RACE VARIABILITY IN THE SIGNAL ACTIVITY OF HONEYBEE IN CONNECTION WITH A NUMBER OF PHYSIOLOGICAL CHARACTERISTICS

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Experimental evidence up to now point out that dancing is an innate form of behaviour. Several researchers (von Frisch, 1923; Wittekindt, 1960; Lopatina, 1963; etc) showed that these forms exist, without previous training, in young bees reared separately from the parent colony.

The race variability of numerous dance components (rhythm; duration and frequency of the sound component, and the increase rate of the latter, dependent on distance, etc) established in our laboratory (Nikitina, 1968) and by other researchers (Boch, 1957; von Frisch, 1964; Eskov, 1966; Levchenko, 1969) has led us to a significant conclusion on the hereditary conditionality of these components. The experimental work concerning signal behaviour of the honey bee is scrace. Only von Frisch's work (1962) is known in this respect; he crossed German dark race bees with Italian bees. Of the hybrids obtained, the yellow bees inherited the sickle-shape dance of the Italian race, while the dark ones – the circle-shape dance of the German bees.

In genetically determining the dance particularities we are mostly interested in the physiological channels along which the action is transmitted by the genes which are decisive in signal behaviour, and especially the gene control of the functional activity of the nervous system. Consequently, in the first stage of our experiments we elucidated the relationship between the signal behaviour forms and the physiological characteristics of excitability of nervous structures, both receptors (chemoreceptors, the mechanical receptors of the honey sac) and of those controlling the reflex activity (sight reception, synaptical transmission, etc). We must point out that this experiment is part of the research conducted in our laboratory of genetics of behaviour, which focuses its activity on the genetical analysis of the motion forms in connection with the nervous system functions.

We watched the signal behaviour forms and the above mentioned physiological characteristics in the following bee races: carnica, Shalkhdag, Persian, Italian, mountain grey Caucasian and the Middle Russian. In this paper we shall dwell only on two bee races namely carnica and the Middle Russian, which exhibit the most marked contrasts with respect to the relevant parameters.

As known, the carnica bees (*Apis mellifera carnica Pollm*) live in the region along the Danube to the East of Vienna, in the Carpathians, and in the Balkans (Ruttner, 1965). They are small, dark coloured, cold resistant, peaceful, and do not swarm. We used 3 carnica colonies from Austrian queens. The Middle Russian bees (either European or Northern) – *A. m. mellifera* L. – live in France, North Poland, in Bohemia (western Czechoslovakia) and in the Northern and Central regions of the USSR (Ruttner, 1965). They are much bigger than carnica bees, have the same colour, are also cold resistant, are aggressive, and have a moderate swarming impulse. We used bees of this race from Bashkiria (town of Ulu-Teleak), Estonia, and Byelorussia (Polessia bees), 1-2 colonies of each (4 colonies in all).

The experiments were made in the 1968-1970 period. Several parameters of the signal behaviour (dance rhythm, duration of sound compound, the number of dancing bees, the mobilization coefficient, etc) were studied, which differ substantially in the two above bee races (Table 1).

Table 1

RACE VARIABILITY IN SIGNAL BEHAVIOUR OF HONEY BEE

Race	Dance rhythm (for 100 m)	Sound duration (no. of sound emissions) during dance for distances of:			Average number of dancing bees in one group (%)	Mobilization coefficient	The moment of the appearance of the first mobilizing bee	No. of pollen plants necessary for the start of the dance
		100 m	200 m	300 m				
		msec						
Carnica	9.8	365 (11)	404 (14)	533 (15)	49	1:2.5	315 sec	1
Middle Russian	7.8	241 (8)	379 (10)	354 (12)	22	1:6.0	1700 sec	At least 15-20

As shown in the table, carnica bees differ from the Middle Russian ones by a faster dance rhythm, a longer sound component of the dance – which however increases more slowly with distance -, by a greater number of dancing bees under the same nectar flow conditions, by a higher mobilization coefficient (we established this term for illustrating the relation of mobilized bees to the number of dancing bees), and by faster and more efficient mobilization. This differences is even more marked when bees are incited – under weak flow conditions.

We think that the indices of the signal behaviour such as dance rhythm, the relative number of dancing bees, the mobilization coefficient, and also the faster and more efficient mobilization can show the general level of the signal behaviour; and, as illustrated by the data in the table, these indices are higher in carnica than in the Middle Russian. Levchenko et al (1969) have reached the same conclusion after having compared the signal behaviour of carnica to that of native Ukrainean bees, i.e. the Middle Russian race.

The signal behaviour forms are closely related to the whole of the food-finding activity (honey collection) studies in bee races. According to a number of researchers (Levchenko et al., 1969, Zherebkin, Chaplygin, 1969 etc) the carnica bees have a higher flying activity as compared to Middle Russian ones, forage on a larger area, supply a higher honey crop under weak flow conditions, have a more intensive activity of digestive enzymes – invertase and diastase (in spring and summer). With carnica bees also other indices are higher than with the Middle Russian bees, indices which may be used as unit of measure for their activity throughout the food collecting period.

Is there any relation between the forms of the signal behaviour (food collecting) and the physiological characteristics of the nervous structures? For answering this question, we studied the functional state of the following fundamental elements of the nervous system:

1. Receptors – responsible for "releasing" the innate reflexes directly related to the food-collecting activity - : the sight receptors, the taste receptors, and those controlling honey sac flexibility; and 2. Synapses, which transmit nervous impulses to the motion organs.

The functional state of the sight receptors was established after bees chose a certain light zone, in photogradients (1-34 luces); the excitability of the chemoreceptors – after the threshold concentration of the sugar solution inducing the first dance; the excitability of the honey sac mechanical receptors – after 50% threshold concentration of the sugar solution in the honey sac which induces the first dance.

Table 2

RACE VARIABILITY OF SEVERAL PHYSIOLOGICAL PARAMETERS

Race	Threshold concentration of sugar solution (%)	Threshold charge of honey sac (in ml)	Number of bees (%) chosing the light zone		The moment of full narcosis (min)
			1-23 luces	24-34 luces	
Carnica	6	14±1.0	41		7.0±0.09
Middle Russian	15-30	30±1.7 30±0.03	63		13.6±0.14

The indices of the functional state of synapsis apparatus were given by the speed of reversible inactivation of synaptical transmission; we appreciated the latter by the effect of 1% ether vapours.

The data in the table show that the carnica bees, differing from the Middle Russian bees in signal behaviour, also differ from them in the indices characteristic to the functional state of the nervous system. Thus, the threshold sugar concentration inducing the first dance (25-30% of the total number of bees) was 6% for carnica, and for the Middle Russian – 2.5-5 times higher i.e. 15-30%. Ror stating to dance, a carnica forager needs to collect 14 ml of sugar syrup, on an average, while the Middle Russian ones – a 2.3-2.7 times bigger quantity. These data are similar to that obtained by Levchenko et al (1969). Thus, the excitability of the taste reception and of the mechanical receptors controlling honey sac flexibility is much higher in carnica bees than in the Middle Russian ones.

The same is true of photoreception. Most carnica bees (59%) chose the light zone of 24-34 luces, while the Middle Russian ones (63%) – of 1-23 luces.

Under the action of ether vapours, the successive stages of narcosis are observed in bees: 1) The excitation stage – intensification of flight activity and movements: buzzing, extension of proboscis and of the sting; 2) Stage of benumbed movements (the bee falls down on her back, extends her extremities, trembles); 3) Full immobility.

By considering the time after which the first two stages appeared, it was not possible to establish any race difference. The first stage started after 0.5-1 min and 2-2.5 min respectively, at the races under study. But significant difference was recorded in terms of the establishment of the full immobility stage. The fastest effect of narcosis was recorded in carnica bees – 7.0 min (with variations ranging between 7 and 8.5 min at different colonies), and the slowest – in the Middle Russian ones – 13.6 min (with variations from 10 to 14 min). The period within which the full effect of narcosis was manifest varied according to season. It was 1.5-2 times longer with spring bees (April-May) than with the summer ones (July-September). Hence, in carnica bees – characterized by a higher level of dance signal activity – also a faster reversible inactivation of synaptical transmission to motion organs was recorded.

Thus, the "signal" aspect of behaviour was closely related to specific physiological parameters characterizing the activity of the nervous system. This testifies to a possible common hereditary conditionality of the nervous system (receptory and synaptical structures) and of the level of the dancing behaviour.

The research up to now enables us to enter a new stage, namely, the establishment of the laws governing the transmission to the descendants of these characteristic features, by using contrasting races for investigation on hybrids.

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