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Typology and morpho-géométric characterization of local bee populations *Apis mellifera intermissa* in the North-West of Algeria

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Abstract

The disappearance of bees would cause serious problems for nature and consequently, for humans. Therefore, the characterization of bees is an important step for better management and the sustainability of bee-keeping production systems. However, in Algeria, bred honey bees are still poorly known. The objective of this study is to identify, by classical morphometry and wing geometry, the possible races and ecotypes of honey bees (*Apis mellifera intermissa*) in the northwest of Algeria. A morphometric and geometric study was carried out on bees sampled in 7 wilayas in northwestern Algeria. In each station, between 10 and 15 bees were randomly sampled, which represents 530 bees. For each bee, 17 morphological characters and the positioning of 20 landmarks were measured using a magnifying glass in order to highlight the differences and commonalities between these bees, which was done using statistical analyzes, such as principal component analysis (PCA) of the values of the morphometric characters' measurements. This study has generally revealed a significant variation in the morphometric characteristics of the bee of *Apis mellifera intermissa* in the North-West of Algeria, especially for the individuals of the region of Chlef, and also gave us additional information concerning the biological diversity of our local race of bees, it is, therefore, important to adopt appropriate strategies for the conservation of their diversity.

Keywords: *Apis mellifera intermissa*, morphometric characterization, wing geometry, statistical analysis, conservation, diversity.

الملخص

قد يتسبب اختفاء النحل في مشاكل خطيرة للطبيعة و بالتالي للبشر.لذلك فان توصيف النحل يشكل خطوة مهمة لتحسين الإدارة و استدامة أنظمة انتاج تربية النحل. و مع ذلك في الجزائر, لا يزال نحل العسل المربى غير مفهوم حتى يومنا هذا. الهدف من هذه الدراسة هو التعرف من خلال قياس تم اجراء *Apis mellifera intermissa* الشكل المورفومتري وجيومتري للاجنحة, على السلالة التلية والانماط البيئية المحتملة لنحل العسل. دراسة شكلية و هندسية على عينات نحل في 7 ولايات في شمال غرب الجزائر, في كل محطة تم اخذ عينات بين 10 و15 نحلة, يمثل مجموعها 530 نحلة. لكل نحلة تم قياس 17 خاصية مورفومترية و تموضع 20 نقطة على الاجنحة باستعمال مجهر العدسة,وذلك من أجل تسليط الضوء على الاختلافات والنقاط المشتركة بين هذه النحل، عن طريق النتائج التي تم الحصول عليها من التحليلات الإحصائية مثل تحليل المكونات الأساسية (PCA) لقيم قياسات الخاصيات المورفومترية. كما أن هذه الدراسة قد كشفت بشكل عام عن تباين كبير في الشخصيات المورفومترية لنحلة عسل *Apis mellifera intermissa* النحل في شمال غرب الجزائر، وقد زودتنا بمعلومات إضافية حول التنوع البيولوجي لسلالاتنا المحلية، لذلك من المهم جدا اعتماد استراتيجيات مناسبة للمحافظة على هذا التنوع.

الكلمات المفتاحية: النحل، *Apis mellifera intermissa*، دراسة مورفومترية، التحليل الإحصائي، المحافظة، التنوع البيولوجي

Introduction

The bee plays a vital role in maintaining the balance of terrestrial ecosystems and in the income of rural populations around the world. Indeed, about 35% of global agricultural production depends on pollinators, the most important of which are the bees (Klein et al., 2007).

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Because of its interest as a producing species (honey, pollen, wax, royal jelly, propolis, venom and swarm) (FAO, 2O12); and its importance in the pollination of wild and cultivated plants, the bee has become one of the most studied insects in the world. The first modern classification of bees was given by Michener (1944) and has recently been modified through molecular analysis by Danforth (2006). According to these authors, bees belong to the Apidae family, which includes four (04) subfamilies: Meliponinae (stingless bees), Euglossinae, Bombinae and Apinae (honey bees) and includes nearly 20,000 species of bees around the world (Michener et al., 2007). However, honey bees, the most known and used in beekeeping in the world, belong to the species *Apis mellifera* comprising 26 subspecies (Segeren et al., 1996). It has a natural distribution throughout Africa and Europe.

Like all living beings, the bee has recently been under a lot of pressure linked to various unfavorable environmental factors (pollution, reduction of plant cover, climate change, humidity, long winter, temperature, etc.) and especially to various pathologies. Bees that are farmed (beekeeping) suffer from many problems related to the anthropization of environments and structural changes in landscapes, stressful beekeeping practices and pollution related to insecticides (Ayme, 2014).

In Algeria, only a few studies were published on the local subspecies (Barour and Baylac, 2016). In this case, those were carried out to determine the different races of bees. In addition, beekeepers do not have a good knowledge of the breeds of bees they exploit. The characterization of these bees is therefore necessary for better management of their diversity and the sustainability of beekeeping production systems.

The aim of this study is thus to identify, using the traditional morphometry and the wing geometry, the possible races and ecotypes of honey bees (*Apis mellifera intermissa*) that exist in the North-West of Algeria, but also to present the current situation of the Algerian beekeeping population based on a field survey, in order to have an idea of the strengths and weaknesses of beekeeping in Algeria.

Materials and Methods

Study area presentation

The study took place in the North-West of Algeria, more particularly in the wilayas of Chlef, Sidi Bel Abbes, Tlemcen, Oran, Ain Tmouchent, Mascara, and Blida (Figure 1)

The northwest region is located at 37° 5' 37" north latitude, and 8° 40' 21" west longitude, with an area of 63,050 km². This vast area is characterized by three major natural ensembles:

-The coastal zone opens onto the Mediterranean Sea and includes mountainous areas.

-A number of mountains and interior basins of the Tell Atlas: the mountains of Tlemcen as well as the interior plains of Maghnia and Sidi Bel Abbes.

-The sub-steppe spaces are located in the south of the region.

The study region enjoys a Mediterranean-type climate, which is characterized by a rainy period, extending generally from October to the end of April, and a dry period extending over 6 to 7 months for the rest of the year. However, the months of June, July, and August remain the driest months for the study area

Field Survey

A field study was carried out by questionnaire (total of 22) addressed to beekeepers whose purpose is observation and collection of different information according to their experience and the different techniques used:

- Information about the beekeeper and the apiary;
- General management of the apiary;
- Health status of bee colonies.

Sampling

The collection of bees was made in apiaries installed in 7 regions of north-west Algeria: Tlemcen, Sidi Bel Abbes, Chlef, Oran, Ain Tmouchent, Mascara, and Blida, during the three months: March, April, and May. In each apiary, 10 to 15 bees were randomly sampled (a total of 530 insects).

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The sampled bees were euthanized by immersion in 96% and stored at -20 °C for later use. The bees sampled are all workers because the males haploid are not representative of a bee population (Toullec, 2008).

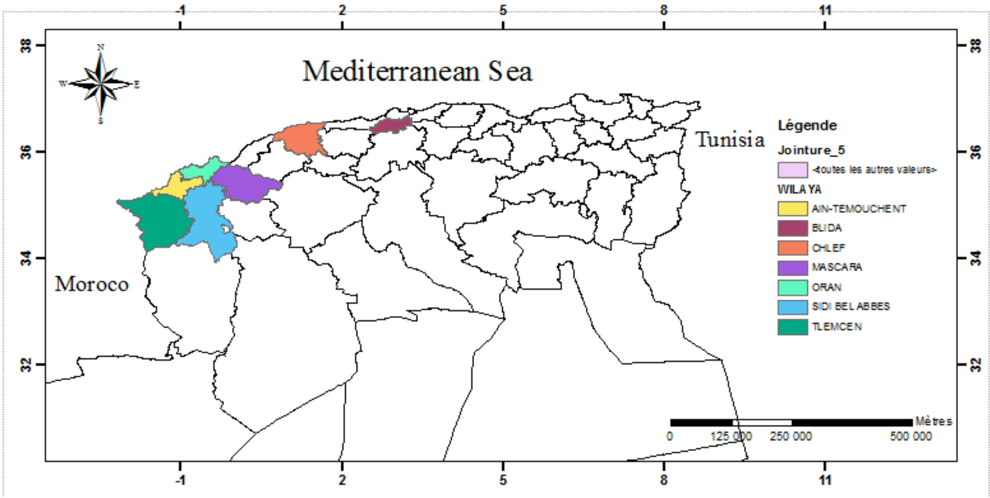

Figure 1: Geographical distribution map of study stations

1. *Measurement of morphometric characters*

During this work, 17 morphological characters were selected according to their discriminating power and their biological significance. These parameters are the length of the hind legs (the length of the femur (Fe) and the tibia (Ti), the length (ML) and the width (MT) of the metatarsus), the length of the tube, the diameter of the two tergites (3) and (4), the diameter of the two sternites (3) and (6) and the length and width of the right forewing **(Figure. 2, 3, 4, 5 and 6).**

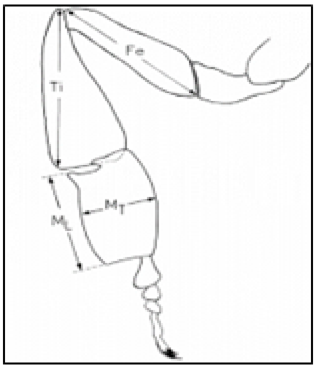

Figure 2: The length of the hind legs (**Fe:** the length of the femur; **Ti**: and the tibia; **ML** the length and **MT** the width of the metatarsus

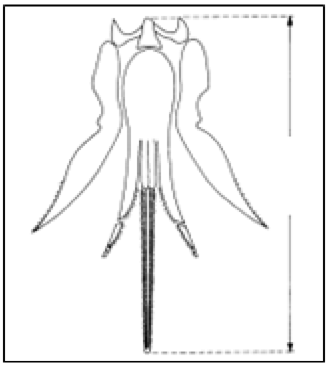

Figure 3: The length of the tube

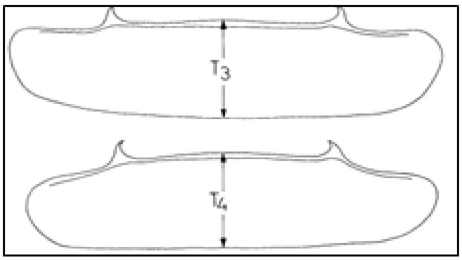

Figure 4: The diameter of the two tergites (3) and (4).

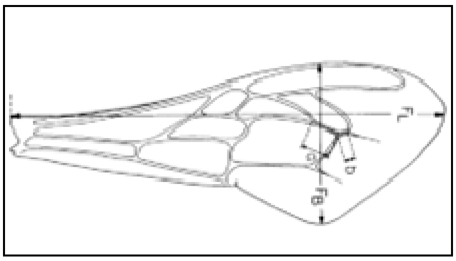

Figure 5: The length and width of the right forewing

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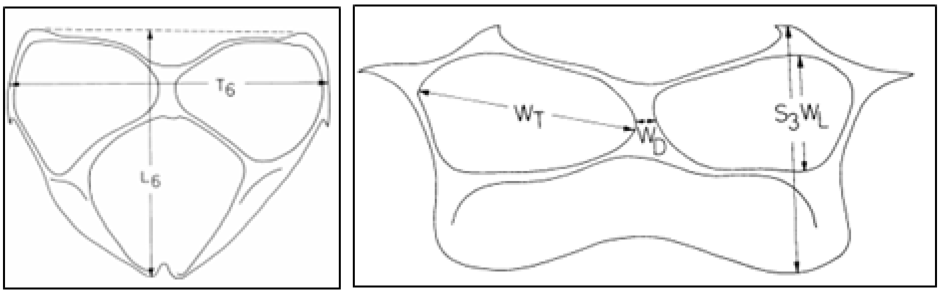

Figure 6: The diameter of the two sternites (3) and (6).

A dissection of the bees according to the method described by **Ruttner et al. (1978)** was carried out. The right hind wings, the right hind leg, as well as the tergites (3rd, 4th), and the sternites (3rd, 6th), the oral apparatus, were removed and mounted between the slide and coverslip **(Figure 7)**

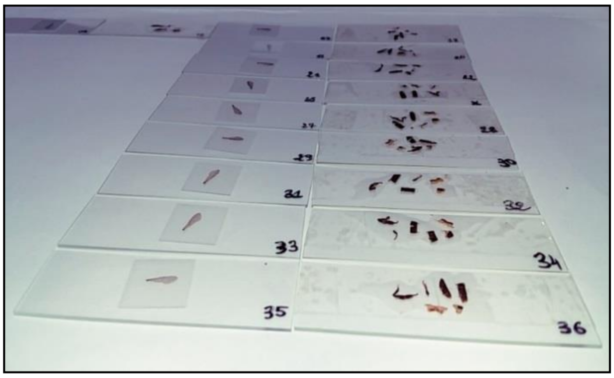

Figure 7: The dissected parts mounted between slide and coverslip

The measurements of the morphometric characters were carried out using a USB microscope via the CoolingTech image acquisition and analysis software to convert all physical data of the image into scientifically exploitable data of the remaining criteria **(Figure 8)**

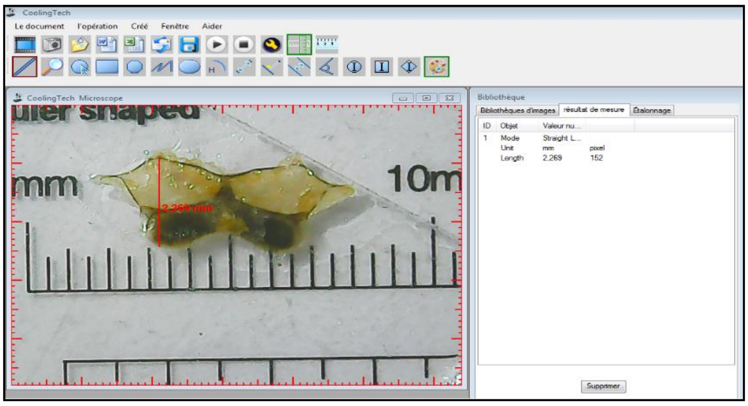

Figure 8: Cooling Tech morphometric measurement the length of the sternite 3

2. *Measurements of wing geometry*

The landmarks were positioned in two dimensions on the right forewings by applying the points to a photograph of the wings sampled with a measurement scale **(Fig.9),** knowing that all the photos were taken in the same orientation and the same magnification, these photos are then directly imported using software from Stony Brook Morphometrics by James Rohlf: TPS, these are respectively:

- ❖ TpsUtil32version1.76 which helps us to convert the images of the right front wings to text format files (.TPS).
- ❖ TpsDig232 version 1.31, which allows us to position the landmarks and then import the coordinates directly into the Morpho J software version 1.06.

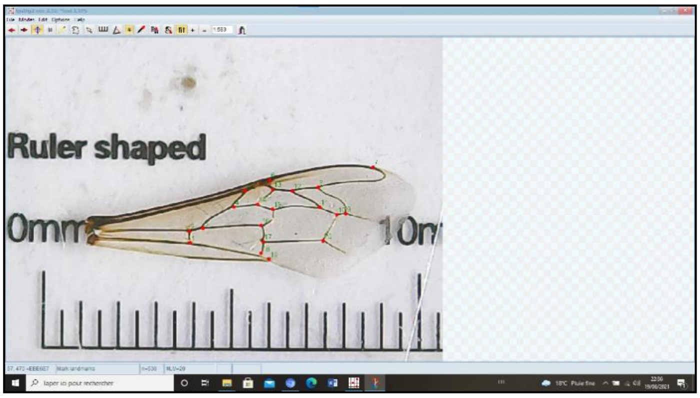

Figure 9: Positioning of landmarks on the right forewing using TpsDig232verdion 1.31 software

Statistical analysis

To determine the biometric characteristics of the collected bees, the arithmetic means, the standard deviation and the minimum and maximum values of the different morphometric parameters were determined for each sample of bees. These average morphometric parameters were compared between the sampling sites by analyzing the Principal Component Analysis (PCA), Hierarchical Classification (HAC), One-way variance (ANOVA) and SHANNON-WEAVER diversity index (H'), which is calculated by the following formula:

$$H' = - \Sigma \, Pi \ln Pi$$

H': *Shannon biodiversity index./* ***i:*** *a species from the study environment./* ***P:*** *Proportion of a species i compared to the total number of species.*

The various calculations were carried out using the Studio interface of R software version 3.5.3 as well as Morpho J software version 1.06d.

The objective of this type of analysis is to first search for any morphological variation within collected bees and to determine their morphometric characteristics in order to confirm the presence or absence of homogeneity within the groups of collected bees.

Results and discussion

Results and interpretations of the questionnaires

1. *Information from beekeepers*

The results of the questionnaire show that the beekeepers are divided into three age categories, namely over 51 years old, between 40 and 50 years old and under 40 years old, the last of which represents 18.18%. For the intellectual level, we recorded the presence of 4 categories whose secondary level represents half (50%) of the population (Figure 10 and 11)

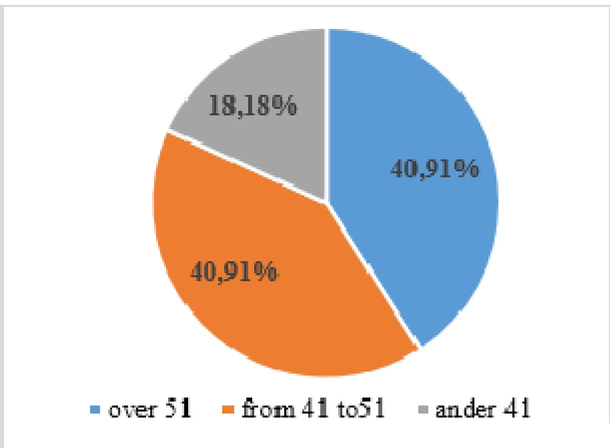

Figure 10: Age of surveyed beekeepers

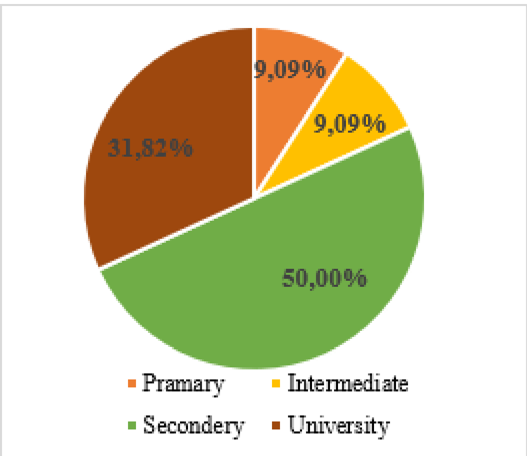

Figure 11: Educational level of beekeepers

2. *Apiaries Information*

Almost half of the beekeepers (45.45%) have 30 to 100 hives, followed by those who have less than 30 hives, with a rate of 36.36%, meanwhile, we recorded a percentage of 9.09% for those who have more than 200 hives. this explains why the majority of beekeepers are amateurs (figure 12). According to the results of the study, 54.55% of the beekeepers questioned the transhumance of their apiaries, while 45.45% have sedentary apiaries (figure13).

In Algeria, the regions are not characterized by the same beekeeping production rates. In addition, Chahbar (2017) reported that regions, which are characterized by high beekeeping production, are also characterized by a high frequency of transhumance. Transhumance is an important factor in the spread of bee diseases according to Fernandez et Coineau. (2007).

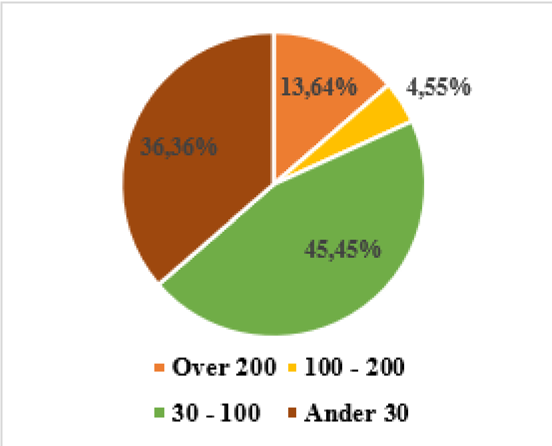

Figure 12: Number of colonies in the apiary of beekeepers

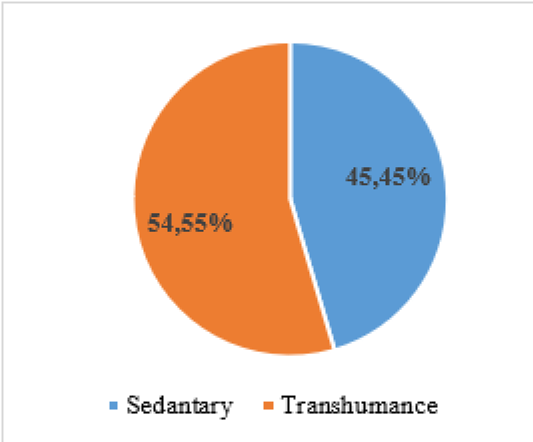

Figure 13: Nature of beekeepers' apiaries

3. *General management of the apiary*

It is noted that 100% of beekeepers practice feeding with syrups and the duration of distribution of stimulating foods varies between 1 and 4 months. We noted the absence of a common criterion between beekeepers, to practice the feeding (stimulant) of the bees. Indeed, a high rate of beekeepers (77.78%) use the feed once a week for 3 months (fig.14). Knowing that the use of stimulating food, begins during the winter season and spreads out until spring, reaching its maximum threshold during the fall (figure15)

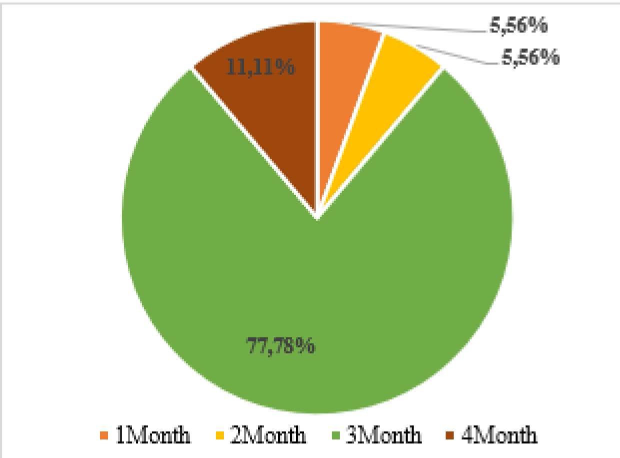

Figure 14: Duration of distribution of stimulant foods

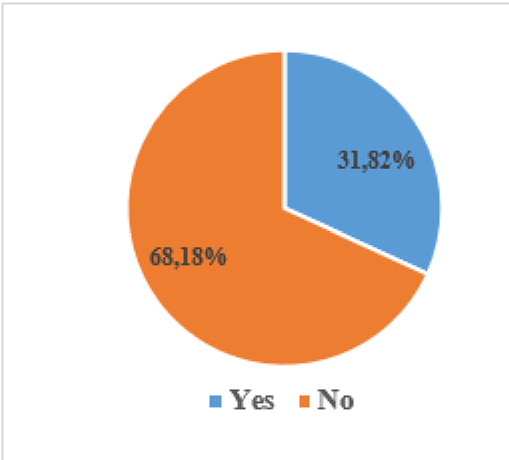

Figure: Using of stimulating foods

According to the survey, 86.36% of beekeepers that were questioned protect their hives against bad weather and winds. However, 13.64% of them do not take protective measures for their hives.

Climate change and its expected magnitude could lead to a time lag between the development of floral resources and that of colonies. This could modify their interactions with consequences on the quality of food intake and therefore the vitality and resistance of colonies to disease (Potts et al., 2010)

In this framework of studies, we found that all of the beekeepers surveyed (100%) renew the frames of their hives periodically according to their professional experience and technical skills.

According to the answers of the beekeepers questioned on the period of renewal of the frames of the hives, 58.82% change the frames during the spring, that is to say, 29.41% during the summer after the harvest, and 5.88% between them renew them once a year during autumn

The results presented above highlight the rate of honey production by the beekeepers surveyed compared to past years. 72.73% appreciate that there is a low production of honey, 18.18% of beekeepers estimate an average production, but only 9% of the beekeepers questioned foresee a good production

In terms of studies, almost the majority of beekeepers questioned do artificial swarming to enlarge their apiaries, or 68.18% of them engage in the sale of hives. Whereas, only 41.18% of beekeepers build their apiaries by buying swarms (Figure17)

The majority of beekeepers only rely on artificial swarming to enlarge their apiaries. This reproduction technology has an impact on the susceptibility of hives to certain pathogens (Tarpy, 2003; Meixner et al., 2010), as well as on disease transmission (Genersch, 2010). The disease can be transmitted by alternating between two modes of transmission, vertical transmission between one of the parents of the first generation to the offspring (the second generation).

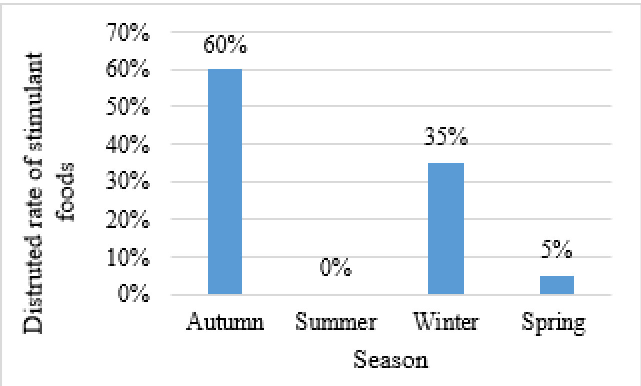

Figure 15: Timing of distribution of stimulant foods

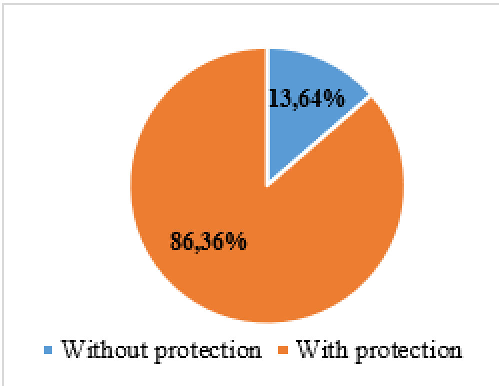

Figure 8: Rate of weather protection

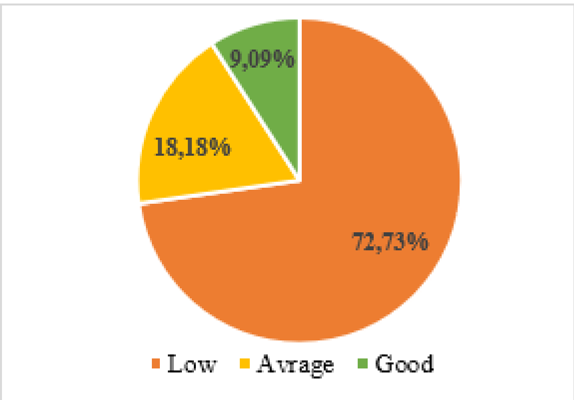

Figure 16: Estimated honey production

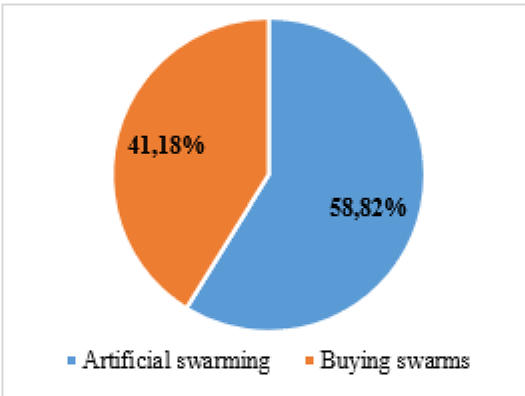

Figure 17: Breeding management to enlarge the hives

The results show the periods of abnormal losses reported by the beekeepers surveyed. We found that 44.44% of beekeepers reported that the losses are observed during the winter and summer periods, while 11.11% of the beekeepers reported abnormal losses during the autumn season. But no abnormal loss during the spring period (Figure 18).

Currently, the losses of the colonies in the world are considerable. Europe was one of the first continents to worry about excess bee mortality (Neumann and Carreck, 2010, Nguyyen et al., 2010; van der Zee et al., 2013, 2014; Pirk et al., 2014). The highest mortality rates were observed during the winter period (Lee et al., 2015).

In Algeria, this factor is not yet called into question. High winter losses, between 20% and 50%, have been reported in some countries around the world, such as Italy (Mutinelli et al., 2010), Denmark (Vejsnæs et al., 2010), Austria and Italy (South Tyrol) (Brodschneider et al., 2010), Scotland (Gray et al., 2010), England (Aston, 2010).

In contrast, winter loss rates were acceptable in other countries, which were reported at 10% in Bulgaria (Topolska et al., 2010) and Norway (Dahle, 2010). Low winter loss rates were reported, less than 5% in China and various other countries (Van der Zee et al., 2012).

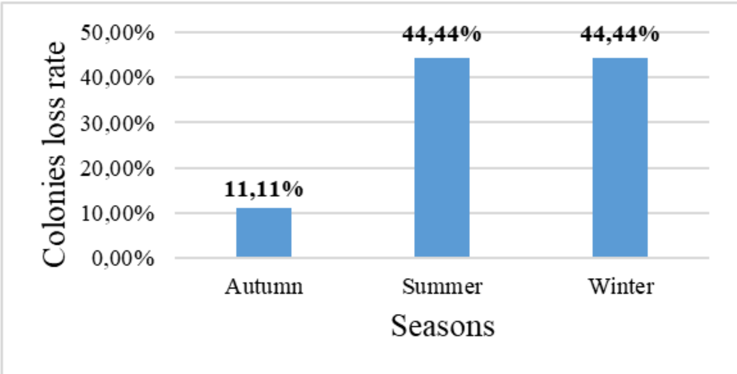

Figure 18: Abnormal loss period

The morphometric measurements of the bee

1. *Descriptive analysis*

The results obtained relating to the univariate analysis of the 17 characters summarized in Table 3 show the following:

Table 1: Descriptives analyses (averages, minimums and maximums)

Variables	Averages	Minimum	Maximum
FL	7.72 ± 0.40	2.43	8.67
FB	2.58 ± 0.13	2.19	3.01
Fe	2.16 ± 0.33	1.34	3.10
Ti	2.32 ± 0.24	1.58	2.89
MT	1.02 ± 0.13	0.58	1.35
ML	1.71 ± 0.24	1.02	2.29
LT3	7.39 ± 0.88	3.85	8.70
T3	1.83 ± 0.23	1.18	2.29
LT4	6.96 ± 0.69	4.49	8.31
T4	1.77 ± 0.21	1.08	2.90
WT	1.91 ± 0.15	1.06	2.31
WD	0.27 ± 0.83	0.14	0.67
S3	2.13 ± 0.50	0.22	2.76
WL	1.19 ± 0.20	0.13	2.35
T6	2.59 ± 0.30	1.07	3.31
L6	2.09 ± 0.24	1.31	2.85
LP	4.47 ± 0.74	2.38	5.98

The analysis of the results obtained after measurement carried out on the 530 forewings, a parameter which influences not only the flight of the bees but also the quantity of pollen collected (Abdellatif et al., 1977), shows that the average length of the fore wings (FL) is 7.72 ± 0.40 mm, it is close to those obtained on the Tellian bee by (Achou, 2007) and (Lagab et al., 2019) which are respectively 8.58 mm and 8, 74 mm on the bee of southern Algeria. Regarding the width of the forewing (FB), the average is 2.58 ± 0.13 mm, which is almost identical to that obtained by (Lagab et al., 2019) in the Tellian bee (*Apis mellifera intermissa*). While Achou (2007) finds a value of 3.05 mm for the southern Algerian bee.

All the measurements taken on the different parts of the hind leg of the bee (femur, tibia, metatarsus) which are parameters related to the capacity of pollen harvesting, their average is:

• 2.16 ± 0.33 mm for the femur (Fe), this value is lower than that obtained by (Lagab et al., 2019) on bees from the Bejaia region and (Achou, 2007), but higher than that of the bee of southern Algeria estimated by (Bendjedid, 2010).

• 2.32 ± 0.24 mm for tibia (Ti); it is close to that described by (Bendjedid and Achou, 2014) with a value of 2.56 mm for bees from southern Algeria, which are Apis mellifera sahariensis bees.

• 1.02 ± 0.13 mm for the metatarsal width (MT) and 1.71 ± 0.24 mm for the metatarsal length (ML). These values are close to those estimated by (Lagab et al., 2019) in bees from the Bejaia region and higher than that of (Bendjedid and Achou, 2014) in bees from southern Algeria.

The average value of the length of tergites 3 (LT3) and 4 (LT4) is respectively 7.39 ± 0.88mm and 6.96 ± 0.96 mm. While the average width is respectively 1.83 ± 0.23 mm and 1.77 ±0/21 mm . These values are significantly lower than those of (Chahbar N, 2013) recorded in the bee of southern Algeria.

These average values of the 3rd abdominal sternite measured are slightly lower than that noted by (Chahbar N, 2013) carried out on the populations of Algeria but higher than that recorded by (Belaid, 2011).

The average values of the length (L6) and the width (T6) of the 6th sternite are respectively 2.09 mm and 2.59 ± 0.24 mm and 0.30 mm. As for those measured by (Chahbar N, 2013), they are higher.

For the length of the tongue (proboscis), the average recorded is 4.47 ± 0.74mm. This value is higher than that found for the populations of southern Algeria (Bendjedid and Achou, 2014).

2. *Principal component analysis (PCA)*

Our data set contains 530 individuals and 18 variables; 17 quantitative variables and 1 qualitative variable are illustrative.

This plan informs us that the labeled individuals are those with the greatest contribution to the construction of the plan. The individuals are colored according to their belonging to the modalities of the Region variable. It is clear that the individuals of the isolated chlef hives are different because the beekeepers among them do not practice transhumance. (Figure 19)

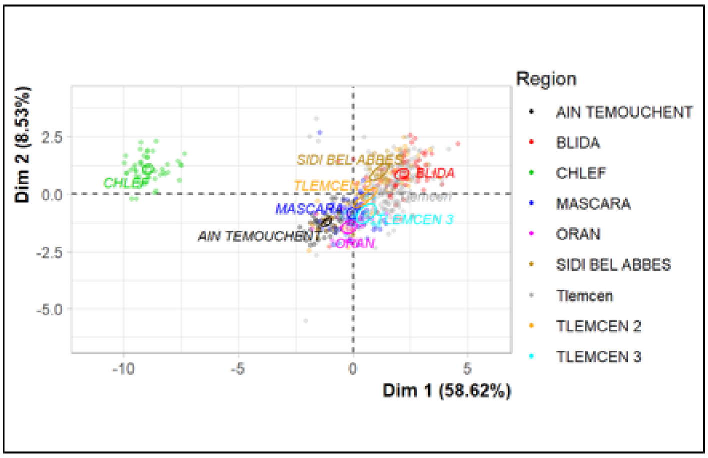

Figure 19 : distribution plan of individuals according to regions

The APC analysis shows that the variables FB, Ti, MT, T3, FL, LT4, T4, LT3, ML, and T6 present a strong correlation with axis 1 and between them forming a group. The WD and Fe variables are closest to the center and correlate very weakly with each other and the other group. Aside from WL illustrates an orthogonality with the other characters so it is independent of the other.

It can be deduced that these representative variables of the first axis have genes in common with them. Regarding the neutral variable WL, it is likely to present a very important genetic particularity.

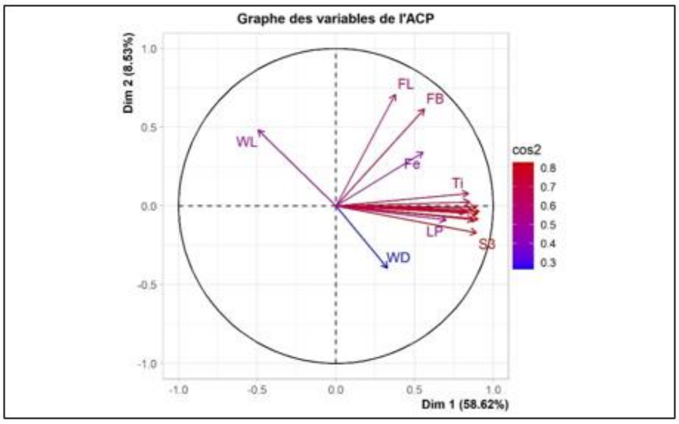

Figure 20: Variable correlation circle

3. *Hierarchical Ascending Classification (HAC)*

The distance of the characters (FL), (FB), (Fe), (WD), and (WL) from the correlation circle of the variables studied is explained by their contribution to dimensions other than Dim1 and Dim2. They contribute according to their orders as follows: Dimensions 2, 3, and 5.

The classification carried out on the populations reveals 3 clusters. We notice that 2 classes are gathered, they are colored in green and blue. On the other hand, the 3rd class is isolated from the others and colored in red (Fig.21). These results may be due to:

The age difference of bees;
Genetic heterogeneity;
Fertilization of the queen by different males;
Tolerance of foreign bees entering the hive.

Cluster 1 in red represents the population of the Chlef region and is composed of individuals expressing high values for the WL variable.

Cluster 2 is in green and is composed of individuals from the Blida, Tlemcen 1, Tlemcen 2 and Sidi Belabbes regions and sharing high values for variables such as FB, FL, LT4, L6, LT3, Ti, Fe, MT, T6 and T3 (from most extreme to least extreme).

Cluster 3 in blue is composed of populations of Mascara, Oran, Tlemcen 3 and Ain Tmouchent regions sharing low values for the variables FL, FB, Fe, LP, WL, Ti and LT4 (from the most extreme to the least extreme).

We note that all the variables have a significant link with the classes and are reported in table 5**.** Binding strength (eta²) is measured by the correlation ratio between the quantitative variable and the class variable. We check whether this correlation ratio is significantly different from 0.

So table 5 shows us the variables which make it possible to best separate the classes, that is to say, which makes it possible to characterize the partition. In this case study, the variable tergite length 3 (LT3) makes it possible to better distinguish the classes obtained, with a P-value equal to $1.37X10^{-246.}$

We note that the critical probability of our study is 0.05, table 6 gives us information that the studied variables contribute to each class by their discriminating powers; when in a class the v-test value of a quantitative parameter is lower than (-2), it means that this class gets a low value (Mean in category) for this parameter compared to a normal individual (Overall mean), the opposite is right.

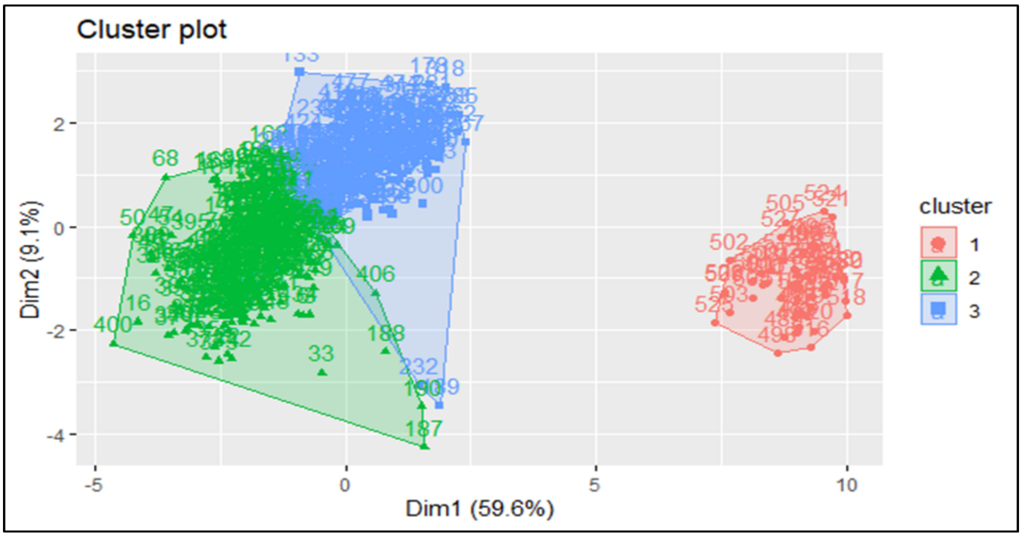

Figure 21 : Hierarchical ascending classification of populations

Table 5. Link of the variables studied with the score

	Eta2	P-value
LT3	0,885	1.37e-246
LT4	0,789	5.4e-177
S3	0,773	6.26e-169
LP	0,754	1.48e-159
T3	0,744	5.28e-159
WT	0,733	2.38e-150
L6	0,713	2.74e-142
T4	0,67	3.81e-126
MT	0,642	6.26e-177
Ti	0,628	2.33e-112
ML	0,613	7.34e-108
T6	0,578	4.44e-98
FB	0,379	4.71e-54
FL	0,355	9.11e-50
WL	0,336	1.97e-46
Fe	0,297	6.49e-40
WD	0,0979	1.01e-11

Note that the value v. Character test is less than -2, meaning it's lower than normal, apart from character WL has a value greater than -2, meaning it's higher than normal.

The classification carried out on the individuals reveals 4 clusters. We note that 3 classes are gathered, on the other hand, the 4th class is isolated. These results may be due to: The age difference of the bees, Genetic heterogeneity, Fertilization of the queen by different males and tolerance of foreign bees to enter the hive.

4. ANOVA Analysis

Statistical analysis by ANOVA shows that there is a highly significant difference between the regions for all the quantitative morphometric characters measured with $P < 0.001$, knowing that the Turkeys HSD test shows that there is a similarity close to 1.00 For the length of the forewing between Sidi Belabbes and Ain Tmouchent. for the width of the forewing there is a resemblance between Oran and Ain Tmouchent. For the length of the femur, there is a resemblance between Mascara and Ain

Tmouchent. For the length of the tibia and metatarsus, there is a resemblance between Blida and Tlemcen. For the width of the metatarsus, there is a resemblance between Tlemcen and Oran. For the width and length of tergite 3 and 4, there is a resemblance between Sidi Belabbes and Tlemcen. Concerning sternites 3, there is a resemblance between the Sidi Belabbes and Blida and Mascara regions. Moreover, sternite 6, the Sidi Belabbes and Mascara regions are close for these characters. Finally, the length of the tongue marked a resemblance for Sidi Belabbes, Oran, and Mascara.

5. *Shannon and Weaver index*

The Shannon and Weaver diversity index H' is calculated in Excel with the following formula to know the diversity rate of the population with the following formula:

$$H' = -\sum_{i=1}^{s} pi\ lnpi$$

The rate of H' obtained equals 0.90 for the populations studied in all the regions (Table 8). This index is relatively high, which is probably the reflection of significant genetic diversity and the absence of very significant selective pressure.

Table 6. Shannon and Weaver index H' of each character studied in all regions

Region	**H'**
Tlemcen	0.92249548
Tlemcen 2	0.89137428
Tlemcen 3	0.89718308
Sidi Belabbes	0.846157519
Oran	0.885667171
chlef	0.949060872
Ain Tmouchent	0.90712536
Mascara	0.94629506
Blida	0.868520669
∑H'	**0.901542166**

Measurements of geo-morphometry of the right front wings of the bee

Principal Component Analysis (PCA)

- *Distribution of inertia*

The majority of analyzes of variance in PCA are expressed by the first two axes; the highest inertia is 15.51% explained by axis 1 **(**Figure 22). This result will not dispense with the observation of the inertia explained by axis 2 and which is not negligible, a value of 8.91%. Their overall sum is 24.42%, which indicates that these main axes carry a low variability, compared to that noted by (Barour . 2005) on the bees of northern Algeria**.**

- *Description of PCA*

The visualization of the changes in wing conformation of the two main components shows that there is a similarity between all the regions, apart from the bee wings of the Oran and Chlef regions. This difference is generally observed in landmarks 6, 7, and 13. (Figure 23)

Canonical Variant Analyzes

In this study, we are interested in identifying the presence of a similarity in the distribution of the 20 landmarks on 530 right forewings of honeybees sampled in northwestern Algeria. (Figure 19)

The graphical representation of the 530 wings in the plane [CV1, CV2] shows that 63.56% of the total variation is taken into account for our dataset. (Figure 24)

The canonical variable analysis informs that the set of most individuals in the regions represents a centric scatter plot, suggesting good homogeneity and similarity of individuals, except for a few individuals in the Blida, Chlef, and Oran regions. (Figure 24)

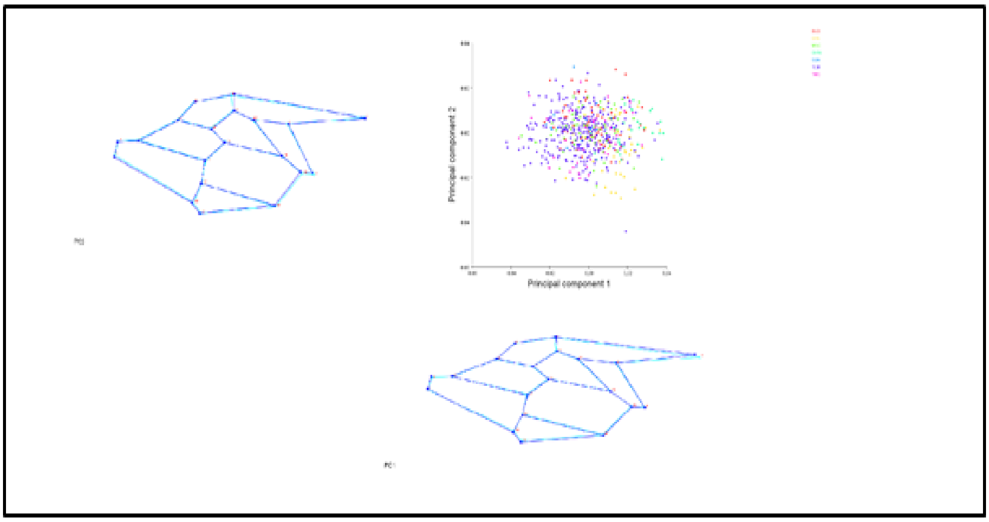

Figure 22: Analysis of the principal components of the 2 axes

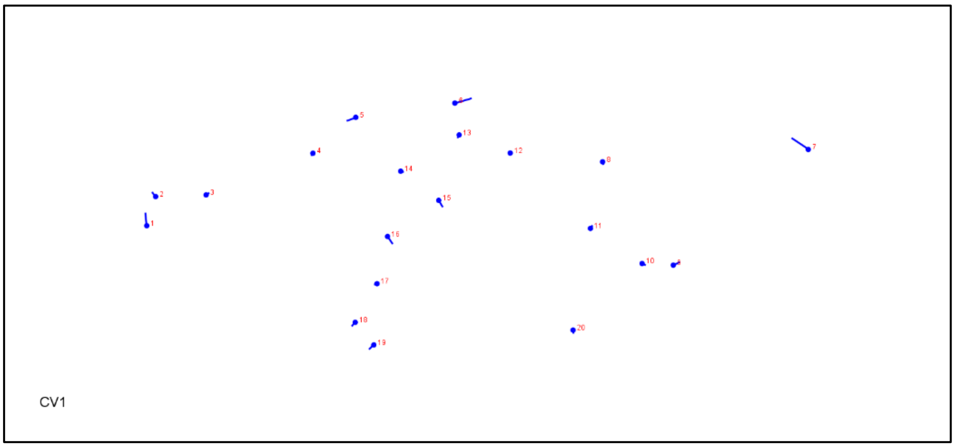

Figure 23: Positioning of the 20 benchmarks on the first two axes of the LCA

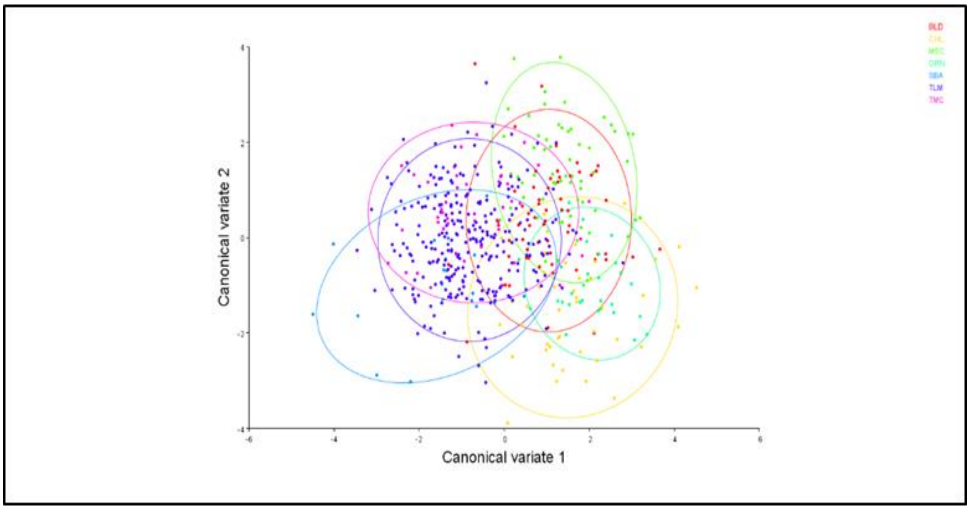

Figure 24: Graphic representation of canonical variants 1 and 2

✓ *Mahalanobis distance (D^2) between groups*

A Mahalanobis distance (D^2) was used to examine the similarity between groups of individuals and show that all groups are significantly different from each other based on 1000 permutations. (Table 7)

CVA-extracted Mahalanobis distances among six groups were found to be highly significant ($p<0.0001$). The classification of individuals into their groups showed a low level of mixing between populations. We notice that the group of individuals from the Tlemcen region has a much greater

Mahalanobis distance value compared to those of the other groups, which shows a similarity between the set of sampled individuals.

Table 7. Results of Mahalanobis distances between groups

	BLD	CHL	MSc	ORN	SBA	TLM
CHL	2.5338					
MSc	2.0015	3,138				
ORN	3.2721	3.3179	3.3239			
SBA	3.9968	4.4365	4,412	4.9373		
TLM	2.2821	3.0976	2.7641	3.6759	2.9887	
TMC	2.7424	3.4803	2.9141	4.0194	3.6979	1.7177

Conclusion

The present work dealt with a morphological study of the honey bees of the North-West of Algeria in 7 different wilayas, the aim of which is to identify the existing bees in this geographical area.

In order to conserve this local genetic heritage, one of the steps is the mastery of the species and races that exist. The study of the morphometric characters of the sampled bees made it possible to define average standards, 17 of which were measured and used statistical analyses. The description of the data obtained revealed to us a certain variability of shape and size in most of these characters studied. This differentiation may be due to certain biological, ecological and social factors, such as the different ages of the bees, the genetic heterogeneity, as well as the tolerance of other bees that do not belong to their original hive, that is to say entering different hives. Also, analyses of the morpho-geometry of the 20 landmarks on the right forewings suggest good homogeneity and similarity of individuals, except for a few individuals from the Blida, Chlef and Oran regions.

This study was conducted a survey addressed to beekeepers from different regions of the national territory. We found that beekeeping is practiced by a very large number of amateurs. Consequently, the level of technicality of amateur beekeepers is insufficient. The technicality of breeding is not only used to maintain the losses of bee colonies, but also for the preservation and conservation of our local bees.

This modest work is only a sketch of the North-West zone of Algeria. It deserves to be broadened and deepened to better enhance the national genetic potential in the diversity of our local breed.

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Contributions

All authors participated in questionnaire design, results interpretation, and paper writing.

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