Review of policies on managing and controlling pests and diseases of honey bees

Evidence profile on European Foulbrood (EFB)

This is the evidence profile on EFB which was developed during the policy review. **Part 1** sets out an overview of EFB, current prevalence., biology and current control policy, including impacts and costs of the policy to beekeepers and Government. **Part 2** summarises the main points from discussions on EFB by the Review Group including insights on beekeeping practices and behaviours provided by Bee Inspectors and beekeeping representatives (note: Part 2 seeks to capture the main points from discussions and are not attributed).

Readers' guide

Part 1 - Overview of European Foul Brood (EFB) and current control policy

Incidence and geographic distribution of disease across England and Wales (E&W)– clinical and sub-clinical

1. **Inspection data**. The National Bee Unit's (NBU) pest and disease control (honey bee health) programme includes risk based and targeted apiary visits to inspect colonies for signs of pests and diseases. The programme uses a number of different processes to identify the number of apiaries to inspect including proximity to known risks and formulas to calculate the number of inspections required to detect a specific percentage disease level with a high level of confidence. Inspection data in Part 1 have been extracted from the NBU's BeeBase database including data on the public pages (www.nationalbeeunit.com).

E&W Inspection data:

Early days of inspections:

- The first foul brood order was introduced in 1942. In this year, around 1000 samples of brood were examined and around 60% were infected with foul brood.
- In 1943 more inspectors resulted in an increase in sampling -approx 1700. EFB was found in 43 samples. Inspections continued to increase in the mid 1940's to the mid 1950's. At the time the number of colonies was estimated at 450,000 to 500,000. [Colony numbers have declined since then due to the end of sugar rationing and increased urbanisation – estimated to be around 250,000 in 2012 with around 137,000 registered on BeeBase.]

Trends in numbers of colonies inspected:

- The number of colonies inspected per year was 75-100,000 from the 1950s until the late 1980s when the number of colonies inspected per year fell by 50% to around 35,000 followed by further reductions in the 1990s and 2000s (lowest level was in 2005 when 19,661 colonies were inspected).

Trends in national EFB infection rates – colonies (since 1952):

- For over 30 of the years between 1952 and 2011, particularly in the early part of this period, EFB was found in fewer than 400 colonies inspected, or around less than 1% of inspected colonies were found to be infected with EFB (see www.nationalbeeunit.com disease pages)
- However, in the last 20-30 years the number of EFB infected colonies per year has increased with 7 years during this period recording over 800 colonies infected. In 2000, 1041 colonies were infected (maximum recorded since 1952) or 3.84% of colonies inspected.
- After inspection levels fell by 50% and more in the 1980s, 1990s and 2000s, the percentage EFB infected colonies tended to stay at less than 1% in the late 1980s, and increased towards 2 or 3+% in the 1990s and 2000s.
- Since 2000, the number of EFB infected colonies has generally declined and the number of cases in 2010 was 445 (1.32% of colonies inspected) which was the lowest level since 1989. However, the number of cases in 2011 increased by over 50% to nearly 700. Even though the trend is one of decline, there is a continuing risk of spread/re-introduction of the disease.

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Inspections E&W	22,055	24,387	25,134	25,698	19,661	24,814	27,248	26,408	39,457	33,304	37,119
EFB cases (colonies)	839	667	673	691	677	556	626	846	588	445	695
EFB %	3.8	2.74	2.68	2.69	3.44	2.24	2.30	3.20	1.49	1.34	1.87

- It is helpful to consider these trends in EFB infection rates in the context of the various control policies deployed since the 1950s (see graph at Annex 1):
    - From 1942-67, symptomatic colonies were destroyed although this was found to be less effective for EFB (compared with AFB) as EFB was found in many more counties and the number of infected colonies detected each year increased.
    - In mid 1967, the antibiotic oxytetracycline (OTC) was introduced as the treatment of choice for symptomatic colonies and all contact colonies associated with the outbreak. Infected and contact colonies were subject to standstill notices (minimum of 8 weeks or overwinter).
    - By the mid- 1980s this policy response was considered to be suppressing, not eradicating or containing the disease. OTC had been widely used during this period as the response to EFB. About this time too, there were concerns about widespread antibiotic use and resistance issues which led to a further change in policy.
    - From 1984 to 2000 the policy response was OTC treatment of infected colonies only. During this period, EFB prevalence continued to increase (towards 4% of inspected colonies) and again it was considered that OTC use was suppressing rather than containing infection.
    - From the late 1990s until now, OTC and destruction continue to be control options for EFB although OTC tends only to be used to control EFB detected late in the season to help the colony get through the winter. In addition, shook-swarm is also deployed as a control option – this is an alternative drug-free method demonstrated by the NBU to be effective [Budge et al. (2010), project report for Defra funded project PH0502]. For example, this research showed a lower recurrence in colonies treated by shook swarm (8%) than with OTC (25%). However, it is not usually practicable to deploy shook swarm late in the season.

County/country data on EFB infection rates

There is a mixed geographical distribution of EFB with a lower incidence of cases in the north which could be linked to a number of different factors such as lower densities of beekeepers (than in the south), apiary density, climate or vegetation diversity. There were some well established entrenched areas with recurrent EFB and other areas where cases were sporadic. Areas of high EFB clinical cases were in the South and East. The disease has had a tendency to move northwards since 2001.

- Annex 2 (a) shows 2001 to 2011 data of the 11 counties in England and 7 counties in Wales which had persistent outbreaks (colonies) over several years.
- Annex 2 (b) shows EFB infections in the remaining counties in England and Wales from 2001 to 2011 (i.e. those where outbreaks tended not to be persistent). [Note: some discrepancies in totals due to differences in aggregation of data on BeeBase before and after 2006/07]

Persistent outbreaks

Looking in more detail at some of the counties (selected at random) with persistent outbreaks highlighted stubborn pockets of EFB and a high number of inspection visits undertaken to deal with recurrent outbreaks (and the associated costs).

In Norfolk, between 2001 and 2011, around 40 beekeepers had colonies infected with EFB. Of these, 15 beekeepers had infected colonies in more than two years (including 5 who had infections in three years, one in four years, one in five years and two beekeepers who had infected colonies in every year from 2001-2011). For these 2 beekeepers around 775 inspection visits were made to their apiaries over this 10 year period (at £200 per inspection visit the total cost to government over 10 years was approximately £155,000, excluding costs of antibiotic treatment).

In Kent, around 60 beekeepers had infected colonies infected with EFB between 2001 and 2011. Of these, 5 beekeepers had infected colonies in 3 years, 2 beekeepers had infected colonies in 4 years and 4 beekeepers had infected colonies in 7 years. One of these beekeepers had recurrent infection at the same apiary over 7 years. These four beekeepers had 168 inspections between them over this 10 year period.

In Dorset, around 70 beekeepers had infected colonies between 2001 and 2011. Of these, 5 beekeepers had infected colonies in 3 years, 3 beekeepers had infected colonies in 4 years. Two of these had over 30 inspections each over this 10 year period. One beekeeper had infected colonies in more than 6 years and had over 125 inspections over this 10 year period.

2. **Prevalence of EFB – Random Apiary Survey (RAS) results**

In 2009, Defra commissioned the NBU to undertake an assessment of the national picture of honey bee pests and diseases (with the intention of using this assessment to inform the future honey bee pest and disease control programme, including establishing agreed outcomes). The NBU undertook this assessment from 2009 to 2011 by a random survey of some 5000 apiaries (RAS) including apiaries with single and with multiple colonies.

From the RAS the prevalence of EFB across England and Wales at apiary level was estimated to be 1.2% in both Year 1 and Year 2. Apiaries owned by professional beekeepers were more likely to have EFB than those owned by amateur beekeepers.

Based on molecular analysis the pathogen prevalence for *M. plutonius* was estimated to be 1.6% in Year 1 and 1.3% in Year 2 which is consistent with the inspection data. However it should be noted that adult bees were used for these analyses and therefore the prevalence of brood pathogens is likely underestimated.

In terms of geographical distribution, [although there are only a limited number of data points from the RAS], EFB disease and the pathogen were detected across England and Wales and in most cases found in the same areas, although both were absent from some areas including northernmost counties (of England). These findings are largely consistent with the inspection data. See Annex 3 for a map based on RAS clinical and sub-clinical and inspection data for EFB (and AFB).

Brief overview of EFB pathogen – infectivity, virulence, pathogenicity, incubation period, clinical signs, impacts on productivity and/or mortality of colony, sources and means of disease spread, susceptibility of bees, persistence of spores.

References: Forsgren, E. (2010) Journal of Invertebrate Pathology, 103: S5-S9

1**. Infectivity, virulence and pathogenicity.** EFB is caused by the bacterium *Melissococcus* *plutonius* and symptoms can only occur when this bacterium is present. Infection occurs when larvae ingest food contaminated with the bacteria which then multiply in the larval mid-gut, competing with the larvae for their own food. The larvae die because they are starved of food and this normally happens before the larval cells are sealed although susceptibility decreases with increasing age. Other species of bacteria can then multiply in the remains of the dead larvae. Usually larvae die when they are 4 or 5 days old but infected larvae can survive and pupate. The infected larvae discharge contaminated faeces on the walls of the brood cells leading to further infection (highlighting the faecal/oral route as important for transmission of the infection).

The pathogenesis and transmission of *M. plutonius* is poorly understood and maybe subject to seasonal influence. It does not always follow that presence of the bacterium in the colony will lead to EFB symptoms and the colony may appear healthy. In addition, little is known about whether there are strains of EFB with different levels of virulence.

2. **Incubation period**. According to the OIE Terrestrial Code the incubation period is 15 days but this does not include the wintering period. Subclinical infections are common.

3. **Clinical signs.** EFB generally affects unsealed brood and kills larvae before they are sealed in the cells. An EFB infected larva moves within its cell instead of remaining in the normal coiled position. Dead larvae are twisted round the walls or stretched out in the cell. Dead larvae often collapse as though melted, turning yellowish-brown and eventually dry up to form loosely attached brown scales. When a high proportion of the larvae are being killed by EFB the bees will remove dead brood leading to a patchy and erratic brood pattern. Despite all these signs, EFB infections can be confused with other brood abnormalities making visual diagnosis difficult [Forsgren (2010)].

4**. Impacts on productivity and/or mortality of colony** EFB causes weakening of colonies which has an impact on productivity. In severe cases of EFB infection colony death can occur.

5. **Sources and means of disease spread**. There are various sources and means of diseases spread:

- Within the colony some infected individuals survive and deposit faeces containing bacteria into the comb when they pupate. Adult worker bees can act as carriers of the bacteria both within the colony and between colonies and apiaries. Significantly higher levels of *M. plutonius* were found in the rectums of dissected bees which supports the hypothesis that EFB has a faecal-oral route of transmission [Defra funded project PH0502].
- EFB has slower development of clinical symptoms (compared with AFB) which can lead to silent spread of this disease within the apiary and elsewhere before symptoms becomes apparent (and detectable at least by eye), leading to a larger outbreak.
- Routine beekeeping practices, such as transfer of brood comb from an infected hive to a healthy hive can also lead to spread of EFB. On a more positive note, in some cases where the NBU has informed beekeepers that the bacteria is present in their otherwise symptomless colonies (for example, as part of a research project), beekeepers have successfully taken steps to reduce the likelihood of an outbreak such as shook swarming their apiary.
- [It is worth noting that, contrary to views held by some beekeepers, moving infected colonies to an uninfected area in an attempt to help the bees overcome the infection will not work and instead will spread the infection into a new area].
- Another potential source of EFB infection is the robbing of weakened infected colonies in an apiary by bees from a neighbour’s healthy apiary.

In relation to other potential sources of the EFB agent in wildlife such as bumble bees, there is no available evidence to help our understanding of the situation.

6. **Susceptibility of bees to infection**. The trigger factors which led from the presence of the organism to clinical disease were not fully understood. There is some evidence to suggest that there may be some genetic resistance to EFB but as yet there are no known lines or breeds that are resistant to EFB. A project assessing UK races of bees did not find any single EFB resistance genetic provenance [Defra funded project PH0505].

There is some evidence to suggest that EFB may have more of an impact when nutrition is poor (for example where there are low levels of forage nectar). However, in the absence of the EFB causative agent, stress or other factors would not lead to or cause disease.

7. **Persistence in environment**
M. plutonius does not form spores and therefore it seems unlikely that the bacteria persist in the environment. However the bacteria can persist for long periods in combs and in addition sub-clinical levels of *M. plutonius* can be detected in colonies where there are no clinical signs of disease.

8. **Future prevalence**
The emergence of new strains of the EFB agent was always a possibility. Current understanding suggested that there are no specific strains causing concerns at present either here or in other countries. The emergence of strains with low virulence could potentially be as damaging, if not more damaging than those with high virulence, as symptoms would be slow to emerge with greater risks of (silent) spread without detection.
The presence of feral bees as potential reservoirs of EFB infection, could also impact on EFB prevalence in the future.

A range of other factors could influence future prevalence of EFB – including climate change, weather patterns, turnover in number of beekeepers, sources of bees, increased movement of bees (particularly due to the increased demands for bees from new beekeepers who have prompted an increase in the sale and movement of bees), and changes in the popularity of different strains of bees leading to changes in the gene pool and possible susceptibilities to EFB infection.

Current policy aims

To prevent, control and eradicate EFB.

The current objective of the bee health programme is :
- To protect stocks of honey bees needed for the pollination of agricultural and horticultural crops, as well as wild plants, and for the production of honey and wax; by
- Preventing the introduction of serious exotic bee diseases into the country, and limiting the spread and impact of serious notifiable diseases that are already present.

Note: this is being updated (see proposals in Defra and Welsh Government's 2012 consultation document ' Improving honey bee health – proposed changes to managing and controlling pests and diseases'

Current controls (including legislation)

1. **Summary overview of legislation and controls**:
EFB is a notifiable disease under domestic legislation. EFB is not notifiable under EU legislation and there are no requirements for freedom of the disease in trade. However, the EU legislation provides for national programmes for certain diseases (including EFB). If a member state can demonstrate freedom from EFB, they can require additional requirements to keep out the disease as part of the intra-trade health certification.

The specific provisions in the Bee Diseases and Pests Control Order 2006 in relation to EFB controls at the apiary are set out in Annex 4. In practice, the NBU implements these provisions as follows:

- following notification by the beekeeper (who is legally obliged to notify suspect cases to the NBU) and confirmation by the bee inspector, the apiary is put under movement restrictions and all affected colonies and associated equipment liable to spread disease are treated or destroyed depending on the level of infection, the time of year and the strength of the colony. In some cases at the end of the season, OTC antibiotic is used as an interim response (administered by a bee inspector) to prevent disease spread until shook swarm (husbandry method) can be carried out as a treatment.
- the standstill on movements remains on the apiary for a minimum of six weeks to allow time for any infection not obvious at the first inspection to develop and become visible. As soon as possible after this period, all the colonies in the apiary will be re-inspected. If the infection is found late in the year, this follow up inspection will be at the beginning of the next season. The standstill notice is withdrawn when there are no signs of the disease.

In addition, when EFB is confirmed, the bee inspector usually inspects apiaries in the surrounding area (up to 3km) and follows up contacts to check for disease symptoms and will implement control measures if disease is found. These additional inspections are precautionary to minimise risk of spread and disease recurrence.

2. **OIE guidelines**
There are OIE guidelines on trade and determination of EFB status of a country/zone. According to the OIE, most member states list EFB as a notifiable disease (Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Latvia, Lithuania, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden) and a number of these have general surveillance and movement controls.

3. **Other discretionary elements of disease control**:
- The NBU's Foulbrood advice leaflet highlights good practice on management and prevention of EFB, such as comb replacement and barrier management (quarantine) at colony or apiary level. Quarantine helps minimise the spread of infection in at risk colonies or in colonies with recent foul brood outbreaks.

- The NBU's surveillance programme both checks the effectiveness of current policy and helps to prevent further spread. It targets apiaries at high risk of disease (whether AFB or EFB). Inspections are normally carried out from April to September and are free of charge. The NBU's current prioritisation of the risk-based inspection programme is as follows:

Inspection Priority	Description
1	Foul brood infected apiaries Apiaries within 3km. of confirmed Foul Brood or 10km of Exotic Pest

	Risk Entry points. Colonies where disease is suspected, or those close to apiaries where foul brood disease has been confirmed. Colonies purchased or moved from infected apiaries, i.e. contact colonies. Apiaries having a history of foul brood disease. Colonies in areas where foul brood disease is thought to be prevalent.
2	Destructions/Treatments. Follow-up inspections in the season (April - September) after Standstill Notices have been withdrawn i.e., where foul brood was confirmed in the previous year.
3	Call out by beekeeper and inspections of colonies from which voluntary samples have been submitted
4	Follow up inspections, e.g. apiaries that have remained under Standstill over the winter.
5	Import and export examinations of bees under veterinary checks directives.
6	Assistance with suspect pesticide damage to honey bee colonies.
7	Honey sampling for statutory residue analysis on behalf of the Veterinary Medicines Directorate.
8	Education and extension programme on disease recognition and other aspects of beekeeping, helping to raise awareness for rapid detection and compulsory reporting of notifiable diseases.
9	Exotic Pest Surveys around known risk points- Exotic pest checks are also carried out within other inspection activities as appropriate.
10	Random 10km square inspections (Random 10km squares are those in which the visits at 1,2,3,4,5,6 and 8 are not required and beekeepers within that square have not been inspected for some time. Priority cascades to those squares that have not had any visits for 5 years or more, with the oldest dates of inspection being targeted before more recently visited squares.

- The NBU provides training and education of beekeepers on disease recognition and on other aspects of beekeeping, helping to raise awareness for rapid detection and compulsory reporting of notifiable diseases.

4. **Actions taken to control EFB outbreaks**

The table below shows data from BeeBase on the actions taken in infected colonies in England and Wales in response to EFB outbreaks and the proportion of each control option. The options comprise: destruction of infected colony(ies), treatment with antibiotics (as an interim response) and shook swarm (husbandry method).

All three control options were used each year with no particular preference shown looking at national level data, except in 2010/11 when the proportion of EFB cases treated with OTC was much lower (14.9%-18.2%) than in previous years (when around 30% of cases were treated with OTC).

Statutory action taken	2006	2007	2008	2009	2010	2011
England						
Destroyed	169	201	318	205	187	309

	(29.5%))	(31%)	(36.7%)	(35.4%)	(41.8%)	(43.7%)
OTC Treatment	227 (39.6%)	195 (30.1%)	227 (26.2%)	194 (33.5%)	67 (14.9%)	129 (18.2%)
Shook swarm	172 (30%)	236 (36.5%)	284 (32.8%)	174 (30%)	182 (40.7%)	247 (34.9%)
Wales						
Destroyed	4 (0.6%)	9 (1.4%)	15 (1.7%)	1 (0.2%)	6 (1.3%)	8 (1.1%)
OTC Treatment	0	0	0	0	1 (0.2%)	4 (0.6%)
Shook swarm	1 (0.2%)	6 (0.9%)	21 (2.4%)	3 (0.5%)	4 (0.9%)	10 (1.41%)
Total colonies from this table(some discrepancies with page 1)	573	647	865	579	447	707
EFB cases E&W from table on page 1	556	626	846	588	445	695

Source: BeeBase data August 2012

Effectiveness and impacts of current controls

Both the inspection data and the RAS data indicate a current low prevalence of EFB in England and Wales:

- Inspection data – EFB has reduced from 1041 colonies in 2000 (maximum recorded since 1952) or 3.84% of colonies inspected to 695 (1.84% of colonies inspected) in 2011. Data for 2010 was lower still at 445 cases (1.32% of colonies inspected) which was the lowest occurrence of EFB since 1989.
- RAS - prevalence of EFB across England and Wales was estimated to be 1.2% at apiary level in both Year 1 and Year 2. Based on molecular analysis the pathogen prevalence for *M. plutonius* was estimated to be 1.6% in Year 1 and 1.3% in Year 2 which is consistent with the inspection data.

Trends in colonies with EFB suggests an increase in the number of colonies infected in the last 20-30 years (see graph at Annex 1), particularly between the late 1980s and early 2000s, although the percentage of colonies infected was still low overall at not more than 4% of colonies inspected. Numbers have declined again in more recent years.

This is a mixed picture when considering the effectiveness of the current controls. Whilst controls do look effective overall given that the prevalence of EFB is low, the variability in the data and the increased prevalence in the 1990s suggests the influence of control measures and/or other factors. One key issue is whether use of OTC since the late 1960s – first to deal with symptomatic and ‘contact colonies’ and later to deal with symptomatic colonies only – rather than destruction of infected colonies, has possibly led to the higher number of EFB cases observed in subsequent years (due to suppression of the bacterium and disease by OTC). It is impossible to assess whether a destruction policy alone would have avoided the increased cases in the 1990s although this remains a valid question (and this would have been a lower cost response for each outbreak to government).

In addition to questions about the predictability and effectiveness of controls, particular features of the causative agent (*M. plutonius*) also present challenges to management and control policies. For example, apparently healthy colonies may harbour the bacterium leading to the potential for silent spread within the apiary or to other apiaries (through bees and/or beekeeping practices). This may suggest that effective management of EFB requires actions across the whole apiary rather than only dealing with the infected colony. Effective management of this disease also demands appropriate actions by the beekeepers to reduce risks of disease spread and/or recurrence in their apiary (ies).

Costs incurred from EFB outbreaks

1. Beekeepers and inspectors have provided the following examples of costs incurred when EFB has been confirmed on an apiary. The replacement costs include the destruction of colonies and lost honey production.

Example 1 (source: beekeeper)
Based on average costs, frame costs for a full colony - £68.74
Lost honey production - £357.00
Replacement queens+50% for losses - £56.25
Replacement bees (taking bees from working hive - £90.00
at 25% of that hives honey production
Cost of destruction and follow up (2 days @£100) - £200.00
Total costs associated with EFB/AFB limited to one hive £571.99

Example 2 (source: beekeeper)
Around £1000 per outbreak in an apiary due to replacement costs of new queen/bees and if he/she has to purchase a new hive/box, plus consequential losses of honey in that season.

Example 3 (source: bee farmer)
In total, the economic impact of a lost colony due to destruction as a result of notifiable disease can be assessed at between £500-£800 per colony from:
a) a complete loss of honey production for the colony for the season
b) a reduced honey production in the donor hive to repopulate the destroyed colony
c) replacement cost of the hive components destroyed
d) labour to destroy the diseased colony and build-up the replacement colony.
Note: some professional beekeepers invest in infrastructure to improve their results e.g. in one case £25,000 in a sterilising plant for cleaning frames.

Note: an infected colony which is treated for EFB rather than destroyed will have reduced honey production that season, falling from 25kg per hive towards zero kg.

Example 4 (source: NBU Bee Inspector)
Average colony value (replacement bees – on frames – and honey yield) £350 plus £60 (frames £20,
foundation £10, plastic queen excluder £5, labour £25 (2hrs)) = total of £410 to replace destroyed colony.

There may also be further costs such as non-fulfilment of pollination contracts (eg, currently a hive is charged at £50 for specialist crop pollination services such as soft top fruit and up to £100 within a greenhouse) and other costs associated with standstill notices being imposed.

Insurance against losses

2. Bee Disease Insurance Ltd. (BDI) is an insurance company set up and run for beekeepers by beekeepers. It promotes research, education and disease control methods for honeybee disease. It also compensates subscribing beekeepers in England and Wales in respect of losses caused to their colonies by the statutory honeybee diseases and pests. For beekeepers owning 40 or more hives a different scheme (Scheme B), operates. This scheme is available to beekeepers that may or may not be members of a BDI member association.

To government

3. The costs incurred by Government relate to surveillance, investigation, diagnosis, disease control measures, including outbreak investigation, education and training (all provided free of charge). Costs incurred per outbreak are difficult to determine. Surveillance costs are the largest element incurred by Government ie, the costs of actively looking for disease and checking the effectiveness of disease control policy – 64% of bee health programme is surveillance for both EFB and AFB = £1.136k per year. In addition the cost of OTC to government = approx £2,400 in 2011.

4. A case study from Scotland showing the costs incurred by the Scottish Government over recent years to deal with AFB and EFB outbreaks is at Annex 5.

Part 2 - Main points made on EFB policy by the Review Group. These points were taken into account in developing the proposed changes to EFB policy.

1. Are we succeeding to achieve our policy aims?

- The low levels of EFB observed from inspection data and from the RAS results suggested that current controls are working well and policy aims are being achieved (to limit the spread and impact of EFB as part of an overall aim of protecting stocks of honey bees for pollination services).

- Whilst EFB is largely under control in England and Wales as demonstrated by the current low prevalence, the variability in the data and the increased prevalence during the 1990s (which has come down since then – see Annex 1) suggest an incomplete understanding about the disease and causative agent. These data also raise questions about the predictability and effectiveness of control measures, including whether use of OTC suppresses (rather than eliminates) the causative agent and/or disease and facilitates silent spread across parts of the country exacerbated by shortcomings in beekeepers' husbandry and disease prevention practices.

2. Effectiveness of the response?

- Key to successful control was finding EFB early and getting on top of it**.** Early notification of suspect cases to the NBU or detection of cases by bee inspectors were important first steps to ensure prompt implementation of control measures, followed by standstill on the rest of the apiary, and inspection of contacts and neighbours to check for disease.

- The Review Group considered the effectiveness of destruction, OTC treatment and shook swarm of infected colonies in controlling disease **and also** the role of beekeepers:

Destruction

- There was some support for the first response to be colony destruction rather than OTC treatment as this would reduce the levels of the causative organism quickly in the apiary (there were greater uncertainties in this regard about the success of OTC treatment and shook swarm).

- Destruction would also be the most cost effective option for government. However, it was recognised that a destruction-only control policy would have cost implications for the beekeepers (although costs would be met in part for those beekeepers insured through BDI).

- Bee farmers who have managed EFB effectively have usually opted for a whole apiary approach to control, and for destruction if EFB was widespread in the apiary.

OTC treatment

- The Review Group had mixed views on the use of OTC as a treatment option. Some members ruled it out on the basis that it had suppressed and masked disease, as demonstrated by the historical data. In addition the use of antibiotics was not supported by most hobby beekeepers.

- Other members thought OTC did have merits in certain cases particularly late in the season when shook swarm cannot be carried out.

Shook swarm

- Although an effective method as demonstrated by NBU research (Budge, et al (2010), the use of shook swarm has been limited in the field as beekeepers were not prepared to invest the time and effort required to get on top of the disease using this method. Some beekeepers still remained to be convinced about the effectiveness of shook swarm.

- NBU analysis has shown that the whole apiary approach to EFB control using shook swarm significantly reduced the number of colonies testing positive post treatment. There was a lower recurrence of EFB in colonies where shook swarm was applied (8%) than where OTC was applied (25%). [Defra funded project PH0502]

- Case studies from NBU's inspection records have demonstrated the effectiveness of whole apiary shook swarm on clearing up EFB infection.

Role of beekeepers in the successful control of EFB

- Case studies from NBU's inspection records highlight the many factors under the direct influence of beekeepers which contributed to the successful control of EFB. The Review Group considered that some beekeepers' attitudes and perceptions were acting as a significant barrier to getting on top of EFB and disproportionately affected its successful control. Such unhelpful attitudes were in evidence from inspection records; for example a high number of repeat inspection visits had been necessary over the last 10 or more years to a limited number of beekeepers who have persistently mis-managed EFB.

- It was crucial for all beekeepers – whether following traditional or natural beekeeping practices

- to recognise the important role they play in preventing and controlling EFB in their apiaries and to take appropriate actions, including in partnership with the bee inspectors and showing consideration for their beekeeping neighbours (eg, when moving their bees). Contact from the bee inspector giving warnings of cases of infection nearby was welcomed and could be used further to encourage cooperation to control outbreaks.

- Factors under the direct control of all beekeepers to manage EFB include:
    - following good husbandry practices such as regular observation of their bees, strict controls on movement of colonies, taking care when sourcing and buying nucleus colonies, regular checks over winter and destroying poor colonies;
    - implementing barrier management and integrated pest management (see the NBU's Foulbrood advisory leaflet) as well as other biosecurity and disease prevention measures.

- Two case studies had shown that when beekeepers were provided with evidence of pathogen presence in their otherwise symptomless apiaries, they had voluntarily decided to treat their colonies by shook swarm to minimise the risk of disease occurrence.

- Although some bee farmers have got on top of EFB and do not feel dependent on the NBU for this, many had not succeeded in dealing with the disease as shown from the recent data from RAS and inspections which found that bee farmers were more likely to have EFB than amateur beekeepers.

- We needed tougher policies to address the problem of (the limited number of) beekeepers with recurrent outbreaks of EFB who do not follow the bee inspector's advice to improve their beekeeping practices leading to continuing disease risks at their apiaries and risks to other beekeepers' apiaries nearby. Current policies in these and possibly other cases did not appear to offer the right incentives or signals for beekeepers to accept disease as a liability and to take appropriate action to address/minimise disease risk and spread.

- It was recognised that paying attention to nutritional requirements of the apiary, access of the bees to forage and colony density (and associated competition for forage) were additional factors for beekeepers to get right in order to help their colonies thrive.

- It was also recognised that 99% of beekeepers kept bees as a hobby which had implications for disease control responsibilities with at least some beekeepers not aware of these responsibilities or not taking them seriously. However, it was also recognised that policies had been developed and were successful in another hobby/amateur sector (pet ownership) which had led to improvements in animal welfare .

4. What's stopping the eradication of EFB?

- Uncertainties about the predictability and effectiveness of control measures and shortcomings in beekeeping practices, as described under Q1 and Q2 of Part 2, suggested that eradication was not likely to be achievable under present policies and circumstances. However, as disease prevalence was low, eradication could be a realistic aim assuming more predictable control measures and improvements in beekeeping standards (although ongoing importation of honey bees, given that EFB is not regulated at EU level, presented a continuing risk of importing the infection. Evidence suggested that this was a low risk – see Annex 2 (c)).

5. Education and training

- Training beekeepers to observe their colonies, to recognise disease and to improve their husbandry skills were the key to the effective management of EFB. Changing attitudes and perceptions of those beekeepers who were uncooperative and a barrier to effective EFB control were important aspects of training programmes.

- Beekeepers should have access to disease materials (under controlled conditions) for training purposes in addition to a wide range of other material and training aids.

- An important role for the NBU was to enable beekeepers to identify and manage disease through training and knowledge transfer.

6. The legal status of EFB as a notifiable disease

- The Review Group considered the case for and against the legal status of EFB as a notifiable disease and alternatives to regulation. EFB was not notifiable under EC law (Directive 92/65/EEC which governs trade in animals and products) although Member States had discretion to have EFB national control programmes – the UK had chosen to do so.

- Some members challenged whether the notifiable status for EFB was necessary for its effective control. If EFB was not notifiable, this raised the possibility of managing it in different ways as a disease needing routine management by beekeepers in cooperation with each other, and with the assumption of a greater role for associations. This approach would require improved education and training to enable beekeepers and grow their self-reliance. It would free up NBU resources for other priorities with an improved overall outcome for bee health. It was important to ensure the efficient allocation of public and private resources based on risks so that the focus is on pests/diseases that cause the maximum damage.

- Other members expressed concern about removing EFB's notifiable status (deregulating) as this would increase EFB prevalence across the country and reverse the impacts of the EFB control programme which had been in place for many years and had reduced EFB prevalence to low levels. More EFB cases would lead to greater private costs to beekeepers and potential impacts on pollination services.

7. Where can we innovate and work in different ways to maintain EFB at current low levels including the role of the beekeepers ?

- The Review Group considered a number options for innovation and change having first reviewed the current EFB control programme, as set out below.

Advantages and disadvantages of the current programme:

- **Advantages** – has led to effective prevention and control of EFB in most cases. Big outbreaks are now rare. It had the added benefit of dealing with other serious pests and diseases as part of the NBU's integrated programme and provided beekeepers with 1 to 1 training.

- **Disadvantages** – the EFB programme uses disproportionate amount of resource given the (current) low level of risk (mismatch between risk and resource) and the per inspection visit cost seemed high (although depends how the benefits were measured given the NBU's integrated programme covers the full range of serious pests and diseases). Current controls were 'too soft' for certain individuals and this was associated with lack of co-operation, barriers to improving disease control and recurrence of EFB in certain areas. The current programme does not fit with government policy of reduced regulation burden and could do more to enable beekeepers to improve the management of their colonies.

Refined objectives/goals for the EFB control programme shared by government and stakeholders:

- **Prevent** – prevent spread to areas where disease is currently absent (1st priority, short term - R_o would be <1) ; **Control** – to reduce incidence of disease in areas where it is currently established (2nd priority, medium term - R_o would be <1); and **Eradicate** – eradicate from areas as/if this becomes feasible (regionally) (3rd priority, longer term - R_o would be 0).

Note: The basic reproduction number of an infection is the mean number of secondary cases caused by an individual infected soon after disease introduction into a population with no pre-existing immunity to the disease in the absence of interventions to control the infection. $R_0 < 1$ the infection will die out in the long run (provided infection rates are constant). But if $R_0 > 1$ the infection will be able to spread in a population. The larger the value of R_0, the harder it is to control an outbreak/epidemic.

Changing policies and approaches to provide the right signals and/or tools for beekeepers to take action on EFB

- Make more use of the powers within the legislation in relation to penalties for beekeepers who knowingly move or sell diseased colonies. The Regulations include a fine of up to £5,000 but this has been rarely imposed.

- Need to consider and develop a new policy for beekeepers with recurrent outbreaks of EFB (from whom we can learn a lot about control policy) and also for difficult beekeepers in order to change their behaviours so that they adopt and develop good practice to reduce disease risks. A ‘three strikes and you’re out’ (or similar) approach could be developed as a workable solution although it might lead to beekeepers not reporting disease and/or refusing visits by bee inspectors. It also might be difficult to justify as beekeepers following good practice could get disease from neighbours who were not following good practice.

- Apply the principles of earned recognition by rewarding beekeepers who follow good practices and effective disease control policies, whereby these beekeepers would have greater autonomy to manage and control EFB (and bee inspectors would not undertake routine inspections of these beekeepers’ apiaries hence reducing inspection burdens on these beekeepers). Consider accrediting these beekeepers so that inspectors focus on high risk beekeepers and rarely visit low risk (accredited) beekeepers except for spot checks or audit purposes. This approach would help free-up inspectors time to focus on work where real improvements could be made. To gain accreditation, the beekeeper would have to ‘prove’ their disease recognition and management skills to the NBU (in a way to be developed/ agreed). This approach would need to be introduced cautiously at first but, subject to success, could numbers could grow over time.

- We need to better understand the current public/private cost sharing. Transferring responsibility for disease control/management to beekeepers needs to be looked at to ensure efficient allocation of public and private resources based on risks so that the focus is on the pests/diseases that cause maximum damage.

- The development of currently available lateral flow devices or other beekeeper-friendly diagnostics was considered in order to provide new tools for beekeepers to detect EFB disease and/or confirm the presence of the pathogen. These tools would empower beekeepers to manage EFB and the pathogen. However, the availability of such tools would be subject to successful technical development, the willingness of beekeepers to purchase and use them and the availability of resources to develop them.

- It was important for beekeepers to have the right information to assess the risk of their operation including impacts of moving their colonies (for forage and/or pollination services). Work was in progress by the NBU to build in a post code search facility on BeeBase (to help identify other apiaries in the new area).

- Beekeepers needed more self-learning tools as part of a coordinated education programme (NBU, associations and other learning providers such as the NDB).

Role of beekeeping associations

- Although some local associations are doing this well, many local beekeeping associations needed to play their part in helping to control EFB by raising awareness and understanding about the disease amongst their members, including giving due prominence at local meetings to sessions on disease prevention and control including those delivered by bee inspectors.

- In relation to BDI's insurance scheme, to which beekeeping associations subscribe on behalf of their members, does this give a false sense of security to beekeepers that they can recoup some of the costs from colony destruction due to notifiable disease, and increase the feeling that EFB (and AFB) can be left to bee inspectors to worry about?

Using population biology to help assessment of EFB response options/control strategies

- Using population biology principles and approaches to determine the population structure of EFB (whether traditional, metapopulation or source-sink) could help the assessment of impacts of changes in policies on the number of EFB cases, including whether (depending on the EFB population structure) all EFB cases needed to be controlled as some cases would die out anyway and be self eliminating (ie, it would not be necessary to control these cases).

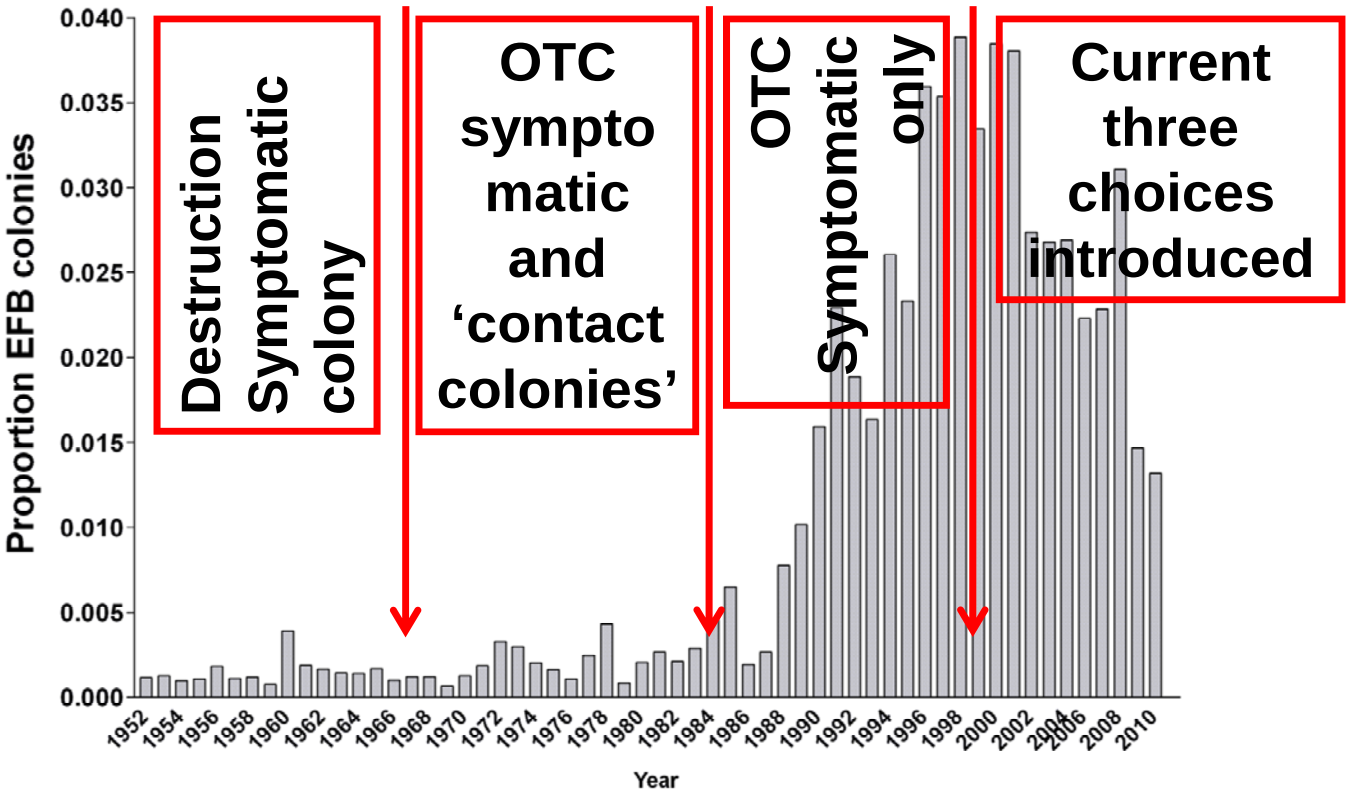
- The focus of controls were currently on eradicating disease in individual colonies or apiaries wherever/whenever it was found, based on assumptions about the dynamics of EFB (although these have not been identified). Whereas a more effective (and potentially lower cost) response could be to control disease in specific local populations of apiaries (to be defined/identified) as these could be the main source of infection in that area (depending on the EFB population structure).

- It was recognised that one of the ongoing projects funded by Defra, Scottish Government, BBSRC, NERC and the Wellcome Trust under the Insect Pollinator Initiative was on the epidemiology of EFB and may help provide understanding of the dynamics of EFB at population level. The project will be completed by December 2013.

Annex 1

Source NBU

The Historic perspective EFB prevalence in E&W



Annex 2 (a) - Shows 2001 to 2011 data of the 11 counties in England and 7 counties in Wales which had persistent EFB outbreaks (colonies) over several years (Source: BeeBase data August 2012)

England	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Gtr London	44	40	29	23	55	19	13	4	34	29	36
Norfolk	66	82	73	92	65	77	104	100	63	64	76
Devon	71	59	70	88	97	84	85	59	45	39	46
Kent	76	26	27	29	35	25	32	39	47	24	55
W Sussex	103	67	51	26	15	7	22	26	21	32	43
Suffolk	25	2	7	10	12	18	47	39	26	12	35
Dorset	35	70	58	38	25	44	36	111	41	7	37
Hampshire	84	55	69	44	32	26	37	57	40	19	56
Oxford	24	12	7	10	11	28	17	63	32	19	31
Surrey	35	49	36	16	26	5	19	20	14	14	17
Somerset	46	57	53	79	70	36	19	45	19	3	21
Other counties (break-down in Annex 1(b))	207	130	173	218	224	179	191	245	202	172	218
Total colonies infected	**816**	**649**	**653**	**673**	**667**	**548**	**611**	**808**	**584**	**434**	**671**
Total Inspect-ions						**20097**	**22147**	**22182**	**33294**	**28431**	**31826**
% colonies found infected						**2.73**	**2.76**	**3.84**	**1.75**	**1.53**	**2.11**
Wales											
Clwyd	7	8	3	3	0	0	0	11	0	0	0

Dyfed	7	10	5	10	10	7	7	17	1	2	2
Gwent	0	0	0	1	0	0	0	7	0	0	2
M. Glamorgan	5	0	3	2	0	0	4	1	3	7	17
S. Glamorgan	0	0	4	1	0	0	1	0	0	1	1
W. Glamorgan	1	0	0	1	0	1	3	0	0	1	2
Powys	3	0	5	0	0	0	0	2	0	0	0
Total colonies	**23**	**18**	**20**	**18**	**10**	**8**	**15**	**38**	**4**	**11**	**24**
Total Inspections						4717	5101	4226	6163	4873	5293
% colonies found infected						0.17	0.29	0.90	0.06	0.23	0.45
Total E&W inspect-ions	**22055**	**24387**	**25134**	**21369**	**19661**	**24814**	**27248**	**26408**	**39457**	**33304**	**37119**
Colonies infected	**839**	**667**	**673**	**691**	**677**	**556**	**626**	**846**	**588**	**445**	**695**
% E&W colonies found infected	**3.8**	**2.7**	**2.6**	**3.2**	**3.4**	**2.24**	**2.30**	**3.20**	**1.49**	**1.34**	**1.87**

Annex 2 (b) - EFB outbreaks (colonies infected) – breakdown of ‘other counties’ shown in Annex 2 (a)

County	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Avon	0	0	0	13	15	11	3	2	0	22	10
Beds	3	3	15	4	0	0	2	0	0	0	0
Berkshire	33	19	7	0	6	8	7	2	2	8	13
Bucks	11	1	3	1	2	4	0	2	9	8	24
Cambs	2	0	0	18	21	6	3	4	0	1	1
Cheshire	6	0	10	8	24	17	22	11	17	7	21
Cornwall	12	25	25	10	35	22	21	11	7	1	1
Cumbria	0	0	0	0	0	0	3	0	0	0	0
Derbyshire	0	0	1	1	12	6	5	15	4	0	2
E. Yorks	0	0	0	0	0	0	4	0	0	0	0
Essex	48	18	23	11	5	1	2	24	15	5	12
E. Sussex	23	4	7	8	4	9	7	7	12	15	10
Gloucs	0	0	2	0	3	6	2	3	17	4	13
Gtr Manchester	1	4	5	8	10	0	2	0	0	0	2
Herefordshire	18	7	13	16	3	3	0	6	4	7	13
Hertfordshire	22	22	16	6	9	4	0	4	8	0	0
Isle of Wight	0	0	1	0	0	0	0	0	3	0	0

County	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Lincs	1	0	18	19	1	0	19	16	18	13	28
Leicestershire	0	0	2	0	4	0	0	0	0	1	0
Merseyside	0	3	1	1	0	0	0	0	0	0	1
Northants	0	0	0	0	0	0	1	2	2	3	4
N. Yorks	0	0	0	0	1	4	19	80	41	28	24
Notts	0	0	0	0	6	0	0	3	4	2	0
Rutland	0	0	0	0	0	0	0	0	2	0	0
Shropshire	5	0	0	3	10	3	0	2	0	1	0
Staffordshire	0	0	1	76	51	25	14	22	15	19	0
S. Yorkshire	0	0	0	0	2	28	27	4	0	1	5
W. Yorks	0	0	0	0	0	12	9	4	11	1	13
Warwickshire	19	12	19	1	0	0	7	0	3	6	10
W. Midlands	0	1	0	8	0	0	0	0	1	0	0
Wiltshire	2	3	3	3	0	8	0	21	2	19	4
Worcs	0	0	0	0	0	2	1	0	5	0	7
Total	206	122	172	215	224	179	180	245	202	172	218

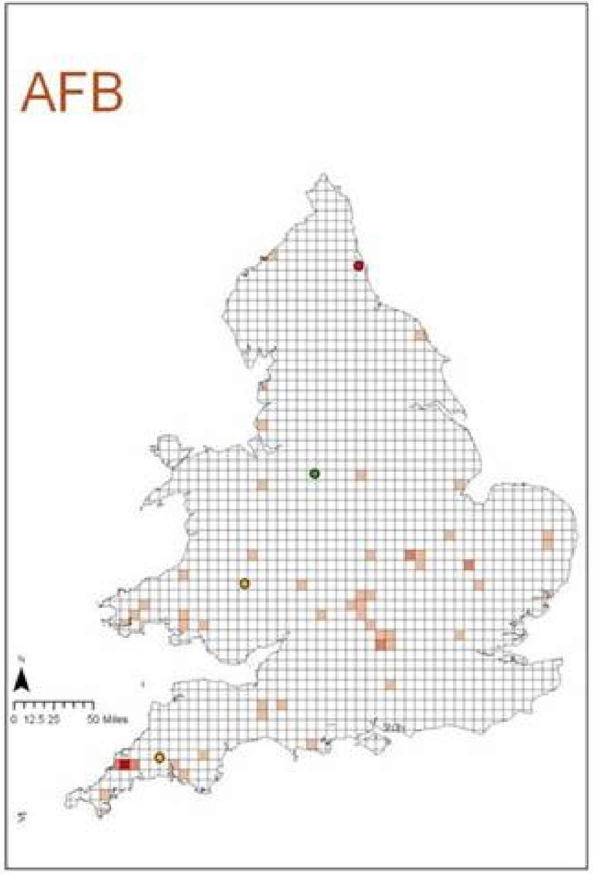
Note: some inconsistencies in totals

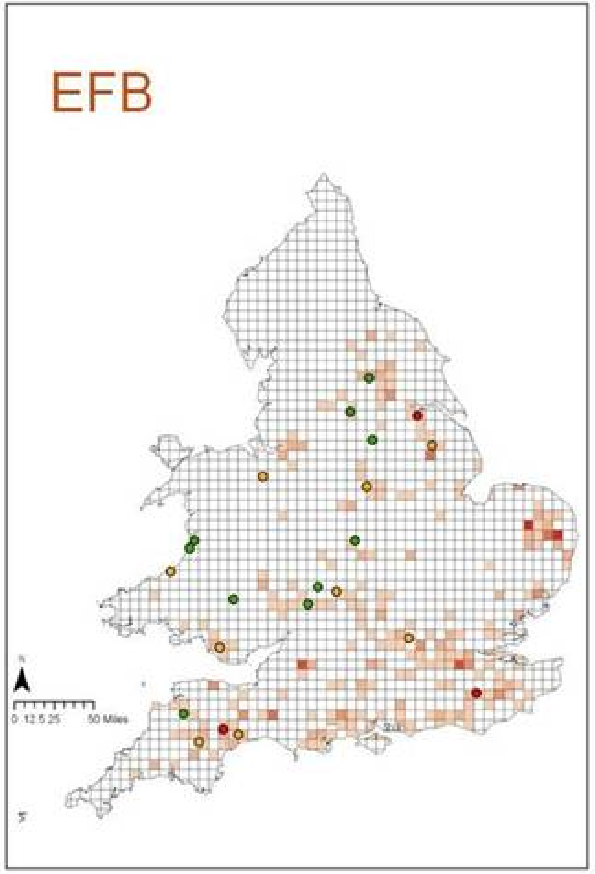
Annex 2(c) - Number of EU imports and detection of pests or diseases from 2007 to 2011

(Source: BeeBase inspection records):

Year	Queens	Nucs	Total No of imported consign-ments	Physical inspections	Documentary checks	Findings
2007	7741	0	97	6 (6%)	4 (4%)	0
2008	5609	300	99	22 (22%)	15 (15%)	4 – bald, chalk brood, failing queen 1 EFB, 2 AFB
2009	5606	12	80	20 (25%)	40 (50%)	3 – chalk brood, varroa
2010	7291	100	125	19 (15%)	75 (60%)	6 – chalk brood, sac brood, varroa
2011	4163	405	86	16 (18%)	37 (43%)	1 AFB. chalk brood

Annex 3 - Map of EFB (and AFB) cases in England and Wales from inspection records and from Random Apiary survey





Red squares represent all disease finds for 2 years (priority + RAS)

Red/ amber/ green circles represent the symptomless positive apiaries

Annex 4 - Further details of legislation governing EFB

EU Legislation:

- EFB is not a notifiable disease under EU legislation.
- There are no requirements relating to EFB for bees traded between member states or imported from third countries.
- Intra-EU trade is not subject to compulsory inspection, although spot checks are allowed. The NBU carries out a 50% documentary check and 30% physical check of consignments imported from other member states. No follow up action can be taken with the member state of origin if EFB is found.

EFB is also listed in the OIE's *Terrestrial Animal Health Code.*

Specific provisions in the Bee Diseases and Pests Control (England) Order 2006 in relation to EFB: Legislation (to control disease outbreaks):

Article 3 of the Order makes provision for the notification of the presence or suspected presence of a notifiable disease or a notifiable pest to the Secretary of State (in practice this is the NBU). The giving of such notification triggers a prohibition on the movement of things that might spread the disease or pest (article 4). Under the Order, European foul brood is specified as a notifiable disease.

Where an authorised person (for the purposes of the Order this is an NBU Bee Inspector) has reasonable grounds for suspecting the presence of a notifiable disease or a notifiable pest, he/she must serve a notice prohibiting the movement of certain items (article 6(1)).

Article 7 sets out the measures that apply on confirmation of the presence of a notifiable disease. In the case of EFB, this provides that a Bee Inspector shall serve a notice to the owner or person in charge of a hive, requiring the destruction or treatment of any bees, combs or bee products from the hive; may serve a notice requiring the destruction or treatment of debris from the hive and any appliances or things liable to spread the disease; and may serve on any other person who is the owner or person in charge of any appliances or other things liable to spread the disease a notice requiring their destruction or treatment.

Article 12 requires the provision of facilities and the giving of information to Bee Inspectors where a notifiable disease is suspected. Article 12 also prohibits the use of substances that may disguise the presence of or render difficult the detection of a notifiable disease other than in accordance with a notice requiring treatment under article 7.

In accordance with section 1(7) of the Bees Act 1980 breach of any provision of the Order or of any condition imposed by any licence issued under the Order constitutes an offence punishable on summary conviction by a fine not exceeding level 5 on the standard scale (currently £5000).

The Order is available at:
http://www.legislation.gov.uk/uksi/2006/342/introduction/made

Annex 5 - Case studies from Scotland

		2009	2010	2011
Inspections		2717	3139	3484
Cases	AFB	136	11	4
	EFB	310	71	126
Response				
Costs (Govt)		£127k	£104k	

*note about 2011 outbreaks – the 126 cases of EFB occurred in 42 apiaries; 12 beekeepers were affected. Perth was the county in Scotland with most cases accounting for 81 of the total; these occurred in 26 apiaries owned by 4 beekeepers.

References:

Budge, G.E., Barrett, B., Jones, B., Pietravalle, S., Marris, G., Chantawannakul, P., Thwaites, R., Hall, J., Cuthbertson, A.G.S. and Brown, M.A. (2010) The occurrence of *Melissococcus plutonius* in healthy colonies of *Apis mellifera* and the efficacy of European foulbrood control measures. *Journal of Invertebrate Pathology,* **105;** 164-170.

Posted on the Defra science pages; http://randd.defra.gov.uk/

Final report for Project PH0502 - Assessing the effectiveness of shook swarm as a husbandry method for the control of European foul brood

Final report for Project PH0505 - Investigating novel control methods for honey bee pests and diseases