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Research Article
Effects of Low Pasture Quality on Body Condition Score and Reproductive Performance of Beef Cattle

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Abstract

Background and Objective: The BCS is one of the main factors affecting the reproduction of cows influencing postpartum interval (PPI), conception rate (CR) and calving interval (CI) in the beef cow. The purpose of this study was to conduct a performance evaluation on body condition score (BCS) of beef cattle raised under natural pasture conditions. The evaluation was objectively to observe the reproductive performance of cows influenced by low BCS. **Materials and Methods:** Body condition score (BCS) of 113 beef cattle in a herd structure of (n = 12 heifer calves, n = 7 bull calves, n = 8 weaner heifers, n = 13 weaner bulls, n = 4 steers, n = 5 heifers 5, n = 63 cows and n = 1 bull for natural service) were assessed using 9-point BCS scale. The BSC assessment was conducted during the 5 months from May to September, 2020. Only three observations were done on BCS of the individual animal (tagged) respective to the normal PNGUNRE beef cattle farm husbandry practices. Weaning rate, conception rate and calf survival rate were calculated to evaluate the assessed BCS of the cattle herd. **Results:** Breeding cows are affected by a low BCS of 4 with obvious indications of very poor reproductive efficiency indicated by increased postpartum interval (PPI) and calving days. Low quality pasture has affected reproduction efficiency in the current herd structure. **Conclusion:** Moderate BCS of 4 has affected the reproductive performance of beef cattle production at PNGUNRE. Genetic improvement using either selection tool within the breed or introducing crossbreeding programs to diversify breeds, AI programs, pasture improvement, supplementary feeding, feedlot system and correcting the bull to cow ratio of 1:63 for the current herd are immediate considerations to improve performance in beef cattle production.

Key words: BCS, reproductive performance, evaluation, herd structure, quality pasture, husbandry practices, genetic improvement

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Beef cattle nutrition is a major management tool that requires a workable cattle herd management strategy to keep the herd under quality feeding systems[1]. The results of poor nutrition are often indicated by their physical conditions. Body condition score (BCS) is a tool that was adopted from many studies to be used to assess the performance of beef cattle under PNGUNRE farm conditions in the tropics[2,3]. Most cattle ranges in Papua New Guinea haven't used BCS in a wider range of studies to assess or evaluate Beef cattle herd performance. Thus, this study has brought about an imperative directional view to document the critical nutritional problem affecting beef cattle industries.

Beef cattle nutrition is a critical criterion that requires equal attention from the breeder and the farm manager. It helps to establish the knowledge that will assist in the establishment and management of quality forage for successive reproductive performance. Low pasture quality has negative impacts on frequently observed reproduction traits like calving rates, weaning rates and lactation length[4]. Pasture management must optimize pasture utilization, production and quality[5] which can reduce infertility in cows[4] if given less attention for improvement on its nutritional values. In addition, carrying capacity, stocking rate and genetics of cattle used in pasture-based systems[6] should also be considered. Carrying capacity and stocking rate are defined by the bodyweight of cows and the potential land to produce quality pasture[7] based on energy reserves.

Body condition score (BCS) was used as an indicator to assess and evaluate the effects of quality of pasture availability on beef cattle performance. Body condition score (BCS) has been conducted in many studies[8-15]. The BCS is a vital management tool that visually assesses the health and nutritional levels relative to reproductive performances of beef cows in farms where the weighing scale is a limiting factor[16]. The most used BCS system in most published journals is the 9-point scale where 1 is thin and 9 is obese. This project has used the 9-point scale to assess the BCS of the breeding beef cattle relative to their reproductive performances.

One of the main goals to revive and improve the beef cattle production system is to optimize the annual fertility rate. To achieve this, the majority of the cows need to have an adequate Body condition score (BCS) in each reproductive cycle[11]. High BCS is relative to beef cattle fed under quality pasture management practices. This depends on climatic conditions which regulate the growth of natural pastures, improvement of pasture genetics and quality management practices having effects on maternal genetics in cows[6,17].

The current study has indicated low BCS performance in beef cattle. Low BCS is a corresponding result of the unavailability of quality pasture under unpredictable weather conditions. Prevailing weather conditions can affect the availability of pasture in required quantity and animal production cycles[18]. Pasture improvement program is an immediate response to correcting the low BCS performance. The long term low nutritional consequences can affect reproduction cycles. The major reproduction effects are, failure in anoestrus and conception, prolonged calving interval, increased postpartum interval and poor lactating ability of cows[19]. Vaz *et al.*[20] also reported the higher weaning weight of early-born female calves when cows were fed quality forage available in larger quantities.

This study is based on observations made overtime on the performance of beef cattle under a low pasture management system. These observations have gone unnoticed to identify and critically measure the cow performance. The purpose of this study was to conduct a performance evaluation on body condition score (BCS) of Beef cattle raised under natural pasture conditions.

MATERIALS AND METHODS

Study area: The study was conducted from May to September in 2020 at the PNGUNRE beef cattle breeding site called South paddock. South paddock is located south of Vudal Campus of Papua New Guinea University of Natural Resources and Environment. South paddock has 107 hectares of land area divided into 11 paddocks of varying paddock sizes (5-16 ha). An estimated 40% of the grazing land is maintained with very low pasture quality management while 60% of the range field is covered with overgrowths with progressive pasture development. Quality pasture production has been the most challenge leading to affect the performance of beef cattle herds at the farm. The beef cattle herd is fed on free grazing of <60% ha of the grazing land on natural pastures (signal grass, para grass, Setaria grass, elephant grass, guinea grass and humidicola). Vance *et al.*[21] reported only one type of pasture species (*Paspalum conjugatum*) was fed to the Holstein-Friesian herd, the large proportion of fields was regarded as weed species.

The area is geographically located on the coastal lowlands of the inland baining around 200 m above sea level, unpredictable wet and dry seasons, monthly rainfall ranging between 5-30 mm and temperature ranging between 24-42°C.

Table 1: Beef cattle herd structure at PNGUNRE with average BCS of respective groups from May to September, 2020

BCS	Bull	Cows	Steer	Heifer	Weaner bull	Weaner heifer	Bull calves	Heifer calves	Total
1								1	1
2		2			1	1			4
3		31	2		7	3	5	8	56
4	1	30	2	5	5	4	2	3	52
Total	1	63	4	5	13	8	7	12	113

Table 2: Visual description of key body locations associated with each body condition score (Olechnowicz and Jaśkowski[23])

	Body condition score								
Reference point	1	2	3	4	5	6	7	8	9
Physical weak	Yes	No	No	No	No	No	No	No	No
Muscle atrophy[a]	Yes	Yes	Yes	Slight	No	No	No	No	No
Outline of spine visible	Yes	Yes	Yes	Slight	No	No	No	No	No
Outline of ribs visible	All	All	All	3-5	1-2	0	0	0	0
Fat in brisket and flanks	No	No	No	No	No	Some	Full	Full	Extreme
Outline of hip and bones visible	Yes	Yes	Yes	Yes	Slight	No	No	No	No
Patchy fat around tail head	No	No	No	No	No	Slight	Yes	Yes	Yes

[a]Muscles of loin, rump and hindquarter are concave and indicating loss of muscle tissue

Data collection: Three consecutive periods were allocated to collect data over a study length of 5 months (May to September, 2020). Three collection dates to assess body condition scores were conducted on 20th May, 2020 (1st assessment), 29th July, 2020 (2nd assessment) and 7th September, 2020 (3rd assessment). The herd structure was maintained during the study period to assist the BCS recording and evaluation relative to reproductive performance.

Performance records of beef cattle herd: The herd size of 113 beef cattle was used in the study consisting of a mixed breed of Brahman, Drought master and Charolais. The population of cattle in a herd is mostly the progenies of the three breeds crossed. Cross-breeds may perform better than pure breeds because of high resistance to many tropical cattle diseases, heat stress and drought. Livestock being an important agricultural enterprise, its progress has contributed 33% of protein consumption in the global food security under the current increasing global temperature of 1-7°C[22]. Despite challenges in global climate change posing risks on global ecological balance and economic security, beef cattle (breeders) are managed in a single herd system with natural breeding all year round. The targeted herd population of 113 breeding beef cattle (n = 12 heifer calves, n = 7 bull calves, n = 8 weaner heifers, n = 13 weaner bulls, n = 4 steers, n = 5 heifers 5, n = 63 cows and n = 1 bull for natural service) were assessed using the 9-point scale[17] body condition score (BCS) system in Table 1.

The data was obtained from monthly stock take within the normal farm breeding programs and beef cattle husbandry practices. Cattle technical staff and a research student were involved to keep records of BSC of the cattle herd. The individual animal was restrained in the stockyard to visually assess the BCS (1-thin to 9-obese). Data collection protocol involves the identification of an individual animal by tag numbers with their individual performance information, then BCS was recorded followed by application of necessary husbandry practices. The assessed individuals were released to the holding pens immediately to minimize stress on an animal.

Body condition scores were recorded according to the standard body description by visual appraisals using a BCS range of 1-9[20]. Formulated data entry sheets were used to record the BCS of an individual animal.

Visual assessment criteria: Seven qualitative reference points were used to describe the corresponding BCS of the herd (Table 2). Each reference point was valued according to the similar study of Vaz *et al.*[20]. Most of these descriptions are optional valuations, for example, for an RP physical weakness is either observed as "yes or no". Only one RP outline of ribs visible was quantitatively described by counting the number of ribs exposed. The physical description of ribs is explained in Fig. 1.

Each qualitative value was assessed using eight visual performance identifiers (Table 3).

Body condition score was clearly defined using the four distinctive classes, thin, borderline, optimum and too fat. The classes are specifically described based on fat percentage and the description is explained to classify the qualitative value of each body condition score (Table 4).

Further observation was done on body condition score and on postpartum interval (PPI) to assist calculate, heat detection rate, conception rate and pregnancy rate (Table 5).

Fig. 1: Physical appearance of beef cattle with the respective BCS values from 1-9

A detailed description of BCS was based on four main criteria, thin (BCS of 1 and 2), borderline (BCS of 3 and 4), borderline condition average (BCS of 5 and 6), over-conditioned (BCS of 7 and 8) and too fat (BCS of 9)

Table 3: Data format sheet with the method of evaluating body condition of breeding cattle at PNGUNRE cattle farm and the actions to be taken once BCS is confirmed

Descriptions	Score	Fat (%)	Spine	Ribs	Hook/Pins	Tail head	Brisket	Muscling	Comment/actions remarks
Thin	1	3.77	Visible	Visible	Visible	No fat	No fat	Nil	Empty cull Supplementary feed Meatworks
	2	7.54	Visible	Visible	Visible	No fat	No fat	Nil	Wet early weaning/creep feeding/ supplementary feeding
Borderline	3	11.30	Visible	Visible	Visible	No fat	No fat	Some	Wet target feed/mating Wet/supplementary feed
	4	15.07	Slightly visible	Fore ribs visible	Visible	No fat	No fat	Full	Wet/empty second chance mating/ pregnant supplement
Borderline condition	5	18.89	Not visible	Not visible	Visible	No fat	No fat	Full	Pregnant/empty second chance mating
average	6	22.61	Not visible	Not visible	Visible	Some fat	Some fat	Full	Pregnant/empty second chance mating on observation
Over conditioned	7	26.31	Not visible	Not visible	Visible slightly	Some fat	Some fat	Full	Pregnant/empty cull
	8	30.15	Not visible	Not visible	Not visible	Very fat	Very fat	Full	Empty cull meatworks
Too fat	9	33.91	Not visible	Not visible	Not visible	Over fat	Over fat	Full	Empty cull meat works

Basic formulae and measurements of reproductive performances in beef cattle:

$$\text{Heat detection rate} = \frac{\text{No. of cows inseminated or serviced by bull over 21 days}}{\text{No. of cows eligible to be bred over 21 days}}$$

$$\text{Conception rate} = \frac{\text{No. of cows pregnant}}{\text{No. of cows inseminated or serviced by bull}}$$

$$\text{Pregnancy rate} = \text{Heat detection rate} \times \text{Conception rate}$$

Body condition score was also used to measure the pregnancy rate (Table 6). Roche *et al.*[26] described the performance referring to Parity, body condition score and pregnancy rates. For example, a parity of 1 with a BCS of $\leq$3 has a pregnancy rate of 20%. A 20% pregnancy rate is calculated on a standard observed BCS responding to a given population of beef cows (refer to formulae above).

Table 4: Description of body condition scoring system for beef cattle-9 points scale (Pryce *et al.*[24])

BCS	Body fat (%)	Detail description
		Thin
1	3.77	Clearly defined bone structure of shoulder, ribs, back, hooks and pins easily visible. Little muscle tissue or fat is present
2	7.54	A small amount of muscling in the hindquarters. Fat is present, but not abundant. Space between the spinous process is easily seen
3	11.30	Fat begins to cover the loin, back and fore ribs. Upper skeletal structures are visible. The spinous process is easily identified
		Borderline
4	15.07	Foreribs becoming less noticeable. The transverse spinous process can be identified by palpation. Fat and muscle tissue are not abundant, but increasing in fullness
		Optimum
5	18.89	Ribs are visible only when the animal has been shrunk. Processes not visible. Each side of the tail head is filled, but not mounded
6	22.61	Ribs are not noticeable to the eye. Muscling in hindquarters plump and full. Fat around tail head and covering the fore ribs
7	26.31	The spinous process can only be felt with firm pressure. Fat cover in abundance on either side of the tail head
		Too fat
8	30.15	Animal smooth and blocky appearance, bone structure difficult to identify. The fat cover is abundant
9	33.91	Structures are difficult to identify. The fat cover is excessive and mobility may be impaired

Table 5: Effect of body condition score (BCS) at parturition on postpartum interval (Houghton *et al.*[25])

BCS	PPI (days)
3	88.5
4	69.7
5	59.4
6	51.7
7	30.6

Table 6: Relationship of parity and body conditions score to pregnancy rate (%) of first-time heifer calf at birth and calving (BCS 1-9)

Parity BCS	≤3	4	≥5	All
1	20	53	90	84
2	28	50	84	81
3	23	60	90	85
4	48	72	92	87
>8	37	67	89	84
All	31	60	89	82

Table 7: Relationship of body conditions score to beef cow performance (Pfeifer *et al.*[27])

BCS of cow	Pregnancy rate (%)	Calving interval days	Calve weaning age
3	43	414	190
4	61	381	223
5	86	364	240
6	93	364	240

The final observation was based on the calculations of pregnancy rate, calving interval and calve weaning age, respective to BCS. In Table 6, a cow with a BCS of 3 is expected to perform with a pregnancy rate of 43%, a calving interval of 414 days and a weaning age of 190 days. Weaning age 240 days for BCS 5-6 decreases as the calving interval increases. Table 7 further explains that Cows with BCS of below 4 have increased calving intervals between 381-414 days. This means that a cow with BCS below 4 will take more days to come on heat and become pregnant again after calving. In addition, cows with BCS less than 4 will have less calf weaning age, meaning the calf will have to be weaned sooner after birth as the mother needs to be on good pastures and be in good condition to prepare for the next anestrus. Cows with BCS of 5 and 6 are optimal and gives acceptable pregnancy rates between 86-93%, calving interval of 364 days is essential with a calf weaned per cow per year, with good condition to come back on heat less than 60 days after calving and an acceptable calf weaning age of 240 days in which the cow can be dried after confirming pregnant and calf weaned[27].

RESULTS AND DISCUSSION

Beef cattle herd structure: Distribution of beef cattle herd of 113 (Fig. 2) represents, breeding cows 56%, weaner bulls 11%, weaner heifer 7%, heifer calves 11%, bull calves 6%, steers 4%, heifers 4% and bull with 1%. The breeding bull for natural service does not compensate the correct mating ratio with 63 breeding cows (1:63) and potential matured heifers. This had resulted in a low heat detection rate as the bull doesn't service all the cows that come on heat causing reproductive failures and low conception rates. In a normal breeding program, a bull can service 10-20 cows in a breeding herd, 1:25 in Central Brazil (Filipini *et al.*[28]).

Performance of body condition score in beef cattle herd: All the beef breeding cattle herd are under the halfway BCS of 4.5 of the 9-point scale (no breeding cattle at PNGUNRE has BCS of 5 or 6 which is required for maximum reproductive performance). In Table 7, heifer calf has a BCS of 1 (1%) at birth, which is very thin. This indicates poor nutritional levels and maternal effects of cows during the pregnancy period which could negatively influence birth and weaning weights[29,30] strongly supported the relevance of under nutritional effects stating that a poor diet having low quality or quantity affects the cow production cycle from peri-implementational period to early gestation. Furthermore, a weaner heifer, weaner bull and 2 breeding cows have a BCS

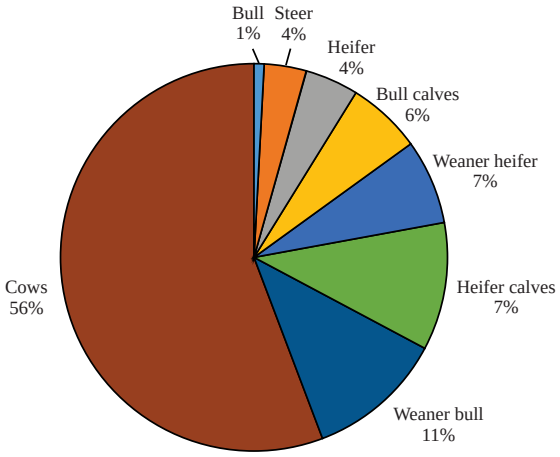

Fig. 2: Pie chart showing the population distribution of breeding cattle herd at a PNG-UNRE cattle farm

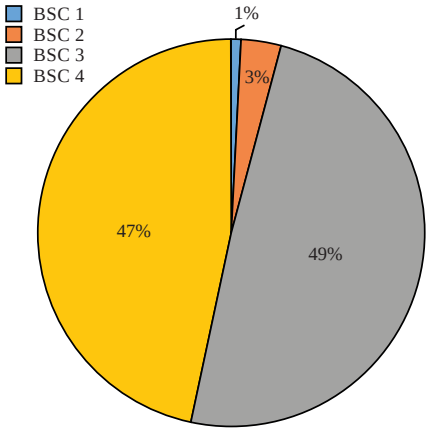

Fig. 3: Distribution of BCS in the breeding beef cattle at PNGUNRE farm, 2020

of 2 (3%) which is poor. This is also an indicator of poor quality and quantity of milk taken from cows or poor quality of pastures grazed during the weaning period[29,30]. Similar observation on dairy cow nutrition has been reported, feed intake is one of the most important factors determining both productivity and reproductive performance in all dairy systems[4]. Lanyasunya *et al.*[4] further explained that quality feed intake will allow the deposition of sufficient nutrients in their bodies to enhance vital metabolic processes for maintenance, growth (including foetus), milk production and reproduction. The majority of the breeding beef herd were ranked with BCS of 3 (49%) and 4 (47%) borderline which is optimal (Fig. 3) reflecting poor performance. However, overall BCS needs improvement to increase reproductive performance and fertility status. Furthermore, Table 6 explains that if the cows or matured heifers with BCS of 3 and 4 show primary heat signs then they should be given special attention to be bred and given supplementary feed with improved diets (Lanyasunya *et al.*[4]). In addition, if they are already pregnant, they should be given supplementary feed and weaned calf at foot from 30 days after calving.

The weaning rate (Table 7) is calculated and known as weaner per cow per year, 8 weaner heifers plus 13 weaner bulls totalling 21 weaners. The 21 weaners out of 63 breeding cows (21/63 = 0.33 so, 0.33×100% = 33% weaners per 63 cows per year. The current 33% is way lower than the optimal 90% meaning from the 33% it indicates that 20 cows out of the 63 had given birth and weaned a calf in a year. For calf survival, it is observed that 12 heifer calves plus 7 bull calves = 19 calves survived after 19 calving which is 100% calf survival.

Conception rates using pregnancy diagnosis and postpartum checks via rectal palpation between these periods were not carried out due to poor level of skills in animal management by the cattle technical staff. However, weaning rate and calf survival were recorded as measures for reproductive performance.

Measurement of BCS (9-point Scale) and its effects on reproductive performance: The most published and commonly used BCS system for beef cattle worldwide is the body condition scoring system from 1-9 (Table 1), with 1 being thin and 9 being obese[25,31,32]. Other scoring systems used are 5 points and 10 points. Using BCS to evaluate beef cattle does not require any special equipment but sound knowledge of the skeletal structures and muscles and fats on the main part of its body for BCS assessment is important and can be conducted anytime during the year. Poor body condition in beef cattle is associated with reduced income per cow, increased postpartum interval, increased dystocia, reduced pregnancy rates, fertility problems and lower weaning weight.

Table 6 illustrates the relationship of parity (BCS of heifer calf at birth) relative to its BCS during calving. Studies carried out at the University of Florida, USA in 1993 explains that BCS of heifer calves at birth affects their pregnancy rates with different BCS. Heifer calves with BCS between 1-3 and 8-9 at birth and calving with BCS of less than 3 will have a pregnancy rate between 20 and 37% and heifer-calves with BCS between 4-7 at birth and BCS of less than 3 at calving will have a pregnancy rate around 48%. Thus, BCS between 4-7 at calving is optimal and essential BCS at birth because it gives higher pregnancy rates compared to other BCS[33].

Furthermore, heifer calves with BCS between 1-3 and 8-9 at birth and BCS of 4 at calving will have a pregnancy rate between 53 and 67% and heifer calves with BCS between 4-7 at birth and BCS of 4 at calving will have pregnancy rates around 72% which is above average. Likewise, BCS between 4-7 at birth and BCS of 4 at calving gives an optimal pregnancy rate. Therefore, Table 3 explains that optimal BCS required at birth is between 4-7 and at calving is above 5 but less than 7 because it gives a higher pregnancy rate between 84 and 90%. There are vital reasons as to why BCS of heifer calves need to hit targeted BCS.

Heifer calves with BCS between 4-7 at birth will reach maturity early and start first heat between 7-8 months which is economical because it helps plan feed requirements and gives a quick replacement when breed at 26-30 months of age and having around the weight of 400 kg. In addition, BCS between 4-7 indicates a healthy calf with a higher fertility status[26].

First-time heifer calves with BCS between 4-7 at birth and BCS of more than 5 at calving is important. This is because first-time heifers have a higher tendency to lose more body mass which results from loss of body fluids during calving, the birth of calf and milk from breastfeeding calf[34].

Breeding cows with BCS between 1 and 2 (Table 6) if empty (not pregnant or mated but not fertile) should be culled or maybe wet (on heat) with calves at foot need special attention, supplement feeding put them on the best available pasture and creep feed them[17]. Bear in mind that the economic life span of a cow is 10 years and on average should be turned off 7-8 calves in an economical breeding life span. Cows with BCS between 3 and 6 may be wet with calves at foot or calves have been weaned off need special attention to bring the condition back before the next mating. Low BCS in cows could affect normal lactation lengths and weaning age up to 90 days with critical weight losses[35]. Target feeding and supplementing is vital including special attention put on feeding on good pastures before joining to maximize conception rates. Cows between 7 and 9 if empty, not fertile should be culled and if pregnant they should be put on forage feed containing less protein to minimize fattening[4].

Accurate early pregnancy diagnosis from 45-60 days is important to determine the pregnancy and fertility status of the cow so decisions are made early for effective management. Don't forget that an ideal bull for breeding should have a body condition score of 5.5-6.5 on a 9-point scale before breeding season. Both over-conditioned bulls and under conditioned bulls can be a problem for natural breeding.

Beef cattle feed on natural pastures perform with decreased BCS from 5-4 resulting in reduced pregnancy rates estimating 30%. Another 30% decline in pregnancy rate is expected if BCS further declines from 4-3. Table 3 explains that reduced pregnancy rates can also be expected from cattle that are obese having BCS[11] of 8-9.

While optimum BCS is targeted for expected pregnancy rates, few studies have reported their respective observations, pregnancy rates at 20, 40 and 60 days of the breeding season are not affected by prepartum BCS changes[30] of <4->7. The consequent critical level is having a BCS of 5 which can affect the reproductive performance of mature beef cows at calving[24]. Postpartum interval (PPI) in thin cows is extended with a BCS of <5 to more than 60 days, a BCS of >5 has a PPI of less than 60 days while to maintain calving rate of one calve per year and ideal condition would be to maintain an acceptable PPI of < = 60 days[24].

Body condition score and reproductive performance: Most breeding cows scored BCS of 3-4 indicating poor body conditions. The total of 61 breeding cows had an almost equal proportion of BCS-3 (31 breeder cows) and BCS-4 (30 breeder cows). Table 2 explains the body conditions that reflect the poor performance of beef cattle cows of PNG-UNRE assessed using seven reference points.

Heifer calf at PNG-UNRE cattle farm-born with BCS 1 and having BCS $\leq$3 at calving will result in a 20% pregnancy rate. That same heifer calf born with BCS 1 and BCS 4 will result in a 53% pregnancy rate at calving. Delgado *et al.*[36] made a comparative analysis of Zebu cattle in the tropics on BCS, availability of forages, farming systems and seasonal weather patterns influencing anoestrus cycles. The above study confirmed that cows with BCS of 3 had low pregnancy rates 5-9 times lower than cows with BCS of 6. Furthermore, a calf born with BCS 1 and BCS $\geq$5 at calving will result in a 90% pregnancy rate which is optimal thus, feeding on quality pastures and supplies of supplementary feed is important for the heifer calf to gain weight and be in good condition before breeding[4]. Table 8 compares the body condition score of first-time heifer calf at birth and calving. This is a relationship comparison between two different regions, the current study at PNG-UNRE is measured against the standards of the University of Florida, USA.

Heifer calves at PNG-UNRE born with BCS 3 and BCS $\leq$3 at calving will result in a 23% pregnancy rate. This hypothesis is strongly supported by Delgado *et al.*[36]. Those same 8 heifer calves born with BCS 3 and if having BCS 4 at calving will result in 60% pregnancy rate, born with BCS 3 and if BCS $\geq$5 at

Table 8: Pregnancy rate (%) of heifer calves of current BCS at PNGUNRE compared with the standards set by University of Florida, USA (Friggens and Badsberg[37])

Parity	Heifer-calf PNGUNRE	≤3	4	≥5	All
1	1	20	53	90	84
2	0	28	50	84	71
3	8	23	60	90	85
4-7	3	48	72	92	87
≥8	0	37	67	89	74
All		31	60	89	82

Source: University of Florida, 1993 and PNGUNRE, 2020, BCS Scale used, 1 (thin) to 9 (obese)

Table 9: Pregnancy rate, calving interval and required weaning age at PNGUNRE compared to standards set by the University of Florida, USA 1993 (Pfeifer *et al.*[27])

BCS[1]	No. of breeding cows at PNGUNRE	Pregnancy rate (%)	Calving interval (days)	Calf rWA[2] (days)
3	31	43	414	190
4	30	61	381	223
5	0	86	364	240
6	0	93	364	240

[1]Body condition score scale (1thin-9 obese), [2]Required weaning age (rWA) 240 days in cows BCS 5 and 6 and decreasing BCS as calving interval increases

calving will result in 90% pregnancy rate which is adequate BCS for first-time heifers. This is because first-time heifers at calving should have adequate body condition to allow for a reduction in the body mass losses during the parturition process and displacement of fluid. During delivery of the calf, the first-time heifer loses more body fluid than cows and also reduction of weight of the calf. Lanyasunya *et al.*[4] observed the correlations between the low energy balances and body weight had prolonged ovulation cycles in a dairy heifer. Furthermore, if the heifer has a retained placenta or had endo-metritis (bacterial infection in the uterus), ketosis, milk fever, diarrhoea, mastitis or any calving related diseases then it can further and vastly reduce its body condition posing life-threatening conditions on the first-time heifer calf[38].

Moreover, 3 heifer calves born with BCS 4 and BCS ≤3 at calving will result in a 48% pregnancy rate. The same 3 heifer calves at PNGUNRE cattle farm-born with BCS 4 at calving will result in a 72% pregnancy rate. If born with BCS 4 and BCS >5 at calving will result in a 92% pregnancy rate which is optimal for higher reproductive performance. Lanyasunya *et al.*[4] clearly explained the relationships between BCS and calving, breeding, weaning curves and calving interval. This study explained that higher BCS has influenced high calving rates, breeding, weaning rates and low calving interval. Table 9 further describes the relationship of BCS, pregnancy rate, calving interval and required weaning age reflecting cow performance.

A total of 31 breeding cows at PNGUNRE cattle farm have a BCS of 3 while 30 breeding cows have a BCS of 4 (Table 9). The 31 breeding cows with BCS of 3 will have predicted pregnancy rates of 43%, an increased calving interval of 414 days which is more than a year (365 days). This group of breeding cows cannot wean a calf per year while also having less weaning age of 190 days to wean calf sooner to gain an improved body condition before next breeding and calving[4]. Calves that are weaned sooner tend to have poor BCS during the weaning period. Whereas, another 30 breeding cows have BCS of 4, thus having a predicted pregnancy rate of 61%, an increased calving interval of 381 days and a weaning calf age of 223 days. To improve BCS during weaning, calves should be allowed only 30 days to suck on to cows' milk to obtain enough colostrum (antibodies) to make their immune system strong and to be with the mother to adapt to grazing behaviours. Early weaning in brahman crossbred cows increases cow body weight and improves body condition score[39]. After this period the calf should be separated from its mother to allow the cow to cease lactating, dry off and start concentrating on gaining body condition. The period between weaning to calving has been proven to be the easiest and most economical time to add a condition to breeding cows. Orihuela *et al.*[39] reported that when brahman crossbred calves were removed at 93 days postpartum (DPP) it helped the thin cows to recover after parturition and reduced calving interval.

It is dip observed and indicated in Table 7 and 9 that no breeding cows at PNGUNRE have acquired required BCS of 5-6 for optimum pregnancy rates above 90% with a good calving interval of 364 days and calving age of 240 days.

What are the opportunities to change BCS to improve the probability of cows becoming pregnant?: There is a high probability of thin cows getting pregnant if BCS conditions are detected earlier to maintain optimum reproductive performance. Evaluation of BCS should be done as early as weaning before introducing first-time heifers in the breeding programs. On the other hand, obese cows are observed to have improved pregnancy rates if the obesity condition is reduced[24].

Livestock researchers have found out that for the reproductive system of a cow to fully function, there is a certain amount of body fat that is required, cows in moderate body condition will have a shorter interval from calving to first estrus (heat) than cows in thin condition. This supports the condition that BCS is one of the most important factors in determining reproductive performances[36]. Montiel and

Ahuja[40] identified nutrition and suckling as the two main contributing factors influencing the resumption of postpartum ovarian cycles, as they affect hypothalamic, pituitary and ovarian activity that inhibits follicular development. Low nutritional levels contribute to prolonging postpartum anestrus in cows that depend on forages. The feed requirements of cows interact with genetics, environment and management influencing the duration of anestrus. Body condition score (BCS), reflects the body energy reserves available for metabolism, growth, lactation and activity, inadequate nutrient intake results in loss of weight that finally ceases oestrous cycles. Xiao *et al.*[41] concluded that a small amount of good quality forage must be introduced to pre-weaned calves under the natural grazing system. This improves their behavioural expressions and rumen environment, which further improve calf performance in the later growth and reproductive stages.

Furthermore, there are high chances (100%) of calf survival but a weaning rate of 33% (20 cows out of the 63 breeding cows had weaned a calf per year), which is below average. There is a need to observe the current fertility status of breeding cows, increase the bull-cow ratio and do regular postpartum checks after calving. Regular postpartum checks are conducted to identify after-calving related problems in breeding stock while maintaining a proper pasture management system. Beef cows are culled for age, failure to rear a calf to wean, poor physical and health conditions during breeding management programs[42].

This study has identified challenges to monitoring and creating a breeding herd performance database. This database includes, improved records of weight performance, breed management plans, quantifying BCS on feed intakes in early lactation, assessing the health of cows (negative energy balances, poor reproductive performance and incidence of diseases) and model genetic correlations between the breed reproductive performance and feed energy reserves. Evaluation of bulls using their daughters at their different stages of lactation to assess BCS and reproductive performance may become significant for beef cattle production. The BCS is easy, inexpensive and a fast criterion that can be used to evaluate cow performance for selection in the breeding programme.

CONCLUSION

Beef cattle herd (breeders) at PNGUNRE cattle farm are under low nutritional levels with a minimum BCS of 1 (thin) and maximum BCS of 4 (borderline). This is due to low pasture availability, lack of feedlot system and breeding all-year-round programs within single herd breeding programs. Body condition score of 5-6 is optimal in all reproductive cycle for higher reproductive performance as there is higher pregnancy rates, conception rates, weaning rates and sufficient calving interval.

SIGNIFICANCE STATEMENT

"This study discovered the critical problem of low BCS as an indicator of reproductive performance in the beef cattle production system that can be beneficial for consideration and improvement. It will help the researchers to uncover the critical areas of low pasture quality having a direct influence on beef cattle performance that many researchers were not able to explore. Thus, a new theory on BCS modelling may be arrived at".

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