The Dark European Honey Bee

Apis mellifera mellifera Linnaeus 1758

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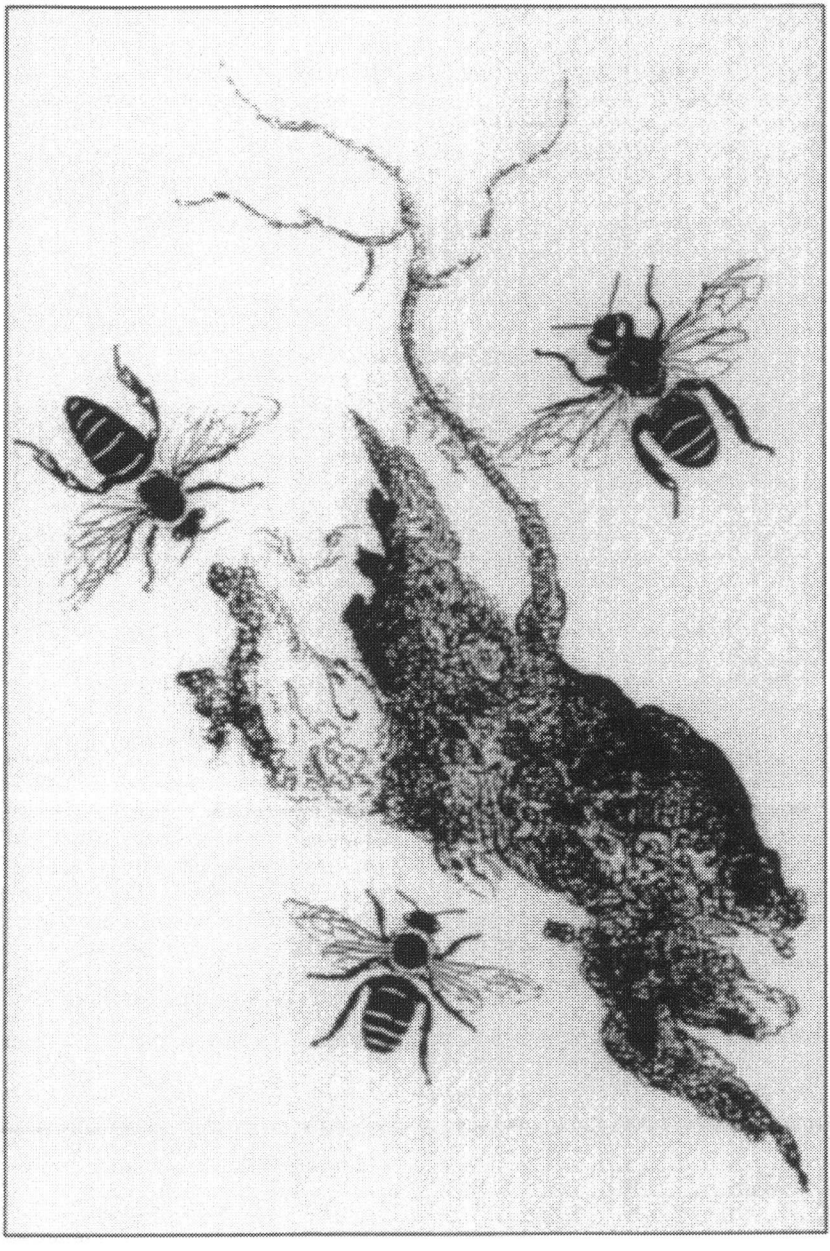
John Curtis (1791-1862) was the most distinguished illustrator of insects of his time. He published "British Entomology" in sixteen volumes, with 769 illustrations, all drawn and engraved by himself.

Cover:
Bee on pear blossom, at Horbury, Yorks. Spring, 1990.
Photograph of typical Dark honeybee: dark, "burly" body, narrow tomenta. by J. E. Dews.



Foreword

While preparing this booklet as a new study of a long neglected bee and as a supplement to the English version of his book "Breeding Techniques and Selection for Breeding of the Honeybee", F. Ruttner wrote about the problems of characterising the Dark European Bee: "The morphometric standard set down for this bee in Germany is scientifically not sound because of the massive importation of foreign races before the start of exact morphometric studies by G.Goetze around 1925."

To test the force of this allegation he asked me whether it would be possible to examine bee specimens in museums that had been collected before and shortly after 1859, the year of the first recorded successful importation of honeybees into the British Isles.

I have received help and information from very many people. I was warned that the harvest of material might be meagre, but there was far more than anyone had expected and more than enough to establish the reliability of the accepted standards. My friend and colleague, John Dews, and I had the good fortune to learn of the remains of bees, from the Coppergate excavations of Viking remains in York, considered to date from about 1000 A.D. (soon after the expulsion of the last Viking king, Erik Bloodaxe, from York, in 954 A.D.). Measurable portions of wings of about 50 bees have been discovered among the remains, together with many legs with pollen baskets clearly visible and other parts that have been studied. Bees from about two centuries later have also been found in Oslo to add to our evidence, and to provide a very welcome comparison with the Scandinavian bees collected by *CARL von LINNÉ* which are now preserved by the Linnaean Society, at Burlington House, London. The oldest museum specimens known to us are in the British Museum, collected before 1697; other museums have provided valuable old specimens. The National Museum of Wales possesses recent specimens which show, by conformity to the standards of their ancestors, that they were of pure race long after imports had begun.

Our many examinations of contemporary colonies have shown, by the same racial standards, that *the native honeybee still exists as a pure race in many parts of the British Isles.*

Dr.Ruttner also asked me to amplify his account of the behaviour of the Dark bee from such sources as lay open to me. My warmest thanks are due to many helpers. Robert Couston drew upon his long experience as a C.B.I. in Scotland, commercial beekeeper, and author. Athole Kirkwood placed his long experience at our disposal. The curators of all the museums to which I applied were helpful to an extraordinary degree: Dr. Adrian Amsden, National Museum of Wales; Dr. Mark A.Shaw, the Royal Museum of Scotland, Mr. James P.O'Connor, The National Museum of Ireland; Mr. Christopher O'Toole, Natural Science Museum (Hope Entomological Collection) Oxford; Mr. Adrian Norris, Leeds City Museum; Mr. Eric G. Philp, Maidstone Museum; Mr. A. J. Boonham, Beverley B. K. A. who

informed us of the York "Viking" Bees, and introduced us to Mr. Harry Kenward, Director of the Environmental Archaeology Unit, University of York; all of whom patiently endured questioning and, when they were available, placed specimens for measurement at our disposal. At the Natural History Museum Mr. M. Day, Mr. G. Else and Dr. M. Fitton (who is also Curator of Insects to the Linnaean Society) also gave much information about other collections, and invaluable help with illustrations. Dr. Eva Crane gave similar help. Our grateful thanks are due to the Linnaean Society of London, for permitting the specimens of honeybees, collected by CARL von LINNÉ himself, to be taken to the British Museum to be photographed and measured. One of these bees was identified by Mr.Else as the lectotype of the species.

William Bielby, (who discovered colonies of feral native bees in Skeldale, Yorks), adding to many previous kindnesses, investigated and informed us about the introduction of the honeybee to New Zealand. He also sent specimens of feral bees from which measurements indistinguishable from those of the York "Viking" bees have been made.

Although I have done the correspondence and when necessary made visits to museums, John has done all the photography of the specimens. This has been a long labour, as they had to be photographed with such accuracy that measurements of 0.01mm., or even finer, could be made. John's measurements were all checked and confirmed at the Institute at Oberursel, by Agnes Mohr, who is described by Dr. Ruttner as the most experienced morphometrician of honeybees in the world. John has had advice from Dr. Ruttner on what was required but his patience and application have brought about these excellent results. The Linnaean bees, and the older specimens in the British Museum were photographed by Adrian and Claire Waring to whom my warmest thanks are due.

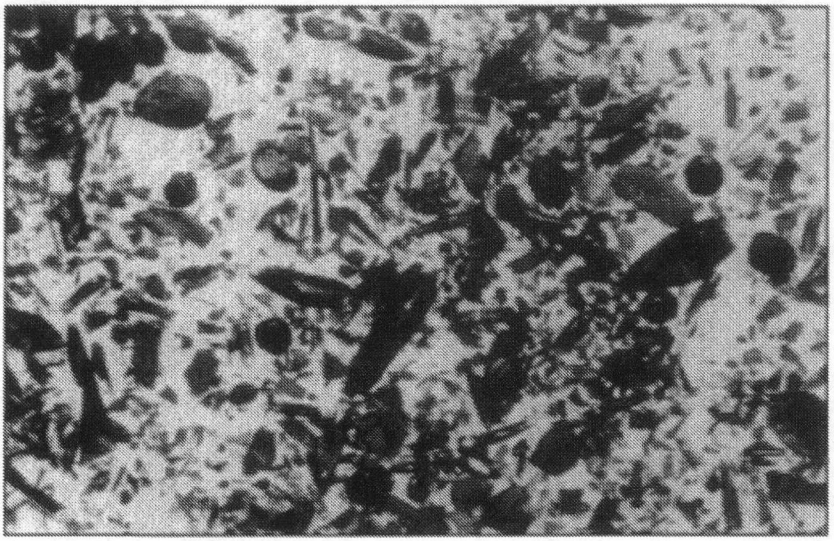
This work is based on a lecture written by Dr. Ruttner for the BIBBA Conference at Cardiff in 1988, which he asked me to see through the press. I have retained the lecture form, and "I" in the text is always Dr. Ruttner, who has been continuously checking and arranging our finds and results.

I felt that it was a great privilege to be entrusted with this work. I was very fortunate to have John as a colleague. The information gathered here, much of it published for the first time, should give pleasure, and be of great benefit, to British beekeepers. Much of it will be new to English readers.

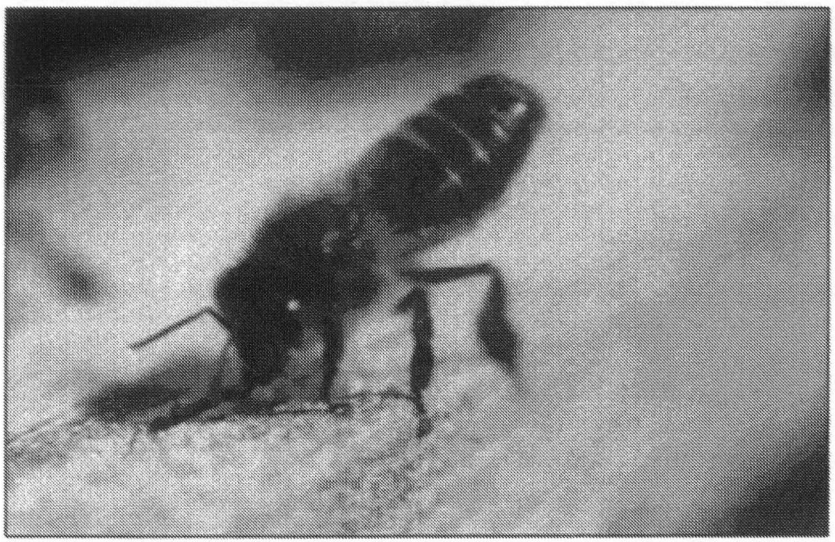
There are important problems still awaiting attention. Studies have been made on the Continent of the temperatures at which queens and drones can fly, and more recently on the height at which CARNICA and LIGUSTICA drones assemble for mating. There is room for such investigations into the habits of the Dark Bee.

The findings might throw light on how so many colonies have retained their racial purity in the presence of a century and a half of foreign imports.

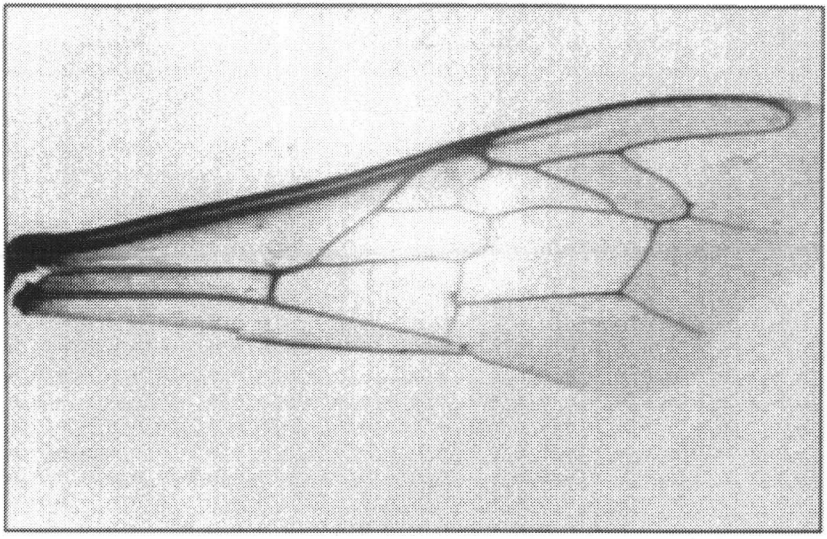
E. M.



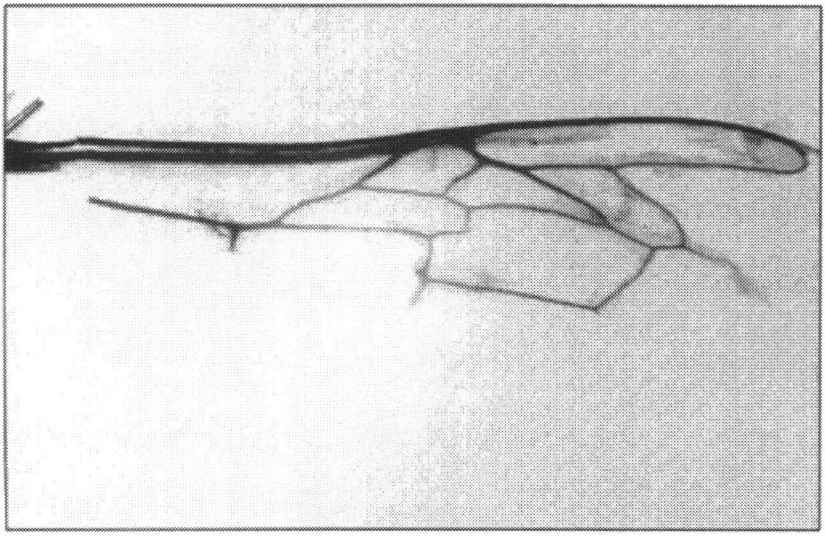
Honeybee fragments excavated at a Viking settlement in York, between 975-1025 A.D.
Photo J. E. Dews.



Norwegian honeybee. Fanning, wings not visible.
Photo Ingvar Vasshus of Ualand, Norway.



Forewing of Oslo honeybee, c.1200 A.D.
Discoidal point in correct position. *Photo J. E. Dews.*



Forewing of York "Viking" Honeybee, c. 1000 A.D. C.I., 1.77. Insufficient membrane remaining to hold the Discoidal point in the correct position. *Photo J. E. Dews.*

PREFACE

The booklet "Breeding Techniques and Selection for Breeding of the Honeybee" originated from weekend classes for beekeepers in Austria and Germany to help them to select better, purely mated queens of the carnica race and to discriminate their stock from the "country bee", the heavily hybridized native honeybee. Since hardly any strains of the European Dark Bee are left in this region, teaching was centred on Carniolans.

The situation, however, is different in other regions. There are countries where a great interest in the old native Dark bee still exists, and this for good reasons. Beekeepers there may feel disappointed while reading the booklet mentioned above, and a supplement seems appropriate in order to give more detailed information on this important race. In fact, no such survey has been published since the early book of POLLMANN (1889) and only one publication exists on a local strain of the Dark bee (B.COOPER: The Honeybees of the British Isles, 1987). With the persistent and effective co-operation of the Rev. Eric Milner and Mr.John Dews, (who contributed many important suggestions) museum specimens of the native British bee collected before the middle of the last century, and remains found in archaeological excavations, have been studied and measured, thus confirming the recognized characters of the unhybridized race.

When there are plans to establish new strains of an old bee, special care has to be taken to avoid serious setbacks. If the initial population is too small - perhaps of necessity in consequence of insufficient stock of pure breeder queens - effects of inbreeding will be visible within a few generations and the whole effort could end up in thorough disillusionment. The ideal way would be first to create a self-supporting closed population and only then to start selection.

This survey of the Dark bee gives a collection of data and experiences as complete as possible, but there is no intention of providing an evaluation. It is up to the beekeeper to come to a conclusion, derived from his environment and his special management methods.

F. Ruttner

SUMMARY

The Dark European honeybee, native to all Europe north of the Alps, was exclusively used in beekeeping in this region until 1850, but afterwards was heavily hybridized in many countries. It was exported to North America, to Australia and New Zealand and formed large feral populations there. The behavioural and morphological characters, as found in various countries, of the Dark bee are described. Reliable means and ranges of variability of some important discriminant characters of *Apis mellifera mellifera* (Cubital index, Discoidal shift, hair length) were calculated from an extensive set of data derived from greatly differing sources such as samples of bees from various parts of the original area in Europe and of populations exported in the early 19th century to Tasmania and New Zealand; specimens from several museums in Great Britain, collected before the start of importation of other races, including the lectotype of *Apis mellifera L* of the Linnaean Collection, and remnants of bees excavated in a Viking settlement in York, from about the year 1000 A.D., and abundant remains from a site in Oslo, dated between 1175 and 1225 A.D.

This race is best adapted to regions with cool climate and scanty flow. The specific morphological characters are given; only in France was diversification found within this race, but not in other regions with presumably younger populations. Two or three characters, which are easily measured, are sufficient to distinguish the Dark bee from other races or from hybrids.

INTRODUCTION

This investigation is long overdue in apicultural science: a comprehensive monograph of one of the most important, but in the beekeeping world more and more forgotten races of honeybees, the European Dark Honeybee, *Apis mellifera mellifera Linnaeus, 1758*, the archetypical honeybee of apiculture.

Few other types of honeybee have a longer historical record, a more extensive apicultural practice and colonisation of new territory than this race which is generally called the "common honeybee" in honeybee literature. It was the first honeybee to be scientifically described, namely by *CARL von LINNÉ* in his fundamental "Systema Naturae" in 1758, and three years later in the local publication "Fauna Suecica". In Germany it was with colonies of this race that *J.DZIERZON* in 1845 invented the first practicable hive with moveable combs, and in the U.S.A. that *L.LANGSTROTH* detected the BEE SPACE. This race was the first honeybee to be brought to North America, quickly becoming an essential part of the local fauna and living in the forests of New England and Virginia by the million. The same happened in Australia, especially in Tasmania where a large feral population has retained the characters of the Dark honeybee up to the present. A colony from England was successfully established in New Zealand in 1838 and another from Australia two years later, from which a feral population was rapidly established. (COTTON, 1842,1848).

The surprising capacity of this race to adapt to a cool climate, long winters and to new areas is not matched by the attention it has found in the scientific and apicultural world. Races from the Mediterranean or the Near East were far more frequently and extensively described, and in several countries the Dark bee is in the process of rapid and final extinction. Only a few apiculturalists have been determined to study the characters and economic advantages of the local bee, among others the late Beowulf COOPER in England (and BIBBA, the Association founded by him), apiculturalists in the USSR, France and Norway, and the Association of Swiss beekeepers. In this paper accumulated knowledge about the history of the Dark bee in evolution and apiculture, distribution and behaviour from as many countries of its original area as possible, and a statistical analysis of a collection of samples from the region are presented. For a more complete bibliography see RUTTNER, (1988.)

Origin and distribution

The same success of rapid colonization by this race of *APIS MELLIFERA* as in recent history happened about 8,000 years earlier during the first post glacial warm period when swarms of this race spread east, crossing all of Europe from the Pyrenees to the Urals and venturing farther north than any other race (Fig.1). It can certainly be taken for granted that no honeybee could exist north of the Alps during the last glaciation. The relatively narrow strip of open land between the northern ice shield and the Alpine glaciers was covered by a treeless arctic tundra, no place for bees. The only possible region for survival during this period was the

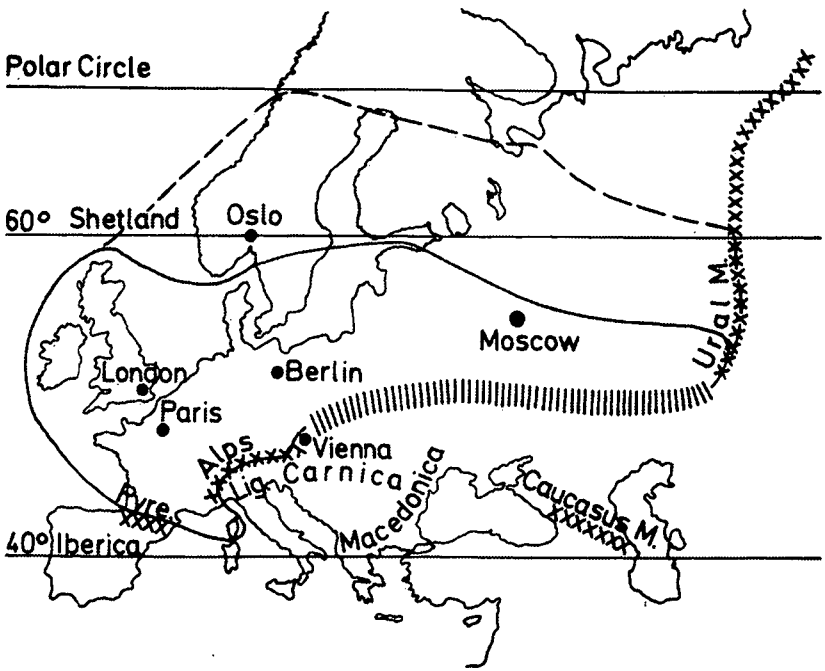


Fig. 1. Distribution map of *A.m.mellifera*. Solid line - historic distribution to the west, north and east; vertically hatched - transition zone to the Ukrainian bee; dotted line - present northern limit of beekeeping.

coast of the Mediterranean, and probably also some parts of southwestern France with a probably very complex climatic situation during the last part of the glaciation. As recently shown by excavation in caves of the

region, besides the pollen grains of an arctic forest (pines), small numbers of thermophilic trees (hazel, oak, beech) were permanently present from about 16,000 years BP. The same species of trees were found among the charcoal left by early man. (LAVILLE & RENAULT-MISKOVSKY 1977)

This puzzling situation is best explained by the assumption that sheltered valleys existed among the plateaux and hills where the climate was still cold. These ecological niches may have provided a home for isolated populations of honeybees, explaining the fact that the native honeybees of France show more variety than the Dark Bee of any other region, indicating a true "gene centre" of this race. Mountain chains are a very effective barrier for bees at present and were even more so in the period when glaciers descended close to the sea.

This explains how three races of bees developed within a short distance along the northern coast of the western Mediterranean: *A.m.iberica -mellifera-ligustica.* Recent studies of the bees of the Iberian Peninsula and Morocco give interesting details on the close links between West European and North African bee populations.(CORNUET & FRESNAYE, 1989; CORNUET et al 1989).

Venturing North

When the climate started to change it can be assumed that the bees followed the migration of the coastal forests inland. But *Iberica* and *Ligustica* found themselves secluded in the Iberian and Appeninian peninsulas by the bordering mountains and later profited from the warm-temperate climate of this zone.

A.m.mellifera, however, found an open field for migration north and east - as far as the climatic conditions would permit. Already selected for wintering capacity during the glacial period, the Dark bee continued to receive a hard test by the severe conditions of the newly colonized area. Colonies managed to advance as far north as the coasts of the Baltic Sea, to about 60 degrees northern latitude, and into northern Britain, (it should be remembered that the British Isles were not separated from the Continent till about 6,000 B.C.; there was no Channel to form a barrier to their advance). In Scandinavia the original bee population was restricted to a northern limit, crossing the districts of Vaermland, Vaestmanland and Uppland in Southern Sweden about 50° north (Fig, 1). An animal husbandry inventory of 1751 gives bee hives for these districts only, but not for districts further north. Since bees were kept exclusively in log hives, as in Poland, it can be assumed that they lived under the same conditions as feral colonies in the surrounding forests (HANSSON 1955). This limit corresponds well with the northern limit of hazel.

Honeybees use a very effective method of generating and regulating heat within the cluster: at higher temperatures they orient the bodies perpendicularly to the surface creating ventilation channels, while at lower temperatures they form tight layers with their abdomens exposed,

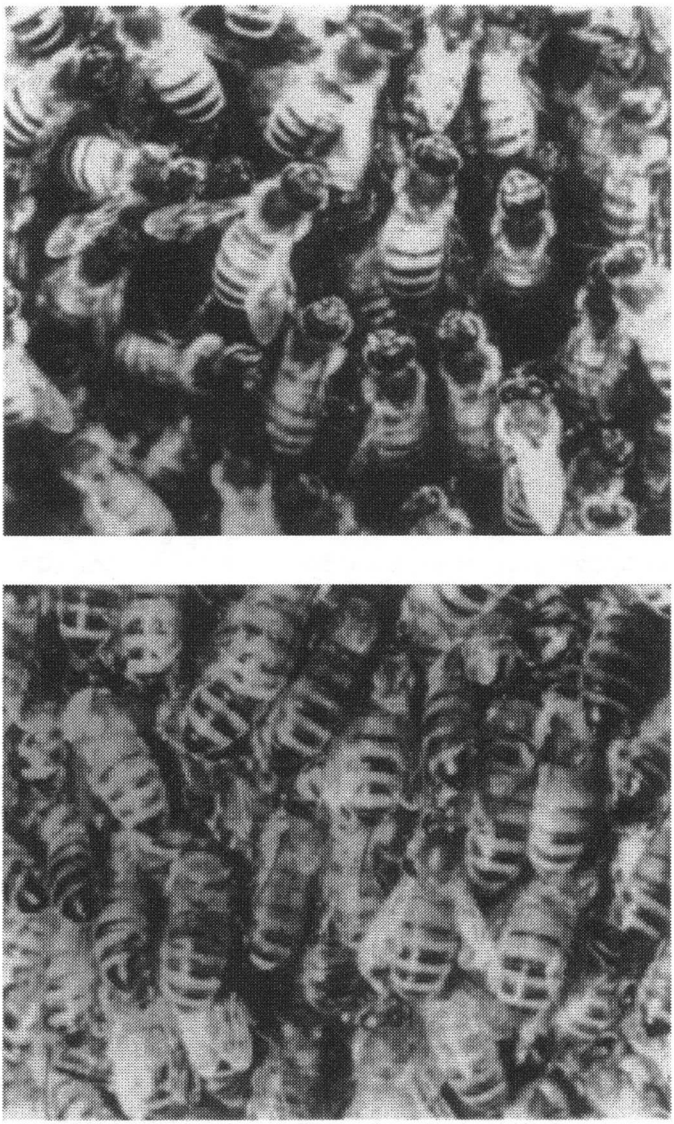


Fig. 2. Bees on the surface of a swarm cluster at 25° C (top) and at 3° C (bottom). From HEINRICH, 1985.

heads turned inward. (Fig. 2) (Other measures for adaptation to the cold will be found under the heading "Wintering".)

The first historical record of "beekeeping" in Sweden (which was of course, no more than an exploitation of the local bee population), dates from 900 A.D., found in a record of the monk and "Apostle of the North", Ansgar. In Norway feral honeybees could have existed during the warm period of Viking times, but not later. The first historical record of honeybee colonies in Norway, probably imported from Sweden, dates from about 1775 (ROSENBERG, per. com.).

The northern limits of honeybees may have oscillated with the changing climatic conditions, together with oak and lime, along the Baltic sea, sometimes extending as far as 64° north. Forests of deciduous trees may have been the home of honeybee colonies already in the post-glacial warm period, as is shown by residues of linden honey found in Denmark in a vessel dating from the early Bronze Age (HANSSEN 1955). The limits of the original area of feral *mellifera* colonies coincide approximately with the northern limits of deciduous trees such as lime, oak, elm, white beech and wild cherry.

Economic beekeeping has been extended farther north by modern apiculture (Fig.1, broken line); it now goes as far as the Polar Circle in Scandinavia and "as far as the rivers are frozen for less than six months" in the Soviet Union (ALPATOV 1976).

2.- Forest beekeeping in Eastern Europe.

To the east, the original limits of the Dark bee were the Ural Mountains. The lime forests of Bashkiria in the southern part of this mountain chain are famous for their honey. "My first impression of this region was that everybody is occupied with bees", reported a tourist. The local feral colonies are adapted for surviving long winters with temperatures sometimes as low as -45° C.

Siberia, however, and the republics of central Asia were colonized for beekeeping by Russian farmers only during the 19th Century. (BILASH, 1979)

Historical "beekeeping" in the huge forests of eastern Europe, begun in the 8th - 10th Century, was not very different from the bee colonies in their feral condition. It basically provided nesting sites in the natural locations by cutting holes in trees, protecting the colonies against bears and harvesting honey without destroying the colony ("Zeidlerei", no English word exists for this traditional way of caring for bees because it occurred only in eastern Europe from the Urals as far west as the "Reichsforst" near Nürnberg) The economic importance of this kind of beekeeping with the Dark bee (known in Russia as the "Forest bee" *A.m.silvarum*, according to ALPATOV, 1935) in the east European forests was enormous. Fur, honey and wax were the only primary products of the region. Bee colonies in Russia were estimated to be numbered in millions, thousands of tons of honey were exported every year (BILASH,1979).

This kind of beekeeping provided most of the honey and wax traded in Europe in the Middle Ages. Market records from Brugge and Hamburg from the 14th to 15th centuries regularly quote Poland and Russia as the source of honey and beeswax, and in a record of the market of Hamburg from 1550 honey ranked third among products from Russia, after furs and flax (BULL, 1961). "Bee Trees" with artificially excavated nests were still frequent in the forests of the eastern provinces of Prussia (now Poland) during the middle of the 19th Century.

Vertical log hives with access from one side (not from bottom and top, as in west European log hives) are the logical descendants of the bee nests in trees. They only appeared during the 17th Century in the villages of the Russian forest region and then disappeared not earlier than the first half of the present century. In 1910, 82% of the more than 6 million beehives in Russia were still this type of hive (BILASH 1979). The further evolution was the unique side-opening hive with moveable frames, placed in bee-houses which became the typical way of beekeeping in all of Central Europe as a result of the teaching of the Silesian priest JOHANNES DZIERZON (1811 - 1906).

The flourishing of the Dark bee in the east European forests with their long cold winters tells much about the specific adaptations of this bee which can be regarded as the true pioneer in the post-glacial period, following the transformation of the Arctic tundra into a dense forest.

3. - The Dark Bee in the West and South

In the western part of the *mellifera* area beekeeping with moveable hives seems to have a much longer tradition. The excavation of a typical wicker hive at Feddersen Wierde, a village on the coast of the North Sea west of the mouth of the river Elbe, dating from the First Century A.D., demonstrated that apiculture was already part of rural economics during early times. Straw skeps, typical for Germanic countries, supposedly came into use about the same epoch because they were brought to the British Isles by the Anglo-Saxons in the 5th or 6th Century. But wicker hives remained in use in Belgium up to our time (RUTTNER 1979). The last recorded use of a wicker hive in the British Isles was in Herefordshire in the 1880s. (CRANE 1983)

The southern limits of the *mellifera* are sharply marked by the Alps: north of the main chain the Dark bee, south the Italian and Carniolan. Only in the extreme west does the Dark bee's domain extend south into the valleys of the Ligurian and Piedmontese Alps. The southernmost extension of the "Dark" area is found on the island of Corsica, where it is represented by a very similar population coexisting with a typical Mediterranean flora and climate, while on Sardinia *A.m.ligustica* is present. East of the Alps, especially in the vast plains of southern Russia, a gradual transition from the "Forest Bee" in the north (*A.m.mellifera*) to the "steppe bee" (*A.m.acervorum Skorikov 1929*) in the south (a type now determined as being close to *A.m.macedonica*) is observed (ALPATOV 1929)

Colonization of new territories

The potential for establishing permanent populations in an area not yet colonized by a certain species is an indicator of its genetic set-up, as convincing as are the ecological conditions of its original area of distribution. The Dark bee contributes good evidence in this respect. In Europe the northern limits where apiculture is possible on a permanent, economic scale were shifted north during historical times by about 7 degrees of geographic latitude. Beekeeping was started in Norway by the end of the 18th century as stated above and it was extended north up to the Arctic circle in all of Scandinavia. A similar development happened in Finland where bees were first imported during the 18th Century from Sweden and Estonia (KOIVULETO, 1974)

Therefore, if sometimes a "Norwegian" or "Finnish" bee is mentioned (Bro. ADAM 1983) it has to be kept in mind that these bees have a very different history from the Dark bees of France or the British Isles: their ancestors were imported about 200 years ago. The bee population of the northern British Isles, (Orkneys, Shetlands) is also very likely related to human settlement. It is of interest that the limiting factor for permanent beekeeping in the zone of the Atlantic climate is evidently less the overwintering problem than the difficulty of performing successful mating flights during the cool - and windy - summers.

Among the most extended acquisitions of the Dark Bee was the huge forest of Siberia which was gradually colonized from west to east from the end of the 18th and throughout the 19th Century. An exception was the far east of Siberia (Ussuria) where Ukrainian bees were imported by the settlers (ALPATOV 1974). Today half of the honey harvested in the USSR is produced in this region (BILASH 1979).

The ideal new environment for the Dark Bee was evidently the northern part of the North American continent, matching that of Bashkiria. After importation to the east Coast, early in the 17th century, a big feral population rapidly established itself and spread west faster than human colonization. "Honey hunting" from wild colonies in the trees became a favourite sport (EDGELL 1949). In some parts the estimated feral population even now exceeds the number of managed hives (TAYLOR 1986). Although colonies of Italian or Carniolan origin have been exclusively used in apiculture for more than 100 years (the reasons for this will be explained later), ALPATOV (1929) was able to find pure "dark" colonies, identified by morphometric methods, in various parts of the U.S.A. Genes of the Dark bee are present in the feral population even today. (SHEPPARD 1988)

A similar "story of success" occurred in Tasmania where Black Bees were imported in 1835. The bees of the large feral population in the eucalyptus forests, as well as in the managed "Black" colonies in the central region of Tarraleah, retained the typical values of the English bee in most characters.

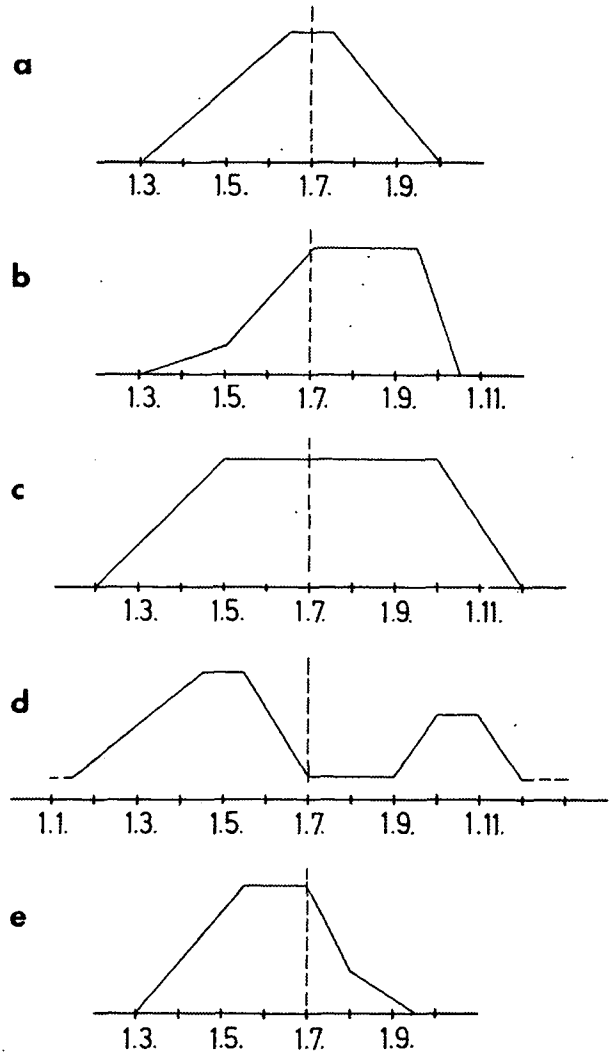


Fig. 3. Different types of brood rhythm (schematically)
a) Early summer type, with peak by the end of June.
b) Heather type, peak in August.
c) Sub-mediterranean type with long peak from May to September.
d) Mediterranean type with two peaks, and a brood depression from July to August.
e) "Atlantic Coast" type, late start, slow increase, low peak, early brood stop.

In New Zealand, Mary Anna Bumby arrived on 20th March,1838, bringing a hive of bees from Thirsk, Yorkshire (BIELBY, pers.comm.); two more hives were brought from Australia. COTTON, (1848 p. 53) reports on a thriving feral population, from which the Maoris had learnt to harvest and market honey. A sample of bees taken from a feral colony in S.Island shows the typical characters of *A.m.mellifera* (BIELBY 1989). Thus we must realise that all of the cool-temperate zones on the globe, both in the northern and southern hemispheres, had been exclusively colonized about 1860 by one single race, the Dark bee.

The limits of adaptability of even this very versatile race became visible in the subtropical and tropical regions of Central and South America. There the Iberian bee, the "cousin" of the Dark bee, which should have been better adapted to the warm climate than the latter, was imported. But almost no feral colonies originated - not until true tropical bees arrived, namely the "Africanised bee" of South African origin, which immediately became firmly established, eradicating all honeybees of European descent. This clearly demonstrates to what extent the European Dark bee (likewise her relative from Iberia) is a bee of the cool temperate zone, unable to cope with the tropics. Concluding, it can be stated that by about 1850 the Dark bee occurred in a larger area and in greater variety of ecological conditions than any other sub-species of *A.mellifera*. At this time the area of the Dark bee extended on the Eurasian continent from the Pyrenees through central Europe north of the Alps to eastern Siberia and it covered a substantial part of North America as well as parts of eastern Australia, Tasmania and New Zealand.

The degree of adaptability shown in the various parts of this unhomogeneous territory is astonishing: in the northwest of Europe, considered as the "heart land" of the Dark bee, this race shows the typical characters of an "Atlantic" bee, living in a temperate climate without extremes, well adapted to the late heather flow; in the Mediterranean area (Provence, Corsica) the same race shows the characteristic bimodal brood pattern of other Mediterranean races (brood rearing depression in summer, second peak in autumn,(FRESNAYE et al 1974) In central and eastern Russia, as well as in North America, however, the Dark bee proved itself able to cope with severe continental climatic conditions with extremely cold winters and warm summers. (Fig 3)

Behavioural characters

A number of specialists from various countries contributed to the knowledge of behavioural characters from an economic standpoint: BRO. ADAM (1983), W. W. ALPATOV. (1948) B. COOPER, (1987), G. GOETZE, (1964) and R. LUNDER, (1953)

These publications, together with my long standing personal experience in different regions and in an experimental apiary gave a surprisingly

congruent result as far as several important aspects common to all the ecotypes are concerned.

a.- Rhythm of brood activity and brood pattern.

Brood rearing in spring starts late and increases slowly to a peak in midsummer which is definitely lower when compared with other races such as Italians or Carniolans. Brood stop in autumn is early when compared with *ligustica*. (Fig. 3e)

COOPER gives the maximum of brood frames with 14 British Standard (350 x 213 mm), but usually this amount is restricted to 10-11 frames by queen excluder. BRO. ADAM estimates the fecundity up to a maximum of 8 frames (in his case, probably Dadant). J. DEWS (pers. com.) regards a Langstroth box as the right size for a *mellifera* colony, but a Dadant box as too large; many beekeepers find that one British National brood box is adequate, while others find that a brood box and a shallow box is required. Additionally, the amount of brood per frame is reduced by this bee's habit of storing great quantities of pollen (even underneath the brood area, making a continuous band round the brood, which is altogether unusual in other races) and the tendency to store honey close to the brood nest (Fig. 4).

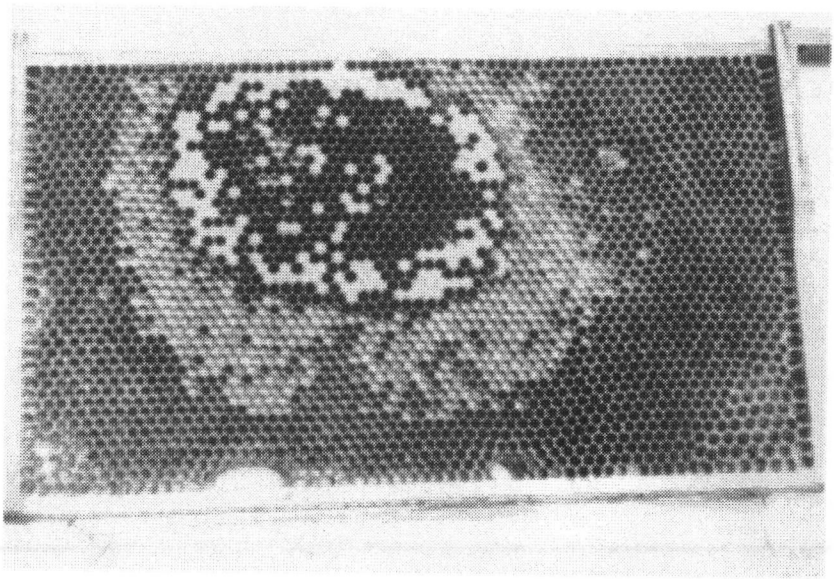


Fig. 4 Brood comb with deposition of stores close to the brood, pollen even placed underneath the brood (COOPER 1978).

This brood pattern - a compact brood area surrounded by heavy circles of pollen and honey - is the ideal of the Swiss beekeepers who favour the "Nigra" bee, called the "HUNGLER" type. Selection with this type of bee is directed to a moderate amount of brood. "If a queen fills the combs with brood from one end bar to the other, I kill her immediately", as ALOIS SCHWARZENBERGER, President of the Tyrolean Beekeeping Association for many years, told me once. "There is no point in looking for a bee which is less prolific than needed to fill one National brood box" (COOPER, 1987). Before the necessity of pollen for brood rearing was known, beekeepers used to talk about "pollen clogged combs"; however, the bees are able to consume or remove this pollen quickly if necessary - they just seem to prefer this pattern. An examination in spring will often reveal a solid comb of pollen beyond the brood nest, which on later examination will have an area of empty cells, prepared for the queen in advance of her needs, so that the comb of pollen does not necessarily form a hindrance to the extension of the brood nest, as is sometimes feared. Some beekeepers have observed, in a mild spring with rapid expansion of the brood nest, that brood is reared in a comb beyond the pollen comb, pollen being used as needed and replaced with brood. (MILNER pers. com.) There is, however,considerable variation between strains and geographic populations.

The prevailing nectar plant on the European Atlantic coast from Biarritz to Trondheim and on the highlands of the British Isles is heather, starting with bell heather in July and with the main crop from ling in August. In these areas flowers are often very scarce in spring and early summer, hardly sufficient for the sustenance of the colony. Only specifically adapted bees are able to cope with this short period of a single mono-floral food supply. (Fig 3b) "Only by the middle of July have the beekeepers in the north of Britain a nectar flow. Their bees start brood rearing not earlier than the end of April. Nowhere in the world could they buy colonies with such late development." wrote H.J.WADEY (Sussex) in the "Schweizerische Bienenzeitung", 1940, p.475. The records of Athole KIRKWOOD, of Perthshire, Scotland are interesting. No attempt has been made to keep his bees unhybridized from the influence of neighbours' bees but recent examination shows them to be predominantly of native type (Mean of 3 samples, CI = 1.95, Hair length = 0.41mm). With 2000 colonies, over a period of 40 years the maximum yield from a single colony was never more than 350 lb, and the maximum average about 150 lb. in an apiary. Recent years have produced a lower average. In the best year, 1975, 1300 colonies produced 57 tons of honey (pers. com.). In southern Norway around Flekkenfjord, although squeezed in a narrow space between the sea and granite rocks, beekeeping is practised which relies exclusively on heather. Other races cannot cope with this type of environment which provides not more than substitute income until August. Bro. ADAM reports that the colonies of his home apiary collected honey from the moor 2 1/4 miles away only so long as he kept Dark bees. The problem of wintering with heather honey is dealt with below.

These records from the Atlantic coast, however, give only the special pattern of a certain population of the Dark bee. In other parts of the *mellifera* area the local populations show different ecological adaptations of the brood rhythm. In France only the bees of the heather region of the southwest (The Landes) show the kind of brood rearing activity described above while strains from the region round Paris with an early honey flow have a quite different "Central European" brood rhythm, an early peak and decline already after 15th July (Fig 3a) (LOUVEAUX 1969). In the Mediterranean zone (Provence) a clear bi-modal brood curve is observed, with a clear depression in the hot, dry summer and a second peak in autumn. (Fig. 3d.). In fact, in France, all possible patterns of brood rearing are found, correlated with climatic conditions. (LAVIE and FRESNAYE, 1973). In *A.m.mellifera* the kind of brood rhythm is clearly a question of the local ecotype and not of the race.

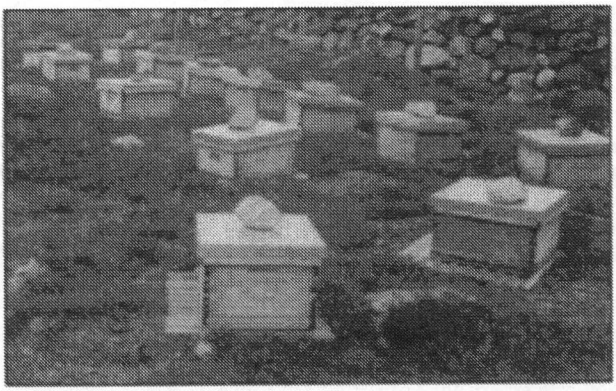
b. Wintering

All authors unanimously attest to an excellent wintering ability of the Dark bee even under harsh conditions. As the colony size is moderate throughout the season the winter cluster is small but very tight. In consequence of the restricted brood activity, the bees excel by their longevity and by a moderate food consumption. The colonies have a high chance of survival with a minimum of assistance. Of course, by venturing further north the bees increase the risk of loss in severe winters. According to B.MÖBUS (Apicultural Adviser in N. E. Scotland) a beekeeper south of Aberdeen lost 850 colonies out of 1,000 in 1979. An Edinburgh beekeeper lost 780 out of 800 in 1986.(pers.com.) Nothing is said, however, whether the victims were of pure imported stock or poorly adapted hybrids. Further, the observation that the bee population of northern England and Scotland remained essentially "dark" in spite of repeated importations might be explained as the effect of natural selection in favour of the native bee. On the other hand there are experiences of good wintering results with Carniolans in middle Norway and with selected Italians in Finland (proper management provided). The problem of wintering ability of various races and selected ecotypes, therefore, is still controversial and experimental data are needed to give a general answer. Winter bees are physiologically different from summer bees; they have accumulated protein, fat and a substance called Biopterin in the food glands and the fat-protein body of the abdomen. The capability of the rectum to store large quantities of faeces seems to be improved by an increased catalase production by the rectal glands in autumn. In the bees of the northern USSR this was found to be double that of the bees of the south; the latter did not increase catalase production in autumn, as did the northern bees, even when the southern bees were taken north. (RUTTNER 1988)

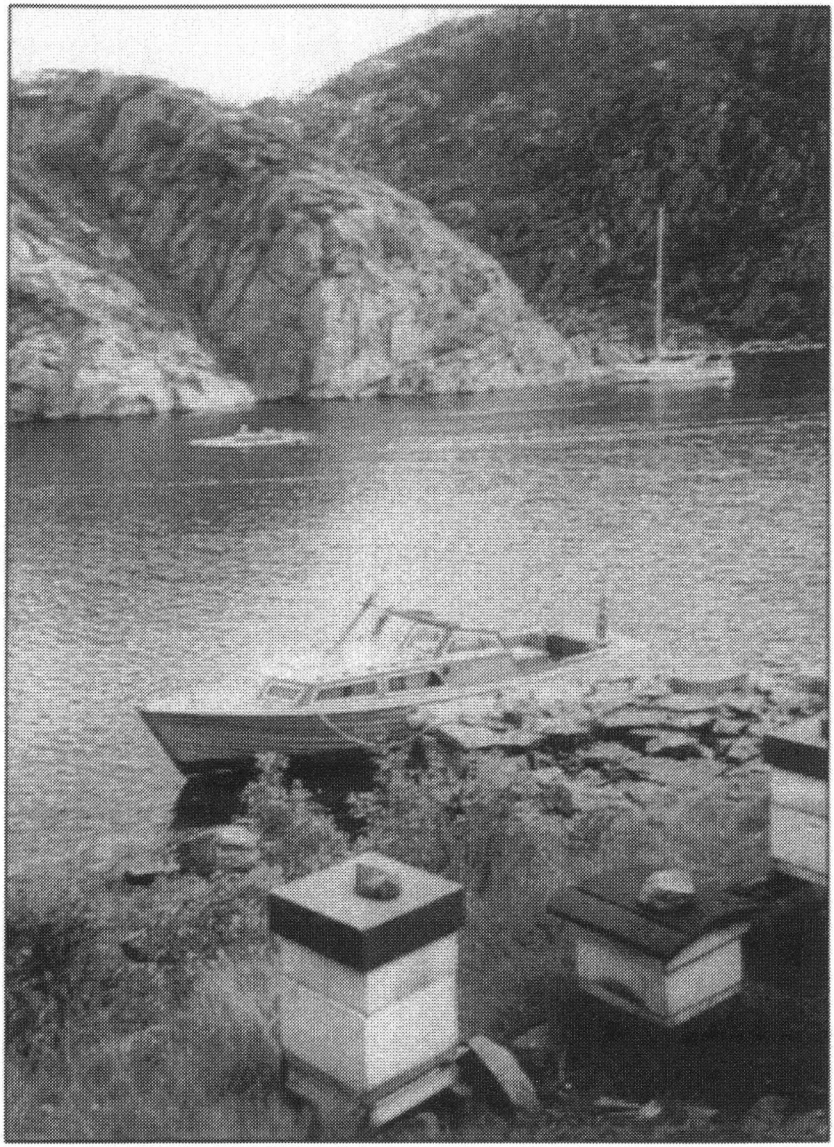
There is a widely held opinion among present day beekeepers in England that heather honey is unsuitable for winter food. If this were generally true it would be hard to explain the survival, or even the

Bee yard in Tarraleah, Tasmania, with Dark British bees.

One of the bee yards of the commercial beekeeper Kirkwood, Scotland.



Ling, the main crop of the Dark bee along the whole Atlantic coast.



On the Norwegian South coast, the only nectar crop is from ling in clefts of glacier-polished rocks (region of Flekkebnfjord). According to longstanding experience of the beekeepers, no other race than the Dark bee succeeds here.

existence, of feral bees in heather districts. There are two aspects of this problem.

1. R.O.B.MANLEY (1888-1978), (1948) the first man to manage 1,000 colonies in England, keeping Italian bees during the fine summers of the '20s and '30s, states that all hives that have been to the moors should be fed 10lb sugar as a precaution against dysentery caused by long confinement during severe winters.

This advice is not found in older bee books (PETTIGREW, 1880, COWAN 1881) The explanation is to be found in the preceding paragraph. The Dark bee is suited to long confinement on a diet which contains much solid matter, the foreign bee requires a diet free of waste matter. MANLEY, (op.cit.) adds that while heather honey was not suitable as winter food during periods of confinement, he knew of nothing better to encourage a rapid spring build-up.

2. When the season is very wet, it has often been observed that foreign bees do not seem able to ripen the honey properly, sealing it when it is unripe, after which it ferments, either in the hive or when extracted.(pers. com. PALMER, KNIGHT, MILNER, DEWS.) After the disastrous winter of 1985-6, BIBBA conducted a survey which showed that losses of imported bees were severe, dysentery resulting from fermented honey being a common cause, while losses of native bees were negligible. COULSON (pers. com.) however,warns that if the Cross-leaved Heath,*(Erica tetralix L)* is sufficiently abundant for the bees to store surplus, it often remains uncapped among the ling honey, and is then liable to ferment.

Doubtless a great genetic variability in overwintering ability exists. The limit of economic beekeeping is reached as soon as the losses cannot be replaced by the reproduction of remaining colonies - or by the value of high honey yields. In the Shetland Isles beekeeping is traditionally practised mainly with straw skeps, and losses are frequently replaced by importation. The situation is similar in Canada where the question whether to overwinter or to kill the colonies in autumn and buy new package bees in spring is being discussed just now.

One main obstacle against wintering honeybee colonies of tropical or sub-tropical races is a lack of the repellent effect of low temperature to flight activity on bright winter days with reflection from the snow: many bees leave the hive in spite of sub-zero temperatures and are lost (RUTTNER 1988.a)

The same behaviour has been observed in England with Italian and hybrid colonies, so that screens have to be placed before the entrances to shut out reflected light to discourage flying; for colonies of native bees this precaution is not usually required.(MILNER, pers. com.)

c. Storing surplus honey

The productivity of a colony depends on several characters which are variable within certain limits. The most important are the following:

1. Number of flight bees during the main flow.
2. Hoarding efficiency of the individual bee.
3. Amount of brood during the nectar flow.

The Dark bee, as already mentioned, can certainly be described as "moderate" in every respect: in quantity of brood, in number of bees, and also in food consumption. Therefore this race is superior in a moderate nectar flow, usually interrupted again and again by spells of bad weather. In this condition the colonies of the Dark bee store a moderate crop without being looked after, while other races with a larger brood nest have to be fed regularly, when the flow is interrupted, to prevent starvation. This thrifty behaviour of the Dark bee results in long-living bees and in a late peak colony development, thus making this bee superior in the heather flow of late summer.

Good results may also be obtained during another period: in early spring, during first blossoming of willows and fruit trees. Unexpected at first sight this can be explained by the small amount of brood present at this time; while other races invest all their strength in the production of brood, the over-wintered bees of the Dark race concentrate even during the early season on the accumulation of stores. Higher crops in early spring are frequently attributed to the capacity of the Dark bee to fly at lower temperatures; but this character has not yet been confirmed scientifically. However, B. MÖBUS reports on the observation of a beekeeper of his area in Scotland regarding a brief period of heavy drone flight during a spell of sunshine at a temperature of 14°C and a strong breeze, after several days without flight; several virgin queens were mated on this day. (pers.com.)

In regions with poor flows during early summer and heather flow in August, as in northern England or southern Norway, the Dark bee was clearly superior, in comparative tests by TERRY THEAKER, Lincolnshire (COOPER, 1986) and by G. GLENDRANGEN, Flekkenfjord (pers.com.).

On the other hand, the Dark bees in the existing native strains were not able to compete with certain other races in the main flow of late spring and early summer because of slow colony development as demonstrated by repeated comparative tests especially in Central Europe and Scandinavia. This was the main reason why the beekeepers' interests shifted to other races. In recent years however, the Dark bee has shown itself capable of gathering large harvests from the oilseed rape in England. (L.C. Mogg, pers com.)

The compact pattern of honey storage results in a restricted number of combs filled with ripe honey during a moderate flow while more "expansive" races scatter unripe honey over many combs. This pattern includes reduction of brood during the flow, medium strength of the colony, and excellent provision throughout the season even in bad years. This character guarantees more reliable though moderate crops, and less need for constant attention in regions with mediocre nectar flow.

d. Swarming

The swarming tendency of the Dark bee varies considerably in different regions. It seems to be very low in parts of the north of England with few queen cells constructed, and high in the south of the MELLIFERA region (France). In some parts of the area of distribution a low swarming tendency in favour of honey collection was already mentioned by early writers such as DZIERZON (POLLMANN 1889). In heather regions, however, populations with an extreme swarming tendency are observed: even colonies with young queens construct drone and queen cells and start a second cycle even if the hive is not completely full ("heather bee"; see Geographic variability, p 43). This character was very likely selected for by beekeepers, because it increases the honey production in the heather flow. Generally, the swarming tendency is a very complex phenomenon, because it shows a high genetic variability in every race, but it is also strongly influenced by external factors.

e. Supersedure

In those strains of the Dark bee where the incidence of swarming is low, queen replacement often takes place by supersedure. Replacement of an old queen in this way differs considerably from replacement by swarming. There is no cessation of the old queen's egg-laying. When the new queen is emerged, and mated, there is no hostility between the two, and should two emerge together they are tolerant of each other, nor does a newly emerged virgin attempt to destroy other queen cells. Two queens are often found on different combs, but to see them on the same comb is not uncommon. They may continue together for months, and instances of the two wintering together have been frequently recorded. It is also often asserted that supersedure queens do not "pipe"and that this is a sign of a lack of animosity between queens, either when they are raised naturally, or when many queens of a supersedure strain are reared together in an incubator. When a colony is preparing to supersede only one or two cells are constructed, near the middle of the comb and built from the midrib of the comb, with the walls of surrounding cells removed to allow for the construction of a full sized cell. The cell walls on the adjacent comb are also broken down for the same purpose. Sometimes a hole is made in the comb, allowing the cell to hang vertically, and receive full attention. Thus they differ from emergency cells, which are usually built from an existing worker cell, and from swarm cells, which are usually on the edge of the comb, and are more numerous. In circumstances when a beekeeper does not interfere, supersedure may take place in the third or fourth year of the queen's life, or even later. When a beekeeper practises annual or two-yearly replacement of queens there is clearly no opportunity for a strain to show if it possesses this character (COOPER 1986). ROBERT COUSTON, Beekeeping Adviser to the East of Scotland College of Agriculture, and for part of his career covering the territory of the West College also, reports that his attention was drawn very early in his training to supersedure

stocks. Many were in isolated sites, where no imports had been recorded, and often had strains which had been quite unaffected by the "Isle of Wight" epidemic of the early part of the century. Apart from the absence of piping by supersedure queens, which he was not observing, he agrees with the above account. During his professional career he examined many thousands of colonies.

f. Temperament

The behaviour of the Dark bee on the comb is nervous everywhere throughout the area of distribution. The bees never sit as quietly on the comb when removed from the hive as usually do Italians and Carniolans. They easily desert the comb completely and cluster on the edges, especially in cool temperatures (Fig.5). In warm conditions they usually run around if the hive is opened and are easily induced to leave the hive, a behaviour used by traditional beekeepers to "drive" the bees out of the skeps to make artificial swarms, or when taking honey, in preference to "burning". Some strains are greatly irritated by even small amounts of

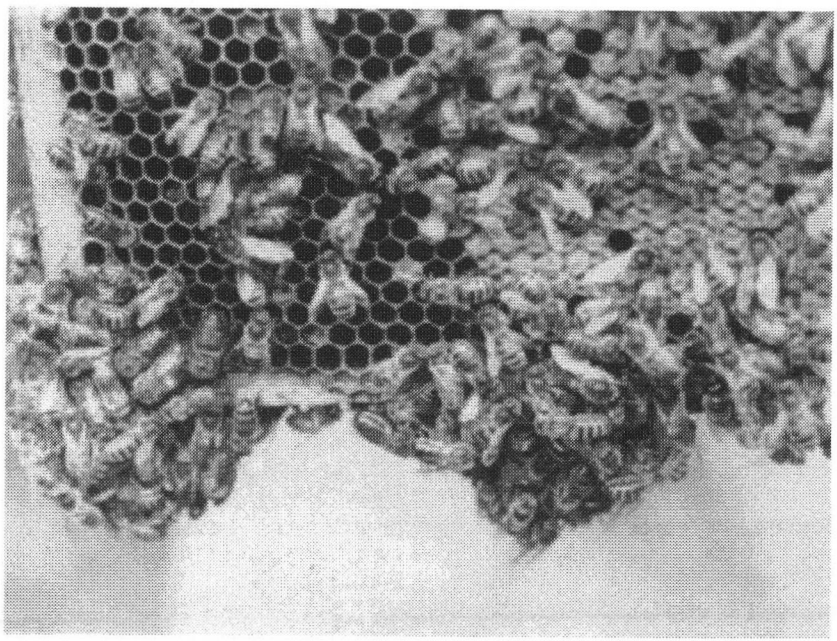


Fig. 5. Clustering of bees in a nervous colony. *Photo B. A. Cooper.*

smoke and have been seen to open sealed honey cells, instead of going to uncapped store cells when smoked. Gentle stocks are found to be much quieter on the combs, less liable to run, when handled without smoke. (MILNER, DEWS) The tendency to sting is variable, some colonies being quite docile, others attack without being disturbed. The defensive behaviour of unhybridized colonies ranges from docile to rather aggressive. The tendency to sting is highly increased in hybrids with other races; this increase can even be taken as a measure of hybridization ("incompatibility of temperament", COOPER). The bad reputation of the Dark bee as being "aggressive" stems, to a great extent according to my experience, from the presence of hybrids in most parts of the native area.

g. - Use of propolis

The Dark bee is second only to the Caucasian in the abundant collection and use of propolis. It is found at the entrance, sometimes accumulated during winter months to form real curtains, in all fissures and between the frames. The amount of propolis found in the hive presents an essential difference to the other two important European races, the Italians and the Carniolans. In southern France I saw a bottle of alcohol to clean the fingers after hive work as part of the habitual outfit of beekeepers. British beekeepers are advised to include some cleansing material as part of their outfit.

h. - Capping of honey cells

Conspicuous pearly white cappings of the honey cells are mentioned for the bees of the British Islands and Norway by all authors. The colour may be influenced by the crop - the primrose cappings of sainfoin honey for example - but the special character of the Dark bee's cappings is that they are dome shaped, with a small air pocket between the wax and the honey, which prevents "weeping". On the continent, however, the capping by the Dark bee is rather dark and watery. Therefore this character cannot be taken as typical for this race.

i. Diseases

A frequently discussed problem is the susceptibility of the Dark bee of the British Islands to acarine disease. According to BROTHER ADAM the whole English population of this race was exterminated by this pest in the decade between 1916 and 1925. C.BUTLER (1954) estimates that 90% of the colonies perished in this period, and STURGES (1928) gives similar figures. These, and other writers, worked mainly in the south, where importation had been heaviest. No scientific survey is available, however, to substantiate this contention. In spite of extensive importations, native or "near native" colonies are found in northern England, in Scotland and in Wales more than in the south, (B COOPER 1987,J DEWS 1987, morphometric data in this paper). Br. ADAM and STURGES claimed that Italian colonies and hybrids suffered much less than the Dark colonies. It

has to be noted, however, that no such catastrophe was ever observed within the "Dark" territory of the European continent. Therefore it seems plausible that a special coincidence of various factors was responsible for the heavy colony losses during those years, as suggested by BAILEY (1981). It might well be that the moderate brood activity and longevity of the Dark bee is one of these factors, because it is well known among bee pathologists that the acarine mite can be outmanoeuvred by a rapid turnover of the bee population (large amount of brood, short living bees). It is not likely, however, that a whole population was completely wiped out by a parasite. Present day evidence is that, in the north at any rate, the native or near native bee is less susceptible to damage by acarine than foreign bees or hybrids (MÖBUS, pers. comm).

"Disregard for wax moths" is another fault ascribed to the Dark bee. The underlying cause for a higher incidence of wax moths is doubtless an under- developed hygienic behaviour of this race. The hive bottom, usually completely clean in *carnica* and *ligustica* colonies is frequently covered by wax particles and other rubbish, (the ideal nutrient for wax moth larvae) in *mellifera* colonies. But there is variation in this respect also, some strains being good house cleaners (MILNER, pers. com.)

j. - Hybrids

Hybrids of the Dark bee with other races, especially with Carniolans are among the most prolific and productive bees I have ever encountered. First crosses develop rapidly to strong colonies in spring, they are healthy, winter excellently and their honey production is usually distinctly superior to both their parental races. Their great drawback, a definite obstacle to apicultural use in densely populated countries, is their fierce temperament, which is in surprising contrast to both their parents.

General behavioural characterisation of the Dark Bee

Most of the behavioural characters described above can be put under one single heading: "extreme economic caution as expression of a defensive strategy directed against a harsh environment". All characters, such as slow development in an uncertain northern spring, moderate brood production throughout the season , resulting in low consumption of food and longevity of worker bees, compact pattern of brood and stores, quick reaction in brood activity to adverse weather conditions, heavy use of propolis, point in the same direction. Almost all along its northern border this bee exists in the "battle zone" for honeybees as such, beyond which no permanent existence is possible. Abundant nectar supply during the long summer days becomes more than equalized by the deadly winters and lack of suitable nesting sites the farther north the colonies venture. Close to the border-line especially hard seasons occur in irregular intervals which

cause heavy losses near to extinction. In the south, in the tropics and subtropics where wintering is not the problem the main strategy for fighting catastrophe is abundant reproduction in favourable years. In the north it is thriftiness which evidently proved the most efficient strategy for survival: avoidance of lack of food, of the risk of short living bees for the long winters, of too early brood rearing. While describing behavioural traits of the Dark bee important for beekeeping, one point has to be kept in mind: although this bee has been continuously selected by nature to suit its environment, *the Dark Bee has never been subject to continuous selection by bee breeders, unlike other races used in modern apiculture, such as Italians and Carniolans, and hybrids (Buckfast Bee)* . It has been described just as it was found in the countryside, usually in the hands of an isolated untrained beekeeper. The Dark bee is certainly a neglected race so far as selection and the development of optimum management conditions are concerned, and any comparison will necessarily be dealing with different levels of development in regard to apiculture.

Decline of the Dark Bee

The Dark European bee was at the height of its distribution around 1850. The downward trend was caused by two factors which deeply changed apicultural practice:

1. The invention of the moveable comb made possible almost unlimited manipulation within the colony. In the traditional skep or log hive the colony remained almost untouched. One of the few techniques used was the "driving" of bees. The nervous behaviour of the Dark bee, which is the readiness to leave the combs and even the hive if disturbed, was a very welcome character for this manipulation. The same behaviour, however, is an annoyance when a colony with moveable combs is being inspected.

2. Beginning about the same time and increasing until today was a drastic change of agriculture. Late crops, such as buckwheat, weeds in the fields, and in many regions also heather diminished or disappeared completely while the main nectar flow shifted more and more to late spring and early summer. Intensively cultivated areas became almost an apicultural desert, forcing the beekeeper to migrate to the next forest where natural vegetation remained. Only strong, quickly developing colonies had a chance to provide good yields under these conditions. Extensive feeding to sustain large brood areas between honey flows, and strong winter populations became essential. These management techniques demanded a bee very different from the *mellifera* race, which is centred mainly on self restraint. It may, however, be repeated that in recent years, with great dependence on oil seed rape as the only crop in some areas, native Dark bees have built up sufficiently to give highly satisfactory yields.

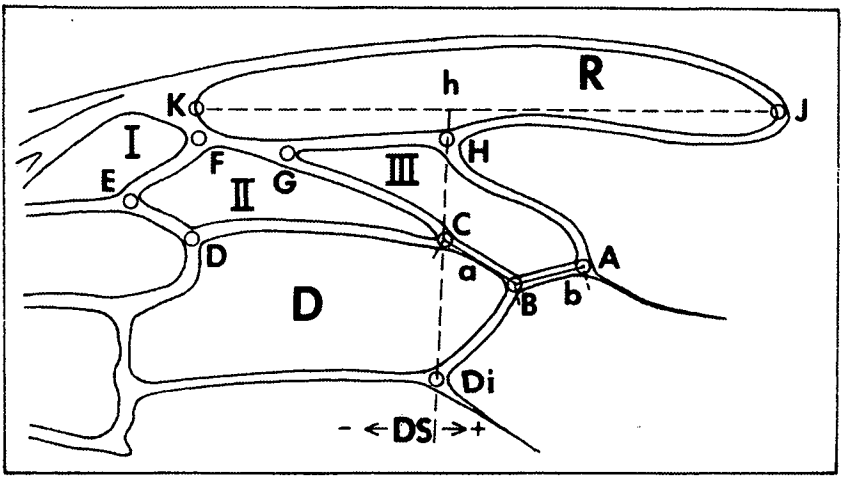


Fig. 6 Measuring characters of wing venation: A,B,C,G,H - corner points of the 3rd Cubital cell; I,II,III - the three Cubital cells; D - Discoidal cell; Di - Discoidal corner; DS - Discoidal shift; R - Radial cell; h perpendicular through point H to determine the Discoidal shift; a, b - the two vein segments whose relation constitutes the Cubital index.

Therefore, for more than 100 years the odds have been against the Dark Bee. It was not by chance that the Rev. JOHANNES DZIERZON, who was the first to use moveable combs in central Europe, was also the first to import Italian queens into Germany (1852). Importations of Italians, Carniolans and other races to various European countries and to the U.S.A. followed shortly after this. Ferocious hybrids as a result of these importations furnished an additional stimulus to replace the local bee completely. This process is most advanced in the U.S.A., Australia and Central Europe (and Germany). But even in the U.S.A. the effect of hybridisation with the Dark bee is still recognisable by a considerably higher irritability of the stock labelled as "Italian" compared to pure *ligustica*, in spite of the large number of commercial beekeepers and the predominant supply of queens by a relatively small number of professional producers. The influence of the Dark bee is probably even more pronounced in the feral population. No country of the original area of distribution remained without heavy importations of other races making it difficult to assess whether the actual bee population represents the original native race or a somewhat changed, hybridized descendant. B. COOPER (1987), used the term "near native" for these more or less hybridized types. However, congruent results of behavioural and morphometric studies in various countries indicate that the pure native bee still exists (COOPER,

England, LAVIE, CORNUET, and coll., France, BORNUS, Poland, ALPATOV, MISSIS, SCHAKIROV, USSR, the author of the present study in various countries.)

It is surprising that the Dark bee is relatively homogeneous throughout its whole territory, even if such distant regions as Britain and Bashkiria are compared (see Fig. 1) Only in France can a number of local populations be discriminated (LOUVEAUX 1969, LAVIE and FRESNAYE 1972, CORNUET et al. 1975). The explanation of these different results may be found in the different age of the populations: it can be assumed that France was colonized first, being close to the glacial refugium near the Mediterranean coast. The *mellifera* populations of the periphery , however, are certainly of comparatively recent origin (probably not earlier than since the first post-glacial warm period ("Atlanticum") 8000 B.C.)

Morphological character of the Dark Bee

In the 19th Century the situation was very simple for the apicultural specialists: Every dark bee was considered to belong to the northern European race as generally understood by the name ("brown" or "dark" Dutch, English, French or German bee). Even in quite differing regions , e.g. in Sicily, a dark bee was ascribed to this northern race without hesitation. On the other hand each yellow mark on the abdomen was naturally taken as evidence of hybridization. This preponderance in the use of colour for classifying bees is still common among beekeepers in our days.

However, as soon as not only Italians, but also two other dark races of the temperate zone, Carniolans and Caucasians, were imported to central and western Europe, hybrids soon became common, but they were all dark and remained undetected in spite of the fact that they were irritable and aggressive, as is almost every cross. What other morphological characters are there to distinguish the Dark bee? The German scientist, G. GOETZE (1899-1964) described the characters which distinguich *A.m.mellifera* from any other race:

1. *The Cubital Index* (CI), that is, the relation of the vein segment a) to the segment b) of the forewing (Fig. 6). In the Dark bee a) is relatively short, and b) long, resulting in a low index (generally below a value of 2.0). In Carniolans and Italians the average CI of a colony is higher than 2.4.

2. *Length of hair.* (H) ("overhair") on the 5th tergite of the abdomen, on which is the third tomentum. In the Dark bee, hair length is more than 0.40mm, in Carniolans below 0.35mm, in Italians short.

3. *Discoidal shift.* (DS): relative position of the perpendicular (h) dropped from the line K-J (axis of the radial cell) through the point H, in

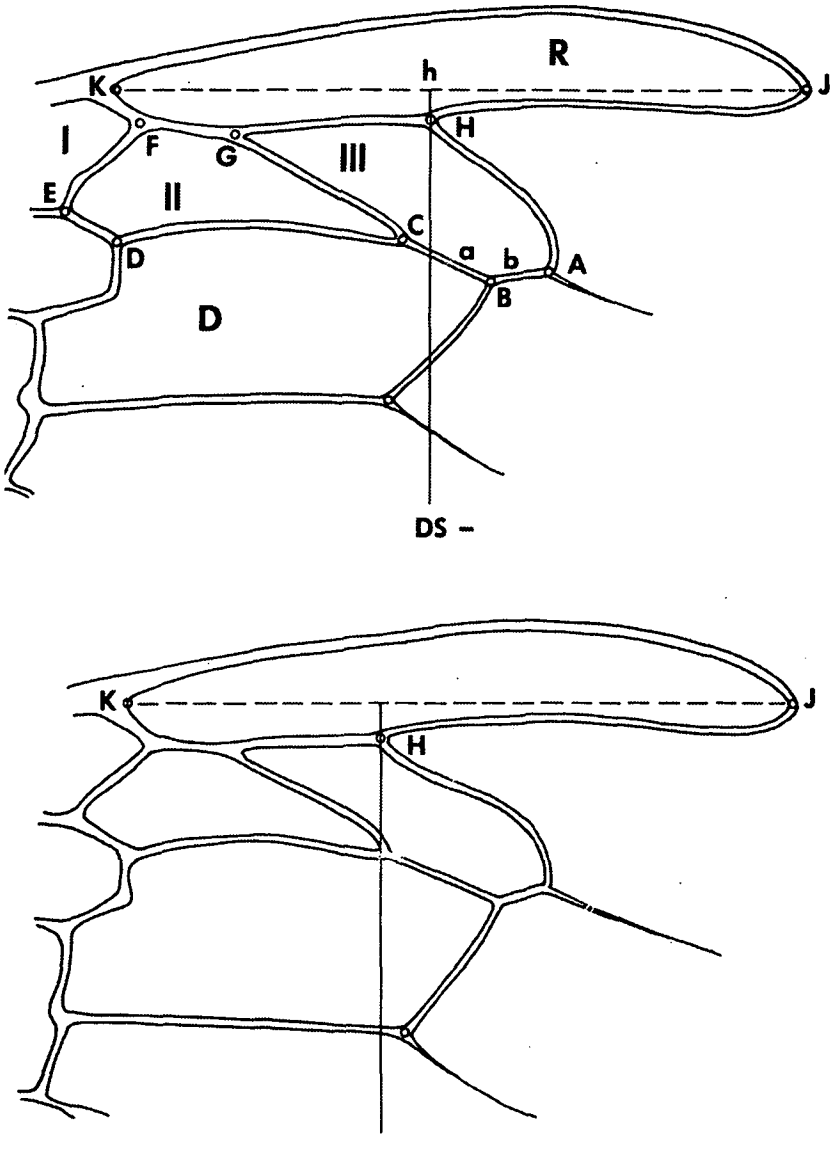


Fig. 7. Negative Di shift (=*A.m.mellifera*) on top; positive DS (=*A.m.carnica*) bottom.

relation to the posterior corner of the Discoidal cell, (Di). If this corner point is found in the direction of the base (point of attachment) of the wing, DS is negative (-) (Fig 7); if it lies approximately on this line, as in Fig. 6, it is zero (0); if the Discoidal corner lies in the direction of the wing tip, DS is positive (+) (Fig. 6). The DS is negative (-) or zero (0) in the Dark bee, but positive (+) in Italians and Carniolans. To achieve a more precise gradation, the DS can be measured in grades instead of a simple classification into three groups. For this purpose J. E. DEWS (1987) introduced the measurement of the angle between the vertical, h, and the line H-Di (discoidal angle). In one of our samples (n=15) with a mean DS -2.167, one wing gave a value of + 8. Not much weight should be attributed to a single deviating bee in an otherwise uniform sample.

No other race of *apis mellifera* has, on the average, *a low CI, long over hair, and a negative DS,* as the Dark bee has. The values of individual bees may however overlap. Therefore groups of at least 20 bees from one colony, rather than single bees, are measured. The curves of variation of, e.g. the CI tell us much about the ancestry and mating of a queen. (RUTTNER 1988a). Applying two characters to different axes of a graph (a "Scattergram" J. E. DEWS) a complete separation of the races *mellifera* from *carnica* and *ligustica* is achieved (Fig. 8). Thus, with three simply measured characters – CI and DS, and hair length – the three European races can be distinguished and hybrids eliminated from breeding programmes even for the purposes of apicultural practice. Week-end classes to teach ordinary beekeepers simple methods of making these measurements are regularly

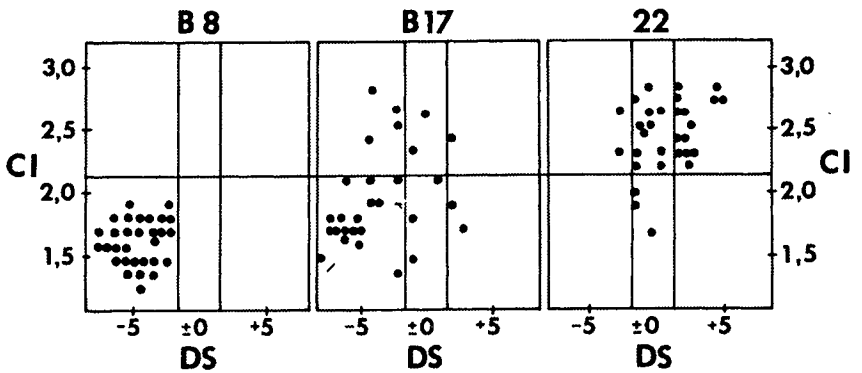


Fig. 8 Scattergram with DS on the horizontal and CI on the vertical axis; each point represents one bee;
Colony B8: low CI and negative DS =Dark bee;
B17: points over all fields: hybrid with predominance of "dark";
B22: CI high, DS +0 and + = *A.m.carnica.*
All colonies can be well discriminated morphometrically.

held in Germany and Austria and are now being introduced into England (DEWS and MILNER 1987, RUTTNER 1988a), giving the beekeeper a powerful tool for selecting his stock.

But what proof is there that these characters represent the original bee of Europe north of the Alps? The Dark European Bee was extensively and uncontrolledly hybridized throughout most of the region of distribution during the last hundred years. Since the main apicultural interest was centred on other races very few analyses of the variability within this race from previous times exist and today it is hard to decide what are the characters of the pure, unhybridized race and what is already an expression of hybridization. To answer this question two methods can be used:

1. Analyse presumably unhybridized samples from all over the area of distribution of *A.m.mellifera* and investigate for common features of the whole region.

2. Analyse morphometrically honeybee specimens collected before the importation of foreign races, that is before 1850.

1. RECENT SAMPLES

To explore the first method, 47 samples of worker bees and 11 samples of drones were collected in the following countries of the original *mellifera* area: Austria, British Isles, Denmark, Ireland , France, Norway, Sweden and USSR (Bashkiria), and in addition, three samples from colonised areas, Tasmania and New Zealand, where Dark bees imported from Britain have lived in feral and managed colonies for 150 years. (Table 1.) The measurements showed a considerable variation between samples; however, a group of 23 samples (from almost all of the countries cited) was rather uniform, especially in the discriminant characters. The samples of this group were almost evenly distributed across all the countries included in this analysis. Mean values were calculated for this group with the following results:

Overhair	0.438mm (min. 0.401, max. 0.505mm, sd (of means) 0.030)
Cubital index	1.721 (min. of samples 1.557, max. 1.900, sd. 0.098)
Discoidal shift	-2.398(min. of samples -4.4, max.0.0, sd. 1.28. Min. of individuals, -9 , Max. +3)

sd = standard deviation.

Surprisingly, the mean values of the unselected total of the *mellifera* samples are almost identical with those of the selected group. This derives from the fact that the deviations of the discarded samples were only small and mostly incongruous (e.g. samples with too short hair had typical low CI). Other discriminant characters of the selected samples (length and width of fore wing, sum of tergites 3+4, index of slenderness and of

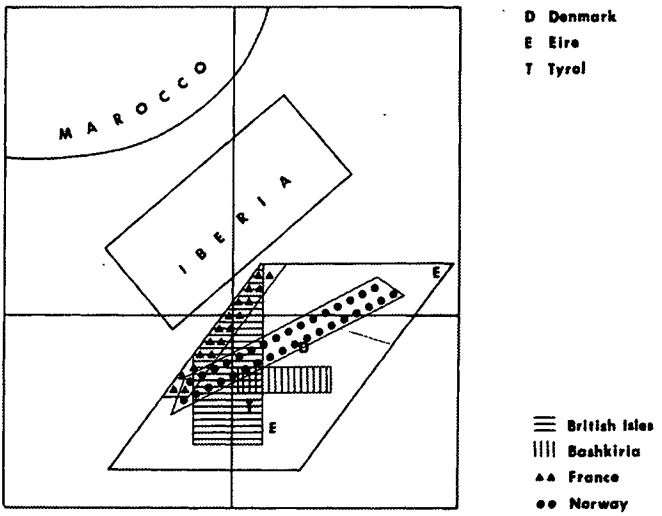


Fig. 9. Statistical analysis (principal component analysis) of 45 samples of the Dark bee originating from various countries as listed in Table 1. together with 10 samples from the Iberian peninsula and 6 samples from Morocco. The *mellifera* samples are all arranged in a compact cluster (here schematically surrounded by a rhombus), but the samples show no clear segregation according to their geographic origin. Single samples are marked by letters, groups of samples by symbols; D Denmark, E Eire, T Tyrol.

tomenta) were also only insignificantly different from the unselected ones. As a result the "near-native" samples are very close to the "true" *mellifera* type and the overall means can be taken as representative for the subspecies.

Table I. Frequency of samples with long overhair (0.40mm) and low cubital index (1.90) among samples from the *mellifera area*.

Country	*no. of samples*	*no. of "mellifera type".*
Austria (Tyrol)	3	3
Denmark(Laesoe)	1	1
Eire	2	2
England	8	4
France	4	0
Isle of Man	4	1
Norway	18	10
Sweden	2	0
USSR (Bashkiria)	5	4
(Tasmania	3	3)
(New Zealand	4	4)

Of course, this result by no means reflects the status of the actual bee population, but is the consequence of a mostly random selection by the author. In Austria, for instance, the Dark bee is found only in a single native strain artificially maintained by the Beekeepers' Association in Tyrol. In France, on the other hand, large populations of the unhybridized Dark bee exist in various regions as is shown by a number of recent studies (CORNUET et al. 1975, 1978; FRESNAYE 1981), while in the present collection of the author not a single "pure" sample is included from that country.

The characterization of the Dark bee resulting from comparison of samples from various parts of the region is corroborated by a review of data by other authors which go back 50 years (Table 2). Unfortunately the CI only was measured regularly while hair length is given sporadically. It is worth noting that about 50 years ago typical "dark German bees" were found at various locations in West and East Germany while at present not even "near-native" populations exist there.

Table 2. Morphometric data of the Dark bee from various published studies.

Country	*Author*	*Location*	*Characters. (1)*			
			Hair(mm)	*CI*	*Proboscis*	*Tergite 3+4*
USSR	Alpatov 1935-48	Moscow, Uisk Smolensk, Ural, Tartar Rep.	0	1.54	5.90-6.20	4.798
USSR	Misis 1976	Lithuania	0	1.81-1.90	6.13-6.27	4.66-4.84
Poland	Bornus	N.Poland	0	1.65	6.117	4.883
Germany	Goetze 1944 Instrburg	Ulm, Hessen Mayen, Soltau	0.45-0.60	1.69	6.27-6.39	0
France	Cornuet et al. 1975, 1978,	Paris, Bretagne Cevennes,	0.40-0.49	1.78 (1.70-1.88)	6.19 - 6.45	0
"	Lefèvre-Lafargue	Bretagne 1973	0.44	1.76	6.14	
Present Study		see Table 1.	0.438 (0.400-0.505)	1.721 (1.56-1.88)	5.95-6.19	4.676 (4.522-4.863)

1) Means of populations

2. MUSEUM SPECIMENS

For the investigation of museum specimens collected in the first half of the 19th Century or earlier, the Rev. E. Milner and J. E. Dews succeeded in finding, in the British Museum, the National Museum of Scotland, and the Hope Entomological Collection, Oxford, quite a number of worker bees,

drones and queens collected prior to 1858. Cubital index, Discoidal shift and hair length were photographed with a macro lens giving a 1x1,(2x1 for hairs) magnification. As can be seen from Table 3 the museum specimens show the same characters as are found today in unhybridized native bees from the British Isles.

Table 3. CI, DS and Overhair(mm) of "historical" specimens of *A.m.mellifera* preserved in British museums.

	number	*C. I*	*Di Shift*	*Overhair (mm)*
Worker bees	16	1.79 (1.40-2.09) sd =0.19	-2.87 (+1.0 - -5) sd 1.72	0.459 (0.400 - 0.596) sd 0.049.
Drones	15	1.45 sd 0.26	-5.87 sd -3.16	

Further, we received permission to investigate the specimens collected by Carl von LINNÉ himself prior to 1758 and preserved by the Linnean Society of London at Burlington House. (3 worker bees, 1 drone) The result:

Linnaean honeybees.

		CI	*Di Shift.*
Bee 1.	left wing	1.61	-4.7.
	right wing	1.58	-2.5
Bee 2.	left wing	1.94	-4.5
	right wing	-	-2.5
Bee 3.	left wing	1.91	-5
	right wing	2.06	+1
	Mean of six wings	1.82	-3.33

3. HONEYBEES FROM ARCHEOLOGICAL EXCAVATIONS

This source of information proved especially important for the study of honeybees from northern Europe. Honeybees have not been reported from archeological digs elsewhere. In each of these three cases they were found in waterlogged soil, with poor drainage, in which anaerobic conditions retarded the decay of organic matter and there was little water movement to damage the remains. Moreover, while insect finds in excavations have been noted occasionally for a century, it is only in recent years that they have received careful attention, and finally, at Oslo and York the discoveries were made in samples taken away for laboratory examination. These discoveries are fortuitous. Each soil sample might have been taken

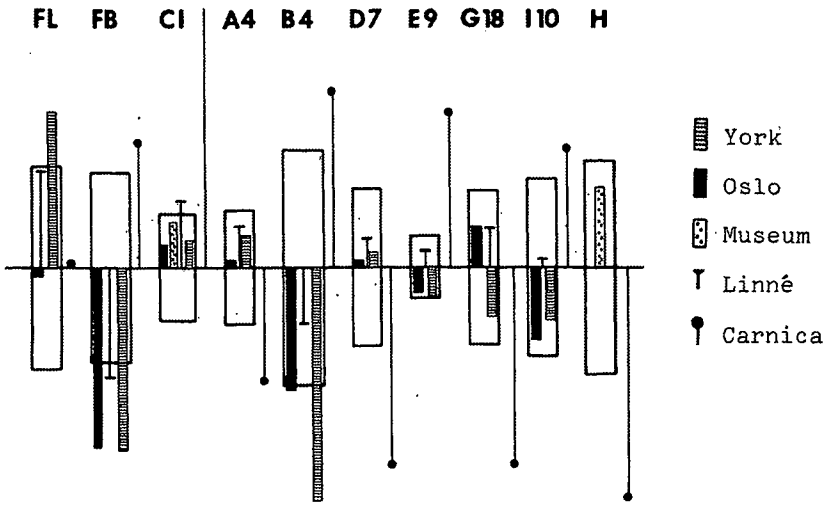


Fig. 10. Characters of archeological and historical specimens of honeybees from Northern Europe, compared with supposedly unhybridized recent honeybees from the same region.
Horizontal axis: mean values of the characters measured on samples of 10 recent colonies.
Vertical blank rectangles: range of standard deviation (sd) of the same samples, expected to include 2/3 of the individuals.
Characters: FL, FB,- length and width of forewing;
CI - Cubital index;
A4——I10 - wing venation angles.
H - length of overhair.

from another part of the trench in which case the bees would not have been found.

3.1 - The first excavated honeybees were found in a "log hive of the Vehnemoor" near Oldenburg, West Germany dating from the 6th Century A.D. The bees were well preserved in the acid mud of the fen, even parts of the comb were found. *G. GOETZE* (1939) described the bees as belonging to *A.m.mellifera*: pigmentation very dark, with some yellow spots on the abdomen. Cubital index was in general well below 2.0, with only a low percentage just above this limit. Unfortunately no morphometric details were published and the bees seem to be lost.

3.2. - *The York "Viking" Bees.* This is a convenient term for bee remains found during excavations at Coppergate, York. Vikings ruled in York intermittently for two centuries till 954 A.D. Viking traders and immigrants

continued to arrive till a later period and the culture appears to have remained largely unchanged.

The sample was dated to Period 5B, provisionally placed in the late 10th or early 11th Century, about 1000 A.D. A series of wooden buildings was discovered, with evidence of domestic occupation, and a variety of trades practised. Evidence shows that the summers were warmer at that time, perhaps comparable to south-east England now, but no evidence for the winter climatic conditions has come to light in this excavation.

A sample of soil was taken for laboratory examination, and it was here, not on the site, that a technician noticed a tangled mass of vegetable matter, which unfortunately disintegrated before its structure could be examined further. Dyers' Greenweed, *Genista tinctoria* and the clubmoss *Diphasium complanatum* were the only abundant fibrous plant remains. In a sub-sample of the deposit processed for insect fossils were the abundant remains of the bees. (H. KENWARD, The Archaeology of York, volume 14, (in preparation) We were able to discover one intact forewing. The CI of 51 wings was measured, as were all the wing venation angles, used in the "standard biometry" (RUTTNER 1988) although in a different frequency (Table 4 a). Parts of legs and abdominal segments were found which may supply further information.

3.3- *The "Oslo Bees"*. A great number of honeybees ("tens of thousands") was found in the layers of "Phase 9a/c" (1175 - 1225 A.D.) of the Gamlebyen dig in the centre of Oslo. The bees were incorporated in a lump of earth taken from the fill of a post-and-wattle lined drain.

The honeybees of York and Oslo correspond perfectly with the present day *A.m.mellifera* (including the present day pure native British bee). Differences in wing venation angles are independent of ecological adaptations. The means of the 11 angles of the York "Viking" and Oslo samples fit into the standard deviation of the global means of the race (Fig. 10). As far as size is concerned, they have very long and very narrow wings compared to the mean of the Dark bee - that is, this bee has one of the longest wings observed so far. But we observed three examples with similar wing length from Norway and one example with even 9.71mm length from western Ireland. The value of forewing width is not very well represented in our excavated samples, since we were not able to measure the width of more than a total of eight wings, but the value was equally low for both locations. *A.m.mellifera* has a general tendency for narrow wings and we found two more examples of recent bees of this race with wing width below 3.0mm.

The Oslo find is of special interest for several reasons. a. Honeybees are not mentioned in written records before the 18th century for Norway (see p. 4) but there were indications regarding beekeeping during early medieval times. Now there is definite proof that honeybees existed in Norway at that time.

b.-During the Gamlebyen dig a great number of plant remains and pollen grains were found and identified. The cultivated and wild flora of this

period - apple, wild cherries, hazel, cereals, flax, horsebeans, hops etc. indicate a rather mild climate and favourable conditions for the survival of feral honeybee colonies. Therefore, it can be concluded that a feral population of honeybees could have existed in Norway in this period, as in Sweden or in the Baltic countries, which perished when the climate became harsher. Fluctuations of the northern boundaries of *A.m.mellifera* as postulated for ecological reasons are now documented by the Oslo bees for the 12th century A.D.

Table 4. Characters of forewing of bees found in archeological digs in York and Oslo compared to the means of 12 recent samples of northwest European countries.

n = number of specimen. forewing length and width in mm.
$\bar{x}$ = mean. s = standard deviation.

Character....Forewing			*C. I.*	*Wing venation angles (Fig. 10)*					
	Length	*Width*		*A4*	*B*	*D7*	*E9*	*G18*	*I 10*
Location									
York									
n	15	4	51	41	41	5	27	4	28
$\bar{x}$	9.565	2.916	1.731	34.1	97.8	107.0	16.7	98.8	46.4
s	0.133	0.072	0.217 (1.24-2.18) over 2.0:6	3.1	5.8	5.1	1.3	3.4	3.6
Oslo									
n	1	4	30	27	27	12	26	17	25
$\bar{x}$	9.400	2.940	1.700	33.2	102.0	106.6	16.9	101.8	45.7
s	0.118	0.231	2.1 (1.22-2.05) over 2.0:4	6.0	5.6	1.7	4.2	3.8	
Recent European Dark Bee.									
n=240 (12 samples)									
$\bar{x}$	9.409	3.112	1.643	33.2	106.1	106.5	17.8	100.5	48.2
s	0.013	0.091	0.181 (1.10-2.06)	1.9	4.0	2.7	1.1	2.6	3.0

It can be concluded from this synopsis of available data, published more than 50 years ago or collected only since 1987, that a clear and consistent morphometric description of the Dark bee can be given which is valid for all regions of distribution. The most discriminant criteria are the following:

1. Body size. Among the largest and definitely the broadest of all known sub-species of *A.mellifera* (see photos). Mean Index of slenderness (length: width of tergite 6; RUTTNER 1988) exceptionally low, 77.57 (min. 74.61). Sample No. 1454 from the river Shannon, West Ireland, has the largest bees of all of the more than 1,300 *A.m.mellifera* samples measured so far at the

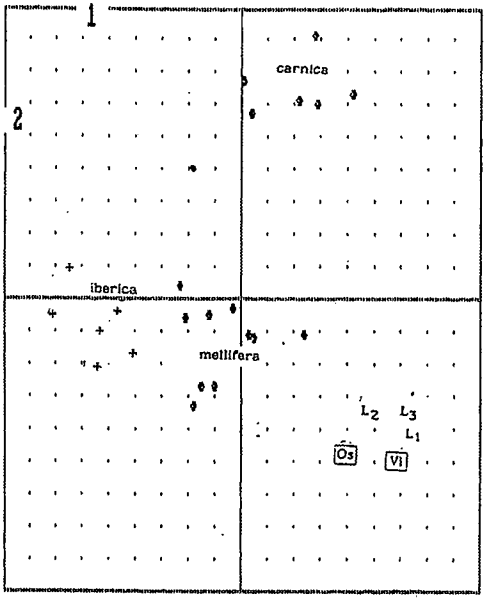


Fig. 11. Factor analysis of wing measurements of archeological and historical honeybees, together with samples of *A.m.iberica* (N.E.Spain) and *A.m.carnica* (Austria); 6 samples each and 10 samples of *A.m.mellifera* (NW Europe)

L_1, L_2, L_3 — Three worker bees of the Linnaean Collection.

Os — Oslo bees (mean values of 30 bees)

Vi — Viking bees (mean values of 50 bees)

Institute, Oberursel, length of fore wing 9.745mm, tergites 3+4, 4.843 (mean values of *A.m.carnica*: 9.403 and 4.514 mm).

2. Body colour: completely dark, except for small bright spots (class 1-3) on tergites 2-4.

3. Length of proboscis: very short compared to body size, increasing from north to south. Means of samples from 5.90mm (Norway) to 6.10mm, longer only in the south - Tyrol, France, 6.15 - 6.45.

4. Hair.

4.1. *Overhair* on tergite 5 longer than in any other subspecies, 0.40 to 0.50mm in unhybridized samples. GOETZE (1940) gives values of 0.60 - 0.70mm for northern Germany and Scandinavia but a similar high value has only been measured so far in two specimens in the Royal Museum of Scotland. Hair length can be taken as the character most sensitive to influences by surrounding short-haired races.

4.2. *Tomenta* narrow and sparse, mean tomentum index 1.45

5. *Cubital index*: mean distinctly lower than 2.0: overall mean in this study 1.72, in others 1.54 - 1.85. Mean of a sample never exceeding 1.90.

6. *Discoidal shift*, always negative or about zero.

Drones

11 samples of drones, originating from the same countries as listed in Table 1 (except for Austria and France) were morphometrically analysed. *Mellifera* drones are very large, sturdy insects, completely black all over the body (frequently including the posterior rim of the tergite also). Hair of thorax is dark brown ("coffee brown") or black. In size they are second only to *caucasica* drones (forewing length 12.331mm). Again the CI is relatively low (mean 1.399). The values of museum specimens correspond with these data (Table 3.) No geographic distribution of characters within the subspecies was detected by multivariate analysis.

The species *A.mellifera* native to all parts of the Old World, differentiated in four directions geographically and morphologically. In tropical Africa very small bees are found (A branch). In the sub-tropical and temperate zone three branches evolved: to NW and NE Europe the M-branch with *A.m.mellifera* as the extreme; to the north of the Balkans and the Danube valley the C-branch with *A.m.carnica* at the end of a chain of races; finally to the Near East the O-branch ending in *A.m. caucasica*. All three races represent large, dark bees, relatively well adapted to a cool climate. They are positioned at a great distance in the taxonomic system of *A.mellifera* and therefore, easily discriminated from each other in spite of their similarity in colour.

Geographic variability within the sub-species

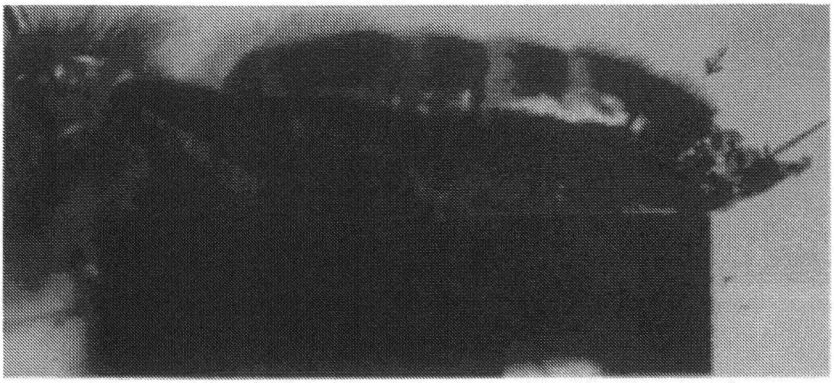
It would not be surprising if morphological differences were found between populations of such contrasting regions as France, Britain, Scandinavia and Central Russia. The area of distribution is so large that different names were given to the same bee in different regions:

1.) "Brown" or "Dark" or "Black" English, French, Dutch or German bee.

2.) "Heather bee" of NW Germany and the Netherlands, named "*lehzeni*" by v.*BUTTEL-REEPEN* in 1906, a term which was later transferred by GOETZE (1964) to the Scandinavian bee, and by BUTLER (1954) to the British bee. This variety is described as very large and dark and an excessive swarmer. A colony of the Heather bee is described as having several after-swarms, and the prime swarm and the after-swarms having secondary swarms, resulting in a reproduction rate of 1:12 - 1:14.

3.) "Forest bee" of Central Russia, *A.m.silvarum* ALPATOV 1935, the easternmost population of the Dark bee.

4.) "Nigra", a selected strain in Switzerland with very black body colour but intermediate characters (CI and hair length) as consequence of earlier



Ox 37. Museum specimen in side view. Arrow: overhair. The Black stripe underneath the bee in Ox 37 ia a piece of film with perforation as standard measure. *Photo by J. E. Dews.*

Historical forest beekeeping in eastern Europe. Exposition of traditional log hives in Czechoslovakia (Beekeeping Ass. CSFR).

hybridization. In Tyrol a true native strain of the Dark bee ("Braunelle") is preserved and maintained by the local Beekeeping Federation.

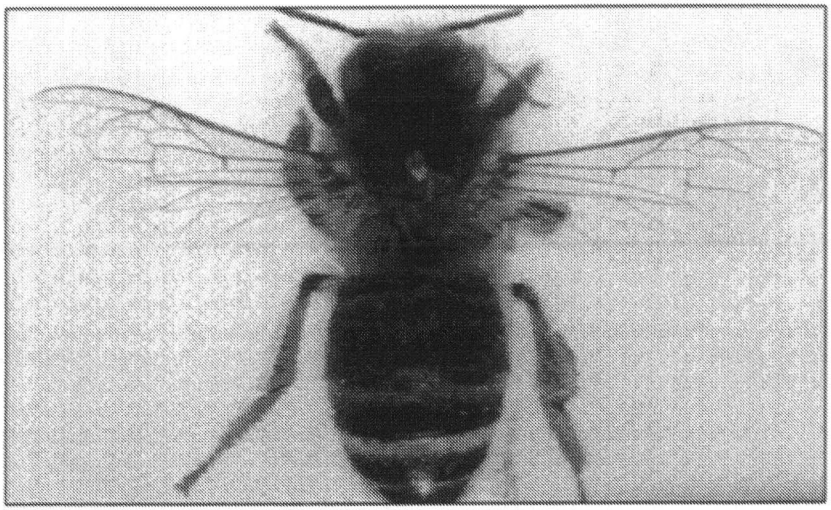
To test the assumption that measurable differences exist between these and other local populations, a multivariate analysis was made with the 34 characters measured in 45 samples. If, in the graph resulting from this analysis the points representing one sample form distinct, well separated clusters, each representing the population of one region (e.g. U.K..Norway, Bashkiria) the respective populations can be discriminated morphometrically; if, however, they overlap, no morphological geographic differentiation exists.

In Fig. 9 the populations represented by a greater number of samples (= points) are indicated by fields of specific symbols, single samples by letters. As can easily be seen, a clear pattern of distribution can hardly be recognised. The fields of the UK, France, Norway and Bashkiria overlap to a great extent and the two samples from Ireland are separated from each other by a considerable distance. The conclusion is that no morphological diversification occurred after the post-glacial dispersion of the race across all of Northern Europe in spite of the great climatic differences and that a rather homogeneous bee exists in the whole region. An explanation may be found in the relatively short period since the beginning of this dispersion. From the viewpoint of this observation it is not surprising that the much more recent populations of Tasmania and New Zealand show the unchanged characters of the original Dark bee.

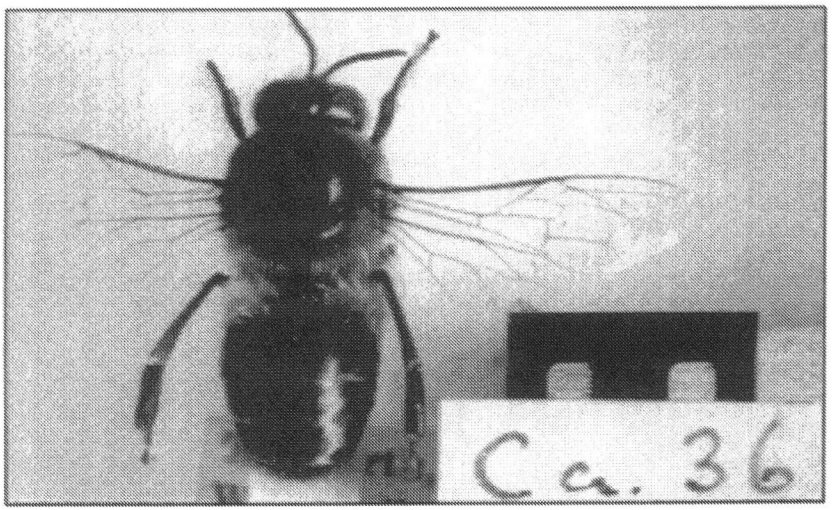
Table 5. Comparison of several characters of size of several populations of the Dark bee, (means, in mm) (N = No. of samples)

Region	*Geogr. Latitude*	*N*	*Tergites 3 + 4*	*Forewing length*	*Hindleg length*	*Proboscis*
Provence, S.France	44	3	4.537	9.231	8.072	6.265
Yorkshire	54	6	4.667	9.346	8.171	6.013
Isle of Man	54	4	4.642	9.380	8.259	6.008
Norway	58-60	23	4.684	9.386	8.223	5.962

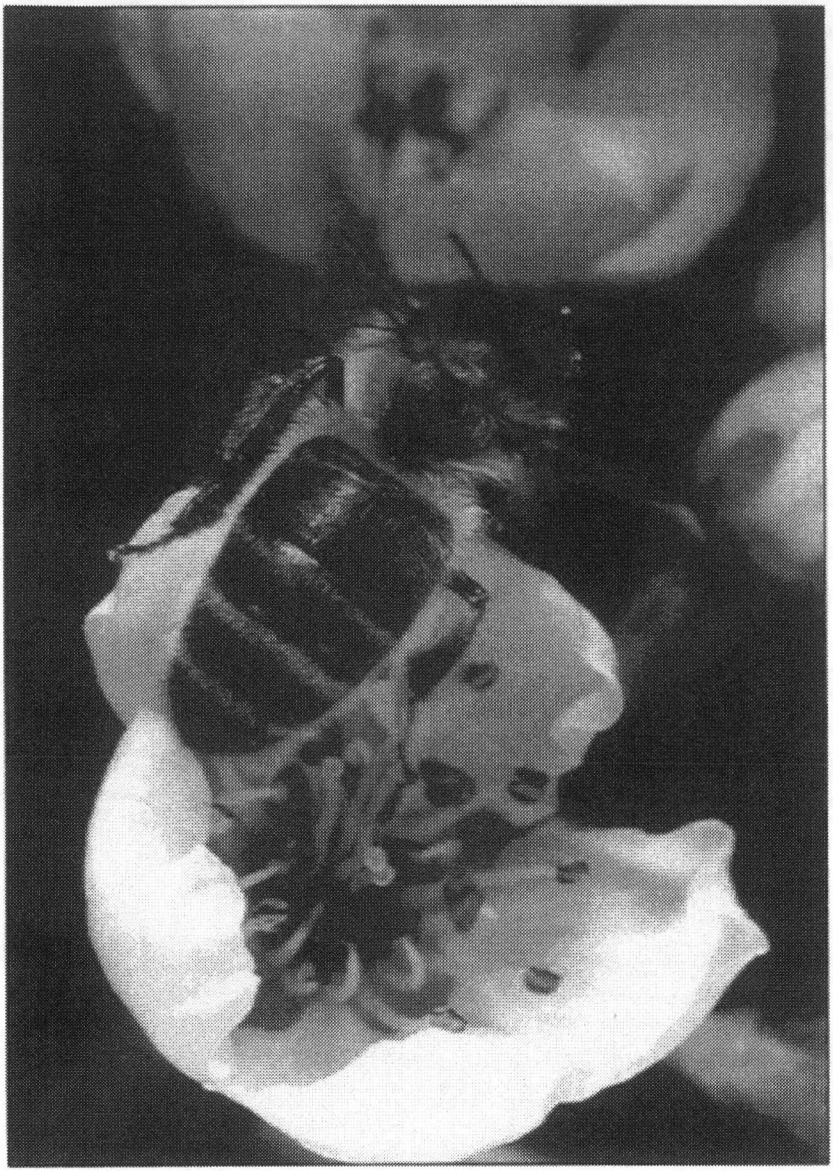
If the characters are compared individually the situation is similar. But in size there is a clear difference between the samples of France with smaller bees and the total of the other regions where the bees are larger, but with shorter proboscis (Table 5), a change in proportions already stated by ALPATOV (1929) while investigating the bee populations of the USSR. Evidently the Dark bee of France (which is only poorly represented in our collection) takes a special position within *A.m.mellifera*. As demonstrated by the investigations of the research group of Montfavet (CORNUET, FRESNAYE, LAVIE, TASSENCOURT et al. 1975, 1978, 1982), a number of local populations can be discriminated morphometrically in France: Paris, Bretagne, The Landes, Cevennes, Provence. The differences are only very slight, but statistically significant. This result is the more interesting since important differences in behaviour were found (see section "brood rhythm"). This diversification is probably the expression of the fact that



Native British Honeybee, Royal Museum of Scotland. Collected, probably in the vicinity of Edinburgh, certainly before 1858, when it was acquired by the Museum. CI 1.95, DS. -5; Overhairs, 0.596mm. *Photo J. E. Dews.*



Mellifera Drone, collected at Timworth, West Suffolk, 24th July 1910. Now in the National Museum of Wales. CI 1.53, DS -5. *Photo J. E. Dews.*



Native British Honeybee, photographed on pear blossom, Spring 1990, Horbury, Yorks. *Photo J. E. Dews.*

the presumed glacial refugium of the Dark bee was located in the south of France; therefore, the bee population of this country was the oldest of the northern part of Europe.

Another insight becomes evident from this overview: the Dark bee is certainly retreating and mostly disregarded by the present apicultural world, but it would be an exaggeration to claim that it does not exist anymore in its pure form. There are still large unhybridized populations of this race in various countries, but only in a few places are efforts made to adapt it by selection to methods of present-day beekeeping. If anybody would like to obtain pure bred queens of *A. mellifera mellifera*, only two addresses can be given for the Continent:

Tiroler Imkerschule, A-6460 Imst, Tyrol, Austria.
Norges Biroekterlag, Bergerveien 15, N-1362 Billinstad, Norway.

In the British Isles a number of BIBBA groups, working in their own localities, have discovered and are propagating and improving by selection, surviving colonies of British native honeybees. Regional variations are recognised which have differing behavioural characters, such as swarminess in the heather districts. Consequently, rearing of local strains is encouraged, and only where none are to be found is purchase outside the area recommended, preferably from localities with similar environmental conditions.

The probability of finding such bees is much higher in the west and north than in the south of the British Isles.

It is important, in order to avoid waste of time and possible disappointment, that an assessment of hair length and wing veins from a sample of at least 20 bees taken from each intended breeding colony should be made before the start of a breeding and selection programme. As already stated in this book, BIBBA regularly holds training classes in the morphometry of the honeybee. The Secretary of BIBBA will supply information about dates and places. Samples may also be sent for examination after arrangement with the Secretary of BIBBA

As shown earlier, the Dark bee possesses a number of characters which are worth preserving. Present knowledge and modern methods of mating control facilitate efforts to work with this long-neglected bee.

The conclusion of the matter

The results of this long and detailed study can be summarized in five short statements.

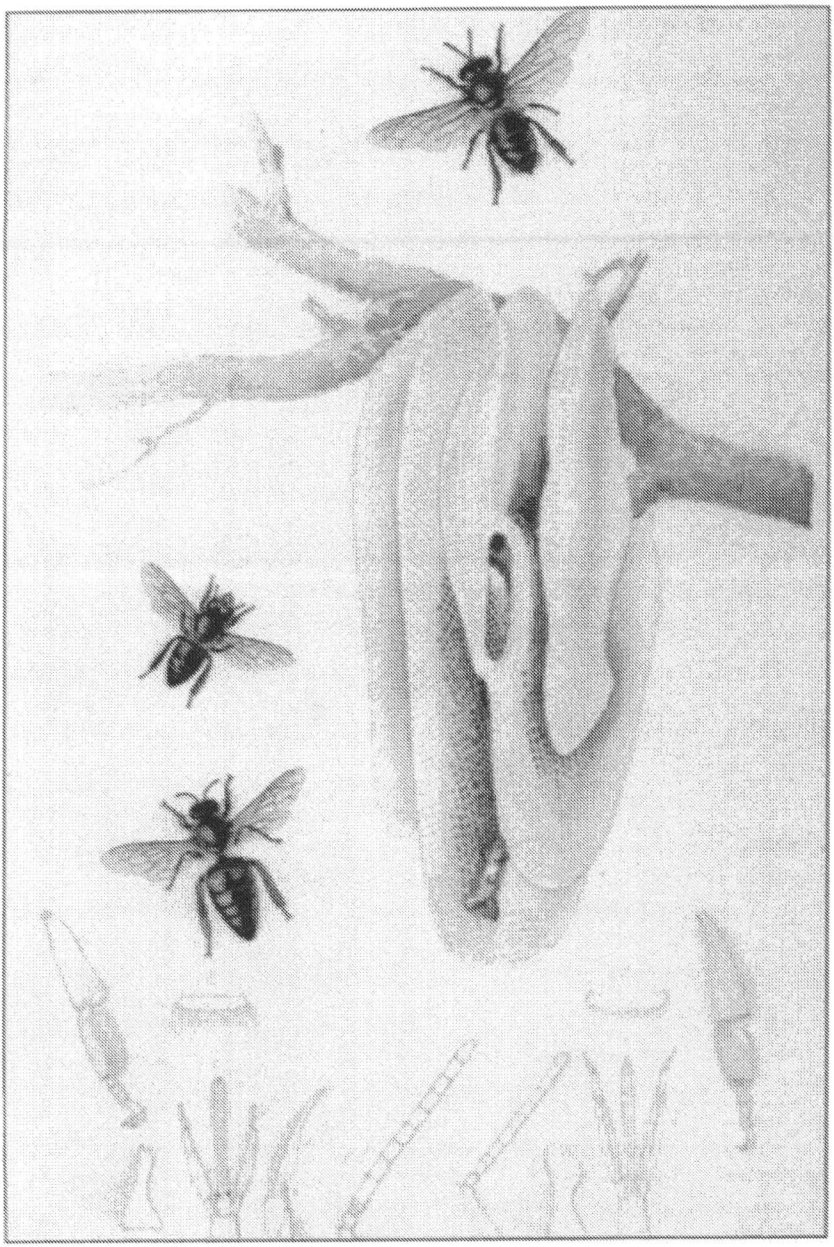
1. The measurable external characters (the phenotype) of the Dark European honeybee, *Apis mellifera mellifera L* has been definitely established by comparing recent samples from NW Europe with specimens from British museums collected early in or before the 19th Century and archeological finds from the excavation of a Viking settlement in York (10th Century) and others from Oslo (end of 12th Century).

2. *A.m.mellifera* can be significantly differentiated from its geographic neighbours, the *Carnica-Ligustica* group, by 12 morphological characters.

3. The phenotype of the Dark honeybee has not substantially changed, neither during the last millenium in Europe nor by transplantation to the southern hemisphere (Tasmania and New Zealand) during the last 150 years.

4. The repeated contention that the "old English bee" is extinct can be assumed to be disproved.

5. It is documented that honeybees existed in the Oslo region at the end of the 12th Century A.D. during a warm climatic period, but not later, till they were reintroduced in the middle of the 18th Century. It can be assumed therefore that the northern limit of *A.m.mellifera* was shifted southward before 1750, because of a deterioration of the climate.



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BIBBA and the Native Bee

The British Isles Bee Breeders' Association exists for the preservation of the **Native Dark Bee** and its improvement by **selective breeding of strains** of the **pure race**.

Beekeepers who have experience of this bee know that the carrying out of this policy makes

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BIBBA encourages members to

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- to conserve bees that are suited to their own locality

The morphometric examination of breeder stocks is essential if purity of race is to be preserved, so that transmission of desirable qualities is secured.

Information about morphometric examination (previously called biometry) is available in several BIBBA publications; workshops for teaching and practice are arranged when requested.

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