Definition of Season in Animal Model Evaluation of Nili-Ravi Buffaloes

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ABSTRACT : Data on 2,571 lactation records of Nili-Ravi buffaloes from four institutional herds and four field recording centers were analyzed under an animal model to see the effect of season definition on the error variance of the fitted model. Herd-year-season (HYS) was the main fixed effect along with permanent environment, breeding value and residuals as the random effects. All known relationships among the animals were considered. The error variance differed for various HYS combinations. It was minimum when the months were not grouped into seasons. The four or five season scenarios were better than the two season scenarios. The average number of lactations represented in a HYS combination varied widely from 6 to 28. Very few subclasses for a given HYS combination warrants the use of fewer seasons for animal model evaluation of buffaloes.
(**Key Words** : Buffaloes, Season Definition, Animal Model, Error Variance)

INTRODUCTION

Buffalo being a polyestrus animal calves throughout the year but calving frequency is not uniform. Season of calving is perhaps the most commonly studied environmental factor affecting yield traits in buffalo. It has been reported to have substantial effect on milk production in most of the studies on buffalo. Definition of season however, varies widely and ranges from two season of equal or unequal intervals to 12 seasons of one month each.

In advanced recording systems, like in United States, season has been defined differently at different times for the evaluation of animals. Currently, however, milk yield records are adjusted for lactation length for four calving seasons (Dec.-Feb., Mar.-May, Jun.-Aug., and Sep.-Nov.) in the National Cooperative Dairy Herd Improvement Program (NCDHIP) (Wiggans and Dickinson, 1985). Records are also adjusted for age and month of calving to predict the mature equivalent milk and fat yields. For genetic evaluation, management groups defined as herd-year-season (HYS) are flexible. The number of months encompassed in increased until at least five lactations are included (Wiggans, 1991). Seasons are, thus, defined as months but are not fixed and are allowed to move depending on the availability of records. Similarly, adjustment factors for milk yield for season adjustment are based on calendar month of calving for Australian dairy cows (Everett et al., 1982). Being the major environmental effect on the performance of an animal, HYS effect is duly taken care of in animal model evaluations. Adjusting for this effect takes care of managemental differences and lactations of cows can be compared with those of contemporaries under similar circumstances of the year and season of calving.

For modeling buffalo data, many season scenarios have been used depending on the tradition, data availability, and temperature or humidity variation etc. Ashfaq and Mason (1954) reported two seasons (winter, Nov.-Mar.; summer, Apr.-Oct.) for studying the influence of environmental factors on milk yield of buffaloes in Pakistan. Cady et al. (1983) and Shah et al. (1981) also defined season as winter and summer but definition was slightly different. Winter was started from October and last month included in the summer was September. Khan (1986) analyzed the data from the same buffalo population as in the previous two studies but used four season scenario: winter, Nov.-Jan.; spring, Feb.-Apr.; summer, May-Jul.; and autumn, Aug.-Oct. In another improtant study on Nili-Ravi buffalo (Salah-ud-din, 1989), although, population under study were not quite differently placed, the four seasons were differently defined. Winter started a month later and included Dec., Jan. and Feb. and so were the other three seasons.

Use of five season scenarios i.e. splitting the summer into hot-humid and hot-dry is also not uncommon in studies on buffales (Mehta, 1985; Javed, 1989). Some

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researchers have preferred to use three seasons instead of two, four or five (Singh and Gopal, 1982; Gogoi et al., 1985; Khosla et al., 1987). In these studies the third season other than winter and summer was rainy or monsoon season. Use of rainy season as fifth season along with the four traditional seasons have also been reported (Tailor and Jain, 1987). Grouping of months or weeks on the basis of frequency of calving (most frequent calving season vs least frequent calving season) have also been used (Dutt and Yadav, 1988; Verma et al., 1988; Singh and Yadav, 1987; Vij and Tiwana, 1987). Grouping of months in these studies also varied widely.

Definition of season in buffalo data analysis is also important for another reason. The limitations imposed by some of the variance component estimation programs require that seasons should be defined reasonably. A multiple trait REMLPK (Meyer, 1986), for example requires at least two daughters per sire, two sires in each HYS, and two HYS represented by each sire (Welper and Freeman, 1992). Edits on buffalo data sets would, thus, exclude many records which were otherwise needed. Very few observations in a HYS are, thus, likely to increase the standard error for estimates. Due to very few contemporaries, the breeding values would, thus, be biased in either direction: underestimating or exaggerating the genetic worth of the individuals being evaluated.

Present study was undertaken to compare different season scenarios and find out their effect on error variance of the fitted model. The number of lactations represented in a HYS combination were, thus, compared for all the possible season definitions to suggest season definition for animal model genetic evaluation of Nili-Ravi buffaloes and bulls in Pakistan.

MATERIALS AND METHODS

Lactation records of four institutional herds and four field recording stations (eight herds) were used in the present study. Editing abnormal lactatios, including those where lactation length was less than two months, left 2,571 records for the analysis. Lactations were truncated at 305-days for calculating milk yield. Records were corrected for age at calving and lactation length as described by Khan et al. (1993). Lactation yields were then analyzed by using an animal model having HYS as a fixed effect and permanent environment and animal breeding value as random factors. The model was;

$$Y_{ijk} = HYS_i + A_j + P_j + e_{ijk}$$

where

Y_{ijk} ; Lactation record

HYS_i ; Herd-year-season effect (fixed)

A_j ; Animal breeding value (random)

P_j ; Permanent environmental effect (random)

e_{ijk} ; Residual (random).

Genetic parameters for variance ratios of random factors to error variance were according to Khan et al. (1993). Ten season scenarios were used where months were grouped as shown in table 1. Estimates from the above model were fitted to predict the lactation yield ($\hat{Y}$), each time a different season scenario was used. Error variances were then calculated as follows and compared.

$$\sigma^2_E = [\sum(Y-\hat{Y})^2]/(n-p)$$

where,

σ^2_E ; Error variance

Y ; Actual lactation milk yield

$\hat{Y}$; Predicted lactation yield

n ; No. of observations

p ; Number of parameters estimated.

The JAA computer program (Misztal, 1993) was modified and used for the analysis.

RESULTS AND DISCUSSION

Choice of different combinations of months (table 1) was based on the season definition in the literature with some modifications. Frequency of calving varied throughout the year (table 2) with September having highest percentage of calvings (16.4%). The first half of this month had higher numbers as compared to the second half. It may be noted that more than 50% of buffaloes calved in four months (July through October) and the other half in the other eight months of the year. Yield was higher for the cooler months when lactation length was also greater.

As mentioned earlier, in most studies, reason for a particular choice of season was not given. Choice of two or four season perhaps in some cases was to save more degrees of freedom for the residual variance, while in other cases, to more precisely estimate the season effect. Choice of least and most frequent calving seasons was to take into account the seasonality of breeding i.e. most frequent being the actual calving season for the buffalo and least frequent, the odd calvings or the non-seasonal calvings. Choice of the months to be pooled was sometimes based on the year in which that study was conducted and a particular month was hotter or cooler and perhaps sometimes this was done on the tradition of defining a particular season and may be that tradition was based on actual temperature and humidity variation in the area where population was studied. Ten such definitions were used in the present study which represents most of the definitions in the literature. Still, season could be

Table 1. Grouping of months into seasons

Month	Date	Season scenario									
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Jan.	01-15	1	Wi	Wi	Wi	Lc	Wi	Wi	Wi	Wi	Wi
	16-31	1	Wi	Wi	Wi	Lc	Wi	Wi	Wi	Wi	Wi
Feb.	01-15	2	Wi	Wi	Wi	Lc	Wi	Sp	Wi	Wi	Wi
	16-29	2	Wi	Wi	Wi	Lc	Wi	Sp	Wi	Sp	Sp
Mar.	01-15	3	Wi	Wi	Su	Lc	Su	Sp	Sp	Sp	Sp
	16-31	3	Wi	Wi	Su	Lc	Su	Sp	Sp	Sp	Sp
Apr.	01-15	4	Su	Wi	Su	Lc	Su	Sp	Sp	Sp	Sp
	16-30	4	Su	Su	Su	Lc	Su	Sp	Sp	Sp	Sp
May	01-15	5	Su	Su	Su	Lc	Su	Sp	Sp	Sp	Hd
	16-31	5	Su	Su	Su	Lc	Su	Su	Sp	Su	Hd
Jun.	01-15	6	Su	Su	Su	Lc	Su	Su	Su	Su	Hd
	16-30	6	Su	Su	Su	Lc	Su	Su	Su	Su	Hd
Jul.	01-15	7	Su	Su	Su	Lc	Ra	Su	Su	Su	Hh
	16-31	7	Su	Su	Su	Mc	Ra	Su	Su	Su	Hh
Aug.	01-15	8	Su	Su	Su	Mc	Ra	Su	Su	Su	Hh
	16-31	8	Su	Su	Su	Mc	Ra	Au	Su	Au	Hh
Sep.	01-15	9	Su	Su	Su	Mc	Ra	Au	Au	Au	Hh
	16-30	9	Su	Su	Su	Mc	Ra	Au	Au	Au	Au
Oct.	01-15	10	Wi	Su	Su	Mc	Ra	Au	Au	Au	Au
	16-31	10	Wi	Wi	Su	Mc	Ra	Au	Au	Au	Au
Nov.	01-15	11	Wi	Wi	Wi	Mc	Wi	Au	Au	Au	Au
	16-30	11	Wi	Wi	Wi	Lc	Wi	Wi	Au	Wi	Au
Dec.	01-15	12	Wi	Wi	Wi	Lc	Wi	Wi	Wi	Wi	Wi
	16-31	12	Wi	Wi	Wi	Lc	Wi	Wi	Wi	Wi	Wi

Wi = Winter; Su = Summer; Lc = Least calving; Mc = Most calving; SP = Spring; Au = Autumn; Ra = Rainy; Hd = Hot dry; Hh = Hot humid.

Table 2. Average milk yield (kg) and lactation length (days) for different months of calvings

Month	% Lactations	Milk yield	Lact. length
January	6.2	2,117	283
February	4.7	2,155	285
March	5.5	2,077	280
April	3.9	1,891	266
May	4.0	1,956	271
June	5.9	1,946	271
July	10.4	1,966	263
August	14.5	1,988	271
September	14.7	1,917	259
October	12.5	1,994	267
November	9.2	1,946	268
December	8.4	2,104	274

defined differently. In the S1, months were not grouped leaving the number of seasons to 12. The S2, S3, and S4 were two season scenarios having months grouped into summer and winter. The S2 (Cady et al., 1983) and S3 (Ashfaq and Mason, 1956) had seasons fo six months each. In the S4, winter was considered as a four months season while summer comprised on eight months. The S5 was a two season scenario but season was defined on the basis of frequency of calving, with most frequent calving season starting after 15 July and ending on 15th of November. This was based on the frequency of calving in the current data (table 2) and is not quite different from Chaudhry and Ahmad (1978). The S6 was a three season scenario according to Gogoi et al. (1985). The S7, S8, and S9 were four season scenarios. The S7 was according to Khan (1986) and Shah et al. (1989), S8 was according to Salah-ud-Din (1989) while S9 was a modification of Bajwa et al. (1982). The S10 was a five season scenario having autumn, winter and spring of two and a half months each while summer was partitioned into hot-dry and hot-humid seasons of two and a half months each.

This difinition has also been used lately by many researchers (Javed, 1989).

Number of parameters used in the animal model were the number of HYS subclasses (table 3), being the only fixed effect in the model. Their number varied according to the definition of season. Highest value was for the first season scenario (S1) where a total of 404 classes were defined while minimum was for two season scenarios (S2, S3, and S4) where it ranged from 91 to 94. The error variance after fitting the parameters estimated, generally increased as the number of HYS classes decreased. Best fit was for the S1 where months were not grouped into seasons. Among the four season scenarios, S9 (a modification of the seasons defined by Bajwa et al., 1982) was better than the other definitions.

Table 3. Error variance (kg^2) for milk yield from different season scenarios

Season scenario	Number of seasons	Number of HYS	Error variance
S1	12	404	68,247
S2	2	94	83,647
S3	2	93	83,340
S4	2	91	83,557
S5	2	97	82,552
S6	3	131	81,821
S7	4	168	80,392
S8	4	163	80,867
S9	4	168	80,083
S10	5	196	80,436

Another important consideration in fitting any model for the genetic evaluation of cows and bulls would be that the comparisons among animals should be valid. This can be achieved by providing a sufficient number of lactations in any year-season subclass within a herd. Wiggans (1991), for example, has reported a minimum of five lactations in any season while grouping the months (moving seasons) in evaluating Holsteins. Such a criteria was tested in the present study (table 4). If S1 is selected due to minimum error variance and the months are not grouped into seasons, on the average, there would be 6 lactations in a HYS subclass. Fixing a minimum of five lactations would result in a loss of 203 HYS subclasses (> 50%) to compare cows and bulls. If however, this minimum is raised to 10 for any HYS, 311 out of 404 subclasses will not meet this criteria. The wider seasons such as S2, S3, and S4 would be better in this regard where lesser number of subclasses would have invalid comparisons; 25% in case of S2, for example. The S5, based on the frequency of calving, although, better in terms of error variance, would results a loss of 31% HYS subclasses. The four-season scenarios better in terms of error variances, would result a similar problem of comparison as the number of classes having even less than five lactations would be one-third of the total lactations.

Table 4. Number of observations represented in a herd-year-season subclass in different season scenarios

Season scenario	Number of Herd-year-seasons	Number of observations per HYS subclass			
		Range	Average	< 5	< 10
S1	404	1-31	6.4	203	311
S2	94	1-72	27.4	24	40
S3	93	1-72	27.6	26	38
S4	91	1-94	28.3	24	36
S5	97	1-77	26.5	30	42
S6	131	1-75	19.6	40	58
S7	168	1-64	15.3	60	82
S8	163	1-68	15.8	52	80
S9	168	1-64	15.3	60	79
S10	196	2-53	13.1	71	102

It may be argued that among the two season scenarios, although, error variance was minimum for the S5, a scenario based on the frequency of calving, number of HYS subclasses having less than five lactations was higher (30) as compared to the other two-season scenarios i.e. S2, S3, and S4 (table 4). Among these season scenarios, S4, a modification of S2 and S3 was slightly better both in terms of error variance and the number of subclasses having less than five or ten lactations. Situation might also change with similar analysis on a different data set making it difficult to recommend any season scenario for all time and all purposes. The S4, having summer from March through October (eight months) and winter from November through February (four months) is, thus, suggested for animal model evaluation of buffaloes. However, as more data accumulate such modelling would be necessary to make the comparisons valid. Another issue not dealt in the present study was the pooling of years to make periods and, thus, increasing the number of lactations in a HYS subclass. Definition of herd would still be another important issue for future buffalo evaluation as the number of herds having as few as one animal would increase with the expansion in the field data recording.

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