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The Effect of Sex and Genetic Lines on the Skull Dimension for Japanese Quail

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Abstract

The aim of this study was to contribute to quail head morphology and Create basic data sources for comparative measurement in the quail skull. The current experiment was done in the poultry farm of the animal production department, college of Agriculture - Kirkuk University, from (22/04/2022 to 22/07/2022), 120 unsexed chicks were used (White quail=40, Brown quail=40, and Gray quail=40), rearing on the cages, the diet and the water *ad libitum* when the flock reached 120 days of age 5 male, and female were chosen randomly to slaughter. Following the slaughter, the heads were gathered, boiled, and the characteristics of the skull were measured using a Caliper Vernier with an accuracy of 0.01 mm. There were significant differences in some dimensions, as the Pro. The Sprameaticus of squamosal bone was larger in the brown genetic line compared to the white one, which was smaller. This is also the case with Postorbital process, as for the other dimensions, there were no significant differences between the genetic lines. There were highly significant differences in many dimensions, where the female white quail excelled over the rest of the birds in the Cerebellar prominent trait, and in the Exoccipital bone trait and Postorbital process, the male white quail excelled over the other birds. The gray female quail also excelled in the Postorbital process, The Dorsal middle point of frontonasal structure, and the Middle point of frontonasal structure Basilar tuberculum of basioccipital bone, over the other of the birds. As for Paraoccipital process, white males, gray males and females outperformed other birds. As for the other characteristics, there was no significant effect among the studied interactions.

Keywords: Japanese quail, genetic line, skull dimension, skull bones,

Introduction

The species known as *Coturnix japonica*, or quail, belongs to the Phasianidae family (1). Japanese quail was successfully transferred from Japan to America, Europe, and the Middle East and Near East. The taming of Japanese quail began in Japan in the 11th decade (2, 3). Quails are also often utilized as experimental animals. Due to these characteristics, rapid development, early sexual maturity, and low feed consumption, quails are commonly employed as in vivo models in physiological, pathological, toxicological, and anatomical research (4, 5). The rise in quail meat and egg consumption in recent years has also bolstered the bird's economic aspect (6, 7, 8). Color of quail feathers is regarded as a race or hereditary characteristic. Mutations in the color are responsible for variations in the color of quail feathers (9). White, brown, yellow, wild type (gray), and roux are the hues of the feathers (10). Owing to their unique mode of transportation, birds acquired some physical characteristics that set them apart from other creatures (11). The avian skeleton is adapted to active flying, in contrast to that of mammals. This special capacity is crucial to the preservation of bird species (12, 13). The thin bony plates of the quail's skull are made of cartilaginous templates or connective tissue, much like in the skulls of all birds (14). Birds have a third form of bone tissue termed the medullary bone in addition to the cortical and cancellous bones. The latter acts as a calcium store, which is crucial for females in relation to the development of their eggshells (15, 16). Like other vertebrates, avian skulls are composed of two parts: the splanchnocranium and the neurocranium. The Occipital, sphenoidale, squamosum, parietale, frontale, paired ossa otica, unpaired os mesethmoidale, ectethmoidale, and lacrimale comprise the neurocranium in birds (17, 18). Aerodynamic in form, the head tapers rostrally. The form and size of the bird's beak mostly determines the size and shape of its thin, typically tiny facial bones. The borders between the bones of the neurocranium are nearly undetectable since the bones of the neurocranium are entirely merged with one another (19).

The shape of the beak dictates the conformation of the facial skeleton (20). Because of the moveable connection with the skull, one unique trait is the capacity to lift the upper half of the beak. The os quadratum, the major component of the maxillopalatine apparatus, ensures this. The temporomandibular joint in mammals is analogous to it (21, 22). Particularly in tiny birds, the braincase is quite massive, and the orbits are very big, divided from one another by a narrow interorbital septum. Other vertebrates are unable to achieve the range of head mobility that the skull has because it is joined to the vertebral column by a single occipital condyle (23, 24). Similar to other birds, it can be difficult, if not completely impossible, to distinguish the sex of quails based only on the physical characteristics of their skulls. We think that the gender distinction in quails will be successfully achieved by the application of geometric morphometrics in skull dimensions (25).

A frequently used method in the taxonomic categorization of animals is craniometrics, in this instance, morphometric data is used to establish interspecific differences (26). From the perspective of intraspecific polymorphism and interspecific comparisons, the skull is an object of both geometric and linear morphometric, the study of species patterns and evolutionary processes is also made possible by geometric morphometries (27). The main uses of feather colors have been in the following domains: sex selection; speciation and regional difference analysis; and diversity evolution (28).

The majority of plumage color variations within and across species have a significant genetic component. According to many recent researches, quail plumage color changes are mostly caused by the interplay of certain gene mutations or combinations of mutations (29). In an effort to connect the effects of feather color with growth characteristics in Japanese quails, also came to the conclusion that morphological traits specifically, feather color played a major role in both the identification process and the choice of quail varieties (30). The taxonomic categorization of animals and the identification of gender differences have benefited from the widespread use of geometric morphometric techniques on a variety of breeds and species in recent years (31). Therefore, the present study was conducted to determine the effect of plumage color patterns to identify the form differences between male and female quail individuals and to use geometric morphometries to assess the sex dimorphism of quail craniums.

Materials And Methods

The current experiment was done in the poultry farm of the animal production department, college of Agriculture - Kirkuk University, from (22/04/2022 to 22/07/2022), 120 unsexed chicks were used (White quail=40, Brown quail=40, and Gray quail=40), rearing on the cages, the diet and the water *ad libitum* when the flock reached 120 days of age 5 male, and female were chosen randomly to slaughter from each line. Following the slaughter all the heads were undergo dissection, muscles ,and skin and soft tissues were removed, the heads were gathered, boiled for a half hour ,and soaked in 5% hydrogen peroxide (H2O2) for 30 min to remove fatty tissue. Following these steps, the skulls were allowed to dry at room temperature in a well-ventilated area for one week (32), and the characteristics of the skull were measured using a Caliper Vernier with an accuracy of 0.01 mm according to (33) landmarks. A general linear model (GLM) within the SPSS program was used to calculate the mean, standard error, and significance. Duncan multiple range test was used to test the differences between the means (34).

Result

Table 1. Shows the effect of the genetic line of the Japanese quail on the size dimensions. There were significant differences in some dimensions, as the Pro. Sprameaticus of sequamosal bone was larger in the brown genetic line (18.876) mm compared to the white one, which was smaller. This is also the case with the Postorbital process (16.833) mm, as for the other dimensions, there were no significant differences between the genetic lines. Table 2 shows the effect of the genetic line of the Japanese quail on the sex of the bird. The table shows that there are no significant differences in the dimensions of size.

Table 3 shows the effect of the interaction between the genetic line and sex of the Japanese quail on size dimensions. There were highly significant differences in many dimensions, where the female white quail excelled over the rest of the birds in the Cerebellar prominentia trait (13.634) mm, and in the Exoccipital bone trait and Postorbital process, the male white quail excelled over the other birds (6.718, 15.731) mm respectively. The gray female quail also excelled in the Postorbital process, Dorsal middle point of frontonsal structure, and Middle point of frontonasal structure Basilar tuberculum of basioccipital bone (17.022, 4.941, 24.626) mm respectively, over the other of the birds. As for Paraoccipital process, white males, gray males and females outperformed other birds (15.481, 15.833, 15.654) respectively. As for the other of the characteristics, there was no significant effect among the studied interactions.

Table 1: The effect of genetic line on the Skull dimensions

Traits	White line		Brown line		Gray line	
	Mean	SD	Mean	SD	Mean	SD
Cerebellar prominentia	13.447 a	0.08	13.412 a	0.07	13.521 a	0.08
Exoccipital Bone	6.272 a	0.13	6.454 a	0.12	6.126 a	0.13
Proc. Suprameaticus of sequamosal bone	18.193 b	0.14	18.867 a	0.13	18.604 ab	0.14
Temporal fossa	15.301 b	0.08	15.650 a	0.08	15.386 b	0.08
Postorbital Process	16.544 ab	0.10	16.833 a	0.09	16.538 b	0.10
Dorsal Middle point of frontonasal structure	4.602 a	0.09	4.757 a	0.08	4.705 a	0.09
Craniolateral terminal point of frontal bone	6.020 a	0.11	6.154 a	0.11	6.294 a	0.11
Foramen magnum high	2.846 a	0.05	2.890 a	0.04	2.959 a	0.05
Foramen magnum Width	3.740 a	0.05	3.907 a	0.04	3.844 a	0.05
Paraoccipital process	14.804 a	0.22	15.358 a	0.21	15.271 a	0.22
Postorbital process	14.917 b	0.17	15.549 a	0.16	15.221 ab	0.17
Middle point of frontonasal structure Basilar tuberculum of basioccipital bone	24.051 a	0.12	24.427 a	0.11	24.421 a	0.12

Means not having a common letter (a, b,) within each column differ significantly (P<0.05).

Discussion

In this experiment, the skull of quail birds was examined to determine and see the morphological differences between the male and female, in addition to the differentiation of dimension in some specific bones that related to the effect of the color. The study found that the male and female samples' form variances were quite close to one another. Meanwhile, the diversity between genetic lines was more evident. And that what was table 1 revealed. It shows the effect of the genetic line of the Japanese quail on the size dimensions. There were significant differences in some dimensions, as the Pro.

Table 2: The effect of gender on the skull dimensions

Traits	Male		Female	
	Mean	**SD**	**Mean**	**SD**
Cerebellar prominentia	13.586	0.07	13.334	0.09
Exoccipital Bone	6.334	0.12	6.234	0.16
Proc. Suprameaticus of sequamosal bone	18.322	0.12	18.787	0.16
Temporal fossa	15.504	0.07	15.387	0.10
Postorbital Process	16.571	0.09	16.706	0.12
Dorsal Middle point of frontonasal structure	4.671	0.08	4.705	0.10
Craniolateral terminal point of frontal bone	6.276	0.10	6.036	0.14
Foramen magnum high	2.886	0.04	2.911	0.06
Foramen magnum Width	3.759	0.04	3.902	0.06
Paraoccipital process	15.370	0.20	14.918	0.27
Postorbital process	15.495	0.15	14.964	0.20
Middle point of frontonasal structure Basilar tuberculum of basioccipital bone	24.254	0.11	24.345	0.15

Means not having a common letter within each column differ significantly (P<0.05).

The Sprameaticus of sequamosal bone was larger in the brown genetic line (18.876) mm compared to the white one, which was smaller. This is also the case with the Postorbital process (16.833) mm, as for the other dimensions, there were no significant differences between the genetic lines. This result was in agreement with (35), which shows the significant effect of the color pattern on the size and shape of the skull in avian. Table 3 shows the effect of the interaction between the genetic line and sex of the Japanese quail on size dimensions. There were highly significant differences in many dimensions, where the female white quail excelled over the rest of the birds in the Cerebellar prominentia trait (13.634) mm, and in the Exoccipital bone trait and Postorbital process, the male white quail excelled over the other birds (6.718, 15.731) mm respectively.

Table 3: The effect of interaction between genetic lines and gender

Traits	**White*Male**		**White*Female**		**Brown*male**		**Brown*Female**		**Gray*Male**		**Gray*Female**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
CP	13.50**ab**	0.13	13.63**a**	0.13	13.34**b**	0.10	13.50**b**	0.12	13.43**b**	0.11	13.35**ab**	0.13
EB	6.72**a**	0.21	6.63**ab**	0.22	5.98**c**	0.17	6.23**bc**	0.21	5.99**c**	0.18	6.16**bc**	0.22
PSSB	19.00**a**	0.22	18.75**a**	0.23	18.31**a**	0.18	18.22**a**	0.21	18.37**a**	0.19	18.68**a**	0.23
TF	15.58 **a**	0.13	15.51**a**	0.14	15.30**a**	0.11	15.45**a**	0.13	15.36**a**	0.11	15.48**a**	0.14
PoP1	16.97ab	0.16	16.45**c**	0.17	16.39**c**	0.13	16.52**abc**	0.16	16.48**bc**	0.14	17.02**a**	0.17
DF	4.65**ab**	0.14	4.81**ab**	0.15	4.64**ab**	0.11	4.50**b**	0.14	4.59**ab**	0.12	4.94**a**	0.15
CTPFB	6.05**a**	0.18	6.28**a**	0.19	6.09**a**	0.15	6.19**a**	0.18	6.06**a**	0.16	6.27**a**	0.19
FMH	2.94**a**	0.08	2.65**b**	0.08	3.00**a**	0.06	2.91**a**	0.07	3.00**a**	0.06	2.88**a**	0.08
FMH	3.82**a**	0.08	3.99**a**	0.08	3.81**a**	0.06	3.70**a**	0.08	3.76**a**	0.07	3.90**a**	0.08
PaP	15.48**a**	0.36	14.58**b**	0.37	14.67**b**	0.29	14.65**b**	0.35	15.83**a**	0.30	15.65**a**	0.38
PoP2	15.73**a**	0.28	15.19**ab**	0.29	15.37**ab**	0.22	15.57**ab**	0.27	14.480**c**	0.23	15.03**b**	0.29
MFB	24.38**ab**	0.20	24.56**ab**	0.21	24.23**ab**	0.16	24.08**ab**	0.19	23.93**b**	0.17	24.63**a**	0.21

Means not having a common letter (a, b) within each column differ significantly ($P<0.05$). CP= Cerebellar prominentia, EB= Exoccipital Bone, PSSB= Proc. Suprameaticus of sequamosal bone, TF= Temporal fossa, PoP1= Postorbital Process, DF= Dorsal Middle point of frontonasal structure, CTPFB= Craniolateral terminal point of frontal bone, FMH= Foramen magnum height, PaP= Paraoccipital process, PoP2= Postorbital process, MFB= Middle point of frontonasal structure Basilar tuberculum of basioccipital bone

The gray female quail also excelled in the Postorbital process, Dorsal middle point of frontonsal structure, and Middle point of frontonasal structure Basilar tuberculum of basioccipital bone (17.022, 4.941, 24.626) mm respectively, over the other of the birds. As for Paraoccipital process, white males, gray males and females outperformed other birds (15.481, 15.833, 15.654) respectively. As for the other of the characteristics, there was no significant effect among the studied interactions. And that was in contrast with (36), which shows no significant effect of sex and color on the weight and head size. Still, one may argue that sex discrimination within the same species benefits from the application of geometric form analysis. The disparities between boys and girls in longitudinal measures were discovered in a variety of skulls using classic morphometric techniques (37). Males exhibited longer dimensions than females in the majority of these investigations. But geometric analysis allowed it to be understood in terms of shape. Information about geometric morphometry was gathered in order to calculate the sexual dimorphism and use it on other species such as dogs, goats, and sheep using geometric analysis (38).

Conclusion

In this study, the effect of sexual dimorphism as well as the plumage color were studied by using the geometric morphometric method on the dimension of quail skull bones. Our study revealed a significant effect of the genetic lines of quail on the dimensions of the skull, especially in brown color line in some specific bones, meanwhile, no significant effect was shown between the sexes. Studies of geometric morphology will be very helpful in the classification of sexual dimorphism studies as well as using the major positive correlations among body weight and most body dimensions in quails and it gives high and low ranges and will bring a different perspective to traditional morphometric studies.

Conflicts of interest

The authors declare that there is no conflict of interest.

Ethical Clearance

This work is approved by The Research Ethical Committee.

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تأثير الجنس والخطوط الوراثية على أبعاد الجمجمة في السمان الياباني

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الخلاصة

هدفت هذه الدراسة إلى المساهمة في مورفولوجيا رأس السمان وتكوين مصادر بيانات أساسية للقياس المقارن في جمجمة السمان. أجريت التجربة الحالية في مزرعة الدواجن التابعة لقسم الإنتاج الحيواني بكلية الزراعة - جامعة كركوك، للفترة من (2022/04/22 إلى 2022/07/22)، واستخدم 120 فرخًا غير مجنس (سمان أبيض = 40، سمان بني = 40، سمان رمادي = 40)، وتم تربيتها على الأقفاص، وتم اختيار 5 ذكور وإناث عشوائيًا للذبح. وبعد الذبح تم جمع الرؤوس وغليها وقياس خصائص الجمجمة باستخدام جهاز الفيرنيا بدقة 0.01 مم. وكانت هناك فروق معنوية في بعض الأبعاد، حيث كان عظم Pro. Sprameaticus of sequamosal bone وهذا هو الحال أيضا في Postorbital process ، أما بالنسبة للأبعاد الأخرى فلم تكن هناك فروق معنوية بين الخطوط الوراثية، وكانت هناك فروق معنوية عالية في العديد من الأبعاد، حيث تفوقت أنثى السمان الأبيض على بقية الطيور في صفة Cerebellar prominentia ، وفي صفة Exoccipital bone و Postorbital process تفوق ذكر السمان الأبيض على بقية الطيور، كما تفوقت أنثى السمان الرمادية في Postorbital process، Dorsal middle point of frontonsal structure، Middle point of frontonasal structure Basilar tuberculum of basioccipital bone ، أما بالنسبة لعملية ما بعد القذالي فقد تفوقت الذكور البيضاء والذكور والإناث الرمادية على بقية الطيور، أما بالنسبة لبقية الصفات فلم يكن هناك تأثير معنوي بين التفاعلات المدروسة.

الكلمات المفتاحية: السمان الياباني، الخط الوراثي، أبعاد الجمجمة، عظام الجمجمة.