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DEVELOPMENT OF DECISION SUPPORT SYSTEM FOR BODY CONDITION SCORE (BCS) IN COWS THROUGH ARTIFICIAL INTELLIGENCE (AI)

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ABSTRACT
Evaluation of BCS is important for analyzing health problems, feed intake, and optimal time interval between calving and first insemination. Research studies suggest that accurate estimation of BCS of animal the farmers may take corrective steps for improvement of health and performance of the animal through various management practices. In view of this, the research was carried out to develop a system that models the body shape of a cow from the back and lateral view images and then assesses the BCS with observed angle features in score estimation. The farmers may take help of these angle features to decide the score of the animal on his mobile phone via developed mobile application. The cows with BCS 1+ and 3- are under conditioned and very thin due to insufficient energy and protein reserves to maintain production. Such animals may show reduced milk production, body weight and care must be taken to maintain production while increasing body reserves. Thin heifers may not grow rapidly enough to reach puberty by 11 to 13 months of age. They may also be too small to calve at 22 to 24 months or to carry enough weight to maintain a normal first lactation production. Scores above 4- indicate that energy intake was too high during late lactation and/or the dry period. Separate dry cows from the milking herd and feed them a low-energy ration with adequate, but not excessive, protein, minerals, and vitamins.

KEYWORDS: body condition score, body reserves, cow, diet, dry period, nutrition

INTRODUCTION

BCS is widely considered as an important factor for management of dairy cattle due to its simplicity and repeatability. Moreover, it can evaluate body fat stores and estimate cumulative energy balance through visual or tactile inspection. Body condition is a reflection of the body fat reserves carried by the animal; these reserves can be used by the cow in periods when she is unable to eat enough to satisfy her energy needs. Cows should be scored both by looking at and handling the backbone, loin and rump areas. Since the pin bone, hip bone, the top of the backbone and ends of the short ribs do not have muscle tissue covering them, any covering you see or feel is the combination of skin and fat deposits.

Cows should be scored regularly to reflect changes in fat reserves in each stage of lactation. Condition scores range from 1, a very thin cow with no fat reserves, to 5, a severely over conditioned cow. Ideal condition scores fall in the range of 3.0-4.0 at dry off and calving and 2.5-3.5, at peak lactation, with no cows changing by more than 1 condition score class over any lactation period. Roii *et al*. stated that automatic and objective BCS will help to ensure that the cow is in the correct condition for each stage of her annual cycle and correct any deficiencies with appropriate dietary changes.

For dairy cattle, the most used scales have 5, 8 or 10 points (Roche *et al*., 2004) but the unit increments may vary and therefore, number of scores is quite similar. Some scales score the body as a whole unit while others only score certain body locations, these are scored separately and then integrated to an absolute score (Wildman *et al*., 1982; Ferguson *et al*., 1994; Roche *et al*., 2004). Combinations of both methods exist as well (Edmonson *et al*., 1989; Gillund *et al*., 1999). For instance, some of the most cited scales are described by Wildman *et al*. (1982), Edmonson *et al*. (1989) and Ferguson *et al*. (1994) and have certain common characteristics; the scales are 1 to 5 point scales with 0.25 units of increment. With such a scoring system the cow can receive 17 different scores. Usually, low numbers represent thin animals and high numbers represent obese animals (Bewely and Schutz, 2008).

Among the many attempts for estimating body condition scores automatically, the first attempt by Coffey *et al*. (2003) tested using line patterns painted with laser light over the tail head area of the cows. Some attempts apply digital images or some system used videos and an analysis of the cow's contour and shape that commonly involved. Roii *et al*. (2016) have taken 3D images from the above view of the cow acquisition of data automatically. Halachmi *et al*. (2008) have also taken thermal images and they made decision that fatter cow's shape are rounder.

Segmentation of the back shape of the cow once we have the preprocessed cows' back view images, we need to

extract the computationally manageable representation of the anatomy of the back shape of cows. A computer program written with Mat lab 2015 was used in annotating of cow images from the dataset. Twenty five anatomical points are identified. Those anatomical points according to recognizable features can influence the important information for representation of the shape. The shapes are then aligned to endure the pose (scaling, rotation and resizing). Angles are measured according to law of cosine method using three points. There are five angles totally computed, two angles around the left and right hooks and two angles around the tail head depression area and one angle at the peak of the tail head.

As a matter of importance of the BCS in relevance to the farmers, it can be stated that by accurate estimation of BCS of animal the farmers may take corrective steps for improvement of health and performance of the animal through various management practices. In view of this, the aim of the proposed research is to develop a system that models the body shape of a cow from the back and lateral view images and then assesses the BCS with observed angle features in score estimation. The farmers may take help of these angle features to decide the score of the animal on his mobile phone via developed mobile application. The research work is undertaken with the following objectives:

1. To develop AI based decision support system for estimating body condition score in cows.
2. To suggest corrective measure to farmers through mobile based BCS application.

MATERIALS AND METHODS

Location of experiment and experimental design

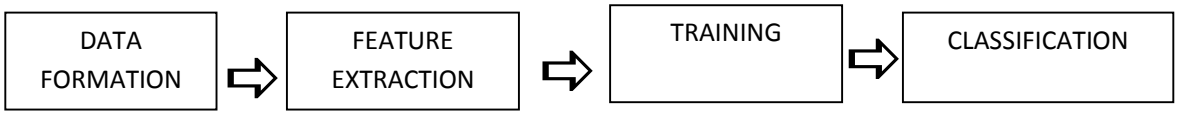
The present study was carried out during the period of December 2019 to May 2020 this experiment was conducted in Nagpur Region nearby villages, and District Nagpur which is located in subtropical region at 21°08′46″ N latitude and 79°05′05″ E longitudes at an altitude of Elevation above sea level: 319 m = 1046 ft. above mean level of sea.

Experimental Design

The Study was conducted on the field, at different Gaushalas and Government and well organized private cattle farms. The photographs of 1000 animals were clicked by the camera of the mobile phone. The photograph of each animal were clicked as 1) Rear View and 2) Lateral View. In all 2000 Photographs of 1000 animals were taken during the study.

The photographs were processed on computer by a computerized program *viz;* Image Analysis & Machine Learning Technique and a mobile application was introduced to the farmers by the farm guider.

The process of development of mobile application by Image Analysis Technique was as given below;



According to the obtained BCS value of the animals through the mobile application, the animals were divided into following categories and conclusion was drawn:

1. Cows with BCS of 1 to 1.75
2. Cows with BCS of 2 to 2.75
3. Cows with BCS of 3 to 3.75
4. Cows with BCS of 4 to 4.75
5. Cows with BCS above 5

Statistical Analysis

Statistical analysis was carried out by using Complete Randomized Design (CRD) and unpaired 't' test by using statistically Web Based Agricultural Statistics Software Package (WASP 1.0).

RESULTS AND DISCUSSION

Cows with BCS 1.00 to 1.75.

The health status of cows was emaciated with very poor body condition. By observation of rear view of the cows the animals shown deep cavity under tail and around tail head. The skin over pelvis was drawn tight with no tissue detectable in between.

By observation of lateral view of cows, no fatty tissue felt at loin. The ends of the short ribs were sharp to the touch and together give a prominent shelf-like appearance to the loin. The Pins, hooks, and short ribs seen prominently and edges feel sharp. The individual vertebrae (spinous processes) of the backbone were prominent.

Fig 1. Lateral view (Left) and Rear view (Right) of a cow with BCS 1.00

Cows with BCS 2.00 to 2.75.

The health status of the cows was thin with poor body condition. By observation of rear view it is observed that the cavity around the tail head was present but less prominent. The fatty tissue between skin and pelvis was not felt but skin was supple/ flexible. By observation of lateral view it is seen that the ends of the short ribs were felt and sharp to the touch but the ribs and the individual vertebrae were less visibly prominent. The hook and pin bones were prominent but the depression of the thurl region between them was less severe. The area around the anus was less sunken and the vulva less prominent. The cows with BCS 2.00 shown thin, saw-tooth spine and ribs and the ribs were visible ¾ of the distance to the spine. The cows with 2.25 BCS showed the ribs visible ½ to the spine and no fat pad on pins. The cows with BCS 2.50 showed the angular pins and fat pad on pins where as the cows with 2.75 BCS shown visibly padded pins and angular hooks.

Fig 2. Lateral view (Left) and Rear view (Right) of a cow with BCS 2.75

Cows with BCS 3.00 to 3.75.

The health status of these cows was good with average body condition. By observation of rear view it is noticed that the cows showed slight cavity at tail head lined with apparent fatty tissue and the area between pins has smoothed out. It is also seen that the anal area was filled out but there was no evidence of fat deposit.

By observation of lateral view it is seen that with moderate pressure the ends of the short ribs felt to the fingers, however, there was no overhanging shelf-like appearance of these bones. It is also noticed that there was slight depression visible in loin area.

Apart from above mentioned observations, the cows with BCS 3.25 showed sacral and tail head and both ligaments visible to the eyes. In cows with 3.50, the tail head ligament was found partly covered in fat and it was barely visible, however, the sacral was visible. The sacral was barely visible and tail head was not visible; similarly sacral and tail head ligament was not seen in cows with BCS 3.75.

Fig 3. Lateral view (Left) and Rear view (Right) of a cow with BCS 3.00

Cows with BCS 4.00 to 4.75

The health status of the cows with BCS 4.00 was Fatty with heavy body condition. By observation of rear view of the cows it is found that there was no depression between pins and tail head because of patches of fat under the skin. The pelvis of the cows felt only with application of firm pressure. The back and area between hooks and pins was found flat.

By observation of lateral view of cows it is seen that the individual short ribs felt only when firm pressure applied. No shelf effect was found as the short ribs were rounded over. The depression in loin between backbone and hip bones was not visible. The hook bones were found to be round and smoothed over and the span between the hook bones over the backbone was flat. The patches of fat deposit were seen in area around the pin bones.

The cows with BCS 4.25 showed flat thurl, short ribs barely visible and area between hooks and pins barely visible. The cows with BCS 4.50 showed flat thurl and area between hooks and pins filled with fat; however, pins and tips of short ribs were invisible. It is seen that the cows with BCS 4.75 showed the area between hooks and pins filled with fat where as pins and hooks and tips of short ribs were invisible.

Fig 4. Lateral view (Left) and Rear view (Right) of a cow with BCS 4.00

Cows with BCS 5.00 and above

The health status of cows with BCS 5.00 was grossly fat. By observation of rear view of the cows it is noticed that the tail head was buried in fatty tissue and the fat deposited around the tailbone and over the ribs. The area between pins and tailbone was round and skin distended.

By observation of the lateral view of the cows it is found that even with firm pressure, no part of pelvis and bony structure felt. It was observed that there were folds of fatty tissue over short ribs. The bony structure of the top line, hook and pin bones and the short ribs was not visible.

Over conditioning or fatness (BCS > 4), may result from poor nutrition or reproduction management. A fat cow is more susceptible to metabolic problems and infections, and is more likely to have difficulty at and after calving. Over conditioning usually begins during the last 3-4 months of lactation, when milk production has decreased, but dietary energy and total nutrient levels have not been reduced accordingly. Other common causes of over conditioning are prolonged dry periods or overfeeding during the dry period. The fat heifers have been shown to be difficult to breed, and if fat when they are near calving, have difficult calving and produce less milk after calving.

The cows carrying excess condition before calving have a greater risk for low feed intake in the critical transition period around the time of calving. This can lead to loss of body condition and deepen the negative energy balance cows experience after calving. Reduced dry matter intake has obvious effects on milk production and can contribute to ketosis, a displaced abomasums, or other metabolic and production consequences of nutritional stress.

Fig 4. Lateral view (Left) and Rear view (Right) of a cow with BCS 5.00

Recommendations for cows with respect to BCS during various stages of production

Cows at Calving

Recommended score: 3+ to 4-

Nutritional objective: Allow cows to calve with adequate, but not excessive, body fat reserves.

Cows at Early Lactation

Recommended score: 3- to 3

Nutritional objective: Maximize intake of a high-energy ration to minimize changes in body condition and counteract negative energy balance. Ration must contain adequate protein to support peak milk production.

Cows at Mid-Lactation

Recommended score: 3

Nutritional objective: Maintain body condition at this score to maximize milk production.

Cows at late lactation

Recommended score: 3 — Aim for 3+ to 4- at time of dry off.

Nutritional objectives:

- Replenish energy and fat reserves to prepare cow for next lactation.
- Avoid over-conditioning.

Dry Cows

Recommended score: 3+ to 4-

Nutritional objectives:

Maintain body condition in recommended range and feed low-energy ration that provides adequate, but not excessive, amounts of protein, vitamins, and minerals.

Heifers

Recommended score: 3- to 3+

Nutritional objectives: Maintain body condition in recommended range. Feed a balanced ration that provides adequate but not excessive amounts of energy, protein, vitamins, and minerals.

CONCLUSION

It is concluded from the present research work that the developed App was useful to the dairy farmers and dairy farms to decide the body condition score of the dairy cow and correct the body condition of the dairy animal by planning and executing the feeding operations.

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Conflict of Interest

Authors declare that there is no conflict of interest.

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