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Validation of a body condition scoring system in Nili Ravi dairy buffaloes (*Bubalus bubalis*): inter- and intra-assessor variability

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Research Article

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Abstract

The aim of the research reported in this Research Communication was to apply the 5-point body condition scoring (BCS) system to dairy buffaloes and subjectively validate it by assessing the intra- and inter-assessor agreement. For this purpose, the BCS system developed for dairy cows was applied to buffaloes. A total of 230 Nili Ravi buffaloes of varying parity, lactation stages and pregnancy status were enrolled from the Buffalo Research Institute, Pattoki, Pakistan. Four observers independently assigned BCS values to each enrolled buffalo in two phases, as follows: (1) during phase I, the assessors were trained for BCS assessment using a BCS chart developed by Elanco Animal Health Ltd.; and (2) during phase II, the assessors were trained using live buffaloes for BCS assessment. Kappa statistics (kw) were used to determine the intra- and inter-assessor agreement. The results revealed that the exact overall inter- and intra-assessor agreement was moderate (kw = 0.48–0.55) and increased to substantial levels after training on live animals (kw = 0.63–0.87). Furthermore, the intra- and inter-assessor exact agreement was higher (kw = 0.57–0.58) for buffaloes tied to the mangers compared to the buffaloes standing in the loafing area (kw = 0.50). The inter-assessor agreements within 0.25 and 0.5 points were almost perfect (kw = 0.97–1.0). The current results suggested that the 5-point BCS system (using a scale from 1 to 5 with 0.25 increments) had substantial agreement for assessment and repeatability when applied to buffaloes.

The body fat reserves at parturition are important determinants of transition success, milk yield, and reproductive performance in dairy animals (Roche *et al.*, 2009). Several different methods are used to measure the body fat reserves in live animals, including metabolic and hormonal factors like non-esterified fatty acids, beta hydroxybutyrate, glucose, cholesterol, urea, insulin, and lactose as well as the use of ultrasound and, finally, digital imaging. Some of these methods are invasive and quite expensive, and it is not generally possible to routinely assess body fat by these methods at dairy farms. The commonly used noninvasive method is to subjectively assess fat reserves by visual or tactile observation, termed body condition scoring (BCS; Edmonson *et al.* 1989).

Various BCS systems are used throughout the world for dairy cattle. In the United States a 5-point scale from 1 to 5 with 0.25 increments (Elanco Animal Health Ltd., 1996) is in practice and in New Zealand, a scale from 1 to 10 with 0.5 increments (Roche *et al.*, 2004) is used. Denmark, uses a scale from 1 to 9 with 1-point increments (Landsverk, 1992) and in the United Kingdom and Ireland, a scale from 0 to 5 with increments of 0.5 is employed (Mulvany, 1977). The Elanco BCS system is user friendly, as it is entirely based on visual assessment and relatively fewer body parts must be observed for scoring. For buffaloes, a BCS system of a scale from 1 to 5 with 0.5 increments has been developed by Anitha *et al.* (2011). This BCS system is based on visual and tactile palpation. One must assign a score separately for each skeletal point and then take an average for overall body condition scoring. This could be time consuming, which might limit its application at the farm level. Furthermore, the larger increment unit (0.5) makes it less effective in determining the finer variation in the body fat reserves of buffaloes. Considering the success of the American BCS system for dairy cows (Kristensen *et al.*, 2006), we posed the following question: Can a BCS system be applied and validated in dairy buffaloes? Therefore, the objective of the present study was to apply the 5-point BCS system developed by Elanco Animal Health Ltd. on Nili Ravi buffaloes and subjectively validate the system by assessing intra- and inter-assessor repeatability.

Table 1. Overall weighted kappa coefficient for inter- and intra-assessor exact agreement and agreement within 0.25 and 0.5 point for BCS of buffaloes

	No. of assessors	No. of BCS points[a]	BCS Range	n	Level of agreement	Mean	SD	Min	Max
Phase I				230					
Inter-assessors	4	6	2.75–4		Exact	0.51	0.03	0.48	0.55
					0.25	0.82	0.06	0.77	0.90
					0.5	0.98	0.01	0.97	0.99
Intra-assessors	4	6	2.75–4		Exact	0.54	0.13	0.45	0.64
					0.25	0.85	0.07	0.80	0.90
					0.5	0.96	0.03	0.94	0.98
Phase II				220[b]					
Inter-assessors	4	8	2.5–4.25		Exact	0.75	0.17	0.63	0.87
					0.25	0.97	0.02	0.96	0.99
					0.5	1	0	1	1
Intra-assessors	4	8	2.5–4.25		Exact	0.63	0.01	0.63	0.64
					0.25	0.97	0.01	0.96	0.98
					0.5	1	0	1	1

[a]The range of BCS points was less in phase I (2.75–4) while it was greater in phase II due to the change in lactation stage of buffaloes.
[b]In phase II the animal number decreased due to culling.

Material and methods

Study site and study animals

The study was conducted at the Buffalo Research Institute in Pattoki, Pakistan. Nili Ravi buffaloes with varying parity (heifer vs. others), stages of lactation, and pregnancy status were enrolled in the study. The buffaloes were kept in a loose housing system and managed according to the farm protocols. All experimental procedures were undertaken in compliance with the Institutional Guidelines of the Ethical Review Committee of the University of Veterinary and Animal Sciences, Lahore, Pakistan.

BCS assessment methodology

Four postgraduate students with limited or no previous experience of body condition scoring were registered as BCS assessors for the study. The assessors recorded the BCS values of buffaloes in two phases, as follows: during phase I, the assessors were trained for BCS assessment using a BCS chart developed by Elanco Animal Health Ltd and during phase II, the assessors were trained using live buffaloes for BCS assessment. During each phase, after training, the assessors recorded the BCS of all enrolled buffaloes and then repeated the BCS assessment for the same buffaloes after two days. During phase II, the BCS of each buffalo was recorded in two different locations: inside the shed at milking time where the buffaloes were tied at the feed bunk and then in the loafing area when the animals were let loose. The average distance between the observer and the experimental animal was about 1 m inside the shed and 2.5 m in the loafing area. A total of 230 and 220 buffaloes were scored on each scoring day during phases I and II, respectively. Further details are given in the online Supplementary materials and methods, Supplementary Table S1 and Supplementary Fig. S1.

Statistical analysis

All statistical procedures were carried out using SAS (SAS for Academics: SAS 9.4M6 Institute Inc., Cary, NC). For validation assessment, agreement statistics were applied to assess whether the BCS values recorded for a buffalo by different assessors at different time points were similar. As the BCS data were ordinal in nature, the inter- and intra-assessor agreement variability was determined using Weighted Kappa statistics (kw). The kw coefficient effectively measures the variation in the proportion of agreement within or between assessors and was appropriate with ordinal scoring systems (Lantz, 1997). The individual kw values were calculated for within and between assessors for exact agreement and agreement within 0.25 and 0.5 points for phases I and II. Means, standard deviations and minimum and maximum kw were reported. The interpretation of kw values for agreement was done according to Landis and Koch (1977), where <0 = poor, 0.0–0.20 = slight, 0.21–0.40 = fair, 0.41–0.60 = moderate, 0.61–0.80 = substantial, and 0.81–1 = almost perfect. Inter-assessor agreement with kw >0.8 was a successful validation of the BCS system (Vasseur *et al.*, 2013).

Results and discussion

Inter- and intra-assessor agreement

The inter- and intra-assessor agreement for exact agreement (within 0.25 and within 0.5 points, respectively) is presented in Table 1. For phase I, the average inter- and intra-assessor exact agreement was moderate (0.51, 0.54 for inter- and intra-assessor agreement, respectively). The average inter- and intra-assessor agreement within 0.25 was almost perfect (0.82, 0.85, respectively). Similarly, the average inter- and intra-assessor agreement within 0.5 points was also almost perfect (0.98, 0.96). For the second phase, when the assessors were trained with live animals, the average inter- and intra-assessor exact agreement increased to the substantial level with kw values of 0.75 and 0.63, respectively (Table 1). The average inter- and intra-assessor agreement within 0.25 was almost perfect (0.97 and 0.97, respectively), whereas the inter- and intra-assessor agreement within 0.5 points was 100% (kw = 1; Table 1). In agreement with the current findings,

Table 2. Weighted kappa coefficient for inter- and intra-assessor exact agreement and agreement within 0.25 and 0.5 point for BCS at different farm locations and buffalo group

	No. of assessors	No. of BCS points	BCS Range	n	Level of agreement	Mean	SD	Min	Max
Farm location[a]									
Tied at mangers				114					
Inter-assessors	4	7	2.5–4.25		Exact	0.57	0.05	0.54	0.61
					0.25	0.94	0.01	0.93	0.95
					0.5	1	0	1	1
Intra-assessors	4	7	2.5–4.25		Exact	0.58	0.06	0.54	0.62
					0.25	0.98	0.03	0.95	1
					0.5	1	0	1	1
In loafing area				114					
Inter-assessors	4	7	2.5–4.25		Exact	0.50	0.02	0.49	0.51
					0.25	0.92	0.11	0.84	1
					0.5	1	0	1	1
Intra-assessors	4	7	2.5–4.25		Exact	0.50	0.02	0.49	0.51
					0.25	0.93	0.02	0.92	0.94
					0.5	1	0	1	1
Buffalo groups									
Milking buffaloes[b]				114					
Inter-assessors	4	7	2.5–4.25		exact	0.57	0.05	0.54	0.61
					0.25	0.94	0.01	0.93	0.95
					0.5	1	0	1	1
Intra-assessors	4	7	2.5–4.25		exact	0.58	0.06	0.54	0.62
					0.25	0.98	0.03	0.95	1
					0.5	1	0	1	1
Dry pregnant[c]				66					
Inter-assessors	4	7	2.5–4.25		exact	0.57	0.10	0.48	0.68
					0.25	0.98	0.04	0.93	1
					0.5	0.99	0.03	0.96	1
Intra-assessors	4	7	2.5–4.25		exact	0.58	0.10	0.49	0.69
					0.25	0.96	0.03	0.93	1
					0.5	1	0	1	1
Heifers[d]				55					
Inter-assessors	4	7	2.5–4.25		exact	0.33	0.05	0.30	0.37
					0.25	0.71	0.09	0.65	0.77
					0.5	1	0	1	1
Intra-assessors	4	7	2.5–4.25		exact	0.36	0.06	0.32	0.41
					0.25	0.95	0.08	0.89	1
					0.5	1	0	1	1

[a]This comparison was only for milking buffaloes.
[b]The milk group includes buffaloes from early to mid-lactation.
[c]The dry pregnant group include buffaloes of all parity.
[d]The heifer group include open buffalo heifers of >1.5 year of age.

Vasseur *et al.* (2013) found that before training, exact agreement was moderate and increased to substantial after training with the BCS system in dairy cows. Some other studies also showed improvement in scoring assessment after training in dairy cows (Kristensen *et al.*, 2006). In Phase II, the increase in intra-assessor exact agreement (0.63) was relatively smaller compared to the

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increase in inter-assessor exact agreement (0.75). This could be due to more buffaloes with lower BCS range (2.5–3.0) in phase II. The assessors had limited opportunity to assign BCS in lower range during phase I, because only <5% of the total BCS assigned was in this range (BCS ≤3). It might have been difficult for the assessors to distinguish the angularity of pin and hook bones in lower BCS range that could explain the lower within assessor reproducibility. Greater exposure to a variety of BCS range would perhaps have increased the reproducibility. The frequency distribution of body condition scores assigned to different buffaloes during the study is presented in the supplementary material (online Supplementary Table S2). The BCS ranged from 2.5 to 4.25, however, the frequency was relatively higher for the range from 3.25 to 3.75.

Scoring location and variability in agreement

The inter- and intra-assessor agreement level was different at different farm locations (Table 2). The average inter- and intra-assessor exact agreement was higher (0.57, 0.58) when scoring was done on tied buffaloes within the shed during milking, whereas it was numerically lower when the buffaloes were let loose in a loafing area (0.50, 0.50; Table 2). However, the inter- and intra-assessor agreement within 0.25 and 0.5 was similar in both locations (kw > 0.90). When buffaloes were tied during milking at the feed bunk, the assessors were within close proximity of the buffaloes (~1 m), ensuring obstruction-free observation of their body parts and allowing BCS to be assessed in 0.25-point increments. Buffalo identification and recording of BCS were both accomplished more quickly when one assessor read the ear tag and the second assessor stood behind the animal in the alley to assess the body condition. A single assessor could still read the ear tag of the buffaloes standing near them in the pen. It took approximately less than 1 min per buffalo to identify and assess the BCS. Our findings were similar to those of Vasseur *et al.* (2013), who reported that when cows were head locked at a feed bunk, the BCS scoring was easy and took less time. The main constraint was being able to approach buffaloes close enough to visualise the body parts, as the buffaloes were not habituated to being approached by unfamiliar people.

Buffalo category and variability in agreement

The inter- and intra-assessor agreement for the different categories of buffaloes is presented in Table 2. The average inter- and intra-assessor exact agreement for lactating buffaloes was moderate (0.57 and 0.58, respectively). The scoring of pregnant buffaloes (7–9 months) had almost similar inter and intra-assessor exact agreement (0.57 and 0.58, respectively) as that of lactating buffaloes. However, the average inter- and intra-assessor exact agreement was lower (0.33, 0.36; Table 2) for buffalo heifers; the average inter- and intra-assessor agreement within 0.25 (0.71 and 0.95, respectively) and 0.5 points (1.0 and 1.0, respectively) was substantial to almost perfect. The lower inter- and intra-assessor exact agreement could be attributed to the fact that the heifers were let loose in the loafing area. It was very difficult to get closer than 2 m from the heifers, which made it almost impossible to correctly identify individual animals and accurately assess BCS. In addition, it took more time (>2 min) to assess a single animal. Likewise, Vasseur *et al.* (2013) also found that when cows were outside the pen, it was difficult to observe them at a distance closer than 2 m, making it difficult to assess exact BCS.

In conclusion, we have successfully applied an existing cattle BCS system to buffaloes and provided a subjective validation of its effectiveness. We concluded that the BCS system, when applied to buffaloes, was repeatable with substantial levels of inter- and intra-assessor agreement. The BCS training with live buffaloes further improved the assessment repeatability.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0022029922000723.

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