

## Morphometrical Study on the Sudanese Honeybees

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**Abstract.** Samples of honeybee workers were collected from wild colonies in 50 localities representing 8 provinces in the Sudan. Twenty five workers were randomly selected from each sample for morphometrical studies which included 12 measurements. The presence of highly significant differences between all morphological characteristics indicate the existence of at least two subspecies in the Sudan: a yellow banded group- *Apis mellifera sudanensis* nov subsp and a mixed group *Apis mellifera nubica* Ruttner. *A.m. sudanensis* is the little honeybee distributed all over the Sudan between latitudes 3°N and 16° 20'N while *A.m. nubica* is distributed along the international boundaries of Sudan, Ethiopia and Uganda.

### Introduction

The Sudanese honeybee *Apis mellifera* L. has not been thoroughly examined by earlier workers. According to Ruttner [1], the Sudanese honeybee is very small in size, covered with very short hairs, having the most slender abdomen of all African bees, and the largest area of yellow colouration on abdomen, with a tongue length of 5.36 mm and a wing length of 7.98 mm. He added that the Sudanese honeybee is similar to *littoria*- but clearly belongs to another group. He considered the Sudanese honeybee as an independent race and suggested the name *Apis mellifera nubica* nov. subsp.

El Sarrag [2] stated that the limited number of samples collected from Khartoum Province and described by Ruttner does not perfectly represent the Sudanese honeybee. Moreover, several foreign races of honeybees were introduced to Khartoum Province [3] and honeybees in Khartoum were definitely hybridized with foreign blood [2]. This was ascertained by comparing the data given by El Sarrag [2] on Khartoum bees with those obtained for their hybrids F<sub>1</sub> (Khartoum X unknown drones). Khartoum X Carniolan drones), their backcross reciprocals and their F<sub>2</sub> hybrids. Later on, Ruttner [4] found that *A.m. nubica* is completely scattered among samples of Yemen, Somalia and Chad. Accordingly he cancelled the name *nubica* and came

to the conclusion that this taxon is incorporated into the subspecies *yemenitica* as a Sudanese population.

Fletcher [5] made some correlations between climatic conditions and honeybee distribution in Africa. He found many blank areas on the map and took a guess that either *nubica* or an unknown race may inhabit these areas. Ruttner [4] based on Fletcher's prediction that *A.m. nubica* is now taken as a synonym for *yemenitica* and this prediction is absolutely correct.

El Sarrag [2], Saeed [6], Mohamed [7], Rashad and El Sarrag [8, 9] and Mogga [10] published thorough morphometric surveys of the Sudanese honeybees. All of them detected a high degree of variability.

The present study is an attempt to clarify in a larger context the geographical variability of the Sudanese honeybees.

### Materials and Methods

Wild honeybee workers were collected at the nest entrance from 50 different localities in 8 different provinces in the Sudan (Fig. 1). Localities within each province were at least 25 miles apart and the provinces were separated from each other by 300 to 1000 miles.

Twenty five workers from each locality were randomly selected and killed in boiling water to ensure full extension of the proboscis. Permanent mounts of mouthparts, antennae, wings, hind legs, abdominal tergites and sternites were carried out according to Alpatov [11]. The following measurements were considered: length of proboscis, length of flagellum, length and width of forewing, cubital index, number of hamuli, length and width of basitarsus III, number of hair-rows on the inner surface of basitarsus III, percentage of yellow colouration on the third abdominal tergite, length of the 3<sup>rd</sup> and 4<sup>th</sup> abdominal tergites (T3+4) and the slenderness of the abdomen. All linear measurements were taken with a micrometer eye-piece fixed within a Stereo-Microscope.

Another group of 25 honeybee workers from each sample were killed by chloroform and mounted on setting boards for studying the number and distribution of hairs and colour variations.

The data were statistically analysed using the following nested design:

$$Y_{ijk} = U + P_i + V_{j,i} + e_{ijk}$$

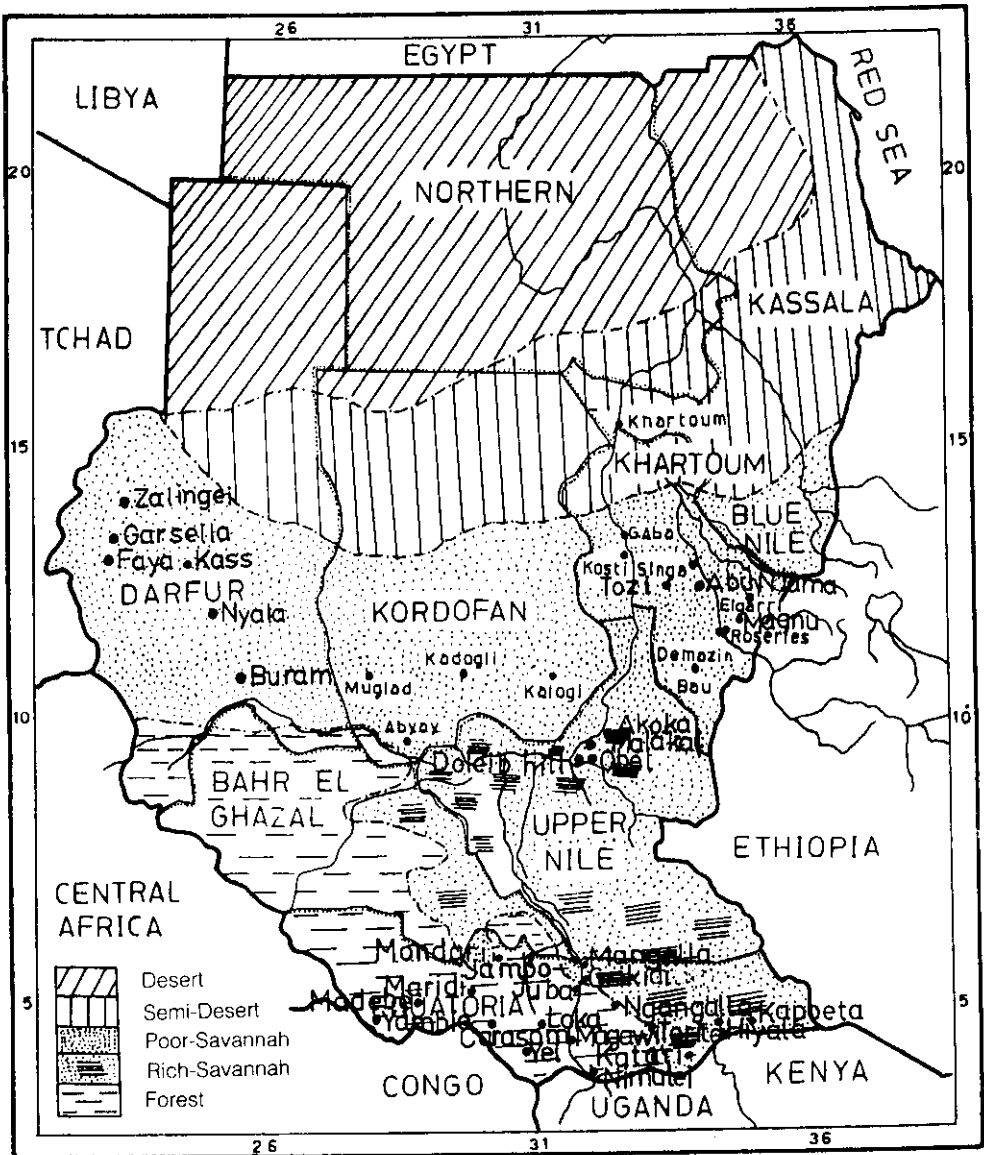


Fig. 1. Map of the Sudan

where:

$Y_{ijk}$  is the  $k$ th observation in the  $j$ th variety nested within the  $i$ th province.  $U$  is the overall mean,  $P_i$  is the effect of  $i$ th province and  $V_{j,i}$  is the effect of  $j$ th variety within the  $i$ th province.  $E_{ijk}$  is the error of the estimate.

## Results and Discussion

### 1- Description of the Sudanese honeybees

#### a) The head

Triangular, flattened dorsoventrally, almost smooth except for some convexities, dark grey to shiny black in colour showing a slightly thick yellow pilosity of long hairs on the vertex and forehead, and short yellowish to greyish hairs on the frons, gena, clypeus and labrum.

Compound eyes elongate, rainiform and dotted with short hairs. Ommatidia shiny dark grey. With 3 ocelli on the two forethirds of head, dome-like, spherical, shiny dark and surrounded by a greyish hairy lid.

Antennae dark grey in colour, 2.40 mm–2.83 mm long with an average of  $2.549 \pm 0.086$  mm (Table 1).

Labrum wider than long; with forepart being convex. Mandibles hard with mean length of 1.21 mm and mean width of 0.528 mm at the base. Tongue length varies between 4.91 mm and 6.00 mm with an average of  $5.375 \pm 0.025$  mm (Table 1). Cardo, stipes, lorum, glossae, submentum and apical portion of galeae pale coloured, mentum and distal portion of galeae light to dark brown.

#### b) The thorax

Dark grey, covered with yellowish long and short hairs, randomly arranged. Pronotum short, mesoscutum large and convex. Scutellum swollen, with a rounded lid. Propodeum full grown and curved.

Wing yellowish to light brown with yellowish veins. Forewing 7.88 mm – 9.07 mm long with an average of  $8.369 \pm 0.034$  mm and 2.72 mm – 3.30 mm wide with an average of  $2.994 \pm 0.015$  mm (Table 1). Cubital index measures 1.85–3.09 with an average of  $2.260 \pm 0.070$  (Table 1). Number of hamuli varies from 19.24–23.36 with an average of  $20.996 \pm 0.329$  (Table 1).

Hairy legs, dark to light brown in colour. Basitarsus III 1.92 mm–2.87 mm long with an average of  $2.116 \pm 0.015$  mm and 0.89 mm–1.50 mm wide with an average of  $1.074 \pm 0.001$  mm (Table 1). Number of hair-rows on inner surface of same varies from 9.52–12.60 with an average of  $11.368 \pm 0.098$  (Table 1). Hair-rows in almost all samples arranged in slightly slanting straight lines, being arranged in an upward curvature in Khartoum honeybee only.

**Table 1.** The average values of measurements taken for the different characters of the Sudanese honeybee workers. (Size of the sample 1250 workers)

Characters	Mean $\pm$ S.E.	F-Test	
		Between provinces	Between samples
Tongue "L" mm	5.375 $\pm$ 0.025	3.98**	3.28**
Tergite 3+4 "L" mm	3.748 $\pm$ 0.025	29.54**	27.25**
Basitarsus III			
L. mm	2.116 $\pm$ 0.015	31.83**	7.43**
W. mm	1.074 $\pm$ 0.001	121.13**	8.44**
Forewing			
L. mm	8.369 $\pm$ 0.034	14.15**	5.15**
W. mm	2.994 $\pm$ 0.015	27.61**	2.45**
Flagellum "L" mm	2.549 $\pm$ 0.086	16.62	7.15**
No. hamuli	20.996 $\pm$ 0.329	16.01**	2.71**
No. hair-rows	11.368 $\pm$ 0.098	34.70**	18.08**
Cubital index	2.260 $\pm$ 0.070	8.27**	11.37**
Slenderness	86.121 $\pm$ 0.713	39.24**	28.84**
% colour T3	70.034 $\pm$ 0.526	24.89**	7.24**

\*\*Highly significant at 1% level.

### c) The abdomen

Tapering apically and conical distally; otherwise spindle-like or petiolate in appearance. First abdominal tergite with short dense hairs, density decreases towards the caudal end. First four abdominal tergites yellow banded, last two tergites almost dark brown to black. First tergite with a dark brown flap-like patch at anterior edge which extends to about one third of the tergite length. This patch intervenes between two sublateral dark patches. Fourth tergite with a small irregular dark area. Depth of the yellow band on the third abdominal tergite ranges between 55.0% and 77.23% with an average of 70.03 $\pm$ 0.526% (Table 1). Intensity of yellow colouration varies from light yellow to dusty, light brown or dull brown. Length of third and fourth abdominal tergites together (T3+4) ranges between 3.47 mm–4.89 mm with

an average of  $4.748 \pm 0.025$  mm (Table 1). Six abdominal sternites with a yellowish ground colour and two faint to light brown spots on the lopsided margins. Wax mirrors oval, with polished surfaces and dark marginal bands. The abdominal slenderness varies between 81.78–94.07 with an average of  $86.12 \pm 0.13$  (Table 1).

## 2- Statistical analysis

Table 1 shows highly significant differences between provinces and samples for all traits. This could be an indication that samples collected from all provinces do not really belong to one and the same group.

When thoroughly examined with the aid of a universal colour catalogue, two types of workers existed; a yellow banded group and a mixed banded group (*i.e.* yellow and black bees are the progeny of the same queen). All honeybee samples of South Kordofan, South Darfur, Upper Nile, Western Equatoria and White Nile Provinces were yellow banded with yellow scutellum in all castes. With the exception of one sample, all honeybees in Eastern Equatoria Province were yellow banded. Samples from Nimulei a city adjacent to the international borders of Uganda were exceptional in having black and yellow bees at the ratio of 1:1.8. In the Blue Nile province which extends to the Ethiopian boundaries, worker bees contained mixed colours, black and yellow at the ratio of 1:2.6, in the drone caste the ratio was reversed to 6.3:1. All castes of bees have black scutellum.

Honeybee workers from Khartoum were yellow banded with yellow scutellum. The drone caste showed great colour variations, but two types of black and yellow drones (0.2:1) could be recognized. In the yellow banded drones, the scutellum had the same yellow colour of the body. It exhibited a black colour surrounded with a yellowish rim in the black drones. The intensity of yellow in Khartoum bees is more or less reddish to brownish yellow.

Measurements taken for the black and the yellow sisters (25 workers each) within a mixed colony showed no significant differences except for the colour of chitin and the hairs covering their abdomen (Table 2) which is either black or yellow according to the colour of individuals. When the entries of the yellow banded colonies were computed and compared with the mixed colonies, very striking results were observed:

- a- Mixed colonies have longer tongues and flagella; longer and wider wings, basitarsus and body size; greater number of hamuli and more abdominal slenderness (Table 3).

**Table 2.** Average values of measurements taken for the mixed colony (*Nimulei*). (Size of the sample 25 workers each)

Characters	Yellow workers	Black workers
	Mean $\pm$ SE	Mean $\pm$ SE
Tongue "L" mm.	5.55 $\pm$ 0.025	5.52 $\pm$ 0.019
Flagellum "L" mm.	2.74 $\pm$ 0.086	2.75 $\pm$ 0.006
Forewing "L" mm.	8.30 $\pm$ 0.034	8.20 $\pm$ 0.014
Forewing "W" mm.	3.00 $\pm$ 0.015	2.90 $\pm$ 0.008
Cubital index	2.50 $\pm$ 0.007	2.50 $\pm$ 0.019
No. hamuli	20.23 $\pm$ 0.032	19.96 $\pm$ 0.009
Basitarsus III "L" mm.	2.10 $\pm$ 0.003	2.11 $\pm$ 0.006
Basitarsus III "W" mm.	1.10 $\pm$ 0.001	1.07 $\pm$ 0.003
No. hair-rows	11.90 $\pm$ 0.015	11.86 $\pm$ 0.014
% colour T3	68.43 $\pm$ 0.052	10.52 $\pm$ 0.003
T3 + 4"L" mm.	3.90 $\pm$ 0.025	3.96 $\pm$ 0.008
Slenderness	89.87 $\pm$ 0.071	88.61 $\pm$ 0.003

b- Yellow banded colonies have larger cubital indices, greater number of hair-rows and higher percentage of abdominal yellow colouration (Table 3).

c- The colour of the scutellum is black in both black and yellow banded sisters of the mixed colonies, being yellow in the yellow banded colonies.

It can be concluded therefore, that at least two independent subspecies exist in the Sudan; a yellow banded subspecies distributed mainly in the Sudan between latitudes 3°N and 16°20', and a mixed subspecies which is abundant along the international boundaries of the Sudan with Ethiopia and Uganda. The name *Apis mellifera sudanensis* nov. subsp is suggested for the former, while the latter remains as it is (*Apis mellifera nubica*) as suggested by Ruttner [1].

Later on, Mogga [10] confirmed these results by using PCA. Three clusters were graphically detected which were geographically correlated. The smallest measurements originated in semi-desert clusters, medium measurements in rich savannah and forest clusters and the largest measurements in border population.

**Table 3.** Average values of measurements taken for the different characters of the yellow and mixed honeybee samples of the Sudan.

Characters	Yellow bees <sup>1</sup>	Mixed bees <sup>2</sup>
	Mean ± SE	Mean ± SE
Tongue "L" mm.	5.359±0.021	5.485±0.022
Flagellum "L" mm.	2.526±0.011	2.715±0.010
Forewing "L" mm.	8.337±0.025	8.605±0.022
Forewing "W" mm.	2.971±0.030	3.163±0.014
Cubital index	2.269±0.061	2.195±0.073
No. hamuli	20.969±0.275	21.193±0.167
Basitarsus "L" mm.	2.108±0.013	2.175±0.012
Basitarsus "W" mm.	1.071±0.009	1.100±0.008
No. hair-rows	11.480±0.081	10.547±0.093
% colour T3	71.261±0.860	61.038±1.637
T3 + 4 mm.	3.738±0.018	3.825±0.016
Slenderness	85.738±0.780	88.927±0.623

<sup>1</sup> Size of the sample 1100 workers.

<sup>2</sup> Size of the sample 150 workers.

### References

- [1] Ruttner, F. "African Races of Honeybees," *xvth. Int. Apic. Congr. Apimon.* (1975), 325-344.
- [2] El Sarrag, M.S.A. "Morphometrical and Biological Studies on Sudanese Honeybees *Apis mellifera* L. (*Hymenoptera, Apidae*)." *Ph.D. Thesis, Faculty of Agric., Cairo Univ., A.R.E.* (1977).
- [3] Rashad, S. and El Sarrag, M.S.A. "Beekeeping in Sudan." *Bee World*, 59 No. 3 (1978), 105-111.
- [4] Ruttner, F. *Biogeography and Taxonomy of Honeybees*, Berlin, Heidelberg, New York: Springer Verlag, 1988.
- [5] Fletcher, D.J.C. "The African Bee *Apis mellifera adansonii*, in Africa". *Ann. Rev. Entomol.* 23 (1982), 151-171.
- [6] Saeed, A.A. "Morphometrical Studies on Honeybees (*Apis mellifera* L., *Apidae, Hymenoptera*) in Eastern, Western and Central Sudan." *M.Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan* (1981).
- [7] Mohamed, M.A.H. "Morphometrical Studies on Honeybees in the Southern Sudan (Eastern and Western Equatoria Provinces). *M.Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan* (1982).
- [8] Rashad, S.E. and El Sarrag, M.S.A. "Some Characters of the Sudanese Honeybee *Apis mellifera* L." *2nd Int. Conf. Apic Trop. Climate*, New Delhi (1980), 301-309.

- [9] ———, Beekeeping in Sudan. "Two Morphometrical Studies on the Sudanese Honeybees." Unpublished manuscript (IBRA), Cardiff, UK (1984).
- [10] Mogga, J.B. "The Taxonomy and Geographical Variability of the Honeybee *Apis mellifera* L. in Sudan." *M.Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan* (1988).
- [11] Alpatov, W.W. "Biometrical Studies on Variation and Races of the Honeybee (*Apis mellifera* L.)." *Quart. Rev. Biol.*, 4 No. 1 (1929), 1-58.

## دراسة مورفومترية عن النحل السوداني

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ملخص البحث. تم جمع عينات النحل من خمسين منطقة بالسودان ممثلة لثاني محافظات مختلفة أجريت عليها دراسة مورفومترية مقارنة للتعرف على نوع السلالات السودانية من خلال اثنتي عشرة صفة.

أظهرت الدراسات الخصائص المورفومترية التالية في النحل السوداني: طول اللسان  $5,375 \pm$   
 $0,25$  - طول سوط قرن الاستشعار  $2,049 \pm 0,86$  مم، طول الجناح الأمامي  $8,369 \pm$   
 $0,034$  مم - عرض الجناح الأمامي  $2,994 \pm 0,15$  مم - طول وعرض عقلة الرسغ الأولى في الرجل  
الخلفية  $2,116 \pm 0,15$  مم،  $1,074 \pm 0,01$  مم مجموع طول حلقتي البطن الثالثة والرابعة  
 $3,748 \pm 0,25$  مم - عدد الخطاطيف بالجناح الخلفي  $20,996 \pm 0,329$  - عدد صفوف  
الشعيرات الداخلية لعقلة الرسغ الأولى في الرجل الخلفية  $11,368 \pm 0,98$  - معامل الجناح  $2,260$   
 $0,7$  - درجة تقوس البطن  $86,121 \pm 7,13$ ، والنسبة المئوية للون الأصفر على الصفيحة الظهرية الثالثة  
للبن  $70,034 \pm 0,526$  %.

ومن نتائج التحليل الإحصائي تبين أن هناك اختلافات معنوية في الصفات بين العينات داخل المحافظة الواحدة وبين عينات المحافظات المختلفة وأن جميع العينات لا تنتمي إلى النوع التقسيمي نفسه.

وكتيجة لتحليل إحصائي للعينات المتماثلة اتضح وجود سلالتين على الأقل من النحل السوداني وقد اقترح الأسم *Apis mellifera sudanensis* subsp. nov. للأولى وهي سلالة صفراء اللون، صغيرة الحجم ذات معامل جناح كبير وعدد أكبر من شعيرات الجسم. صفيحة الاسكيوتلم صفراء اللون وهي تنتشر في السودان بين خطي عرض  $3^\circ$ ،  $20^\circ$ ،  $16^\circ$  شمالاً، واقترح الأسم *Apis mellifera nubica* Rut. للثانية وهي سلالة مختلطة اللون بعض أفرادها سوداء والبعض الآخر صفراء صفيحة الاسكيوتلم سوداء اللون في جميع الأفراد المختلطة ذات طول نسبي في اللسان وقرون الاستشعار، أجنحتها طويلة وعريضة وذات جسم أكبر مقارنة بالسلالة *A.m. sudanensis*. تنتشر هذه السلالة في المناطق الحدودية بين السودان وأثيوبيا وأوغندا.