SOME BEHAVIOURAL CHARACTERISTICS OF THE SUDANESE HONEY BEE

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Introduction

Knowledge of honey bee biology, especially behaviour, is essential for efficient colony management. The biology of African honey bees is much less well known than that of European honey bees. Of the African honey bees, *Apis mellifera scutellata*, the honey bee introduced into Brazil in the 1950s, is the best known[4, 9, 13, 15]. The behaviour of Africanized bees in the Americas may differ from that of African honey bees. Some behavioural characteristics of *A. m. adansonii* are also known[16, 17].

In this article, some of the characteristics of the Sudanese honey bee (*Apis mellifera yemenitica* Ruttner 1975, ecotype *nubica*) are described, placing particular emphasis on the differences between this bee and European honey bees and bees from the south of the Arabian peninsula. As the behaviour of the same bees may differ in different conditions, the circumstances of this study are briefly described here. The observations were conducted during three FAO missions in Sudan; (1) from 3 October to 6 November 1988, during the dearth period; (2) from 29 January to 28 February 1989; and (3) from 22 January to 30 March 1990, during the honey flow and swarming period. Most of the work was done in a desert area in northern Sudan near the Nile river in Ed Damar, and some in Shendi. Good nectar and pollen sources were available in both locations in orchards (citrus, mango) and from alfalfa cultivated near the river. Further observations were made in a savanna area in Kosti in central Sudan near the White Nile river. Nectar and pollen was available here in orchards and from two different species of acacia (*Acacia nilotica* and *A. seyal*).

The Sudanese honey bee

The Sudanese honey bee (*A. m. yemenitica* Ruttner 1975[12], ecotype *nubica*) is one of the smallest honey bees yet found. It has a slightly larger body size than that of *A. m. yemenitica* from Yemen and Oman, however, and it has an even more slender and brighter abdomen[13]. The queens are almost entirely yellow with a black tip to the abdomen. Rashad and El-Sarrag[10] described a small yellow bee (*A. m. sudanensis*) found in the major part of Sudan, and a larger darker bee (*A. m. nubica*) along the southern border. According to the priority of nomenclature, the small yellow bee should be called *A. m. yemenitica* ecotype *nubica*; the other, darker bee might be named *A. m. sudanensis*.

Sudanese honey bees build comb with small cells: the width between parallel cell walls is 4.8 mm for workers and 6.2 mm for drones. The bees seldom accept comb foundation made with a cell size suitable for European honey bees. Often they

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will build a thin comb near the foundation, which remains untouched. A mixture of worker and drone brood can be found in combs drawn on this type of foundation and sometimes the foundation cells are restructured into drone cells.

As will be discussed later, several behavioural differences exist between *A. m. yemenitica* from Yemen and Oman and the bee from Sudan. It is therefore suggested that the Sudanese bee should be recognized as a *nubica* ecotype within the subspecies *A. m. yemenitica*. The results of my observations are summarized in table 1.

Flight activity

European honey bees are easiest to work during periods of the greatest flight activity, usually midday. At this time, the older, more defensive workers are away foraging, making it easier to manage the colonies. Fletcher[4] recorded one early morning peak of flight activity for *A. m. scutellata*. Two peaks of flight activity, one early in the morning at sunrise, and the other late in the evening at sunset were observed for *A. m. adansonii* bees in Ghana[16, 18].

The flight activity of Sudanese honey bees was investigated by counting workers returning to three different colonies at 5-min intervals during a whole day. Counts conducted in February 1990 were repeated in March. Worker bees started flying quite late at about 09.30 h. One peak of flight activity occurred between 10.00 h and 10.30 h, after which activity lessened. A second peak of flight activity occurred between 15.00 h and 16.00 h; this was usually the time for orientation flights and drone flights. Thus the Sudanese drones fly later than the European ones. By 17.30 h flight activity had almost completely ceased.

Defensiveness

The 'aggressiveness' of some African bees is well known[19], but *A. m. yemenitica* in Yemen and Oman is very docile, although morphologically it is very similar to the Sudanese bee. Karpowicz[7] reports that protective clothing is not worn by beekeepers while working in apiaries in Yemen; and Dutton *et al.*[2] observed that the transfer of a colony to a Langstroth hive in Oman could very often be done without any protective clothing.

Sudanese honey bees, in contrast, are extremely defensive. It is not possible to work them without good protective clothing, and some beekeepers use double layers[3]. It was noticed that the degree of defensiveness varied during the day. Sometimes the bees were very aggressive even when the beekeeper was not working in the apiary. At other times, it was possible to work in the apiary without being stung. To explain this variation, a detailed investigation was conducted. A dark leather ball, 70 mm diameter, was suspended at the edge of the apiary for 1 min. Workers stung the ball, leaving their stings behind, and the stings were then counted. This experiment was carried out every half-hour during the day.

A peak of stinging behaviour occurred between 10.00 h and 10.30 h followed by a second peak at 15.30 h. (315 stings in 1 min). Thus a positive correlation was found between flight activity and aggressiveness, which is opposite to the behaviour of

European honey bees. During the periods of greatest flight activity, Sudanese workers were attacking not only people in the apiary, but they were also flying to nearby buildings 100–250 m away, and were attacking the screened shelter and windows. Several animals present in the vicinity of the apiary were killed.

On the basis of these observations, work in the apiary was conducted during the periods of lowest flight activity, i.e. in the morning up to 09.45 h, then from 10.45 h to 14.30 h, and again from 16.30 h till the end of the day. This reduced considerably the potential stinging and made working in the apiary easier.

Absconding and migration

Absconding, provoked by disturbance of the colony, is the main problem hindering the introduction of modern colony management practices for *A. m. adansonii*[16, 17]. Sometimes colonies abscond after the honey is harvested or even after the colonies have just been examined. It has been found to be practically impossible to make mating nuclei because the nuclei as well as the original mother colonies abscond[17]. Dutton *et al.*[2] reports disturbance, such as the examination of brood combs, also results in desertion of hives by *A. m. yemenitica*. Karpowicz[7] found that excessive smoking provokes panic in *yemenitica* bees, and that the entire colony leaves the hive and hangs outside the entrance.

Surprisingly, absconding among Sudanese honey bees very seldom occurs. Some examples of my own observations follow: (1) About 10 colonies were divided during the second mission and none absconded. (2) A total of 30 nuclei of four combs each were created; neither the nucleus colonies nor the remaining bee colonies absconded. (3) Two established colonies were removed from tree cavities and they did not abscond. (4) Two colonies each occupying eight combs hanging free on orange trees were removed; the combs were cut and fixed into frames, and the entire colonies were transferred into Langstroth hives. Three days later each colony was divided into three nuclei. Four nuclei were moved out and two were left in each of the two original positions. None absconded. (5) Frames containing combs with brood and honey were reconstructed and placed in 10 Langstroth hives. The bees were shaken down, all the combs were removed and, after the frames were cut appropriately, the combs were returned to the hives. Out of these colonies, the three weakest ones absconded. (6) Two swarms hanging on trees were shaken into hives each containing two empty combs. Bees of the first swarm immediately accepted the hive and started fanning and attracting free-flying bees. Bees of the second swarm started immediately to abscond. They gathered on a branch of the tree, from which they were shaken a second time into the hive. The hive entrance was then closed until the evening and opened at sunset. The bees started to abscond at once. The first swarm was collected near the apiary and I concluded that it was composed of bees which had just absconded from our apiary. The second swarm was collected in the town, and it seems that this was a migratory one.

Contrary to *A. m. yemenitica* in Yemen, which does not migrate, seasonal migration does occur in the Sudanese bee[10]. The swarms migrate towards the river in the drought season, and during the honey flow period (December–March), they return to the savanna.

TABLE 1. Comparison of behavioural characteristics of some African and the European race of *Apis mellifera*.

Characteristic	*nubica*	*yemenitica*	*mellifera*	*adansonii*	*scutellata*
Morning and evening peak of flight	+	?	–	+	?
Defensiveness	+	–	+/–	+	+
Absconding	–	+	–	+	+
Migration	+	?	–	+	+
Laying workers in presence of virgin queen	+	?	–	?	?
Emergency queen cells in presence of virgin queen	+	?	–	?	?
Late time of swarm issue	+	?	–	?	?
Multiple queens	+	?	–	?	?
Nesting in open air	+	?	–	+	+
Taking light syrup inside the hive	–	?	+	–	?
Heavy propolization of hive entrance	+	?	+/–	?	?

Laying workers

Laying workers appear in European bee colonies after the bees are 'hopelessly queenless' for a prolonged period. Laying workers appear in Sudanese bee colonies very soon after the absence of a laying queen. They appear in the presence of queen cells as well as in the presence of young non-laying queens.

Queens were reared in three queenless colonies. Laying workers appeared in all three colonies. Queen larvae disappeared from some accepted queen cells which had contained larvae for 2–3 days. However, none of the sealed queen cells were destroyed. Laying workers deposited eggs not only into comb cells but also into queen cell cups.

About 30 nucleus colonies were created, each of which contained, apart from workers, two combs with brood of different ages and two combs with stores on either side of the brood nest. The following day, mature queen cells were added. All queen cells were accepted and produced virgin queens. Within a few days, laying workers appeared in all nuclei. Workers continued to lay eggs at least until the time when the queen started to lay eggs. All queens were inseminated instrumentally, and so they started to lay eggs later than naturally mated queens would have done. Laying workers were still laying eggs in nuclei in which a young non-laying queen had been present for 15 days. There was no doubt that the eggs originated from laying workers and not from the queen as the eggs were deposited in drone cells or very irregularly in worker cells. When queens started to lay eggs, their eggs were deposited regularly in worker cells.

In European honey bee colonies with laying workers, introduced queen cells or queens are usually not accepted. When queen cells, virgin queens or laying queens were introduced into several Sudanese honey bee colonies or nuclei with laying workers, all of them were accepted. Thus, all the precautions necessary for the introduction of queens into European honey bee colonies with laying workers are not required for colonies of Sudanese bees.

Buttel-Reepen[1] and Gough[5], in the 1920s, reported that laying workers appear very soon after the loss of the queen in an *A. m. lamarckii* colony. According to Ruttner and Hesse[14], laying workers appeared in colonies of some African honey bee races within 5–10 days after the loss of the queen. However, the workers did not have the opportunity to construct emergency queen cells. In the Sudanese honey bee, the laying workers appeared in queenless colonies in the presence of young brood and queen cells. I also observed this same phenomenon in *A. cerana*. The presence of queen cells did not inhibit the activity of laying workers. Their activity was lowered or stopped by the introduction of one or two combs with unsealed brood which required a large amount of royal jelly.

The very early occurrence of laying workers, at the beginning of rearing emergency queens, may be advantageous for the colony. It assures the presence of drones in a period without a laying queen. The development period and the time taken to reach sexual maturity in drones is longer than that of queens. Nevertheless, in a period of absence of drones in other colonies, the virgin queen can be inseminated, with some delay, by drones produced by laying workers from the same colony.

Queen cells in the presence of virgin queens

In European honey bees, workers do not construct emergency queen cells in the presence of a queen. Furthermore, existing queen cells are destroyed in the presence of young virgin queens, when the colony is not preparing to swarm.

We introduced about 30 mature queen cells into Sudanese nuclei or colonies (queenless for one day), one day before emergence of the queens and we destroyed all visible emergency queen cells. After 3–4 days all the queens had been accepted, nevertheless, unsealed emergency queen cells were found in all nuclei; these cells were also destroyed. A few days later, the nuclei and colonies were checked again, and new emergency queen cells containing larvae were found once more. The older cells contained partly eaten larvae 3–4 days old, or royal jelly only (the larvae had already been eaten), or they were empty. Some queen cells were already sealed; these had probably been overlooked during the first check. The nuclei were weak and were not in swarming condition. We destroyed these sealed cells and so it is not known whether, or when, they would have been destroyed by the bees. Contrary to European honey bees, emergency queen cells are present in Sudanese bee colonies for some period in the presence of young queens.

I did not find any reports in the literature on the construction of emergency queen cells in the presence of a virgin queen. It may be that Sudanese virgin queens produce less queen substance, or that the workers require a greater stimulus to inhibit the construction of emergency queen cells. This phenomenon is advantageous for the colony: if the virgin queen is lost during the mating flight, the colony will not perish because new queens emerge from the existing queen cells.

Time of swarm issue after queen-cell sealing

In European honey bees, the first swarm leaves the hive on the day after the first queen cell is sealed (this is nine days after the egg was deposited in the queen cell). Thus, a spinning larva or prepupa is present in the oldest queen cell at the time the first swarm leaves the hive.

Sealed queen cells were opened in 10 Sudanese honey bee colonies preparing to swarm. Examination of the appearance of the premature queens allowed us to determine their ages. The presence of the old queen in the colony was confirmed, and eggs were present in all the colonies; this was checked again four days later. In all colonies, pupae of different ages were already present in the oldest queen cells. In several cases the pupae had pink, red or light violet eyes thus, according to Jay[6] or Rembold *et al.*[11], they had been present inside sealed queen cells for 4–6 days, and the colonies had not swarmed. As an example, the queen cells found in a wild colony hanging on an orange tree are described here; altogether, 12 queen cells were found, seven of which were sealed. Their contents were as follows: in one cell, a spinning larva (1 day after sealing); in one cell, a white-eyed pupa (3–4 days); in two cells, pink-eyed pupae, (4–5 days); in one cell, a pupa with light violet eyes and light yellow body (6–7 days); in two cells, pupae with violet eyes, light brown body and appendages, and a grey thorax (7 days). Thus, the oldest pupa had only one day left before emerging from its cell. Eggs were present in that colony, and the queen was found and introduced into a nucleus, where she continued to lay eggs.

When artificial queen rearing was started, queens were removed from colonies preparing to swarm. Swarming queen cells were destroyed. However, acceptance of larvae grafted into queen cell cups was very low (2–4 cells accepted) in four colonies. Later a second queen was found in all four colonies.

It is not clear whether the swarm leaves the colony before the new queen emerges. Perhaps swarms leave after the emergence of the new queen. No doubt Sudanese swarms leave the colony much later after sealing the first queen cell, compared to European bees.

I found 20 virgin *A. m. lamarckii* queens in a colony in Egypt. The presence of multiple virgin queens in a colony or a swarm has been reported for several races: *A. m. syriaca*[5], *A. m. punica* (*intermissa*)[8], *A. m. lamarckii*[13]. Colonies would benefit from this phenomenon when the virgin queen is lost during the mating flight as the lost virgin would be replaced immediately by another one.

Nesting in open air

Feral honey bee colonies do not just occupy the cavities of tree trunks. Nests were found on several occasions between twigs and small branches of trees. In the nest I examined, several combs containing brood as well as pollen and honey were present. The brown colour of the combs suggested that the colony had been nesting in the open air for an extended period of time.

Feeding sugar syrup inside the hive

Very often European honey bees are fed using feeders inside the hive containing sugar syrup composed of 2 parts water and 1 part sugar. However, I observed that in Ghana, *A. m. adansonii* workers did not take syrup of this concentration at all, or only with difficulty, when it was provided near the brood combs.

I have often observed that Sudanese workers also will not accept syrup of this concentration provided in a feeder placed at the side of the hive: on some occasions the bees were almost starving due to lack of food, but they would not take the syrup, which had started to ferment. Workers did take the syrup when the feeder was placed next to a brood comb, but it took a long time (1–2 days) to empty the feeder. When the concentration of the syrup was increased to 1 : 1, there was no problem with feeding bees inside the hive. Therefore, Sudanese honey bees must be fed with syrup of a higher concentration than that used for European bees. Flight activity did not increase after syrup feeding, which also occurs with European bees.

Propolizing hive entrances

During the hot summer months, the entrances of hives containing European bees are kept open across the whole length of the front of the hive. When a beekeeper does not reduce the entrance size during the winter, the bees use propolis to make the entrance smaller. Even so, the entrance still remains open for several centimetres in width.

Sudanese bees propolize the entrances much more, leaving only extremely small entrances (fig. 1). This phenomenon was especially visible on Abba island in the

FIG. 1. The hive entrance is reduced by propolis to two small holes.

White Nile river near Kosti. The temperature at night was 17–20°C and during the day was 37°C. When the entrance bar extending the length of the entire front hive wall was removed by the beekeeper, the bees propolized the entrance almost completely leaving only two or three small holes through which only one worker bee could pass at a time. It is hard to imagine how the bees could have ventilated the inside of the hive. Apart from hindering the access of predators, perhaps this propolis barrier is useful in keeping out heat from the outside.

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