Association of Body Condition Score with Lactation and Reproductive Performance in Murrah Cross Buffaloes in Chitwan, Nepal

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ABSTRACT

Body condition score (BCS) is a precise method for determining the stored energy reserves of dairy animals, which are located in the form of subcutaneous fat tissue, indicated by the animal's degree of accomplished nutrition, and could be used as a management and selection tool to improve reproductive performance. The objective of this research was to investigate and quantify relationships between BCS and milk production, milk composition, and reproductive performance in Murrah cross buffalo. For this purpose, a semi-structured questionnaire was created and BCS was calculated using a visual technique based on a BCS chart. The sampling approach employed was a completely randomized design. A total of 165 Murrah cross buffaloes from 59 household farms were used in the study, where 130 milk samples were collected and used to assess the milk parameters by lacto-scan. Four BCS groups were namely 2.5-2.99, 3.0-3.49, 3.5-3.99, and 4.0-4.99 where the BCS score was found to grow during the dry period until calving, then decreased as milk production increased. BCS group (3.5-3.99) had higher performance during all the lactation periods with a peak milk yield of 11.4 ± 1.1 kg. At the late lactation stage BCS group (3.5-3.99) showed higher values of SNF (9.77), protein (4.01), and lactose (3.82), followed by BCS groups 4.0-4.49, 3.0-3.49, and 2.5-2.99. At the early, lactation stages, the BCS group (3.5-3.99) had the highest ($P<0.01$) average milk yield of 10.28, 9.50, 9.37 kg, and the BCS group (4- 4.49) had highest ($P<0.01$) average fat percent of 9.19, 10.20, and 10.32, respectively. The buffaloes of BCS group 3.5-3.99 had shorter post-partum estrus (61.14days) ($P<0.01$), fewer services for conception (1.30) ($P<0.01$) and higher first service conception rate (79.87%) ($P<0.01$). Similarly, the incidence of associated reproductive disorders such as uterine prolapse, retained placenta, metritis, and mastitis are lowest in BCS group 3.5-3.99 with values of 7.69%, 3.44%, 3.44%, and 6.89% respectively. It can be concluded that the BCS group (3.5–3.99) provided the greatest production results in both milk and reproductive function. For optimal animal lactation and reproductive performance, the nutrition management of dairy cows should be necessarily monitored using the BCS score.

Keywords: *BCS, milk parameters, Reproductive performance, Lactation stages, Chitwan*

INTRODUCTION

The body condition score (BCS) system is a precise, instantaneous, inexpensive and universally accepted method for determining the stored energy reserves of dairy animals (Alapati et al., 2010). BCS is assessed in terms of subcutaneous fat cover, muscle appearance, and apparent skeletal features through subjective visual appraisal and (or) manual palpation, indicated by the animal's degree of accomplished nutrition (Momon & Pruitt, 2016). It gives the visual evaluation of the animal's body fat reserves thus influencing the energy balance. It provides the biological relationship between milk production, milk parameter, and reproductive performance. A computed relationship between BCS and other parameters facilitates the adoption of the most advantageous control practices to derive maximum production and maintain better health status (Obese & Tecku, 2019). The most widely used and traditional method of body condition scoring is by manual observation and or physical examination of the animal to assess overall body condition (Edmonson et al., 1989). Animals with higher BCS have early post-partum estrus, better breeding efficiency, and lower reproductive disturbances (Pryce et al., 2001). During early lactation, the animal undergoes a negative energy balance as a result of the utilization of energy reserves for the production of milk; as a result BCS goes on decreasing (Souissi & Bouraoui, 2020). Various body condition scoring systems have been developed by many scientists like (Jefferies, 1961) using 0 to 5 scale in ewes,(Lowman et al., 1976) using a 0 to 5 scale in beef cattle and (Earle, 1976) using an eighth-grade system in dairy cows. (Edmonson et al., 1989) developed a chart for body condition scoring of Holstein dairy cows on a 1 to 5 scale using 0.25 increments. Recently, a new BCS system was developed for Murrah buffalos with a 1-5 scale having 0.5 increments examining eight skeletal checkpoints that adequately reflected the actual fat reserves (Alapati et al., 2010).

In Nepal, livestock is an important part of the national economy and an important sub-sector of agriculture. Agriculture contributes 33% of total GDP and the livestock sub-sector contributes 11 percent to the national GDP, and approximately 27 percent to AGDP (MOALD, 2019). There are in total 5.30 million populations of buffaloes with annual milk production of 1,372,905 liters of which 76,112 buffaloes in Chitwan with total milk production 23,909 liters of annual milk productions (MOALD, 2019). Livestock creates employment opportunities for unemployed and influence on the upliftment of rural economy. Buffalo contributes to milk, meat, manure and draught purposes. Murrah is an important buffalo breed introduced from India for improving indigenous buffalo production and has major cross breed population of buffaloes in Nepal. BCS is an indicator for the energy reserve of an animal which influences the productive and reproductive parameters of the dairy animals. BCS is related to the animal's puberty, sexual maturity, fertility, ovulation, overall health of reproductive tracts and calf, milk production and milk compositions. Body condition score is one of the determining factors for the resumption of the reproductive performances and occurrence of reproductive disorders after calving.

Estimation of the body condition of dairy animals and relating it to productive and reproductive status helps farmers access their overall efficiency of feeding and husbandry practices of farm animals. BCS system helps to acquire optimum management practices for better health, production and reproduction of dairy animals. Poor availability of nutrition during summer season shows higher ovarian inactivity in buffaloes. Poor body condition score leads to the prolongation of the postpartum anestrus and postpartum reproductive disorders (Devkota et al., 2012). Murrah cross buffaloes have better reproductive and productive efficiency than indigenous local buffaloes and has added economic benefits to farmers. Knowing the impact of income and livelihood of buffaloes farming communities and future prospective of making buffaloes as major dairy farming animals, there is also a national policy for cross breeding of high producing murrah buffaloes with indigenous for the genetic improvement of native buffaloes. This study investigates the nutritional status of murrah buffalo in terms of BCS and quantifies relationships between BCS, milk production, milk composition, and reproductive efficiency in murrah crosses buffalo in Chitwan, Nepal.

MATERIALS AND METHODS

Study Area

The present study was conducted at buffalo farming areas of Bharatpur Metropolitan City, Chitwan, Nepal, which lies in the tropical zone around 27 degrees 39 minutes and 14 seconds latitude and 84 degrees, 21 minutes and 6 seconds longitude with the altitude of about 415 m from the sea level. The area has a tropical monsoon climate with high humidity all through the year. The seasonal environmental fluctuation in chitwan, Nepal is typical with cold and semi-dry to dry winter, rapidly increasing hot and dry spring, very hot and rainy monsoon summer and moderate autumn. Annual rainfall and temperatures range between 13- 690 mm and 15.2°C to 27.6°C respectively and relative humidity ranges from 52.85 to 86.87 % (Weather_24, 2021). The Indian Murrah breed or its crosses with indigenous breeds make up the majority of the buffalo population in this area. The main feed supply for buffaloes here is seasonal monsoon fodder during the rainy months and rice straw hay after October/November.

Sampling Procedure and Data Collection

The sampling approach employed was completely randomized design. For documentation a pre-tested semi-structured questionnaire was made. The total 165 Murrah cross buffaloes from 59 household farms were used for the study. Parity (mean ± S.E.) of buffaloes was 3.65±1.71 (range: 2 to13). Fifty one buffaloes were of early (0-3 months) lactation stages, forty three were of mid (4-6 months), thirty six were of late (>7months), and thirty five were of dry periods (Yadav et al., 2013). Milk samples from 150 buffaloes were taken from the milking bucket during morning milking and placed in a screw-capped plastic tube, which was then carried to the laboratory in a cool box to determine the fat, SNF,

lactose, and protein levels by Lacto-scan (Ultrasonic Milk Analyzer, Milkotronic Ltd., Bulgaria) in the laboratory of the National Cattle Research Program (NCRP), Rampur, Chitwan.

Determination of body condition score (BCS)

The body condition score (BCS) of each buffalo in the study was determined at calving using a visual technique devised by (Alapati et al., 2010) based on a BCS chart of (1-5) scale with 0.5 increments analyzing eight skeletal checkpoints. A score of 1 indicates emaciated, 2 indicates thin, 3 indicates average, 4 indicates fat and 5 indicates obese condition (Alapati et al., 2010). Based on BCS, the buffaloes were classified into following four groups, namely 2.5-2.99, 3.0-3.49, 3.5-3.99, 4.0-4.99.

Recording of milk yield, reproductive performance parameters and reproductive disorders

The data regarding daily milk yield, peak milk yield, calving to first postpartum estrus interval, number of services per conception, and first service conception rate (%) were obtained from the records of the farm.

Data entry and analysis

The collected information and data were coded, entered and analyzed by using MS-Excel and SPSS 16.0 software. Relationship between BCS with present milk yield, peak milk yield, milk composition, reproductive parameters were assessed using a one-way ANOVA followed by post Hoc Tukey test. The incidence rate of reproductive disorders and mastitis in association with BCS were calculated using simple descriptive statistics and mean were obtained. P value ≤ 0.05 was considered to be significant whereas $0.1 \leq P > 0.05$ considered to have tendency.

RESULTS

Relationship between BCS with present milk yield and peak milk yield

The current daily milk yield for each lactation stage computed in relation to body condition score (BCS) groups of 2.5-2.99, 3.0-3.49, 3.5-3.99, and 4.0-4.99 is shown in Table 1. Buffaloes of BCS group 3.5-3.99 had higher ($P < 0.01$) present milk yields (kg) at early, mid and late lactation, followed by buffaloes of BCS group 4.0-4.49, 3.0-3.49 and 2.5-2.99.

Table 1. Relationship between BCS and present milk yield

BCS	No. of buffalo(n)	Present milk yield (kg/day)		
		Early lactation (n=51)	Mid lactation (n=43)	Late lactation (n=36)
2.5-2.99	52	6.9±1.04[a]	5.9±1.2[a]	5.6±0.9[a]

3.0-3.49	58	8.4±0.6[b]	7.7±0.9[b]	7.3±0.5[b]
3.5-3.99	29	10.3±0.5[c]	9.5±0.5[c]	9.4±0.8[c]
4.0-4.49	26	8.7±0.4[b]	8.4±0.2[bc]	7.6±0.4[b]

Note: a, b, c: values with different superscripts within the column differ significantly ($P < 0.05$).

Table 2 shows the relationship between BCS and peak milk yield. Buffaloes of BCS group 3.5-3.99 had higher ($P < 0.01$) peak milk yield followed by buffaloes of BCS group 4.0-4.49, 3.0-3.49 and 2.5-2.99.

Table 2. Relationship between BCS and peak milk yield in test herd

BCS	No. of buffaloes	Peak milk yield(kg/day)	P-value
2.5-2.99	52	7.4 ± 0.8[a]	<0.0001
3.0-3.49	58	9.2 ± 0.9[b]	
3.5-3.99	29	11.4 ± 1.1[c]	
4.0-4.49	26	9.8 ± 0.8[b]	

Note: a, b, c: values with different superscripts within the column differ significantly ($P < 0.05$).

3.2 Relationship between body condition score (BCS) and milk composition

Milk composition i.e. fat, SNF, lactose, and protein percentages in milk were evaluated independently for three stages of lactation with respect to BCS groups of 2.5-2.99, 3.0-3.49, 3.5-3.99, and 4.0-4.99.

3.2.1 Variation in milk composition with respect to BCS at different stage of lactation

Table 3 shows the milk composition with respect to BCS at different stage of lactation. At all three stages of lactation, the buffaloes of BCS group 4.0-4.49 had the highest ($P < 0.01$) milk fat percentages followed by the buffaloes of BCS groups 3.5-3.99, 3.0-3.49, and 2.5-2.99. Similarly, at all stages of lactation, the buffaloes of BCS 3.5-3.99 had the highest ($P<0.01$) Solid Not Fat (SNF) percentages followed by the buffaloes of BCS group 4.0-4.49, 3.0- 3.49, and 2.5-2.99. Lactose and protein percentages in the milk sample also followed a similar pattern. The buffaloes of BCS 3.5-3.99 had the highest ($P<0.01$) lactose percentages followed by the buffaloes of BCS group 4.0-4.49, 3.0- 3.49, and 2.5-2.99. On overall evaluation, milk fat, SNF, lactose, and protein increased with the advancement of the lactation stage standing on the same body condition score.

Table 3. Relationship between BCS and milk composition

Early lactation					
BCS	No. of buffaloes	Fat%	SNF%	Lactose%	Protein%
2.5-2.99	20	4.80[a]	7.35[a]	3.08[a]	3.13[a]
3.0-3.49	19	6.72[b]	8.35[b]	3.21[b]	3.40[b]

3.5-3.99	7	7.83[b]	9.50[c]	3.46[c]	3.88[c]
4.0-4.49	5	9.19[c]	8.65[b]	3.39[c]	3.69[d]
Mid lactation					
BCS	No. of buffaloes	Fat%	SNF%	Lactose%	Protein%
2.5-2.99	15	5.88[a]	7.78[a]	3.22[a]	3.21[a]
3.0-3.49	16	7.11[b]	8.55[b]	3.39[a]	3.47[b]
3.5-3.99	6	8.10[b]	9.74[c]	3.75[b]	3.97[d]
4.0-4.49	6	10.20[c]	8.83[b]	3.42[a]	3.72[c]
Late lactation					
BCS	No. of buffaloes	Fat%	SNF%	Lactose%	Protein%
2.5-2.99	12	6.72[a]	7.88[a]	3.27[a]	3.32[a]
3.0-3.49	11	7.51[b]	8.59[b]	3.45[b]	3.50[b]
3.5-3.99	8	8.65[c]	9.77[d]	3.82[d]	4.01[c]
4.0-4.49	5	10.32[d]	8.87[c]	3.61[c]	3.76[d]

Note: a, b, c, d: values with different superscripts within the column differ significantly ($P < 0.05$).

3.3. Relationship between body condition score (BCS) and reproductive performance

The reproductive performance of the buffaloes was significantly affected by BCS. Table 4 shows the reproductive performance of buffaloes from various BCS groups. The buffaloes of BCS group 3.5-3.99 had shorter ($P<0.01$) calving to first postpartum interval (days), fewer ($P<0.01$) services for conception and higher ($P<0.01$) first service conception rate as compared to other groups of buffaloes. While summarizing the data, it was shown that reproductive performance improved as the BCS grew up to 3.99, but then began to decline.

Table 4. Reproductive performance of buffaloes of various BCS group

Reproductive Parameter	BCS			
	2.5-2.99 (n=52)	3.0-3.49 (n=58)	3.5-3.99 (n=29)	4.0-4.49 (n=26)
Post-partum estrus (days)	82.25[b]	67.97[ab]	61.14[a]	62.00[a]
No. of services per conception	1.5945[b]	1.3074[a]	1.2442[a]	1.3012[a]
1st service conception rate (%)	50.6779[a]	74.0498[b]	79.8724[b]	74.1338[b]

Note: a, b, c, d: values with different superscripts within the column differ significantly ($P < 0.05$).

3.3. Relationship between body condition score (BCS) and reproductive disorders

Table 5 showed that out of 200 buffaloes included in this study, the highest incidence of

uterine prolapse was observed in the buffaloes with body condition score (BCS) group 2.5-2.99 with 17.3% which was followed by BCS group 4.0-4.49 with 15.38%, 3.0-3.49 with 10.34%, and 3.5-3.99 with 7.69%. It was showed that highly emaciated and obsessed buffaloes were prone to uterine prolapse. Buffaloes of BCS group 2.5-2.99 were the most susceptible to the retained placenta, with 21.15%, followed by BCS group 4.0-4.49 with 11.53%, BCS group 3.0-3.49 with 6.89%, and BCS group 3.5-3.99 with 3.44 %. Occurrence of metritis, on the other hand, followed a slightly different pattern than uterine prolapse and retained placenta. Buffaloes with a BCS score of 2.5-2.99 had the highest prevalence of metritis (25%) followed by BCS groups 3.0-3.49 (13.79%), 4.0-4.9 (7.39%), and 3.5-3.99 (3.44%). Mastitis had a similar trend to metritis in terms of occurrence. Buffaloes with a BCS score of 2.5-2.99 had the highest prevalence of mastitis (26.92%), followed by BCS groups 3.0-3.49 (13.79%), 4.0-4.9 (7.39%), and 3.5-3.99 (6.69%).

Table 5. Association of BCS with various reproductive disorders and mastitis

Disorders	BCS			
	2.5-2.99 (n=52)	3.0-3.49 (n=58)	3.5-3.99 (n=29)	4.0-4.49 (n=26)
Uterine Prolapse	17.3%	10.3 %	7.7%	15.4%
Retained Placenta	21.2%	6.9%	3.4%	11.5%
Metritis	25%	13.8%	3.4%	7.7%
Mastitis	26.9%	8.6%	6.9%	7.7%

DISCUSSION

In this research, the tripod relationship shown between BCS, lactation stages and milk yield is novel approach. The present study revealed that milk production increased with BCS up to a score of 3.99 at all stages of lactation, then began to fall. This finding supported the finding of (Braun et al., 1986), that cows with a BCS 3-3.5 produce more milk then those with a BCS of 2.5 or less. Similarly,(Domecq et al., 1997) observed that cows who gained condition during the dry period provided more milk in the first 120 days of lactation and had a faster rate of growth in milk supply.(Alapati et al., 2010) also showed that lactation yield, 305 day predicted lactation yield, and peak milk yield increased with increase in BCS up to 3.99. In contrast to this study (Ruegg & Milton, 1995) reported that condition score had no effect on either peak or 305-d milk yields. The majority of studies have found a favorable link between BCS and milk output (Roche et al., 2005; Stockdale, 2005), which is similar to the findings of this study. Present research suggested that BCS of (3.50-3.99) is the most appropriate and highly profitable BCS range to maintain in term of peak milk yield. It might be because thin or low BCS animal are more likely to have a higher milk somatic cell count (SCC) and are more prone to mastitis which drastically reduce the milk production (Berry et al., 2007) similarly low

BCS animal or severe negative energy balance may be more susceptible to infection resulting reduced DMI (dry matter intake), poor udder development subsequently reduce in milk production (Bauman & Bruce Currie, 1980; Collard et al., 2000).

Study suggested that buffaloes of BCS group 4.0-4.49 had the highest milk fat percentages 9.19, 10.20, and 10.32 at early, mid and late stages of lactation respectively followed by BCS group 3.5-3.99, 3.0- 3.49, and 2.5-2.99. This is consistent with the findings of (Alapati et al., 2010), who discovered that for every one unit rise in BCS, milk fat percent increased by 1.8 to 2.0 percent. While (Ducháček et al., 2013) observed that milk fat content dropped from 4.89 percent at the start of lactation to 3.27 percent in week 7, then climbed to 4.06 percent in weeks 14 and 16. More the fat reserved in the body more will be the milk fat percentage, it might be because animals with BCS > 3.5 are subjected to significant fat mobilization during the transition period, resulting in higher plasma NEFA to meet the energy demand (Locher et al., 2015). Furthermore, postpartum NEFA discharge typically exceeds the liver's energy requirements and oxidation capacities, resulting in the formation of ketone bodies such as β-hydroxybutyrate and re-esterification to triglycerides (TG) (Locher et al., 2015) might be excreted via milk. In accordance with the present finding (Holter et al., 1990; Roche et al., 2007) also found that under conditioned cow had reduced fat content of milk and it increased with increased in BCS.

Present study revealed that other parameters such as SNF, lactose, and protein were found to be best established at BCS group 3.50-3.99, with declines occurred above and below this level. Study on SNF and lactose by (Alapati et al., 2010) also found buffaloes with BCS group 3.50-3.99 have the highest milk SNF at 6-8 and 16-18 weeks after calving. In contrast to the current findings (Roche et al., 2005) insist that, BCS at calving had no significant effect on milk SNF, protein and lactose content of milk.

The findings revealed that the body condition at calving was the most important determinant in reestablishing ovarian function. Buffaloes of body condition group 3.5-3.99 had least post-partum estrus period, 61.14 days while the buffaloes of body condition score 2.5-2.99 had the long post-partum estrus period, 82.25 days. These findings were in agreement with the finding of (Alapati et al., 2010) but was short than the values of the present study, who observed that buffaloes of body condition group 3.5-3.99 had least post-partum estrus period, while the buffaloes of body condition score 2.5-2.99 had the long post-partum estrus period. (K. Sarjan Rao et al., 2021) reported that buffaloes of BCS group 3.5 – 3.99 have shown early postpartum estrus which was comparable with BCS group of 4.0 – 4.49 when compared to BCS groups of 3.0 – 3.49 and 2.5 – 2.99 which were shorter in value but in accordance with the present study. Sakaguchi (2009) concluded that in a herd of primiparous and multiparous cows, BW loss (percent) or BCS loss ultimately lead to decline in reproductive performance such as postpartum first ovulation, estrus, and insemination. Butler (2005) concluded that high levels of NEFA

and ketones in plasma and increased buildup of triglycerides in the liver during the first three weeks of lactation might be the causes of failure of ovulation of the first wave dominant follicle in animal with low BCS.

Present study found that number of service per conception decrease with the increase in BCS of buffaloes till 3.99 but decline above it which are low in 3.5-3.99 and high in 2.5-2.99. This finding was similar to the finding of (Alapati et al., 2010) but value was greater than the value of present study, he observed that service per conception is low in 3.5-3.99 and high in 2.5-2.99. The reason behind high number of service per conception in buffaloes with low BCS might be related to prolonged non-ovulatory interval (López-Gatius et al., 2003). However, (Montiel-Olguín et al., 2019) study on small scale dairy system found that first lactation cows with BCS <3.0 at calving and second lactation cows with BCS <2.5 at calving had greater first service conception rates this might be due to different management factors in small scale system while our study includes both large and small scale dairy system.

The results suggest that buffaloes in the body condition group 3.5-3.99 have the best reproductive performance based on first service conception rate while buffaloes in the body condition group 2.5-2.99 have the poor. These findings were in agreement with the reports of (Alapati et al., 2010) who observed the same but the value was lesser than present finding. (K. Sarjan Rao et al., 2021) also found that murrah buffaloes with BCS group 3.5-3.99 had the highest breeding efficiency 88.32 % while BCS group 2.5-2.99 had lowest breeding efficiency 67.70. It might be because decrease in BCS creates a NEB which limits dominant follicle growth and estradiol production through decreases in circulating insulin, IGF-1, and LH pulses leads to reduction in reproductive performance(Butler, 2000, 2005; Chagas et al., 2007).

According to present research, too obese (4.0-4.49) and too thin (2.5-2.99) buffaloes are more susceptible to uterine prolapse and retained placenta. It may be due to obesity leading to poor calcium mobilization in the blood and ultimately lead to suppression of uterine contraction and then expulsion of placenta (Zhang et al., 2019). But (Qu et al., 2014) found that the retained placenta cows had lower BCS than the healthy or cows that developed other disease in early lactation. Present study found that the incidence of metritis and mastitis decreases with increasing BCS until 3.99, it increases after that. (Domecq et al., 1997) reported that poor body condition score is positively related with retained placenta, metritis, lameness, milk fever, and twins and was negatively related to dystocia and displaced abomasum which support the present study. Similarly (Schöpke et al., 2013) suggested that under conditioned and over conditioned, cows were seemed to had the higher incidence of disorders and disease. In accordance to present finding increased BCS at calving was associated with reduced somatic cell score (SCS) and

subclinical mastitis (Berry et al., 2007). Kadivar et al. (2014) reported that cows with clinical endometritis had significantly lower body condition score (BCS) than normal cows at all weeks pre- and post-calving which supported present study. (D. Claire Wathes, 2009) found that cows in lower BCS have severe negative energy balance and poor immune response lead to various diseases and disorder which affect the productivity.

CONCLUSION

BCS is easy to measure and could be used both for improving management practices and in a breeding program. Although result shows that obese animal has high fat% in their milk it is good to maintain BCS at 3.50-3.99 since all other parameter i.e SNF, lactose and protein are found to be best established in this BCS group. From the point of daily milk yield and peak milk yield also suggested that BCS of (3.50-3.99) is the most appropriate and highly profitable. Study shows that too obese and too thin buffalo are highly prone to various disorders like uterine prolapse, retained placenta, metritis and mastitis which directly or indirectly hamper the milk and reproductive function of buffalo. The optimum reproductive performance indicators were found best established in (3.5-3.99) BCS group for post-partum estrus, first service and conception rate. Thus the present study suggests that a BCS of (3.50-3.99) was ideal or standard score for better reproductive and productive performance of Murrah cross buffalo in Nepal and hence the feeding management should be done in such a way that the buffaloes maintain BCS Score at (3.50-3.99) at the time of calving for better performance.

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