Genetic and Environmental Influences on the Shape of the Adult Dog Skull

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This investigation examines the relative role of genetic and environmental factors in the production of shape in the skull of the adult dog. Changes in shape during growth are illustrated by the use of angular measurements on over-all skull shape. The final or adult values attained as a result of the growth process are compared in a variety of different animals selected for similarities and differences in genetic and/or environmental background. Similar adult angular values should suggest similar genetic and environmental influences, while variations in adult values suggest genetic and/or environmental differences in the animals concerned.

The material presented comes from studies on skull growth and variations in dogs and related animals.

MATERIAL

A longitudinal growth study was carried out on ten dogs from birth until maturity. A litter of five pointers and a litter of five boxers were examined. Dry skulls were prepared from twenty-one adult greyhounds who were thought to be unrelated to one another.

A collection of 120 adult dogs of known breed was recorded in museums in Britain, and a collection of 75 adult foxes collected from two counties of Northern Ireland over a two-year period was also studied. The fox group was considered to be a representative sample of the local fox population Reference will also be made to parallel cross-sectional and longitudinal material from other species including man.

METHODS

The longitudinal data comprised cephalometric radiographs taken at regular intervals throughout growth and including the adult stage. Radiographs were taken in anteroposterior and 90° basilar orientations using an Adams' cephalostat with x-ray anode placed five feet from the centre of the machine.[1] In the anteroposterior position, the head or skull was placed with the Frankfort plane at right angles to the film and parallel to the film in the 90° basilar position.

Records of dry skulls were also made using a photographic technique. This involved the placement of a single lens reflex camera with 1,000 mm Zeiss compound lens at twelve meters from the cephalostat. The resulting records were printed on dimensionally stable photographic paper. The three-dimensional distortion incurred is very much lower than that found in cephalometric radiographs using the standard five feet anode distance.

The points and lines used in the study were traced directly from the radiographs and photographs and then measured. The precision of the records for the dry skull analysis was considered critical; thus reproducibility tests were carried out to determine the error of the method.

Radiographic records were made on Dupont Cronex 4 12" x 10" film using film cassettes with fast intensifying screens. Most records were made at 90 KV with exposure times of 0.2 - 0.5

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TABLE I

REPRODUCIBILITY TEST ON A GREYHOUND SKULL

	Angle 1	Angle 2	Angle 3	Angle 4	Angle 5
Range of Variation of 21 Records	1.0°	1.5°	1.5°	1.25°	7.0°*
Orientation test					
Normal position +10°	34.5°	44.5°	91.0°	77.5°	Not measureable
Normal position —10°	36.0°	49.0°	98.5°	82.5°	Not measureable
Difference	1.5°	4.5°	7.5°	5.0°	———

* On photographic records the variation was 2.5°

seconds. Photographic records were made on Ilford Pan F 35 mm film and printed on Ilfoprint stabilization paper.

Reproducibility Records

A greyhound skull was placed in the cephalostat on twenty-one separate occasions and basilar and AP radiographs taken. The resulting films were each measured and the range of variation for each angle calculated. This was also done using the photographic technique. In addition, radiographs were taken with the skull tipped forward and backward from the normal orientation so that the Frankfort horizontal plane lay at plus and minus 10° to the correct orientation in an attempt to assess the error created by unknowingly incorrect positioning. The results are shown in Table I.

The Analysis

Points were chosen and angles measured in accordance with the following principles:

1. Points chosen should be identifiable in a wide variety of animals and at different stages in their growth.

2. The points, or close approximations to them, must be identifiable on photographs of the dry skulls as well as on the radiographs of living animals. This allows comparisons between longitudinal, cross-sectional, and adult data.

3. The points chosen, and the angles derived from them, should reflect the shape of the entire head and be referable to a common baseline (the intercondylar axis).

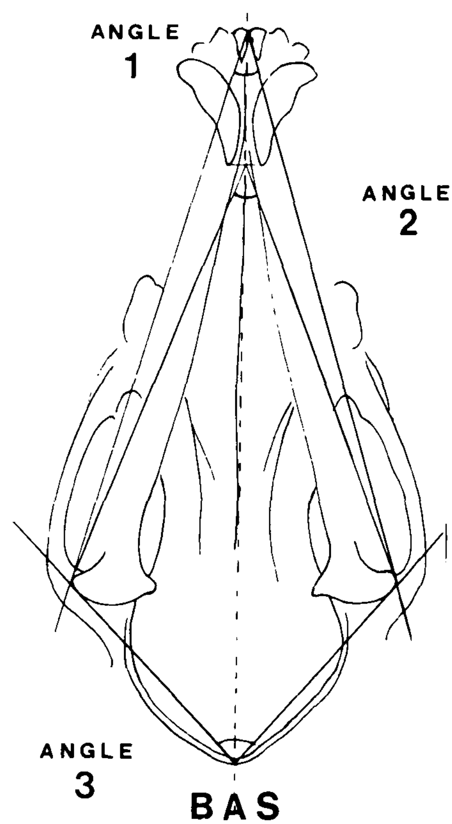

Fig. 1

In the basilar view, Fig. 1, Point 1 is the most anterior point on the alveolus of the lower jaw in the midline; Point 2 is the midpoint of the line joining the apices of the perman-

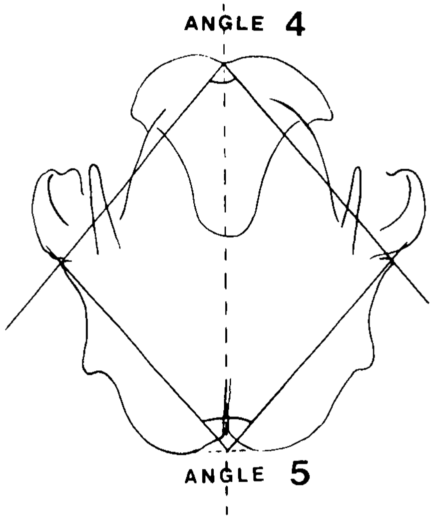

Fig. 2

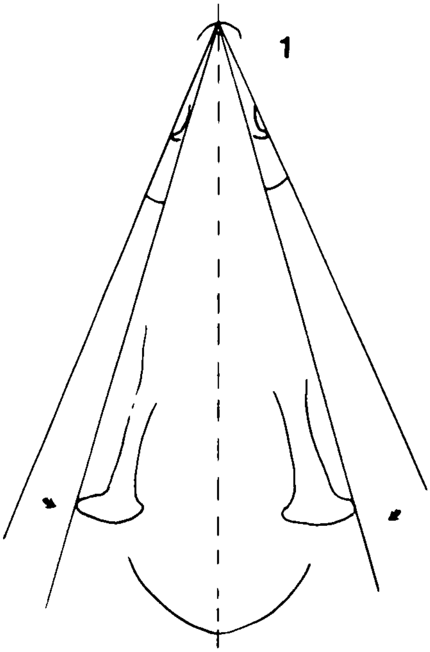

Fig. 3

ent lower canines and Point 3 is the most posterior point on the cranial outline at the back of the skull. On photographic records, the point used was the most anterior point on the rim of the foramen magnum.

Anteroposteriorly (Fig. 2) Point 4 is the most superior point on the external cranial outline, situated in the midline and being the point of maximum concavity on the bony profile between the frontal sinuses; Point 5 is the lowermost point in the midline at the point of intersection of the line joining the lowest points of the body of the mandible on each side with the midline. The condylar points are the most external points on the periphery of each condyle. The condylar references axis is the line joining the two condylar points in either anteroposterior or basilar views. It lies by definition at right angles to the centre plane of the head; to obviate any slight asymmetry the left condyle takes precedence.

The Angles

Angle 1 is the angle created by

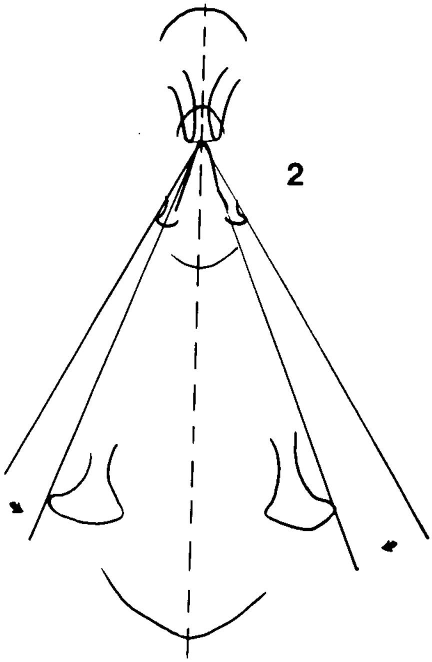

Fig. 4

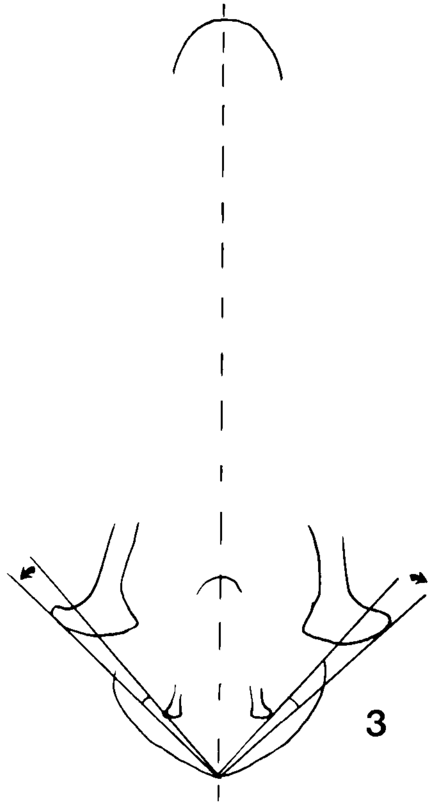

Fig. 5

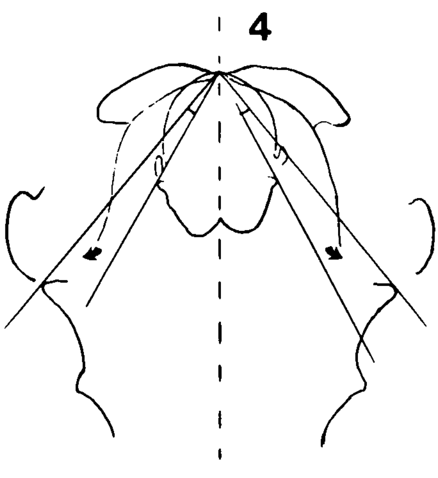

Fig. 6

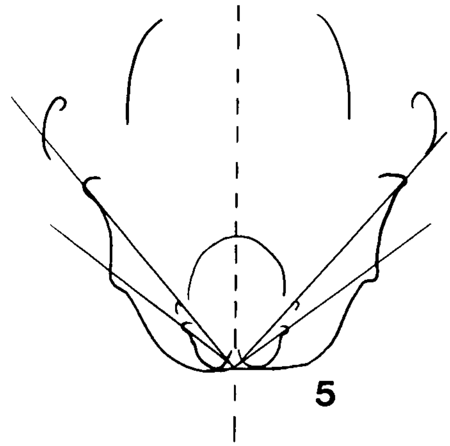

Fig. 7

joining Point 1 to the condylar axis. Angle 2 is the angle created by joining Point 2 to the condylar points and similarly for Angles 3, 4, and 5.

Results

Figures 3-7 illustrate the angular changes occurring between birth and maturity in the dog skull. Angles 1 and 2 decreased in value during growth while Angle 3 increased (basilar view). Angle 4 increased and Angle 5 decreased (anteroposterior view). This occurred in all ten dogs.

Studies in other animals and species including man show that these angular changes appear to be universal for the mammalian skull. The magnitude of angular change and, of course, the adult values differ in every instance. In the dogs the change of angularity is approximately 10° in each angle. This investigation is not concerned with the details of the changes, but with the adult angularity arrived at as a result of the total growth activity.

Adult Analysis

The angular measurements of the adult boxers and pointers were compared with the greyhound, dog breeds and fox collections. The results are shown in Table II.

TABLE II

ADULT MEAN ANGLES AND THE RANGE OF VARIATION

ANGLES	1		2		3		4		5	
	M	R	M	R	M	R	M	R	M	R
Boxers	41.5	3.0	46.0	3.75	105.0	3.0	76.8	10.0	98.8	5.0
Pointers	34.4	1.0	41.5	1.5	89.8	7.0	63.0	6.0	86.8	10.0
Greyhounds		4.0		5.5		20.5*		9.5		13.5
Assorted Breeds		38.0		25.0		40.0		20.0		46.0
Foxes		5.0		7.5		8.5		11.5		11.0

*This variation would have been 8.5° if one animal had been excluded.
M = Adult mean angularity
R = Range of adult angular variation

If Angle 1 is examined, it can be seen that the range of variation in the five pointers is only 1° and in the boxers 3°. The mean values for each group are, of course, different. The reproducibility tests indicate that this is the most reproducible angle thus the true variation is very limited. The greyhound group showed a variation of only 4° for this angle which is surprisingly small considering the animals were unrelated and grew up separately. All came from racing dog sources and were presumed to have enjoyed favorable conditions during growth. In marked contrast the museum collection of dog breeds showed a variation of 38° in Angle 1. In the absence of a wild dog to act as comparison, the fox collection was examined. The fox skull is very similar to that of the dog. Angle 1 varied only 5°, a similar variation to that seen in the greyhounds.

The other four angles vary in a manner similar to Angle 1. In some instances, e.g., Angles 3 and 5, the greyhound variation exceeds that of the fox. The variation of all the other angles is greater than Angle 1, and this is only partly accounted for by the error of the method. It should not be assumed that increased angular variation necessarily indicates a greater environmental influence on the areas being measured when comparisons between groups are not involved.

Conclusions

A limited angular variation in adult groups in comparison to the changes occurring throughout growth suggests a high degree of consistency in the results of the growth process, e.g., a range of variation of 1° for Angle 1 in the pointers is remarkably small. It could also be argued that, since the measurement is bilateral, the magnitude of the angles and their variation is biologically half of the recorded value, since the structure is basically bilaterally symmetrical. Even if one has eliminated measurable environmental variation in a group of animals brought up under similar environmental conditions, the very small angular variation suggests that adult shape is precisely attained and that the growth process itself is accurate to the degree observed. While variation is always attributed to genetic and environmental factors, it is seldom asked whether it could be the result of imprecision in the growth process itself. These results suggest that this is not the case.

The fact that foxes vary no more than greyhounds suggests that their more vigorous environment has little influence on their adult angular values. This comparison unfortunately crosses a species barrier. Studies on variation in other wild canidae, however, suggest that the magnitude of variation in wild species is generally similar; thus it is hoped that the comparison is valid. The domestic dog exhibits an enormous range of variation. It seems certain that most of this has developed by the perpetuation of mutant forms by man.

It is not suggested, however, that environment has no effect on the growth of the skull. Much evidence exists to the contrary. It seems that whatever alterations occur in the rate of growth at specific times during growth, compensatory activity results in the attainment of a consistent end point in angular terms. An important element not considered here is size. The relationship between size and shape is extremely important. The animals examined here often showed marked size variation in spite of their shape similarity. It seems possible that environment could affect size much more than shape.

The results strongly support the hypothesis that adult shape (as measured in the study) is little affected by environmental factors. This should be qualified by adding that the magnitude of environmental differences in the group is largely undetermined but is felt to approximate that usually encountered by the animals concerned. This type of investigation can be criticized in that it does not adhere to the traditional one variable experimental situation. The "clinical" problem does, however, involve the whole environment and its total effect. A measure of this can only be obtained by this type of approach. It is suggested that this type of comparative investigation in conjunction with experiments on specific environmental alterations in animals can give us a much better understanding of the response of the growing skull to its environment.

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REFERENCE

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