SECTION IX

CONTAMINATION OF WILD HONEY-BEE STOCKS BY GENETIC EXCHANGE WITH IMPORTED DOMESTICATED RACES

G.W.ELMES
ITE, Furzebrook

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Summary

Throughout most of the world domesticated Honey-bees belong to the species *Apis mellifera*, which is native to Europe, Western Asia and Africa and comprises several distinct subspecies. The native British race of Honey-bee belongs to the subspecies *Apis mellifera mellifera* whereas most commercial apiarists stock either with the Italian subspecies *Apis mellifera ligustica* or some specially bred hybrid cocktail of several subspecies.

The native British Honey-bee was believed to have gone extinct in about 1920. However, common sense suggested that this was most unlikely and recent studies have tended to support this view: it is almost certain that in some regions of Britain there are both wild and domesticated honey-bees that are genetically very close to the ancestral native British Honey-bee. The behavioural and physiological characteristics of the native British Honey-bee makes it better suited to the cooler and damper climate that prevails in most of Britain. It thrives in domestication with much less active husbandry, making it more suitable for Cottage style bee-keeping than the Italian Honey-bee.

Despite active selective breeding programmes, the honey-bee has remained a more or less wild animal because the bee-keeper lacks control over which drones mate with the young queens. However, modern developments, particularly advances in artificial insemination, may lead to a dominant domesticated strain that might eliminate the remains of the native population. The domesticated genotype would probably spread in the wild population by drone migration; the reverse situation to the Africanized Honey-bee problem in the Americas, where drones spread the wild-type into domesticated stocks.

In principle it seems undesirable that we should lose the genetic diversity contained in the wild stock of native British Honey-bees. This race could become commercially important once more, given unpredictable climate change. In any event, it undoubtably possesses characteristics that could be of great use to British bee-breeders in future breeding programmes (Cooper 1986).

Introduction

It is generally accepted that there are four species of Honey Bee which collectively form the genus *Apis* (Figure 1). *Apis mellifera* (The Honey Bee) is endemic to Europe and Africa and is now used by bee-keepers throughout the world. The other three species are endemic to Southern Asia: the Giant Honey Bee (*A.dorsata*) is too large for domestication and colonies of the Dwarf Honey Bee (*A.florea*) are too small. The Eastern Honey Bee (*A.cerana*) has been domesticated in India and China, and, in fact, may be two separate species. However, its use has been dropped by most oriental commercial bee-keepers in favour of introduced colonies of *A.mellifera*.

Twenty four major sub-species of *A.mellifera* are used in apiculture (Ruttner 1988); five of these are commonly used in breeding programmes (Figure 1). Each is distinguished by morphological characteristics, such as colour, hairiness and size, but of more interest to bee-keepers are their social differences: eg. size of colony, work rate, response to climate and temper. *Apis m. mellifera* is the North-western European subspecies. Isolation has produced a number of distinct races and varieties throughout its range; the native British race is given the name *A. mellifera mellifera lehzeni*.

Honey Bees evolved from tropical bees which developed the trick of surviving the winter, in colder climates, by clustering together and maintaining the colony temperature at about 30° C.. They do this by metabolising sugar which they store as honey. The *Apis* genus invaded the temperate regions, developing the specialized physiological races associated with different geographical areas (Rutner 1988). They became woodland creatures, living in hollow trees and foraging flowers on the tree tops, in glades, meadows and river margins. Although, in the wild, bees normally favour hollow trees for nest sites any ventilated, dry cavity, of about 20litres volume, can be used.

Cave paintings indicate that neolithic man hunted the honey of wild bees. *Apis mellifera* has lived in Britain since the last Ice Age and, by the bronze age, there is considerable historical evidence that the Britons probably knew "Opportunistic Bee-keeping" techniques (ie. gathering wild swarms into hives which are destroyed when the honey is harvested). If not these were certainly introduced during the Roman occupation.

Opportunistic Bee-keeping reached its zenith with the Saxon and Viking invasions when many large commercial apiaries were established because honey was the main source of alcoholic beverage for these peoples. The still extensive woodlands and relatively few people suggests that a large native population of *A. mellifera* provided the stock for domestication. During the middle ages mead became less popular and by the time cane sugar was imported,the numbers of bees in captivity declined remarkably. Most bee-keeping was of either the Opportunistic or small-scale "Cottage" (ie. colonies are maintained from year to year but interbreed with wild stock and are replaced by wild swarms). The large urban populations, resulting from the industrial revolution, produced an increased demand for honey so that commercial bee-keeping became a viable business once again. Throughout Europe 19th and 20th centuary apiarists set about improving their strains

of bee, developing better hives, increasing honey cropping and developing all the techniques now called "Commercial Beekeeping".

The loss of natural woodland habitat meant that wild bees declined in proportion to the number of domesticated stocks. Nevertheless, the native bee, *A. m. mellifera lehzeni*, persisted in most areas, and in areas where there was little Commercial Beekeeping, they still provided the stock for Cottage Bee-keepers. At this time there were probably very little genetic differences between wild and domesticated strains.

In 1906 "Isle of Wight disease" wiped out a large number of apiaries, particularly in southern Britain. The tribulations of the First World War combined with some exceptionally cold winters caused further enormous mortalities so that by 1920, bee stocks were at a very low level. Consequently, the Ministry of Agriculture started a training programme for beekeepers and encouraged the importation of bees, notably the Italian subspecies *A.m. ligustica*. The net result was the general belief that the native British Bee was extinct and that all colonies, both domestic and feral, were hybrids of the imported races. However, some apiarists did not support this view, notably Beowulf Cooper (Cooper 1986), who maintained that the native race still thrived in many of the more isolated regions of Britain.

Bee-breeding:- drones and mating.

Bees have been in domestication for at least ten thousand years but for nearly the whole of that time bees were still wild animals. It is only in the last two hundred years that bee-keepers have seriously attempted to produce distinct domestic strains. Each year an average colony produces one new young queen which takes over the colony. The old queen is either killed (supersedure) or she leaves the colony with about half the worker force and attempts to find a new nest site (swarming). A major problem for bee-breeders is that before they will mate, the young, virgin queen bees must be stimulated by leaving the hive and flying for some considerable distance. After mating they return home.

Drones from many colonies (both wild and domestic) tend to congregate at certain landmarks (Cooper 1986). The queens fly to these drone assemblies where they choose and mate with a number of different drones. A young queen may make several such flights and carry the sperm of up to 40 different drones. However once she is finished she never mates again. Thus bee-breeders have very little control over the paternal line and can only select for the maternal characteristics by destroying poor colonies and propagating from those that suit their purposes. Breeders, such as Father Adams of Buckfast Abbey, tried to overcome this problem by isolating their breeding stock in areas where they believe there are very few bees (either wild or domesticated). This maximises the chances of their queens mating with drones of known origin. Recently advances in artificial insemination techniques have overcome this problem and more and more bee-breeders are using this method of selective breeding.

It can be anticipated that eeders may soon produce many truely domesticated strains of the Honey-bee, having completely eliminated the genetic input from wild stocks. However, the problem for the wild

populations are that whilst queens of the domesticated strains may be husbanded carefully, the beekeepers are less particular about drone production. Drones may have a significant role in spreading the genes of domesticated stock into the wild British populations; they certainly have contributed to the spread of the "Africanized Honey Bee" in America.

The Africanized Honey-bee.

Until European man discovered America there were no Honey Bees in the New World. Early settlers introduced colonies of *A. m. melliffera*, *A.m.carnica* and *A.m.ligustica.* Escaping swarms led to the establishment of large feral (in the true sense) populations so that, by 1950, "native" New World Honey Bees consisted of a patchwork or either pure European subspecies or hybrids derived from the originally imported European stock.

In 1956 47 queens of the African subspecies *A.mellifera scutella* were imported and introduced into native hives in Brazil as part of a commercial breeding programme. This subspecies has a greater inclination to abscond from the hive and 26 of these queens were lost to the wild. When hybridized with the native strains, the offspring seem to have the worst of the African habits: they are bad-tempered, readily abscond from a hive after disturbance and they are extremely aggressive near to their hive. In 30 years this strain of bee spread throughout South and Central America and has just reached the USA. This has caused considerable alarm because numerous people have been stung to death after accidentaly disturbing colonies, usually feral ones. Commercially it has been an economic disaster for small apiarists who have neither the ability or resources to maintain a pure European strain.

The African strain has spread as far as 500km. in a single year. This is not simply the result of its greater swarming and dispersal abilities, it is mostly due to the interbreeding with and "Africanization" of the native European strains. Drone dispersal Drone migration is the key to this (Smith, Taylor & Brown 1989). Africanized drones fly further than European drones and are more inclined to drift. Drifting means that whereas, after a mating swarm, European drones tend to return to their own hive, Africanized drones are more inclined to seek temoporary accomodation in the nearest hive. A drone may thus drift hundreds of kilometers from the parent colony in a few weeks. Africanized strains produce more drones than European strains so that within in a few years a large apiary may be dominated by African genes transferred by drones.

Recent studies (Smith,Taylor & Brown 1989) have shown that the gene flow is assymetrical. That is, although an Africanized apiary still contains a large proportion of European genetic material, which its more frequent swarming liberates into the wild, these swarms do not significantly "Europeanize" the feral African population. It is assumed that swarms with European genes are less able to survive in the tropical and sub-tropical conditions of S. America than those with a greater proportion of African genes.

Both apiarists and politicians assume that the feral European races of *A. mellifera* living in N.America will fare better than those of South America. They hope that the Africanized form will be selected against in

the more temperate zone, starting north of Texas. Although the present evidence suggests that this is likely, insufficient is known about the requirements and population regulation of feral bees to be absolutely sure of it. A worry is that the Africanized bee could well maintain its dispersal and aggressive attributes whilst incorporating the physiological attributes of the European races, permitting it to extend its range considerably further north than so far predicted.

Whilst Africanization is never likely to be a problem in Britain and most of Europe, this story does show how the feral Honey bee genome can be rapidly altered. Most importantly, the interest in bee population genetics, stimulated by this problem, has lead to the development of genetic probes which may be of great use in studying wild Honey bee populations in Britain.

Characteristics of the Native British Bee

Cooper (1986) gave the characteristics, summarised in Table 1, as being diagnostic of the *A. m.lehzeni* (The British Honeybee). Many of these merely distinguish the northern forms of *A.m.mellifera* from its southern forms; especially it distinguishes between *A.m.mellifera* and the Italian bee *A.m.ligustica*. However races of *A.m.mellifera* can be distinguished by morphological critera and by genetical studies (Rothenbuler, Kulincevic & Kerr 1968, Rutner 1988).

All the distinguishing characteristics of *A.m.lehzeni* appear to be related to its ability to live and forage at cooler temperatures and to withstand colder, damper winters. Like many northern races of insects, it is darker coloured, larger, more hairy and probably is less physiologically active, at any temperature, compared with the southern races. More important to the maintenance of a local British race are the adaptations to the local flora and weather conditions that are maintained by its tendency for local inbreeding, by mating close to the hive. The greature frequency of supersedure, rather than swarming, prevents weakening the parent colony by worker loss and may either be a northern adaptation to restricted foraging periods or, in wild populations, a shortage of suitable new nest sites. Supersedure reduces the mortality of existing colonies but also reduces the rate of spread of new colonies.

The Honey Bee must be one of the most studied insects in terms of its sociality, pheremones, behaviour and cultivation, yet there have been very few studies of wild populations of *Apis mellifera*. The conventional wisdom of most bee-keepers is that any wild bee colony is a feral domesticated bee. This view ignores the evidence for the presence of *A. mellifera* in Europe before man became widespread and the fact that until relatively recently all bee-keeping in Europe was either opportunistic or honey-hunting. There are three possible situations that might exist in parts of Britain today:

1. areas where wild strains of *A.mellifera* have lived since the last Ice Age and co-exist with domesticated strains of the same origin. There are certainly regions like this in parts of Europe but they are probably rare in Britain.

2. areas where imported "foreign" domestic strains coexist with the native wild strains. This is often the case in parts of Africa, where European races are considered to be more tractable than the African *A.mellifera scutella*, and may be a fairly common situation in parts of Britain.

3. areas where it is believed the native race may be extinct and all wild bees originate from the imported domestic varieties. While believed by some to be the case in the whole of Britain, it is probably true only for Southern England. In many ways it is analagous to the situation in the New World, where Honey bees are not endemic and all colonies of *A. mellifera*, both domesticated and wild, have decended from imported domestic stock.

The Problem and need for research in Britain

In principle it seems undesirable that we should lose the genetic diversity contained in the wild stock of native British Honey-bees. This race could become commercially important once more, given unpredictable climate change - see Rutner (1988) for description of races. In any event, it undoubtedly possesses characteristics that could be of great use to bee-breeders in future breeding programmes (Cooper 1986).

In terms of nature conservation, the ecology of the honey-bee as a wild animal should be given some consideration. For, although the honey-bee has long been acknowledged to be an important pollinator of domestic crops (orchards and now oil-seed rape), bee-keepers are not sure whether the native races are more efficient at pollinating native wild plants than the domesticated imported races.

At the moment, despite the thousands of published works on honey-bees, virtually nothing is known about wild honey-bee stocks in Britain; we have no idea of their abundance, distribution and racial origins. There appears to be just one study on the ecology of wild honey-bee colonies (excluding studies of the Africanized Bee in South America) and that was done in Arizona, USA (Taber 1979).

Priority should be given to rectifying the lack of knowledge of British wild honey-bee populations. There should be a desk study, similar to one in France (Canteneur 1982), enlisting the help of the numerous honey-bee keeper clubs and societies to get some idea of the abundance of wild colonies. Ideally this should be supported by field research in selected areas to develop techniques for work on wild honey-bees and to attempt accurate censuses. A method of triangulating on wild colonies has been described from the USA (Visscher & Seeley 1989)>

Once the numbers and distribution of native honey-bees are known predictions about genetic exchange with domestic stock can be made. At the moment we can only extrapolate from study of the Africanized Honey-bee, which has shown: 1. The rate of spread of hybrids greatly exceeded all early forecasts. 2. African genes tend to get into the domestic "European" stock by drone transference. 3. It is possible for a very few individuals to "infect" a vast wild populations with their genes in a very short time. This work has lessons for the European situation but is not of direct relevance. We are fortunate that the scare created in the USA, by the northward spread of the Africanized Honey-bee, has lead to the development

of genetic probes that might be adapted to the study of *A.mellifera* in Britain.

The biggest future threat to wild honey-bees will come from selectively bred strains, including genetically engineered varieties. At the moment many apiaries are breeding special strains and it will not be long before gene transference may be attempted somewhere in the world. These forms may be contained in large commercial apiaries but, if sold to "Cottage bee-keepers", they are effectively released into the wild.

Conclusions

1. The native British Honey-bee was believed to be extinct, this is unlikely to be the case.

2. Very little is known about wild honey-bee populations on a wide scale and particularly in Britain.

3. Very little is known about the relative importance of wild honey-bees versus domesticated stock, for the pollination of native wild flowers.

4. Work on the Africanized Honey-bee in America has shown that there can be rapid and widespread exchange of genetic material between domesticated and wild stocks of honey-bee.

5. This work is not of direct application to Europe because all honey-bees have been introduced to the New World since 1500. Honey bees are endemic in Europe.

6. The importation of continental stock is temporarily banned to prevent the spread of the mite *Varroa jacobsoni* to Britain. This is unlikely to affect the spread of foreign genetic material into wild colonies because many "pure" imported strains are maintained in commercial apiaries.

7. Future problems are likely to arise from new strains, both selectively bred and genetically engineered to exploit specific crops (eg. oil seed rape), excaping and contaminating wild stocks, including those maintained in "Cottage Apiaries".

8. It is possible to forsee an "artificial strain" spreading in much the same way as the Africanised Honey-bee in South America but with the effects being more subtle than simple aggression.

Figure 1. The species and races of Honey-bee.

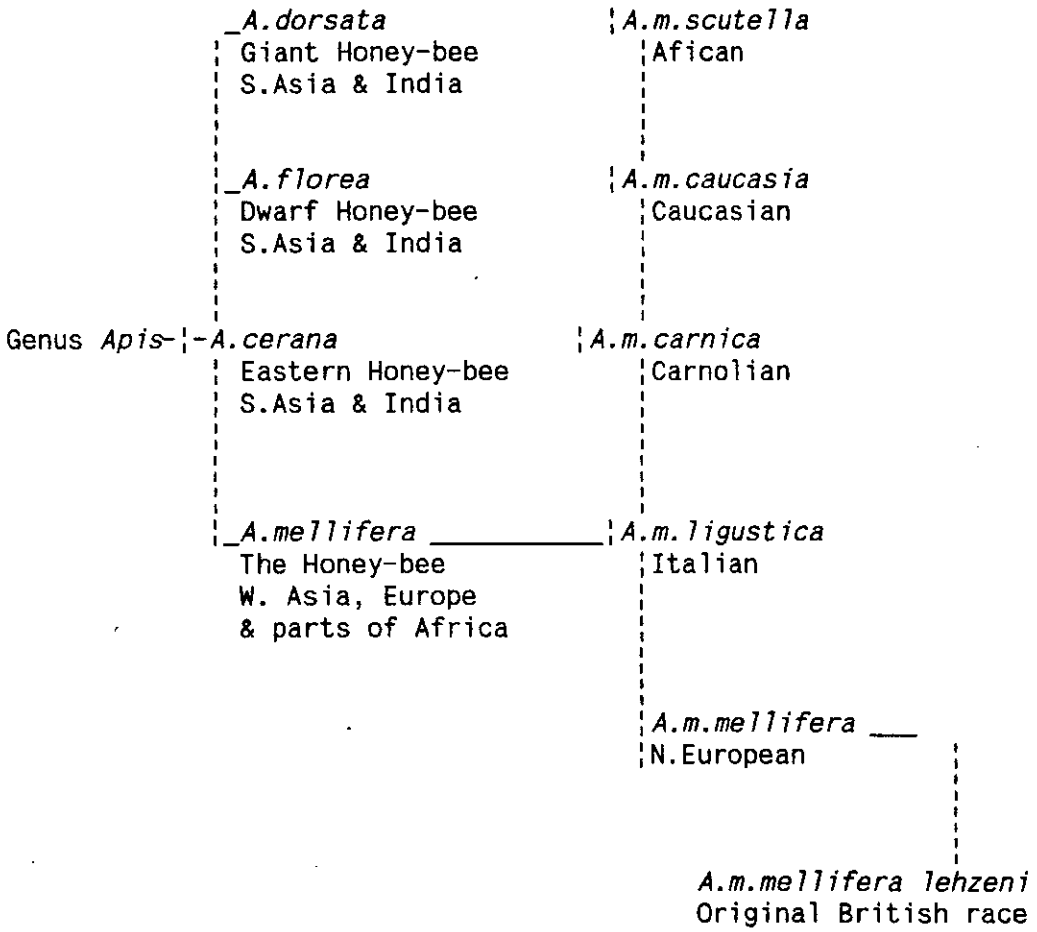

TABLE 1.

Diagnostic characters of the native bee, *Apis mellifera mellifera lehzeni*. Taken from Cooper 1986.

PHYSICAL CHARACTERS:

1. Colour: Black - helps with heat absorbtion.
2. Size: Genetically larger
3. Hairiness: Long abdominal overhairs (helps reduce heat loss)
4. Wing shape: Adaptations for power and endurance.

BEHAVIOURAL AND SOCIAL CHARACTERS:

1. Flight patterns:
   a. Fly at low temperatures.
   b. Do not collect water (dew) at dawn.
   c. Rarely fly when snow is lying.

2. Worker production:
   a. Produces fewer workers.
   b. Workers tend to live longer.
   c. Brood production ceases earlier.

3. Hive characters:
   a. Distinct comb capping pattern.
   b. More compact (smaller) combs (honey & brood).
   c. Bees form tight cluster near hive entrance in winter (avoid damp).
   d. Adapted to more variable brood-nest temperatures.

4. Breeding:
   a. Less likely to enter foreign hive (drifting)
   b. Shorter breeding period (drones expelled from hive earlier).
   c. Colonies swarm less often and tend to supersede (new queen takes over the colony without swarming).
   d. Young queens are more inclined to mate close to the hive.