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Comparative Analysis of Differentiation of the Albanian Bee Population Made by the Wings Traits and Other Morphological Traits

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Abstract: This study treats a comparative analysis of local differentiation of Albanian bee population according to 12 front wing traits and 18 other traits. To conduct this study, were used evaluations for the averages of these morphological traits measured in 3600 honey bees, in 60 different regions, scattered in all the place territory. The measurement of 30 traits was done using Scan Photo Technique (SPT). Local differentiation that was obtained in Albanian bee population by its front wing traits is not great. This differentiation does not explain by the phenomenon of isolation in distance. Human interventions in the bee population, made over the past fifteen years have brought significant changes in the morphological variations of the morphological traits. By increasing the number of morphological traits was best evidenced the local differentiation of Albanian bee. Populations were approximately grouped in three groups according to climatic zones: subpopulations group in the north east region; the subpopulations group in the field coastal area and the subpopulations group in central and east Albania. Such a differentiation of our bee population can be a consequence of the phenomena of “differentiation in distance” or the effects of genes exchanges.

Keywords: Worker bee, Morphological traits, Local differentiation

Introduction

Beekeeping is spread all over the country and the number has tripled in the last 20 years. There are large parks stabilized in bees, with a number of hives over 100 or even over 300, but the dominant part in Albania is occupied by amateur beekeepers who keeps up to 20 hives.

In our country, although the range of flowering melifera plants is wide, the pastures are scattered in different districts. Beekeepers tend to change their habitat and abandon areas that have become very dry in exchange for wet areas. Due to the microclimate, when the flowering of plants in one pasture is over, the flowering of plants in the other pasture begins and many beekeepers to realize their use, transport the bees along the different pastures at the time of their flowering. Therefore, our aim in this paper was to study the local differentiation of honeybee populations in Albania. To conduct this study, we focused on the morphological traits of the honey bee. These bodily traits can be measured for a variety of reasons. Their main use is to characterize the honeybee breeds but also to determine the degree of hybridization with foreign breeds (Ruttner, 1978; Meixner et al. 2007; Radloff et al. 2003; Bienefeld et al., 1996) and local differentiation of bee populations.

Materials and Methods

- Selection and peer-review under responsibility of the Organizing Committee of the Conference

Study area

The study area included 20 districts of Albania. In each district we took samples in three bee parks (different climatic zones) and in total 60 parks were sampled. We caught the bees by a small brush inside and at the entrance of the hive.

Storage

The bees after drowning were transferred to hermetically sealed containers and stored in ethanol. The best method of preserving bee samples for morphometric analysis is storing them in ethanol 70 degrees (Ruttner, 1978). In this way the chitin stays soft enough for dissection. Their storage is done in cool places.

Preparation of Preparations

The dissected parts of 3600 worker bees are: proboscis, third sternite, forewings, hind wings, hind legs, fourth tergite and fifth tergite. The dissected parts are mounted inside the 2 microscope slides and then were fixed on the both sides. From 60 different parks in Albania, 1260 preparations have been prepared and scanned.

Scan Method

The measurement of morphological traits was done with the modern computer method Scan Photo Technic (SPT technique). In this study the trait measurements were made with the help of Photoshop program (El-Aw et al, 2012).

Morphological Traits

Table 1 presents the morphological traits, which were taken into account for taxonomic analysis in this study.

Table 1. Morphological traits measured in this study

Traits of the head and abdomen		Traits of limbs articulated in the thorax	
1. Length of proboscis	(PL)	10. Forewing Length	(FWL)
2. Longitudinal diameter of tergitite 4	(T4)	11. Forewing Width	(FWW)
3. Width of Tomentum, tergite 4	(TOM A)	12. Hind wing length	(HWL)
4. Width of the dark stripe between tomentum and posterior rim of tergite 4	(TOM B)	13. Hind wing width	(HWW)
5. Length of hairs on tergite 5	(HLT 5)	14. Femur Length	(FL)
6. Sternite 3, Longitudinal	(LS_3)	15. Tibia Length	(TL)
7. Wax mirror of sternite 3 longitudinal	(WL)	16. Basitarsus Length	(BL)
8. Wax mirror of sternite 3 transversal	(WT)	17. Basitarsus Width	(BW)
9. Distance between wax mirrors St. 3	(WD)	18. Number of hooks	(HA)
		19. Cubital index	(CI)
		20-30. Forewing angles	(A_4, B_4, D_7, E_9, G_{18}, K_{19}, J_{10}, J_{16}, N_{23}, O26, L_{13})

Results and Discussion

Statistical analysis was performed with STATISTICS 7 and EXCEL programs. Averages were evaluated for all traits taken in the analysis, for each subpopulation identified as such with the geographical region. In table 2 are given averages and standard errors, estimated for the 12 analyzed traits on the front wings of 20 bee populations. While in table 3 are given the estimates of the averages for the other 18 traits taken in the study, measured in 20 bee populations in different regions of Albania.

Table 2. Means and standard errors of selected measures for the bee samples from Albania. Sizes of angles are given in degree (^{o}).

	CI	A4	B4	D7	E9	G18	K19	J10	J16	N23	L13	O26
Saranda	2.94±0.01^{a}	30.17±0.11^{a}	108.54±0.28^{a}	97.62±0.18^{a}	23.42±0.11^{a}	89.29±0.21^{a}	73.68±0.14^{a}	53.09±0.22^{a}	90.79±0.16^{a}	89.37±0.19^{a}	12.76±0.08^{a}	37.49±0.17^{a}
Vlora	2.83±0.03^{b}	29.31±0.11^{a}	111.73±0.28^{b}	97.17±0.27^{a}	23.61±0.11^{a}	89.78±0.21^{a}	75.32±0.15^{b}	52.7±0.24^{a}	90.49±0.16^{a}	90.14±0.17^{a}	13.41±0.09^{b}	38.62±0.66^{b}
Fier	2.86±0.02^{b}	29.54±0.11^{a}	111.35±0.28^{b}	97.38±0.31^{a}	24.59±0.13^{b}	88.33±0.18^{a}	73.54±0.17^{a}	53.32±0.22^{a}	91.65±0.18^{b}	91.11±0.22^{ab}	13.05±0.08^{b}	37.82±0.21^{a}
Lushnjë	2.91±0.02^{a}	28.92±0.12^{ab}	111.22±0.27^{b}	97.31±0.22^{a}	23.38±0.11^{a}	88.20±0.21^{a}	75.62±0.12^{b}	52.77±0.22^{a}	91.62±0.26^{b}	91.59±0.23^{b}	13.94±0.09^{b}	37.16±0.19^{a}
Berat	2.70±0.04^{c}	29.42±0.12^{a}	111.15±0.30^{b}	97.84±0.24^{a}	23.86±0.11^{ab}	87.66±0.21^{b}	75.56±0.15^{b}	52.9±0.24^{a}	89.94±0.16^{b}	90.07±0.22^{a}	13.52±0.08^{b}	37.11±0.19^{a}
Tirana	2.59±0.04^{d}	29.41±0.13^{a}	111.02±0.35^{b}	97.75±0.29^{a}	23.25±0.12^{a}	89.28±0.21^{a}	75.64±0.23^{b}	53.46±0.28^{a}	90.39±0.21^{a}	91.11±0.27^{ab}	11.03±0.09^{c}	35.86±0.23^{c}
Kruje	2.85±0.02^{b}	29.92±0.14^{a}	111.08±0.24^{b}	97.49±0.28^{a}	23.74±0.12^{a}	88.58±0.18^{ab}	74.86±0.15^{b}	53.28±0.23^{a}	91.28±0.21^{b}	91.01±0.22^{a}	13.24±0.09^{b}	37.08±0.18^{a}
Lezhë	2.82±0.04^{b}	29.08±0.14^{a}	111.21±0.35^{b}	97.68±0.29^{a}	23.31±0.12^{a}	89.33±0.27^{a}	75.14±0.22^{b}	53.1±0.27^{a}	89.54±0.22^{a}	89.94±0.25^{a}	12.48±0.12^{a}	37.03±0.26^{a}
Puka	2.68±0.03^{c}	29.15±0.14^{a}	112.04±0.34^{c}	96.88±0.29^{b}	23.27±0.11^{a}	89.43±0.2^{a}	77.12±0.46^{c}	53.17±0.24^{a}	89.96±0.23^{a}	94.87±0.31^{c}	11.69±0.1^{d}	35.88±0.24^{c}
Shkoder	2.76±0.03^{c}	29.58±0.15^{a}	110.08±0.31^{d}	97.51±0.29^{a}	23.37±0.11^{a}	89.22±0.19^{a}	75.67±0.22^{c}	52.42±0.23^{a}	90.45±0.22^{a}	92.43±0.31^{d}	12.45±0.13^{a}	35.68±0.22^{c}
Mat	2.95±0.02^{a}	29.55±0.14^{a}	110.18±0.35^{d}	98.19±0.3^{a}	23.42±0.14^{a}	89.25±0.25^{a}	75.04±0.24^{c}	52.62±0.2^{a}	90.39±0.17^{a}	89.83±0.25^{a}	12.44±0.09^{a}	36.27±0.24^{d}
Elbasan	2.73±0.03^{c}	29.18±0.15^{a}	112.38±0.37^{be}	97.83±0.28^{a}	23.46±0.13^{a}	90.01±0.19^{c}	76.76±0.2^{c}	54.12±0.26^{b}	91.08±0.28^{ab}	96.05±0.25^{f}	10.46±0.09^{df}	36.5±0.26^{d}
Librazhd	2.63±0.03^{cd}	28.53±0.14^{ab}	112.44±0.31^{e}	96.65±0.31^{b}	23.79±0.13^{a}	89.57±0.18^{ac}	77.3±0.18^{c}	52.6±0.25^{a}	90.25±0.31^{a}	94.96±0.23^{c}	11.28±0.09^{d}	36.6±0.24^{d}
Diber	2.73±0.03^{c}	29.18±0.15^{a}	112.38±0.37^{be}	97.83±0.28^{a}	23.46±0.13^{a}	90.01±0.19^{c}	76.76±0.2^{c}	54.12±0.26^{b}	91.08±0.28^{ab}	96.05±0.25^{f}	10.46±0.09^{df}	36.5±0.26^{d}
Grams	2.72±0.03^{c}	31.04±0.	109.28±0.29^{d}	99.11±0.29^{c}	23.04±0.11^{a}	89.21±0.19^{a}	74.72±0.22^{ab}	52.16±0.	90.96±0.14^{a}	90.45±0.	13.12±0.08^{b}	36.44±0.

h		18^{c}						21^{a}		25^{a}		17^{d}
Korça	2.94±0.02^{a}	29.5±0.14^{ac}	110.52±0.31^{d}	97.76±0.28^{a}	23.22±0.12^{a}	87.9±0.19^{d}	74.49±0.21^{a}	53.09±0.26^{a}	90.57±0.19^{a}	90.18±0.23^{a}	12.86±0.09^{a}	38.21±0.24^{b}
Erseka	2.85±0.03^{b}	30.22±0.13^{a}	109.26±0.3^{d}	97.89±0.23^{a}	23.29±0.11^{a}	88.21±0.19^{ad}	75.32±0.14^{b}	54.25±0.27^{b}	91.67±0.18^{b}	90.81±0.22^{a}	13.37±0.09^{b}	37.82±0.21^{b}
Permet	2.82±0.02^{b}	28.83±0.13^{ab}	110.93±0.25^{d}	97.51±0.2^{a}	24.06±0.11^{ab}	88.86±0.19^{ad}	76.57±0.22^{c}	52.43±0.23^{a}	90.01±0.14^{a}	91.1±0.19^{b}	12.92±0.08^{a}	37.05±0.2^{b}
Kukës	2.77±0.03^{c}	28.74±0.16^{ab}	112.81±0.34^{f}	98.42±0.37^{c}	23.62±0.13^{a}	90.19±0.21^{a}	76.71±0.25^{c}	54.09±0.26^{b}	89.11±0.32^{b}	91.88±0.27^{b}	11.97±0.11^{d}	37.96±0.26^{b}
Tropojë	2.33±0.04^{e}	28.42±0.14^{ab}	112.04±0.36^{fb}	96.59±0.27^{d}	23.59±0.14^{a}	88.71±0.22^{ad}	75.29±0.21^{b}	54.22±0.29^{b}	91.02±0.28^{ab}	93.25±0.29^{dc}	11.67±0.11^{d}	35.8±0.24^{c}

Table 3. Evaluations of means for 18 morphological traits in bee populations that reared in different regions (in mm)

Region	*PL*	*FWL*	*FWW*	*HWL*	*HWW*	*FL*	*TL*	*BL*	*BW*	*HA*	*LS_3*	*WL*	*WT*	*WD*	*TOMA*	*HLT_5*	*TOMB*	*T4*
Berat	6.48	9.36	3.188	6.46	1.87	2.63	3.24	2.13	1.21	21.07	2.80	1.34	2.39	0.32	0.768	0.342	0.458	2.122
Ersekë	6.549	9.457	3.213	6.547	1.867	2.652	3.223	2.133	1.228	20.728	2.801	1.354	2.421	0.327	0.832	0.299	0.46	2.114
Krujë	6.633	9.443	3.233	6.567	1.878	2.671	3.224	2.124	1.214	20.717	2.774	1.344	2.423	0.331	0.848	0.296	0.41	2.087
Përmet	6.582	9.215	3.26	6.494	1.847	2.602	3.254	2.13	1.212	20.4	2.807	1.348	2.404	0.304	0.785	0.291	0.522	2.076
Pukë	6.569	9.335	3.2	6.528	1.873	2.613	3.197	2.063	1.221	19.822	2.772	1.358	2.377	0.316	0.754	0.276	0.542	2.101
Tiranë	6.417	9.172	3.159	6.374	1.838	2.529	3.217	2.066	1.217	20.006	2.772	1.347	2.366	0.338	0.81	0.287	0.513	2.08
Vlorë	6.361	9.123	3.121	6.339	1.81	2.589	3.157	2.108	1.207	20.061	2.725	1.298	2.342	0.327	0.83	0.301	0.44	2.39
Dibër	6.398	9.406	3.167	6.628	1.857	2.434	3.217	2.073	1.231	20.394	2.8	1.386	2.396	0.288	0.753	0.274	0.585	2.14
Elbasan	6.229	9.441	3.307	6.555	1.846	2.637	3.227	2.144	1.244	20.64	2.82	1.338	2.431	0.314	0.801	0.301	0.512	2.12
Fier	6.325	9.178	3.129	6.372	1.818	2.591	3.202	2.061	1.2	20.033	2.697	1.333	2.381	0.323	0.81	0.295	0.485	2.027
Gramsh	6.404	9.391	3.262	6.511	1.837	2.609	3.194	2.079	1.219	21.066	2.811	1.371	2.418	0.314	0.783	0.317	0.504	2.09
Korçë	6.379	9.392	3.232	6.514	1.835	2.636	3.232	2.098	1.216	21.094	2.786	1.363	2.416	0.383	0.796	0.339	0.493	2.102
Shkodër	6.524	9.169	3.195	6.38	1.828	2.561	3.156	2.086	1.198	20.617	2.753	1.314	2.373	0.312	0.773	0.293	0.52	2.057
Tropojë	6.483	9.325	3.088	6.397	1.803	2.34	3.209	2.026	1.246	19.644	2.757	1.353	2.339	0.303	0.749	0.267	0.565	2.108
Lezhë	6.544	9.223	3.179	6.438	1.832	2.59	3.192	2.077	1.201	20.75	2.739	1.353	2.388	0.32	0.753	0.297	0.499	2.055
Kukës	6.555	9.348	3.209	6.561	1.889	2.566	3.236	2.097	1.219	20.016	2.798	1.342	2.386	0.333	0.759	0.298	0.554	2.101
Librazhd	6.419	9.398	3.225	6.433	1.852	2.389	3.239	1.996	1.227	20.902	2.787	1.346	2.363	0.337	0.784	0.353	0.596	2.153

Lushnje	6.419	9.152	3.189	6.428	1.884	2.628	3.18	2.11	1.201	20.016	2.737	1.308	2.366	0.336	0.82	0.307	0.483	2.063
Mat	6.426	9.343	3.175	6.529	1.858	2.583	3.171	2.122	1.209	20.433	2.743	1.322	2.356	0.294	0.75	0.286	0.541	2.136
Sarandë	6.741	9.434	3.193	6.512	1.866	2.653	3.281	2.146	1.226	21.6	2.843	1.372	2.464	0.313	0.835	0.318	0.443	2.071

As mentioned above, we initially made a preliminary differentiation of bee subpopulations in Albania using only the forewings traits where by means of Statgraphic Centurion IX program we performed cluster analysis. Using averages of 11 forewings traits the Euclidean distances between the 20 subpopulations were calculated. Using the averages of the 11 angles on the front wing, we calculated the Euclidean distances between 20 subpopulations of bees scattered in 20 different districts, which served to conduct the dendrogram that we have shown in Figure 1.

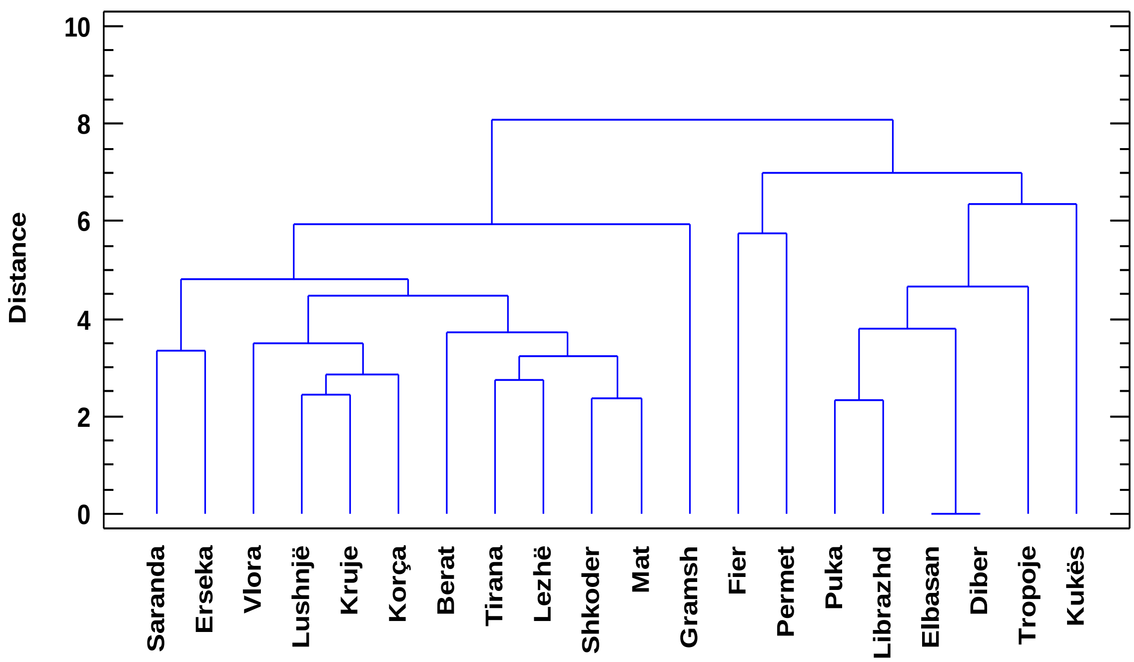

Figure 1. Dendrogram that shows local differentiation in Albanian bee population based on the traits of the forewings

Judging by this, we expect to have groupings by geographical proximity or climatic zones but none of these occur. Under these conditions it must be accepted that the differentiation observed according to these traits is not a consequence of the phenomenon known as isolation in distance. The grouping of subpopulations it’s not done according to geographical proximity and this is clear. As notice, we do not have a division according to climatic zones and mountainous or plain areas. From all of this, it probably remains to admit that it is a caustic distribution that has no regularity in it and this does not matter because beekeepers move them from time to time and exchange them frequently. It is more likely to be true the hypothesis that between bee parks located in different regions, over the years have done exchanges and migrations of genes, which have made that the differences between them to be small.

So, we do not have a distribution as expected from the above parameters. The only reason will remain that this has happened from human interventions. The human factor has influenced in several ways:

Firstly: The massive movements of bees. At the time of agricultural cooperatives, mass deliveries were made. Bees were transferred to the institutional level. It was the borrowing that was done between them because there was a central organization.

Secondly: There were transfers at the individual level. Beekeepers make their movements periodically and controlled. They do this for the reason of using of the pasture in different areas.

Thirdly: Another reason for these large movements which may have influenced this distribution, was their free trade. Today, the trade of queens or even hives and parks as a whole is practiced. These trades become uncontrolled and unstudied. We have taken into consideration only 12 forewing traits and did a preliminary study of the differentiation for the populations of the 20 districts but apparently considering only these traits was not effective and we got such a distribution.

From the above results, reinforced by the relevant interpretations of the forewings traits, we conclude that the local differentiation in Albanian bee population is not great. There are small differences between different groups of bees, within the native population as was the difference between the population of Elbasan and Dibra (cluster analysis, figure 1), but the distances between them do not follow the geographical distances between their locations.

Since the distribution of subpopulations focusing only on these traits turned out to be a caustic distribution, we thought of realizing a differentiation of these populations based on a larger number of traits. We did this with an advanced program such as STATISTICS 7. Using the mean values of 17 morphological characters such as: PL, FWL, FWW, CI, HWL, HWW, HLT5, FL, TL, BL, BW, HA, LS3, WL WT, WD, and TOM A, are calculated again the Euclidean distances among 20 bee subpopulations distributed in 20 different districts, which were used to conduct the dendrogram (Kulici et al., 2014). Figure 2 shows the groupings of bee subpopulations according to cluster analysis, referring to Euclidean distances estimated using the averages of 17 morphological trait values.

From the comparison of the two dendrograms we notice that the grouping identified according to the traits of the front wings is not the same with the grouping of the subpopulations presented in dendrogram 2. In the first dendrogram the bee subpopulations of different regions are grouped in two main groups: Tropoja, Kukës, Dibër, Elbasan, Librazhd, Puka, Fier, Përmet and Saranda, Ersekë, Vlora, Lushnje, Krujë, Korçë, Berat, Tirana , Lezhë, Mat, Shkodër. It is obvious that these groupings are not made according to geographical proximity. In favor of this idea are the proximity between the subpopulations of Elbasan and Dibra, Puka and Librazhd, Kruja and Lushnje, Saranda and Erseka.

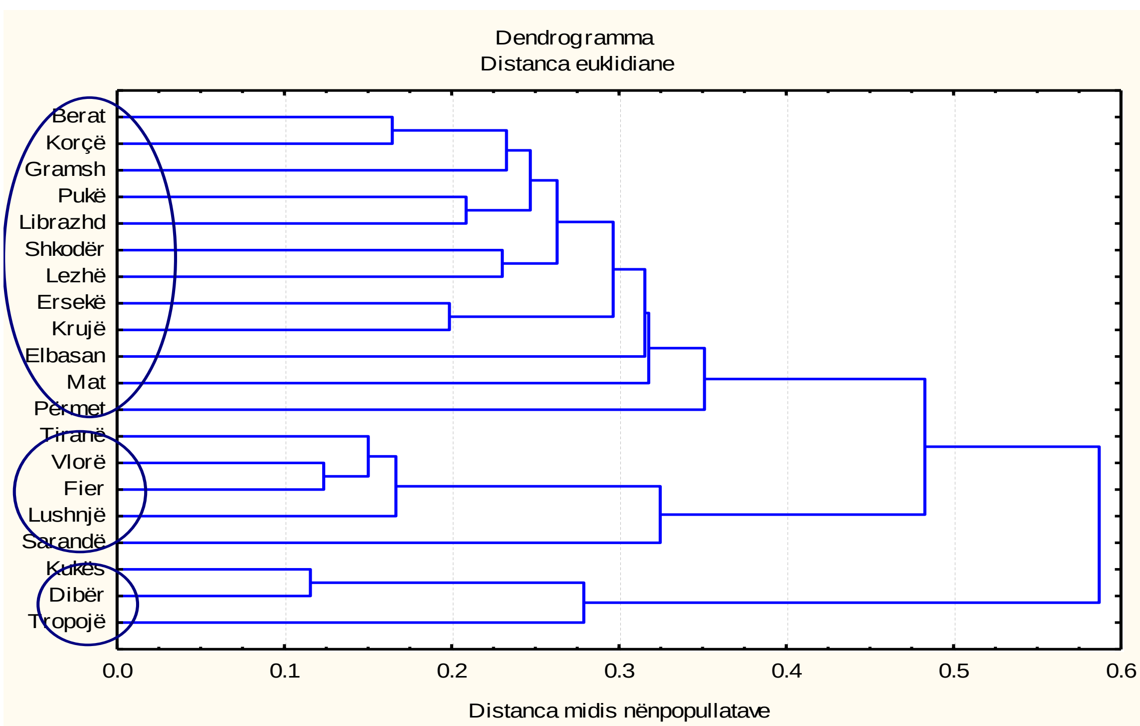

Figure 2. Dendrogram that shows local differentiation in Albanian bee population based on the other morphological traits

Such a grouping does not exist in dendrogram 2. Here are the data that contradicts the above opinions. So, these two dendrograms do not approve each other. We have a grouping of subpopulations in the way that we expected. They are grouped approximately according to climatic zones. As a result, three groups of populations have been created: the subpopulations group in the north east region; the subpopulations group in the field coastal area and the subpopulations group in central and east Albania. This distribution is more accurate; it approaches an explanation according to isolation in distance. So, we can notice a proximity between populations that bred in similar geographical and climatic zones.

The above groupings of 20 bee subpopulations show that the phenomenon of local differentiation is present in the Albanian bee population. The affiliation of groups with geographical regions may be a consequence of the phenomenon of isolation in distance or its interaction with the effects of exchanges of genetic materials. In this way we managed to get a clearer differentiation of the Albanian bee population after increasing the number of morphological traits, some of which are very important in determining of the breeds, such as PL, CI, HLT5 and TOM A.

Conclusions

The local differentiation in the Albanian bee population according to the forewing traits is not great. There are small differences between different groups of bees, but the distances between them do not follow the geographical distances between their locations. This differentiation cannot be explained by the phenomenon of isolation in distance. Human interventions in the bee population, made during the last fifteen years, massive and uncontrolled individual movements have also changed the picture of local differentiation in this population.

By increasing the number of traits, we managed a better identify of the local differentiation of Albanian bee. Subpopulations were grouped closely according to climatic zones. As a result, three groups have been created: the subpopulations group in the north east region; the subpopulations group in the field coastal area and the subpopulations group in central and east Albania. Proximity is observed between populations that bred in similar geographical and climatic zones. This grouping is further explained through the similarities of relief and climatic conditions between the three areas where Albanian bee populations were grouped.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in EPHELS journal belongs to the author.

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