Initially Observed Some Important Morphological Characteristics on Phu Quoc Ridgeback Dogs (*Canis familiaris*) in Vietnam

Quoc – Dang Quan[1, 2], Anh – Dung Chung[2], Hoang – Dung Tran[3]

[1]Center of Science and Technology Development, HCM City, Vietnam

[2]Institute of Agricultural Science for Southern Vietnam

[3]Nguyen Tat Thanh University, Vietnam.

*Corresponding author mail: dangquan3580[at]gmail.com

Abstract: *Phu Quoc Ridgeback dogs (Canis familiaris) were one of the endemic species of Phu Quoc Island – Vietnam, This animal is one of the rarest dog in the world, which has a ridgeback. Currently, Phu Quoc dogs have not been put into separate group and they are classified in the Thai Ridgeback group (according to FCI - Fédération Cynologique Internationale). The mainly reason is not studies which showing differences in phenotype and genotype of Phu Quoc dogs to other breeds. This study was carried out in a few research papers about the phenotype and genotype of Phu Quoc dogs that was taken in Viet Nam previous. The 29Phu Quoc dogs (18 – 36 yrs) were initially observed in shape, color and measure the phenotypic characteristics. The data obtained through statistical processing by t-test and regression correlation. Results showed Phu Quoc dogs have important properties such as nails weared and webbed feet on all dogs observed; most of them have black tongue spotted; dominant color is yellow and black, the other colors appear on a few individual dog which are weak expression and not responsive health of the flock, this could be the recessive mutation unexpected survival; mainly curved tail upstream 2/4 - 3/4 circle; function correlation between growth indicators basic size is $y = 0,03.x^{1,68}$ (body weight and height), $y = 0,02.x^{1,64}$ (body weight and chest size), $y = 0,03.x^{1,64}$ (body weight and waist circumference).*

Keywords: ridgeback dog, Phu Quoc Island, nails weared, webbed feet, allometric method.

1. Introduction

The Phu Quoc Ridgeback is a breed of dog from Phu Quoc Island in Vietnam's southern Kien Giang Province. The Phu Quoc is the smallest of the three ridgeback breeds. The Phu Quoc dog was included in the *Larousse Dictionary* and is steadily gaining notice in the Western world. This means due to the scarcity of true examples they are not able to enter many international dog shows as they are simply considered too rare to be able to judge the breed standard.
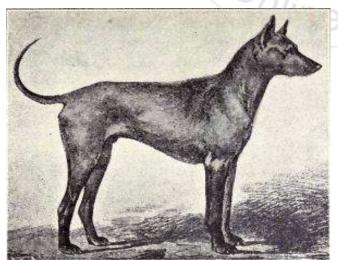

Figure 1: Phu Quoc Ridgeback circa 1915, then known as the Phu-Quoc greyhound.
(Mason, Walter Esplin, 1867)[1]

Phu Quoc dog was a specific animal in Vietnam's Phu Quoc Island. Phu Quoc dog was one of the rarest breed dog, which had the ridgeback in the world, the others were Thai Ridgeback dog and Rhodesian Ridgeback dog. Their important characteristics that distinguish these breed dog with others was the presence of swirling feathers (ridge back) along the spine. Phu Quoc dog had a lot of features which not appear on other dogs such as intelligent, agile, loyal, capable hunting and good housekeeping [2].

However, at present, only two ridgeback breed dogs were Rhodesian Ridgebacks and Thai Ridgebacks were recognized by Federation Cynologique International (FCI), while Phu Quoc ridgebackdog was closely bunched with Thai ridgeback dog, and was considered have originated from the Thai Ridgebacks (http://www.fci.be/en/nomenclature/THAI-RIDGEBACK-DOG-338.html) [3].

Recently, in Vietnam, in the genetics data collected and researched by Tran Hoang Dung et al (2014), the analysis shows that the Phu Quoc Ridgeback dog was different and separated group from Thai Ridgebacks. This research had the significant results while analyzes the control region (CR) on mitochondrial genome, the results from this study encouraged we to have perform the initial basic research to figure out the morphological revaluation and phylogenetic origin of Vietnam Phu Quoc Ridgeback dog [4].

In this preliminary study, we have observed, recorded and processed the collected data to preliminary assessment the growing of common and significant features in Phu Quoc

Ridgeback dogs. We also use assessment allometric method to evaluate the phenotype relationship and development between the similar characteristics in Phu Quoc dog.

2. Methods

Sampling size and data collecting

Total includes 32 Phu Quoc Ridgeback dogs (17 males, 15 females) were observed and recorded for the basic measurements to quantify include age, weight, bust, waist circumference, height high, body length, tail length, ear length, snout length, number of nails weared; observation of qualitative indicators on gender, coat color, eye color, curvature of the tail, webbed foot (measurement according to the principles prescribed by the Fédération Cynologique Internationale).

All dogs observed in the mature phase and could reproduce. Sampling location and experiments in Thanh Nga Kennels, Phu Quoc Island, Vietnam from November 2014 to January 2016.
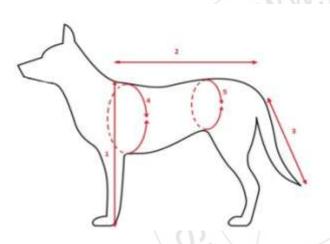

Figure 2: Measurement methods to apply on Phu Quoc Ridgeback dogs. The data collect include: (1) body height, (2) body length, (3) tail length, (4) chest, (5) wairst (http://www.fci.be/en/FCI-Standards-Commission-72.html)

Data analysis
The multi-parameter analysis of variance by the common software MS-Excel (Version: 14.0.7140.5002, Product ID: 02260-018-0000106-48584). The lack data are excluded when statistics and correlation analysis. The growth characteristics were analyzed and compared between the two genders male and female by analysis of variance heterogeneity t-test (sample size distribution for the average number) for the characteristics (height, length, weight) and compare rate for properties without dimensions (shape, color)[5].

Allometric equation
Allometric was the concept of increasing the proportion of body shape features which was the scientists developed from the 19th century to the early years of the 20th century [6] and completion of the theoretical basis and research methods in the late 20th century [7]. This method was based on the change rate of growth characteristics to assess the development of physiology, ecology and animal behavior

with the aim of initially evaluated differences within the same species and of other species fellowship rescaled through the body structure. [8].

The Phu Quoc Ridgeback characteristics had the correlation parameter. The relative shape and weight between them had not a linear-function, that they were convert to log factor as good as non-linear function.

Non-linear function:
Allometric were analyzed by multivariate regression nonlinear models based on nonlinear function

$$y = kx^{\alpha}$$
$$\text{or } \ln(y) = \alpha \ln(x) + \ln(k)$$

When:
y: weight of dog
x: interested in characteristics (body height, chest, waist)
for small sample sizes mean and heterogeneity variance. [9]

3. Results and Discussion

Breed history

Native to Vietnam, the Phu Quoc Ridgeback's history has not been well documented. Enthusiasts and few experts believe that all ridgeback breeds (including the Phu Quoc, Rhodesian, and Thai) originated in either Asia or Africa, due to their distinct ridge markings along the spine, though this has never been confirmed scientifically. It is also believed that, like the Thai ridgeback, the Phu Quoc has been used as a carting, escort, hunting, and guard dog throughout its history due to its impressive appearance and muscular physique.

Weight, body length, body height, chest, waist, tail length of Phu Quoc Ridgeback

Table 1: Comparison the phenotypic parameters weight (W), body length (BL) and body height (BH) on male (M) and female (F) Phu Quoc Ridgeback dogs

Statistics	W(kg)		BL(cm)		BH(cm)	
	M	F	M	F	M	F
Mean	18.38	17.31	**54.08[a]**	**50.46[a]**	49.38	46.54
Variance	16.92	10.90	22.74	7.27	23.92	3.94
df	23.00		19.00		16.00	
tS	0.74		2.38		1.94	
p	0.47		**0.03**		0.07	
tC	2.07		2.09		2.12	

df: *degree of freedom*; tS (t Statistical): *coefficients to estimate test hypotheses*; p: *p-value*; tC (t Critical): *coefficients compared to tS*; a: *significant different*
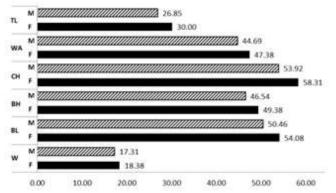
Chart 1: Some average morphological characteristics can quantify on Phu Quoc Ridgeback dog.

T-test analysis of the parameters of weight (W), body length (BL) and body height (BH) between males and females indicates that only differences in body length, and this difference was significant at p-value = 0.03 (p<0.05) and the value of tS >tC (2.38 > 2.09).

Table 2: Comparison the phenotypic parameters chest(CH), Waist(WA) and tail length(TL) on male (M) and female (F) Phu Quoc Ridgeback dogs

Statistics	CH(cm)		WA(cm)		TL(cm)	
	M	F	M	F	M	F
Mean	58,31	53,92	47,38	44,69	**30.00[a]**	**26.85[a]**
Variance	37,56	29,08	29,92	29,40	8.83	2.97
df	24,00		24,00		19.00	
tS	1,94		1,26		3.31	
p	0,06		0,22		**0.00**	
tC	2,06		2,06		2.09	
df: *degree of freedom*; tS (t Statistical): *coefficients to estimate test hypotheses*; p: *p-value*; tC (t Critical): *coefficients compared to tS*; a: *significant different*						

The mean of chest (CH) was 58.31(cm) in male and 53.92(cm) in female. Similarly, WA was 47.38(cm) on male and 44.69(cm) on female, TL was 30.00(cm) on male and 26.85(cm) on female.

T-test analysis of the parameters of chest (CH), Waist (WA) and tail length (TL) between males and females indicates that only differences in tail length, and this difference was significant at p-value = 0.00 (p<0.05) and the value of tS > tC (3.31 > 2.09).

On the individual observations show that the similarities between the male and female when statistics on phenotypic characteristics including weight, body height, chest and waist. These parameters could be used in evaluating relative growth by allometric method on Phu Quoc Ridgeback dogs. This figure above showed that the quantifiable characteristics of male higher than female, but only two characteristics had significant different include body length and tail length.

This difference may depend on the behavior described above, hunting and their reproduction. However, these need further research to find out the details and clarity. Body weight of Phu Quoc Ridgeback showed clear differences, and quite large compared to the Thai Ridgeback dogs (Male: 23-34kg; Female: 20-28kg). [10]

The dorsal hair ridge(ridgeback) in Phu Quoc dog
Phu Quoc dog was one of the rarest breed dog in the world, the others were Thai Ridgeback dog and Rhodesian Ridgebackdog. Their important characteristics that distinguish these breed dog with others was the presence of swirling feathers or dorsal hair ridge (ridge back) along the spine.

The breed-defining ridge on the back (dorsal ridge) of Rhodesian Ridgeback dogs and Thai Ridgeback dogs was the due to the presence of a duplication of a specific region on chromosome 18, which has resulted in multiple gene copies.[11]

The dorsal hair ridge in Rhodesian and Thai Ridgeback dogs is caused by a dominant mutation that also predisposes to the congenital developmental disorder dermoid sinus. The causative mutation is a 133-kb duplication involving three fibroblast growth factor (FGF) genes. FGFs play a crucial role in development, suggesting that the ridge and dermoid sinus are caused by dysregulation of one or more of the three FGF genes during development.[11]

An important sign to recognize a true Phu Quoc dog is the sword shaped ridge on its back, together with short, thin hair. When facing competitors or running after prey, the hair on their back becomes erect, creating a ridge making the dog look brave and strong. Now, it is difficult to find purebred Phu Quoc dogs, as they have mixed with other breeds. Currently, despite many dorsal hair ridge shapes be observed and monitored, however, are no genotype specific studies on Phu Quoc dogs breed.

Figure 3: Dorsal hair ridge (ridgeback) on Phu Quoc dogs. (A) musicnote shape, (B) sword shape, (C) saddle shape, (D) half saddle shape

There are many dorsal hair ridge shapes on Phu Quoc Ridgeback dogs in wild, however when be observations it can be divided into 5 main types: music note shape, sword shape, saddle shape, half saddle shape, arrow shape (not show above). Ridgeback phenomenon is caused by dorsal neural tube formed in the embryos process, leading different to formation of hair pores.

Table 3: Dorsal hair ridge shape in Phu Quoc dogs

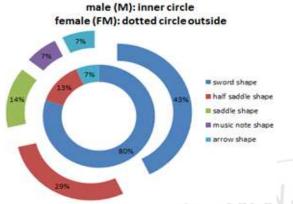| Shape	M	%	FM	%	Total	%
Sum	**15**	**100**	**14**	**100**	**29**	**100**
sword shape	12	80	6	43	18	62
half saddle shape	2	13	4	29	6	21
Saddle shape	0	0	2	14	2	7
music not shape	0	0	1	7	1	3
arrow shape	1	7	1	7	2	7

Chart 2: Percentage of dorsal hair ridge shapeson Phu Quoc dogs

Phu Quoc dogs coat colour

The coat of the domestic dog (*Canis familiaris*) refers to the hair that covers its body. A dog's coat may be a double coat, made up of a soft undercoat and a coarser topcoat, or a single coat, which lacks an undercoat. Double coats have a top coat, made of stiff hairs to help repel water and shield from dirt, and an undercoat to serve as insulation.

There are currently eight known genes within the canine genome that are associated with coat color. Each of these genes occurs in at least two variants, or alleles, which accounts for the variation in coat color between animals. Each of these genes exists at a fixed location, or locus, of the animal's genome.[12]

Table 4: Coat colour on Phu Quoc Ridgeback

Coat colour	M	%	FM	%	Total	%
Sum	**15**	**100**	**14**	**100**	**29**	**100**
Black	2	13	1	7	3	10
Black /White part	2	13	2	15	4	14
Light Yellow	1	6	4	29	5	18
Yellow	5	33	2	14	7	25
Yellow/ White part	0	0	1	7	1	3
Fawn	1	6	2	14	3	10
Brindle	2	13	1	7	3	10
Other (Red, Blue ...)	2	13	1	7	3	10

Phu Quoc dogs observed coat colors divided into two main groups: dominant are the black and tan, appeared a lot of brindle individuals through breeding and hybridization process by human.

The previous research on Thai Ridgeback dog, coat color is also under a control of two groups of epistatic genes. The first determines the color of the coat if it should be black, brindle, red or white. The series of dominance is black to brindle to red to white. The intensity of the coat color is under control of a set of modifying genes. The other group controls the dilution of the colors. Black can be dilute to gray/silver/blue, and red will turn fawn. The normal color is dominance over the diluted.[13]

At present, there are no genetic researches on the Phu Quoc dog coat color. Based on the phenotype observed results, the coat color is similar between Phu Quoc and Thai Ridgeback dogs.

Tail shape, tongue spotted nails weared and feet webbed
Tail shape

Figure 4: Phu Quoc dogs tail shape. (A) straigth shape, (B) curve up ¼ shape, (C) curve up ½ shape and (D) curve up ¾ shape.

The tail is the most posterior or caudal terminal appendage of the vertebral column on a dog. It extends beyond the trunk or main part of the body.

The tail is important as a means of counterbalance when the dog is carrying out complicated movements such as leaping, walking along narrow structures or climbing. Their tails may increase their agility and ability to turn quickly, so they can keep up with their prey. Tail muscles are also important in stabilizing the vertebral column and supporting the action of the extensor muscles of the back, as well as those of the croup and buttocks.

As the island specific animal, Phu Quoc dog can swim in the sea very well, they use their tails as rudders when swimming. Dogs bred for swimming frequently have tails that are thick, strong and very flexible, which helps them to move easily through the water and make quick turns.

Table 5: Tail shape percentage on Phu Quoc Ridgeback

Tail shape	M	%	FM	%	Total	%
Sum	**15**	**100**	**14**	**100**	**29**	**100**
Straigth	0	0	2	14	2	7
Curve up ¼	0	0	0	0	0	0
Curve up ½	6	40	11	79	17	59
Curve up ¾	9	60	1	7	10	34

Curve up ½ shape tail is highest proportion (59%) in dogs observed. Percentage in female is as twice as male (79% and 40%).

Tongue spotted
Was defined as dark speckles on the tongue. Most of Phu

Quoc Ridgeback had tongue spotted. It's one of the specific morphologies on this breed.

Universally, according the information's obtained from the people raising this breed about this morphology, the acreage tongue spotted as much as to feed and breed them.

Figure 5: Tongue spotted on Phu Quoc Ridgeback. (A) acreage spotted less than 50% on tongue, (B) acreage spotted more than 50% on tongue, (C) acreage spotted cover tongue.

Table 6: Tongue spotted shape percentage on Phu Quoc Ridgeback

Spotted acreage	M	%	FM	%	Total	%
Sum	**15**	**100**	**14**	**100**	**29**	**100**
None	2	13	2	13	4	14
Less 50%	11	73	9	60	20	69
More 50%	1	7	3	20	4	14
100%	1	7	0	0	1	3

The result show that the dogs which had tongue spotted was 24/29 individuals (86%). The most dogs had black spotted less than 50% tongue acreage. A few had tongue which covered by black spotted.

Nails weared

Nails weared had keratin structure, that is a characteristic of Phu Quoc dogs and is one of the criteria in for Phu Quoc Ridgeback selection by Vietnam Kennels Association (VKA). But according to information obtained from the dog breeder, the nail weared is one of the unfavorable factors in the Phu Quoc dog life. Causes of their behavior are a type of hunting dog, so the nails weared structure will easily make them entangled in the moving. Phu Quoc dog owners tend to cut it away throughout the dog's life.
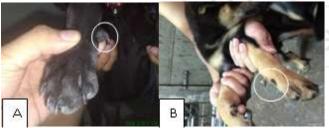

Figure 6: Nails weared on Phu Quoc Ridgeback, (A) one nail weared on forefoot, (B) two nails weared on forefoot

According to the observation, results showed that all dogs have nails weared. Nails weared present on the forelegs or hind legs, each leg have 1 to 2 nails weared. Previously, no studies on the heritability of this trait as well as the difference between the male and female about the number of nails weared.

Table 7: Nails weared on Phu Quoc Ridgeback

Nº of nails weared	M	%	FM	%	Total	%
Sum	**15**	**100**	**14**	**100**	**29**	**100**
Two	13	87	12	86	25	86
Three	0	0	1	7	1	4
Four	2	13	1	7	3	10

Feet webbed

Webbed foot of Phu Quoc dogs appeared on whole individual, the result showed that this is a common genetic characteristic and most stable in the Phu Quoc Ridgeback population observed. According to information collected from the people on the Phu Quoc Phu Quoc Island, dogs showing adapted to the aquatic environment should it formed webbed. But this is not true, because of the formation of Phu Quoc Island about 350 years ago (Mac Cuu General found Phu Quoc Island in 1671), It cannot having a quick evolution and formation such this body shape in mammals. Therefore this trait can only have existed in this breed long years ago, may be before time which they appeared on the Phu Quoc Island by geographic isolation. This character needs further researchs based on the Phu Quoc dog's origin in Vietnam.

Figure 7: Feet webbed on Phu Quoc Ridgeback

Allometric on Phu Quoc Ridgeback dog
In the results above, we can see that there are not different significant in some characteristics: weight, body height, chest and waist between male and female Phu Quoc dogs. So that they can apply for both of sex in Phu Quoc Ridgeback. Allometric were analyzed by multivariate regression nonlinear models based on nonlinear function, using for small sample sizes mean and heterogeneity variance.

$$y = kx^{\alpha}$$
$$\text{or } \ln(y) = \alpha\ln(x) + \ln(k)$$

When:
y: body weight of dog
x: interested in characteristics (body height, chest, waist)

Table 8: The correlation between characteristics

	W	*BH*	*CH*	*WA*
W	⬆ 1			
BH	⬇ 0,5966	⬆ 1		
CH	➡ 0,7893	⬇ 0,6672	⬆ 1	
WA	➡ 0,8392	⬇ 0,5813	⬆ 0,9119	⬆ 1

Preliminary assessment shows that there is a correlation between weight and other characteristics. However, the coefficient R should be evaluated more accurate by regression methods and evaluate the residual of the non-linear function

Estimate the non-linear function between body weight and body height

The nonlinear function form:
$$\ln(W) = \alpha\ln(BH) + \ln(k)$$
and W can estimate simple:
$$W = k(BH)^\alpha$$

Chart 3: The ln(BH) residuals estimated in non linear function

The residual ln(BH] in function above different than zero, so that we can estimate the non-linear function to predict an characteristic when know other.
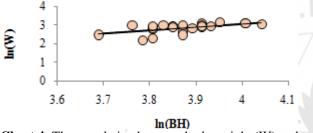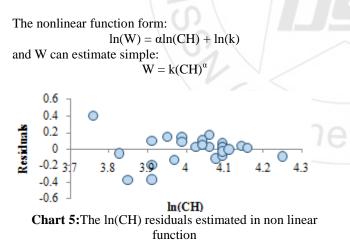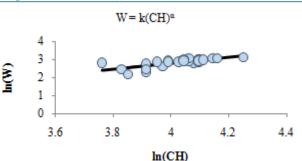
Chart 4: The correlation between body weight (W) and body height (BH) on Phu Quoc Ridgeback.

Estimate the non-linear function between body weight and chest

The nonlinear function form:
$$\ln(W) = \alpha\ln(CH) + \ln(k)$$
and W can estimate simple:
$$W = k(CH)^\alpha$$

Chart 5: The ln(CH) residuals estimated in non linear function

The residual ln(CH) in function above different than zero, so that we can estimate the non-linear function to predict an characteristic when know other.
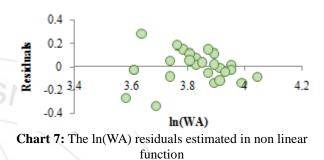
$$W = k(CH)^\alpha$$

Chart 6: The correlation between body weight (W) and body height (BH) on Phu Quoc Ridgeback.

Estimate the non-linear function between body weight and waist

Chart 7: The ln(WA) residuals estimated in non linear function

The residua ln(WA) in function above different than zero, so that we can estimate the non-linear function to predict an characteristic when know other.
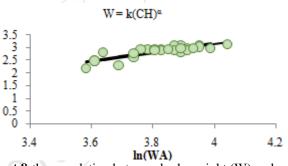
$$W = k(CH)^\alpha$$

Chart 8: the correlation between body weight (W) and waist(WA) on Phu Quoc Ridgeback.

Estimated non linear function for some morphological characteristics on Phu Quoc Ridgeback

Table 9: The parameters using for estimate the correlation for non-linear function

	W and BH	W and CH	W and WA
R	0.56	0.75	0.83
F Regression	10.98	30.63	53.50
k	0.02	0.02	0.03
ln(x)	1.68	1.64	1.64
p-value	**0.000291**	**1.08E-05**	**1.48E-07**
	$\mathbf{y= 0.03x^{1,68}}$	$\mathbf{y = 0.02x^{1,64}}$	$\mathbf{y = 0.03x^{1,64}}$

Correlation parameter R has differences after adjustment compared to the preliminary assessment because the fit for non-linear models of correlation of allometric on animal. The p-value are very small, it explain the accuracy of the regression model to determine and estimates the non-linear function is accurate although sample size to small. The

Regression parameter F is also seen as a factor in determining the accuracy of the estimation method. This coefficient proportional withcorrelation parameter R and inversely proportional to the p-value.

4. Conclusion

The information and sample collected can acquire initial preliminary conclusions about the characteristics of the body shape on the Phu Quoc Ridgeback dogs. This particular breed clever and agile observed. The characteristics of this breed are recognized and preliminary analysed by statistics on the small number of population (n = 29). Phu Quoc Ridgeback phenotype and Thai Ridgeback (similar in shape) have similar characteristics. However the same characteristics are not representative of the common origin of species. In other words, there is no basis that Phu Quoc Ridgeback originated from Thailand Ridgeback as the other previous reviews. Initially identified non-linear function of the relationship between some phenotype characteristics on Phu Quoc dogs, but R factor needs to correct by collect larger numbers of samples in order to optimize the results as a basis for statistics for genetic studies further.

5. Future Scope

The our next goals are to get our more samples to assess the difference between Phu Quoc Ridgeback and the Thai Ridgeback, and take to adjusting the relevant parameters between phenotypic traits on Phu Quoc Ridgeback dogs. Furthermore, we are to be used for modern molecular biological methods, our purpose check the specified target gene relative to phenotypic traits characteristic of Phu Quoc Ridgeback. We hope those study will contribute to the evaluation process of the origin of Vietnam ridgeback dog in the future.

6. Acknowledgments

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