REVIEW ARTICLE

Selection of Heifers and Breeding Bulls for Reducing Calving Difficulties in the First Calvers: An Overview

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Abstract

Calving difficulty is associated with cow mortality, calf loss, veterinary and labor costs, and causes delayed return to estrus and lower conception rate. Dystocia is common in heifers, and the frequency decreases with the increasing age of the cow. Farmers need to consider both genetics and management factors in an attempt to reduce dystocia. Calf birth weight, the pelvic area of the dam and their interrelationships are major determinants of dystocia. The weight of the calf is governed by genetic, environmental and management factors. Genetic factors include sex, length of gestation, breed, inbreeding, and genotype. Non-genetic factors include age and parity of the dam, nutrition of the dam during various phases of gestation, and environmental temperature and humidity. Dystocia management must begin with a selection of heifer for mating with respect to the body weight of heifers, body condition score (BCS) and dam's pelvic area should be considered before heifer selection. Not only heifer selection but sire selection using an estimated breeding value for calving ease should also be considered to lessen the dystocia rate in a herd. A combination of culling heifers with small pelvic areas and using bulls reported to be calving ease sire may reduce dystocia significantly. Apart from all these factors, genomic selection for reducing calving difficulties is a new tool for dystocia management.

Keywords: Calving ease sire, Heifer, Pelvic area.

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Introduction

Calving difficulties, also known as dystocia, are more common in heifers than in multiparous cows. Dystocia is a condition in which calving labor is prolonged or difficult due to the dam's small pelvic size and or high birth weight of a calf. These calves, and sometimes their dams, die due to injuries sustained during a difficult delivery. This causes a reduction in calf crop and potential profits. Cows with dystocia have a lower rate of rebreeding than those who have regular and unassisted deliveries (Kovacs *et al.,* 2016). Calving difficulties have been identified as a concern in heifers. Calving difficulty is three to four times higher in heifers than in pluriparous cows. It is quite difficult to predict with 100% accuracy which heifers will have calving difficulty as various factors can influence dystocia (Pearson, 2019), which are calf birth weight, breed of dam, dam's pelvic measurement, age of cow, nutrition, calf shape, calf sex, environmental temperature, season, gestation duration, body state of a cow, presentation of a calf, heterosis and sire breed (Zaborski *et al.,* 2009). Calf birth weight plays an important role in attaining growth and sexual maturity and 6% of the dam's body weight is desirable and optimum for calf birth weight. Higher calf birth weight is the most strongly linked to calving difficulty keeping in view the pelvic frame size. The percentage of cows that need calving assistance rises as calf birth weight increases. The effect of some of the factors mentioned above are most likely manifested through their relationship with calf birth weight (calf sex and gestation length) (Nogalski and Piwczynski, 2012). Birth weight is a highly heritable (0.30-0.40) trait suggesting that selection for optimum birth weights is attainable as a means to reduce calving difficulty (Massey and Vogt, 2018). It is very important to note that to achieve the optimum birth weight of the calf and keep in view the pelvic area's frame size, the selection of a superior male for breeding as calving ease sire is important and needs scientific validation under Indian conditions. Several

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factors influence dystocia; fortunately, most of them can be controlled by selecting heifers and breeding bulls with good management practices. This review mainly focuses on the factors to consider before selecting heifers for mating. However, it will also reflect the factors to consider before selecting a breeding bull to avoid dystocia in the first calvers.

Selection of Heifers

1. History of calving difficulty (in Dam)

Select the heifer whose dam has no history of dystocia.

2. Body condition score (BCS)

Animals with a high BCS and excess fat in the pelvic region can develop dystocia.

3. Breed

Some breeds tend to have more extended gestation periods and bigger or heavier calves in comparison to the maternal pelvic region. Various researchers reported that dystocia is more common in HF, Charolais heifers, and Belgian Blue than other breeds (Steinbock *et al.,* 2006; Kebede *et al.,* 2017). Jersey, Brahman, and Sahiwal F1 cows were having marginally easier Calving than the other crosses (Herring, 1996). Other research supports the notion that dairy and zebu breeds need less assistance during Calving (Anderson, 1992). Differences in the relative pelvic area, muscling, or fatness are most likely the reasons for differences in dystocia events in different breeds.

4. Dam's pelvic area

The pelvic region has recently gained much attention as a dystocia-related characteristic. However, not all scientists agree on the significance of this characteristic. Calving difficulty is more than twice as common in heifers with below-average pelvic areas as above average (Anderson, 1992).

Heifer selection based on growth rate is one of the factors to consider when choosing a heifer for breeding purposes. If a comparison is made between underdeveloped heifers and fully developed heifers then small and underdeveloped ones have higher chances of dystocia than the latter (Mee, 2008). Select heifers that are heaviest and feed them to ensure proper growth (500 to 750 gm gain per day depending on the breed). If they continue to grow at this growth rate, the heifers should weigh between 50 to 55% at the time of puberty, 65-70% at the time of breeding of their estimated mature body weight (Sprott and Troxel, 1988). As cows mature and their pelvic openings grow larger, the incidence of dystocia decreases (Daly and Riese, 1992). Therefore, the new dimension to the present heifer selection is optimum development of pelvic frame size along with the sexual maturity at proper age should be the focus of the dairy farmers. Certainly, the scenario will be different for zebu, crossbred cattle, and buffalo, and further it requires scientific validation. Knowing this, many producers design their farm breeding program to calve their heifers at three years of age rather than at two years in case of crossbred; it can reduce the chances but never eliminates dystocia. Furthermore, calving heifers at three years of age is not recommended because it raises production costs per animal and lowers their overall lifetime productivity.

The size of the calf and the dam's pelvic opening at birth are incompatible, resulting in dystocia. As a result, the pelvic opening specifies the maximum birth weight that individual cows can tolerate before calving difficulty occurs (Hiew, 2014). Heritability estimates for the pelvic dimensions range from 0.40 to 0.53. The usefulness of pelvic measurements sometimes raises the question of contradictory studies linking the pelvic region to dystocia, although dystocia is moderately heritable. Dystocia is inversely linked to the pelvic area, according to research conducted in Montana and Nebraska, whereas reports from Kansas and Indiana show that pelvic dimensions do not affect dystocia incidence, especially when the female's size and body condition score, the calf's sex, and weight, and the female and calf's genetic background are taken into account (Houghton and Corah, 1989), as the pelvic region appears to be strongly associated with heifer's body size.

As a result, producers are implicitly opting for a greater pelvic region by selecting larger and growing heifers. When bigger, faster-growing heifers are chosen, the calves born to these heifers have a higher birth weight. On the other hand, pelvic measurements have the potential to be useful as a selection tool for heifers of a certain weight and age (Patterson and Herring, 2017). If the pelvic region is only used to compare heifers of similar weight and frame, then pelvic measurement can be advantageous. Pelvic measurements could be used to cull heifers that do not meet predetermined pelvic frame size criteria.

Calving difficulties were recorded in 85 percent of heifers with small pelvic areas and 31 percent of heifers with large pelvic areas (Herring, 1996). There is no advantage of having a larger pelvis if a female's pelvic region is broad enough to accommodate calves, as the pelvis should have the optimal size for easy Calving. The pelvic region contributed only marginally to understand the calving difficulty. Although there is a strong connection between pelvic area and frame size, but the relationship is not always ideal. The most significant variables were birth weight, dam weight, and the ratio of those characteristics since all females had a large pelvic area (Johnson *et al.,* 1988). It's also worth noting that the ratio of birth weight to dam's hip height had no impact on calving difficulty (Bures *et al.,* 2008). There are no external dimensions that can be used to predict the size of the pelvic region reliably. The pelvic area should be directly measured. It is common to see that all big-framed animals have a large pelvis and that all small animals have a small pelvis. However exceptionally, Jersey cattle have a small frame with a big pelvis compared to other breeds of comparable size (Nogalski and Mordas, 2012).

Heifers with a pelvic area and birth weight ratio of ≥2.1 required little or no assistance, while those with ratios of ≤1.9 experienced calving difficulty. When measuring the pelvic region during a pregnancy diagnosis, a ratio of 2.7 should be used (Deutscher, 1995[a]). If the age of a group of heifers differs significantly at the time of measurement, different ratios should be considered.

Importance of Pelvic Measurements

Dystocia is caused by various factors like small first-calf heifer, sex as well as the size of the fetus, pelvic size, long gestation of the dam, heavy birth weight sire, dam too thin or too fat, and abnormal fetal presentation at Calving (Patterson and Herring, 2017; Troxel, 2011; Deutscher, 1996). The most common cause of dystocia is a mismatch between the calf's birth weight and the cow's birth canal (pelvic area). Broad-framed cows have large pelvic areas, but their calves are proportionately heavier at birth, negating the benefit of easier Calving (Wiley, 2019). Choosing a cow solely based on its size seems to be inefficient.

Measurement of Pelvic Area

Large calves carried by females with small pelvis will experience dystocia. Females with wide pelvis and small calves, on the other hand, would have a very low incidence of dystocia. Producers who want to minimize the occurrence of dystocia in their herds should select against the wide pelvis because the pelvic region is highly heritable. Culling of heifers with small pelvis has reduced dystocia among 2-year females in two major purebred herds to 4-5 % (Anderson, 1992). In the first few years of using pelvic scales, as many as 10% of replacement heifers in these herds were culled due to insufficient pelvic region. After a few years, however, only a small percentage of females failed to meet the pelvic region selection criterion (Van Donkersgoed *et al.,* 1993).

Development of Replacement Heifers

Purchasing only mature replacement females is rarely feasible or desirable. Despite the anticipated calving difficulties, most cattle producers would calve a group of first-calf heifers regularly. There are methods for preventing dystocia in first-calf heifers. Replacement heifers must be fed to grow and mature quickly enough to cycle and become pregnant early enough to calve at 24 months in case of exotic cattle. Another benefit of feeding is that when they calve for the first time, they will be as similar to their mature skeletal scale as a possible way to help reduce calving problems (Hickson *et al.,* 2006). As a general thumb rule, heifers should weigh at least 65 percent of their expected mature weight at the time of first breeding and 85 percent at first Calving. Weighing heifers regularly and adjusting their diets to achieve desired gains without overfeeding them can be beneficial.

Since some study findings are contradictory, the use of hormonal growth-promoting implants in the production of replacement heifers is a contentious subject. Implants in heifer calves have been shown to increase the pelvic area, although, in several instances, the pelvic area was increased at yearling or breeding but not at first Calving (Anderson, 1992). According to Deutscher (1995[b]), hormone implanting at the age of 6 months raises the pelvic area at Calving, while implanting at the earlier age of 2 months does not. The use of growth-promoting implants in beef heifers during the suckling process will improve productivity by increasing body weight at weaning without compromising the reproductive output of heifers that may be kept as replacement animals (Rosasco *et al.,* 2018). Until solid recommendations can be made, further research is needed, and factors other than the pelvic area should be considered when determining whether or not to implant replacement heifers.

General Recommendations to Reduce Dystocia

- Bulls that will sire small calves should be mated to heifers and cows. When making mating decisions, breed, birth weight, Expected Progeny Difference (EPD), actual birth weight and physical structure of the bull should be considered (Bitencourt *et al.,* 2020).
- Feed heifers well enough to weigh at least 85% of their expected mature weight at first Calving (Rhinehart, 2014).
- If calving difficulty is a problem in a herd, measure the pelvic area in replacement heifers and cull those too small. The required size will differ from one breed to the other. In general, however, heifers of medium-sized breeds should have pelvis of at least 160 square cms, at breeding, and those of large breeds, 180 or more (Fenlon *et al.,* 2017).
- Cull the daughters of cows with a record of calving difficulty (Snelling *et al.,* 2019).
- Breeding of heifers should be done 21 to 30 days earlier than cows so farmers can observe heifers more at calving time. During calving season, feed the herd late in the day to encourage more calves to be born during daylight hours (Bitencourt *et al.,* 2020).
- Record a calving ease score for all calves you observe at birth (Dhakal *et al.,* 2013). If Calving ease or difficulty changes over time, consider the reason for this.

Key Messages to Prevent Calving Difficulties

- Heifers with a body condition score (BCS) of 2.5 at Calving tend to have fewer calving difficulties and a shorter interval to first heat (Roche *et al.,* 2009).
- In general, very fat or very thin cows are at greater risk of difficulties around Calving (Roche *et al.,* 2009; Mee, 2008).
- Estimated breeding values (EBVs) can be used to select bulls that produce females that are likely to calve more easily and produce calves that are born easily (Goddard, 2009).
- The dam must be up to date with her vaccinations and in good health.

- Before Calving begins, be prepared with suitable dry, clean shelter, plus handling facilities and essential equipment on hand (Whittier *et al.,* 2005).
- Record the birth dates and calving ease of each calf to track the parent cow and bull reproductive efficiency (Haile-Mariam and Pryce, 2019).
- When faced with a cow in difficulty, be patient, think about hygiene, and use plenty of lubrication.
- Ropes and/or pulley systems must be attached correctly to prevent injury to the calf.
- Calving problems caused by a relatively oversized calf can be minimized by using calving ease sires.
- Restricting feed in the last month of pregnancy can do more harm than good. Cows should attain targeted BCS one month before Calving and then fed to requirements (Lorenz *et al.,* 2011).
- Leave cows and heifers undisturbed for four hours after mucus or slime is first seen at the vulva unless the animal has powerful contractions every five minutes.
- It is easier to correct a malpositioned calf when the cow is standing because it can be pushed back or manipulated (Funnell and Hilton, 2016).
- The calf should consume good quality colostrum minimum 10% of the body weight and sixty percent of it within six hours of birth to acquire adequate passive immunity (Verma *et al.,* 2018).
- Cows should remove the placenta within 12-24 hours of Calving.

Characteristics of the Desired Bull

Although some breeds have a reputation for being difficult to calve, others have not. This is tragic and unjustified because there are "easy calving" and "hard calving" bulls in every breed. Some breeds that have been selectively bred for development rather than calving ease have a higher proportion of hard calving bulls. This is not to say that these breeds no longer have any easy calving bulls, and categorizing any breed as hard or easy Calving is unwarranted (Haskell *et al.,* 2014). Random mating of the same bulls to females of the same breed will minimize the incidence of dystocia, but by crossing bulls of a light mature weight breed with females of a heavy mature weight breed, on the other hand, may or may not influence dystocia (Hickson *et al.,* 2006). Therein lies the problem. What can be done to find a sire which is an easy calver in every breed or within any breed? Using a decent collection of progeny records for that breed may serve as a solution to finding the easy calving bulls, and several breed associations have adopted these procedures. The accuracy of a sire's projected success improves as the number of his offsprings grow. These estimates of sires are expressed as fractions ranging from 0.5 to 1.0. The more precise the figures, the more predictable the bull's output would be (Wiggans *et al.,* 2011).

For traits related to calving ability, genetic tests are available, namely-

Sire Calving Ease (SCE) – A sire's ability to produce a calf that is born easily.

Daughter Calving Ease (DCE) – The ability of daughters of a sire to deliver a calf easily and their tendency to produce a calf that is born easily.

Sire Still Birth (SSB) – The tendency of calves from a sire to be stillborn (Holstein only).

Daughter Still Birth (DSB) – The tendency of daughters of a sire to produce stillborn calves (Holstein only).

Bull's 'Calving Difficulty Calculation

Three factors contribute to what the 'Calving Difficulty %' index figure in bull that starts with and also how it changes over time.

1. Back Pedigree
2. Genotype
3. Calving Data

Back Pedigree

The first 'Calving Difficulty index bull will be called as 'Parent Average' index, which is an average figure derived from his sire's and dam's index figures at the time of his birth. Even if the bull calf was born naturally from difficult calver parents, he will begin with a high figure, and vice versa if his back pedigree contains many animals with easy calving figures (Hayes *et al.,* 2009).

Genotype

When genotype assessment of bull's DNA is done, alteration in parent average which the bull received from his first evaluation will be there. As a result, a breeder might find a difference in a bull's 'Calving Difficulty %' from the calf's first assessment to the one after the genotype was added (Berry *et al.,* 2019).

Calving Survey Data

When the bull begins to sire calves and the degree of calving difficulty (if any) is registered, his calving difficulty will be affected. The key to determining how much of an impact this data has is to consider the following factors:

1. How many of his calves were tagged with calving surveys?
2. How many other bulls' calves (especially AI bulls) had calving surveys registered on them at the same time?
3. How much difference was found in calving surveys?

If any bull has a large number of calves born alongside calves from other bulls, and the full range of the scale is used (1=Easy – 4=Vet. Assistance), the calving data collected on his calves would have a considerable effect on his calving index. If his calves are born alongside AI Sires progeny, the effect will be even more significant, as the AI sire calves will serve as a great benchmark against which your bull's progeny can be measured (Berry *et al.,* 2019).

Bull Selection

Expected Progeny Differences (EPDs)

Expected Progeny Differences (EPDs) are a useful method for predicting bull output in case of bull selection. EPDs are a way of calculating an animal's genetic worth. They can't be compared across breeds because they're compared to a breed average EPD (not zero) (Greiner, 2005).

Expected Progeny Difference (EPD) Indicators by Category

The most useful method available to producers for identifying genetically superior sires for any trait is expected progeny differences (EPDs). Since birth weight is the most critical factor influencing dystocia, only bulls with appropriate birth weight EPDs should be considered for use on first-calf heifers. Bulls that are below breed average in terms of birth weight EPD should generally be used on heifers. The EPD value for a given breed's threshold birth weight that will result in appropriate birth weights/calving ease varies from one procedure to the next. When determining this importance, several factors must be considered, including labor availability at calving time, heifer size/weight, and heifer breed (Garcia *et al.,* 2018; Bullock, 2014; Hansen and Riley, 2006).

The relationship between birth weight and growth rate is positive. As a result, most sires with lower-than-average birth weight EPDs would also have lower-than-average weaning and yearling weight EPDs (Griffith *et al.,* 2020; Boyer *et al.,* 2019; Deutscher, 1995[a]). There are, however, sires available that are below average in terms of birth weight but above breed average in terms of growth traits. This is a vital factor since a good growth rate does not have to be lost to have a live calf. This EPD predicts the ease with which a bull's calves are born to first-calf heifers.

Maternal and Fertility Traits

Calving ease is an important factor that affects profitability. Dystocia causes higher labor costs, lower calf survival (higher calf deaths), and delayed rebreeding for the cow, which results in younger calves at weaning in the following year.

The expected progeny difference (EPD) for calving ease considers a variety of variables, including birth weight. Studies suggest birth weight is the most important factor for calving ease; 450 gram increase in birth weight increases the probability of dystocia by 0.7-2.0% (Herring, 1996). However when selecting bulls, concentrating solely on low birth weights can be detrimental, since low birth weight is genetically linked to weaning and yearling weights, (Lopez *et al.,* 2020; Herring, 1996).

The objectives and type of activity should be considered when determining the significance of calving ease in bull selection. Calving ease should be prioritized if there is a lack of labor, a high proportion of heifers calving on pasture, or a new producer with limited time and experience. On the other hand, calving ease may not be as relevant in a high-volume activity based on selling large calves. If calving in the late winter, calving ease can be a significant trait, as cold weather has been linked to larger calves and lower calf survivability (Bennett *et al.,* 2021; Lopez-Paredes *et al.,* 2018; Johanson and Berger, 2003).

Bull conformation has a significant impact on calf survival, and the herd benefits from its structural soundness. The bull's ability to walk safely without pain, the slope and angle of the leg joints, the absence of claw defects (e.g., toes that cross over or curl up), and joints free of swelling and inflammation are all important considerations. As because of any deviation away from the normal angles of the calf may produce an abnormal calf shape, causing dystocia (Sundstorm and Cumming, 2000). For the breeding purpose, healthy legs and feet of breeding bulls are also important (Chenoweth, 2015) to reduce the chance of calving difficulty.

When it comes to body condition score (BCS), selecting a bull with a moderate score is the target. If the score is poor, the bull's output suffers throughout the breeding season as he loses weight. If the BCS is too high, sperm quality and stamina are adversely affected (Yadav *et al.,* 2018; Bhakat *et al.,* 2009). Temperament is another consideration for bull selection. Bulls that are aggressive and nervous may be undesirable due to safety concerns. However, since temperament is moderately heritable, excessively docile cows can be a problem when calving on pasture where predation is a concern (Haskell *et al.,* 2014).

Breed of Sire

The relatively high incidence of calving difficulty in some double-muscled beef breeds, or double-muscled bloodlines inside breeds that have the trait, is an extreme example. Even if birth weights are not different, it is widely assumed that cattle with a smooth appearance (smooth, right shoulder positioning, absence of coarse muscling) sire calves that are born more easily than those with coarse muscling (Purohit *et al.,* 2012; Zaborski *et al.,* 2009). While this is likely true, some breeders have taken this to extremes, which have reduced productivity in other ways.

Genomic Selection for Reducing Calving Difficulty

Dystocia has been linked to a variety of contributing risk factors. Dystocia in domestic dairy cattle is caused by a disparity in calf birth weight and maternal pelvic size (Purohit *et al.,* 2012). Gestational length influences calf birth weight, which is determined by paternal and maternal breed. Both gestational length and dystocia have been linked to a genetic aspect, and pedigree records have made it possible to calculate direct and maternal impact. Furthermore, genetic associations between these functional traits and various conformation traits have been discovered. Eaglen *et al.* (2013) reported significant genetic correlations of gestation length with rump width and maternal calving difficulty with chest width and body depth. Furthermore, even assuming a similar heritability across breeds, there is an intrinsic variability for calving difficulty within a breed. According to various authors, cows calving to Holstein bulls caused the most dystocia, while Jersey's calves caused the least dystocia, and suggested a link between quantitative trait loci (QTL) and difficult birth in dairy cattle, only in Holsteins (Tiezzi *et al.,* 2018; Hu *et al.,* 2019; Harder *et al.,* 2006).

Single nucleotide polymorphisms (SNPs) associated with distinct phenotypes has been discovered using genome-wide association studies (GWAS). If a large number of individual and dense SNP panels were available, GWAS could reveal important functional mutations (Tiezzi *et al.,* 2018; McCarthy *et al.,* 2008). Genomic information has been officially incorporated into genetic evaluations of Holstein, Brown Swiss, and Jersey cattle since 2009 (Wiggans *et al.,* 2011), and Ayrshires since 2013 (Cooper *et al.,* 2014). The success of genomic selection relies on the accuracy of the SNP effects calculated and the linkage disequilibrium (LD) between the SNP and the QTL for the trait (Goddard, 2009). Genomic selection is crucial for complex traits with low heritability, such as fertility and health, where traditional selection is less accurate than output traits (Hayes *et al.,* 2009). An appealing approach to enhance genomic predictions is to improve prediction using insight into the underlying molecular mechanisms of complex traits. In this regard, correlation networks have been widely used both with gene expression (Hudson *et al.,* 2012) or genotype data to integrate information from different levels.

Fortes *et al.* (2013) investigated biological networks linked to fertility traits and puberty in cattle using genotype data. Two genes, the SIGLEC12 (or SIGLEC5) gene (Cole *et al.,* 2009) and the CEACAM18 gene (Mao *et al.,* 2013), were found to be associated with dystocia. Purfield *et al.* (2015) reported a strong association within the 1-Mb region (5.6-6.6 Mb) of chromosome 2 and direct calving difficulty in Limousin and Charolais breeds suggesting that this area includes a QTL for this trait; within this region, 11 candidate genes were discovered, including the myostatin gene, which contributes to muscle hypertrophy, whereas no connection between the QTL and direct calving difficulty reported in the HF breed (Hu *et al.,* 2019). Myostatin has been linked to calving difficulty for a long time, and homozygous animals with double muscle mutation have a 19% higher risk of calving difficulty than heterozygous animals (Casas *et al.,* 1999). It may be due to the connection between this genomic region and direct calving difficulty is unique to breeds. Constructing relevant within and across-breed gene networks related to dystocia may provide insight into the biology of the trait and produce robust predictions for dystocia in different cattle breeds.

Conclusion

The major factors affecting dystocia in first calver bovine animals are calf birth weight, heifer pelvic size, and heifer weight. Strategies to minimize dystocia include the selection of bulls with low birth weight EPDs (expected progeny differences) and acceptable growth rates to use on heifers, select heifers with moderate birth weights and yearling weights, plus provide heifers with good nutrition, breeding, calving management, and cull heifers with relatively small pelvic sizes,. The birth weight EPD should be the primary selection criterion for bulls used on heifers. The use of proven sires through AI will improve calving ease even more and finally; genetics exist that will result in optimal birth weight and ease of Calving.

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