Asian-Aust. J. Anim. Sci.
Vol. 24, No. 11 : 1587 - 1594
November 2011

www.ajas.info
http://dx.doi.org/10.5713/ajas.2011.11070

A Body Condition Scoring System for Bali Cattle

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ABSTRACT : Live weight, body length, hip and shoulder heights, heart girth, and metatarsal length were measured on 100 one to two years old Bali (*Bos javanicus*) bulls. Multiple regression of these measurements on live weight gave a prediction equation involving heart girth and body length (prediction R^2 = 0.845). These measurements were also used to derive several frame scores (FS). Live weight (Lwt) divided by FS was used as an index of body condition. Lwt/(length+hip height) was normally distributed and highly correlated with other normally-distributed condition indexes. This index was used to define five body condition scores. These were used to develop a five-point body condition scoring system in which the amount of fleshing over the vertebral processes, ribs, hindquarters, tail head, hooks, at the top of the neck, and the shoulders, the development of wrinkles in the skin above the hock and the neck, and the size of the dewlap, were used to describe the different body condition scores. Animals of score 1 had prominent hooks, shoulders, vertebrae and ribs, and hollow hindquarters and flat tailhead. Score 5 animals had rounded hindquarters, well-filled upper hind legs, small mounds of soft tissue were apparent on the tailhead, their hooks, necks, shoulders, vertebrae and ribs were well covered, and the dewlap was prominent. (**Key Words :** Bali Cattle, *Bos javanicus*, Body Condition Scoring, Liveweight Prediction)

INTRODUCTION

The anatomical characteristics of animals, i.e. their external shape, subcutaneous fat thickness, or amount of soft tissue in relation to frame size, can be related to their current nutritional status and future productivity. Body condition scores (BCS) are a way of subjectively assessing the amount of soft tissue, especially fat cover, in relation to the animal's skeletal size. Because the relationship between body condition and frame size is an indicator of the animal's nutritional history, BCS can be used to monitor the success of a feeding program in situations where owners can not use more direct measures of nutritional status such as feed analysis, nutritional faecal profiling, or monitoring blood chemistry.

BCS can also be used to monitor and predict growth and reproductive performance. BCS are positively related to future success in conception, and avoidance of dystocia and retained placenta and other illnesses (Delgado et al., 2004; Morris et al., 2006; Jilek et al., 2008; Hoedemaker et al., 2008, 2009). The ovulation rate of females increases with body condition (or liveweight), and the post-partum anoestrus interval is reduced when cows calve at higher BCS (Graham, 1982; Markusfeld et al., 1997). Fat-corrected lactation yield is related to BCS at calving (Berry et al., 2007; de Freitas et al., 2008), and calves born to cows with lower BCS may be less viable than those born to cows with higher BCS (Ezanno et al., 2005). For these reasons, cows should reach a BCS of 3 or 3.5 (5-point scale) prior to mating and calving. BCS are related to body weight (Northcutt et al., 1992; Enevoldsen and Kristensen, 1997), and to body composition (Gregory et al., 1998; Apple et al., 1999), especially subcutaneous fat thickness (Domecq et al., 1995; Ayres et al., 2009). Beef animals destined for slaughter may need to have a BCS of at least 3.5, although this will depend on individual market requirements.

To be most useful, body scoring systems must be suited to the type of animal. There are several beef cattle systems (NRC, 2000; CSIRO, 2007) which were originally designed for temperate (*Bos taurus*) breeds. They have been applied to *B. indicus* breeds as well but this has been criticised (Ndlovu et al., 2007) on the grounds that tropical cattle are smaller than temperate breeds. Further, temperate dairy breeds and *B. indicus* cattle deposit more fat internally than subcutaneously, compared to temperate beef breeds (Ledger, 1959; Kempster, 1981). This difference is translated into different relationships between carcase fat content and BCS

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Received March 18, 2011; Accepted May 11, 2011

(Wright and Russel, 1984).

There is no published BCS system for Bali cattle (*B. javanicus*). As these animals are a different species, and are typically smaller and have a different appearance to both *B. taurus* and *B. indicus* cattle, existing beef cattle BCS systems may not be appropriate for Bali cattle. The present paper reports measurements of young, entire male Bali cattle and suggests a BCS system for these bovids.

MATERIALS AND METHODS

Cattle

Animals were made available for this project by owners in villages in the Loes, Bobonaro, Covalima and Manufahi districts of Timor Leste. Measurements were made on 100 young (19.3±3.87 months; mean±sd) entire male Bali (*B. javanicus*) cattle, 25 from each district. All of these were maintained under intensive management, which included a combination of tethering, cut-and-carry feeding, and free grazing in a restricted area. All appeared to be in good health, and were accustomed to the presence of people and to confinement in single-animal stalls. The bulls were confined in single-animal stalls while the measurements were taken.

Measurements

Each bull was weighed using portable electronic scales, and measurements made of heights at the withers and the hips from the ground to their highest points, chest (heart) girth measured just behind the forelegs, the body length from the anterior point of the withers to the joint between the sacrum and the first coccygeal vertebra, and the length of the metatarsus from the tuber calcanei to a point between the proximal sesamoid bones. These were the “measured variables”. Subjective assessments of 11 anatomical features (“subjectively assessed characters”) were made and scored as described in Table 1.

Statistical analyses

A preliminary examination of the measured variables (liveweight, girth, body length, hip height, wither height and metatarsal length) identified three cases with outliers (values >4 sd from the mean). These cases were removed from the data as they were probably measurement errors. Between-district comparisons of anatomical measurements were made by analysis of variance, and also by using age as a covariate as this variable differed significantly ($p<0.05$) between districts. Means were separated using the Tukey simultaneous test. Correlation analyses were used to test the

Table 1. Scoring system used to rank eleven anatomical features of Bali cattle

Feature	Score	Description
Coat	1-3	Appearance of the coat: 1 = rough, 2 = normal (smooth), 3 = very smooth
Vertebral processes	1-5	The ends of the transverse vertebral processes in the lumbar region: 1 = very prominent, 2 = easily seen, 3 = can be seen but are covered with soft tissue, 4 = can only be seen by looking closely (e.g. by looking obliquely at the animal and the processes are indicated by shadows), 5 = not visible
Ribs	1-5	As for the vertebral processes
Hindquarters	1-5	The area at the top of the pelvis, between the tuber ischium and the tuber coxae, and covering the upper part of the femur: 1 = hollow or “dished”, 2 = flat, 3 = slightly rounded, 4 = slightly rounded and the hind legs below this area are full, 5 = very full
Tail head	1-4	The sacrum: 1 = very flat, 2 = slightly rounded, 3 = covered with a small amount of soft tissue, 4 = well covered with soft tissue
Leg wrinkles	0-4	The skin is wrinkled at the back of the hind leg above the hock: 0 = no wrinkles present, 1 = one or two wrinkles, 4 = several wrinkles
Neck wrinkles	0-1	The skin of the neck is wrinkled: 0 = no wrinkles, 1 = some wrinkles present
Dewlap	1-4	A flap of loose skin underneath the neck: 1 = non-existent or very small, 2 = loose skin situated near the brisket, 3 = a thin flap extending along the neck, 4 = a large flap of skin underneath the neck, becoming up to approximately 10 cm wide near the brisket
Shoulder	1-3	The area around the withers and upper forelegs, covering the scapula and humerus: 1 = shoulder bones are easily apparent, 2 = the shoulders are well covered with soft tissue, 3 = the shoulders and forequarters are rounded and very well covered with soft tissue
Neck rounding	1-3	The amount of soft tissue present on top of the neck in front of the withers: 1 = fairly flat, 2 = quite full and distinctly rounded, 3 = the rounding extends below the top of the neck down the sides of the neck
Hooks	1-3	The tuber coxae: 1 = easily seen, 2 = presented as small mounds of tissue but can be seen, 3 = well covered by soft tissue and are difficult to see

measured and assessed variables for collinearity before they were used in regression analyses. Regression equations were developed to predict liveweight, and to describe frame size and body condition, from the measured variables. Regression analysis was used to explore the significance of relationships between body condition and the assessed variables. All regressions were derived by stepwise elimination, α to enter = α to remove = 0.15, and using R^2, the significance ($p<0.05$) of regressor variables, and parsimony (an equation with the fewest number of variables) to identify suitable equations.

RESULTS

Anatomical measurements (measured variables)

Cattle from the Loes district were older and larger than those from the other districts, and were heavier than those from Bobonaro and Covalima (Table 2; analysis of variance). However, these differences disappeared when age was used as a covariate ($p<0.001$ in all analyses) except that Loes cattle had shorter metatarsals than those from the other districts. All variables except metatarsal length were correlated with each other, with $0.609<r<0.847$. Correlations of metatarsal length with the other variables were between 0.369 and 0.528.

Derivation of a liveweight (Lwt, kg) prediction equation

After two variables (metatarsal length and wither height) were excluded by the stepwise process, the three variables remaining in the equation were hip height (H, cm), body length (L, cm) and girth (G, cm). This equation had adjusted R^2 = 85.55%, prediction R^2 = 84.72% and standard error of prediction = 1.534 kg, and was:

$$Lwt = 2.48G+2.14L-0.74H-271.3$$

The coefficient for hip height was only just significant ($p = 0.107$). Removing this variable gave an equation with adjusted R^2 = 85.29%, prediction R^2 = 84.52% and standard error of prediction = 1.556 kg:

$$Lwt = 2.34G+1.86L-307.6$$

Derivation of frame scores (FS) and body condition scores

Sixteen FS versions were tested (Table 3). FS1 and FS3 described the “scale” or “ranginess” of the animal’s body (height×length) or (height+length), FS2 described its “compactness” or “blockiness” (height/length), and FS4 combined both ((height×length)+(height/length)). For each of these scores, FS were calculated from hip heights uncorrected for metatarsal length (A), or hip heights corrected for metatarsal length (B), or from the average of hip and wither heights either uncorrected (C) or corrected (D) for metatarsal length. Correlations between the “ranginess” FS (FS1 and FS3) were high ($r\geq0.97$), and correlations between the four FS (i.e. A, B, C and D) within each of the compactness, ranginess and combined FS groups were also high ($0.82<r<0.99$). Correlations between the ranginess FS and the blockiness FS were low especially when the blockiness FS were corrected for metatarsal length ($-0.16<r<-0.32$). The combination of blockiness and ranginess measures in the one FS did not give a qualitatively different result to those obtained for FS1 or FS3 v. FS2; rather these FS4 measures fell between the other two approaches.

FS were tested for sensitivity (size of the coefficient of variation) and normal distribution. On this basis FS1A, FS2A, FS2C, FS2D, FS3A and FS4A were chosen to derive six different indexes of body condition.

Assessment of body condition from anatomical scores

Live weight divided by FS (Lwt/FS) was used as an indicator of body condition. Lwt/FS values calculated from FS2A, FS2C, and FS3A were not normally distributed (Anderson-Darling statistics between 0.051 and 0.086, $p<0.05$) and so were not considered further. Lwt/FS1A was chosen as the indicator of choice because of simplicity in

Table 2. Anatomical measurements (unadjusted least squares means) of young male Bali cattle in four districts of Timor Leste

Characteristic	District			
	Bobonaro	Covalima	Loes	Manufahi
Age (months)	17.0[a]	17.6[a]	23.9[b]	18.8[a]
Hip height (cm)	104.5[a]	103.6[a]	108.8[b]	102.4[b]
Wither height (cm)	100.1[a]	100.2[a]	107.5[b]	101.3[a]
Girth (cm)	126.3[a]	125.7[a]	139.8[b]	131.4[a]
Metatarsal length (cm)	37.2	37.7	37.3	37.3
Body length (cm)	79.8[a]	79.0[a]	85.8[b]	81.7[a,b]
Weight (kg)	133.1[a]	130.3[a]	184.0[c]	157.2[b]

[a,b,c] Within characteristics, means with similar notations are not different (p<0.05).

Table 3. Scores derived to describe the frame size of young male Bali cattle[1]

Frame attribute	Correction	Symbol	Equation
Ranginess (additive)	none	FS1A	L+H
	metatarsal length subtracted	FS1B	L+(H-T)
	hip and wither heights averaged	FS1C	L+((H+W)/2)
	hip and wither heights averaged and metatarsal length subtracted	FS1D	L+((H+W)/2)-T
Blockiness	none	FS2A	H/L×100
	metatarsal length subtracted	FS2B	(H-T)/L×100
	hip and wither heights averaged	FS2C	((H+W)/2)/L×100
	hip and wither heights averaged and metatarsal length subtracted	FS2D	(((H+W)/2)-T)/L×100
Ranginess (multiplicative)	none	FS3A	H×L/100
	metatarsal length subtracted	FS3B	(H-T)×L/100
	hip and wither heights averaged	FS3C	((H+W)/2)×L/100
	hip and wither heights averaged and metatarsal length subtracted	FS3D	(((H+W)/2)-T)×L/100
Combined	none	FS4A	((H×L/100)+(H/L×100))/2
	metatarsal length subtracted	FS4B	(((H-T)×L/100)+((H-T)/L×100))/2
	hip and wither heights averaged	FS4C	((((H+W)/2)×L/100)+(((H+W)/2)/L×100))/2
	hip and wither heights averaged and metatarsal length subtracted	FS4D	(((((H+W)/2)-T)×L/100)+ ((((H+W)/2)-T)/L×100))/2

[1] L = Body length (cm), W = Wither height (cm), H = Hip height (cm), T = Metatarsal length (cm).

calculation and the high correlation of this frame score with FS3A and FS4A. The distribution of values for Lwt/FS1A was divided into five bands (Table 4). The rankings for the 11 subjectively assessed characters in each of these bands are given in Table 5 and a suggested body condition scoring system is described in Table 6.

DISCUSSION

Prediction of live weight

Live weight prediction equations have been developed for Bali cattle (Soeroso, 2004), and for *Bos taurus* and *Bos indicus* beef and dairy cattle breeds and their crossbreeds (Ulutas et al., 2002; Mantysaari and Mantysaari, 2008; Reis et al., 2008; Ozkaya and Bozkurt, 2009; Yan et al., 2009), and buffalo (Bhakat et al., 2008). These models all include girth, height and body length, but in each case, chest girth was found to be a more useful predictor than body length or height. A set of prediction equations which was developed by Soeroso (2004) incorporated chest girth in all the equations as well as measures of body width at the chest, and pelvis and wither heights. Calibration $R^2 = 0.77$ when girth was used as the only predictor variable in that study; inclusion of variables other than girth increased the R^2 to 0.88. Girth, length and hip height were identified by stepwise regression as predictors of live weight in the present experiment, but hip height was subsequently removed from the equation. It contributed little to the accuracy of prediction, and it is more difficult to measure than length or girth because it requires special equipment. Thus its removal improved the practicality of the equation without affecting its statistical quality. The precision of this relationship (prediction $R^2 = 0.85$) is similar to equations developed for other cattle types, e.g. 0.78 (Yan et al., 2009), 0.72 (Bhakat et al., 2008) and 0.61 to 0.91 (Ozkaya and Bozkurt, 2009) and 0.67 in buffaloes (Bhakat et al., 2008).

Table 4. Distribution of the body condition indicator W/FS1A, and the bands selected to represent five body condition scores

Body condition score	Band[1]	Band limits		% of cases in band
		Lower	Upper	
1	x≤(u-1sd)		0.636108	15.9
2	(u-1sd)<x<(u-0.3sd)	0.636109	0.757184	22.3
3	(u-0.3sd)<x<(u+0.3sd)	0.757184	0.860962	23.6
4	(u+0.3sd)<x<(u+1sd)	0.860962	0.982037	22.3
5	x≥(u+1sd)	0.982038		15.9

[1] u = Mean of the Lwt/FS1A distribution; x = Value for Lwt/FS1A; sd = Standard deviation.

Table 5. Occurrence of scores for anatomical subjectively assessed characters for each of the five body condition bands

Parameter	Body condition score	Coat	Leg wrinkles	Hind-quarter	Shoulders	Neck	Tailhead	Neck wrinkles	Vertebrae	Ribs	Dewlap	Hooks
Mode	1	2	2	2	3	2	1	2	0	1	0	1
	2	2	2	2	3	2	1	2	0	2	0	1
	3	2	2	2	2	2	1	2	0	2	1	1
	4	2	0	4	3	1	1	0	4	2	1	1
	5	2	4	4	3	3	1	3	0	3	2	2
Median	1	2	2	2	2	2	1	2	0	1	0	1
	2	2	2	2	3	2	1	2	0	2	0	1
	3	2	2	2	2	2	1	2	0	2	1	1
	4	2	1	3	3	2	1	0	2	3	1	1
	5	2	3.5	4	3	3	1	2.5	1	3	2	2
Mean	1	1.8	2.0	1.8	2.1	1.7	0.7	1.7	0.1	1.4	0.3	1.0
	2	2.1	2.8	2.1	2.4	2.1	1.1	1.7	0.2	1.6	0.4	1.0
	3	2.1	2.1	2.6	2.4	2.1	1.2	1.6	0.9	2.0	0.7	1.4
	4	2.1	1.5	3.1	2.9	1.9	1.7	1.1	2.2	2.8	1.3	1.6
	5	2.1	2.9	3.9	3.5	2.6	1.8	2.1	1.9	3.2	2.0	2.1

Derivation of frame scores (FS) and body condition scores

FS are commonly used to describe cattle body shape, e.g. the product of body depth by hip width (Sloniewski et al., 2005). A good frame score should be sensitive (i.e. have a large range when measured in a population of normal animals), describe the 3-dimensional aspects of an animal (e.g. length×height×width), and should be not too much influenced by leg length, as most soft tissue is found in the trunk. In this experiment, the two FS which measured ranginess were highly correlated ($r\geq0.97$) indicating that the additive and multiplicative forms of the ranginess FS gave very similar results. Correcting wither or hip heights by subtracting the metatarsal length, or averaging the hip and wither heights, gave similar results to the uncorrected measurements when these were compared within each of the compactness, ranginess and combined FS groups ($0.82<r<0.99$). On the other hand, the low correlations ($-0.16<r<-0.32$) between the ranginess FS and the blockiness FS where these were corrected for metatarsal length indicates that these measures described different aspects of the animal's shape.

Body condition score development

Body condition scores (BCS) are measures of the amount of soft tissue in an animal's body relative to its frame size, and may quantify this more accurately than a simple measure of live weight (Ayres et al., 2009). BCS reflect the animal's recent nutritional history, and are indicators of its future productivity. Published BCS systems for *Bos taurus* and *Bos indicus* cattle (East of Scotland Agricultural College, 1976; Earle, 1976; Wildman et al., 1982; Nicholson and Butterworth, 1986; NRC, 2000; CSIRO, 2007) are all similar, although they may use scales of different size (e.g. 5- or 9-point scales) and may use half-score intervals. The system developed here for Bali cattle uses a 5-point scale. Nicholson and Sayers (1987) have suggested that "The greater the number of scores (in a BCS system) the more sensitive the estimate", and demonstrated that their 9-point scale distinguished between two groups of malnourished cattle better than a 6-point scale. However, a 5-point scale is used for beef cattle in Australia (CSIRO, 2007) including in extensive regions where animals may be under-nourished, and 5- and 10-point systems gave similar results in dairy cattle (Roche et al., 2004). Further, a system with fewer points may be easier to use than one with a much larger number of points, especially by inexperienced operators.

Ferguson et al. (1994) have described in detail the assessment of a BCS for *Bos taurus* cattle. The data collected in the present work show that hindquarter and shoulder shape and tissue cover, and the prominence of the vertebral transverse and spinous processes, are important identifiers of BCS in Bali cattle. As condition improves these become covered with more tissue. Fleshing at the top of the neck, the brisket and the leg above the hock also increase as condition improves.

There are some similarities between the BCS system developed here and those of Nicholson and Butterworth (1986) and CSIRO (2007). All systems consider the prominence of the bones around the tailhead, the pelvis, the vertebrae and the ribs. Fleshing over the shoulder is important in Bali cattle, but is mentioned by Nicholson and Butterworth (1986) only in thin or emaciated animals, and

Table 6. A suggested body condition scoring (BCS) system for Bali cattle

Score	Character	Description
BCS 1	hindquarters	top is flat, may be hollow or “dished”
	shoulders	shoulder bones are prominent and easy to see
	neck	the upper part of the neck below the vertebrae is fairly flat
	tailhead	very flat
	vertebrae	very prominent
	ribs	very prominent
	dewlap	non-existent or very small
	hooks	prominent, easily seen
BCS 2	hindquarters	top is flat
	shoulders	the shoulders are well covered with soft tissue
	neck	quite full with a distinctly rounded appearance
	tailhead	flat
	vertebrae	easily seen
	ribs	easily seen
	dewlap	present
	hooks	easily seen
BCS 3	hindquarters	top is flat
	shoulders	the shoulders are well covered with soft tissue
	neck	quite full with a distinctly rounded appearance
	tailhead	essentially flat, with very slight rounding
	vertebrae	can be seen but are covered with soft tissue
	ribs	can be seen but are covered with soft tissue
	dewlap	present
	hooks	easily seen
BCS 4	hindquarters	top is flat or slightly rounded
	shoulders	the shoulders are well covered with soft tissue
	neck	quite full with a distinctly rounded appearance
	tailhead	essentially flat, with very slight rounding
	vertebrae	can be seen only by looking closely (e.g. by looking obliquely at the animal and the processes are indicated by shadows)
	ribs	can be seen but are covered with soft tissue
	dewlap	present
	hooks	easily seen
BCS 5	leg wrinkles	several wrinkles are present
	hindquarters	top is slightly rounded, the hind legs below this area are very full
	shoulders	the shoulders and forequarters are very well covered with soft tissue
	neck	rounding extends below the top of the neck down the sides of the neck
	tailhead	has small mounds of soft tissue
	neck wrinkles	apparent/present
	vertebrae	covered by soft tissue and are not visible
	ribs	can only be seen by close inspection
	dewlap	a large flap of skin, especially near the brisket
	hooks	covered with soft tissue, but are usually able to be seen

not at all by CSIRO (2007). Fleshing of the hind leg (above the hock) is an indicator of condition in temperate cattle breeds (CSIRO, 2007) and in Bali cattle, but the top surface of the hindquarters of Bali cattle remains rather flat even in well-conditioned animals. The dewlap and the neck are useful indicators of condition in Bali cattle but are not specifically mentioned in the other two systems.

The application of liveweight prediction and body condition scoring in Bali cattle farming

A satisfactory equation, based on body length and girth, is presented to predict the live weight of Bali bulls. The equation was developed for young bulls, as these were the only animals available for this experiment. For improved robustness, data from animals of different ages and sexes should be included. In the present experiment, age accounted for 61% of the variation in live weight.

This BCS system was developed from data collected from bulls, but it is expected to be applicable to females. BCS systems may apply similarly to males and females as there is little difference in their carcase fat distribution, at the same degree of fatness, at least in temperate breeds (Kempster, 1981). The BCS technique can be easily learned by cattle owners, who are able to use it with acceptable accuracy (Kleibohmer et al., 1998; Kristensen et al., 2006), provided that they use a standard approach to scoring (Hady and Tinguely, 1996). The repeatability of BCS improves as the users gain experience (Grainger and McGowan, 1982; Nicholson and Sayers, 1987; Ferguson et al., 1994). Pictorial descriptions, such as those provided by Nicholson and Butterworth (1986) and Robins et al. (2003) would assist in teaching the method to farmers.

High-value beef cattle markets demand animals which meet certain age, live weight and body condition standards. Live weight prediction (i.e. rather than subjective estimation) and BCS are practical ways of monitoring animal performance. Their use will help cattle owners to recognise when animals fail to meet required growth paths and thus help them to achieve desired levels of productivity.

ACKNOWLEDGEMENTS

We thank the owners of cattle in the Loes, Bobonaro, Covalima and Manufahi districts of Timor Leste for allowing us to use their cattle and for their hospitality, and our colleagues in the Agriculture Faculty of the Universidade Nacional de Timor Leste for help in making these measurements. The interest and support of the manager and staff of Co-operativa Café Timor Leste is also appreciated. The work was funded by the Australian Centre for International Agricultural Research.

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