MORPHOLOGICAL AND BIOLOGICAL CHARACTERIZATION OF ECONOMICALLY INTERESTING BEE SPECIES AND RACES

F. RUTTNER

FRG

Of the four species in the genus Apis (honey bees), two build their nests in the open with a single comb. Only one of these two, *Apis dorsata* in S.E. Asia, is important as a source of honey and wax. Here the honey is collected from the nests, but the colonies are not kept commercially. On the basis of its biological peculiarities (migratory swarms, aggressiveness), there seems to be a little hope that these bees can be managed under controlled conditions as a domesticated animal.

Apis cerana

The remaining two species, *Apis mellifera* from the west and *Apis cerana* from the east have on the contrary been kept domestically for thousands of years. When we speak of honey bees, in most parts of the world we mean only *Apis mellifera*, although *Apis cerana* which is found in all of South and East Asia, including the islands, covers an area equally as large and also has a large number of races and subraces. Both species are alike in that their nests are located in cavities and consist of more than one comb. Thus they have been able to extend their ranges far to the north and even into the high mountain ranges. In the west they have spread into Scandinavia and the valleys of the Alps and the Caucasus, in the east as far as Ussuria and high into the mountain ranges of the Himalayas. The Eastern honey bee achieves the outstanding physiological feat of overwintering under harsh weather conditions perhaps even better that the Western honey bee, but no one until now has critically considered the specific breeding and management techniques required to keep it. Today in many countries these bee is inattentively removed or restricted by its sister species. In some cases, for instance in Afghanistan or Japan, this extinction process is nearly completed.

I wish to speak next about this neglected bee and try to point out its meaning for our future work. The Indian or Eastern bee is easy to distinguish from the Western bee. It has 4 tomentum, instead of 3 and has an extended radial vein on the hind wing, which does not occur in our bee. This bee fans in reverse position at the entrance, builds cell caps over drone cells with a hole for air in the middle and uses no propolis. In size it is smaller than the northern races of *Apis mellifera*, but the large differences between southern and northern races are just as large as that between races of the Western bee.

Does the Eastern honeybee produce as much honey as the Western? Usually the answer is no and for that reason, people justify the change to the Western bee. But isn't this perhaps a little to quick? Shouldn't we spend a fraction of our research on this bee before making any final conclusions? From my own personal experiences with this bee, I wish to mention some important facts in order to point out that this bee deserves our full attention.

1. Apis cerana can be maintained outside for its usual range in the common bee hives just as well as *Apis mellifera*. Lack of success is a result of our lack of knowledge of its biological characteristics.

2. At least in the strains studied up to now, *Apis cerana* is resistant to nosema. For this reason, *cerana* colonies from the northern regions winter better in cold climates than *mellifera* colonies. The northern most ocurrance of *Apis cerana* according to Lavrjochin is in the Primorje region (Ussuria) at 46^{o} latitude. Here, without the help of man, they are able to survive long harsh winters.

3. Apis cerana nectar collectors have different flower preferences and fly at lower temperatures than *mellifera* bees. This could be a determining factor for the pollination of specific crops.

4. It is not possible to cross *Apis cerana* either by natural or artificial insemination with *Apis mellifera*. Thus there is no danger of hybridization to fear.

These findings ought to be a real encouragement to all researchers in areas where these bees occur naturally, to concentrate their energies on the economic utilization to the fullest extent possible for this bee. This holds true especially for countries with temperate climates such as the U.S.S.R, China, Japan and also the northern mountainous regions of India and Pakistan.

At any rate, no time must be lost as the extinction of this bee is proceeding rapidly and in many areas it soon will be extinct.

Races of Apis mellifera

Morphological and physiological differences

In many land in the last few years, there has been a much greater concern with the development of new breeding and management techniques for the Western honeybee *Apis mellifera.* Now as before, the basis for this work is the study of geographical races. In addition to the classical methods of Alpatov and Goetze used in biometrical studies, new characters such as Du Praw's front wing vein angle are being used. It is to be expected that with the modern statistical studies such as those of Bornus and Gromisz in Poland, Sheremetiev, Gubin, Lekishvily, Veliev, Trishina and others in the USSR, Louis, Fresnaye and Thomasson in France, and F. Ruttner, a much more complete natural classification for the relationship between bee races will emerge than the case previously.

In addition to morphological differences, increasing numbers of biological differences are being studied. This differences are most important for the beekeeper because they are related to productivity. Many of these studies have been made in Russia, where in addition to the endemic races, also the Carniolan and the Ligustica races have been compared. Up until now, differences in digestive enzyme activity (Zherebkin et al.) in resistance to nosema (Tscherepov and Kusnezovna) and insecticides (Wafa et al.) in pollination activity and preference for specific plants (Gasanov) and the communication of food sources (v. Frisch et al., Levchenko et al.) have been demonstrated. Direct economic correlations have been found for differences in brood cycles, amount of brood and brood nest arrangement, swarming tendency, wax production and nectar storage, and also temperament.

Ecotypes

In the economic assessment of bee races, the term “specific adaptation” is often used. The use of this term is especially illustrated in the long extended experiments made by Louveaux and Bilash. In comparisons made on a large scale, it is found that each race has its unmistakable “face”, makes its own specific claims and demonstrates specific behavior and performance characteristics. In addition, variations within geographical races (ecotypes) can be found which are the results of thousands of years of natural selection for a specific niche. A Carniolan colony from the Hungarian Puszta is different from her sisters in the Austrian Alps, and a strain of dark bees on the French Atlantic coast differ from those in the part of France called the Provence. These findings have wide reaching implications for the bee breeder. His first responsibility is to find the best races and the best ecotypes for his area. Only after completion of this first step does it make sense to begin the second step, ie., development of a standard line from the selected material which contains all of the economically important characteristics required for an optimum adaptation to a given area.

Economically important races

Looked at from this point of view, there are only a limited number of races which come into the question for a particular area. Of these, a few are left in the long run. During the last 100 years in central Europe for instance, most of the races which could be kept there were imported and many experiments were made with hybrids. Of these importations, only the Carnolian ecotypes from the Alps remain, having replaced at the same time the endemic dark bee. In the USSR with its many large differences in nectar flow and climate, there occur numerous zones which are optimal for specific races or race hybrids. The Georgian mountain bee (Caucasian) for example gives good results in the South. In the middle and northern regions of the Soviet Union, especially in areas with much honeydew, this bee does not overwinter well and for this reason is inferior (Bilash). In areas with bad climate, Avetisyan states that the Carpathian and “Far Eastern” bee (both belong to the Carniolan race) are superior, the first especially good for poor and the last for large flows. It is of the great interest, that precisely these two ecotypes which are adapted to long hard winters, overwinter very poorly in central Europe. This is exactly the opposite of what we would normally expect. This is a good demonstration of how complex biological systems are, and that because of the many factors which influence them, we cannot make a survey from the start, but must learn through experience.

A further example of the interaction between the bees genetic disposition and its environment is the present problem of the African race *A.m. adansoni* in South America. This race was brought to South America under the correct assumption that an ecotype adapted to a tropical area would adapt here better than up to then cultivated European races. Who could see in advance, that this African race and its hybrids would demonstrate a “super adaptation” which in a few years would allow it to explosively overflow a whole continent. Very often when a new race is introduced, the environmental balance is distributed. Usually only the individual beekeeper is damaged and not everybody as in this case.

We must conclude after considering the comparative studies completed up to now, that on a world scale only 3 large races of *A. mellifera* are of enough economic value to warrant breeding efforts.

1. The Italian bee (*A.m ligustica*), above all in areas with warm summers and large nectar flows.

2. The Carniolan in a broader sense (*A.m carnica*), especially in cooler areas with early nectar flows and where there is much honeydew.

3. The Caucasian bee (*A.m caucasica*) for areas where the winter is not too long, without honeydew and with moderate honey flows.

Under some specific local conditions, other races are too important to be displaced. For instance the dark bee (*A.m mellifica*) in the eastern European forest areas. The Tell bee (*A.m intermissa*) with its brood cycle adapted to North Africa conditions and *A. m. adansoni* for tropical Africa. The Carniolan race probably has the largest number of ecotypes due to the fact that the Carpathian, Ukrainian and the Macedonian are also considered subraces.

Under natural conditions it is not possible to find a non-selected race which will give optimal results. Races must undergo a process of selection and because this means a cost of time and money (we need only to think of mating control and the comparative performance tests), the question is always whether or not it is financially feasible. This, of course, depends upon the methods used and the performance level of the comparative breed. But when we consider a number of experiments whose results agree with one another such as those of Bilash and my own, we can expect a 30-40% increase in performance. This values compare quite well with those obtained for other animal groups.

Race hybrids

In conclusion, I would like to mention the problem of the race hybrids. Today in this area are already many extensive experiments wich have been made (for a summary see Ruttner, XXIst APIMONDIA Congress Maryland) which in part have produced some very positive results. For this reason it is surprising, that nowhere even today is there really a general application of this principle in practice. The reason for this can be found when we take the problem of economics into account: constant utilization of controlled hybrids (and only this give good results) requires a relatively high investment. Both initial races must remain pure and the hybrids must be made from controlled matings only. For large enterprises for whom this techniques would be of the most interest, a very large investment would be necessary. When this system is abandoned for a period of time, there is a quick drop in the production and behavior characteristics. When breeding within a race on the other hand, we need only a small number of selected breeding queens. The queens for the production colonies can be matted in the open. For this reason they are relatively cheap. Hybrid breeding within a race ("Starline" from Dadant, Hybrid Carniolan – combination in the FRG) takes a middle position. It is true that in order to have a hybrid vigor, breeding lines must be maintained separate from each other, but in areas with similar races, a few generations of yard matings can be tolerated without risking the negative side of race hybrids.

Regardless of which way the breeding work in the future will go, work on the natural races will in all cases form an indispensable basis. It will remain the responsibility of breeding to increase our knowledge of the genetical diversity and to widen the economic possibilities of our bee races, to maintain breeding lines for the future and to encourage their commercial exploitation.