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MORPHOMETRIC CHARACTERISTICS OF BEES *APIS MELLIFERA* ADANSONII IN BENIN

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RESUME

La détermination précise des différentes races d'abeilles mellifères et de leurs hybrides est essentielle dans un programme de sélection moderne. Contrairement aux races européennes dont les caractéristiques et la répartition géographique sont connues avec précision, l'étude de la morphologie des races d'abeilles mellifères d'Afrique est à peine ébauchée. L'objectif de l'étude était de déterminer les différents morphotypes d'abeilles du Bénin indispensable à la description des morphotypes. A cet effet, 100 à 300 abeilles ont été collectées par localité et par ruche. Les échantillons étaient issus de 30 localités (colonies) appartenant à huit phytodistricts et aux trois zones climatiques du Bénin. Dans chaque localité, 100 abeilles ont été mesurées (sauf sur le site de Yarakéou où 60 abeilles ont été mesurées). Au total, 14 caractères morphométriques ont été mesurés sur chaque abeille à l'aide d'un microscope muni d'oculaires gradués. La classification hiérarchique ascendante des abeilles a été réalisée au niveau des individus d'abeilles sur la base d'une matrice de 2.960 lignes représentant les abeilles et de 14 colonnes représentant les 14 caractères morphométriques. Une analyse factorielle discriminante a été faite avec le logiciel SAS v9.2 sur ces morphotypes afin d'analyser leurs caractéristiques morphométriques. Les résultats obtenus ont montré l'existence de 10 morphotypes avec un coefficient de détermination (R^2) de 59,8 %, et chaque morphotype avait ses spécificités. Ainsi, une diversité d'abeilles mellifères existe au Bénin. Par conséquent, des prises de mesures s'imposent afin de sauvegarder ces importants pollinisateurs que constituent les abeilles mellifères.

Mots clés : Abeilles mellifères, morphotypes, diversité, spécificité, Bénin.

ABSTRACT

The precise determination of the different races of honeybees and their hybrids is essential in a modern breeding program. Unlike the European races whose characteristics and geographical distribution are known with precision, the morphometry of the honeybee races of Africa is hardly outlined. The objective of our study was to determine the different morphotypes of honeybees in Benin and to describe the characteristics of each morphotype. To this end, 100 to 300 bees were collected by locality and hive. The samples are from 30 localities (colonies) belonging to eight phytodistricts and the three climatic zones of Benin. In each locality, 100 bees were measured (except the site of Yarakéou where 60 bees were measured). Thus, 14 morphometric characteristics were measured per bee using a microscope equipped with graduated eyepieces. The ascending hierarchical classification of the bees was done at the level of individual bees on the basis of a matrix of 2.960 lines representing the bees and of 14 columns representing the 14 morphometric characteristics. A discriminant factorial analysis was then done on these morphotypes using the software SAS v9.2 in order to analyze their morphometric characteristics. The results obtained revealed the existence of 10 morphotypes with a coefficient of determination (R^2) of 59.8 %, and each morphotype had its morphometric specificities. So, a diversity of honeybees exists in Benin. It is therefore important to take some measures to safeguard these important pollinators that honeybees are.

Keys words: Honeybees, morphotypes, diversity, specificity, Benin.

INTRODUCTION

The community of pollinators, in particular that of bees, is important for agriculture and plant conservation. Pollinators' contribution worldwide is annually estimated to be 117 billion dollars (Costanza *et al*., 1997). A French-German study estimated at 153 billion euros the share of food production in 2005 actually attributable to insects, i.e. 9.5% of the value of agricultural production worldwide for that year (Gallai *et al*., 2009). Bees, *Apis mellifera* (Hymenoptera: Apidae), are the pollinators whose economic importance is the highest worldwide (Johnson, 2007).

Beekeeping is not only important for wild and cultivated plant pollination, but also for beekeeping products such as honey, pollen, wax, propolis, royal jelly, etc. (Imdorf *et al*. 2010). In the Northwest of Cameroun, beekeeping profitability is estimated to be 50% (Tassei, 1996). Beekeepers in the Central African Republic harvest on average per year 12 liters per hive (Mbétid-Bessane, 2004). Beekeepers of Manigri in Central Benin harvest annually 11.2 ± 3.7 liters of honey per hive (Yédomonhan and Akoègninou, 2009). Thus, compared to other countries, the economic performances of honey production and in particular of beekeeping are very low in Benin (Paraïso *et al.,* 2012). In Northwest Benin, honey production meets food and economic needs of the population (Paraïso *et al.,* 2013). However, the lack of final market for honey and the high price of modern beekeeping equipment are the major constraints related to honey production that hamper the development of modern beekeeping (Paraïso *et al.,* 2013. In Benin, the national agricultural policy does not give enough attention to honey production (Paraïso *et al.,* 2012). However, this production contributes to the revenue of households and diversifies agricultural sectors.

There is a relationship between honeybees and agriculture, the environment, food, nutrition, medicine, cosmetics, industry, etc. Unlike European honeybee races whose characteristics and geographic distribution are known with precision, the morphometry and the exact limits of the regions occupied by the different races of bees in Africa are yet not known (Gadbin *et al*., 1979). Benin has enormous beekeeping potentialities (Paraïso *et al*., 2011) but very few studies have covered the morphometry of bees. Latreille (1804), described *Apis mellifera* adansonii as one sub-species of bees for all West and Central Africa. Likewise, Hounkpè *et al.,* (2007) indicated the existence of *Apis mellifera* adansonii as the sub-species of honeybees existing in Central and Northern Benin. However, studies carried out in the commune of Djidja in Southern Benin, show the existence of three distinct groups of bees (Amakpé, 2010). Moreover, Viniwanou (2009) and Paraïso *et al*., (2011) have identified three groups of bees with very distinct morphometric characteristics in the hives of three neighboring communes in North-East Benin. Thus, presently, no study has specified the different groups of bees found throughout Benin territory. The twofold objective of the study was to determine the morphotypes of honeybees in Benin and to describe their characteristics indispensable to differentiate the different groups of honeybees existing in Benin. Based on the works of the abovementioned authors (Viniwanou, 2009; Amakpé, 2010; Paraïso *et al*., 2011), we hypothesize that the study of bees in Benin will lead to a multitude of morphotypes of honeybees with distinct morphometric characteristics in Benin.

MATERIALS AND METHODES

Study zones

The samples of honeybees were collected from 42 beekeepers located in 30 localities belonging to height phytodistricts in the three climatic zones of the Republic of Benin (Figure 1). The Republic of Benin is limited in the North by the Republics of Niger and Burkina Faso, in the South by the Atlantic Ocean, in the West by the Republic of Togo and in the East by the Republic of Nigeria (MEPN, 2009). It is located between the parallels 6°15' and 12°25' of latitude North and 0° 40' and 3° 45' of longitude East, and covers a surface area of 112,622 km^2 (Tossou *et al*., 2011).

Sampling of bees

Depending on the availability of the biological material and the willingness of the beekeepers, the 100 to 300 samples of bees were collected per locality and per hive. The laths containing the broods on which young bees hang (Toullec, 2008), were removed and shook into a plastic pot covered automatically with fine grid of 0.05 mm diameter. Bees collected were killed using ether and conserved in ethanol at 70%.

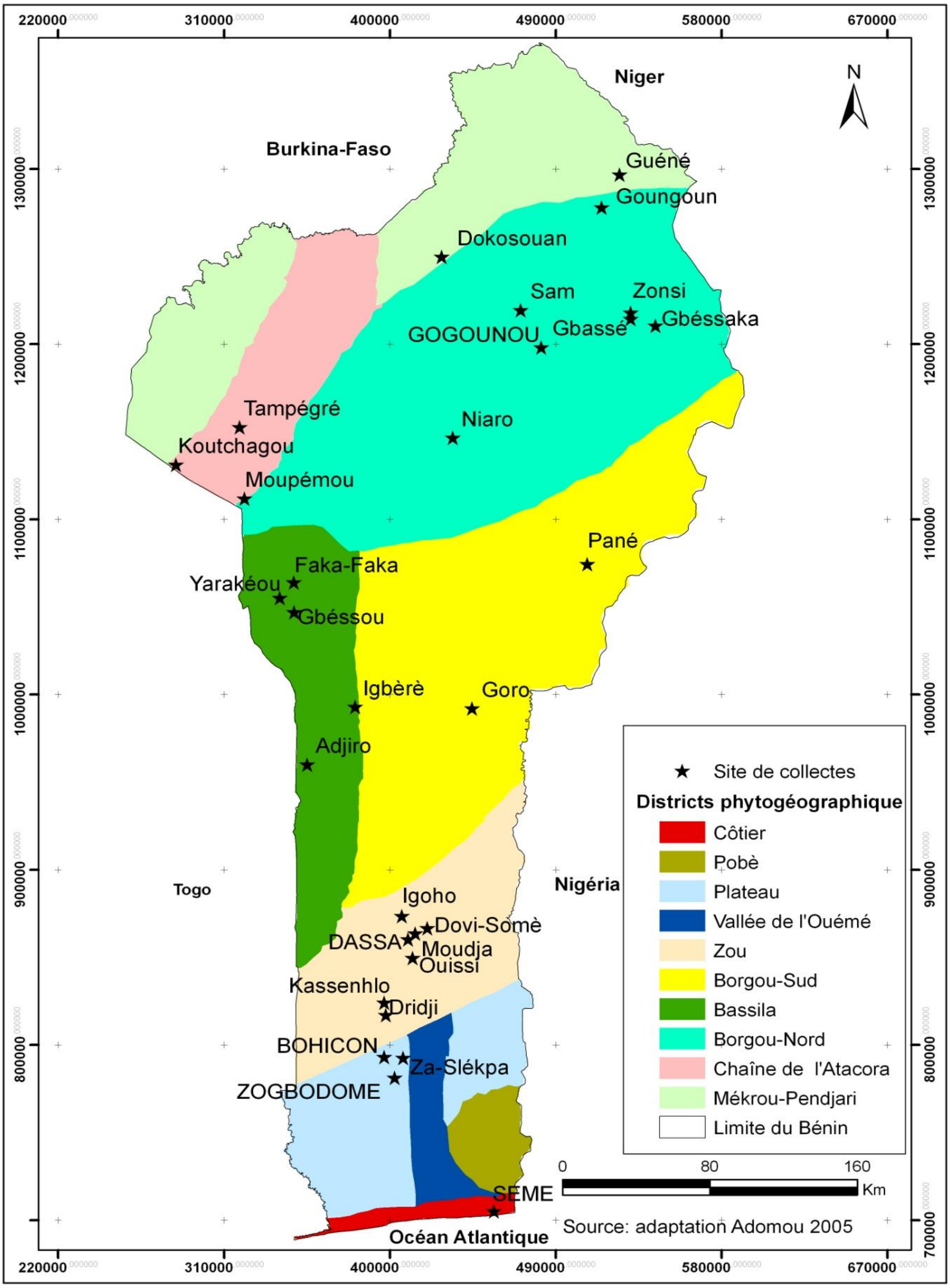

Figure 2. The 30 sites of honeybees' sample collection in Benin

Data collection

The 100 honeybees of each locality were counted and measured following 14 morphometric characteristics, except the locality of Yarakéou were only 60 honeybees were measured because of the non-availability of the animal material. Measures were taken on 2960 workers (Fresnaye, 1965) because haploid males are not representative in a bee population (Toullec, 2008). These measures were taken using a microscope equipped with graduated eyepiece, at 10 to 20 times magnification (Fresnaye, 1965; Boudegga, 2006; Toullec, 2008). Measures taken on each honeybee included the following:

The length of the bee was measured by putting the bee on the abdominal side on graph paper and using a microscope at 10 times magnification.

The length and the width of fore and hind wings: the bee was put on a white paper and the right (fore and hind) wings were cut at the base. These wings were then spread delicately and stuck using transparent scotch on a printing paper. Each wing was numbered and labelled with its locality. Using the microscope equipped with graduated eyepiece, the measures were taken at 20 times magnification (Fresnay, 1965; Cornuet *et al*., 1975; Toullec, 2008).

The length of the tongue: the head of the honeybee was cut and pined on a soft stand (cork). Before taking the measure, a slight traction was done using fine tweezers to maintain the head straight. The measures were taken using a microscope equipped with graduated eyepiece at 10 times magnification (Fresnay, 1965; Cornuet *et al*., 1975; Boudegga, 2006).

The width of the tomentum on the fourth abdominal tergite: the observation was done where the felted stripe of the 4th tergite is the widest (on the side rather than on the center). The body of the honeybee was stretched using a fine clip or tweezers and the part of the tergite under the 3rd segment was displayed (Cornuet *et al*., 1975; Boudegga, 2006). The measure was taken using the microscope equipped with graduated eyepiece at 10 times magnification.

The width of the hairy zone of the 5th abdominal tergite: The body of the bee was stretched using a fine clip then the measure was taken using the microscope equipped with graduated eyepiece at 10 times magnification.

Cubital ribs A and B which ratio A/B gives the cubital index: Two rib segments, A and B, were measured on the third cubital cell. The cubital index is the ratio A/B (Toullec, 2008).

The length of the radial cell: the radial cell is the most elongated and located above the other cells towards the right end of the wing. Using the graduated microscope at 20 times magnification, the length from the left end of the cell to the right end was measured.

The distance between the radial cell and the discoidal point: The segment (h) perpendicular to the radial cell and going through the joint point (H) was traced. The distance between the radial cell and the level of the discoidal point is on this segment. It is marked by the orange arrow on Figure 2. The measures were read and taken.

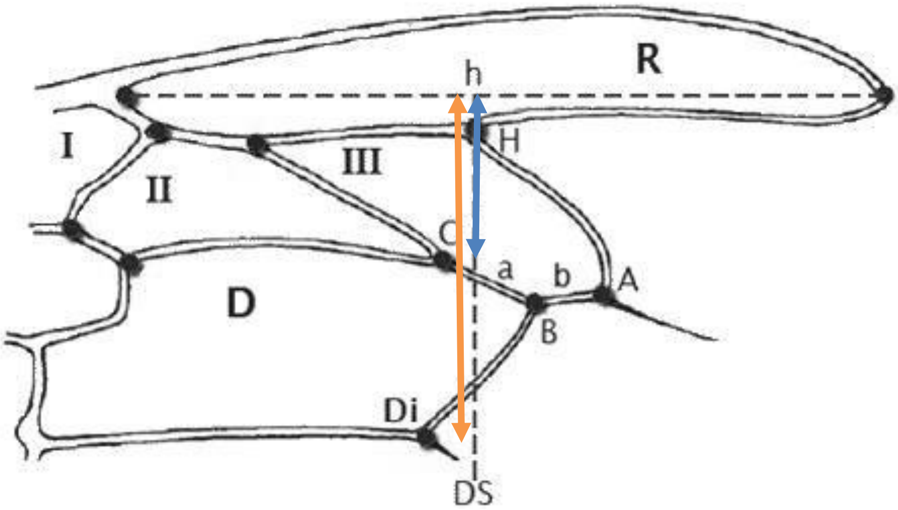

Figure 2. Measure on the fore wing of the bee.

Source: Toullec (2008)

The distance between the radial cell and the left end of rib A: A segment (DS) perpendicular to the radial cell (h) and going through the junction point (H) was traced. The distance between the radial cell and the left end of rib A (noted exceptionally a on Figure 2) is shown by the blue arrow on Figure 2.

The discoidal transgression: the position of the discoidal point (noted Di on Figure 2) was used to determine the discoidal transgression. When the discoidal point is on the right of the segment (DS), towards the end of the wing, the transgression is positive; when it is on the left of the segment (DS), towards the base of the wings, it is negative; when the segment (DS) goes through exactly on the discoidal point, the transgression is nil. The measures were taken using a microscope equipped with graduated eyepiece at 20 times magnification.

The angle of lag of the discoidal point: With the microscope at 20 times magnification and the protractor, the junction point (H) was considered as the summit. The segment (DS) was merged with the main axis of the protractor. The lag of the discoidal point with the main axis of the protractor gives the angle of lag of the discoidal point.

All measures were in mm except the cubital index which is dimensionless and the angle of lag of the discoidal point which is in degree (°).

Statistical analyses

The ascending hierarchical classification of honeybees was done at the level of the 2,960 individual honeybees. The number of representative morphotypes was determined based on the value of the coefficient of determination (R^2). The considered threshold is 50% (Glèlè Kakaï *et al*., 2006). Then, the proportion of each locality in each morphotype was calculated in order to analyze the heterogeneity based on the origin of each morphotype thus obtained. Then a discriminant factorial analysis (DFA) was done on these morphotypes in order to analyze their morphometric characteristics. Finally, the means and the coefficients of variation of the parameters were calculated for each morphotype in order to facilitate the analysis of the results. The analyses were done using the software SAS v9.2.

RESULTS

The ascending hierarchical classification of the 2.960 honeybees measured on the basis of the 14 morphometric characteristics identified 10 morphotypes or groups of honeybees that are morphologically distinct with a coefficient of determination (R^2) of 59.8%. The analysis of the composition of each morphotype in terms of origin of the bees (Table 1) revealed that except the morphotypes C3 (31.26% from Gbèssou and 42.30% from Igbèrè), C4 (100% from Yarakéou) and C10 (94.19% from Adjiro and 5.81% from Yarakéou) which had had a relatively specific composition because largely dominated by one or two origins, most of the morphotypes formed were a quite heterogeneous mixture of different localities. The morphotype C3 was thus the morphotype of honeybees from Gbèssou and Igbèrè, the morphotype C4 was that of the honeybees from Yarakéou and the morphotype C10, that of the honeybees from Adjiro. The results of the discriminant factorial analyses done on the ten morphotypes indicated a significant difference (Wilks' Lambda = 0.011; $P < 0.0001$) between the morphotypes. The same results revealed that, the first three axes are highly significant ($P<0.001$) and explained alone 81.47% of the information related to the different morphotypes.

Table 1. Representation level of the different localities per morphotype obtained.

Localities of origin	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Adjiro	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**94.19**
CBDIBA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	2.26	0.00
Dassa	0.61	4.10	0.00	0.00	0.44	1.11	**13.06**	4.78	1.51	0.00
Dokossouan	0.81	3.21	0.00	0.00	5.81	5.99	2.52	3.57	5.53	0.00
Dovi-Somè	0.00	5.51	0.00	0.00	4.65	9.76	0.38	0.74	3.02	0.00
Dridji	0.00	5.28	0.00	0.00	4.07	2.66	5.30	8.46	0.00	0.00
Faka-Faka	**34.26**	0.00	5.44	0.00	0.29	0.42	0.00	0.00	2.00	0.00
Gbassè	0.40	2.75	0.00	0.00	7.56	2.66	4.17	5.92	2.76	0.00
Gbèssou	**16.53**	0.00	**31.26**	0.00	0.58	0.00	0.00	0.00	1.26	0.00
Gbéssaka	0.00	3.75	0.00	0.00	7.56	7.76	2.46	1.10	2.76	0.00
Gogounou	0.00	1.61	0.00	0.00	5.23	1.77	3.03	**19.65**	0.75	0.00
Goro	0.40	**13.55**	0.00	0.00	1.16	3.10	3.22	1.84	3.27	0.00
Goungoun	0.00	2.06	0.00	0.00	8.43	3.46	2.46	**11.93**	2.01	0.00
Guéné	0.00	0.89	0.00	0.00	**10.17**	8.87	1.52	0.77	3.27	0.00
Igbèrè	8.07	0.00	**42.30**	0.00	0.00	0.00	0.19	0.00	0.75	0.00
Igoho	0.00	6.42	0.00	0.00	1.63	3.99	9.39	3.31	0.50	0.00
Kassenhlo	0.00	3.90	0.00	0.00	2.91	2.66	7.20	7.92	0.25	0.00
Koutchagou	2.44	0.92	7.76	0.00	0.87	2.32	0.95	1.10	**12.81**	0.00
Moudja	0.00	4.36	0.00	0.00	6.69	8.20	4.46	1.84	0.75	0.00
Moupemou	6.86	1.84	1.63	0.00	0.87	1.77	0.38	2.47	**13.82**	0.00
Niaro	4.84	1.38	2.72	0.00	0.29	2.66	1.89	1.74	**13.07**	0.00
Ouissi	0.40	5.73	0.00	0.00	6.40	5.99	3.03	2.57	0.80	0.00
Pane	2.21	9.40	0.54	0.00	1.16	1.33	5.30	4.04	1.51	0.00
Sam	0.40	0.46	0.00	0.00	4.94	**10.87**	0.69	0.00	7.50	0.00
Sèmè	0.00	1.84	0.00	0.00	0.29	0.22	**14.21**	5.52	0.00	0.00
Tempégré	8.47	0.66	1.29	0.00	5.49	1.33	0.57	0.74	13.07	0.00
Yarakéou	**12.10**	0.00	7.07	**100.00**	0.00	0.00	0.00	0.00	0.00	5.81
Za-Slékpa	0.00	5.96	0.00	0.00	2.62	5.54	5.30	4.04	0.50	0.00
Zogbodomè	1.21	**12.16**	0.00	0.00	2.91	1.77	3.60	1.10	1.01	0.00
Zonsi	0.00	2.29	0.00	0.00	6.98	3.77	4.74	4.78	3.26	0.00

The correlations between the canonical axes and the morphometric variables of honeybees (Table 2) revealed that the length of the honeybee, the width of the tomentum, the width of the hairy zone of the 5th abdominal tergite and the angle of lag of the discoidal point were positively and highly correlated with the first axis while the length of the tongue, the width of the hind wing and the cubital index were negatively and highly correlated with this axis. The first axis was an axis of the size and wing characteristics. The variables: width of the fore wing, width of the hind wing as well as the distance between the radial cell and the discoidal point and the distance between the radial cell and the left end of rib A, were positively and well correlated with the second axis which was the axis of the characteristics of the fore wing. The third axis was the axis of the discoidal transgression. Thus, axis 1 revealed that the longest honeybees often had a large tomentum, a large hairy zone of the 5th abdominal tergite and a wider angle of lag of the discoidal point but a short tongue, a low cubital index and a narrow hind wing. Axis 2 showed that honeybees that had a large fore wing often had also long hind winds and long distance between the radial cell and the discoidal point on the one hand and between the radial cell and the left end of rib A on the other hand. Axis 3 has shown that honeybees had a positive discoidal transgression.

Table 2. Correlation between the morphometric variables of honeybees and the discriminant axes

Variables	Can1 (47.16 %)	Can2 (23.11 %)	Can3 (11.16 %)
Length of the bee	**.**	-0.133	0.0894
Length of the tongue	**-0.980**	0.075	-0.1244
Width of the tomentum	**0.943**	-0.162	0.1822
Width of the hairy zone of the 5th abdominal tergite	**0.925**	-0.253	0.1901
Length of the fore wing	-0.081	0.234	0.0668
Width of the fore wing	-0.334	**0.502**	-0.0101
Length of the hind wing	-0.056	**0.501**	0.0440
Width of the hind wing	**-0.639**	0.170	0.0342
Cubital index	**-0.723**	0.257	0.3074
Length of the radial cell	-0.175	0.096	0.1845
Distance between the radial cell and the discoidal point	0.166	**0.788**	0.0710
Distance between the radial cell and the left end of rib A	0.235	**0.959**	-0.1081
Discoïdale transgression	-0.273	0.044	**0.9058**
Angle of lag of the discoidal point	**0.826**	0.035	-0.0557

The analysis of the scores of each morphotype of honeybees on each of the canonical axes (Table 3) revealed that the morphotypes 10, 1, 3 and 4 have presented successively the highest scores because higher than the mean on axis 1. Thus, honeybees of these morphotypes, namely those of morphotype 10, were long and had a large tomentum and a large hairy zone of the 5^{th} abdominal tergite, a wide angle of lag of the discoidal point but had a short tongue and short hind wing as well as a low cubital index. Bees of the morphotypes 4 and 10 were again those best represented on axis 2 with respectively negative and positive scores. Therefore, honeybees of the morphotype 4 had the shortest hind wings, the narrowest fore wings as well as the shortest distances between the radial cell and the discoidal point on the one hand and between the radial point and the left end of rib A, on the other hand. Honey bees of the morphotype 10 presented exactly the opposite characteristics to those described for the morphotype 4 on axis 2. Bees of the morphotype 2 present a good negative score on axis 3 while honey bees of the morphotypes 4, 5 and 8 presented positives scores on axis 3. This means that honeybees of the morphotype 2 had had a negative discoidal transgression while honeybees of the morphotypes 4, 5 and 8 had recorded a positive discoidal transgression.

Table 3. Representation of each morphotype of honeybees on each of the canonical axes

Morphotypes	Can1	Can2	Can3
Morphotype 1	**3.645**	-0.785	0.601
Morphotype 2	-0.839	0.166	**-1.036**
Morphotype 3	**3.681**	-1.421	-0.299
Morphotype 4	**2.360**	**-13.408**	**2.132**
Morphotype 5	-1.568	0.326	**1.342**
Morphotype 6	-1.035	0.170	-0.706
Morphotype 7	-0.987	-0.004	-0.604
Morphotype 8	-1.539	0.364	**1.935**
Morphotype 9	0.577	-0.556	-0.115
Morphotype 10	**5.509**	**5.584**	0.295
m	***2.174***	***2.278***	***0.907***
sd	***0.510***	***1.343***	***0.220***

m=mean; sd=standard deviation

The means (m) were determined based on the distances between the morphotypes and the axes.

Moreover, the test of discrimination by the distance of Mahalanobis (Table 4) revealed very highly significant distances ($p<0.0001$) between all the morphotypes of honeybees. The most distant morphotypes of honeybees were the morphotype 10 and the morphotype 7, the morphotype 10 and the morphotype 5, and the morphotype 10 and the morphotype 8. On the other hand, the closest morphotypes of honeybees were the morphotype 7 and the morphotype 2, then the morphotype 6 and the morphotype 2.

Table 4. Test of discrimination by the distance of Mahalanobis

Morphotypes	1	2	3	4	5	6	7	8	9	10
1	0.00ns									
2	288.10***	0.00ns								
3	66.81***	255.13***	0.00ns							
4	219.73***	244.83***	211.88***	0.00ns						
5	315.44***	105.63***	328.83***	246.33***	0.00ns					
6	308.53***	**25.84*** **	285.93***	241.26***	69.92***	0.00ns				
7	309.72***	**21.98*** **	263.74***	245.29***	90.81***	40.08***	0.00ns			
8	309.68***	123.09***	293.29***	247.65***	39.27***	124.54***	99.11***	0.00ns		
9	124.43***	88.64***	152.58***	229.55***	110.74***	72.76***	91.39***	154.97***	0.00ns	
10	245.75***	390.53***	270.43***	321.05***	**414.25*** **	396.55***	**422.50*** **	**403.39*** **	356.01***	0.00ns

Prob > Mahalanobis Distance for Squared Distance to Cluster
ns: non-significant, * significant at 0.05; **significant at 0.01; *** significant at 0.001

Table 5 came to complete previous analyses and presented the means and the coefficients of variation of the 14 morphometric characteristics depending on the morphotypes. Therefore, the morphometric specificities of each morphotype of honeybees could be deducted as follows**:**

- *Morphotype 1*: the honeybees of the morphotype 1 were characterized by the largest tomentum (0.72 mm±30.66%) and the largest hairy zone of the 5th abdominal tergite (0.75 mm±31.33%);
- *Morphotype 2*: the honeybees of the morphotype 2 had the longest tongue (7.53 mm±6.90%); the smallest tomentum (0.15 mm±54.50%), the narrowest hairy zone of the 5th abdominal tergite (0.16 mm±52.50%);
- *Morphotype 3*: the honeybees of the morphotype 3 had the narrowest hind wing (1.65 mm±8.18%) and the shortest distance between the radial cell and the discoidal point (1.73 mm±5.13%);
- *Morphotype 4*: the honeybees of the morphotype 4 have been the longest (12.3 mm±7.07%) with the shortest tongue (4.83 mm±14.17%), the narrowest fore wing (2.88 mm±3.96%), the shortest hind wing (5.55 mm±6.88%), the lowest cubital index (1.55±5.76%), the shortest radial cell (3.05±1.71%) and the shortest distance between the radial cell and the left end of rib A (0.11 mm±7.75%);

– *Morphotype 5*: the honeybees of the morphotype 5 had the longest fore wing (8.74 mm±2.53%), the longest hind wing (5.90 mm±3.10%), the largest hind wing (1.78 mm±3.52%), the longest radial cell (3.19 mm±2.07%) and the narrowest angle of lag of the discoidal point (0.89°±141.76%);
– *Morphotype 6*: the honeybees of the morphotype 6 were characterized by the smallest tomentum (0.15 mm±55.65%); the shorted hairy zone of the 5th abdominal tergite (0.16 mm±53.35%) and the largest fore wing (3.00 mm±1.04%);
– *Morphotype 7*: the honeybees of the morphotype 7 had the shortest fore wing (8.39 mm±3.39%);
– *Morphotype 8*: the honeybees of the morphotype 8 were the shortest (10.4 mm±9.50%), with the longest tongue (7.53 mm±6.38%) and the highest cubital index (2.68±25.36%);
– *Morphotype 9*: the honeybees of the morphotype 9 had the longest hind wing (5.90 mm±3.51%),
– *Morphotype 10*: the honey bees of the morphotype 10 had the largest fore wing (3.00 mm±4.70%), the longest distance between the radial cell and the discoidal point (2.06 mm±5.60%), the longest distance between the radial cell and the left end of rib A (1.19 mm±11.65%) and the widest angle of lag of the discoidal point (5.23°±6.78%).

Our results have also shown that the honeybees of the morphotypes 4, 5 and 8 had a positive discoidal transgression and those of the other morphotypes a negative discoidal transgression.

Table 5. Variations of the fourteen morphometric characteristics of honeybees depending on the morphotypes: mean (m) and coefficient of variation (cv).

Morphotypes		Lng_ab	Lng_lang	lar_tom	BF5TA	Lng_ailant	lar_ailant	Lng_ailpost	lar_ailpost	a/b	Lng_celrad	D	X	Pos_pd	Agdecal_pd
C1	m	1.22	5.71	0.72	0.75	8.50	2.98	5.85	1.74	2.13	3.11	1.79	0.89	-0.34	2.68
	cv(%)	*9.85*	*17.13*	*30.66*	*31.33*	*3.75*	*2.49*	*3.84*	*5.12*	*15.80*	*3.07*	*2.48*	*7.92*	*-237.65*	*74.87*
C2	m	1.05	7.53	0.15	0.16	8.52	2.99	5.81	1.75	2.20	3.06	1.80	0.90	-0.78	2.01
	cv(%)	*9.12*	*6.90*	*54.50*	*52.50*	*3.25*	*1.21*	*3.32*	*3.83*	*14.75*	*2.80*	*1.12*	*3.43*	*-59.18*	*68.87*
C3	m	1.21	5.23	0.57	0.57	8.40	2.90	5.66	1.65	2.04	3.08	1.73	0.86	-0.72	5.02
	cv(%)	*10.12*	*11.23*	*41.51*	*44.27*	*3.96*	*4.23*	*5.57*	*8.18*	*13.87*	*2.67*	*5.13*	*9.69*	*-88.22*	*58.39*
C4	m	1.23	4.83	0.55	0.74	8.50	2.88	5.55	1.73	1.55	3.05	1.78	0.11	-0.50	4.45
	cv(%)	*7.07*	*14.17*	*37.58*	*47.95*	*2.61*	*3.96*	*6.88*	*5.02*	*5.76*	*1.71*	*2.55*	*7.75*	*-180.91*	*19.56*
C5	m	1.08	7.52	0.19	0.18	8.74	2.98	5.90	1.78	2.44	3.19	1.81	0.88	0.30	0.89
	cv(%)	*9.97*	*7.14*	*70.31*	*62.02*	*2.53*	*1.33*	*3.10*	*3.52*	*13.68*	*2.07*	*1.84*	*4.57*	*182.62*	*141.76*
C6	m	1.08	7.52	0.15	0.16	8.71	3.00	5.89	1.77	2.31	3.16	1.82	0.89	-0.86	2.01
	cv(%)	*8.00*	*7.80*	*55.65*	*53.35*	*2.63*	*1.04*	*3.18*	*3.39*	*13.61*	*2.54*	*2.45*	*4.65*	*-48.18*	*56.87*
C7	m	1.05	7.50	0.16	0.17	8.39	2.96	5.71	1.73	2.38	3.10	1.80	0.88	-0.58	1.35
	cv(%)	*9.93*	*6.65*	*63.65*	*60.57*	*3.89*	*1.86*	*4.70*	*4.32*	*14.72*	*3.54*	*2.04*	*5.32*	*-87.83*	*99.37*
C8	m	1.04	7.53	0.16	0.17	8.44	2.98	5.75	1.73	2.68	3.10	1.80	0.88	0.71	2.02
	cv(%)	*9.50*	*6.38*	*65.11*	*68.16*	*3.26*	*1.54*	*3.87*	*4.60*	*25.36*	*2.95*	*1.93*	*5.19*	*83.05*	*62.80*
C9	m	1.13	6.95	0.41	0.39	8.69	2.99	5.90	1.72	2.26	3.17	1.78	0.87	-0.63	1.82
	cv(%)	*9.58*	*11.95*	*50.37*	*46.55*	*2.95*	*1.42*	*3.51*	*5.66*	*13.60*	*3.13*	*3.19*	*6.20*	*-87.43*	*90.57*
C10	m	1.22	4.88	0.59	0.51	8.73	3.00	5.89	1.70	2.09	3.12	2.06	1.19	-0.77	5.23
	cv(%)	*9.92*	*11.66*	*61.00*	*55.87*	*3.63*	*4.70*	*5.37*	*8.14*	*15.67*	*2.98*	*5.60*	*11.65*	*-68.29*	*60.78*

Caption: Lng_ab=Length of the honeybee in mm; Lng_lang= Length of the tongue in mm; lar_tom= Width of the tomentum in mm; BF5TA=Width hairy zone of the 5th abdominal tergite in mm; Lng_ailant= Length fore wing in mm; lar_ailant= Width fore wing in mm; Lng_ailpost= Length hind wing in mm; lar_ailpost=Width hind wing in mm; a/b=Cubital index (dimensionless); Lng_celrad= Length radial cell; D=Distance between radial cell and discoidal point; X=Distance radial cell-left end of rib A; Pos_pd= Discoidal transgression (dimensionless); Agdecal_pd=Angle of lag of the discoidal point in degree (°)

Table 6. Conformity of the characteristics of the honeybees studied with the characteristics described for *Apis mellifera* by Viniwanou (2009) and Paraïso *et al*. (2011) in Benin

	Group I				Group II				Group III			
Characteristics (in mm)[1]	Size μ=11.35	L aile ant μ=8.62	Langue μ=2.93	a/b μ=2.28	Size μ=12.02	L aile ant μ=8.71	Langue μ=2.65	a/b μ=1.96	Size μ=14.80	L aile ant μ=11.14	Langue μ=1.20	a/b μ=2.09
Global	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Morphotypes level												
Morphotype 1	0.000	0,000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Morphotype 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.029
Morphotype 3	0.000	0.000	0.000	0.000	**0.562**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Morphotype 4	0.004	**0.087**	0.000	0.000	**0.377**	0.007	0.000	0.000	0.000	0.000	0.000	0.000
Morphotype 5	0.000	0.000	0.000	0.000	0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.000
Morphotype 6	0.000	0.000	0.000	0.029	0.000	**0.791**	0.000	0.000	0.000	0.000	0.000	0.000
Morphotype 7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Morphotype 8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Morphotype 9	**0.664**	0.000	0.000	**0.276**	0.000	**0.129**	0.000	0.000	0.000	0.000	0.000	0.000
Morphotype 10	0.000	0.002	0.000	0.000	**0.128**	**0.602**	0.000	0.000	0.000	0.000	0.000	**0.971**

Caption:
Size=length of the bee; L ail ant=length of the fore wing; a/b= cubital index

DISCUSSION

Although each of the ten identified morphotypes contains honeybees that are morphologically similar, all morphotypes are nevertheless a mixture of honeybees of several localities except the morphotypes C4 (100% from Yarakéou) and C10 (94.19% from Adjiro and 5.81% from Yarakéou). These results, consequences of the intracolonial variability, tallied with those of Viniwanou, (2009) and Paraïso *et al*. (2011). Considering a colony as a simple individual leads to a regrettable loss of information (Cornuet *et al*., 1975). Our results also confirmed the fact that, in the same hive, yellow small honeybees and big black honeybees cohabite in several apiaries in North Benin (Hounkpè *et al*., 2007). The morphometric parameters used in this study were related to the size and wings of the honeybees. In general, for such morphometric characteristics, the intracolonial variability is higher than the intercolonial variability (Pokluka and Kezic, 1994; Radloff *et al*., 2003). Another explanation of the results obtained may be linked to the frequent natural merges of honeybees in tropical Africa (Hepburn and Radloff, 1998). During the depopulation of bees' colonies due to the seasonal lack of honey resources in foraging zones (Ramalho *et al*., 1998), or due to the effect of pesticides, or again due to the complete harvest of honey without feeding, bees may merge with other colonies. The fight begins at the entrance of the nest, but when the merge starts, aggression stops (Neumann *et al*., 2001). Secondly, for a colony to develop normally, the queen must be inseminated by several males during its mating flight (Chevalet and Cornuet, 1982). In natural setting, the queen is inseminated by males (polyandry) that may come from several of neighboring colonies (Chevalet and Cornuet, 1982; Baudry *et al*., 1998). According to Franck (1999), polyandry is significantly higher in the colonies of Africa honeybees than in European honeybees' colonies (Garnery, 1998). Thus, polyandry leads to the simultaneous presence of various siblings in the colony (Rey, 2012) proportionally to the number of couplings (Franck, 1999). Moreover, division of labor between the workers of the same colony (Seeley, 1995; Leoncini, 2002; Dechaume-Moncharmont, 2003; Rafalimana, 2003; Toullec, 2008; Rey, 2012) compels honeybees to develop more organs related to their task. Thus, fanning bees must develop their wings more than those of nurse bees. Foraging bees must have large hind legs, adapted to pollen transportation (Rey, 2012). Robinson and Page (1988) have shown a difference in the distribution of the genotypes between honeybees guarding the entrance of the hive, those having a sanitary behavior (cleaning brood cells) and all the workers. Lenor (2002) has proved that, for a task (protecting the hive), all worker honeybees from the same queen do not have the same profile of responses. A genetic difference, in terms of the proportions of the different siblings, exists between foraging bees which collect pollen and those that prefer nectar (Calderone *et al*., 1989). Despite an apparent homogeneity of the workers of a colony, the study of their morphometric characteristics revealed a very big disparity between them. Thus, other sub-species than *Apis mellifera* adansonii may exist in Benin, as mentioned by Viniwanou, (2009) and Paraïso *et al*., (2011). Moreover, two species of honeybees (*Apis cerana* and *Apis mellifera*) can cohabit in a single colony (Tan *et al*., 2007). However, resorting to the molecular characterization of the different morphotypes of honey bees identified could definitely shed light on this hypothesis of the existence of other species of *Apis* sp. other than *Apis mellifera* (*mellifica*) in Benin.

Studies in the apiaries in North-East Benin have identified three groups of honeybees with very distinct morphometric characteristics. Group I is made of 79.2% of the honeybees sampled on the entire six sites of the study, group II is made of 20.4% of all the bees sampled and group III is made of 0.4% of all bees sampled. The three groups are characterized by the size of the bee, the length of the fore wing, the length of the tongue and the cubital index. The comparison of the 10 morphotypes of honeybees obtained and these three groups (Table 6) has shown that at the threshold of 5%, honeybees of the morphotype 9 had a size that statistically match (P=0.664) the bees of group I studied in North-East Benin by Viniwanou, (2009) and Paraïso *et al*., (2011). Honeybees of the morphotypes 3 (P=0.562) and 4 (P=0.377) and those of the phytodistrict of Bassila (P=0.091) have a size similar to that of the bees of group II recorded in North-East Benin. Honeybees of the morphotype 10 have a shape that is statistically different (P<0.001) from that of the bees of group III found in North-East Benin. The lenght of the fore wing of the bees of the morphotype 4 (P=0.087) and from the Sudanian climatic zone (P=0.513) is statistically similar to the length of the fore wing of the bees of group I found in North-East Benin by Viniwanou, (2009) and Paraïso *et al*., (2011). The length of the fore wing of the bees of the morphotypes 6 (P=0.791); 9 (P=0.129); 10 (P=0.602) and from the phytodistricts Chaine of Atacora (P=0.089) and Mékrou Pendjari (P=0.474) is statistically similar to that of the bees of group II identified in the North-East of Benin.

Moreover, honeybees of all the morphotypes have a cubital index statistically different (P< 0.001) from the mean that Amakpé (2010) found in the commune of Djidja (South Benin).

CONCLUSION

To have performing colonies, first of all, they must be known. Beyond the apparent homogeneity of honeybees, the study reveals the existence of a high intercolonial variability inside most hives. Honeybees in Benin are distributed into ten statistically different morphotypes. The big difference of honey bees in Benin may be an asset to exploit in breeding programs. However, ethological and molecular studies are indispensable in order to confirm and identify with precision the different morphotypes of honeybees recorded in Benin.

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