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INVESTIGATION ON THE OCCURRENCE AND POPULATION DENSITIES OF HONEYBEES IN NORTHERN SUDAN

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ABSTRACT

Northern Sudan lies within the bee zone of Africa, but the situation looks different as the occurrence of wild honeybee, *Apis mellifera*, seems to be limited in this region. Field surveys were conducted in such area to investigate the population densities and distribution of *A. mellifera* and *A. florea* (a newly introduced dwarf bee) as affected by the prevailing conditions. Among such limiting factors, argel (*Solenostemma argel*) plant was detected for the first time in this study to act as a bee killer. Argel flowers were observed to trap *A. florea* through a sticky material and dense hairs, causing > 50% mortality of foraging bees. Then, a comparative study on distribution of bees along the Nile River confirmed that the densities of both honeybee species were very low in the argel area (Abu-Hammed Locality) and northwards as compared with areas southwards. This suggested the detrimental effect of this plant on the buildup and distribution of bees in the Northern State, which needs to be fully evaluated. Moreover, other important natural and climatic factors affecting honeybees in the area were briefly discussed. However, rehabilitation of the north may change the area to be more attractive for bees' establishment.

Keywords: Bees, Distribution, Population density, *Solenostemma argel*, Sudan.

INTRODUCTION

Wild honeybees of the species *Apis mellifera* are widely spreading in Sudan since ancient times, establishing their nests on trees and fallen logs in various forests or on rocks roofs and crevices of some mountains [1]. For domesticated honeybees, beekeepers mainly utilize different kinds of traditional hives [2], whereas in recent years modern beekeeping is flourished using Langstroth hives [3]. However, due to aggressiveness of Sudanese honeybees, Carnio-Egyptian bees are imported and used for honey production in most modern apiaries. Regrettably, this approach has contributed to introduction of several pests and diseases of honeybees to the country [3-5]. On the other hand, the invasive dwarf honeybee, *Apisflorea*, was introduced accidentally to Khartoum in 1985 [6-7], thenceforth it became established and continuously invading other States. The last northern limit for *A. florea* was recorded to be at Abu-Hammed area [8]. In several reports it became clear that *A. florea* was expanding from Southeast Asia towards the west. The occurrences of *A. florea* in the warmer parts of Oman, Iran and Pakistan were well documented [9-10]. It is now found in the Middle East including Iraq and has established sustainable populations in the Arabian Peninsula and central Saudi Arabia [10-11]. Most recently *A. florea* has been reported in Eilat and Aqaba [12-13].

The highest populations of wild honeybees (*A. mellifera*) were found in the Southern parts of the country including, Blue Nile, Southern Kordofan and Southern Darfur States. However, the populations decrease gradually as we go northward. Therefore, it is claimed that there were no honeybees in the Northern State of the Sudan [14]. Nevertheless, the wild Sudanese *A. mellifera* was detected in very limited parts and the highly invasive a small bee *A. florea* is hardly invading the north. Indeed, the harsh desert climate in the north might have negative impacts on the occurrence of honeybees in that region [15]. However, different subspecies were reported in similar climatic regions including: *A. m. sahariensis* in Maghrebin, *A. m. lamarckii* from north east Africa (Egypt), and *A. m. jemenitica* from Arabian Peninsula [9,

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16]. The honeybees from Sudan morphometrically belongs to *A. m. jemenitica* in Mashriq [9] and genetically has consequences for the interpretation of the biogeography of *A. mellifera* in the Maghreb and Mashriq regions [17]. Moreover, the drawings of bees detected inside temples and pyramids of ancient Nubian civilization in the north, clearly demonstrated that the people in this area were well acquainted with bees at that time. Hence, the question is that why honeybees are rarely found in this part of the country, although their occurrences in neighboring areas particularly the south part of Egypt were documented [16].

In an attempt to find some answers, recent surveys were carried out covering all parts of the northern Sudan (River Nile and Northern States) to monitor the population abundance of both *Apis mellifera* and *A. florea* along the whole area. The investigation emphasizes argel plant, *Solenostemma argel*, which detected during the surveys as a bee killer, and thought to be among the main reasons hampering spreading of bees in the north. Moreover, the study also included brief account on important environmental factors affecting the occurrence and population buildup of honeybees in such area.

MATERIALS AND METHODS

This study aimed to monitor the presence of the Sudanese honeybee (*Apis mellifera*) in northern Sudan (Northern and River Nile States), and to know to what extent is the exotic dwarf honeybee (*Apis florea*) invading the north. Moreover, the important factors affecting the occurrence and population buildup of honeybees in that area were briefly investigated. The data were obtained through surveys and field observations, genetic approach to estimate the population density, and meteorological records regarding some climatic conditions.

Since classical surveys poorly reflect the actual population sizes due to the large area covered by *A. mellifera*, as the mating range of queens and drones can exceed 80 km² [18], that is why the visual observations were supported by pheromone trapping to catch drones for genetic studies. With the advance of DNA technologies, it becomes possible to estimate the population density from genotype data of worker honeybees collected from their colonies or drones trapped from drone congregation area (DCA) [19].

Survey of Honeybees in Northern Sudan

A survey was carried out in northern Sudan during January 2008 covering different areas along the River Nile including Shendi, Aliab Scheme, Atbara, Abu-Hammed area (around Um-Giday), Merowe, El-Gorier Scheme, Old Dongola, El-Goled, El-Silaim Scheme and Karma area (Fig. 1). The survey was done either through visual observations to investigate the nesting sites and forage sources, or by setting a trap utilizes synthetic queen mating pheromone [20]. The presence or absence of honeybees (*Apis mellifera* and *A. florea*) in these areas was recorded.

Population Density

Apis florea

Adult workers (>48) were collected from four *A. florea* colonies each at five locations starting at Shendi (*1), then Atbara (*3), Abu-Hammed (*4) Merowe (*5), and Old Dongola (*7), whereas no *A.florea* colonies were detected at the other locations northward (Fig. 1). Twenty four workers were taken from each colony for DNA analyses and DNA extracted from the hind leg using the Chelex® method [21]. The extracted DNA was amplified by polymerase chain reaction (PCR) with three already known microsatellite loci [A76, A88, and A107 as in Oldroyd *et al*. (1995) and Palmer and Oldroyd (2001)] and two loci (BI 47 and Ap 19) used for the first time in *A. florea* [22, 23]. The queen and siring drone genotypes were determined from the worker genotypes by Mendelian inference [19].

Apis mellifera

Samples of *A. mellifera* were collected from three of locations (Shendi, Atbara and Merowe) indicated for *A. florea* (Fig. 1). Only adult workers were taken from Shendi and Merowe, whereas drones were trapped from one DCA at Atbara using Williams's trap. However, neither drones nor workers were found in Abu-Hammed and other locations northwards. The traps were used as indicated by Williams (1987) [20]. Pheromone lures made of blackened cigarette filters were treated with about 10 queen equivalents of 9-oxodecenoic acid (2.5 mg) dissolved in dichloromethane. All the drones caught were immediately transferred into 95% EtOH until further processing for DNA extraction. Colony locations and DCAs were all within a radius of 3 km. DNA was extracted from 24 workers/colony using routine methods [21] and genotyped with 5 tightly linked microsatellite *loci* (HB5, HB7, HB10, HB15, SV240) [24]. The genotypes of the father drones were determined with DNA fingerprinting through Mendelian inference. The numbers of drone producing colonies were inferred from the genotypes of the siring males yielding an exceptionally robust estimate of the actual number of colonies in the population [19].

RESULTS AND DISCUSSION

Survey Results

The presence or absence of honeybees (*Apis mellifera* and *A. florea*) in the surveyed area was recorded in Table 1. *Apis florea* was found in all locations except El-Goled, El-Silaim and Karma, whereas *Apis mellifera* was detected only in Shendi and Atbara and at very low level in Merowe. However, the occurrence frequency of both *A. mellifera* and *A. florea* was found to be significantly lower in the area of argel (Abu-Hammed)

and other locations northward when compared with those areas at the southern part (Shendi - Atbara).

Detection of a Honeybee Deadly Plant

During the survey and investigations of honeybee forage sources, it was observed that a number of foraging *A. florea* bees were trapped and killed on flowers of argel herb, *Solenostemma argel*, at Abu-Hammed area (Pl. 1). This point nearly represents the middle part of the whole surveyed area. Close observations revealed the presence of sticky material and dense hairs on flowers entangling bees until being died. From counting the total number of visiting bees and the number of killed individuals per half an hour per plant, more than 50% mortality of foraging bees was recorded. However, according to Smith (1960), different plants are suspected to be poisonous to bees [25]. Among these plants are: *Solanum magram* L. *Aesculus californica* Nutt, *Zygadenus venesosus* (S. Wats), *Cuscuta* spp., *Cyrilla racemifora* L., *Kalmia latifolia* L., *Veratrum californicum* Durand and *Gelsemium sempervirens* A it. Barker (1978) also listed *Nicotiana tabacum* as a poisonous plant [26]. But, regarding argel plant in this study, it seems that the mortality effect on *A. florea* is exerted through mechanical rather than toxic effect.

Many concerns have been expressed showing that introduced bees may have negative impact on the native plants. Bees can reduce the pollination and alter the population structure of plants by mediating different patterns of pollen transfer to native pollinators, and increase seed set and hence weediness of some exotic plants [27]. On the other hand, very little is known about the negative impact of the native plants on introduced honeybees. The present results clearly showed that the native plant *S. argel* has detrimental effect on the build-up and distribution of the exotic honeybee *A. florea* in northern Sudan. Similar effect might also be induced to *A. mellifera*, so this is waiting an additional research. Indeed, other factors such as the harsh climate of the area or competition may contribute to decline honeybee populations. Moreover, the complete absent of the native honeybee *A. mellifera* which supposed to be adapted to the local climate, insures that the studied area by way or another is currently not favourable for honeybees occurrence. Nevertheless, such killing effect of argel also needs to be confirmed on *A. mellifera* as mentioned above, and further investigations on constituents and characteristics of *S. argel* flowers is ultimately important.

Population Density

The population density of *A. florea* in the five sampled areas ranged from one colony/km² in Old Dongola to 39 colonies/km² in Atbara, whereas the population density of *A. Mellifera* ranged from 2 colonies/km² in Merowe to 16 colonies/km² in Atbara (Table 2). Accordingly, the population density of the non-native *A. Florae* was significantly higher ($p < 0.03$;T-test) than that of the wild native *A. mellifera* in all investigated areas along the Nile River (Table 2). Such data in the table also showed that the population densities of both *A. mellifera* and *A. florea* were significantly lower at the area of argel (Abu-Hammed) and northward than at the area southern Abu-Hammed (Shendi - Atbara). This might insured the negative impact of *S. argel* on distribution and buildup of the two honeybee species in the studied area.

As explained above, *A. florea* consistently had higher occurrence frequency and population densities than *A. mellifera*, along the Nile River. This could be attributed to the multiple reproductive swarms of *A. Florae* [28]. Although, competitive foraging between *A. florea* and other *Apis* species have been reported in Asia [29, 30], no evidence of competition between *A. florea* and *A. mellifera* has yet been reported in Sudan [15, 31]. However, the population densities of both species were markedly declined in the more northern sampling locations. This also suggests that there may be other factors, besides the argel plant, contribute to this decline.

Other Factors Affecting Honeybees in the North

Besides the deadly plant mentioned, several other factors seem to contribute to such poor distribution of honeybees in northern Sudan. Some of these factors are manmade, while others are natural, and indeed certain adverse environmental conditions can result from human activities. However, such factors affecting honeybees directly or indirectly in the area can be summarized as follows:

► Deforestation

Natural *Acacia* forests present along the River Nile during earlier times especially of *Acacia nilotica* and *A. seyal*, in addition to the indigenous upland trees and shrubs such as "Tundub", *Capparis deciduas*, "Marikh" *Leptadenia pyrotechnica*, "Salam" *Acacia ehrenbergiana* and many others were eradicated gradually for many purposes. They were used as fire wood, house timber, wood for brickyards and charcoals or sometimes removed for increasing agricultural or residential lands.

► Effect of drought and desertification on vegetation cover

Northern Sudan witnessed severe desertification during last centuries, where all natural trees were removed, and rainfalls drastically decreased leading to dryness and bareness of plains and valleys. Hence, large expanses of desert and arid planes occur, and sand encroached to agricultural areas carried by the northerly dry winds (very hot in summer and cold in winter) which prevailing throughout the year. It was reported that Sahara encroachment southwards occurs at about ten kilometers a year in the 1980s [32]. Just considering the past 50 years, it was reported that the levels of rainfalls have decreased

by > 30% in the northern part of the country. Thus, no natural replacement for any removed tree in the area can be occurred. As the vegetation degrades from the semi-desert zone near Khartoum to the desert zone of the northern part, with that very light and irregular rainfalls (0 - 50mm per year), it is only in regions along the river Nile banks where honeybees can survive. But, the further north the more narrow the strip of suitable habitats, both in diversity and abundance. This reduced habitat size may be the further driver of the honeybee population decline northward in Sudan.

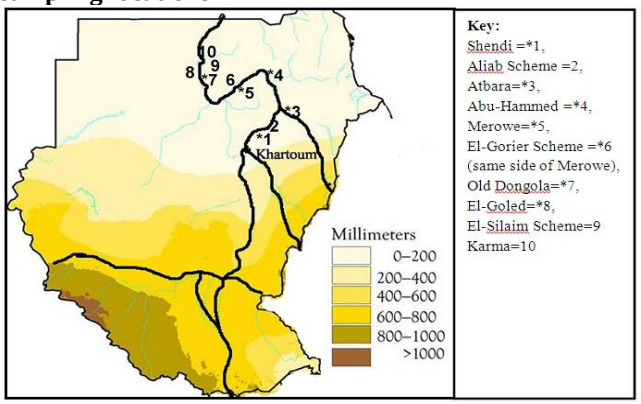
► Effect of desert climate on honeybees

Climatically that part of Sudan, north of latitude 19°N, was classified as a desert region. It shows extreme variations in temperature degrees between summer and winter seasons, and even a large difference between day time and night time temperatures is found. The daily maximum temperature of 24°C in January and 49.9°C in June was recorded. Therefore, summer temperature greatly surpassed the optimum temperature range (31-34°C) for honeybees and their food plants, while winter temperature is far below. Although, honeybees are able to maintain colony temperatures throughout the year, but higher energy is devoted to do so and this is difficult with shortage of food sources as in the case of northern Sudan. Regarding bee survival as affected by climatic variations, Winston (1987) stated that honeybees live only 15-38 days in summer, 30-60 days in fall, and 140 days over winter [33]. Therefore, the behavior and survival of honeybees were found to be significantly influenced by the environmental circumstances in the area of living, especially climatic stresses such as rain, wind and temperature extremes [34, 35].

► Expansion in date palm plantations

Most of the cultivated land in the north was planted with date palms at the expense of other horticultural and field crops. This situation narrowed the floral diversity in the north, and no flowering plants were available as forage sources for honeybees in most time of the year. The short flowering period of date palms which occurs once a year is not fairly enough alone to sustain honeybees in that area.

Figure 1. A map of Sudan shows climate data and the sampling locations



* Asterisk denote occurrence of bees.

Pl 1. A dead bee (*Apis florea*) trapped on flower of *Solenostemma argel* at Abu-Hammed area, Northern Sudan

Table 1.The survey results showing the occurrence of *Apis mellifera* and *Apis florea*, in a quantitative manner, along the Nile River (Northern and River Nile States).

Location	Occurrence	
	Apis mellifera	***Apis florea***
Shendi	**	**
Aliab	*	**
Atbara	**	**
Abu-Hammed	-	*
Merowe	*	*
El-Gorier	*	*
Old Dongola	-	*
El-Goled	-	-
El-Silaim	-	-
Karma	-	-

**=present; * =rare; - absent

Table 2. Population densities of *Apis mellifera* and *Apis florea* based on the genetic structure of colonies.

Location	Poulation density (No. of colonies/ km²)	
	Apis mellifera	***Apis florea***
Shendi	11	23
Atbara	16	39
mean	**(13.50**)**	**(31.00**)**
Abu-Hammed	0	18
Merowe	2	18
Old Dongola	0	1
El-Goled	0	0
El-Silaim	0	0
Karma	0	0
Mean	**(0.33)**	**(6.17)**

** = Highly significant difference.

CONCLUSION

The results suggested that *Solenostemma argel* has considerable contribution, besides the harsh climate and poor vegetation, in limiting the occurrence of honeybees in northern Sudan. Empirical study is needed to confirm the present findings includingthe effectof *S. argel* on the native *Apis mellifera*. Due to the absence of *Apis mellifera*, the northern part can be exploited as isolated area for breeding purposes. However, the current situation in the north is not suitable for beekeeping unless intensive and diversified cropping systems are realized.

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