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Phenotypic differentiation between linear body measurements and body weight in two species of Japanese quail (*Coturnix coturnix japonica*)

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Abstract

The present study was designed at determining the relationship between body weight and body linear measurements in two species of Japanese quails. A total of30 Japanese quails comprising (15 Panda white and 15 Cinnamon brown species) in a standardized student t-test package were used to determine the difference between the linear body measurements and body weight of the two species of Japanese quails. Each species was replicated three times, consisting of both males and females. The parameters measured were body weight, shank length, keel length, wing length, body length, body girth, thigh length and the overall growth performance in the two species of Japanese quails. Discriminant analysis was used to distinguish the two species of quails, whether they are the same or not and to determine the correctness of the predicted number of quails used indiscriminately. Also, a simple correlation procedure was used to establish the strength of relationship between the two species of quails and their growth traits. The result observed from this study revealed significant (P<0.05) differences in the daily weight gain, daily feed intake and feed conversion ratio among the two species. Panda white performed appreciably than Cinnamon Brown species in terms of body weight, and linear body traits. There was significantly higher correlation value of body weight with linear body measurements in panda white at 2nd and 4th week than in Cinnamon brown. The difference prediction among the species was done at 2nd week of age, while discriminant analysis using the group centroid established that Panda white and Cinnamon brown are different using their body weight and linear body measurements. Over 65.3% of Panda white and 54.9% of Cinnamon brown of Japanese quails were correctly predicted. From this study, it can therefore be recommended that Panda white can be selected for improvement towards future development.

Keywords: Performance, discriminant, Japanese quail and linear trait

Différenciation phénotypique entre les mesures corporelles linéaires et le poids corporel chez deux espèces de cailles japonaises (Coturnix coturnix japonica)

Résumé

La présente étude a été conçue pour déterminer la relation entre le poids corporel et les mesures linéaires corporelles chez deux espèces de cailles japonaises. Un total de 30 cailles japonaises comprenant (15 espèces Panda blanc et 15 espèces marron cannelle) dans un ensemble de tests t standardisés pour étudiants ont été utilisées pour déterminer la différence entre les mesures corporelles linéaires et le poids corporel des deux espèces de cailles japonaises. Chaque espèce a été reproduite trois fois, composée à la fois de mâles et de femelles. Les paramètres mesurés étaient le poids corporel, la longueur de la tige, la longueur de la quille, la longueur de l'aile, la longueur du corps, la circonférence du corps, la longueur de la cuisse et la performance de croissance globale chez les deux espèces de *cailles japonaises. L'analyse discriminante a été utilisée pour distinguer les deux espèces de cailles, qu'elles soient identiques ou non et pour déterminer l'exactitude du nombre prédit de cailles utilisées sans distinction. De plus, une simple procédure de corrélation a été utilisée pour établir la force de la relation entre les deux espèces de cailles et leurs traits de croissance. Le résultat observé à partir de cette étude a révélé des différences significatives (P<0,05) dans le gain de poids quotidien, l'apport alimentaire quotidien et le taux de conversion alimentaire entre les deux espèces. Le panda blanc a obtenu des résultats appréciables par rapport à l'espèce Cinnamon Brown en termes de poids corporel et de traits corporels linéaires. Il y avait une valeur de corrélation significativement plus élevée du poids corporel avec des mesures corporelles linéaires chez le panda blanc à la 2e et à la 4e semaine que chez le brun cannelle. La prédiction de la différence entre les espèces a été effectuée à la 2e semaine d'âge, tandis que l'analyse discriminante à l'aide du centroïde de groupe a établi que le blanc Panda et le brun cannelle sont différents en fonction de leur poids corporel et de leurs mesures corporelles linéaires. Plus de 65,3 % de Panda blanc et 54,9 % de Cinnamonbrown de cailles japonaises ont été correctement prédits. A partir de cette étude, il peut donc être recommandé que Panda blanc soit sélectionné pour une amélioration en vue d'un développement futur.*

Mots-clés: Performance, discriminant, caille japonaise et trait linéaire

Introduction

The high shortage of animal protein Nigeria demanded that serious effort be harnessed for production of animals that are prolific with short generational interval such as poultry, rabbit and pigs (Smith, 2001). According to Babangida and Ubosi (2005), the Japanese quail is potentiated to serve as an excellent and affordable source of animal protein in Nigeria. Quails are small bodied birds reared for its meat and eggproduction in the world. Its domestication started as early as in the 14th century. The Japanese quail is found in Japan, Korea, Eastern China, Mongolia and Sakhalin as migratory birds (Mizutani, 2003).

There are about forty-four (44) species of Japanese quails, twenty-four (24) of which have so far been domesticated (Whyte *et al*., 2004). The Japanese quail though being the smallest avian specie reared for meat and egg production (Panda and Singh, 1990) has assumed global importance as a laboratory animal (Baumgartner, 1993). Many of the plumage colour variant of Japanese quails have been reported by Traux and Johnson, (1979); Somes (1979); Roberts *et al.,* (1978) but the plumage colour in this study is Panda white and Cinnamon brown varieties of Japanese quails. The Japanese quails have distinct characteristics such as rapid growth rate which makes quails ready for market at 5-6 weeks of age; early sexual maturity, short generational interval, high rate of lay, less feed consumption, minimal space requirement compared to other poultry species, less capital involvement and resistance to common diseases of poultry (Adeogun and Adeoye, 2004), making it a huge asset for researchers and poultry industry. The morphological features of the Japanese quails differ depending on its stage of life. At the early stage, both sexes (male and female) individuals exhibit the same kind of plumage and colour (Hubretch *et al*., 2010). The plumage of the Japanese quail is sexually dimorphic allowing different sexes to be distinguished from one another (Mills *et al*., 1997). Both male and female Cinnamon brown adult exhibits predominantly brown plumage. However, markings on the throats and breast as well as the particular shade of brown can vary quite a bit (Hubretch *et al*., 2010). The breast feathers of females are filled with dark spots among generally dark feathers. Contrastingly, male breast feathers reflect a uniform dark reddish brown colour. There is no sex difference about the plumage pattern of Panda white, while adults (male and female) are distinguishable ventral plumage pattern. Sequel to the importance of quail in poultry, it becomes imperative to initiate improvement program that can genetically improve the birds for efficient and effective productivity. The relationship existing among body traits provide useful information on the performance, productivity, shape or form and carcass characteristics in animals (Oke *et al*., 2004). Most of the body linear measurement shows primarily the length of the long bones and when taken sequentially over a long period of time, they genetically indicate the way the animal body is changing shape and being useful in weight and carcass composition evaluation (Oke *et al*., 2004). According to Marks (1993b), selection in quails for body weight improved feed utilization, although increase in total feed intake was as a result of the maintenance of a large body mass. The genetic studies on different species of Japanese quail in Nigeria will enable breeders to design suitable improvement programme and obtain reliable estimate of genetic parameters which are necessary to predict direct or indirect selection. There is dearth of information on the type of species appropriate for efficient improvement and profitable performance in quail production especially in terms of body weight and other linear measurements. The present study was undertaken to differentiate between *the linear body measurements and body weight of the two species of Japanese quails.*

Materials and methods

Experimental site

The research was conducted at the poultry unit of the Teaching and Research Farm of Michael Okpara University of Agriculture Umudike, Abia State located at latitude 5° 29"N and Latitude 7° 32"N and the altitude 123m above sea level with an annual rainfall of 2177mm, and temperature of 22-36 with relative humidity of above 50-90% (NRCRI Umudike, 2010).

Experimental birds

The Japanese quails species (*Coturnixcoturnix Japanese*) were procured from Dhenah Nigeria Limited in plateau State. A total of 60 Japanese quails birds of two species of Panda white and Cinnamon brown of six males and 24 females each were used as the base population to generate progeny that was used for the experiment. A ratio of 1:4 (Cock to hen) was the mating ratio used to generate progeny.

Egg collection

The collection of eggs was done on a daily basis to avoid crakes and damage by the birds and taken to the incubator with adequate and optimum temperature of 37° C was provided and the relative humidity of 56% was maintained. A total of 30 eggs were collected from the two varieties and incubated.

Incubation and hatching procedure

The collected eggs were candled and selected for incubation which lasted for 16-18 days. At the end of each week, the eggs collected were taken to a local hatching. The temperature was 37 °C and the relative humidity of 56-60%. Egg turning was two days before hatching and the eggs were transferred to the hatcher with some temperature and humidity condition.

Management of experimental birds

Thirty quails' chicks (15 Panda White and 15 Cinnamon Brown) gotten from reputable hatchery brooded for two weeks at the brooding section of the farm. Adequate protective measures were ensured with the aid of a cage covered with polythene to prevent falling off of the birds. Provision of heat was achieved with the installations of lanterns and electric bulbs maintained at a moderate temperature of 35°C with adequate drinkers and feeders. Sufficient wood shaven was gathered to ease the collection of their feaces/litter. Medication administration was strictly adhered to as required at various stage of development. Good hygiene and other routine management measures were ensured throughout the experimental period. At the end of the two weeks, the birds were transferred to the rearing pen and replicated three times in variety basis.

Table 1: Composition of experimental diets

	Starter	Finisher
Ingredients	**Composition (%)**	**Composition (%)**
Maize	50.00	63.00
Soya bean cake	15.00	30.00
Wheat offal	14.20	-
Groundnut cake	7.00	-
Palm kernel cake	4.00	-
Fish meal	5.00	3.00
Bone meal	4.00	3.00
Salt	0.25	0.25
Vit/Premix	0.25	0.25
Lysine	0.20	0.10
Methionine	0.10	0.10
Total	**100**	**100**
Crude Protein (%)	19.80	20.00
Metabolizable Energy (Kcal/Kg)	2859	2900

Parameters measured

Data was collected on the following linear body parameters as measured in individuals.

Body weight (Kg) was monitored using a table scale and the initial measurement was at day old, thereafter weekly weighing was carried out. Body length (cm) was monitored using a tape rule and the initial measurement was at day old, thereafter weekly weighing was carried out; Bogy girth (cm) was monitored using a tape rule and the initial measurement was at day old, thereafter weekly weighing was carried out; Shank length (cm) was monitored using a tape rule and the initial measurement was at day old, thereafter weekly weighing was carried out; Keel length (cm) was monitored using a tape rule and the initial measurement was at day old, thereafter weekly weighing was carried out; Wing length was monitored using a tape rule and the initial measurement was at day old, thereafter weekly weighing was carried out.

Average weekly feed intake (g/birds):

$$\frac{\text{Quantity of feed given} - \text{left over}}{\text{Number of birds x days of experiment}}$$

Average weekly weigh gain (g/birds):

$$\frac{\text{Final weight} - \text{initial of weight}}{\text{Number of birds x weeks of experiments}}$$

Average mortality *(%)*:

$$\frac{\text{Number of dead birds x 100}}{\text{Initial stock x Number of weeks}}$$

Feed conversion ratio:

$$\frac{\text{Average feed intake}}{\text{Average weight gain}}$$

Experimental design and statistical analysis

The experimental design followed a standardized t-test. The data collected was subjected to discriminant analysis using Statistical Package for Social Science (SPSS 2011).

Correlation between the means of linear body parameters was done using Pearson's production moment of coefficient of correlation.

Statistical model

The appropriate statistical model used is:

$Y_{ij} = \mu + S_j + b_{ij}$

Y_{ij}= observation of the kth population, of the jth species

μ= common mean

S_j = fixed effect of j th species (i=2)

b_{ij}= random error

Results and discussion

Growth performance of two species of Japanese quails

Table 2 shows growth performance of Panda white and Cinnamon brown Japanese quails at six weeks of age. The result obtained in this study revealed that significant ($P<0.05$) difference were observed in the body weight gain, daily feed intake and feed conversion ratio. Panda white had higher values of body weight gain, daily feed intake and feed conversion ratio (2.89g, 20.84 and 7.21) than Cinnamon brown (2.42g, 18.55 and 6.58). The significant difference observed in the daily weight gain may be as a result of the breed of birds or genetic makeup of the birds used for the study. However, the values obtained in this study is slightly higher than of the findings of Dauda*et al*. (2014) who reported 2.14g at 6th weeks.

The feed intake observed in this study is similar to the findings of Ekine (2007) and Ani*et al*. (2009), which are 19.91-24.43g/quail and 20-25g/quail, respectively.

Feed conversion ratio at the 6th week was in consonant with the findings of Dauda*et al.* (2014) who reported 7.08±0.18g FCR Japanese quail. Cinnamon brown variety had lower value of FCR as compared to Panda white. Also, the value of FCR obtained in this study at 6 weeks of age for both varieties were higher than 4.67 reported by Vali (2008) at the 6th week.

Table 2: Mean ± S.E Growth Performance of two species of Japanese quails

Parameters	Panda white	Cinnamon brown
Daily weight gain (g/bird)	2.89±0.01^{a}	2.42±0.41^{b}
Daily feed intake (g/bird)	20.84±0.47^{a}	18.55±2.45^{b}
Feed conversion ratio	7.21±0.16^{a}	6.58±0.87^{b}

^{a,b}Means across rows with different superscript differ significantly at $P<0.05$; S.E = Standard Error

Average body weight and linear traits in two varieties of Japanese quails of six weeks

Table 3 shows the mean comparison of body weight and linear traits in Panda white and Cinnamon brown Japanese quails at different ages. The result obtained showed a progressive increase in the body weight measured over six weeks. There were significant ($P<0.05$) differences observed in 2nd, 3rd and 4th weeks of age among the two species, while there was no significant ($P>0.05$) difference observed in body weight at 1st, 5th and 6th weeks of age among the two varieties. Panda white had higher body weight value as compared to Cinnamon brown over the 6-week period. However, the value obtained in this study for body weight was lower than the one reported by Sezer *et al*. (2006) for Japanese quails. This could be as a result of the type of breed used, difference in climate and environmental conditions under which the flocks were reared.

The result revealed progressive increase in linear traits over the six weeks. There were significant ($P<0.05$) differences at the 2nd, 4th and 6th weeks of age, panda white variety had higher value than cinnamon brown in terms of shank length, whereas at the 1st, 3rd and 5th weeks, there were no significant difference between the two varieties.The mean value of shank length obtained in this study for the two varieties were lower than the range reported by Sezer *et al.* (2006) for Japanese quail at the same period.

Also, for wing length, Panda white had significantly ($P<0.05$) higher value than Cinnamon brown at 2nd, 4th and 6th weeks of age which are; 6.12 vs 5.13; 6.44 vs 5.66; 7.93 vs 7.58 respectively while non-significant ($P>0.05$) difference were observed at the 1st, 3rd and 5th weeks of age. This result obtained in this study was compared with the values obtained by Adeogun and Adeoye (2004) for Japanese quails at the same period. Furthermore, significant ($P<0.05$) differences were observed in the body girth measurements of the two varieties of Japanese quail at 3rd and 4th weeks of age while 1st, 2nd, 5th and 6th weeks recorded similar ($P>0.05$) values. The range of values obtained for body girth in this study were higher than that of Raji (2009) who reported 5.35cm for body girth at 6th weeks. The result obtained for keel length showed significant ($P<0.05$) differences at the 4th, 5th and 6th weeks while other weeks showed no significant ($P>0.05$) difference for body length. For body length, 3rd and 6th weeks showed significant ($P<0.05$) differences in the two varieties of Japanese quails. Thigh length was significantly ($P<0.05$) different between the varieties of Japanese quail at the 6th weeks. The value obtained in this study for keel length and thigh length were within the values reported by Singh *et al*, (1993) for Japanese quail at 5th weeks of age. Body length values obtained in this study were higher than the range reported by Wilson *et al.* (1961). However, among the linear traits measured, body length showed the greatest variability at all ages. This high variability inherent in body length could be used for breeding characterization as well as selection for genetic improvement. Thus, the high body weight recorded by Panda white Japanese quail can be selected for better productive purposes and efficient breeding for farmers. Also, the observed differences in growth pattern when compared with previous studies could be as a result of environment al condition, nutrition and genetic make-up of the breeds of quail used in this study. Furthermore, the findings of the present study between body weight and linear measurements are in constant with the finding of Raji (2009) and Hassan (1997)

Phenotypic correlations between body weight and linear traits

Table 4 shows the correlation between body weight and linear body traits in Panda white and Cinnamon brown Japanese quail at 2nd, 4th and 6th weeks of age. The result revealed positive significant correlations between body weight and wing length ($r = 0.778$); body weight and body girth ($r = 0.641$); body weight and keel length ($r = 0.848$) and body weight and thigh length ($r = 0.839$) in Panda white species whereas Cinnamon brown variety had significant positive correlations between body weight and wing length ($r = 0.679$) and body weight and thigh length ($r = 0.710$) at the 2nd weeks of age. The high positive correlations observed between body weight and linear traits in Panda white species are good indicators of body weight and they appear to be linked genes controlling these traits. This implies that any selection for one trait will result to the improvement of others. There was no significant correlation observed in Panda white between body weight and shank length while in Cinnamon brown between body weight and shank length; body weight and body girth and body weight and keel length at the 2nd weeks. Non - significant negative correlation was observed between body weight and body length at 2nd weeks in both varieties, thus suggest that an increase in body weight was associated with a decrease in body length for both species, thus making them similar. Positive significant

Table 3: Overall body weight and linear traits for six weeks in two species of Japanese quail

Week	Variety	Body weight	Shank length	Wing length	Body girth	Keel length	Body length	Thigh length
1	**PW**	6.33±0.7	1.47±0.06	3.22±0.09	2.25±0.11	1.31±0.05	5.48±0.16	1.68±0.06
	CB	6.22±0.04	1.38±0.06	3.26±0.16	2.14±0.12	1.72±0.08	5.30±0.15	1.63±0.09
2	**PW**	34.26±0.69^{a}	2.31±0.08^{a}	6.12±0.20^{a}	3.16±0.12	3.32±0.08	6.59±0.12	2.10±0.06
	CB	32.63±0.47^{b}	2.05±0.04^{b}	5.13±0.13^{b}	3.11±0.13	3.17±0.06	6.78±0.08	2.25±0.05
3	**PW**	54.83±1.09^{a}	2.49±0.10	4.22±0.04	2.58±0.08^{b}	4.08±0.02	8.80±0.35^{a}	2.83±0.10
	CB	51.84±0.93^{b}	2.48±0.11	4.18±0.05	2.96±0.16^{a}	4.10±0.09	7.43±0.40^{b}	2.92±0.25
4	**PW**	90.33±1.79^{a}	2.82±0.13^{a}	6.44±0.11^{a}	3.28±0.08^{b}	4.49±0.04^{a}	9.64±0.06	3.10±0.12
	CB	70.92±2.22^{b}	2.76±0.11^{b}	5.66±0.19^{b}	3.95±0.07^{a}	4.19±0.02^{b}	9.69±0.07	3.74±0.04
5	**PW**	113.46±1.99	3.23±0.02	6.93±0.04	4.88±0.03	4.93±0.02^{a}	10.72±0.21	4.29±0.04
	CB	110.00±1.84	3.21±0.01	7.01±0.05	4.96±0.08	4.35±0.03^{b}	9.88±0.45	4.35±0.03
6	**PW**	127.63±1.54	3.37±0.01^{a}	7.93±0.06^{a}	5.93±0.05	5.49±0.09^{a}	12.93±0.45^{a}	4.80±0.07^{a}
	CB	124.50±2.08	3.31±0.02^{b}	7.58±0.09^{b}	5.93±0.05	4.74±0.20^{b}	11.08±0.38^{b}	4.56±0.03^{b}
	PW	71.14±5.15	2.61±0.08	5.81±0.20	3.68±0.16	3.94±0.16	9.02±0.31^{a}	3.30±0.12
$\bar{X}$	**CB**	66.22±5.01	2.54±0.08	5.49±0.19	3.85±0.16	3.78±0.13	8.35±0.27^{b}	3.25±0.13

^{a,b} Means across rows with different superscripts differ significantly at $p<0.05$; S.E = Standard error, PW = Panda white and CB =Cinnamon brown correlation were observed between body weight and wing length; body weight and thigh length in Panda white while body weight and wing length was significant in Cinnamon brown at 4th weeks of age. Also, there was no significant correlation between body weight and body length for the two varieties at 4th weeks. This association showed that an increase in body weight led to a decrease in body length of the birds. This could be attributed to the small nature of the bird. Non-significant correlations were observed between body weight and wing length, keel length and body girth in Panda white at 6th weeks while in Cinnamon brown, it was observed only between body weight and keel length. However, Cinnamon brown showed significant correlation between body weight and wing length whereas Panda white was associated with a decrease in wing length. Association between body weight and keel length showed similarities at 6th weeks as an increase in body weight is associated with a decrease in keel length for the two varieties. There was no significant positive correlation between body weight and body length in Cinnamon brown whereas non-significant negative correlation was observed between body weight and body length in Panda white at 6th weeks of age. The associations between body weight and body length was consistently negative across the weeks in Panda white and also in Cinnamon brown except at 6th weeks. Oyetade (2011) reported a positive and mostly significant ($P<0.05$) phenotypic relationship between body weight and all linear body measurements at various ages. The result of these findings which are not all positive in both species except for thigh length which appeared positive in all the weeks in both species, contradicts previous findings. The phenotypic correlations that were positively correlated in this study indicate that they could be simultaneously improved and the present results corroborated with the findings of Adeogun and Adeoye (2004) who reported a positively high phenotypic correlation estimates in Japanese quails. The wing length showed the strongest correlation with body weight at 4th week, followed by keel length with body weight at 2nd week and thigh length with body weight at 2nd week in Panda white. Thus, selection may be done from 2nd to 4th weeks for Panda white. For Cinnamon brown, thigh length showed the strongest correlation with body weight at 2nd week, shank length portrayed the strongest correlation with body weight at week 4, followed by wing length at 6th week. Therefore, selection may be possible from week 4 to 6 in Cinnamon brown species. It is important to add that the varying level of positive association between body weight and linear measurements in both species will have direct impact on the level of success or improvement to be recorded in any selection program. However, notable findings obtained from this study shows that certain traits such as wing length, keel length and thigh length can be categorized as having high phenotypic correlation values with body weight in both varieties. Traits such as shank length and body girth have intermediate phenotypic correlation values while body length had low phenotypic correlations with body weight. The implication of this is that selection for growth traits with high phenotypic correlations will results to rapid improvement in body weight of the animal due to linkage gene effect operating on them.

Table 4: Correlation between body weight and other linear trait in panda white and cinnamon brown at 2nd, 4th and 6th weeks

Weeks	Correlating parameters	Linear Traits					
		Shank length	Wing length	Body girth	Keel length	Body length	Thigh length
Panda White							
2	Body weight	0.315	0.778**	0.641*	0.848**	-0.290	0.839**
4	Body weight	-0.393	0.885**	0.240	-0.403	-0.570	0.764**
6	Body weight	0.346	-0.343	0.273	-0.317	-0.130	0.545
Cinnamon Brown							
2	Body weight	0.490	0.679*	0.568	0.456	-0.416	0.710**
4	Body weight	0.533	0.713**	0.264	0.322	-0.489	0.533
6	Body weight	0.122	0.815**	0.276	-0.014	0.060	0.057

* Correlation is significant at the 0.05 level

**Correlation is significant at the 0.01 level

Linear discriminant analysis for distinguishing panda white and cinnamon brown

The Table 5 presents discriminant evaluation for distinguishing Panda white and Cinnamon brown species of Japanese quails. The case processing summary showed the number of observations used for discriminant analysis, about 72 Panda white and 71 Cinnamon brown species respectively. Cinnamon brown had one missing case which made it 71, making the total valid cases to be 143 and the percentage of valid cases was 99.3% which is very high. The box's test of equality of covariance uses Box's M® to test the significant of this analysis. This significant (P<0.05) of the Box's M® value showed that there were variations between the discriminant variables (body weight and linear traits) of Panda white and Cinnamon brown species. The summary of canonical discriminant functions showed the Eigen value of 0.103 which explained 100% variation existed between the discriminant variable and the categorical variables making this model reliable, the canonical correlation between the categorical and discriminant variables showed a low association here. Test of functions showed significance (P<0.05) of this model using Wilk's Lambda function. The discriminant function model was used to distinguish between Panda white and Cinnamon brown, which were computed from the mean values of body weight and linear traits. The group centroids show that the two species are different using magnitude and opposing signs. The classification summary shows about 65.3% and 54.9% was correctly predicted in Panda white and Cinnamon brown respectively. This could be due to some phenotypic or measurement errors. These results showed that the two species are not the same. Panda white is a spotted plumage colour mutant (Mizutani *et al.*, 1974). Rahman*et al.* (2010) reported that different colour mutants of Japanese quails had differences in majority of the productive and reproductive parameters.

Table 5: Canonical linear discriminant analysis for comparing panda white and cinnamon brown

DISCRIMINANT PARAMETERS	EVALUATION BREEDS DISCRIMINATED (Panda White and Cinnamon Brown)
Case Processing Summary	
Valid cases (N)	143
Valid cases (%)	99.3
Box's Test of Equality of Covariance	
Box's M	58.018*
Summary of canonical discriminant functions	
Eigen values	0.103
% of variance	100.0
Canonical correlation	0.306
Test of functions	
Wilks' Lambda	0.906
Chi-square	13.535
Significance	0.060
Discriminant Function Model	
Unstandardized discriminant function model	**D = -0.023BW+0.943SL+0.769WL-1.017BG-0.825KL+0.708BL+0.064TL**
Group Centroids	
Panda White	0.317
Cinnamon Brown	-0.322
Classification Summary	
1. Prior probabilities for groups	
Panda White (N = 72)	0.50
Cinnamon Brown (N = 71)	0.50
2. Predicted Group Membership	
% Panda White	65.3
%Cinnamon Brown predicted	54.9

*Significant; BW = Body weight; SL = Shank length; WL = Wing length; BG = Body girth; KL = Keel length; BL = Body length; TL = Thigh length; D = Discriminant function

Conclusion

The comparison between body weight and linear measurements revealed that Panda white had high body weight, wing length, keel length, body length and thigh length measurements than Cinnamon brown variety. Thus, Panda white appeared better in body weight and linear traits when compared to Cinnamon brown species. The study also showed body weight related to linear body traits in Japanese quail especially in thigh length, keel length and wing length for Panda white; and thigh length, shank length and wing length for Cinnamon brown. Therefore, a breeding program to achieve an optimum combination of body weight and good conformation for maximum economic returns in Japanese quail can be easily organized using measured parts like keel length, wing length, thigh length and shank length. The study also indicated that the two species examined (Panda white and Cinnamon brown) are different based on their body weight and linear body parameters.

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