Honey Bee Health

Research Concepts

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British Beekeepers' Association

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Executive Summary

Honey bees play a vital role in the environment and agriculture through their pollination activity

Food security is dependent on honey bee pollination

There is a global problem with honey bee health

Existing disease threats are not fully understood and new problems such as CCD are as yet unexplained and unresolved.

Research is urgently needed to elucidate disease issues and to provide solutions.

Substantially increased Government funding is required to provide the £8+ million needed to finance a programme of research to confront the problems.

Beekeeping in the UK contributes over £165 million p.a. to the economy and has a nil service provision cost.

The BBKA herein puts forward a programme of research covering some 12 key programme areas in need of urgent action . These range from cutting edge scientific projects through to regulatory steps to improve honey bee medication availability.

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Honey Bee Health Research Concepts

Honey bees are of significant economic and ecological importance. Their contribution to food production through pollination activity defines their role in ensuring food security. Honey bee health is compromised on a global basis, and there are many unanswered questions relating to the reasons for this. New diseases and pests are adding to the regular threats encountered by bees. Colony Collapse Disorder (CCD) first observed in the USA has alerted us all to the potential crisis at hand. In the last few years, similar losses have been observed in Europe and across the UK. Following consultation, the BBKA proposes herein, a programme of research into honey bee health and beekeeping husbandry to exploit the expertise of the research community in the UK and beyond and to contribute to the wider efforts being mounted in Europe and the USA. It is important that issues relating to the particular circumstances found in the UK are examined, as well as those on a wider basis. This document gives some background to the current research needs and contains details of the BBKA research programme in a series of short concept papers.

Introduction

Like any other animal, honey bees are susceptible to disease and historically have suffered some spectacular declines, often not fully understood nor explained. The emergence of the so-called Colony Collapse Disorder (CCD) in the USA following the winter of 2006-07 and subsequent declines in Canada and Europe, reporting losses of up to 70% of some large commercial beekeepers' stocks, alerted UK beekeepers to a new, potentially highly damaging threat to their honey bee colonies. This new danger might superimpose itself on the existing havoc wrought by the varroa mite and the omni-present problem of bacterial brood disease, particularly European Foul Brood (EFB) and American Foul Brood (AFB). *Nosema ceranae* infection has also been found and is becoming increasingly common. Additional 'exotic' threats from the possible arrival in the UK of Small Hive Beetle (SHB) and *Tropilaelaps* mites have generated further concern for the future of beekeeping. Habitat loss and the possible impact of inappropriate agro-chemical use together with poor weather conditions have served to further aggravate these challenges. The stark reality of the gathering storm is evidenced by the 2007-08 winter losses in England which reached a record 30%, almost double that of the previous year. There is much that we do not understand in the current wave of colony losses and only good quality research can provide answers.

The importance of honey bees and beekeeping

The effect of losing large numbers of bee colonies is deeply worrying for a number of reasons. In the UK, the vast majority of honey bee colonies are managed by amateur beekeepers, who pursue the activity for pleasure rather than profit. In contrast to the USA and other countries, where there are substantial commercial beekeeping sectors and thus financial incentive to re-generate lost honey bee colonies, in the UK, amateurs with their 4 or 5 colonies, cannot recover from high year on year losses and as was seen when the varroa mite arrived on these shores in the early 1990s, will result in many beekeepers giving up the craft, with a further notable effect on bee stocks. If we lose beekeepers, we lose bee colonies. Given the honey bee's dependence on beekeepers for their survival there are few if any wild honey bee colonies left, due to the ravages of varroa and the inability of beekeepers to treat feral colonies.

Losses naturally have an impact on the availability of the honey bee's primary product, honey. Already the UK market imports more than 80% of the honey consumed, and whilst this confers a premium price on UK honey, clearly world shortages compound the problem. It is thus important to increase our bee stocks rather than see them reduced. Given the predominantly amateur nature of UK beekeeping, growth is most likely to be achievable through growing the number of beekeepers rather than the number of hives that each one owns. This is hard to achieve in a climate of worsening threat from diseases to be combated. The 2008 honey harvest appears to be some 50% down on previous years, demonstrating the seriousness of the problem.

Of far greater importance, however, is the effect of honey bee colony losses on the bee's less well recognised but more vital role in ecological and economic terms, namely pollination. They have a key role in early spring, when they are the only pollinators present in substantial numbers and thus important for early flowering crops such as top fruit. Revised figures (2007) based on the ten crops in the ADAS report commissioned by Defra in 2001 show that honey bees contribute £165M p.a. to the agricultural economy through enhanced production (see Table 1 below). Looked at another way, each of the estimated 240,000 hives in the UK contributes £600 per annum to the economy, which is effectively a donation on the part of beekeepers, who receive no payment, with the exception of a very small group of bee farmers and semi-commercial operators. A great part of the income from bee pollination enhanced production makes its way into the exchequer through increased corporation tax, PAYE, VAT and fuel taxes. This more than offsets the relatively small sum (£1.5M) spent by Government on beekeeping services including the extremely modest sum of £200K committed to research. It is contended that beekeeping is thus self-funding with a nil cost service provision. It is generally held that one in three mouthfuls of the food that we eat is bee pollinated and bees likewise play an immeasurable part in providing food for our wildlife. Colony losses thus have a significant impact on food production and sustainability.

Crop	**% Role of bees in pollination**	**Value of bee pollination £M**
Oil Seed Rape	8	24.6
Field bean	8	4.2
Broad bean	8	0.3
Runner & Dwarf	40	7.8
Apple	90	85.5
Pear	30	3.3
Other Orchard	15	5.7
Raspberry	30	19.5
Strawberry	10	11.1
Other Soft Fruit	15	3.8
Total		165.7

Table 1: % Role of honey bees and pollination value for 10 crops
(ADAS/Agriculture in the UK 2006)

Challenges and threats to bee health

As indicated earlier, there are many areas of disease and management that are inadequately understood and are touched upon briefly here, in no order of importance, more perhaps in chronological terms. There are also regulatory issues to be confronted, not least because beekeeping is a relatively small sector with limited financial attraction for industry, taking into account the high cost of developing products themselves and appropriate documentation to seek marketing authorisations from the Veterinary Medicines Directorate (VMD). This is aggravated by the somewhat unsatisfactory classification by the EU of bees as food producing animals (FPA), which arguably they are, but certainly not in the same manner as cattle, fish and poultry, for example.

Brood diseases particularly AFB and EFB are serious and contagious, being 'notifiable' and covered by legislation. The present approach of destruction for AFB and bad cases of EFB and antibiotic application or shook swarming for lighter infections of EFB has not proved to be a solution. The biology, pathology and epidemiology of these diseases are still poorly understood and work is needed to give a better informed approach to their management and possible alternative treatments.

Varroa represented a challenge when first it arrived in the early 1990s, causing extensive colony losses. It is still in all probability the single biggest problem facing beekeeping today due to the complexity and unsatisfactory nature of its control. The development of resistance by the varroa mite to the initially effective pyrethroid based products in fewer than ten years now leaves beekeepers searching for an effective means of control. Thymol based products have some value, but there are problems relating to the latitude and consequent ambient conditions they are used in. Integrated Pest Management (IPM) has been promoted with the use of special hive equipment (mesh floors, drone brood traps etc) and the use of other substances as medication or hive cleansing agents. The nature of the Veterinary Medicines Regulations (VMR) as noted earlier makes the use of these other substances a problem, as the use of a substance intended to treat or prevent disease or modify the physiology or metabolism of an animal is defined by the VMR as a medicine and thus must receive authorisation by the VMD. Icing sugar for example, used to dust bees to induce hygienic behaviour thus becomes a medicine requiring authorisation. Likewise organic acids such as oxalic acid (contained in fruits and vegetables and honey itself), requires approval as a medicine for legal application to bees. A novel approach to varroa management has been proposed using biological (fungal) control and much promising initial investigatory work has been undertaken, funded by Defra, but this work has now ceased due to lack of continuing research funding. There is a great need for the elucidation of husbandry measures, regulatory amelioration of treatment availability for use in varroa management and the development of new approaches to treatment.

Viruses are of growing importance. The emergence of CCD and initial investigations into its cause or causes has again drawn attention to the virus problem. Rothamsted Research some years ago, in world leading work funded by MAFF / Defra, which has now ceased, again due to lack of the necessary continuing funding, identified up to 15 different viruses associated with honey bees. Amongst these are acute paralysis virus, deformed wing virus, black queen cell virus, slow paralysis virus, and Kashmir bee virus. These have been shown to have serious and varying virulence and may be associated with CCD. Many viruses can be vectored by the varroa mite and it is this viral load, injected into the bee by mite feeding which proves lethal and overwhelms colonies. The prospect of anti-viral agents is currently remote but a better understanding of the pathology and epidemiology of viral disease may enable changes in the husbandry of bees and lower incidences of virus induced colony collapses. Work in this area clearly links closely with that on varroa.

Nosema in the form of *N. apis* preoccupied beekeepers at one time, being later somewhat supplanted by concerns over varroa. The recent detection of the apparently more virulent *N. ceranae* with increased frequency has brought these microsporidians back into focus. There is a suggestion from recent work that Nosema plays a part in the multi-factorial CCD syndrome. Treatment is possible with an authorised medicine, Fumidil B, but its availability is at risk due to the lack of a maximum residue level (MRL) which is required for medicines used in bees as FPAs. There is a need for optimisation of treatment and the identification of other effective treatments to deal with this agent.

Queen quality and **bee breeding** are matters of growing concern. The British black bee, much admired for its productivity and suitability to our climate has been somewhat lost through the introduction and interbreeding of imported strains. We are now left with a rather 'mongreloid' stock which is not ideal for our circumstances, often being difficult to handle and less disease resistant. The recent mapping of the honey bee genome and associated technologies such as micro-arrays enable us to look with far greater precision at gene expression and genetic characteristics, with the prospect of breeding better bees. Poor queen performance, albeit influenced as many believe by bad weather, almost certainly involves other factors such as nutrition. With the need to restore colony numbers, greater certainty in queen breeding is needed.

Husbandry remains at the root of beekeeping and many of the more scientific developments sought through the research programme eventually depend on husbandry for their proper application and exploitation. Controlling pathogen load in hives no doubt draws on elements of varroa, nosema and foul brood management. It is at the husbandry level that important extension work is needed to turn the benefits of research into practical beekeeping.

Small Hive Beetle has been identified as an important monitoring task under Defra's Bee Health Strategy. However, more work is needed to identify better ways of preventing its (and other 'exotics') arrival, its early detection, containment, control and treatment. Ready approval, strategic stocking and distribution plans for appropriate pesticides are necessary. Much of this 'research' can be of an administrative nature.

Pesticides continue to give cause for concern. Whilst interaction encouraging best practice stewardship and the safe use of pesticides between agro-chemical companies, farmers and the BBKA have led to dramatically reduced poisoning incidents involving honey bee colonies over the last 10-15 years, there are concerns that the newer classes of pesticide in use or late stage development may exert an insidious long term effect on honey bee populations. These substances may appear ‘safe’ in current testing protocols but their potential cumulative sub-lethal effects warrant further investigation.

Medicinal honey is growing in use in dermatology and post-surgical management. At present, the principal source of this material is Manuka honey from New Zealand which has been shown to have anti-bacterial and anti-inflammatory properties. It seems appropriate to examine the potential for medical application of domestically produced honey, not just to save on ‘honey miles’ shipping material around the world, but to explore whether local material has any additional properties to exploit.

Habitat loss through modern agricultural practice has over the years resulted in a paucity of good bee forage in terms of pollen and nectar. Swathes of ‘green concrete’ in areas of intensive mono-culture are unsupportive of bees and may lead to poor **nutrition** which again is addressed in these research concepts.

The Research Programme

Table 2 lists the 12 programme areas identified by the BBKA in discussion with experts and researchers that require attention. The annexes attached give further details of the research concepts involved and attempt to provide an indication of costings. The programme is intended to be indicative and not prescriptive, in that it may need to be modified and adjusted in the light of developments and needs.

Priorities: Clear priorities need to be set for the programme, although it should be accepted that certain pieces of work, perhaps of apparently lesser impact, may be undertaken more quickly. There are also some pieces of work that follow-on in sequence to other activity. Priority levels should be attached to each element in the programme on the basis of further discussion.

Commissioning: It is intended to share the programme amongst the research community so that projects may be developed in line with perceived needs, and by those institutions most suited to the type of work. This is not to exclude other valuable work which may be proposed, but to ensure that current needs are understood. The programme will be circulated amongst funding bodies so that they have an awareness of needs. The BBKA will continue to work to secure Government and other third party funding and its allocation in line with agreed needs.

Funding: The programme as originally conceived (and presented to Government in the BBKA document *Beekeeping Research* Oct 2007) envisaged investment of £8M of research funding over five years. This figure has grown slightly as the programme has been extended in the light of new information and defined needs. The costings are necessarily indicative. There will be an initial period while the programme gains momentum and expenditure limited, however, funding of the order of £1.6 million p.a., or a doubling of the current total expenditure on bee health will thus be required. In the light of the return on investment of more than £800 million over the same five year period, this seems an eminently reasonable and indeed a sensible investment to ensure honey bee survival and continued related economic and ecological benefits.

Given the substantial benefit to the nation, it seems entirely reasonable that Government should contribute the lion's share of the investment. The management of these funds requires careful consideration, however, not least to ensure that research groups may be made aware of priority projects and allowed to bid for funding to carry them out. Industry, Beekeeping Associations, research funding bodies and charitable trusts all, too have a role to play in funding this research, but the degree of national interest involved, indicates that Government must lead.

Bee Health Research Concepts			
1	**Varroa Programme**		Cost £K
1.1	Biological Control		2000
1.2	Varroa Control Optimisation		250
1.3	Oxalic acid Regulatory Status		210
1.4	Optimisation of Thymol efficacy on a UK wide basis		250
2	**Nosema Programme**		
2.1	Optimisation of Nosema Control on a regional basis		100
2.2	Nosema interactions with varroa & viruses		200
2.3	Fumidil B Regulatory Status		200
2.4	Alternative Nosema treatments		50
3	**European Foul Brood Programme**		
3.1	Pathogen levels in infected and uninfected colonies		25
3.2	EFB Infectivity on old brood comb		25
3.3	Optimisation of measures to control EFB		100
3.4	Interaction of EFB with honeybee viruses		50
3.5	Establishment of an Economic Injury Level threshold		25
3.6	Nutrition in larval & adult survival & function		25
4	**The Genetic Potential of the Honey Bee Programme**		
4.1	Genomic Approaches		1500
4.2	Bee Strain Improvement		300
4.3	Resistance to Varroa		200
5	**Queen Quality Programme**		
5.1	Queen Rearing		100
5.2	Swarm management as a queen resource		100
6	**Honey Bee Nutrition Programme**		
6.1	Protein supplementation		500
7	**Husbandry Programme**		
7.1	Hive cleansing for reduction of pathogen Levels		100
7.2	Integrated Pest Management; the effectiveness of mesh floors		100
8	**Small Hive Beetle Programme**		
8.1	Bio-security measures		100
8,2	Medication availability		50
8.3	IPM and prophylaxis		100
9	**Viruses Programme**		
9.1	Virus-mediated Honey Bee Colony Collapse		2000
10	**Agri-chemicals Programme**		
10.1	Influence of Chronic Pesticide Exposure		100
11	**Medicinal Properties of British Honey Programme**		
11.1	A survey of British Honeys		100
12	**Honey Bee Habitat Programme**		
12.1	Honey Bee Forage		100
12.2	Habitat Re-Creation		25
	BUDGET TOTAL		**8985**

1. Varroa Programme

The parasitic mite *Varroa destructor* was first discovered living on honey bees in the far eastern USSR in the 1950s. By the 1970s it was causing extensive colony losses in central Europe. Since then it has spread to all major countries part from Australia, being discovered in the UK in 1992. It is generally considered to be the greatest problem affecting beekeeping worldwide.

The female mites enter bee brood cells, parasitize the developing pupae, and then lay eggs, which develop into mature female mites before the bee emerges. Adult mites can live for long periods on adult bees. Much research, mainly carried out by UK scientists in MAFF / Defra funded projects during the 1990s, established that damage to colonies is not caused by the direct feeding action of the mite, but by honey bee viruses, which it vectors between bees and between colonies.

In the UK, the mite was at first successfully controlled by the use of plastic strips containing the synthetic pyrethroids flumethrin (Bayvarol) and tau-fluvalinate (Apistan). In recent years, populations of mites resistant to these chemicals have emerged and spread throughout the country. The only other licensed treatment, a thymol gel (Apiguard) is of variable efficacy, and is not reliable in all parts of the UK. Protocols based on integrated pest management (IPM) have been developed to help overcome the lack of effective, approved pharmaceutical agents and it is noted that the use of several unapproved substances has grown to fill the therapeutic gap.

Although varroa is not considered to be the primary cause of Colony Collapse Disorder in the USA, it is present in all affected colonies, and is considered to be a component in the multi-factorial nature of the disorder. Similarly, it is thought to be a factor in the colony losses experienced in Europe in recent years, and is almost certainly the primary cause of colony losses experienced in the UK in the last few years.

1.1 Biological control of *Varroa destructor*

The role of varroa in the activation and transmission of various viral diseases of honey bees is recognised. The spread of varroa throughout the UK, despite the best efforts of beekeepers to protect the health of their bee colonies from varroa, has caused previously unimportant diseases to increase in abundance and distribution, leading to significant colony losses, particularly over the winter.

Beekeepers have experienced increasing problems with pesticide resistance, and alternative control agents (both authorised and unauthorised) are only partially effective. Such agents include organic acids, essential oils and biotechnical methods.

The biological control of varroa has many perceived benefits, especially with regard to sustainability and the reduction in the potential for unacceptable residues in hive products.

A substantial body of research has already been carried out identifying potential fungal control agents. There is, however, an urgent need to provide proof of concept through all the technological, regulatory and practical application stages to enable the commercial availability of a fungal biological control agent for the control of varroa.

Project:

The project would be multi-facetted but could consist of the following elements, which may or may not be carried out in the sequence set out below.

1. The Assessment of candidate isolates at the laboratory scale.
2. Development of the potential delivery mechanism.
3. Semi-field and field scale trials including optimisation of efficacy.
4. Agreement with regulators on the regulatory issues to be cleared.
5. Environmental studies to meet regulatory requirements.
6. Optimisation of formulation technology.
7. Preparation, submission and execution of the product dossier to achieve product authorisation.
8. Selection of commercial bodies to make the product and supply it to the market, including the provision of technical support.
9. Monitoring of product acceptability and effectiveness.

Cost £2,000K

1.2 Optimisation of varroacide treatment combinations

There are many techniques that have been developed over the last few years to reduce the number of varroa mites in honey bee colonies following the advent of pyrethroid resistant varroa mites. Some IPM techniques are simple (e.g. dusting with icing sugar) whilst others are quite complex (e.g. queen trapping) and it has proved difficult to encourage beekeepers to adopt these methods. It is also unclear whether the non-use of pyrethroids for a number of years would eventually allow this treatment to be again used successfully.

Basic work is required to assess the relative effectiveness of various treatments under different climatic conditions (i.e. Northern *vs.* Southern UK). It is also important to assess the benefits of withdrawal periods.

Once the science has been understood it is necessary to develop a set of simple varroa control methods that can be combined over the beekeeping year to present a framework that beekeepers can use with confidence to control varroa. It is probable that the effectiveness of treatments will vary across the UK and will also be affected by climatic variations.

Recent analyses have shown that colony losses have increased significantly in the last few years and that there is a relationship (still unclear) between colony losses and the arrival of pyrethroid resistant varroa mites. It is apparent that the use of the only alternative licensed varroa control product Apiguard (a thymol gel) is less effective in colder temperatures. The paradigm for varroa control is thus not uniform throughout the UK.

Beekeepers need good, accurate and effective advice on how to control varroa.

Project:

The work would include a set of field trials to assess the reduction of varroa mite populations in colonies following the application of various techniques. The work would be repeated in different parts of the country to determine climatic variations. The work would include reviewing current peer reviewed evidence.

The basic data will then be applied to treatment modalities, with the objective of providing simple means/protocols of keeping the level of varroa mites below the economic injury threshold.

Cost: £250K

1.3 Oxalic acid – Regulatory approval

Oxalic acid (OA) has been shown to be an effective treatment for varroa, and is most effectively applied during the winter when there is no (or at least little) brood present. There is a large body of evidence in the literature on efficacy, and its safety has been well studied. Oxalic acid is becoming widely used on essentially an illegal basis.

Bees are classified as food producing animals (FPA) in the EU Veterinary Medicines Directive and for the purposes of the Veterinary Medicines Regulations. This then requires that all medicines are registered and classified as POM-V (prescription only) unless an 'exemption' has been established by the national authority under the 'criteria' agreed by the Commission, enabling General Sales List (GSL) supply by merchants rather than under the direction of a veterinary surgeon. Furthermore, a Maximum Residue Level (MRL) is required for all compounds to be used in FPAs. An MRL has been established for OA and is listed in Appendix 2 of EEC No: 2377/90 but no Marketing Authorisation (MA) exists nor has it been submitted in the UK to date.

The Veterinary Medicines Directorate (VMD) is aware of approvals in Germany, Italy and Spain of oxalic acid based products. The approach should be to encourage an existing MA holder to submit an application in the UK with the view to making a fully approved oxalic acid product available as a GSL product and thus easily available to beekeepers. (An interim arrangement under the 'Cascade System' whereby a vet imports the product on an importation certificate may be possible at nominal cost but is essentially clumsy and not practicable on a wide scale).

Project:

To obtain approval of OA in the UK for use in varroa control by:

1) cooperation with the MA holder through the mutual recognition procedure – cost of updating of files, regulatory fees, regulatory consultancy services etc.

Cost: £100K

2) application for a UK MA by the company– cost of assembling file, regulatory fees, regulatory consultancy services etc

Cost: £100K

3) The cost of admin for an interim arrangement is put at

Cost: £10K

1.4 Optimise the efficacy of thymol- based treatments to control honey bee pests and diseases in all parts of the UK.

Experience shows that the efficacy of thymol is dependent on the temperature within the hive during the application period. In many parts of the UK, conditions may never be suitable to enable the optimum efficacy of thymol to be reached. There is, therefore, an urgent need to determine the beekeeping equipment and management practices that will achieve optimal performance.

Thymol based products are also reputed to show varying degrees of effectiveness against the tracheal mite (*Acarapis woodi*) and chalk brood (*Ascosphaera apis*).

There is no substantive knowledge about the potential for thymol to act as an anti-viral substance which, if found to be effective against one or more bee viruses would also enhance the benefits of using thymol based products in honey bee colonies.

Project:

1. Conduct an extensive international literature review to determine the current understanding of the efficacy of thymol based products against honey bee pests and diseases.

2. Evaluate the application techniques and management practices used in countries where thymol based products are regularly used in honey bee disease management.

3. Determine the experiences of UK beekeepers throughout the UK in the use of thymol based products and determine optimal management practices used to date.

4. Evaluate the risks in the use of thymol based products in terms of honey bee health and hive products and determine whether proposed changes in product use could cause unacceptable risks.

5. Using field data logging techniques monitor hive internal temperatures and humidity during product application, testing a number of application regimes, e.g. the use of mesh floors. Determine which management techniques ensure optimal thymol vapour concentrations.

6. Conduct lab based tests to determine efficacy against *A. woodi*, the small hive beetle, chalk brood and *Nosema* spp.

Cost: 250K

2. Nosema Programme

Nosema is a genus of microsporidian parasites of insects. *Nosema apis* has long been known to infect the western honey bee *Apis mellifera*. It invades the mid-gut of adult bees, shortening the lives of infected individuals, and reducing the ability of nurse bees to feed larvae. It rarely kills colonies outright, but has a significant adverse effect on honey production and is an important contributor to the loss of colonies in the spring. It has a strong seasonal pattern of occurrence, mainly being found in the spring, and rarely being present in the summer. Three common bee viruses; black queen cell virus, filamentous virus and bee virus Y, are known to be associated with *N. apis* infection and to add to its harmful effects. *Nosema apis* has for many years been treated using the antibiotic fumagillin (Fumidil B) in sugar syrup.

In 1994, another species of the parasite, *Nosema ceranae*, was first reported to infect the eastern hive bee *Apis cerana* in China, and was believed to be confined to south East Asia. More recently, colonies of *A. mellifera* in Spain were found to be infected with *N. ceranae*. Preliminary experiments have suggested that it is more damaging than *N. apis* and does not show the typical seasonal variation.

The two species of *Nosema* cannot be reliably differentiated using light microscopy. The recent development of molecular tools for identifying *N. ceranae* has confirmed that it is present in many European countries as well as in the USA, and that it may have been present for at least ten years. It has been implicated as a possible contributory factor in Colony Collapse Disorder in the USA. In 2008 the presence of *N. ceranae* was confirmed in several counties in England and Wales.

2.1 Optimisation of Nosema sp. control on a regional basis

Both species of *Nosema*, namely *N. apis* and *N. ceranae* have been found in the UK, and currently the National Bee Unit is attempting to establish the distribution of the two species throughout the honey bee population of the UK. In addition, *N. apis* is known to be associated with black queen cell virus, filamentous virus and bee virus Y.

Currently the only control agent recognised as being effective against *Nosema* sp. is fumagillin (Fumidil B).

The biotechnical control method which beekeepers are being encouraged to use is that of increasing the frequency of brood comb changes. The ability of beekeepers to practice effective brood comb change management techniques relies on their competence as beekeepers, and equally important are the conditions which will enable wax foundation to be drawn quickly, in particular the availability of sufficient nectar. Reliance on the comb change technique will, however, probably not be sufficient to control *Nosema* alone, so prophylactic treatment with a control agent such as Fumidil B will have to become part of practical management to control *Nosema*.

Although Fumidil B has been available and used by UK beekeepers for nearly half a century to control *N. apis*, there is no recent work which confirms its effectiveness under the current UK conditions.

Project:

The requirement is to confirm the effectiveness of Fumidil B against both species of *Nosema* in the laboratory and under practical field conditions.

An important part of the work required is to determine the optimal time and conditions when Fumidil B should be applied, and to develop means whereby beekeepers can monitor the effectiveness of the treatment, whilst minimising the risk of honey contamination.

Cost: £100K

2.2 *Nosema* sp. Interactions with varroa and viruses

Three common bee viruses: black queen cell virus; filamentous virus; and bee virus Y, are known to be associated with *Nosema apis* infection and to add to its harmful effects. No studies have yet been carried out on the synergistic effect of *N. ceranae* with bee viruses. There seems, however, to be growing scientific consensus that Colony Collapse Disorder, affecting honey bee colonies in the USA has a multi-factorial cause. The suspected factors include *N. ceranae* and various bee viruses.

N. ceranae was originally discovered in honey bee colonies in Spain showing severe damage. It was therefore concluded that *N. ceranae* was a considerably more virulent parasite than *N. apis*. The discovery that *N. ceranae* is much more widespread than originally thought, being present in the UK as well as many other parts of Europe, often in colonies showing few symptoms, raises the possibility that secondary infections, perhaps of viruses, may be responsible for some of the observed colony damage. In addition, interactions with varroa infestation and its associated viruses are currently unknown. These need to be studied before the harmful effects of *N. ceranae* on bee colonies can be accurately predicted.

Project:

To study the effect of *N. ceranae* on honey bee colonies in the UK and its interactions with varroa infestation and virus incidence. There is evidence that the impact of one pathogen can be enhanced when a honey bee is subject to another pathogen. This work will study the 'amplifying' effect of *N. ceranae* on the damaging effect of various viruses and the ability of a colony to withstand the impact of varroosis. The project will include field work to assess the relative incidences of *N. ceranae* and other possible associated pathogens. There will be laboratory work to determine their associations under controlled conditions. In addition, the impact of stress caused by varroa infestation on the damage caused by *N. ceranae* will be determined.

Cost: £200 K

2.3 Fumidil B Regulatory Status

The microsporidian parasite *Nosema apis* has been known to be present in the UK for many years, but recently *Nosema ceranae* has also been found in bee colonies in the UK. This is of considerable concern in that *N. ceranae* appears to be a more virulent pathogen than *N. apis* and has further been implicated in Colony Collapse Disorder in the USA and colony losses elsewhere, and may now be threatening the UK bee population. An effective treatment for *Nosema* spp. is thus vital for maintaining the health of honey bees.

The antibiotic fumagillin, marketed for many years as Fumidil B (CEVA) has a Marketing Approval (MA) for the treatment of *Nosema* in honey bees. However, this MA is technically a 'hanging' approval awaiting renewal, due to changes over the years in the regulations, particularly for Food Producing Animals (as honey bees are classified), and there is thus a requirement for a Maximum Residue Level (MRL). By treating the Fumidil MA as a hanging MA, the Veterinary Medicines Directorate (VMD) have been able to grant time to the MA holder to produce the data required in order to regularise the position. The EU is now exerting pressure in general on 'hanging' MAs and thus there is concern that the product could lose its MA and would no longer be available for use on bees. It has been withdrawn in many EU countries.

CEVA faces a considerable cost in providing metabolism, carcinogenicity and mutagenicity data, and whilst they have started to gather some of this information there is some way to go. The bee medication market is small and commercially unattractive. Current sales of Fumidil in Europe do not justify intense investment to generate data for the MRL, and the Veterinary Medicines Directive makes disproportionate demands on the company given the small reward that can be expected for the product in return for investing in an MRL. There is a clear 'need' for the product and thus assistance and encouragement in effectively treating the product as an 'orphan' drug, should be given to the company to establish an MRL.

Project:

To provide 'LINK' type support to CEVA to generate data for the fumagillin MRL, with the VMD waving fees and charges to further incentivise the company and this project. The objective is to regularise the marketing approval of Fumidil by establishing an MRL, permitting MA renewal and securing product availability.

Cost £200K

2.4 Alternative *Nosema* Treatments

Currently, there are limited means of managing *Nosema* spp. infections in honey bees. These are primarily based on good husbandry, particularly moving colonies onto clean comb and treatment of colonies with fumagillin (Fumidil B; CEVA). This has been the therapeutic mainstay of *N. apis* control, but the recent discovery of the presence of *N. ceranae*, apparently a more virulent species, makes the beekeeper even more dependent on this drug. Whilst fumagillin appears to be reasonably effective, its continuing approved use is jeopardised due to the lack of an established MRL which has resulted in the withdrawal of the product from sale in a number of countries, particularly in the EU (see 2.2 & 2.3).

It thus seems prudent to investigate the availability of alternative treatments which could replace or supplement the use of fumagillin in the management of *Nosema* spp infections. *Nosema* is classified as a microsporidian, a unicellular organism formerly classified as a protozoan, but now considered as fungus-like, as its spore stage and development has a close resemblance to fungi. These properties may indicate the direction in which the identification and selection of candidate substances may proceed. Antifungal and antiprotozoal substances should form a possible basis for screening. A number of antibiotics used elsewhere in veterinary or human medicine are known to have efficacy against protozoa and microsporidia, but have not been tested against *Nosema* or on honey bees. Other treatments have been trialled against *Nosema* in various countries. These have included plant extracts (Protofil), a formic acid and iodine formulation (Nosestat), a preparation of vegetable oil and vitamins (Apiherb) an extract containing salicylic acid (Vita Feed Gold), garlic or thymol. Whilst these products have been shown to be effective in varying degrees against *N. apis*, they appear to have little effect against *N. ceranae.*

Project:

Through literature research and subsequent laboratory testing, potential new treatments for *Nosema* spp infection can be identified with reference to their application in honey bee husbandry. This is a first step to obtaining an MA and ultimate commercialisation of an effective agent.

Cost: 50K

3. European foulbrood Programme

European Foul Brood (EFB), together with American Foul Brood (AFB) has been considered over a long period, to be a problem in British beekeeping. Concern over controlling it resulted in the introduction of statutory orders in 1942 and both diseases have been subjected to statutes since that date. The Bee Disease order of 1942 made both diseases notifiable, and infected colonies were destroyed. Action under the order resulted in the reduction of AFB, but the level of EFB remained static until the early 1990's when it began to rise; since that time it has become an increasing problem. AFB is known to be caused by a spore forming bacteria persistent in the spore stage for some considerable length of time, measured in tens of years. However, little is known about the natural history of EFB, and recent information might lead to a questioning of beliefs and understanding about the current control protocols.

This programme examines a number of factors and their relationship with EFB.

It is thought that EFB increased from the early 1990's onwards for two possible reasons:

Firstly, in 1967, the foul brood disease order was changed to allow for the treatment of EFB with antibiotics, and blanket treatment of contact colonies in the apiary. In the mid to late 1980's the blanket treatment was removed. It is thought that the blanket treatment had suppressed clinical signs of the disease, and it may be that it had allowed it to spread into colonies whereas destruction would have removed it. Secondly the explanation may be that the stress to colonies caused by varroa has resulted in an increase in colonies showing clinical signs of the EFB pathogen.

The various components of this programme are inter-related and seek to establish the level of EFB present in colonies, the relationship between the disease and new and old comb and implications for management by for example 'shook swarm'; the effectiveness of infected colony destruction; the interaction between EFB and viruses, the effect of nutrition in EFB infection and the establishment of an economic injury level at which management intervention is worthwhile.

3.1 Pathogen incidence and distribution in UK honey bee colonies

Recent work on European foul brood (EFB) suggests that the causative bacterium *Melissococcus plutonius* is carried over on the bees as well as on the comb. If this is the case, it suggests that transferring colonies on to clean comb will only temporally alleviate the disease and that a reservoir of bacteria may remain to cause infection at a later date. Monitoring of bacteria levels will help to establish the proportion of disease present in colonies and the proportion of colonies which carry the bacteria without showing overt signs of the disease. Monitoring over a period of time will give an indication of the levels of bacteria present within colonies, and relate to conditions which affect disease incidence.

Project:

The project seeks to establish whether transferring honey bee colonies infected with EFB onto clean combs reduces the risk of infection in the future.

The project will entail the collection of sample material from colonies over a twelve month and longer period from colonies known to have been infected with EFB, and also from colonies which carry the pathogen but show no symptoms and from colonies which are not carrying the pathogen. The samples will be monitored for levels of the pathogen.

This project could be carried out in conjunction with other EFB studies, and could utilise data that the National Bee Unit (NBU) already collect or could easily collect without much further effort, and would require the employment of a student to analyse the data.

Costs: £25K

3.2 Infectivity of EFB from old brood comb

Current management of European foul brood (EFB) entails shaking the bees on to clean comb, and destruction of the old comb. If the supposition behind this practice is correct, there should be more colonies infected with EFB on old comb than on new comb.

Project:

The study seeks to establish whether colonies on old comb are more susceptible to EFB than those on new, and that transferring to clean comb is an effective method reducing the level of the disease.

It would include the collection of data relating to levels of bacteria on new and old comb from colonies known to be infected with EFB and from colonies not showing overt symptoms in apiaries known to carry the infection. Colonies known to be free from bacteria would also be monitored as would the reinfection rate of colonies on new combs.

This study involves the collection of data to determine bacterial levels in colonies, and could be run in conjunction with a number of others on EFB and utilise data collected by the National Bee Unit (NBU) and Bee Diseases Insurance (BDI).

It would necessitate the employment of a student to collate and analyse data.

Cost: £25K

3.3 Optimisation of measures to control EFB

For many years prior to the 1990s the incidence of European foul brood in UK colonies was always below that of American foul brood. At some point a change took place, and from about 1990, EFB became the prominent disease of the two.

There have been three explanations given for this: i)that inspectors became better at detecting the disease; ii)that the level of infection started to rise when blanket antibiotic treatment of EFB was withdrawn; and iii) the increased stress load caused by varroa infestation.

In recent years, the geographical distribution of EFB has changed, it now being found in areas where it was not recorded before. One suggestion is that the background level of the disease rose with the introduction of the use of antibiotics and blanket treatment of colonies in infected apiaries. If this link to antibiotic use is correct, destruction of colonies would reduce this level.

Project:

The work will set out to assess whether the destruction of honey bee colonies infected by EFB will reduce the overall level of the disease and the background level. It will identify the amount of re-infection occurring in apiaries destroyed and re-established as opposed to those using the 'shook swarm technique' or antibiotics.

The work will require an area to be set up for destruction of colonies with EFB. Levels of infection within the area would need to monitored against control areas outside. There may be difficulties in terms of the compensation that would need to be paid. The study will need to be continued over a three year period.

Cost: £100K

3.4 Interaction of EFB with honey bee viruses

If, as seems likely, European foulbrood (EFB) is more widely distributed in honey bee colonies than has been previously considered to be the case, and the fact that a number of honey bee viruses are being vectored and their activity potentiated by the varroa mite suggests that the relationship between EFB and viruses requires investigation.

In addition an important question to be answered is whether the varroa mite can also act as a vector for EFB.

Project:

This would require establishing the level of both viruses and EFB present in colonies as a base point, and then comparisons of colonies with known levels to determine differences in clinical signs of the pathogens in question as well as the performance of the bee colonies.

Costs: £50K

3.5 Establishment of an Economic Injury Level Threshold

Current approaches to the management and control of European foul brood (EFB) rely on an assessment made by a Bee Inspector when assessing a colony which is found to have the disease.

If antibiotic treatments are not considered suitable for use in controlling the disease, biotechnical controls such as the 'shook swarm technique' are employed. In severe cases the colonies are destroyed and burned.

The increasing reliance on Integrated Pest Management (IPM) techniques and the potential for EFB to cease to be a Notifiable Disease have important consequences for its management and control.

The current criteria for assessing colonies appear to be arbitrary and beekeepers and Bee Inspectors need to know whether an Economic Injury Threshold can be established for EFB and determination of the related best management practice to adopt when that level is exceeded.

Project:

This study would entail the monitoring of colonies infected with EFB and those free from EFB, by evaluating the progress of the disease and performance of colonies.

Costs: £25K

3.6 The role of nutrition in larval survival and subsequent adult survival and function

It is well known that some larvae infected with European foul brood (EFB) are able to survive and mature. The role of nutrition has thus been implicated in the survival of the infected larva.

Enhancing the nutrition of honey bee colonies at risk from EFB could be a means, in conjunction with comb changing, of helping colonies resist the establishment of the disease.

Project:

This would look at the role of nutrition in the survival of larvae and the subsequent adult survival and function. It will investigate the value of supplementary feeding as a means of improving the survival rate of colonies.

Cost: £25K

4. The genetic potential of the honey bee Programme

Since the genomes of the honey bee *Apis mellifera*, and its pathogens *Paenibacillus larvae* (American foul brood), *Ascophaera apis* (chalk brood), *Nosema* spp. and a number of honey bee viruses were published, opportunities have arisen using a variety of post genomic methods to investigate a number of areas of honey bee biology.

To date these have involved the attempted correlation of Colony Collapse Disorder (CCD) in the USA with the presence of particular pathogens, the impairment of honey bee immunity by the varroa mite, and pathogen interference with honey bee learning.

The role of DNA methylation in the programming of larval development into workers and queens has been investigated as has the differential expression of the insulin signalling pathway in queen and worker larvae.

Behavioural studies have been carried out, correlating the gene expression profiles from pre and post mated queens with changes in behaviour and physiology, as well as studies on the differential gene expression underlying the transition from nurse to foraging behaviour under field conditions.

4.1 Genomic approaches for studying honey bee biology and improving bee health

With the new techniques available there are opportunities for a more systematic approach to be made in understanding honey bee biology with the view to develop new understandings of honey bee - pathogen interactions in an environmental and social setting.

Project:

Areas of work could include

- The quantification of the effect of generalist and co-evolved pathogens on within-hive honey bee behaviour and foraging behaviour outside the hive.
- The characterisation of gene expression responses underlying the effects of pathogen infection on honey bee behaviour.
- Gene silencing of functional genes and the characterisation of their effect on honey bee behaviour.

Cost £1,500K

4.2 Bee strain improvement.

Because of the mating behaviour of honey bees, it is difficult to carry out a planned breeding programme in the UK. There have been some attempts at achieving this, using isolated mating apiaries such as those used by Brother Adam on Dartmoor. His programme was designed primarily to meet the needs and particular circumstances of Buckfast Abbey, so it would not follow that the bees were necessarily suited to all areas of the UK. Because of the vagaries of queen mating under UK climatic conditions, the UK honey bee population is currently a very mixed bag, and in many cases the type of bee that a beekeeper uses is very much a lottery. There is thus a need to produce bees that behave consistently in terms of good temper, non swarming, production of honey, utilisation of stores, and disease resistance.

Project:

1. It is important to produce a basis for comparisons that can usefully score the performance of colonies against each other, and for this it will be necessary to collect data relating to colony performance over a period of time. The data may be collected by using apiary sites located around the UK, looking at bees that are of unknown parentage or those that have been raised with specific traits in mind. Performance through several generations should be recorded.

2. Having selected bees that might be suitable for UK conditions, a mechanism for propagation and distribution of genetic material needs to be found. Instrumental Insemination could be used for production of breeder stock, and the setting up and training of a team to deliver this would have to be costed in.

Cost: £300K

4.3 Resistance to *Varroa destructor*

Since the varroa mite became established in the honey bee population there have been many claims that some colonies are resistant to the mite, with a number of claims as to the mechanism that may be responsible, such as grooming, ‘hygienic behaviour’ or ‘suppressed mite reproduction’. Anecdotal evidence does suggest that mite levels in some colonies decrease more quickly than in others when colonies are treated. It would be useful to establish whether there is some inbuilt resistance in UK colonies, and if that is the case, to identify the mechanism by which it operates, and to enhance this resistance by selective breeding.

Project:

To establish whether there is an ability of colonies to suppress mite levels, it will be necessary to monitor and record data from colonies over a period of time throughout the season. The data can be collected in a variety of a ways, natural mite drop, sampling of adult bees and drone brood, or testing for ‘hygienic behaviour’.

The objective of the project would be to establish whether there is resistance to varroa in the UK native honey bee population, and if present, the level to which is capable of suppressing mite population. Such resistance would then be enhanced by selective breeding.

Cost: £200K

5. Queen quality Programme

There is a number of key honey bee characteristics which if managed well will contribute to the health and vitality of the colony and the queen bee is crucial to achieving this.

The careful selection and propagation of queen bees whose colonies show desirable characteristics such as disease resistance should be an important part of beekeeping husbandry no matter how many, or how few, the beekeeper manages.

Such husbandry requires the acquisition and development of a number of skills and the ability to manage the resources available.

This programme is aimed at improving the overall quality queen honey bees, keeping as much genetic diversity as possible and promoting methods which can be used by beekeepers, even those with limited experience.

5.1 Queen rearing

For many beekeepers in the UK, queen rearing is a poorly understood management technique and there is much reliance on the supply of queens from a relatively small number of suppliers with a limited genetic diversity.

Genetic diversity allows natural selection to act, and this must in turn mean that honey bees become fitter and better adapted to their changing environment. There is a need to determine the best practical techniques which will allow the average beekeeper in the UK to rear good quality queens.

Swarming tends to be seen as an undesirable trait, yet queens raised under the swarming impulse are usually produced when conditions inside and outside the hive are the most favourable.

In recent years, unfavourable weather during the post queen emergence period has resulted in many poorly mated queens, resulting in early supersedure or the queens becoming drone layers early in their natural life. Whilst it is recognised that there is little that the beekeeper can do to mitigate the effects of weather, the beekeeper may also wish to rear queens outside the typical swarming period.

Project:

Beekeeping manuals include descriptions of queen raising techniques, but there is no authoritative guidance on the optimal technique(s) which need to be used in the UK. There is a need to demonstrate scientifically the best techniques to use using indicators such as queen weight, ovariole weight, number of ova, and spermathecal weight. Another indicator could be the relationship between the crude protein status of the colony and queen ovariole weight.

Establish optimum time and conditions for queen rearing practice.

Cost: £100K

5.2 Swarm management as a queen resource

Swarming is the natural process of colony reproduction, yet it is also considered to be a nuisance and a potential danger to the public. Beekeepers in urban areas need to be vigilant to prevent swarming. Before the advent of varroa, lost swarms could survive in the wild and provided a background source of pollination. Nearly all feral colonies have now succumbed to varroa, so a swarm lost to the environment also represents a significant loss to the pollinating force in this country.

The signs of imminent swarming are taught to all beekeepers, as are methods to prevent swarms, but without careful inspections at regular intervals it is easy for a colony to produce a swarm. Many beekeepers have other work commitments and are not often available or present when their bees swarm. An early indication of swarming is required that gives the beekeeper say two to three days notice of an impending swarm **without** the need to thoroughly inspect the hive.

In the past, efforts have focussed on monitoring the sound inside the hive to detect the early onset of swarming. This concept could be developed further with modern technology to provide a remote alarm of an impending swarm. The underlying science was, however, not clear, so the method would need further investigation to provide a practical solution.

An alternative approach would be to monitor the relative concentrations of pheromones within the hive, as these are known to change as the queen is prepared for swarming.

Project:

The project would initially be laboratory based to find a reliable indicator for impending swarming. Once the most significant indicator has been determined, the work would then progress to designing an electronic method for the remote monitoring of this particular indicator.

Field trials will then be required to ensure that the monitor is robust and can be practical in an operational environment.

Having developed a better swarm prediction indicator, further practical guidance could then be developed to promote the better utilisation of the queen cells that are produced during the swarming process. A review of current techniques to raise queen cells which would be suitable for the average beekeeper would also be carried out.

Cost: £100K

6. Honey bee nutrition Programme

Honeybees are vegetarians. They forage for nectar which they either consume directly or process it into a more complex product called honey and store it for use in times when there is a dearth of forage, for example over winter.

Pollen provides the only source of proteins which are essential for the growth and development of the bees. Honeybee colonies require a continuous supply of pollen throughout the active season as they only store about 1 weeks supply in the comb at any one time.

Habitat destruction, fragmentation, intensive agriculture and urbanization all impact on the amount of pollen available to the colonies. Poor protein availability leads to poorly developed bees which are more susceptible to disease and unable to develop their full potential.

Beekeepers need to have available protein supplement feeds which can easily be fed to the bees at the appropriate time.

6.1 Protein supplementation

Pollen is the only source of protein for honey bee development, growth and maturation. Habitat destruction, loss of successional forage resources, and deteriorating weather conditions reducing productive foraging activities are all factors which are impacting on honey bee colony development and the ability of the bees to resist disease and other stressors.

Winter bees, which will carry the colony over the winter and provide a resource of protein stored in their bodies to rear the vital young brood early in the season when there is little pollen forage available, are produced in colonies in the late summer and early autumn. In recent years honey bees colonies in the UK have struggled to produce such winter bees, which ideally should be raised in a pollen rich environment.

Being able to give colonies supplemental feeding of protein / amino acids during this period should enable them to survive over winter and thrive in the following season as well as increasing their ability to resist disease.

Current protein supplementation and pollen substitution products are difficult to make and apply and are of doubtful effectiveness.

Project:

The objective of this project would be to develop novel feeds and methods of feeding bees with supplement proteins (or their constituent parts).

1. Evaluate current protein supplements worldwide and assess their applicability and effectiveness.

2. Review the current understanding of nutritional requirements of honey bee colonies, in particular the role of protein and amino acids or other precursor substances and determine data gaps.

3. Dependent on the outcomes of 1 and 2, assess current technologies available for the delivery of potential nutrients.

4. Formulate and trial candidate feeds.

Cost: £500K

7. Husbandry Programme

For too long, beekeeping practices have been based on anecdotal evidence of the 'best' way to look after a colony or carry out a specific manipulation. There has been an almost complete lack of basic research into the most effective ways to achieve an objective in husbandry. Experienced beekeepers (experienced in this case relates to the number of years beekeeping) in local areas pass on their 'knowledge' to newer beekeepers and thus myths are propagated. Since the advent of varroosis in 1992 it is no longer acceptable to continue keeping bees based on narrow and unscientific evidence. This has been recognised by the BBKA and the Bee Health Strategy. The husbandry programme builds on the current best practice propagated by the BBKA in advisory leaflets and is focussed on two specific projects that are designed to determine how the environment which a colony occupies (the hive) may be maintained with minimal pathogens and stress components to give the colony the best chance of staying healthy.

7.1 Hive Cleansing for reduction of pathogen levels

In the past, when outbreaks of disease have occurred that necessitate the destruction of a colony (e.g. foul brood), it has been common practice to scorch the inside of the hive with a blow torch to kill any pathogens that might remain. Similarly, when hive components are stored, it has been good advice to seal them in a container and drench them in acetic acid vapour. This is known to kill many pathogens that attack honey bee colonies, but not all.

There has been a recent move to use alternative materials other than wood, such as polystyrene, for hive components and this has made some of these traditional methods inappropriate. It is important to find safe alternatives for cleansing hive components for use as a prophylactic or following an outbreak of disease. The approach should be practical, not harmful to honey bees, beekeepers or hive products.

Project:

The project would identify means to remove all known pathogens from honey bee hives and would start with a literature survey of cleansing materials used in other industries to identify safe candidate products and processes. This would be followed by practical application to hives to determine dose rates and concentrations.

Field trials would follow to prove the concept and ensure that the process can be applied safely by amateur beekeepers.

The work could be undertaken by a post graduate student with the objective of achieving a Masters degree.

Cost: £100K

7.2 Integrated Pest Management: the effectiveness of mesh floors

Open mesh floors were introduced into beekeeping practices as a method of reducing the numbers of varroa mites in a colony of honey bees. The rationale was that mites will fall from bees whilst in the phoretic state through being displaced by the grooming behaviour or physical contact between bees, or other measures used by the beekeeper to dislodge the mites from the bees. The mites fall to the floor and through the mesh floor, thereby no longer being able to crawl back into the colony and onto the bees.

A scientific evaluation of the use of open mesh floors under UK conditions is needed in order to support or dispute the belief that open mesh floors can be used as a tool in the treatment and control of the varroa mite. Such an evaluation would also enable guidance to be given on the design, duration of use and any particular considerations which need to be taken into account in varroa control management and what impacts such guidance might have on other aspects of the colony's health.

Project:

The project could be set up using techniques which disclose whether the bees are producing significant levels of stress proteins and for the presence of honey bee pathogens in response to a variety of scenarios developed for the use of the mesh floor. Controls using solid floors would be employed.

Data logging of the internal temperature and humidity measurements and profiles would be a useful way of comparing the colony responses to the varying profiles.

Cost: £100K

8. Small Hive Beetle Programme

The small hive beetle (SHB) *Aethina tumida* is an opportunistic pest of honey bee colonies. It is native to South Africa, where it is considered only to be a minor pest. It can live inside bee hives, where the larvae eat brood, pollen and honey and destroy combs. Pupation occurs in soil, and adults can fly up to five miles to infest fresh colonies.

In 1998 SHB were found in Florida, USA, where they were rapidly found to be a serious pest. Under the warm conditions, SHB were found to lay vast number of eggs, and thousands of colonies were lost. In 2002 SHB were found in Australia and became established there. SHB have proved to be a pest in moist coastal regions, but are not considered a serious pest in drier regions. Outbreaks in Canada in 2002 and 2006 and in Portugal in 2004 are thought to have been successfully controlled. *Aethina tumida* is a notifiable disease within the EU (Commission Decision 2003/881/EC). It is likely that *A. tumida* will reach the UK in bee colonies, hive products or in fruit. It is thought that it could survive in the UK and will be a particular problem in areas with warm light sandy soils.

8.1 SHB Contingency Plan

The current contingency plan produced by Defra has been trialled and shown to work within the constraints set by the model used to determine the spread of SHB once it reaches this country. Unfortunately, experiences with *Varroa destructor* have shown the signal failure of current biosecurity strategies and practice to keep the UK free from exotic honey bee pests.

The plan relies upon early detection and the ability to produce a security zone for the detection of collateral infestations. Early detection is the joint responsibility of the Bee Inspectorate and some locally co-opted beekeepers. Regrettably, the general beekeeper has not been made aware of, nor has been party to, these plans. Effective biosecurity has to involve all stakeholders if it is to be successful.

Project:

There is a need for further investment in such a contingency plan to ensure that if late detection occurs there is an effective action plan to control the outbreak. The plan needs to be communicated with all beekeepers to ensure that there is a wide population looking for early signs of the arrival of SHB.

Cost: £100K

8.2 SHB control; medication availability

Once eradication has been shown to be impossible, the current contingency plan relies on the ability of the National Bee Unit to have an emergency authorisation to use an organophosphate based insecticide (coumaphos). The use of such a product would be limited to application by named persons and is highly undesirable as a medication for honey bee colonies.

Experience with varroa in the UK has clearly demonstrated the inability to be able to control the introduction of exotic bee pests using the inspectorate alone.

The experience of US beekeepers has shown that, whilst biotechnical techniques help to contain an infestation of SHB, there is an urgent need to evaluate and have authorisations in hand to place alternative products on the market which could be readily employed by beekeepers after appropriate training.

The use of an organophosphate is inappropriate, and alternative treatments and regimes that are appropriate for the UK need to be found and promulgated to all beekeepers.

The impact of SHB on a colony and a beekeeping operation can rapidly prove devastating. It may well be that without appropriate medication and training the effects of SHB could be worse that the effects of *Varroa destructor.*

Project:

The project will start with a literature survey of control method used in other countries and then identify the appropriate approach for this country based on climatic and soil conditions and in recognition of the primarily amateur status of British beekeepers

Costs: £50K

8.3 Integrated Pest Management of SHB

Should SHB become established in the UK, beekeepers require a range of tools to be able to monitor and control beetles both in their colonies and in the local environment. It has taken more than 10 years for a similar approach to be developed for *Varroa destructor*.

Project:

This project should determine, clearly define and set out the management techniques to maintain colonies either free from SHB or below an Economic Injury Level if one can be determined. The project should start with a literature search of the control mechanisms that have been shown to be effective in other countries, and then establish their effectiveness in the UK. The outcome should be a training programme for all beekeepers that provides a simple yet effective regime throughout the year to maintain SHB numbers in a colony below the Economic Injury Level.

Cost: £100K

9. Virus Programme

Work carried out mainly by UK based scientists funded by MAFF during the 1960s and 1970s established that honey bees suffer from a number of viral diseases, and that these can act in conjunction with other pests and pathogens such as the tracheal mite *Acarapis woo*di and the gut parasite *Nosema apis,* thereby increasing their harmful effects. The difficulty of identifying virus diseases, has led, however, to their role in bee diseases being largely ignored.

The arrival of the varroa mite, together with the availability of new, more sensitive and more widely available techniques for virus detection and identification, has resulted in increasing recognition of their role in colony losses worldwide. In association with varroa, acute paralysis virus, slow paralysis virus and deformed wing virus are now known to have caused extensive colony losses in Europe. In the USA, Israeli acute paralysis virus is implicated in Colony Collapse Disorder.

9.1 Virus mediated honey bee colony collapse

Honey bee viruses are now known to cause significant losses of honey bee colonies. It is widely accepted that the exotic introduction and the subsequent widespread occurrence of the mite *Varroa destructor* has resulted in mite mediated infection and dissemination of a number of bee viruses, with the result that viruses which hitherto appeared not to cause damage to honey bees or colony losses, have now become a key factor.

It is also now recognised that there is the possibility for the transmission of these viruses to occur vertically (e.g. from drone / queen to offspring) or horizontally (e.g. faecal, cannibalism and oral transfer) without the need for the presence of varroa. There is concern also that viruses may be vectored in conjunction with *Nosema* spp. or EFB infections (see 2.2 & 3.4)

The ability of an individual or colony to tolerate or resist viruses in part depends on the environmental stresses which induce the virus to replicate and damage the colony. Such stresses are poorly understood in managed honey bee colonies, and there is a need to assess the potential of current honey bee management techniques in setting up such stresses.

The identification of those aspects of beekeeping practices which generate such stresses would enable changes in management including diagnostic tools to be developed, and for identifying potential management strategies which can be adopted if a viral outbreak does occur.

As well as the management techniques used, there is a need to assess the influence of environmental factors, as honey bees are kept in many diverse locations with wide ranging climatic conditions which in turn influence the forage available to the bees.

Project:

A programme involving honey bee colonies being kept and monitored in a number locations throughout the UK. There is the opportunity for competent beekeepers to actively participate in this work.

Cost: £2,000K

10. Agri-chemical Programme

Increasing demand for food production to meet population growth has been confronted by plant breeding, advanced horticultural and agricultural practices and the wider use of chemicals to control pests and diseases to improve yields and product quality. The rising cost of agri-chemicals, stricter regulatory requirements and pressure from consumer and environmental groups has seen more careful use of these substances over the years with reductions in frank bee poisonings. However, new technological developments must be monitored in ever more sophisticated and appropriate ways to determine their effects on the environment and its flora and fauna. Work is thus indicated over and above that which is currently laid down under pesticide regulations to augment our understanding of the potential damage they may inflict on honey bees and how to minimise this.

10.1 The effects of pesticides on honey bee health

In recent years, much concern has been expressed about the potential sub-lethal effects of the neonicotinoid range of systemic insecticides to honey bees. These systemic insecticides have been investigated under UK field conditions, and crops have been sampled for the presence of the active substance and metabolites in pollen and nectar. The work has shown that the levels expressed are well below the toxicity levels for honey bees and, it is on this basis, that the Pesticides Safety Directorate (PSD) have approved these compounds to be used for application on certain crop seeds.

These compounds appear not to be very widely used in UK agriculture at present but there is every reason to believe this could change in the near future.

Incidents in Europe involving the neonicotinoids imidacloprid and chlothiandin impacting on honey bees have recentlybeen observed. Whilst these have been considered to be the result of bad practices, beekeepers are concerned about the potential of this class of insecticidal compounds having sub-lethal effects on honey bee health.

Project:

Current risk assessment methods used for assessing the potential impact of pesticides on honeybees may not be sensitive enough to detect sub lethal effects, especially influences on honeybee behaviour.

Such an example might be with neonicotinoid compounds with disorientation and possible memory loss contributing to colony losses. Whilst insecticides and acaricides might be considered to be of highest potential risk, fungicides and their co-formulants may also have sublethal properties.

This project should consist of a comprehensive literature review carried out in discussions with agri-chemical and regulatory authorities to appraise critically the ability of the risk assessment methodology to detect such behavioural changes and their impact on colony survival.

In the light of the findings proposals should be developed to address this issue and pilot projects carried out to determine how to measure the sub-lethal effects of pesticides.

Costs: £100K

11. Medicinal properties of UK honey Programme

Honey is an ancient remedy for wound healing, and has recently been reintroduced into modern medicine, being used increasingly in the developed world for such purposes with a number of approved products being available.

World demand for medical grade anti-microbial honeys is growing, and demand begins to approach a level whereby existing sources, predominantly New Zealand manuka honey may need to be supplemented by other sources. There is also the well rehearsed environmental argument in favour of sourcing active material closer to home.

11.1 A survey of UK honeys to evaluate their medicinal value

The therapeutic potential of honey depends on its ability to inhibit bacteria, to scavenge free radicals, and to activate macrophages. Undiluted honey exerts an antimicrobial effect by virtue of its high sugar content, low water content and acidity. Many diluted honeys produce hydrogen peroxide which exerts an antimicrobial effect. There is a third smaller group of honeys such as manuka honey, which exhibit non-peroxide activity.

UK honeys have not yet been formally tested for their therapeutic potential, although there is anecdotal evidence of activity and such a project would identify whether there are any honeys which could be utilised in wound care products.

Project:

To screen and evaluate the antimicrobial, anti-inflammatory, antioxidant and monocyte activating potential of UK honeys

Cost: £100K

12. Honey bee habitat Programme

Ensuring the health of UK honeybees not only requires effective control measures against pests and diseases but also requires bees can obtain all the forage they require. Forage availability, e.g. pollen is especially important in the development of strong and healthy colonies.

Honeybees pollinate all kinds of flowers including those of crops, vegetables and for seed production essential to man but perhaps as important those flowers whose fruits / berries and seeds form the basis of many food chains. Such food chains ensure biodiversity. Honeybees are important pollinators and require a constant supply of nectar and pollen throughout the active season.

Clearly there could be many stakeholders involved in the promotion and provision of management practices which could encourage the provision of such forage.

The cost set out in this document would be to support the BBKA to interact with these stakeholders and to encourage them to consider honeybees in their land management practices.

12.1 Counter-acting habitat loss

In recent years there has been a significant reduction in the amount and geographical availability of forage sources for pollinating insects, including honey bees, due to a number of factors including:

- Habitat loss due to housing and industrial development and 'tidying the environment'; e.g. loss of rough pasture and streamside vegetation.

- Garden makeovers that usually involve the loss of corners and small patches useful for wildlife.

- Increase in hard surfaces in gardens such as concrete, gravel and paving.

- Habitat loss due to intensification of agricultural practices.

- Reduction in the take up of environmental stewardship and the loss of set-aside field margins and other wildlife conservation schemes.

- Hedgerow destruction and poor hedgerow management.

- Excessive roadside verge cutting.

Project:

This project area would require the creation of a forum for the large number of stakeholders with a remit to undertake an in-depth review and reappraisal of all land management practices including those surrounding urban development and in agricultural and conservation areas, with the objective of developing best practice to achieve maximum sustainable and practical biodiversity.

The key aspect will be the agreement and implementation of such practices through all training materials and courses and land use management with both fiscal and other inducements to ensure success.

The BBKA will seek to encourage the creation and development of such a forum which will involve a wide range of parties and stakeholders.

Cost: £100K

12.2 Habitat creation

As well as developing and implementing best practices to manage existing resources, it is essential to create new habitats and forage resources which are sustainable and will deliver nectar and pollen throughout the honey bee foraging season from February to the beginning of November.

Areas of search for habitat creation should include:

- Domestic gardens, allotments and community gardens.
- Local authority owned and managed land, including parks, gardens and roadside verges.
- Land used for agriculture and horticulture.
- Public and private forestry.
- All types of land designated and protected for conservation.
- Significant landowners, e.g. the National Trust

Project:
As a minimum the project would involve significant awareness of the needs of honey bees and other pollinating insects, through publicity and promotion.

In partnership with seed companies, agricultural and horticultural training establishments and other relevant stakeholders, there is the need for the development of relevant education and training material. A key aspect should be the selection and development of appropriate meadow seed mixes, as well as the selection of combinations of trees, shrubs and where appropriate annual and perennial plants to optimise their value to pollinating insects.

Cost: £ 25K