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Original article

Factors affecting the body condition score of N'Dama cows under extensive range management in Southern Senegal

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Abstract — The aim of the present study was to determine the factors affecting N'Dama heifer and adult cow body conditions, which were scored between 0 and 5 points (BCS), in Southern Senegal under an extensive range management system. BCS at 3 years of age was mainly affected by the prevailing season and birth date. The means were 3.52, 3.41 and 3.12 for births occurring respectively in the rainy season (RS), in the cool dry season (CDS) and in the hot dry season (HDS). BCS at calving was mainly affected by the calving season, with average scores of 3.12, 2.77 and 2.40 in the RS, CDS and HDS, respectively. When removing the effects of calving season and parity, 3 patterns of BCS profile appeared between the 6th month of pregnancy and the 2nd month of lactation. Cow body condition at any given month "t" compared to the threshold of 2.5 points could be predicted by the BCS during the two previous months, parity, physiological status, herd size and season.

cattle / N'Dama / body condition scoring (BCS) / Senegal / extensive range management

Résumé — **Facteurs de variation de la note d'état corporel des vaches de race N'Dama en élevage extensif dans le sud du Sénégal.** L'objectif de cette étude était de déterminer les facteurs influant sur l'état corporel, noté entre 0 et 5 points (Body Condition Score – BCS : note d'état corporel), des génisses et des vaches adultes de race N'Dama dans le sud du Sénégal en élevage extensif. La BCS à 3 ans était essentiellement influencée par la saison en cours et la date de naissance. Elle était en moyenne de 3,52, 3,41 et 3,12 pour des naissances respectivement en saison des pluies (Rainy Season – RS), en saison sèche fraîche (Cool Dry Season – CDS) et en saison sèche chaude (Hot Dry

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Season – HDS). La BCS à la mise bas était surtout influencée par la saison de vêlage, avec des notes moyennes de 3,12, 2,77 et 2,40 en RS, CDS et HDS, respectivement. Les effets saison de mise bas et parité retirés, 3 profils d'évolution de la BCS étaient mis en évidence entre le 6[e] mois de gestation et le 2[e] mois de lactation. L'état corporel des vaches à un mois *t* quelconque par rapport au seuil de 2,5 points était prédit par les BCS des deux mois précédents, la parité, l'état physiologique, la taille du troupeau et la saison.

bovins / N'Dama / note d'état corporel / Sénégal / élevage extensif

1. INTRODUCTION

In tropical environments, cattle performance under extensive range management is strongly limited by feeding resource availability and quality, especially during the dry season [28]. In such contexts, breeders are interested in simple indicators to better control feeding and production. The evaluation of animal nutritional status may explain the observed variability in performance between the animals and at different seasons. This nutritional status can be estimated through the evaluation of in vivo body reserves, since it reflects the cumulative energy balance [4, 40]. Among the methods that have been developed to assess the in vivo body composition [8], body condition scoring (BCS) is of particular interest [1, 30]. This method is easy to handle, rather cheap and gives a sufficiently reliable estimation of body energy reserves [2]. Moreover, it is well adapted to large-scale surveys with numerous data in an environment where animals are subject to large variations of body fat. Many authors have studied the effect of feeding level and the period since calving on BCS variations in cattle under either temperate [5, 34, 37, 41] or tropical [9] climates. The general consensus is that BCS is particularly influenced by season and feeding. It decreases during early lactation and subsequently increases progressively until it reaches its initial level. However, the pattern of variation of cow BCS under extensive tropical management has not been studied yet.

The aim of the present study was to evaluate the amplitude of variation in BCS during key periods in the life cycle and to determine and quantify the impact of factors affecting the monthly BCS of N'Dama cows raised under extensive range management conditions in Southern Senegal (Kolda). Two critical periods in the cow productive life cycle were analysed: (1) the third year of age, which is the minimum age for the first conception in our data; (2) around calving in adult cows, which is a critical period for nutritional balance. Two-and a-half points is a classical threshold in range cows scored on a 5-point scale, since the positioning of cow BCS under this value is known to have an impact on reproductive performances [42]. Hence, the probability for a cow to be scored under 2.5 points on a 5-point scale at any given time (month) "*t*" of the life cycle was predicted by taking into account the previous monthly BCS.

2. MATERIALS AND METHODS

2.1. Study zone and animal monitoring

This work was conducted with a multidisciplinary approach including aspects of ecology, husbandry and socio-economy [17–19, 32]. Due to the complexity of the surveys conducted on natural rangelands and on traditional animal management [31], we focused on one village, Saré Yéro Bana, located 15 kms from Kolda [14.94 W; 12.88 N] in Upper-Casamance (Senegal).

The geographical classification of this region is of a Sudano-Guinean type with an average annual rainfall of 1 110 mm. For the purpose of this study, the year was divided into 3 seasons of 4 months. The rainy season (RS), which generally occurs between July and October (950 mm), is followed by a cool dry season (CDS) from November to February (13 mm), and then by a hot dry season (HDS) from March to June (147 mm). The village land of Saré Yéro Bana includes 110 ha planted with crops (maize, millet, groundnut, sorghum and rice) and 4 500 ha of rangelands. Cattle are bred in 10 herds of varying sizes (with 10 to 110 females). N'Dama is the main breed. Two and eight herds respectively contain more and less than 100 females in an average year. One hundred females were chosen as the upper threshold size because of the observed differences in herd management between small and large herds in the studied area. N'Dama cows are well adapted to the prevailing environment [10, 24]. Since supplementary feeding is not a common practice, the seasonal effect is mainly due to variations in pasture availability and quality on croplands and rangelands.

The survey was conducted from 1993 to 1998. The method was designed by Faugère [14]. In the village, cattle were identified with a plastic ear tag and professional survey staff visited the herds twice a month, supervised by the second author of the present paper. Five hundred and 10 cows were monitored after they were 3 years old. The records included demographic events (births, deaths, input and output) and BCS. Data were collected into a relational database [26].

Local herd management has already been described [19, 32]. Briefly, calves are kept in the village until they are at least 6 months old. Then, as soon as forage quality and availability is sufficient, they join the herd of adults and heifers. Hence, they are not weaned at a specific age. The herds graze on fallow land and woody savannah from ploughing to harvest time (during the RS and early CDS). After harvest, the animals are fed on crop residues (in the CDS). When fodder availability decreases (in the HDS), they are left to roam around the village. In this agro-sylvo-pastoral context, there is a trade-off between rained agriculture and livestock rearing in terms of land use. Hence, breeders should manage the feeding system, in particular the use of crop residues, to optimise feeding availability. Reproduction is not controlled since the bulls are permanently kept with the cows. Thus, calving takes place all year round, mostly occurring during the RS (54%). First calving occurs in average at 5 years of age (range = 4 to 9 years). The averaged calving interval is 27 months (range = 11 to 47 months). Cows in lactation are partially milked twice daily (0.5 to 2 litres in the presence of the calves), and the remaining milk is suckled by the calves.

2.2. BCS measures

In the present study, total body fat reserves of the N'Dama breed were estimated from the amount of subcutaneous fatty tissues assessed by visual scoring. A 6-point grid (0 = emaciated to 5 = very fat cows; [33]) was used for 3 observations (face, lateral and back views). Attention was focused on the lumbar, the costal and the tailhead areas of the cows. The mean score was retained as the body condition score (continuous variable comprised between 0 and 5). All cows in the survey were scored by the same technician. A single grid has been applied to every cow whatever its age and parity. The scores for each cow were recorded on several sheets to prevent bias in the data collection (Ickowicz A., personal communication).

2.3. Data analysis

2.3.1. BCS around 3 years of age

Most cows were scored at 37 months of age (n = 111). First, a logistic regression model was designed for BCS at 37 months of age and during the season of birth. Second, in order to by-pass the seasonal effect (a season is 4 months), analyses were extended to a 5-month period after the baseline age (i.e. until the age of 41 months). Heifer BCS for each month between 37 and 41 months of age were calculated by linear interpolation between the nearest BCS before and after these ages. A linear mixed model was fitted [25] on BCS, with ages from 37 to 41 months of age and season of birth (RS, CDS and HDS) as fixed effects and animals as random effects. Thereafter, the residual variations were analysed by a principal component analysis (PCA; [11]).

2.3.2. BCS around calving

BCS at calving (BCS_c) was determined for each cow by linear interpolation between the closest observations to calving. Only data from females that had calved and that were regularly scored were considered (n = 426). Both parity (primi- and multiparous cows) and calving season (RS, CDS and HDS) have been included in the first analysis. A Welch test [38] was performed to compare BCS_c between parity classes and between calving seasons.

Other factors than parity and season should affect calving BCS, with for instance an individual effect, a breeder effect or others. However, such explanatory variables are not easily quantifiable because of potentially confusing effects. Hence, the residues of the preceding model were classified into patterns depending on time. Individual BCS profiles were isolated by a PCA during late pregnancy and early lactation, i.e. from the 6th month of pregnancy to the 2nd month of lactation (n = 380). Variables included in the PCA were the BCS residues between predicted and observed values computed at calving, at 6th, 7th and 8th months of pregnancy and at the 1st and 2nd month of lactation. Residues were standardised to minimise the effect of absolute values and to better distinguish relative deviation in BCS variation. The first two factors of the PCA explained most of the variance. Individual BCS profiles, expressed in points of BCS, were clustered by a hierarchical ascendant classification based on the second order moment method, also called the Ward method [22, 27].

2.3.3. BCS at any given month t

BCS at any given month t (BCS_t) were categorised in 2 levels: under (U) and above (A) 2.5 points. The BCS level at month $t-3$ did not explain the variations in the proportion of cows scored under 2.5 points at month t, as shown by the observed proportion of cows scored under 2.5 points according to the 3 previous levels of BCS (Tab. I). Cows scored above 2.5 points during the 2 previous months seemed to be less at risk to be scored under 2.5 points at month t than those scored under 2.5 points at month $t-2$ and above 2.5 points at month $t-1$. Hence, the BCS levels in the two previous months (BCS_{t-1} and BCS_{t-2}) were included in the statistical analysis. Other explanatory variables included in the complete model were parity (nulliparous, primiparous and multiparous), season (RS, CDS and HDS), year (1993 to 1997), herd size (small and large with respectively less and more than 100 females in an average year) and physiological status (early pregnancy from the first to the 6th month of pregnancy, late pregnancy from the 7th month of pregnancy to calving, early lactation from calving to the 3rd month of lactation, and the remaining status). Thresholds were based on preliminary graphical analyses (not presented here). Nulliparous cows, that have never calved, cannot be in early lactation but can be pregnant. At any given month t, the probability $p(U)$ for a cow to be scored under 2.5 points was estimated by a logistic regression model (n = 429). The saturated model including all the effects and all the first order interactions fitted correctly to the data ($P < 0.001$). The

Table I. Observed proportions (p) of cows scored under (U) 2.5 points during the month *t* according to the levels of the scores in the months $t-1$ ($p^U{}_X$), $t-2$ ($p^U{}_{XX}$) and $t-3$ ($p^U{}_{XXX}$) compared to the threshold of 2.5 points.

BCS_{t-1}	BCS_{t-2}	BCS_{t-3}	nrisk	nU	$p^U{}_{XXX}$	$p^U{}_{XX}$	$p^U{}_X$
U	U	U	4342	3772	0.87	0.86	0.85
U	U	A	770	620	0.80		
U	A	U	187	146	0.78	0.82	
U	A	A	758	633	0.83		
A	U	U	718	157	0.22	0.22	0.11
A	U	A	166	34	0.20		
A	A	U	698	104	0.15	0.09	
A	A	A	7673	684	0.09		

BCS: body condition score; U: BCS under 2.5 points; A: BCS above 2.5 points; nrisk: number of cows per category; nU: number of cows scored under 2.5 points; p^U = nU / nrisk.
BCS_{t-1}, BCS_{t-2}, BCS_{t-3}: BCS levels during the first, second and third previous month, respectively.

covariable pattern i, can be described as follows:

$y_i = r_i/m_i$
$E(Y_i) = \mu_i$
$\log\{\mu_i/(1-\mu_i)\} = \beta_0 + x_i\beta_i$
$var(Y_i) = V(\mu_i)/m_i$
$V(\mu_i) = \mu_i(1-\mu_i)$

with y_i the response, r_i the observed number of cows scored under 2.5 points, m_i the observed number of cows, μ_i the expected value, β_0 the constant term, x_i the explanatory variables vector and β_i the vector of the linear predictors for the covariable pattern i.

The model minimising the Akaike Information Criterion (AIC, [6]) was stepwise selected. The AIC is a selection criterion which gives a compromise between fitness and parsimony of the model:

AIC = –2 × log(maximum likelihood) + 2 × number of parameters in the model.

With this definition, the best model is the one which has the smallest AIC.

3. RESULTS

Mean BCS was 2.8 (s.d. 0.8) with a minimum BCS of 0.25 and a maximum BCS of 5 points. No variation between years in mean BCS was observed (2.5 s.d. 0.8, 2.9 s.d. 0.9, 2.8 s.d. 0.9, 2.8 s.d. 0.7 and 2.7 s.d. 0.7 for years 1993 to 1997, respectively). As already demonstrated in another study in the tropics [13], graphical analysis clearly showed that the observed proportion of open N'Dama cows which became pregnant each month was strongly related to their BCS at the month of conception (Fig. 1). The threshold of 2.5 points of BCS might be adequate in explaining reproductive performance variability.

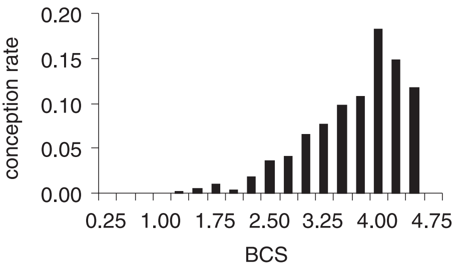

Figure 1. Monthly proportions of open cows which begin a pregnancy depending on their body condition, scored between 0 and 5 points.

3.1. Heifers BCS variation

Mean BCS at 37 months of age were 3.52 (s.d. 0.42; n = 80), 3.41 (s.d. 0.61; n = 12) and 3.12 (s.d. 0.46; n = 19) for heifers born in the RS, CDS and HDS respectively. Here season of birth coincided with the actual season (anniversary). Classically, 3-year old heifers were on average in better body condition in the RS than in the HDS ($P < 0.005$). The evolution of BCS between the 37th and 41st month also differed according to the season. In the RS, heifers maintained a good body condition on average (> 3.6 points). In the CDS and HDS, they were leaner (< 3.3 points). They lost fat in the CDS (–0.25 point), whereas they improved their body condition in the HDS (+0.70 point; Fig. 2). Globally, 3-year old heifers were scored above 2.5 points (99%, 90% and 83% in the RS, HDS and CDS, respectively). After adjusting the BCS for the season of birth, the residues did not vary significantly, strengthening the hypothesis that season is the main factor influencing the body condition of 3-year old N'Dama heifers kept under traditional management. Heifers born in the RS were in significantly better body condition during the first HDS encountered after the age of 3 years than heifers born either in the CDS or in the HDS ($P = 0.01$; Tab. II). Hence, not only season but also season of birth influences BCS at 3 years of age.

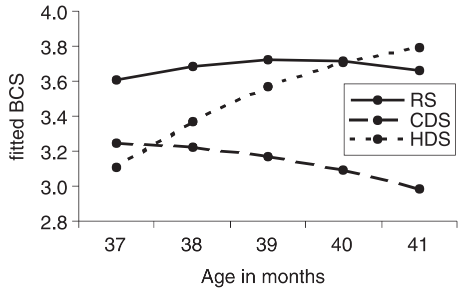

Figure 2. Evolution of cow BCS between 37- and 41-months of age between 1993 and 1997 according to season of birth (RS: rainy season; CDS: cool dry season; HDS: hot dry season).

3.2. BCS variation around calving

Mean BCS_c was 2.80 points (s.d. 0.64; n = 426) on a 5-point scale. Minimal and maximal interpolated scores at calving were respectively 1.00 and 4.34 points. Primiparous (2.88; s.d. 0.63; n = 151) and multiparous cows (2.76; s.d. 0.65; n = 275) did not significantly differ ($P > 0.05$). Females calving in the CDS were in better body condition at calving than those calving in the RS, which were in better condition than those calving in the HDS ($P < 0.005$; Fig. 3). The means were 3.12 (s.d. 0.59; n = 95), 2.77 (s.d. 0.63; n = 281) and 2.40 (s.d. 0.55; n = 50) points, for the CDS, RS and HDS respectively.

Table II. Body condition score of the heifer for each season after the age of 3 years, according to the birth season.

	Birth season			
	RS[a]	CDS[a]	HDS[a]	
BCSrs[b]	3.35	3.35	3.11	NS
BCScds[b]	3.94	4.00	3.64	*
BCShds[b]	3.40	3.13	3.09	**

NS: not significant; *: $P < 0.10$, **: $P < 0.01$.
[a] Rainy season (RS), cool dry season (CDS) and hot dry season (HDS).
[b] Body condition score (BCS) at each season (RS, CDS and HDS).

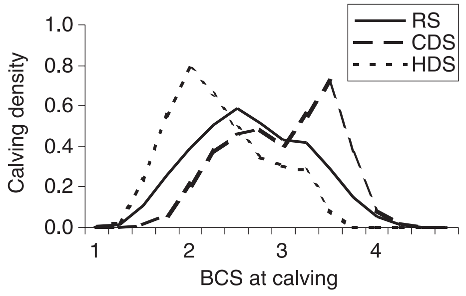

Figure 3. Calving density according to calving BCS and season of calving between 1993 and 1997 (RS: rainy season; CDS: cool dry season; HDS: hot dry season).

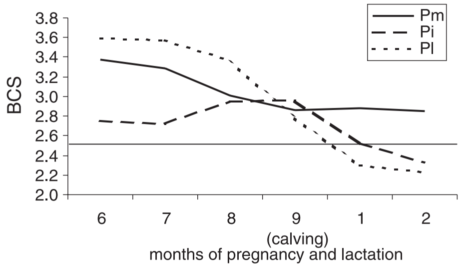

Figure 4. Patterns of BCS profile between the 6th month of pregnancy and the 2nd month of lactation when removing the effects of parity and calving season between 1993 and 1997.

When removing the effects of parity and calving season, 3 patterns of the BCS profile can be isolated during pregnancy and early lactation (Fig. 4):

– cows maintaining (P_m) their BCS above 2.5 points in early lactation, losing only 0.4 points in 2 months in late pregnancy (n = 96);

– cows in good body condition in late pregnancy but losing (P_l) BCS around calving, scoring less than 2.5 points in early lactation (–0.90 points in 2 months; n = 178). This pattern was the most frequent;

– intermediate cows (P_i) with an intermediate but stable BCS in late pregnancy (+0.2 point) and losing BCS after calving, scoring less than 2.5 points in early lactation (–0.60 points in 2 months; n = 106).

3.3. Variation factors of BCS_t

The most pertinent factor explaining BCS_t variations was the previous BCS, i.e. BCS_{t-1}, which explained 62% of the decrease in the deviance of the model. Whatever the cow factors (parity, physiological state, herd size) and the environmental factor (season), females scored under 2.5 points at month $t-1$ (females "–U") were the most at risk to be scored under 2.5 points at month t. Females with a BCS_{t-1} above 2.5 points and BCS_{t-2} under 2.5 points ("UA") were more at risk than females in good body condition during the 2 previous months ("AA"). The other significant factors were parity, physiological state, herd size, season and the interaction between parity and the physiological status (Fig. 5). The year was not retained in the model. The risk to be scored under 2.5 points increased with parity (average ages by parity were 4, 6 and 8 years for nulli-, primi- and multiparous cows, respectively). It was on average lower in early pregnancy than in the other physiological states, increasing until lactation. Furthermore, it was higher in the HDS, the other 2 seasons being almost equivalent in terms of risk. Lastly, it was smaller for small herds (< 100) than for larger herds, with a difference ranging from 5 to 25%.

4. DISCUSSION

4.1. A strong seasonal effect on BCS

The season is a main factor of BCS variations for it influences both heifer and adult

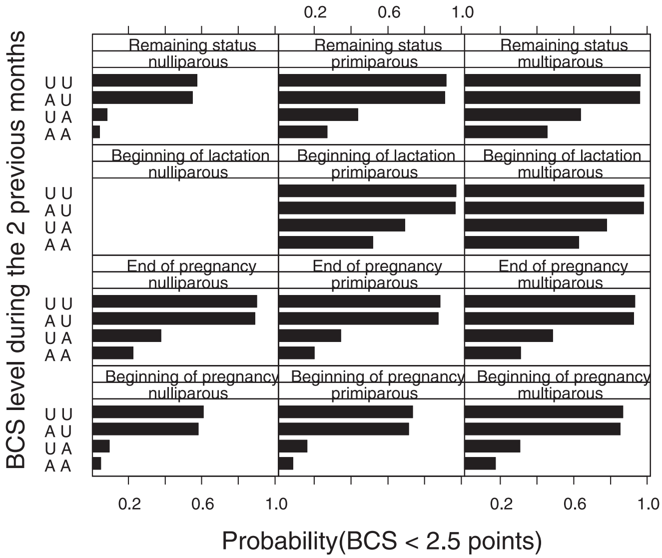

Figure 5. Probability for a cow to be scored under 2.5 points on a 5-point scale – p(U) – as a function of the BCS levels the two previous months, the physiological state and the parity, in a large herd in the HDS. Previous BCS levels are "AA" for females scored above 2.5 points at months *t – 2* and *t – 1*, "UA" for females scored under 2.5 points at *t – 2* and above 2.5 points at *t – 1*, "AU" for females scored above 2.5 points at *t – 2* and under 2.5 points at *t – 1* and "UU" for females scored under 2.5 points at *t – 2* and *t – 1*. The physiological status varies in rows, with remaining status corresponding to cows still open more than 3 months after calving. Parity varies in columns, nulliparous corresponding to heifers, primiparous to females that have calved once and multiparous to females that have calved more than once.

BCS at any given month "*t*" and BCS profile. However, compensatory effects of opposite factors may be hidden, such as age and farmers' practices on animal health. Confusion cannot be totally avoided between feeding and health sources of seasonally induced variations. Correctly fed cows have both a better health status and a better body condition [3]. Hence, health should be part of the seasonal effect as an aggravating factor in situations of underfeeding. However, the N'Dama breed is well-adapted to the local temperature and humidity and has a good tolerance to the local diseases. A minimal and equitable cover of health status was assured during the survey. Given this context, the seasonal effect should be mainly related to the availability of food resources.

4.2. Relationship between the heifers BCS and the subsequent performance

The season of birth also influences heifer BCS since heifers born in the rainy season are in better body condition than other heifers during the first hot dry season following their third birthday. Hence, the season of birth may also influence subsequent reproductive performances of heifers, in particular their age at puberty occurrence [23]. However, whereas N'Dama heifers raised under extensive range management can be considered to be in good body condition at 3 years of age, first conception occurs in average later for these heifers than for those raised under a better controlled environment (20 to 51 months of age in stations [39] compared to 50 to 60 months of age in villages (the present study; [21, 43]). As a result, body weight and/or body condition may not have been directly responsible for the delayed occurrence of puberty when compared to temperate breeds in their environment. In particular, mineral deficiencies may have no impact on BCS whereas they may result in hormonal disorders and delayed puberty [35]. Moreover, energy available in the diet should be sufficient to fulfil the growth requirements (resulting in a good BCS) but not the reproductive maturity (resulting in a delayed first conception; [36]).

Body condition decreases with parity. Cows that have already calved need both to mobilise and restore their body reserves while being pregnant and/or lactating, whereas nulliparous cows have lower nutritional requirements and can maintain their body reserves even when food supply is low. Heifers should be able to start their reproductive cycle only when they have a sufficient amount of body lipids, used during the life span of the cow.

4.3. Relationship between the BCS and the physiological status

The physiological status also influences the BCS, due to higher nutritional requirements for cows in late pregnancy and early lactation than for non-lactating open cows [20]. In general agreement with other conclusions presented in the available literature, the BCS decreases in late pregnancy and in early lactation, then progressively returns to its initial value [37, 41]. Under temperate climates, patterns of BCS variations during lactation are generally better explained by complementary information beyond lactation status and/or calves' growth and parity. Multiparous cows lost more BCS in early lactation than primi- parous ones, which need more time to regain their initial BCS [16]. In the present study, differences in milk yield may explain the differences between the BCS profiles. However, in the dual purpose breeding context, milk yield is both influenced by the calf demand and by the farmer milking practices. It is then rather difficult to estimate this milk output [12]. No other indicator of the variations in the nutritional requirements than the physiological status could be included in the present analysis. The higher probability to be scored under 2.5 points in early lactation than in late gestation confirms that the nutritional requirements are higher in early lactation than in late pregnancy, even if they are lower than for temperate dairy cows [15].

4.4. Influence of the herd management on cow BCS

The risk to be scored under 2.5 points is slightly higher in large herds than in small ones. In the Kolda area, breeders have the dual objective to maximise milk yield and to develop their herd and generally give priority to capitalisation. This increase in herd size gives rise to an increase in stocking rate. Large herds cannot stay close to the village long since forage and water are in insufficient quantities for all the cows. They go longer distances to reach rangelands and to find water in sufficient quantity for the whole herd. They stay longer on poor quality ranges and come back later to feed on crop residues than smaller herds. Under these conditions, size is a pertinent criterion to explain the differences observed between herds [29].

4.5. Persistence in the evolution of the BCS

Lastly, this study clearly demonstrates the interest in taking account of BCS for the two previous months in order to arrive at a good prediction of the BCS at a given month. Accounting for successive BCS gives information both on the amount of body reserves and on its temporal variations. The results were concordant between analyses: three BCS patterns were isolated between late pregnancy and early lactation that were in good agreement with the BCS predicted in early lactation taking into account the two previous BCS in late pregnancy. Cows scoring *AA* in late pregnancy were frequently found ($0.15 < P < 0.65$) to be scored under 2.5 points in early lactation, in agreement with the P_m profile. Both methods are complementary since BCS patterns result from relative data of BCS, whereas the probabilistic prediction indicates the probable state of animals relative to a threshold.

5. CONCLUSIONS

This study quantified the seasonal effect on the BCS of N'Dama heifers under extensive range management in Southern Senegal. In adult cows, calving BCS is not only affected by the season since 3 patterns of BCS profiles were relevant after removing this seasonal effect. A better control of cow body condition for a given season requires the knowledge of 3 consecutive monthly BCS, physiological status and parity for each female or group of females.

The present study draws two main conclusions. First, most N'Dama heifers are scored above 2.5 points. Their subsequent reproductive performances are probably not limited by body condition. On the contrary, multiparous cows, that have higher nutritional requirements, are subjected to a decrease in body fat and mineral reserves during their reproductive life. In the area of Kolda, breeding is limited by a relative undernutrition since food availability is sufficient to fulfil maintenance requirements but not those of producing animals [7]. Second, the prediction for a cow to be scored under 2.5 points is improved when the 2 previous monthly BCS are considered. This longitudinal approach can be adapted to other species and/or other management systems. It is a useful indicator of the risk to fall below a critical threshold of BCS that can lead to detrimental effects on performance. Of course, this implies re-evaluating the number of previous scores to include in the predictive model as well as the BCS threshold. The present study clearly showed that BCS varies between and within individuals on a sufficient scale to be a potentially good indicator of the variability in performance. Complementary studies are under way to determine the influence of BCS on N'Dama cow performance, especially on reproductive capacity and milk production.

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