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HERITABILITY ESTIMATES OF SOME BODY MEASUREMENTS IN NILI RAVI BUFFALOES

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ABSTRACT

Current study was conducted to find out heritability estimates of some body measurements of Nili Ravi buffaloes maintained at 5 Livestock Experiment Stations in Punjab Pakistan. Recording of body measurements was continued for 3 years since 2010 to 2012. Heritabilities of traits were estimated using BLUP (Best Linear Unbiased Prediction) evaluation techniques. Influencing factors such as age of the buffalo at scoring, stage of lactation, parity, herd and season were included in the model. Individual Animal Model was fitted under Restricted Maximum Likelihood (REML) Procedure. Data were analysed using the mixed model procedure of the Statistical Analysis Systems. Fixed effects observed to be significant in the initial analysis were included in the model for estimation of variance components from which genetic parameters were estimated. The ASREML set of computer programs was used to estimate heritabilities. Least squares means for head length, poll width, horn diameter, ear length, ear width, neck circumference, neck length, bodylength, tail length, tail diameter, height at sacrum and rump length were found as 54.13±3.48, 30.95±2.35, 18.65±2.06, 29.5±2.12, 18.66±1.22, 95.77±8.58, 53.32±4.56, 139.56±6.29, 103.51±12.55, 22.41±2.00, 135.77±4.40, 43.52±2.58 cm respectively. Results from univariate analysis of body measurement traits showed that most of the body measurements were low to moderate in heritablility. Overall range of heritability estimates for body measurements was found as 0.03±0.06 for neck circumference to 0.41±0.09 for tail length. Head length, tail length, tail diameter at base and ear length showed reasonably high estimates of heritability. The breeders preference for buffaloes with relatively smart head, thin tail and longer tail is supported through current study and these traits can be included for selection decisions for the production of replacement stock.

Key words: body measurements, heritability, Nili Ravi buffalo, variance components
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INTRODUCTION

Morphological evaluation of different breeds of dairy cattle and buffaloes is still considered important from selection point of view. For proper use of morphological traits in selection programs, the knowledge of their descriptive statistics and genetic parameters are necessary. Such information is needed for management of animal genetic resources at global levels (FAO, 2012). Khan *et al*., (2007) has reported Nili Ravi a unique animal genetic resource of Pakistani farming system. There are certain body characters and features of every breed that distinguish it from other breeds and animals. Knowledge of these characters helps in further breeding and improvement programs of breeds. The characters like that are considered important for description include height and length of the animal, head shape and neck conformation, tail length and thickness at base, ear length and width and rump length and horn shape. These characteristics are considered important features of buffaloes. In case of Nili Ravi buffaloes, horn shape is very much emphasized and animals with hook shaped horns fetch more prices at market level.

The buffaloes both Swamp and Riverine have been characterized on the basis of physical features by different scientists. The focus of the studies was limited to a few body measurement traits. A few studies have been performed on Pakistani buffalo (Nili-Ravi breed). The main focus of the studies conducted by Phangchung and Roden (1996) for crossbred buffaloes of Bhutan, Prasad and Kumar (2005) for Tarahi buffalo breed and Sahu *et al*. (2017) for Indian buffalo (Sambalpuri) has been phenotypic characterization. The study of Mehboob (1996) focused on phenotypic correlation of body measurements with milk production. A very few studies have reported gentic parameters for buffalo body measurement traits. The genetic parameetrs particularly

heritability of the trait is required for genetic improvement of animals through selective breeding.

A lot of literature is available on different dairy cattle breeds in the world but information on this aspect of buffalo breeds is very limited. The same has been pointed out in a published book on buffaloes "Buffalo the Animal of Future" that the information on the body measurements of buffaloes in Pakistan is scanty (Khan, 2009). This emphasized the need for studies on Nili Ravi buffaloes. With this back ground in mind the current study was planned. The study aimed at to characterize Nili-Ravi buffaloes in terms of morphology, to quantify the magnitude of fixed effects like herd, stage of lactation, parity and age of animal at recording affecting body measurement traits and heritability estimation of body measurement traits of Nili-Ravi buffaloes of Pakistan.

MATERIALS AND METHODS

The data consisted of body measurements of the buffaloes mainted at institutional herds of the Punjab province including Livestcock Experiment Station, Bhunikey, Pattoki, Livestcock Experiment Station, Chack Katora Hasilpur, Livestcock Experiment Station, Haroonabad, Livestcock Experiment Station, Khushab and Livestcock Experiment Station, Rakh Ghulaman, Kalurkot. The major recorded population of buffalo is being maintained at these Livestock Experiment Stations. The pedigree records of these animals were maintained routinely at the farms.

The feeding, breeding and housing practices at all these farms were similar. Such information included that animals were housed in open sheds. The animals were sent for grazing in the morning and chaffed fodder was fed in the evening. The winter fodder included legumes like berseem and sarson and cereals like oat fodder. The summer fodders consisted of mainly grasses like sorghum and sudan-sorghum hybrid, maize and Jantar were offered. The lactating buffaloes were supplemented with mixed ration depending on daily milk yield. As a thumb rule 1 kg of mix ration was fed for every 3 kg of milk produced by the buffalo. Additional minerals specially common salt was offered in manger as a lick.

Data collection: Body measurements were recorded on 437 lactating buffaloes through year 2010 to 2012. The measurmeents were recorded three times during the course of lactation period. The first record was made at 15 to 90 days after date of calving, second measurement was made at 91 to 180 days after calving and third meaurment was made at 181 to 270 days after calving. The buffaloes were restrained in the cattle crush and all the measurements were made during day time from 7 am through 3 pm. The traits measured and their description is tabulated in Table 1.

The information regarding animal identification, ancestory, birth date, calving date, parity, age of buffalo at classification was collected from the records available at the farm.

Table 1. Body points and their description for Nili Ravi buffaloes

Sr. No	Trait	Description
1	Head length (cm)	From the centre of the poll to the muzzle
2	Poll width (cm)	The distance between base of horns
3	Horn diameter (cm)	Horn diameter measured around the base of the horn with measuring tape
4	Ear length (cm)	Start of the ear to its tip holding ear at right angle of the body surface
5	Ear width (cm)	Width of the ear from outside at the centre
6	Neck circumference (cm)	At the centre of the neck
7	Neck length (cm)	Horizontal distance measured from first thoracic vertebra to the centre of poll while animal standing in normal position with straight neck
8	Body length (cm)	Horizontal distance from first thoracic vertebra to the most posterior point of the pin bone
9	Tail length (cm)	From base of tail to its tip at the end using measuring tape
10	Tail diameter (cm)	Around the base of the tail using measuring tape
11	Height at sacrum (cm)	Using L shaped metal stick
12	Rump length (cm)	Distance from hook to pin bone

Evaluation Model: The fixed effect model was fitted to find out the factors influencing the body points. The model included season, herd, parity, and stage of lactation as fixed effect and linear and quadratic effect of age of buffalo at measurement day was added as covariable. The pedigree records were traced back to five generations. There were total 1180 records on 437 buffaloes. These buffaloes were the progeny of 88 sires and 303 Dams. Number of animals with no pedigree records were 119 which were base population. Separate data and pedigree files for each trait were prepared in excel sheets.

The year was divided into five seasons as defined by Mirza *et al*. (2015). The other factors were herd (1-5), parity (1-4). The 4th level included buffaloes with fourth and later parity. Satge of lactation was

divided into four levels (early mid and late lactation and dry stage). Data were analysed using the mixed model procedure of the Statistical Analysis Systems (SAS, 2011). The factors affecting the body points significantly were inluded in animal model for estimation of variance component with Restricted Maximum Likelihood (REML) procedure outlined by Patterson and Thompson (1971). The ASREML Version (3.0) was the computer software used for this purpose (Gilmour *et al*., 2009). The individual animal model for estimation of animal variance was assumed as follows:

$$Y_{ijk} = \mu + F_i + A_j + Pe + e_{ijk}$$

Where,

Y_{ijk} = measurement of a particular trait:

μ = population mean;

F_i = fixed effects observed to be significant from the initial analyses

A_j = random additive genetic effect of j^{th} animal with mean zero and variance σ^2_A

P_e= random permanent effect of j^{th} animal with mean zero and variance σ^2 pe

e_{ijk} = random error associated with each observation

The heritability was estimated by the following formula:

$$\text{Heritability } (h^2) = \sigma^2_A / \sigma^2_P$$

RESULTS

Least square means for body measurements: There were total 1180 observations on 437 buffaloes. These buffaloes were the progeny of 88 sires and 303 dams. There were 119 base animals with no pedigree records. The least square means±SD, co-efficient of variation and ranges for different body measurements are presented in table 2. The head of the animal is very important for characterization of animals of any breed. The coefficient of variation indicates the variation that exists in a trait. For most of the traits included in the study the coefficient of variation was small which indicates very small variation. However the coefficient of variation for tail length, horn diameter at base, neck circumference, neck length and tail diameter at base were high indicating that much variation exist among the animals.

Table 2. Least squares means for body measurements in Nili Ravi buffaloes

S.No	Trait	N	Mean±StdDev	Coefficient of Variation (%)	Range
1.	Head length(cm)	1179	54.13±3.48	6.43	45-70
2.	Poll width(cm)	1172	30.95±2.35	7.61	23-40
3.	Horn diameter at base(cm)	1178	18.65±2.06	11.04	13.5-26
4.	Ear length(cm)	1179	29.5±2.12	7.18	16-37
5.	Ear width(cm)	1179	18.66±1.22	6.52	14-23
6.	Neck circumference(cm)	1175	95.77±8.58	8.96	52-124
7.	Neck length (horizontal) (cm)	1088	53.32±4.56	8.55	40-69
8.	Body length (cm)	1176	139.56±6.29	4.51	118-160
9.	Tail length (cm)	952	103.51±12.55	12.12	63-148
10.	Tail diameter at base(cm)	1178	22.41±2.00	8.95	16-31
11.	Height at sacrum	1179	135.77±4.40	3.24	121-151
12.	Rump length(cm)	1179	43.52±2.58	5.93	36-52

Table 3 Heritability estimates of body measurements in Nili Ravi buffaloes

S.No	Traits	N	h^2±SE
1.	Head length	1168	0.25±0.091
2.	Poll width	1161	0.14±0.09
3.	Horn diameter at base	1168	0.16±0.09
4.	Ear length	1168	0.38±0.04
5.	Ear width	1168	0.06±0.09
6.	Neck circumference	1079	0.03±0.06
7.	Neck length (horizontal)	1079	0.05±0.07
8.	Body length	1165	0.05±0.09
9.	Tail length	942	0.41±0.09
10.	Tail diameter at base	1165	0.28±0.091
11.	Height at sacrum	1133	0.11±0.09
12.	Rump length	1168	0.13±0.08

The least square means±SD for head related measurements i.e included head length, horn diameter at base, length of ear, ear width and poll width were 54.13±3.48, 18.65±2.06, 29.5±2.12, 18.66±1.22 and

30.95±2.35 cm, respectively. Average values for neck length and neck circumference were observed as 53.32±4.56 and 95.77±8.58 cm, respectively. The least square meas±SD for height at sacrum and horizontal body length were 135.77±4.4 cm and 139.56±6.29 cm, respectively. The length of tail and its diameter at base was measured and its value averaged 103.51±12.55, 22.41±2.005 cm, respectively. Mean value for rump length was observed as 43.52±2.582 cm.

Heritability estimates of body measurements: The univariate animal model heritability estimates for body measurement traits are presented in table 3. The heritability estimates for most of the body measurements have been found in low to modium range. It indicates that most of the variation in traits was due to environmental effects and additive genetic effect has very low role to play. The lowest heritability was found for neck circumference (0.03±0.06) and highest estimate was for tail length 0.41±0.09. The heritability estimates for tail diameter at base (0.28±0.091) and ear length (0.38±0.04) fall in medium to high range.

DISCUSSION

Body measurements

Head length: The measurement of head length obtained in the current study was found as 54.13±3.48 cm. The means values for the face length of Nili Ravi buffaloes as 55 cm (Shah and Hussain, 1953), for Banni Buffalo breed as 53.7±0.20 cm (Mishra *et al*., 2009) are not very different from present study means.Vohra *et al*. (2015) reported head length as 48.58±0.11 in lesser known buffaloes of north India. Sahu *et al*. (2017) reported head length as 49.47 ±0.41 cm in Sambalpuri buffaloes. These buffaloes are of riverine types and could be compared with NIli-Ravi buffaloes. The mean head length as 42.9±2.6 cm reported by Campanile *et al*. (2003) for Italian Buffaloes which are of meditarreanian type and 47±0.1 cm for Chilika Buffaloes (Patro *et al*., 2003) are low than present study values. Kalita *et al*. (2010) reported 51.27± 0.38 cm head length in Swamp buffaloes. It looks that Nili Ravi buffaloes posses longer head as compared many other breeds.

Poll width: Nili Ravi is a riverine type buffaloe. These buffaloes vary in body structure and face and head shape from Swamp bufflaoes. Their comparison could not be justified. However the poll width reported for Swamp buffaloes of Assam is 19.01±0.31 cm which is less than present study estimate. Breed differences might be the reason.

Horn diameter at base: An average estimate of 18.65±2.06 cm for horn diameter at base has been observed in Nili Ravi buffaloes. Almost similar value (19.82±0.12 cm) was reported by Vohra *et al*. (2015) for lesser known buffaloes (Bubalus Bubalis) of north India. Berthouly *et al*. (2010) and Kalita *et al*. (2010) have reported an average estimte of horn diameter at base in Swamp buffaloes as 23.2±0.4 and 29.17±0.49 cm, respectively. It looks that horns of the swamp buffaloes are thicker at base as compared to Nili Ravi buffaloes included in current study.

Ear length: The means values reported for ear length of Banni buffaloes 29.3±0.1 cm (Mishra *et al*., 2009) and lesser known buffaloes of India (Bubalus Bubalis) 28.76±0.09 cm (Vohra *et al*., 2015) are of similar magnitude as for this study. However the ear length 26±0.1 cm for Chilika buffaloes reported by Patro *et al*. (2003) is less than current study mean value for ear length. Yakubu *et al*. (2009) has reported an ear length of 17.57±0.27 cm in White Fulani cows. Khan *et al*. (2018) in a study on Sahiwal cows has documented an average estimate of ear length as 25.6±1.70 cm. The reason for differences from the current study could be the species difference.

Ear width: Shah and Hussain (1953) have reported ear width as 18.17 and 18.18 cm in Nili and in Ravi breed, respectively which is in agreement to current study means. The Nili and Ravi breeds are parents of Nili Ravi Buffaloes. So there is no difference for ear width as reported in these studies. Khan *et al*. (2009) has reported ear width as 16.2±0.15 cm in AzaKheli buffaloes. In a study on Sahiwal cows, Khan *et al*. (2018) has described ear width as 15.8±0.89 cm. Pundir *et al*. (2011) has also reported a similar value as 16.10± 0.05 in Kankrej cows. All these findings vary from the findings of the current study and the reason could be due to species, breed, herd, year, age and other environmental differences.

Neck circumference: The lean neck is considered as dairy character. The farmers have preferences for the buflaoes with long and thin neck. Long and thin neck is an indicative of good milk producing ability. While going through the literature, it has been observed that very scanty documented information is available for buffaloes as concern neck circumference. Some of the studies have reported neck circumference in different breeds of cattle. The neck circumference reported for Siri breed of cattle 70±0.9 cm (Phangchung and Roden, 1996) and 73.21±0.32 for Kankrej cattle (Pundir *et al*., 2011) are very low as compared to present study mean values. The species differences could be one the reason for this variation.

Neck length: Neck length adds to beauty of dairy animals. It is an important component of dairy character. Shah and Hussain (1953) have reported neck length as 51.45 and 53 cm in Nili and in Ravi breed, respectively. This is in consensus with present study findings because of common origin of the breeds. However the mean values as reported by Patro *et al*. (2003) in Chilika

Buffaloes and Prasad and Kumar (2005) in Tarai buffaloes 60±0.1 cm and 63 cm, respectively are higher than current study means. The trait definition could be one of the causes of difference. In present study the neck length was taken as horizontal distance from first thoracic vertebra to center of poll where as in some other studies it is taken as flapping distance from anterior point of hump to poll (Khan *et al*., 2018). Khan *et al*. (2009) documented a score of 42.0±0.48 cm in AzaKheli buffaloes. Pundir *et al*. (2011) has reported an average neck length of 50.63± 0.18 cm in Kankrej cows which slightly coincide with the findings of the current study. Aamir *et al*. (2010) has reported this value as 43.04±0.07 cm in Kenana cattle. In case of Sahiwal cows, Khan *et al*. (2018) has reported an estimate of 37.4±4.90 for this trait. The differences of traits definition and breed and species could be important.

Body length: In present study, the least squares means for body length in Nili Ravi buffaloes was found as 139.56±6.29 cm. Khan *et al*. (2009) and Khan (2009) has reproetd body length for AziKheli and Bhadwari Buffloaes of same magnitude as in present study 139.0±1.32 cm and 139 cm, respectively. Lower estimates have been documented as 121±1 cm and 122±0.2 cm in Iranian and Chilika Buffaloes by Dezfuli *et al*. (2010) and Patro *et al*. (2003), respectively and Sahu *et al*. (2017) reported body length as 128.76 ±0.86 in Sambalpuri buffaloes. Vohra *et al*. (2015) reported body length as 133.33±0.35 cm in lesser known buffaloes of north India. Higher means values have been reported by Andrea *et al*. (2010) as 142±8 cm and Djaja (2011) as 147.98±8.96 cm in Murrah Buffaloes, Mishra *et al*. (2009) as 153.7±0.4 cm in Banni Buffaloes, Campanile *et al*. (2003) as 146.2±7.9 cm in Italian Buffaloes, Mehboob (1996) as 151.6±8.7, Khalid (2013) as 147.3± 7.2 cm, and Ahmad *et al*. (2013) 147.3 ±7.2, respectively in Nili Ravi Buffaloes and Kalita *et al*. (2010) as 142.22±0.67 cm in Swamp buffaloes. The breed differences might be the main cause for such variation. Amongst other trait definition is very important. Some of the studies report this trait as diagonal body lenth from point of shoulder to pin bone where as others recorded as horizontal distance from wither to the pin bone at dorsal side of the body.

Tail length: The means reported for Nili Ravi buffaloes by Mehboob (1996) as 104.65±16.26 cm and for Iraqi buffaloes as 106.0 ± 0.9 cm (Avadesian *et al*., 2017) are similar to current study mean. Slightly higher than present study means were reported by Shah and Hussain (1953) as 108 and 115 cm in Nili and in Ravi breed, respectively. All other estimates in various buffalo breeds are comparatively less from this breed and included 90.57±1.15 cm in lesser known buffaloes of north India (Vohra *et al*., 2015), 71.9±1.61 cm in AzaKheli buffaloes (Khan *et al*., 2009), 88.4±0.53 cm in Banni Buffaloes (Mishra *et al*., 2009), 68±0.2 cm in Chilika Buffaloes (Patro *et al*., 2003) and 79.19±0.56 cm in Swamp buffaloes (Kalita *et al*., 2010). Sahu *et al*. (2017) reported tail length as 81.33 ±0.90 cm in Sambalpuri buffaloes. The present study results vary due to breed, herd, age and other environmental differences.

Tail diameter at base: Diameter of tail at its base has been found as 22.41±2.01 cm in Nili Ravi buffaloes in the current study. Alsiddig *et al*. (2010) has reported width of tail base instead of diameter as 7.15±0.08 cm and 6.37±0.13 cm in Nyalawi and Mesairi cattle, respectively. The results of these findings are not comparable with the findings of current study.

Height at sacrum: The traits related to height and bone conformation in the current study showed a smaller variation with coefficient of variation ranging from 3.24 to 3.75. Average value of 135.77±4.40 cm for height at sacrum has been observed in the present study. Ahmad *et al*. (2013) reported body height as 140.2±7.2 cm, in Nili Ravi Buffaloes. Campanile *et al*. (2003) reported an average estimate of 139.2±4.1 cm for this trait in Italian Buffaloes. Negretti *et al*. (2008) and Andrea *et al*. (2010) have reported average height at sacrum as 139.7±4.3 cm and 1.39±0.04 m in Mediterranean Buffaloes and Murrah Buffaloes, respectively. Bhooshan *et al*. (2016) reported height at sacrum as 141.30±0.38 cm in graded Murrah buffaloes. These findings are not in agreement with the findings of the current study and the reason may be due to breed, herd, age and other environmental differences.

Rump length: Mean value for rump length in Nili Ravi buffaloes was found as 43.52±2.58 cm. Almost similar findings have been reported by Negretti *et al*. (2008) as 44.9±2.6 in Mediterranean Buffaloes and by Andrea *et al*. (2010) as 0.45±0.03 m in Murrah Buffaloes. The findings of the current study are slightly higher than the values reported by Prasad and Kumar (2005) in Tarai buffaloes as 40 cm and by Khan *et al*. (2009) in AzaKheli buffaloes as 41.4±0.45 cm. Campanile *et al*. (2003) has reported a rump length of 46.8±3.2 cm in Italian Buffaloes. The variations in the results are due to anatomical differences among the breeds and might be due to herd, age and other managemental differences.

Heritability estimates for head and neck related traits: In general the heritability estimates for most of the traits were in low range. It means that the traits were mostly being effected by non genetic reasons. Among the non genetic reason, the scorer variation, the traits definitions and facilities available at difeent stations for restraining of animals while recording observation might be important resaons. The authenticity of pedigree record could affect the heritability estimates. It has been observed in general that buffloes do not feel comfortable while taking measurements thus affecting the recording. However the traits like head length, ear length, tail length

and tail diameter have heritability estimates in medium to high range.

Khan *et al*. (2018) has reported a higher heritability estimates for ear length, ear width and neck length as 0.68±0.03, 0.75±0.02 and 0.52±0.04 respectively in Sahiwal cows. Lower than current study the heritability estimate 0.10±0.03 of head length was reported for Holstein cows (Smith *et al*., 1985). Some traits have higher genetic control as compared to others hence they showed higher heritabilities. Many other studies have reported higher heritability estimates for body lenth contrary to current study estimates. Brum and Ludwick (1969) and Lin *et al*. (1987) have reported heritability estimates for body length as 0.47±0.08 and 0.91±0.07, respectively in Holstein Friesian cows. Andoyo *et al*. (2012) has reported heritability estimate for body length as 0.38±0.08 in Bali cattle. Khan *et al*. (2018) has reported heritability estimate for body length as 0.81±0.02 in Sahiwal cows. The species-breed differences and small data set and recording parcatices might have influences the estimation of additive genetic variance and hence affected the estimates.

Similar trend of estimates has been found for body length where heritabilities are reported in higher range 0.58±0.014 for Czech Fleckvieh cattle (Novotny *et al*., 2017) and 0.83±0.02 for Sahiwal cows (Khan *et al*., 2018). However heritability estimate for height at hip bone of Holstein cows was in low range 0.20 (Shanks and Spahr, 1982) but even higher than current study estimate.

The maximum value of heritability estimate among all the body measurements has been observed for tail length as 0.41±0.09. Khan *et al*. (2018) has reported corresponding value as 0.95±0.01 which is very high and does not coincide with the findings of current study. Heritability estimate for tail diameter was observed slightly low as 0.28±0.091 in the current study. Heritability estimate for tail length was based on 942 records while that of tail diameter was based on 1165 records. Relatively less number of records for tail length were due to tail injuries in buffaloes resulting in the cutting of tails. Selection for tail length will be effective however, animal with longer tails mostly suffer from tail injuries.

The heritability estimate for rump length was found as 0.13±0.08. Smothers *et al*. (1993), Larroque *et al*. (1999) and Daliri *et al*. (2008) have reported heritability estimates for rump length as 0.19, 0.29 and 0.23±0.013, respectively. Novotny *et al*. (2017) has reported heritability estimate for rump length as 0.26±0.012 in Czech Fleckvieh cattle. Corresponding value for this trait was reported as 0.76±0.02 by Khan *et al*. (2018) which does not match with current study estimates. Trait definition is one of the important factors for this variation. Because in some studies, the rump length is the distance between top most positions of the hook bones and some other studies have said as distance between outer most positions on lateral sides of the hook bone.

Conclusions: Generally, the least squares means for most of the body measurements were found in the normal range and were in agreement with most of the reports in literature. Most of the body measurements were affected by the herd and age factors but the effect of parity, stage of lactation and season of scoring was variable for different traits and showed not very clear trend. Most of the body measurements have been found to be lowly to moderately heritable in the current study.

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