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Morphological similarities between Spanish pigeon breeds

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Abstract: Relationships among 30 pigeon breeds were studied using data from 31 morphological characteristics. The relationships between breeds obtained from the study were rather congruent with the classification used by fanciers groups. The average Euclidean distance between pigeon breeds was 0.93 ± 0.16 STD. The results obtained were very compatible with those described in the literature for each classificatory group. Three large, perfectly definite clusters could be observed in this tree. A cluster was formed by Balearic nonpouter breeds and the Catalan Bare Pigeon. Another cluster occupied an intermediate position and was formed by thief pouters. They shared some remarkable peculiar features that are morphologically very different from the other breeds. A third more diversified cluster was close to the Turkish Takla Tumbler, which was used as outgroup.

Key words: Cladogram, *Columba livia*, doves, morphology

1. Introduction

The great diversity of pigeon breeds that exists in the world and attempts at systematic classification of these breeds into closely related groups are widely known (1). However, studies of filiations or possible genetic relationships among the different pigeon breeds differ substantially, because not enough archaeological or historical documents are provided to allow one to reconstruct clearly the diversification of the pigeon from its origin. According to Sambraus (2), there are 10 groups of pigeons: form, tubenose, hen, crop, colour, drummer, structure, little gulls, tumblers, and display doves. Pigeon breeds differ in body shape and structure, and colour and markings of the plumage, but few studies from morphological characters in pigeon breeds have been performed (3,4). Pigeon fanciers, with their own favourite breeds or particular interests, have provided partial histories in books and magazines dedicated to these birds; they are often selective and perhaps inaccurate. Thus, attempting to cobble together a classification of local breeds requires relying largely on scientific methods. Morphological characters can provide very useful information to complete other investigations about genetic relationships of domestic and all other breeds in general as well as being extremely important anthropologically. Statistical techniques such as multivariate analyses and the application of numerical taxonomy to the data derived from morphological characters allow a different treatment of the information generated. This is shown in the research by Jordana et al. (5).

This paper presents a study comprising qualitative and quantitative data analyses, using statistical methods and available computing packages specially designed for such analyses. The research is centred in Spanish pigeon breeds although a Turkish breed has been included.

2. Materials and methods

2.1. Breeds studied

Twenty-nine Spanish pigeon breeds were studied: Borina (BBO), Balearic Pouter ("Gavatxut", BBP), Canary Pouter (CAP), Sevilian Colillano Pouter (COP), Gaditano Pouter (also called "Isleño" and "Jerezano", GAP), Granadian Pouter (GRP), Jaén Pouter (JIP), Sevilian Thief Pouter (LSP), Marchenero Pouter (MAP), Marteño Pouter (MTP), Moroncelo Pouter (MEP), Nape Pigeon ("Quebrado Murciano", MUP), Spanish Owl Pouter ("Rafeño", SOP), Veleño Pouter (VEP), Spanish Owl ("Xorrera" or "Colom d'Enreixat", SOW), "Escampadissa" Roller (BES), Valencian Frill (VFI), Flamenca Runt ("Colom d'Ull", FLR), Giant Mallorquina Runt ("Mallorquina de Casta Grossa", BGR), Balearic Homer ("Nas de Xot", BHO), Valencian New Pouter (VNP), Strawberry Eye ("Ull de Maduixa", STE), Balearic Esbart Roller ("Pinta Balear" or "d´Esbart", BER), Fish Eye Roller ("Refilador" or "Ull de Peix", REF), Catalonian Tumbler (CAT), Rumped Pouter ("Buchón Morrillero", RRP), Alteño Pouter (ALP), Spanish Barb ("Flamenquilla", FLA), and Catalan Bare or Naked-Neck Pigeon ("Coll Pelat", NNP). Takla Tumbler (TUT)

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was included as outgroup. This Turkish tumbler originated from Central Asia and in Turkey can be considered the most popular pigeon breed.

2.2. Qualitative and quantitative analyses

A total of 31 morphological characters were studied in an ideal specimen of each of the studied breeds. The characteristics were those described habitually in a breed description (6) and were considered as being informative (colours have not been considered). The state of each character for each breed was obtained from official racial standards recognised by the "Real Federación Española de Colombicultura" or from descriptions by Levy (4), Mackrott (7), and Schille (8). Numbers were assigned to each state of the different character in an arbitrary manner. These numbers did not represent any specific weight. The number of states for each character was established depending upon the number of distinguishable phenotypic classes. Coded states were in the range 1 to 4 and unique states in multistate characters were avoided. Characters and their states are shown in Table 1.

For qualitative analysis, discrete characters (F, G, J, U, and AA) were recoded into a series of 2- or 3-state characters, denoting the absence of, the presence of, or both the absence or presence of the characters. Continuous characters may be split into a small number of classes, each representing one of the states of each character in the data matrix. The original matrix of morphological resemblances is shown in Table 2. Their analysis was based on the parsimony principle, and the criterion was to find the tree (cladogram) that required the least number of changes (9). The method used was Fitch parsimony. The heuristic algorithm used was Subtree Pruning and Regrafting (SPR) (10).

For quantitative analysis, qualitative data were transformed and processed into a matrix of similarity coming from indices pairwise distance formulae (11,12). The Euclidean distance (13) was calculated as a measure of this distance resemblance, under the assumption of independence between considered characters. With these values a cluster tree was elaborated using Ward's method, which is a hierarchical method designed to optimise the minimum variance within clusters. The method searches for objects that can be grouped together while minimising the increase in error sum of squares.

All analyses were performed using the PAST computing package (Paleontological Statistics Software Package for Education and Data Analysis).

3. Results

3.1. Qualitative analysis

The cladogram resulting from the application of the Fitch parsimony method to the morphological traits is shown in Figure 1. Fitch parsimony evaluated 12,700 trees. The values in the tree indicated the number of replicates from the bootstrap analysis (loosely, the width of the confidence interval). Fitch parsimony needed 200 steps (total length of the tree) to rearrange the characters to obtain the minimum parsimonious tree. It is imperative to note that the obtained cladogram must be viewed merely as a group tree concerning morphological relationships among the studied breeds more than a phylogenetic tree. Their similarities between groups must not be used to group like with like in descending order of specificity. The consistency index (CI) of 0.31 indicated that characters fit the obtained cladogram rather imperfectly. Figure 2 represents the strict-rule consensus tree formed after 100 bootstrap replicates. The parsimony tree and the strict-rule consensus tree were very similar, which is frequently the case.

3.2. Quantitative analysis

The average value of Euclidean distances between breeds was 0.93 ± 0.16 STD, with extreme values of 0.35 for the Borina vs. "Escampadissa" Roller pair, and 1.42 for the Spanish Owl Pouter vs. "Escampadissa" Roller. That average distance had a magnitude different to that obtained between other domestic animal species; for instance, sheep had a Euclidean distance of 1.15 ± 0.21 STD (5), which indicates that a different degree of morphological difference exists between the breeds of other species. Figure 3 shows the dendrogram produced by hierarchical cluster analysis of the data, using Ward's method and the Euclidean distance measure. Again Balearic breeds and pouters were clearly clustered (with the uncertain position of Moroncelo Pouter (MEP) again but with the Canary Pouter (CAP) included). Carunculated breeds formed a little cluster as was the case for Catalan fliers and Takla Tumbler.

4. Discussion

The values obtained are slightly different from those obtained in research on sheep (CI = 0.368; RI = 0.614) (5), which in fact included 44 characters. However, such CI comparisons only make sense when comparing levels of homoplasy exhibited by cladograms concerning somewhat similar number of characters referring to a similar type of data set in the same biological group. Indeed, there is no reason to think that sheep and pigeon breeds exhibit exactly the same levels of homoplasy.

Although low significance levels indicate that there is little confidence in this arrangement, our results are very compatible with those described for each classificatory group. Three large, perfectly definite clusters can be observed in this tree. Cluster A is formed by Balearic nonpouter breeds [Borina (BBO), "Escampadissa" Roller (BES), Giant Mallorquina Runt (BGR), Balearic Esbart Roller (BER) and Balearic Homer (BHO)] that are all from

Table 1. Characters and their states, used for the construction of the morphological resemblance matrix.

(A) Weight
1. Elipometrical (<250 g)
2. Eumetrical (250–350 g)
3. Subhypermetrical (>350 g)
(B) Size
1. Very small
2. Small
3. Medium
4. Big
5. Very big
(C) Chest
1. Medium
2. Wide
3. Very wide
(D) Legs length
1. Short
2. Medium
3. Long
(E) Legs thickness
1. Fine
2. Medium
3. Thick
(F) Leg frills? ("pants")
1. Yes
2. No
3. Grouse-legged
(G) Clean legged?
1. Yes
2. No
3. Yes or no
4. Muffed
(H) Relative head size
1. Small
2. Medium
3. Big
(I) Head shape
1. Rounded
2. Squared
3. Longish or almond shape ("ram head")
4. Dice shaped ("owl head")
(J) Crest?
1. Yes or no (plain or peak-crested)
2. No (plain headed)
(K) Beak bulkiness
1. Fine
2. Medium
3. Thick
(L) Beak length
1. Very short
2. Short
3. Medium
4. Long
(M) Beak form
1. Straight
2. Slightly curved
3. Curved
4. Very curved ("owlish")
(N) Nose wattles?
1. Little
2. Slightly developed
3. Developed
(O) Aspect of nose wattles
1. Fine
2. Rough
(P) Chin wattles?
1. Without
2. Fine
3. Well developed
(Q) Eye ceres?
1. Fine
2. Developed
3. Well developed
(R) Globe seize
1. Little
2. Medium
3. Well developed
(S) Globe form
1. Slight
2. Round
3. Oval ("pear shaped")
(T) Hanging of globe
1. Not hanging
2. Pendulous ("low crop")
3. Hanging ("high crop")
(U) Vertical crease in the globe?
1. Yes
2. No
3. Yes or no
(W) Neck length
1. Short
2. Medium
3. Long
(X) Neck thickness
1. Fine
2. Medium
3. Thick
(Z) Back
1. Flat
2. Slightly arched
3. Roached or arched
(AA) Garland?
1. No
2. Yes
(AB) Tail length
1. Short
2. Medium
3. Long
(AC) Tail form
1. Flat-tailed
2. Arched ("tile-tailed")
(AD) Rump width
1. Medium
2. Broad
(AE) Point of primaries
1. Extending to tip of tail
2. Not extending to tip of tail
3. Longer than tip of tail
(AF) Position of wings upon the tail
1. Upon the tail
2. Below the tail
3. Upon or below the tail
(AG) Station
1. Horizontal (low carriage)
2. Vertical (upright)

Table 2. Morphological resemblance matrix. Abbreviations in the text.

Breeds/ character	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	W	X	Z	AA	AB	AC	AD	AE	AF	AG
ALP	2	3	1	1	3	1	2	2	1	2	3	3	3	2	1	1	1	3	3	2	2	2	2	3	1	2	1	1	1	1	2
BBO	2	3	1	1	2	2	2	1	1	2	2	3	1	1	1	1	1	1	1	1	2	1	3	1	1	3	1	1	1	2	1
BBP	3	3	2	1	1	1	2	2	1	2	3	2	2	2	1	2	1	2	2	3	2	1	3	1	1	2	2	1	2	1	2
BER	2	3	2	2	2	2	2	1	3	2	2	2	2	1	1	2	1	1	1	1	2	1	2	1	1	3	1	1	2	2	1
BES	2	3	1	1	2	2	2	2	1	2	1	3	1	1	1	1	1	1	1	1	2	1	2	1	1	3	1	1	1	3	1
BGR	3	5	3	1	2	2	2	1	1	2	2	3	1	1	1	2	1	1	1	1	2	1	3	1	1	3	1	2	1	2	1
BHO	2	3	1	3	2	2	2	2	3	2	2	3	3	1	1	3	3	1	1	1	2	2	3	1	1	2	1	1	2	1	2
CAP	2	3	1	1	2	1	2	2	3	2	3	2	2	3	1	2	1	2	3	1	1	2	2	1	1	1	1	1	1	1	1
CAT	2	1	2	2	2	2	2	1	1	2	1	3	2	1	1	2	1	1	1	1	2	3	2	1	1	2	1	1	1	1	2
COP	3	3	2	2	2	1	2	2	1	2	1	3	2	1	1	2	1	3	3	3	2	3	3	1	1	2	1	1	3	1	2
FLA	2	2	2	1	2	1	2	3	2	2	3	2	2	3	1	1	3	1	1	1	2	1	2	1	1	2	1	1	1	1	2
FLR	3	4	2	1	2	3	2	3	1	2	3	2	4	3	1	2	3	1	1	1	2	1	2	1	1	2	1	1	1	1	1
GAP	2	3	2	2	1	1	2	2	3	2	1	2	2	3	1	2	1	3	2	3	1	2	2	1	1	1	2	2	1	1	2
GRP	3	4	2	3	2	1	2	3	4	2	3	3	2	3	2	2	2	2	2	3	1	3	3	1	1	2	2	1	1	2	2
JIP	2	3	2	2	2	1	2	3	3	2	3	4	2	3	1	3	1	2	3	2	3	3	3	1	1	2	1	1	1	2	2
LSP	3	3	2	2	2	1	2	2	3	2	3	3	2	3	1	3	1	3	3	2	1	3	2	1	1	2	1	2	1	1	2
MAP	2	2	1	1	1	1	2	2	1	2	1	2	2	1	1	2	1	3	2	3	1	1	3	3	1	1	2	2	1	1	1
MEP	2	2	1	2	2	1	2	2	3	2	2	3	2	2	1	2	1	1	2	1	2	3	1	1	1	2	2	1	1	1	2
MTP	3	3	1	3	3	1	2	2	1	2	1	2	3	2	1	2	1	2	2	2	2	3	2	1	1	2	1	2	1	1	2
MUP	2	2	1	3	3	1	2	1	1	2	1	3	1	2	1	2	1	3	3	2	2	3	1	2	1	1	1	2	1	1	1
NNP	2	2	1	2	2	2	2	2	1	2	2	3	1	1	1	2	1	1	1	1	2	2	2	1	2	2	1	1	1	1	2
REF	2	3	3	2	2	2	2	2	2	1	1	4	1	1	1	1	1	1	1	1	2	3	2	1	1	2	1	1	1	1	2
RRP	3	3	1	3	1	1	2	2	1	2	1	3	2	1	1	2	1	1	1	3	1	3	1	1	1	2	2	1	2	2	2
SOP	3	3	2	2	3	1	2	3	4	2	3	1	4	3	1	2	2	3	3	2	1	1	3	3	1	1	1	2	1	1	2
SOW	2	2	1	1	1	1	1	1	2	2	1	2	2	1	1	1	1	1	1	1	2	2	3	3	1	2	1	1	1	1	2
STE	2	4	2	1	3	1	3	3	1	1	3	1	2	3	1	2	3	1	1	1	2	1	2	1	1	2	1	1	1	1	2
TUT	3	2	2	2	2	1	4	2	1	1	2	3	2	1	1	1	1	1	1	1	2	2	2	1	1	2	1	1	1	3	2
VEP	3	3	1	3	1	1	2	1	1	2	1	3	2	1	1	2	1	2	2	3	1	3	2	1	1	2	2	2	2	1	1
VFI	1	1	2	2	2	3	2	1	2	2	1	2	2	1	1	1	1	1	1	1	2	2	2	1	1	2	1	1	1	1	2
VNP	2	3	1	2	3	1	2	2	1	2	2	3	1	2	1	2	2	3	3	2	3	2	3	1	1	2	1	1	1	1	1

the Balearic Islands. The Catalan Bare Pigeon (NNP), which is included in this cluster, is a tumbler with a striking appearance that was spread all around the Iberian Peninsula. Cluster B occupies an intermediate position and is formed by thief pouters [Rumped Pouter (RRP), Veleño Pouter (VEP), Balearic Pouter (BBP), Granadian Pouter (GRP), Gaditano Pouter (GAP), Marchenero Pouter (MAP), Sevilian Thief Pouter (LSP), Spanish Owl Pouter (SOP), Jaén Pouter (JIP), Sevilian Colillano Pouter (COP), Marteño Pouter (MTP), Nape Pigeon (MUP), Alteño Pouter (ALP), Valencian New Pouter (VNP), and Moroncelo Pouter (MEP)]. The pouters share some remarkable peculiar features that are morphologically very different from the other breeds (these characters concern, naturally, those related with globe and global weight and justify their clustering), and so they appear clearly clustered. The Moroncelo Pouter (MEP) is the most separated breed in this group and this can be explained by the fact that the breeds have a small crop that is never hanging down. Moreover, the more diversified cluster C is close to the outgroup. Some of them [Valencian Frill (VFI), Fish Eye Roller (REF), and Catalonian Tumbler (CAT)] are good fliers (Sambraus' group IX). The Canary Pouter (CAP) is included.

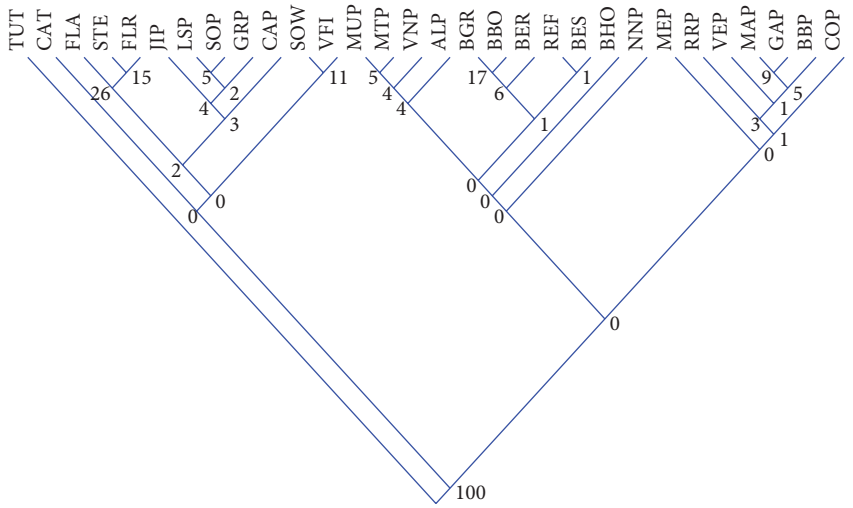

Figure 1. Qualitative analysis of morphological data. Cladogram resulting from the application of Fitch parsimony method and SPR heuristic algorithm. Abbreviations in the text.

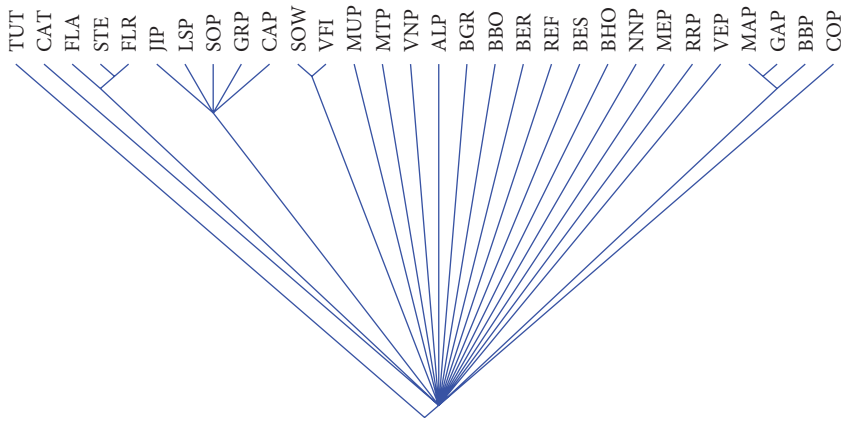

Figure 2. Strict-rule consensus tree from morphological data. Abbreviations in the text.

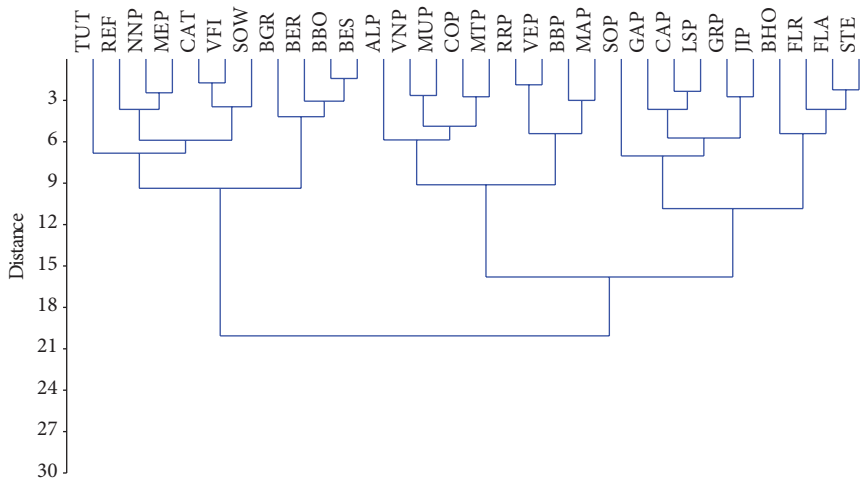

Figure 3. Dendrogram produced by hierarchical cluster analysis of the data, using Ward's method and the Euclidean distance measure. Abbreviations in the text.

At an individual breed level, morphological analysis perfectly assigned each population into their functional group. In cluster C, the Flamenca Runt (FLR), Spanish Barb (FLA) and Strawberry Eye (STE) are included together, forming a carunculated subgroup (Sambraus' group VII). The Spanish Owl (SOW) is an exhibition pigeon that shares some rather peculiar morphological characters with the Valencian Frill (VFI) and that do not appear in the rest of the breeds (pants, feather-legged, breast frill). Moreover, it is said that Valencian Frill is an offshoot of the ancient Tunisian Owl (4). The Fish Eye Roller (REF) appears closest to the Takla Tumbler (TUT) and that is an interesting case, because the Fish Eye Roller is probably related to the Pappatacci ("Spanish Primitive Jacobin", not considered here), and the Pappatacci breed has its origins in Greece (from 1302–1313 the Catalonians ruled Athens, by conquest) (4). Perhaps the Fish Eye Roller is the most oriental Spanish pigeon breed. The rest of the pigeons of cluster C belong to ancient breeds and it is said they were brought to the Iberian Peninsula from the Barbary Coast (North Africa) (4). The Canary Pouter (CAP) presents remarkable peculiar features that are morphologically very different from the other thief pouters, perhaps due to the influence of the Rock pigeon from the Canary Islands (*Columba livia canariensis*), which is said to have had an influence on its origin.

It must be remembered that morphological characters have been subjected to great pressure through artificial selection. Artificial selection has had evolutionary strength, and would have been the major influence on the process of breed differentiation. The cladogram would show that the Balearic breeds had maintained little influence from other representatives of continental Spanish breeds. It seems naive not to conclude that insular breeds are influenced more easily by neighbour breeds than continental ones. Ancient breeders did breed, and they did pass on information to other breeds. This transmission created what it is referred to as breed traditions. As Jerolmack states (14): "culture is inscribed in animals through the process of domestication in ways that, while context specific and somewhat fluid, are also cumulative and grounded in the biology of the animal".

Breeds with the same functional purpose have thus more similarities in character states for the evident reason of functionality. For instance, in thief pouters, while each breed has its own morphological features, breeders were selected for ways of flying, rendering their morphological similarities clearly associated to an adaptation to the flying ability, or structure pigeons are the less related ones as they have been selected for external appearance in order to obtain aesthetically attractive birds, but not in terms of functional traits.

In conclusion, it must be pointed out that the results obtained in this study attempted to show only the degree of relationship of morphological similarity among some current Spanish pigeon breeds, which may or may not be indicative of the true evolutionary history of their populations. It ought to be considered that morphological characters have been subjected to artificial selection over a long period of time and there has been genetic migration among some of these populations. For studies of evolutionary divergence, neutral genes, with a high rate of polymorphism and no relationship with the fitness of the individuals, would be more appropriate, especially for alleles that appeared by mutation and fixation or lost by drift, specifically the markers of DNA, minisatellites, and microsatellites. Nevertheless, analysis of morphological characters indicated the relationships of similarity, at this level, between current Spanish pigeons.

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