Variability of Skull Shape in the Domestic Dog and Its Implications for Variability in Other Mammals and Humans since the Flood

Celedonio García-Pozuelo-Ramos*

Abstract

The domestic dog (*Canis familiaris*) has been used by creationists as an example of a creature showing great variability in a short time and as an example of how to account for the variation in living beings (including humans), since the Flood. The spectacular diversity of the domestic dog species occurs not only in size but also in shape. This variability excludes the morphological differences from other wild canids, except wolf-like canids (gray wolf, coyote and jackal).

Introduction

Living beings undergo variation but they do so within their "kinds." (e.g. Marsh, 1976; Lester and Bohlin, 1984; and Brand and Gibson, 1993). Variation is limited, but when it does occur, it can transpire rapidly. This swiftness has been discussed by creationist authors (e.g. Jones, 1982; Lester and Bolin, 1984; Brand and Gibson, 1993; Woodmorappe, 1996), as well as evolutionists (e.g. Johnston and Selander, 1964; Losos, 1997; Reznick et al., 1997).

A familiar example of such great and rapid variation is that of the domestic dog. The variation of dog skulls in both size and shape is quite extensive, but their overall morphology still remains close to that of other wolf-like canids.

Studies of the cranial shape variation in the domestic dog can be useful to help us speculate about morphologic differences that may have been produced in other mammals (including humans) since the Flood.

Materials and Methods

The set of canid skulls from which these measurements have been taken belong to the author. The text refers to small and large domestic dogs. The prosthion-condyle length (see Figure 1) is the measure of choice for differentiating between small or large domestic dogs. The range of size in the small dogs is 105.4 mm to 131.8 mm (105.4 mm plus 25 per cent of 105.4 mm). The range of size in large domestic dogs is 168.8 mm to 225.1 mm (225.1 mm minus 25 per cent of 225.1 mm). The addition or subtraction of 25 per cent (a proportion) is in each case arbitrary but useful for distinguishing between large and small dogs. The smaller domestic dog in this study has a 105.4 mm prosthion-condyle length, and that of the larger domestic dog is 225.1mm. The range of size in the intermediate group is 131.9 mm to 168.7 mm. In Figure 1 the prosthion-condyle length is 185.5 mm in skull "a" and 109.2 mm in skull "b".

The triangles formed by joining three points in the saggital plane of the cranium of canids have been used to study the variation in this plane. The three vertices of the triangle correspond to the points prosthion-bregma-condyle, as seen in Figure 1.

The comparison of the shapes of the triangles (saggital planes) is possible by standardizing the scale of each triangle examined. Thus, we arbitrarily assign a prosthion-condyle length value of 100, coordinates in Cartesian axes (100.0) for the condyle, and (0.0) for the prosthion. After standardizing each triangle it is possible to plot their shapes as a scatter-plot of the coordinates (Figure 2). The coordinate shapes are formed by the bregma coordinates. All the information about the shape is contained in this point or parameter called the "bregma landmark", a method that was originally developed by Wilson (1990).

Eighteen variables (Table I) were measured and used for the Principal Component Analysis, PCA. The PCA process transforms the original variables (eighteen in this study) into new variables, called Principal Components. The eighteen PCs are PC1 to PC18. This multivariate analysis involves calculating the principal axes of the ellipsoids constituted by a scatter plot of specimens (dots) defined by his variables, in Cartesian coordinate systems. With three variables are tridimensional ellipsoids, but in this study there is actually a "space" of eighteen dimensions. The principal axes represent the directions of maximum variation (characteristic vectors), that correspond to

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*Camino Viejo de Pinto 3, 1^0 D; 28903 Getafe, Madrid, Spain, email: pkymp@latinmail.com

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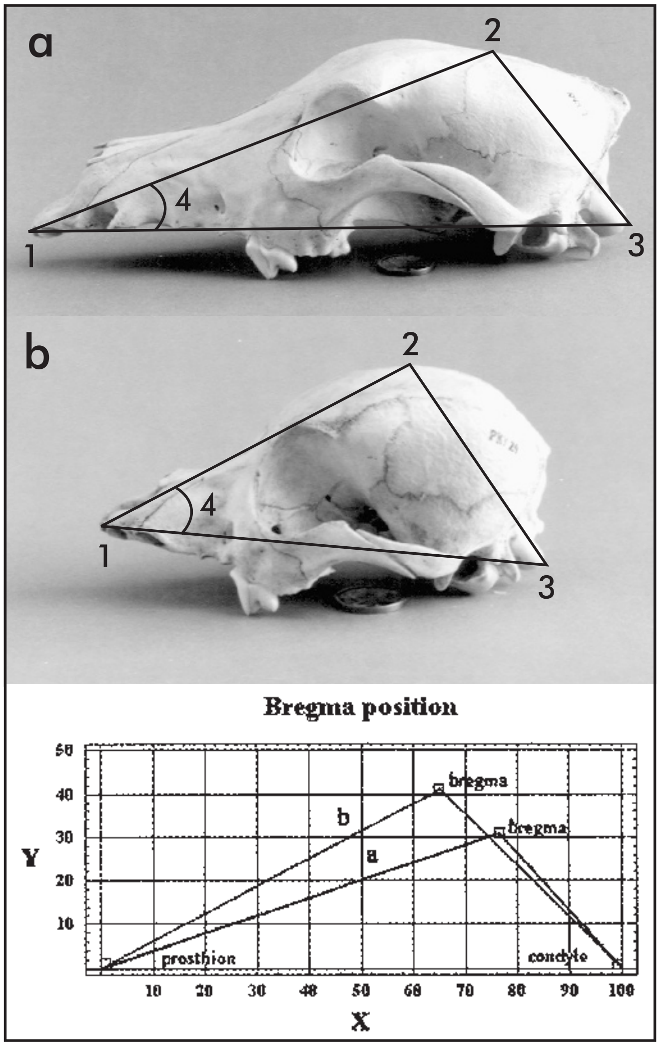

Figure 1. Large (a) and small (b) domestic dog skulls. The actual prosthion-condyle length of a is 185.5 mm, and the actual prosthion-condyle length of b is 109.2 mm. The graph provides a comparison between standardizing triangles prosthion-bregma-condyle of skulls a and b. Skull b is relatively taller than skull a. For a comparison of bregma position in different canid skulls see Figure 2. Axis X on this figure shows the relative "x" coordinate of the bregma while axis Y shows the relative "y" coordinate of the bregma. Coin in the photographs is 17.5 mm. Key: 1–prosthion, 2–bregma, 3–condyle, 4–facial angle.

Table I. Description of measurements.

(a) M^1L. Length of upper first molar.
(b) M^1W. Width of upper first molar.
(c) M^2L. Length of upper second molar.
(d) M^2W. Width of upper second molar.
(e) P^4L. Length of upper fourth premolar.
(a') Condylobasal length.
(b') Maximum skull width across the zygomatic arches.
(c') Skull breadth across the mastoid process.
(d') Postorbital proces width.
(e') Interorbital breadth.
(f') Minimum width of cranium at postorbital constriction.
(g') Cranial vault width to parietal-temporal suture.
(i') Face length.
(j') Length of auditory bulla from the carotid channel to the farthest back area.
(k') Basicranial axis length.
(p') Basisphenoid-presphenoid suture to bregma length.
(q') Opisthion–bregma length.
(r') Prosthion-bregma length.

For aditional information on cited landmarks, see García-Pozuelo-Ramos (1998,1999).

principal variance components. Because PC axes are perpendicular, variation on one axis is not correlated to another and can be used to define independent patterns of variation in the group of crania studied. It has been proved that the effects of size that usually dominate PC1 (in this study 83.4 per cent of variance was attributable to differences of size) can be viewed independently, to some degree, from variability of shape (Lemen, 1983). The contribution of the PC2 to the variance is 6 per cent, and that of PC3 is 4.6 per cent. Besides this, PC2 and PC3 both reveal readily interpretable patterns that permit the differentiation of domestic and wild dogs (PC2 axis in Figure 3), and small and large domestic dogs (PC3 axis in Figure 3). On the contrary, the contribution of the PC4's to PC18 to the variance is 6 per cent, and did not reveal any readily interpretable patterns of the differentiation for canids (data not shown). Hence I used PC2 and PC3 in the analysis of the canid shape. The variable loading on each PC provides an indication of the relative contribution of each measurement (eighteen in this study) to the variation along that component (Table II). Samples were assessed by a PCA on the correlation matrix. The data were log transformed since the raw data would overemphasize large traits such as the prosthion-condyle length , which, is approximately 15 times the length of upper first molar, a small trait.

Results and Discussion

The variability of the domestic dog skulls is evident when we look at two different skulls. Figure 1 shows the crania of the two representative adult dogs (1a and 1b) belonging to different breeds. The landmarks prosthion, condyle, and bregma create a triangle which allows us to study the variability in the sagittal plane of the cranium. The graph shows these standardized triangles plotted on coordinates. The landmark prosthion is located at the origin of the coordinates (0.0), and the landmark condyle on the X axis (100.0). The measurements have been standardized to

Table II. Table of Component Weights in Principal Component Analysis(PCA)

Measure	PC 1	PC2	PC3
a	0.23492	0.10473	0.36075
b	0.23729	0.15763	0.32922
c	0.23398	0.17848	0.15326
d	0.22817	0.30508	0.24338
e	0.23026	0.01121	0.40352
a’	0.24943	0.16302	-0.16101
b’	0.24066	-0.21964	-0.13482
c’	0.24813	-0.03339	-0.23762
d’	0.22281	-0.15012	-0.23153
e’	0.23951	-0.18815	-0.22195
f’	0.20964	-0.43792	0.25888
g’	0.23765	-0.18898	0.18471
i’	0.24652	0.18647	-0.05749
j’	0.20826	0.43406	-0.29114
k’	0.23840	0.15012	-0.31090
p’	0.23063	-0.35399	-0.01677
q’	0.24939	-0.02341	-0.13520
r’	0.25128	0.07814	-0.08961
Variance	83.4%	6.0%	4.6%

compare the shapes and avoid the effect produced by the difference in size (see Materials and Methods). The landmark bregma constitutes the point that distinguishes the different sagittal triangles of the crania. Figure 2 shows the scatter plot of bregma coordinates of a sample of domestic dog and wild dog skulls. Intermediate size dogs have been eliminated to emphasize the differences between large and small dogs. We can see the dispersion of points, that is, the variability of this sagittal plane triangle in the crania of domestic dogs when they are compared with a limited sample of several different genera of wild canids. Variability in the domestic dog is greater than variability within other canid species in this study.

This domestic dog variability is at least a variability characteristic of a typical genus taxon, if not greater, as some authors have remarked (McKeown, 1975; Wayne, 1986). The skulls of small dogs are relatively taller than the crania of large dogs or those of wild dogs. The facial angle bregma-prosthion-condyle in the small dogs is greater than in large dogs or wild canids. Large dogs, however, can have a skull as short as the shortest of wild dogs (see Figures 1 and 2). All small breeeds as adults have a skull which is in gereral morphology “juvenile” (paedomorphic adults, Wayne, 1986). Figure 2 shows how one of the small dogs has a sagittal triangle practically identical to two juveniles (see uppermost three points in Figure 2.)

The PCA gives a more general view in cranium study. To avoid most of the differences of size between the canid’s crania we do not include in this work PC1. PC1 is responsible for most of the variability in dogs, and it refers

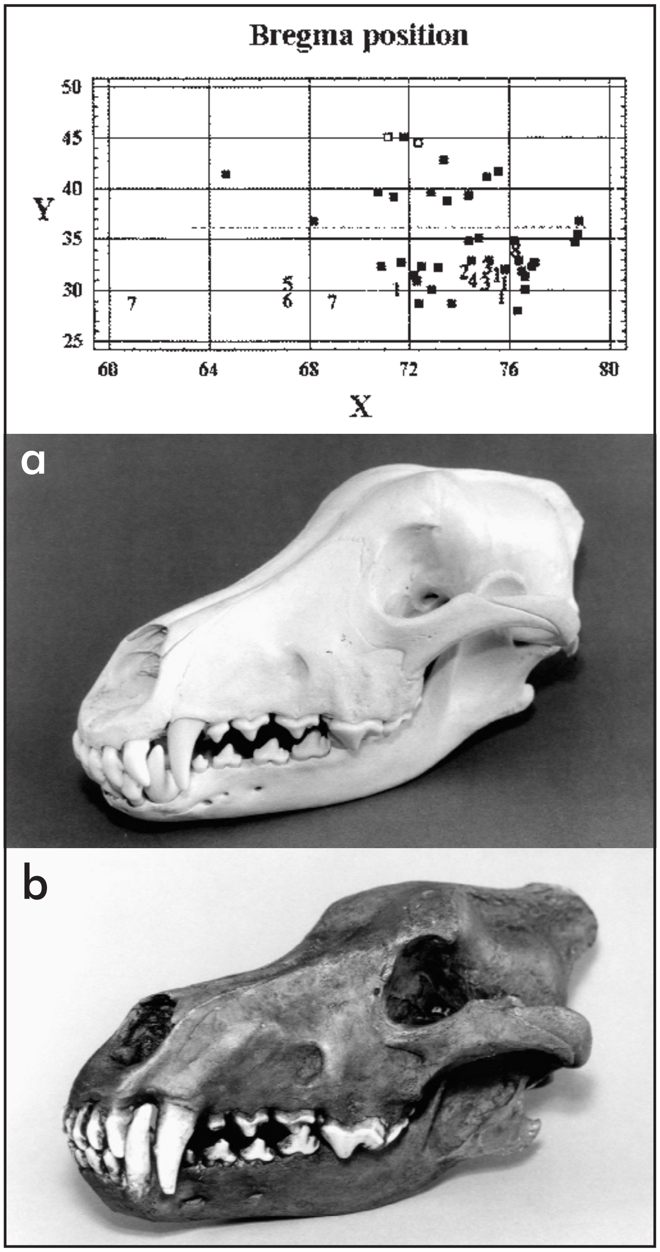

Figure 2. Scatter plot of relative bregma position. The dotted line separates the smaller skulls (above the line) from the larger skulls and those of other species of canids (below line). White squares correspond to juvenile domestic dogs. Solid squares correspond to adult domestic dogs. Numbers correspond to wild dogs. (1) Coyote (*Canis latrans*). (2) Black-Backed Jackal (*C. mesomelas*). (3) Gray-Wolf (*C. lupus*). (4) Red fox (*Vulpes vulpes*). (5) Racoon dog (*Nyctereutes procionides*). (6) Swift fox (*V. velox*). (7) Gray fox (*Urocyon cinereoargenteus*). (8) Dire wolf, fossil (*Canis dirus*). X on this plot is a particular skull’s relative bregma “x” and Y is its relative bregma “y”. Each point represents one animal. Small dog skulls n=12. Large dog skulls n=24. Wild dog skulls n=13. a) *Canis lupus* (Gray Wolf) skull. b) *Canis dirus* (Dire Wolf) skull.

especially to size. PC2 entails 6 per cent of the variability and allows one to differentiate between domestic dogs and wild canids effectively, as show the Figure 3. The variables implicated in the differentiation between domestic dogs and wild dogs are the ones corresponding with the teeth (a, b, c, d, and e), the lateral face length (i'), basicranial length (k'), and the tympanic bulla (j'). Of these variables, the most prominent are d and j'.

PC3 consists of 4.6 per cent of the variability and allows to differentiate the small domestic dogs from other domestic dogs. The variables implicated in this discrimination are teeth (a, b, c, d, and e), as well as the maximum cranial width (g'), and least cranial width (f'). In PC2 as well as in PC3 the dental variable M^2W (d) prominently figures in the discrimination between domestic dogs and wild dogs, and between large versus small domestic dogs. The research by Wayne (1986) also highlights the value M^2W as a discriminant between domestic dogs and wild dogs. Each point on the scatter plot of Figure 3 has the PC2 and PC3 values of each particular domestic dog skull for its X and Y coordinates respectively. Figure 3 shows the morphologic spaces of domestic dogs and wild canids. It is obvious that the morphologic space of the domestic dog is quite large, compared to the space made from the sample of wild canids. It is also obvious that the small dog sample has a distinct morphologic space from the large dogs (PC3 axis in Figure 3).

The space occupied by the domestic dog does not include breeds of dogs with prominent disharmony of the jaw, evidenced by the lower jaw protrusion. An example of this type of prognathic dog has been situated in the graph of Figure 3 as a reference (point labeled "+"), and it belongs to boxer-like dog. In the research of Wayne (1986), we observe that the pattern of skull morphology among domestic dogs and wild dogs is not similar, and it overlaps only with the close wolf-like relatives, the gray wolf and the black-backed jackal.

The extensive variation of the shape observed in the domestic dog is not accompanied by a prominent genetic variation. Cases similar to this are frequent among domestic animals and plants (Darwin, 1868). And the same variation that occurs under domestication can occur in the natural environment, given the proper conditions (Johnston and Selander,1964; Losos, 1997; Reznick et al., 1997). Under stressful conditions of domestication, the fox (*Vulpes vulpes)* increases its variability. In approximately 20 years time, the wild fox has altered its behavior becoming a domestic animal. It changed a few aspects of its morphology, undergoing hormonal changes. It even underwent changes of the karyotype (Belyaev, 1979). Parsons (1986) has suggested that these explosions of variability concentrate in periods of environmental stress.

Cases of environmental stress could have been frequent in nature on a worldwide scale after the Fall and again as a result of the Flood. But what is it that unleashes a process of variation under conditions of stress? Crossing-over (i.e., genetic recombination) is more frequent and mutations are more common under stress. Mobile genetic elements increase their mobility, passing from one place to another in the genome which produces alterations of genetic function (Belyaev and Borodin, 1982; Parsons, 1986). Molecular details of these processes have been seen in recent investigations. Heat-shock proteins are produced under high temperatures stress conditions. One of these protein (Hsp90) under normal conditions involving no stress, masked certain genetic determinants in *Drosophila*. When Hsp90 was altered, under stress conditions, the hidden genetic variation is expressed and continued to be expressed even when Hsp90 was restored to its normal state. Morphological alterations depended only on the genetic background.

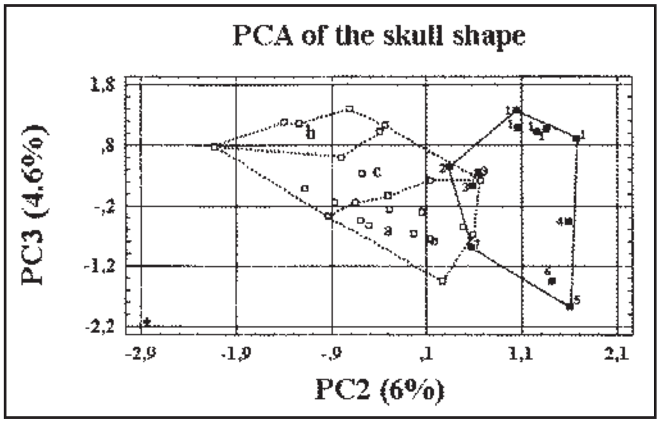

Figure 3. Polygons with dotted line correspond to domestic dog morphospace. Poligon "a" correspond to large skulls (n=15). Polygon "b" correspond to small skulls (n=7). Polygon "c" correspond to intermediate skulls (n=3). The point on this figure which represents a typical prognathic dog like the boxer is in left inferior corner, labeled with symbol +. Poligon with continuous line correspond to wild canids morphospace (n=12). See Figure 2 for numeration. It is obvious that the domestic dog has undergone great variation. But its morphospace has very little overlap with that of the wild canids species. Likewise small dogs and large dogs occupy different morphologic spaces. Each point represents one animal.

To demonstrate that stress played an important role in the diversification of baramins after the Fall and after the Flood would be more difficult. Currently, however, there is a theoretical possibility of checking this. Under environmental stress, a fluctuating asymmetry is produced, that is, an alteration of the organismal morphological symmetry produced by a developmental instability (Parsons, 1992). Study of fluctuating asymmetry can reveal whether or not stress was a cause for the increase in variability in living beings after the Fall and after the Flood.

The great number of fossil specimens required to make this research possible, however, would present a problem.

Also it is possible that the Creator may have manipulated and enriched the genetic pool of mankind, animals, and plants after the Flood (Lammerts and Howe, 1974; Lammerts, 1983). An exceptionally favorable situation for change must have also occurred after the Flood, at which time the Earth was being completely repopulated (Woodmorappe, 1996; Brand, 1998). In that environment, the potential for variation in the species had the right opportunity to be manifested and life would have undergone diversification in a great measure. But even this post-Flood enhanced variation would have been within the limits imposed by the biological laws of Creation.

It should not astound us that human beings would have also varied under those post-Flood conditions. Ethnic groups like the Neanderthal, different from any present ethnic groups, could have emerged at the end of the Flood. Or perhaps it was modern man who differentiated from Neanderthal. Something similar could have happened with *H. erectus*. It also is possible that the differences were the result of different longevities among those ethnic groups and present man (Cuozzo, 1998). The craniodental variability of metric traits within the group that includes *H. erectus*, fossil *H. sapiens*, and *H. sapiens sapiens* (present) is not greater than that found in the domestic dog (García-Pozuelo-Ramos, 1998; 1999). Concerning variation of the craneodental shape in fossil humans, it is very difficult to study because the remains are quite scarce and fragmentary. Yet, it is possible that *H. erectus*, fossil *H. sapiens*, and *H. sapiens sapiens* form part of a common morpho-space characteristic of the holobaramin to which they belong. They may all be the post-Flood descendants of the Biblical Adam and Eve.

Conclusion

Humans have modified the genetics and hence the morpho-space of dogs by selective breeding for centuries. Thus it is obvious that each kind (like the dog kind) has a tremendous potential for variation, a potential which is seldom expressed so completely as it has been in dogs. Perhaps after the Biblical Flood, human beings, migrating to different localities, were forced into such diversified nascent habitats that the original *Homo sapiens* rapidly underwent enough variation to yield modern man and the fossil men including *H. erectus* and fossil *H. sapiens* as direct descendants of Noah and his sons. It is also possible that the Creator exercised some direct genetic manipulation when people were migrating into the post-Flood world.

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Book Review

Quest for Truth: Scientific Progress and Religious Beliefs by Mano Singham

Phi Delta Kappa Education Foundation, Bloomington, IN. 2000, 184 pp., $22

Mano Singham is a professor of nuclear physics at Case Western Reserve University in Cleveland. I first became aware of Prof. Singham through his recent thought-provoking article, *The Science and Religion Wars (2000)*. In *Quest for Truth*, Dr. Singham expands on the subject introduced in his *Kappan* article. He also delves fully into the realm of the philosophy of science. His insights are intriguing and in places difficult to understand. But the book is nevertheless an excellent read for those interested in the overlap between science and religion.

Prof. Singham starts out by describing four models of "creationism":

1. *Creation science*, the belief that "the universe, life, humans, and other major species were created more or less whole by a divine Creator within the last ten thousand years or so" (p. 9).
2. *Gap theory*, in which the "creation process could have involved multiple cataclysms and creations and is flexible enough to accommodate most geological evidence" (p. 9). In other words, the universe is old and God intervened only at specific critical times in history.
3. *Day-age model*, in which the "six 'days' of creation in the Genesis story are interpreted metaphorically as representing long but indeterminate periods of time. . ." (p. 10).
4. *Intelligent design*, in which proponents "*infer* that some form of divine guidance (a Creator) had to be present and actively involved . . . to explain the appearance of life in all its present forms. . ." (p. 11).

One may quibble a bit with Singham's terminology; for example, intelligent design proponents don't normally refer to their position as creationist. However, it is clear from the book that Dr. Singham has studied creation positions in detail and knows the basic tenets.

Singham accurately defines what he calls the creationist point of view: "If there is one common thread that all creationists share, it is that the world as we know it now is too complex and subtle to have come about without the active and repeated intervention of an external agent or a diety, acting outside the laws of science" (p. 11).

Singham goes on to contrast this with the naturalist point of view: "The scientific establishment, conversely, starts with the assumption that all natural phenomena should be explainable by natural [material, physical] laws that can be discovered using the methods of science" (p. 13). Since supernatural miracles "have no place in this framework" (p. 13), the creationist and naturalist worldviews are inevitably in conflict. (It may be noted that many scientists do not support this definition, but Singham is certainly correct that the science *establishment* adopts a naturalistic posture.)

Prof. Singham laments the fact that "there seems to be very little attempt by any of the protagonists in the science-religion wars to really understand what the other groups are saying" (p. 31). Instead, both sides typically use vitriolic