* is carried out by Appointed Bee Inspectors, as outlined in SOP NBU/135 (The detection of the Small Hive Beetle (*Aethina tumida*)) and SOP NBU/082 (Organising and arranging visits to beekeepers) (NBU, 2010). Beekeepers who maintain ARAs are made aware of their status, and their need for extra vigilance. It is the

		responsibility of the Head of the NBU to agree the extent, duration and targets for small hive beetle searches in England and Wales (i.e. the number of ARAs to be visited, and the number of hives to be sampled at each one). In a typical year, between 5% and 7% of apiary visits made by Appointed Inspectors are for the purposes of EPS. The NBU is currently (in spring 2010) revising its annual target for the desired level of EPS to in excess of 7.5% (equivalent to ~780 EPS inspections/annum). In addition to routine EPS, the inspectorate will also visit an additional number of "sentinel" apiaries (15/region = 120 total). Sentinel apiaries will add to existing awareness of exotic pest threats. They will be sampled bi-annually, from risk and random areas. Note. The NBU has a nominated Contingency Planning Officer, who coordinates Pests Emergency Exercises, to train Inspectors in what to do in the event of incursion by small hive beetle. Current management methods are thorough for those beekeepers registered on BeeBase. However, the presence in the UK of unregistered beekeepers means that despite this monitoring and measures the small hive beetle could still establish without detection in the UK. Chemical control within bee hives is carefully controlled due to the potential effect on the bees themselves. This may be a particular problem with the small hive beetle as several lifestages are closely associated with the bee hives and will restrict the chemicals available to control this pest if found.
42 - How likely is it that the organism could survive eradication campaigns in the Risk Assessment Area?	Likely could eradicate if found early. Unlikely if found after established for number of years. Low level of uncertainty	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 (Hood, 2004) and in Australia it is believed to have been present for at least twelve months prior to identification (White, 2004). Experience in Portugal and Mexico shows that swift intervention can result in eradication. In Portugal this involved the destruction of colonies and hives, the removal and deep burial of soil and treatment with permethrin soil drenches (Murilhas, 2005). Currently none of the chemical treatments that could be used for treatment are registered for this use in the UK, including the permethrin soil drenches used in Portugal. Control measures and veterinary products known to be effective against small hive beetle in other countries will be considered and adopted, provided they are appropriate, safe and approved by the veterinary medicines directorate (VMD) or chemical regulations directorate (CRD). In the absence of any authorised products approval must be sought from the VMD to apply emergency treatments. The

		VMD has recently launched an action plan to facilitate licensing of new honeybee medicines, including those already authorised in other EU Member States (Parliamentary Office of Science and Technology, 2010), although there is a general decline in the number of broad spectrum chemicals available for use. It would be possible to import organophospahtes like Checkmite +, which is used in the USA for small hive beetle control and contains the active ingredient coumaphos, via a Special Import Licence (NBU, pers. comm.). Alternative methods are being researched, including the use of biological control agents such as entomopathogenic fungi and entomopathogenic nematodes. However, these are still at the research stage and are not currently registered for use in any country. Biological control agents that are registered in the UK for other uses are currently being assessed for the ability to control the small hive beetle under a Defra funded project. Good hygiene and husbandry practices are likely to be important in the control of this pest.
43 - How likely is the establishment to be aided by the biological characteristics of the species?	Very likely Low level of uncertainty	The small hive beetle may have 1-6 generations per year, depending on environmental conditions (Somerville, 2003). Small hive beetles are sexually mature at about one week following emergence from the soil (Ellis, 2004). Adult females will oviposit directly on pollen or brood comb if unhindered by worker bees. Schmolke (1974) estimated that female beetles may potentially lay up to 1000 eggs in their lifetime although other estimates range up to 2000 eggs (Somerville, 2003). Small hive beetle eggs are normally laid in clusters of between 10 and 30 plus in number (Stedman, 2006). Female beetles lay eggs in cracks and crevices around the periphery of the inside of a highly populated bee colony, but they will lay eggs in the brood area if unhindered by adult bees. Most beetle eggs hatch in about three days but the incubation period can continue for up to six days (Lundie, 1940). The larval period lasts an average 13.3 days inside the bee colony and three more days in the soil. Eischen *et al.* (1999) reported beetle larvae completing maturity in 5–6 days under favourable conditions. The length of mature larvae is variable with smaller larvae maturing slower and reaching less length on poorer diets (Lundie, 1940). Once larval feeding is complete, mature larvae enter a wandering phase. These larvae are attracted by light, migrating predominantly at dusk from colonies in search of suitable pupation substrate (Stedman, 2006). Wandering larvae have been recorded as being able to survive for up to 48 days without feeding and still develop into viable adults (Cuthbertson *et al.*, 2008). On exiting the colony, mature small hive beetle larvae enter the soil to pupate (Fore, 1999) where they reach the pupal stage, a process which lasts anywhere from eight days (Schmolke, 1974) until two

		months (Taber, 1999). Small hive beetles spend >75% of their developmental time in the soil (de Guzman & Frake, 2007). The number of generations per year and the small hive beetles habit of laying eggs in cracks and crevices whether they may be difficult to detect strongly aids the establishment of this species.
44 - How likely is establishment to be facilitated by the organism's capacity to spread?	Very likely Low level of uncertainty	Adult small hive beetles are strong fliers and are capable of flying several kilometres, with flights in excess of 10km possible (Somerville, 2003), which aids their natural spread. They are known to frequently migrate between colonies of the same apiary (Ellis *et al*., 2003) regardless of colony strength (Lundie, 1940).
45 - How likely is the organism to adapt to a changing environment?	Likely Low level of uncertainty	Given how quickly the small hive beetle reproduces it has the potential to be quite adaptable. The small hive beetles ability to survive experimentally on hosts which do not seem to be favoured in the field, such as fruit and *Bombus terrestris* (Neumann & Elzen, 2004; OIE, 2009), and its establishment outside of its native area also suggests the adaptability of this pest species. Within the host colony environmental changes are likely to be dampened and the small hive beetle is therefore less subject to these changes. However despite being introduced to Canada it does not seem to have overwintered here, suggesting that its adaptability to environmental conditions may have limits. Climate change could enable the beetle to complete its lifecycle further north than currently is believed possible.
46 - How likely is it that small, relatively genetically homogeneous populations could become established?	Unlikely Low level of uncertainty	Due to migration this pest is unlikely to stay in one place
47 - How likely is the organism to be recorded in protected conditions (such as glasshouses, aquaculture facilities, terraria, zoological gardens) in the Risk Assessment Area?	Moderately likely Medium level of uncertainty	*Aethina tumida* has been shown to invade colonies of the bumblebee, *Bombus impatiens*, in the field (Spiewok and Neumann, 2006) and in glasshouses (Hoffmann *et al*., 2008) in the USA. If *A. tumida* can have an association with *B. terrestris* populations under protection may be possible in the UK – but this association has only been documented under experimental conditions (OIE, 2009).
48 - How likely is it that the organism has established in	Unlikely Low level of	In the last five years the small hive beetle is not known to have established anywhere new. Other establishments outside its native area were earlier than this. There have been introductions e.g. to

new areas outside its original area of distribution within the past five years? (If possible, specify the instances in the comments box)	uncertainty	Mexico and Canada but the pest is not known to have established. This may be due to eradication campaigns (Mexico) or the inability of the pest to adapt to some conditions (Canada) (see question 45).
49 - If the organism does not establish, then how likely is it that transient populations will continue to occur?	Unlikely from third countries - moderate uncertainty Likely if established in northern EU – low level of uncertainty	If the first introduction allows the identification of a pathway which can be controlled this could potentially be blocked for future introductions – however if the status quo is maintained it could be argued that the pest could come back at any time. There is a greater risk if the pest becomes established in mainland northern Europe as the potential number of uncontrollable pathways is increased e.g. transport via the channel tunnel, shipping, trade and natural flight, and there is a greater chance of frequent introductions.
50 - Please estimate the overall likelihood of establishment (mention any key issues in the comment box)	**Likely** **Low level of uncertainty**	**Key issues:** **Suitable conditions: Unregistered beekeepers and a range of bad management practices could aid establishment.** **Eradication is only likely if the beetle is found quickly.**
51 - How rapidly is the organism liable to spread in the Risk Assessment Area by natural means? (The scoring is on a log scale below)	Likely Low level of uncertainty	Adult small hive beetles are strong fliers and are capable of flying several kilometres, with flights in excess of 10km being possible (Somerville, 2003). Wandering larvae can move up to 200m from hives to find a suitable place for pupation, which also aids their natural spread (Somerville, 2003). How far a small hive beetle could fly within a given time period is unknown.
52 - How rapidly is the organism liable to spread in the Risk Assessment Area by human assistance? (The scoring is on a log scale below)	Very likely Low level of uncertainty	Small hive beetles often hide on the bottom of cells, in hive debris, or in small cracks (Lundie, 1940; Schmolke, 1974; Neumann & Elzen, 2004). This tendency means its presence may be missed and movement of hives around the UK may spread the pest. In the USA it is not clear whether single or multiple introductions occurred, (Evans *et al*., 2000, 2003) but the rapid spread is likely to be as a result of movement of infested colonies / bees, migratory beekeeping and beekeeping equipment (Delaplane, 1998). Soil movement on farm machinery may also be a means of spread. Fruit growers may also move bee materials as well as beekeepers. Commercial fruit growers (apples) routinely hire and move hives of

		honey bees to ensure pollination. This would aid spread.
53 - Within the Risk Assessment Area, how difficult would it be to contain the organism? (The scoring is on a log scale below)	With some difficulty Low level of uncertainty	Non registered beekeepers may hinder the containment of small hive beetle spread as their locations are unknown. Containment will also depend on the lifestage present – adults will be harder to contain than perhaps larvae and pupae
54 - Based on the answers to questions on the potential for establishment and spread in the Risk Assessment Area, define the area endangered by the organism.		**Whole of UK is at risk.** **However there is uncertainty over the more northern areas being as suitable climatically for its establishment.**
55 - Please estimate overall potential for spread (using the comment box to indicate any key issues). (The scoring is on a log scale below)	**High potential**	**Due to the pests' ability to fly and the uncontrolled movement of beekeeping equipment around the UK.**

Assessment of potential impacts

Authors: Helen Anderson, Andy Cuthbertson, Gay Marris, Maureen Wakefield

56 - How great is the economic loss caused by the organism within its existing geographic range, including the cost of any current management?	Minimal in Africa. Only Major in Florida Overall Moderate Medium level of uncertainty – hard facts and figures difficult to come by	The small hive beetle, *Aethina tumida*, is native to sub-Saharan Africa, where it is a scavenger in honey bee colonies (Lundie, 1940; Schmolke, 1974). Although it is known to damage stored bee products (Lundie, 1940, Schmolke, 1974) and will reproduce in weak or stressed colonies, the species is regarded as a minor pest of little economic importance in its native area and, prior to 1998, very little research had been conducted and published for this species (Hood, 2004). The introduction to the USA, and consequent impact on bee colonies, has resulted in research into the biology and potential control methods. In the USA and Australia there are mixed reports as to the degree of damage caused by the small hive beetle in managed colonies. Damage is mainly caused by the larvae, which feed on honey, pollen and brood. The excrement from the larvae can cause the honey to ferment, rendering it unfit for human consumption. In hives with very heavy infestations, where larval feeding is extensive, the bees may abscond. A recent survey of beekeepers in Queensland has shown that the small hive beetle is causing more extensive damage than originally thought. The survey showed that more than 3000 hives had been lost to the pest across the state. The cost, including clean up, control and restoration was more than $400 per hive. In Florida the conditions appear to have been particularly conducive to the small hive beetle and its impact has been significant. In 1998, economic damage from beetle infestation and honey contamination cost the industry $3 million (US), with over 30,000 colonies lost (Neumann & Elzen, 2004). In others areas of the USA the impact appears to have been less severe, though there is no available data on the infestation levels required to cause economic damage.

57 - Considering the ecological conditions in the Risk Assessment Area, how serious is the direct negative economic effect of the organism likely to be, for example on crop yield and/or quality, livestock or fish health and production? (describe in the comment box)	Moderate High level of uncertainty	**Effects on crops of reduced pollinator numbers.** Honey bees are the major managed commercial pollinator outdoors in the UK and are known to be susceptible to this pest. Certain crops such as apples are heavily reliant on this type of commercial pollination, and without them, or a replacement pollinator, yields would be reduced. Crops under protection are also reliant on commercial pollination, however in this case *Bombus terrestris* are bought in as required so protected crops are less likely to be affected unless the production area for this species of bumble bee is actually infected. Specifically the subspecies imported for commercial use are: *Bombus terrestris terrestris* (B.t.t.) and *Bombus terrestris dalmatinus* (B.t.d.), neither of which is the native sub-species, though the use of this is being investigated. Most of the bumble bees are imported from the EU, not produced in the UK. *Bombus terrestris* is not a reported natural host for the small hive beetle. Commercially produced *Bombus terrestris* is also increasingly being used in open sided polytunnels or on out of doors fruits crops (NBU, 2010). **Effects on honey production** The yield in honey production is dependent on a healthy honey bee population and there can be large differences in production levels between a good year and bad (NBU, pers. comm.).
58 - How great a loss in producer profits, production costs, yields, etc, is the organism likely to cause in the Risk Assessment Area?	Moderate High level of uncertainty	**Effects on crops of reduced pollinator numbers.** If the UK were to suffer a total loss of pollinators (not just bees) the cost is estimated at £440 million per year, about 13% of the UK income from farming. Insect dependant crops can be pollinated by hand, but initial labour costs are prohibitive being estimated at £1500 million. Honey bees are generalists and contribute a significant part to the total number of pollinators (Parliamentary Office of Science and Technology, 2010). The effect on the apple industry in particular was examined and the increased labour costs could double the cost of an apple (Marris *et al*, in submission). **Effects on honey production** Honey production in the UK is typically worth between 10 and 35 million pounds a year and is dependent on a honey bee population being healthy. As well as losses due to loss of honey revenue there may also be replacement costs for a beekeeper if a hive is lost. Although the loss of pollinators, including bees, would have a significant cost to crop production in the UK, the threat to food security may be only moderate because key food crops such as cereals are wind pollinated. A reduction in pollinating bees would notably reduce the diversity of food available but not necessarily the quantity.

59 - How great a reduction in consumer demand is the organism likely to cause in the Risk Assessment Area?	Minimal Low level of uncertainty	
60 - How significant might the losses in export markets be due to the presence of the organism in the Risk Assessment Area?	Minor Medium uncertainty	**Export of bees** – this is a relatively minor market. However, in the event of an introduction of small hive beetle, there will be restrictions on the movement of bees. **Export of honey** – a larger market. In 2009 natural honey exports were worth over 10 million Euros to the UK economy (Eurostat, 2010). However the impact of the presence of the small hive beetle on this market may be minor – most products will be processed and low risk. **Export of fruit** – no limitations have been put on fruit movement from other countries with the small hive beetle and given that the link with fruit in the field is weak no effect on this market would be expected.
61 - How important might other economic costs be resulting from introduction of the organism? (specify in the comment box)	Major Low level of uncertainty	Costs are likely to be incurred from: research, advice, publicity, certification schemes, increased surveillance, multi-fold increases in existing inspectorate, eradication costs and training. Figures for these types of costs are very difficult to find even for pests which have already established in the UK, such as *Varroa destructor*, but are likely to be high. Beekeepers in the UK were noted to have difficulties adapting to the problems caused by *Varroa destructor*, resulting in high costs of training for beekeepers, and *A. tumida* is believed to be a more destructive pest (NBU, pers. comm.). A recent Australian paper considered the likely impact of *Varroa destructor* following the hypothetical introduction of this mite into Australia (Cook *et al*., 2007) and concluded that preventing the pest from entering the country avoided costs of 16.4 – 38.8 million US$, including loss of pollination, reduced crop yields, additional production and eradication costs.
62 - How important is environmental harm caused by the organism within its existing geographic range under any current management regime?	Minor High level of uncertainty	In its native range of sub-Saharan Africa, the small hive beetle is a colony scavenger, existing in colonies of African subspecies of western honey bees (*Apis mellifera* L.) (Lundie, 1940; Neumann & Elzen, 2004), feeding on pollen, honey and bee brood. In extreme circumstances, the beetle may act as a superorganismic parasite that destroys weakend or diseased colonies, but this scenario is the exception rather than the rule (Ellis & Hepburn, 2006). In Africa, beetle reproduction is maximised in bee colonies that abscond (abandon the nest leaving pollen, honey and partially cannibalized brood behind). In this instance, the beetle confers a positive benefit, disposing of weakened/diseased hives or abandoned nests that can harbour diseased organisms.

		Outside of Africa there is very little information on environmental impact - In the USA there is evidence that the small hive beetle can use indigenous non-managed bumble bees as hosts. Managed honey bees in the USA and Australia are not just pollinating commercial crops they also play a part in pollinating and diversity maintenance of natural landscapes. Effects of reduced numbers of bees on this type of pollination have not been documented. Additionally, bees pollinate hedgerow trees which provide important food sources for variety of overwintering bird and mammal species, again any effects on reduction of bees on this type of pollination are unmeasured.
63 - How important is environmental harm likely to be in the Risk Assessment Area taking into account any management interventions that might be implemented?	Minimal High level of uncertainty	As mentioned a reduction in the number of bee pollinators could have effects on the diversity in the natural environment and could affect hedgerow trees which provide important food sources for variety of overwintering bird and mammal species. These potential effects are all unmeasured so uncertainty is high. There may also be an effect on managed environments, such as parks and gardens. The potential impact of pesticide treatments to combat the pest is not likely to be high, applications being localised around known infested hives. Disturbance of soil to eliminate the pupae would also be targeted and localised.
64 - How important is social, health or other harm (not directly included in economic and environmental categories) caused by the organism within its existing geographic range under any current management regime?	Minimal Low level of uncertainty	No social harm known in its existing range.
65 - How important is the social, health or other harm likely to be in the Risk Assessment Area taking into account any management interventions that might be	Minimal Low level of uncertainty	Honey bees are major pollinators for apple orchards in the UK. One potential social impact could be that on the orchard growers. Would growing apples become unsustainable, would other crops have to be grown instead requiring growers to become specialists in other areas or would other pollination methods be found? Bee losses may also be upsetting for the hobbyist bee keepers in the UK and an introduction of a pest

implemented?		such as this would be an educational wake up call to the bee keeping industry as a whole.
66 - How likely is it that genetic traits of the organism could be carried to native species, modifying their genetic nature and making their economic, environmental or social effects more serious?	Very Unlikely Low level of uncertainty	No documentation of such effects.
67 - How likely is it that the organism will not be kept under control by other organisms, such as predators, parasites or pathogens, that may already be present in the Risk Assessment Area?	Unlikely Medium level of uncertainty	There are known natural enemies present in the UK, species of soil borne fungi, such as *Aspergillus niger* and entomopathogenic nematodes such as *Heterorhabiditis megidis*. How great an effect these may have on the small hive beetle, though, is unclear, with most documented effects being experimental (see question 39). Birds may predate on the wandering larval stage of the small hive beetle, but again how great an effect this may have at controlling the pest is unclear, though believed likely to be low.
68 - How difficult is it likely to be to control the organism in the the Risk Assessment Area?	Difficult Medium level of uncertainty	The control of the small hive beetle is likely to be difficult and is more likely to be successful if the pest is detected early on. There have been successful eradications, such as that in Portugal (Murilhas, 2005), but these have not been tried on a large scale. A major limiting factor would be the unknown distribution of bee hives and potential for populations of the beetle in feral hosts, which may act as a reservoir for reinfestation of managed colonies. The range of chemical or biological controls available may also be limited. Those used in other parts of the world are not licensed for use within the UK.
69 - How likely are control measures introduced for this new organism to disrupt existing biological or integrated systems used to	Very unlikely Medium level of uncertainty	If an outbreak did occur in a glasshouse disruption would be high, with all biological control being potentially affected by the application of chemical treatments. An outbreak in a glasshouse is, however, unlikely. In terms of the chemical treatment of apiaries this is unlikely to disrupt other control mechanisms, as no real biological controls are currently used.

control other organisms in the Risk Assessment Area?		Disruption to the bees themselves should be minimal, unless complete destruction of the hive is necessary, as any chemicals licensed for use in apiaries should have been deemed safe for use in connection with honey bees.
70 - How likely is the organism to act as food, a host, a symbiont or a vector for other damaging organisms?	Likely Medium level of uncertainty	In laboratory studies, *Aethina tumida* has been shown to act as a vector for *Paenibacillus larvae*, the causative agent of American foulbrood (AFB), with both adults and larvae becoming infected with spores when exposed to honeybee brood combs with clinical symptoms (Schäfer *et al*., 2009). In a field test, honeybee colonies infested with contaminated adult beetles had higher numbers of *P. larvae* spores in adult workers and honey after five weeks; however, the number of spores on adult beetles was low (Schäfer *et al*., 2009). It was concluded by the authors that, due to the low number of spores on the adult beetles, clinical AFB outbreaks were less likely, but the spread of even low spore numbers could be sufficient to spread *P. larvae* (Schäfer *et al*., 2009). Adult small hive beetles have also shown the potential to act as vectors for honey bee viruses (Eyer *et al*., 2009a, b). It has been demonstrated that adult small hive beetle can be infected with deformed wing virus (Eyer *et al*., 2009a) and sacbrood virus (Eyer *et al.*, 2009b) via food-borne transmission. The presence of negative stranded RNA of the viruses in the beetles indicated that these viruses are able to replicate in adults and the insects therefore have potential to act as vectors (Eyer *et al*., 2009a, b). Further studies are required to ascertain the degree to which this may occur in the field, and the effect on honey bee health. These viruses and bacteria are already present in the UK so small hive beetle would act as an additional vector to the bees themselves and bad hygiene regimes of bee keepers. The studies carried out have been small scale only. The potential for the small hive beetle to act as a vector is present, but how good a vector they may be is unknown.
71 - Indicate any parts of the Risk Assessment Area where economic, environmental and social impacts are particularly likely to occur.		From an economic point of view fruit growing regions of the UK, particularly in the South of England, are likely to feel the biggest impact of the introduction of this pest. Honey bee apiaries are likely to be most seriously impacted – 80% of managed *Apis mellifera* are found in England.

72 - Overall impact rating (please comment on the main reasons for this rating)	**Moderate**	**Due to direct effect on the apiaries and potential effects on bee pollination reliant fruit crops.**

References

Authors: Helen Anderson, Andy Cuthbertson, Gay Marris, Maureen Wakefield

Ambrose, J.T., Stanghellini, M.S. & Hopkins, D.I. (2000) A scientific note on the threat of small hive beetles (*Aethina tumida* Murray) to bumble bee (*Bombus spp*.) colonies in the United States. *Apidologie*, **31 (3)**, 455-456.

Animal Health Australia. (2003). Small Hive Beetle National Management Plan. Deakin ACT, 2600, Australia: Animal Health Australia Council Ltd, ACN071890956. P.17.

Annand, N. (2008) Small hive beetle management options. NSW DPI Primefact 764 p. 7.

Ansari, M.A., Shah, F.A. & Butt, T. (2008) First report of *Heterorhabditis bacteriophora* (Nematoda: Heterorhabditidae) from UK. *Nematology*, **10(2)**, 289-291.

Bee Health Policy (2009) The importation of bees into England: A guidance note for importers. Fera, Sand Hutton, York.

Beebase (2010) National Bee Unit website for bee keepers and to support the Defra and Welsh Assembly Government's Bee Health Programme. Available online at: www.nationalbeeunit.com Accessed March 2010.

Brown, I. (2005) Jamaica Information Service (JIS). Available online at: http://www.jis.gov.jm/tools/printable.asp?print=/agriculture/html/20050807T170000-0500_6510_JIS_APICULTURE_UNIT_IMPLEMENTS_INTEGRATED_PEST_MANAGEMENT_SYSTEM_TO_CONTROL_SMALL_HIVE_BEETLE.asp. Accessed March 2010.

Brown, M. A. (2004) UK Non-native risk assessment scheme on *Aethina tumida* (Murray).

Brown, M. (2006a) NBU procedures for examination and reporting of honey bee imports and exports within the European Union and Third Countries. NBU Standard Operating Procedure, SOP NBU/084, 12 pp.

Brown, M. (2006b) Statutory bee health control procedures and responsibilities implemented by the Central Science Laboratory on behalf of the Agiculture departments in England and Wales. SOP No., NBU/074, pp.42.

Buchholz, S., Schafer, M.O., Spiewok, S., Pettis, J.S., Duncan, M., Ritter, W., Spooner-Hart, R & Neumann, P. (2008) Alternative food sources of *Aethina tumida*. *Journal of Apicultural Research* **47(3)**, 202-209.

Cabanillas, H.E. & Elzen, P.J. (2006) Infectivity of entomopathogenic nematodes (Steinernematidae and Heterorhabditidae) against the small hive beetle *Aethina tumida* (Coleoptera: Nitidulidae). *Journal of Apicultural Research*. **45**, 49-50

CABI Bioscience (CABI); Centre for Environment, Fisheries and Aquaculture Science (CEFAS); Centre for Ecology and Hydrology (CEH); Central Science Laboratory (CSL); Imperial College London (IC) and the University of Greenwich (UoG) (2005). *Bombus terrestris* – subspecies not native to the UK e.g. *B. terrestris terrestris*, *B. terrestris dalmatinus*. UK Non-native Organism Risk Assesment Scheme, Version 3.3. DEFRA contract CRO293. Available online at: https://secure.fera.defra.gov.uk/nonnativespecies/home/index.cfm

Clay, H. (2006). Small Hive Beetle in Canada. *Hivelights*, **19,** 14-16.

Commission Regulation (EC) No 829/2007 (2007) Amending regulation of certain animal by-products. Published by the Official Journal of the European Union. Available online at: http://eur-lex.europa.eu/LexUriServ/site/en/oj/2007/l_191/l_19120070721en00010099.pdf

Cook, D.C., Thomas, M.B., Cunningham, S.A., Anderson, D.L. & De Barro, P.J. (2007) Predicting the economic impact of an invasive species on an ecosystem service. *Ecological Applications*, **17(6)**, 1832-1840.

Cuthbertson, A.G.S., Mathers, J.J., Blackburn, L.F., Wakefield, M.E, Collins, L.E., Luo, W. & Brown, M.A. (2008). Maintaining *Aethina tumida* (Coleoptera: Nitidulidae) under quarantine laboratory conditions in the UK and preliminary observations on its behaviour. Jo*urnal of Apicultural Reearch*. **47**, 192-193.

Cuthbertson, A.G.S., Mathers, J.J., Blackburn, L.F., Brown, M.A. & Marris, G. (2010). Small Hive Beetle: the next threat to British honey bees? *Biologist*. **57**, 35-39

DEFRA 2007. Imports – OVS Note 07/98: Imports of apiculture products for technical use. Importation of products of animal origin: Notes for Official Veterinary Surgeons (OVS) at Border Inspection Posts (BIPs) – 2007. Available online at: http://www.defra.gov.uk/foodfarm/animaltrade/imports/ovsnotes/07/0798.htm

DEFRA, 2009. The BIP (Border Inspection Post) Manual. Available online at: http://www.defra.gov.uk/foodfarm/animaltrade/imports/vetchecks.htm

De Guzman, LI & Frake, AM (2007) Temperature affects *Aethina tumida* (Coleoptera: Nitidulidae) development. *Journal of Apicultural Research* **46,** 88-93.

Delaplane, K.S. (1998) The small hive beetle, *Aethina tumida*, in the Southeast. *American Bee Journal*, **138,** 884-885.

Dixon, D. & Lafreniere, R. (2002) The small hive beetle in Manitoba. *Manitoba Beekeeper*, **Fall 2002**, p8.

Edwards, M. & Jenner, M (2009) Field Guide to the Bumblebees of Great Britain & Ireland (revised edition). Countryside and Garden Conservation Series.

Eischen F.A., Westervelt, D. & Randall, C. (1999) Does the small hive beetle have alternate food sources? *American Bee Journal* **139**, p125.

Ellis, JD; Neumann, P; Hepburn, R. & Elzen, PJ (2002) Longevity and reproductive success of *Aethina tumida* (Coleoptera: Nitidulidae) fed different natural diets. *Journal of Economic Entomology* **95**, 902-907.

Ellis, JD., Hepburn, HR., Delaplane, KS., Neumann, P. & Elzen, PJ. (2003). The effects of adult small hive beetles, *Aethina tumida* (Coleoptera: Nitidulidae), on nests and flight activity of Cape and European honey bees (*Apis mellifera*). *Apidologie,* **34,** 399-408.

Ellis, JD. 2004. The ecology and control of small hive beetle (*Aethina tumida* Murray). PhD dissertation, Rhodes University, Grahamstown, South Africa. 385 pp.

Ellis, JD., Rong, IH., Hill, MP., Hepburn, HR. & Elzen, PJ. (2004). The susceptibility of small hive beetle (*Aethina tumida* Murray) pupae to fungal pathogens. *American Bee Journal*, **144,** 486-488.

Ellis, JD.& Hepburn, HR. (2006). An ecological digest of the small hive beetle (*Aethina tumida*), a symbiont in honey bee colonies (*Apis mellifera*). *Insectes Sociaux*, **53,** 8-19.

Ellis, J.D., Spiewok, S., Delaphane, K.S., Buchholz, S., Neumann, P. & Tedders, W.L. (2010) Susceptibility of *Aethina tumida* (Coleoptera: Nitidulidae) larvae and pupae to entomopathogenic nematodes. *Journal of Economic Entomology*, **103(1)**, 1-9.

Elzen, PJ., Baxter, JR, Westervelt, D., Randall, C., KS, Cutts, L., Wilson,WT., Eishen, F., Delaplane, KS. & Hopkins, D. (1999a). Status of the small hive beetle in the US. *Bee Culture*, **127 (1)**, 28-29.

Elzen, PJ., Baxter, JR., Westervelt, D., Randall, C., Delaplane, KS., Cutts, L. & Wilson, WT. (1999b). Field control and biology studies of a new pest species, *Aethina tumida* Murray (Coleoptera, Nitidulidae), attacking European honeybees in Western Hemisphere. *Apidologie*, **31,** 361-366.

Elzen, PJ., Baxter, JR., Westervelt, D., Randall, C. & Wilson, WT. (2000). A scientific note on observations of the small hive beetle, *Aethina tumida* Murray (Coleoptera, Nitidulidae), in Florida, USA. *Apidologie*, **31,** 593-594.

Eurostat (2010) European Commission External Trade Statistics. Accessed March 2010. Available at: http://epp.eurostat.ec.europa.eu/newxtweb/setupdimselection.do#

Evans, J.D., Pettis, J. & Shimanuki, H. (2000) Mitochondrial DNA relationships in an emergent pest of honey bees, *Aethina tumida* (Colepotera: Nitidulidae) from the United States and Africa. *Annals of the Entomological Society of America*, **93,** 415-420.

Evans, J.D., Pettis, J., Hood, W.M. & Shimanuki, H. (2003) Tracking an invasive honey bee pest: mitochondrial DNA variation in North American small hive beetles. *Apidologie*, **34,** 103-109.

Eyer, M., Chen, Y.P., Schäfer, M.O., Pettis, J. & Neumann, P. (2009a) Small hive beetle, *Aethina tumida*, as a potential biological vector of honeybee viruses. *Apidologie*, **40,** 419-428.

Eyer, M., Chen, Y.P., Schäfer, M.O., Pettis, J & Neumann, P. (2009b) Honey bee sacbrood virus infects small hive beetles, *Aethina tumida* (Coleoptera: Nitidulidae). *Journal of Apicultural Research and Bee World*, **48,** 296-297.

Fletcher, M.J. and Cook, L.G. (2002). Small hive beetle. Agnote DAI-288. NSW Agriculure. p 3.

Fore, T. (1999). The small hive beetle. *Bee Biz* **9**, 3-4.

Frake, A.M. & Tubbs, H. (2009). Population of small hive beetles (*Aethina tumida* Murray) in two apiaries having different soil textures in Mississippi. *Science of Bee Culture*, **1,** 4-8.

Giovenazzo, P., & Boucher, C. (2010) A scientific note on the occurrence of the small hive beetle (*Aethina tumida* Murray) in Southern Quebec. *American Bee Journal*, **150**, 275-276.

Gwynn, R.L. & Richardson, P.N. (1996) Incidence of entomopathogenic nematodes in soil samples collected from Scotland, England and Wales. *Fundam., appl., Nematol.*, **19(5)**, 427-431.

Hassan, A.R. & Neumann, P. (2008). A survey for the small hive beetle in Eygpt. *Journal of Apicultural Research*, **47(3),** 186-189

Hoffmann, D., Pettis, J. & Neumann, P. (2008) Potential host shift of the small hive beetle (*Aethina tumida*) to bumblebee colonies (*Bombus impatiens*). *Insectes Sociaux*. **55**, 153-162.

Hood, WM. (2000). Overview of the small hive bettle, *Aethina tumida*, in North America. Bee *World*, **81(3)**, 129-137.

Leemon, D & McMahon, J. (2009) Feasibility study into in-hive fungal bio-control of small hive beetle. Rural Industries Research and Development Corporation Publication no. 09/090.

Lundie, A.E. (1940) The small hive beetle, *Aethina tumida*. Science Bulletin 220, Entomological Series 3. Dept. of Agriculture and Forestry, Pretoria, South Africa.

MAF Biosecurity (2002) Import Risk Analysis: Honey bee hive products and used equipment. Biosecurity Authority, Ministry of Agriculture and Forestry, Wellington, New Zealand. Available online at: http://www.biosecurity.govt.nz/regs/imports/ihs/risk

MAF Biosecurity (2003) Import Risk Analysis: Honey bee (*Apis mellifera*) genetic material. Biosecurity Authority, Ministry of Agriculture and Forestry, Wellington, New Zealand. Available online at: http://www.biosecurity.govt.nz/regs/imports/ihs/risk

MAF Biosecurity New Zealand (2004) Import Risk Analysis: Honey bee products. Biosecurity New Zealand, Ministry of Agriculture and Forestry, Wellington, New Zealand. Available online at: http://www.biosecurity.govt.nz/regs/imports/ihs/risk

Marris, G; Budge, G.; Jones, G.; Brown, M.A.; Areikin, E.; Potts, S.; Breeze, T.; Bailey, A.; Cuthbertson, A.G.S. & Macleod, A. Quantifying the value of ecosystem services: Replacement Cost Scenarios for Honey Bee pollination in the UK. *Journal of Environmental Economics and Management*. **In submission**.

Mostafa, AM & Williams, RN. (2000). New record of the small hive beetle in Egypt and notes on its distribution and control. *Bee World*, **83(3),** 99-108.

Mulherin, T. (2009) Stepping up the small hive beetle battle. Minister for Primary Industries, Fisheries and Rural and Regional Queensland, Queensland Government. Available at: http://statements.cabinet.qld.gov.au/MMS/StatementDisplaySingle.aspx?id=66217 Accessed March 2010.

Murilhas, A.M. (2005) *Aethina tumida* arrives in Portugal. Will it be eradicated? *EurBee Newsletter* **No. 2, April 2005**, 7-9.

Mürrle, T. & Neumann, P. (2004) Mass production of small hive beetles (*Aethina tumida*, Coleoptera: Nitidulidae). *Journal of Apicultural Research* **43(2)**, 144-145

NBU (2010). National Bee Unit data. Fera, UK.

Neumann, P & Elzen, P.J. (2004). The biology of the small hive beetle (*Aethina tumida* Murray, Coleoptera: Nitidulidae): Gaps in our knowledge of an invasive species. *Apidologie* **35,** 229-247.

Neumann, P. & Ellis, J.D. (2008). The small hive beetle (*Aethina tumida* Murray, Coleoptera: Nitidulidae): distribution, biology and control of an invasive species. *Journal of Apicultural Research and Bee World* **47(3),** 181-183

Neumann, P; Pirk, CWW; Hepburn, R; Elzen, PJ & Baxter, JR (2001) Laboratory rearing of small hive beetles *Aethina tumida* (Coleoptera, Nitidulidae). *Journal of Apicultural Research* **40**, 111-112.

OIE (2009). Chapter 9.4 Small Hive Beetle Infestation (*Aethina tumida*) in the Terrestrial Animal Health Code. Last updated 2009. Available online at: http://www.oie.int/eng/normes/mcode/en_chapitre_1.9.4.htm

Parliamentary Office of Science and Technology (2010) Postnote: Insect Pollination. Published Jan 2010, Number 348. Available online at: http://www.parliament.uk/parliamentary_offices/post/pubs2010.cfm

Pettis, JS & Shimanuki, H (2000) Observations on the small hive beetle, *Aethina tumida* Murray, in the United States. *American Bee Journal* **140 (2),** 152-155.

PHIW (2010) Plant Health Information Warehouse. Fera (Food and Environmental Research Agency) database.

Plant Health Directive 2000/29/EC (2009). Available online at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2000L0029:20091224:EN:PDF

re-Fresh Directory (2009) An essential resource for the fresh produce industry: product guide and availability on UK markets. *FPJ*.

Richards, C.S., Hill, M.P. & Dames, J.F. (2005) The susceptibility of small hive beetle (*Aethina tumida* Murray) pupae to *Aspergillus niger* (van Tieghem) and *A. flavus* (Link:Grey). *American Bee Journal*, **145**, 748-751.

Schäfer, M.O., Ritter, W., Pettis, J.S. & Neumann, P. (2009) Small hive beetles, *Aethina tumida*, are vectors of *Paenibacillus larvae*. *Apidologie* **41,** 14-20.

Schäfer, M.O., Ritter, W., Pettis, J.S. & Neumann, P. (2010) Winter losses of honeybee colonies (Hymenoptera: Apidae); the role of infestations with *Aethina tumida* (Coleoptera: Nitidulidae) and *Varroa destructor* (Parasitiformes: Varroidae). *Journal of Economic Entomology* **103,** 10-16.

Schmolke, MD. (1974) A study of *Aethina tumida*: the small hive beetle. Project report, University of Rhodesia, 178pp.

Somerville, D. (2003) Study of the small hive beetle in the USA. A report for the Rural Industries Research and Development Corporation. Pub. No. 03/050: 57.

Spiewok, S. & Neumann, P. (2006) Infestation of commercial bumblebee (*Bombus impatians)* field colonies by small hive beetles (*Aethina tumida*). *Ecological Entomology* **31**, 623-628.

Stanghellini, M.S., Ambrose, J.T. & Hopkins, D.I. (2000) Bumble bee colonies as potential alternative hosts for the small hive beetle (*Aethina tumida* Murray). *American Bee Journal*, **140(1)**, 71-75

Stedman, M. 2006. Small Hive Beetle (SHB): *Aethina tumida* Murray (Coleoptera: Nitidulidae). Primary Industries and Resources for South Australia. Factsheet 03/06: 13 pp.

SFVO (2004) Swiss Federal Veterinary Office. Risk Analysis: Animal Health: Summaries. Risk of importing *Aethina tumida* (small hive beetle) is available at: http://www.bvet.admin.ch/gesundheit_tiere/00315/00317/02600/index.html?lang=en

Taber, S. (1999a). The small hive beetle, as described by A.E. Lundie in 1940. *American Bee Journal* **139**, 450-451.

Tarpy, D.R. (2007). Africanized Honey Bees: Where are they now, and when will they arrive in North Carolina? North Carolina Cooperative Extension, College of Agricultural & Life Sciences. Available online at: http://www.cals.ncsu.edu/entomology/apiculture/PDF%20files/1.01.pdf

Thompson, C., Budge, G. & Biesmeijer, J. (2010) Feral bees in the UK: The real story. *Bee Craft*, **April 2010**, 22-24.

WAHID (2010) OIE World Animal Health Information Database: Interface on Disease Notifications. Available online at: http://www.oie.int/wahis/public.php?page=disease_immediate_summary. Last Accessed March 2010.

Wenning, C.J. (2001) Spread and threat of the small hive beetle. *American Bee Journal*, **141**, pp640-643.

PROTECT-CONTRACTS

White, B. (2004) Small hive beetle. *Apiacta* **38**: 295-301.

Risk Management for *Aethina tumida*

Pathways of risk which have been identified during the risk assessment

Commodity pathways

1. **Movement of honey bees: queens and packaged bees for the purposes of trade. From the EU only this includes the movement of whole colonies** - Likely to be associated with pathway – but pathway is already regulated for EU and third country imports. Risk is through illegal imports or legislation not being followed. Imports from the EU are less thoroughly checked and this poses a greater risk.
2. **Movement of alternative hosts e.g. bumble bees for pollination purposes** - Unlikely to be associated with pathway – pathway is already regulated and the species being moved are not known hosts. However, while imports must have a health certificate, inspections are not made on bumble bees entering the UK in the same way as for honey bees. There is additional risk through illegal imports. Especially if alternative known host species were imported.
3. **Trade in hive products –specifically rendered beeswax and honey post extraction in drums from third countries and the EU and honeycomb and any other unprocessed wax products from the EU** – Association with such products is likely, although survival is less certain. All consignments from third countries require documentary and a proportion of physical checks..
4. **Soil or compost associated with plant trade from third countries other than Mediterranean countries. Soil from the EU and Mediterranean countries** – regulated pathway and therefore low chance of association from third countries outside the Mediterranean. No restriction on EU or Mediterranean imports. Illicit trade and soil from Egypt pose the greatest risk.
5. **Fruit imports – in particular avocado, bananas, grapes, grapefruit, kei apples, mango, melons and pineapples** – weak association with pathway. Association in the field not proven. RMI or PHSI inspections may pick up the larvae within fruit entering EU. If the pest was present within the EU infected fruit would be less likely to be picked up by official inspection.

Non-commodity pathways

6. **Movement on beekeeping clothing / equipment** – There is high uncertainty as to trade or transport of beekeeping equipment from third countries, but association of the pest is possible. Of much greater risk is the movement of equipment and clothing from the EU.
7. **Freight containers and transport vehicles themselves** – weak association, but evidence suggests this is how the pest reached the USA and there may be the possibility of association with host swarms during transport. Therefore feasible pathway though very little information on it. Likely to be a higher risk if present in EU due to rapid train and ferry links.
8. **Natural spread of pest itself by flight, on its own or possibly in association with a host swarm – relevant only if present in EU** – very unlikely but could happen. Insufficient information on flight capability, both of European honey bee and the small hive beetle.

`Commodity pathways

Pathways > / Question	1. Honey bees	2. Alternative hosts	3. Hive products	4. Soil and soil associated with plants for planting	5. Fruit imports
2.10 - Are there any existing measures applied on the pathway that could prevent the introduction of *A. tumida*? **If yes: list the measures**	Yes, There are already regulations regarding the import of honey bees from both the EU and third countries – including health certification, requirements on the origin to be pest free and inspections on arrival.	Yes, There are already regulations regarding the import of bumble bees from both the EU and third countries – including health certification and requirements on the origin to be pest free.	Yes, There is legislation covering the importation of hive products, both for human consumption and for other uses. Honey, beeswax, propolis and pollen of third country origin is restricted and must comply with current legislation.	Yes, There is already legislation in the Plant Health Directive that restricts the importation of soil associated with plants from third countries to soil that has been shown to be free from insects and harmful nematodes. There are no such restrictions on movement from the EU or specified Mediterranean countries.	No - Fruit entering the EU from third countries will be subject to plant health inspection – but the small hive beetle is not a listed plant pest and will not be specifically looked for. Fruit from within the EU has no such existing measures.
2.11 – Can *A. tumida* be reliably detected by inspection of a consignment at the time of export? **If yes: possible measures: visual inspection**	Yes – but a visual inspection would not be reliable. Dependant on the numbers of the pest present and the commodity e.g. whether a whole colony or queen with attendants.	Yes – but a visual inspection would not be reliable. Dependant on the numbers of the pest present and the commodity e.g. whether a whole colony or queen with attendants.	Probably not – could be inside the product. A visual inspection would not be reliable.	Yes - Could be detected, but possibly not reliably. Examining soil associated with growing plants in particular is difficult.	Yes - Visual detection of this pest is possible, but probably not reliably. The fruit is likely to deteriorate due to the presence of the larvae, which may indicate presence of infestation to an

Pathways > / Question	1. Honey bees	2. Alternative hosts	3. Hive products	4. Soil and soil associated with plants for planting	5. Fruit imports
					observer.
2.12 – Can *A. tumida* be reliably detected by testing? **If yes: possible measures: specified testing**	A molecular based diagnostic assay is available for detection of small hive beetle in hive debris. This is currently used to screen hive debris submitted by NBU inspectors conducting exotic pest surveys. Any debris associated with imported bees could be tested.	A molecular based diagnostic assay is available for detection of small hive beetle in hive debris. Any debris associated with imported bees could be tested.	A molecular based diagnostic assay is available for detection of small hive beetle in hive debris. Changes to extraction and processing methods would be required for use with hive products	A molecular based diagnostic assay is available for detection of small hive beetle in hive debris. Changes to extraction and processing methods would be required for use with hive products	A molecular based diagnostic assay is available for detection of small hive beetle in hive debris. Changes to extraction and processing methods would be required for use with fruit and the volume of fruit imported would make this a difficult method to use.
2.13 – Can *A. tumida* be reliably detected during post-entry quarantine procedures? **If yes: possible measures: import under special licence/permit and post-entry quarantine procedures.**	Yes – the pest could be detected during post quarantine inspections of the bees and the packaging in which they are transported	Yes - the pest could be detected during post-entry inspections, but currently there are no inspections of bumble bees on arrival in the UK.	If products are held under appropriate conditions any small hive beetle eggs present may hatch, resulting in the presence of larvae. However, it is unlikely due to the nature of the products that small hive beetle would be reliably detected.	It is possible that the pest may emerge if the plants are held for a period of time – but it may not be reliably detected.	Possible – post entry quarantine would enable any larvae to cause more damage to the fruit and this may possibly become more obvious. Unlikely to be reliably detected. Long period of post entry quarantine not practical due to commodity deterioration.
2.14 – Can *A. tumida* be effectively destroyed in the consignment by treatment (chemical,	No – any treatments would also destroy the bee consignment.	No – any treatments would also destroy the bee consignment.	Treatments of consignments of beeswax and honey such as freezing may	If the commodity were soil or compost on its own then this would be possible.	Yes – could irradiate or fumigate the fruit which would destroy any larvae inside.

Pathways > / Question	1. Honey bees	2. Alternative hosts	3. Hive products	4. Soil and soil associated with plants for planting	5. Fruit imports
thermal, irradiation, physical)? **If yes: possible measure: specified treatment**			be possible. It is not known if these treatments would be reliable.	With plant material associated not possible as plants would be damaged.	However, presence of larvae in the fruit may down grade its use, such that it is suitable for processing only.
2.15 – Does *A. tumida* occur only on certain parts of the plant/animal or plant/animal products (e.g. bark, flowers), which can be removed without reducing the value of the consignment? **If yes: possible measure: removal of parts of the plant/animal or plant/animal products from the consignment**	No. The pest lives in close association with honey bees and associated hive equipment. It may be more likely associated with hives but association with adult bees and hive products would be expected	No. The pest has been shown to associate with some bumble bee species and there is concern that it could be found associated with *Bombus terrestris*, which is the species imported into the UK for pollination.	No. Adult and larval stages may use hive products as a food source	No. Larvae migrate to soil to pupate and a wide range of soil types are appropriate for this.	No. A limited range of fruits have been associated with the pest to date.
2.16 – Can infestation of the consignment be reliably prevented by handling and packing methods? **If yes: possible measures: specific handling/packing methods**	Possibly – good hive hygiene and the use of clean packaging would increase the possibility of the bees being clean and pest free.	Possibly – good hygiene in the place of production and the use of clean packaging would limit the risk of infestation.	Possibly – if honey or beeswax is extracted and processed quickly, under strictly imposed hygiene measures, eliminating cappings and other hive debris, which are attractive to the pest. Certification of these practices could reduce risk, but it is	Possibly - plants could be grown in sterilised growing media and replanted in such before export.	Possibly – at the point of origin, if there was more stringent checking for fruit that appeared rotting or infested.

Pathways > / Question	1. Honey bees	2. Alternative hosts	3. Hive products	4. Soil and soil associated with plants for planting	5. Fruit imports
			unclear whether it would reduce risk reliably.		
2.17 – Could consignments that may be infested be accepted without risk for certain end uses, limited distribution in the Risk Assessment area, or limited periods of entry, and can such limitations be applied in practice? **If yes: possible measure: import under special licence/permit and specified restrictions.**	No – end use involves association with honey bee hives in the UK	No – end use involves release of bumble bees for pollination, often under protection, but potentially also outside.	No – although the end use may be processing there is concern that the pest may be able to escape the processing plant and transfer to a suitable host.	No – end use of both plants and soil is most likely to involve exposure to land in the UK.	No – even if fruit is sent for processing there may be a possibility of the pest escaping the processing plant.
2.18 – Can infestation of the commodity be reliably prevented by treatment before export? **If yes: possible measure: specified treatment and / or period of treatment**	No – any reliable treatments would also destroy the bee consignment.	No – any reliable treatments would also destroy the bee consignment.	Treatments of consignments of beeswax and honey may be possible It is not known if treatments would be reliable.	If the commodity were soil or compost on its own then this would be possible. With plant material associated this may not be possible as plants would be damaged.	Yes – could irradiate or fumigate the fruit which would destroy any larvae inside.
2.19 – For invasive non-native species that are pests of plants or animals can infestation of the plant or animal commodity be reliably prevented by growing /	No. African subspecies of honey bees are less susceptible to the small hive beetle, but the pest may still be associated with the	No. The species currently imported is not a known host of the small hive beetle, but there is concern that any bumbles bees may be	N/A	N/A	No. Although association with fruit in the field is not proven there are no known resistant strains of those fruit where association

Pathways > / Question	1. Honey bees	2. Alternative hosts	3. Hive products	4. Soil and soil associated with plants for planting	5. Fruit imports
rearing resistant cultivars/strains/breeds? **If yes: possible measure: consignment should be composed of specified cultivars**	bees. This subspecies would not be imported to the UK as it itself is a non-native invasive species.	potential hosts.			has been documented.
2.20 – Can infestation of the commodity be reliably prevented by growing/rearing or storing in specified conditions (e.g. protected conditions, sterilized growing medium..)? **If yes: possible measures: specified growing conditions**	No. *Apis mellifera* can not be reared indoors	Yes – bumblebees are reared in licensed facilities which could be declared to be free of the pest	Secure storage is important, but unlikely to be able to reliably prevent pest presence in areas where it is established.	Yes – plants could be grown in sterilised growing media and replanted in such before export. They could also be grown under protection where it could be certified free from small hive beetle.	No – the fruit growing regions are too big. This would be impractical.
2.21 – Can infestation of the commodity be reliably prevented by harvesting/marketing only at certain times of the year, at specific ages or growth stages? **If yes: possible measures: specified age, growth stage or time of year or harvest/marketing**	No – the small hive beetle is likely to be associated with honey bees at any time of year.	No – the small hive beetle is likely to be associated with bumble bees at any time of year.	No – there is potential for the pest to become associated with the products at any time.	No – association could potentially be at any time.	No – association could potentially be at any time when fruit is marketable.
2.22 – Can infestation of	Possibly queen bees	Yes – bumble bees	No – as even hive	Yes for plants for	No - the fruit

Pathways > / Question	1. Honey bees	2. Alternative hosts	3. Hive products	4. Soil and soil associated with plants for planting	5. Fruit imports
the commodity be reliably prevented by production in a certification/breeding scheme (e.g. official scheme for the production of healthy plants for planting)? **If yes: possible measures: certification/breeding scheme**	could be produced under certified schemes. Currently honey bees from third countries do have to be certified as coming from an area which is free from the small hive beetle	can and already are produced under certified schemes – schemes already existing are for bumble bees coming into glasshouses.	products originating from a clean hive may become contaminated at the processing plant – small hive beetles are known to be attracted to packing facilities.	planting – see answer to 2.20. N/A for soil itself	growing regions are too big. This would be impractical.
2.23 – Does *Aethina tumida* have low mobility? **If yes: possible measures: crop/population free from invasive non-native species, or place of production free from invasive non-native species, or place of production free from invasive non-native species and appropriate buffer zone, or area free from invasive non-native species.**	*Aethina tumida* eggs have low mobility. Eggs, may be associated with honey bee colonies and packaging.	*Aethina tumida* eggs have low mobility. Eggs, may be associated with honey bee colonies and packaging.	Eggs may be present on drums of honey	Pupae are the lifestage most likely to be associated with this pathway. They have a very low mobility.	*Aethina tumida* eggs have low mobility. Eggs may be present on fruit
2.24 – Does *Aethina tumida* have medium	Larvae may be associated with this pathway. They are	Larvae may be associated with this pathway. They are	Larvae may be associated with this pathway. They are	N/A for this pathway	Larvae may be associated with this pathway. They are

Pathways > / Question	1. Honey bees	2. Alternative hosts	3. Hive products	4. Soil and soil associated with plants for planting	5. Fruit imports
mobility? **If yes: possible measures: place of production free from invasive non-native species and appropriate buffer zone, or area free from invasive non-native species.**	capable of moving distances up to 200 m in search of suitable pupation sites.	capable of moving distances up to 200 m in search of suitable pupation sites.	capable of moving distances up to 200 m in search of suitable pupation sites.		capable of moving distances up to 200 m in search of suitable pupation sites.
2.25 – Does *Aethina tumida* have high mobility? **If yes: Possible measures: area free from invasive non-native species**	Adult small hive beetles have high mobility. Adults may be associated with this pathway.	Adult small hive beetles have high mobility. Adults may be associated with this pathway.	Adult small hive beetles have high mobility. Adults may be associated with this pathway, particularly at origin, though it may be larvae which are actually transported.	N/A for this pathway	N/A for this pathway
2.26 – Can the crop, place of production or an area be reliably guaranteed free from invasive non-native species? **If no: Possible measures identified in 2.23 – 2.25 would not be suitable**	Yes – in so far as the surveillance suggests freedom from infestation. This is already the case under legislation	Yes – this is already the case under legislation	If it could be certified that the place of extraction as well as the production area was free from small hive beetle then this may be possible.	Yes – Plants and soil could also be certified as coming from an area where there are no small hive beetles present. Such legislation is already in place for bees	Yes – as with the bees, there are areas in some countries known to have small hive beetle which can be certified as being free of this pest. However, this could not be the case for all fruit growing regions and would restrict trade.
2.27 – Are there effective measures that could be taken in the importing	Yes – visual inspection and surveillance of	Yes – visual inspection and surveillance of	Yes – inspection on arrival. This is done for a selected	No – can have visual inspection of the soil –but this is difficult	Visual inspection of the fruit may show signs of the pest, but

Pathways > Question	1. Honey bees	2. Alternative hosts	3. Hive products	4. Soil and soil associated with plants for planting	5. Fruit imports
country/ Risk assessment area to prevent establishment and / or economic or other impacts? **If yes: Measures available in the importing country / area**	known (i.e. registered) bee hives. Not possible to monitor comprehensively on a national scale as not all honey bee colonies are currently registered.	colonies. Restriction of use of bumble bees as pollinators to closed systems.	quantity of imports from third countries.	and may not be reliable on its own. The Plant Health and Seed Inspectorate (PHSI) already inspects imports of such materials for the purpose of plant health surveillance. Training of PHSI inspectors would increase recognition of this species.	not every piece of fruit will be examined. Training of HMI and PHSI inspectors would increase recognition and reporting of this species.
2.28 – Have any measures been identified that will reduce the risk of introduction of the invasive non-native species? **If yes: Go to 2.29** **If no: Go to 2.37**	Yes – though there still remains a danger of illicit trade which these measures would not cover.	Yes – though there still remains a danger of illicit trade which these measures would not cover.	Yes – though none of the measures identified would be sufficient on their own	Yes – plants could be certified as being free from small hive beetle as they are for some other pests if originating from a country where this pest is present. There still remains a danger with illicit trade in soil itself and with the potential import from the EU and Mediterranean region.	Yes - could irradiate or fumigate fruit – though this may turn out to be expensive. Could source fruit only from areas known to be free from small hive beetle – though this may be impractical and restrictive to trade.

Non-Commodity pathways

Pathway / Question	6. Beekeeping clothing / equipment	7. Freight containers and transport itself	8. Natural spread - flight
2.3 – Is the pathway the natural spread of *A. tumida*? Natural spread includes movement of the invasive non-native species by migration of dispersal, wind/water dispersal and transport by vectors such as insects or birds. **If yes: go to 2.4.** **If no: go to2.8**	No	No	Yes – natural spread by flight, with or without a host swarm.
2.4 – Is *A. tumida* already entering the Risk Assessment area by natural spread or likely to enter in the immediate future? **If yes: go to 2.5** **If no: go to 2.8**	N/A	N/A	Assuming presence of *Aethina tumida* in the EU - Yes
2.5 – Could entry by natural spread be reduced or eliminated by control measures applied in the area of origin?	N/A	N/A	If the pest is eradicated in the EU – yes, but just controlling or limiting the population may not reliably prevent natural spread. Therefore, spread could be reduced but not reliably eliminated.
2.6 – Could *A. tumida* be effectively contained or eradicated after entry?	N/A	N/A	If the pest is detected early upon entry control measures may be effective. More intensive exotic pest survey inspections as carried out by the NBU, with increased

Pathway / Question	6. Beekeeping clothing / equipment	7. Freight containers and transport itself	8. Natural spread - flight
			use of sentinel apiaries may help detect the pest. Destruction of infested hives and contaminated soil treatments may be used to eradicate the pest.
2.7 – Was the answer yes to either 2.5 or 2.6? **If yes: go to 2.37** **If no: go to 2.45**	N/A	N/A	
2.8 – Is the pathway the entry of the species with human travellers? **If yes: possible measures: inspection of human travellers, luggage, publicity to enhance public awareness of invasive non-native species risks, fines or incentives. Treatments may also be possible. Go to 2.29** **If no: go to 2.9**	Yes – on PPE clothing and with beekeeping equipment used in areas where the pest is present and then brought into the UK. Increased publicity would raise public awareness to this threat.	No	N/A
2.9 – Is the pathway the entry of the species on contaminated machinery or vehicles? **If yes: possible measures: cleaning or disinfection of machinery / vehicles.**	Yes – on machinery or vehicles which may have been used in an area where the small hive beetle is present. In particular pest may be associated with soil on the wheels of vehicles used by beekeepers and brought back into the UK. Raised public awareness and cleaning of vehicles would reduce	Yes – on freight transporters. Possible measures would be cleaning or disinfection of machinery / vehicles – but on the scale necessary for freight shipping – impractical.	N/A

Pathway / Question	6. Beekeeping clothing / equipment	7. Freight containers and transport itself	8. Natural spread - flight
	this risk.		

2.29 – Have any measures been identified that will reduce the risk of introduction of the invasive non-native species? **If yes: Go to 2.30** **If no: Go to 2.37**	Yes. Existing legislation, inspection and surveillance schemes. Inspection of bees imported from EU countries. Restrictions on imports. Certified areas of production as free from *A. tumida*. Production of bumble bees and plants for planting under certified schemes. Increasing awareness in the beekeeping sector and the general public. Cleaning of beekeepers equipment and vehicles if used in an area where the pest is known. Training of HMI and PHSI inspectors. Use of alternative detection and monitoring technologies.
2.30 – Does each of the measures identified reduce the risk to an acceptable level? **If yes: Go to 2.33** **If no: Go to 2.31**	No. Illegal trade and movement would still pose a risk. Trade from the EU on which there are fewer checks. Unregistered beekeepers may make surveillance and early detection difficult. Cleaning of freight containers and transport mechanism on a large scale is impractical. Some measures may reduce the risk, but not reliably: visual inspections, post quarantine entry procedures, hygiene in place of production, clean packaging and checks on the commodity while packing, molecular testing where applicable, treatments of some commodities.
2.31 – For those measures that do not reduce the risk to an acceptable level, can two or more measures be combined to reduce the risk to an acceptable level? **If yes: Go to 2.33** **If no: Go to 2.32**	A combination of the measures listed above (2.30) as specified for the different pathways would reduce the risk in each pathway further.

2.32 – If the only measures available reduce the risk but not down to an acceptable level, such measures may still be applied, as they may at least delay the introduction of the invasive non-native species. In this case, a combination of measures at or before export and internal measures should be considered.	Depending on the pathway, it may not be possible to apply effective measures at or before export (see above).
2.33 – Estimate to what extent the measures (or combination of measures) being considered interfere with trade. It is necessary to consider the relationship between the negative effect on trade and the importance / desirability of that trade. If this analysis concerns an invasive non-native species already established in the Risk Assessment area but under official control, measures that are applied for international trade should not be more stringent than those applied domestically / internally.	If small hive beetle is present in the EU, import restrictions that could be applied may be limited due to the effect this would have on trade. However, increased restrictions would apply e.g. imports could only be from areas declared free of small hive beetle. The level of inspection and surveillance would need to be increased and this could also impact on trade. The full impacts have not been measured.
2.34 – Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.	The cost of the measures is unknown, but is likely to be outweighed by the cost to eradicate/control *Aethina tumida* should it arrive in the UK.
2.35 – Have measures (or a combination of measures) been identified that reduce the risk for the pathways, do not unduly interfere with trade, are cost-effective and have no undesirable social or environmental consequences? **If yes: for invasive non-native species initiated analysis go to 2.37**	Yes, although the extent, if any with which they may interfere with trade and the cost of implementation can not be fully assessed at this time.
2.37 – Have all major pathways been analysed (for an invasive non-native species initiated analysis)? **If yes: Go to 2.38** **If no: Go to beginning to analyse the next major**	Yes

pathway	
2.38 – Is the risk for all the pathways considered to be acceptable? **If yes: no further action is necessary** **If no: Go to 2.42**	No
2.42 – Indicate the relative importance of pathways. **Go to 2.43**	Importation of honey bees Movement of beekeeping equipment Importation of bumble bees Hive products Soil Freight Fruit Natural spread (although this would move up the list if SHB was present in EU countries)
2.43 – All the measures identified as being appropriate for each pathway can be considered for inclusion in regulations in order to offer a package of potential measures. In the interests of trade and cost effectiveness, the general principle should be to apply the least stringent measure (or measures) capable of performing the task adequately. The minimum measure applied to any invasive non-native species is the declaration in regulations that it	For each pathway the following measures should be considered: Importation of honeybees: increase awareness of pest in the beekeeping sector and for the general public, compulsory registration of beekeepers, determination of presence of feral colonies, increased surveillance (particularly if enters another EU country), use of appropriate field monitoring systems. Importation of bumblebees: increase end user (grower) and public awareness of pest, research to determine whether *Bombus spp*. imported to UK can act as a host, restriction of use of imported pollinators to closed systems, increased surveillance (particularly if enters

is regulated. This declaration prohibits both the entry of the invasive non-native species in an isolated state, and the import of consignments infested by the invasive non-native species.	another EU country), development and validation of rapid diagnostic tests, similar to those for honey bees. Hive products: increase public awareness of pest, investigation into molecular testing and treatment possibilities Soil: training of PHSI inspectors to recognise pest, investigation into molecular testing and treatment possibilities, increase public awareness of pest. Fruit: training of HMI and PHSI inspectors to recognise pest, investigation into molecular testing and treatment possibilities, increase public awareness of pest. Bee-keeping equipment: increase awareness of pest in beekeeping sector and of the general public, consideration of restriction of movement of beekeeping equipment, in particular PPE, from countries where SHB is present, cleaning of vehicles / equipment – especially if pest becomes present in EU. Freight: increase public awareness of pest Natural Spread (if SHB is present in EU countries): increase public awareness, increased surveillance and use of sentinel colonies.
Conclusion of invasive non-native species Risk Management.	Although current legislation and management practices are in place to prevent incursion of *Aethina tumida* to the UK, there are some additional measures that could be taken to reduce the risk. These would involve increasing public awareness, changes in policy and additional surveillance/training. In addition research is required in some areas to fully ascertain the threat posed by a pathway, for example, to determine whether the *Bombus* spp. imported to the UK can act as a host for *A, tumida*.