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Analysis of age and lactation specific survival rate, stayability and expected herd life in Sahiwal cattle

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ABSTRACT

Demographic analysis was carried out on 830 female calves and 473 cows of Sahiwal breed born between 1985 to 2009 and maintained at the National Dairy Research Institute, Karnal. Survival rate was lowest during 0–1 month of age and was highest during 9–12 months of age. The trend of stayability in female calves up to AFC was declining along with increase in age. Among adult cows the survival rate was 82.0 % in the first lactation and showed decreasing trend up to the fifth lactation. Stayability was noted as 0.421, 0.076 and 0.015 at fourth, eighth and eleventh lactation respectively, indicating that only 42.1, 7.6 and 1.5 % of cows retained in the herd during respective lactations. More than half (58%) of the total cows of first lactation left the herd by the time they completed third lactation; moreover, more than one-fourth (27.82%) of total herd comprised first calvers. It was observed that 79% of total cows present in the herd belonged to first 4 lactations and less than 3% cows belonged to 9 and above lactations, which indicated that this herd of Sahiwal mostly comprised younger cows. The probability of cows being lost from the herd due to their disposal was 0.18 at first lactation, indicating that 18.0 % replacements are required to maintain the herd size constant. Expected herd life was 2.59 lactations more at first lactation and showed decreasing trend along with increase in lactation number.

Key words: Herd dynamics, Expected herd life, Sahiwal, Survival

Herd dynamics is the mathematical description of population structure and provides an insight that how the characteristics of a population change over time. It helps in understanding the size, status, and behaviour of a population. Knowledge of demography of population helps in formulating breeding plans for genetic improvement of herd (Kumar *et al*. 2013) and to determine optimum culling or replacement rate to maintain or enhance the herd size. Demographic analysis of a herd could provide useful information and act as a guide for sustainable livestock development (Ahunu *et al*. 1999). Therefore, keeping in view importance of herd dynamics of a population the present study was conducted to study demographic parameters, viz. survival rate (P_x), disposal rate (Q_x), stayability (L_x), lactation-specific herd structure and expected herd life (E_x) of a Sahiwal herd, which will further facilitate in planning breeding programmes for genetic improvement and sustainable utilization of this breed.

MATERIALS AND METHODS

Present investigation was carried out on data of 830 female calves and 473 cows of Sahiwal breed born between 1985 and 2009, maintained at NDRI, Karnal. Data on female calves were classified into 6 age groups (0–1mo., 1-3mo., 3–6mo., 6-9mo., 9–12mo. and 12mo. to AFC) to study age specific herd dynamics of female calves up to AFC. Lactation specific herd dynamics was calculated for adult cows from their entry into milch herd till last completed lactation.

The influence of age groups and parity orders on incidence of disposal of female calves and adult cows, respectively, were assessed by use of Chi-Squares statistics (Snedecor and Cochran 1994). The following age/lactation-specific parameters (I-III) were calculated as described by Schons *et al.* (1985)

Survival rate (P_x): It is the probability of a cow, assuming survival to lactation x, of surviving to lactation x+1 and estimated as $P_X = \frac{L_X + 1}{L_X}$. Thus it is the probability of an animal being present at lactation x in the herd to the next lactation of x+1.

Disposal rate (Q_x): This is complement of P_x. It is the probability of a cow, assuming survival to lactation x, of dying or culling before lactation x+1. Thus, $Q_X = \frac{d_X}{n_X} = 1 - P_X$, where, d_x is the number of animals died or culled during lactation x and n_x is the number of animals present in the herd at the beginning of lactation x.

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Stayability (L_x): This was calculated as the probability of a cow at first lactation present in herd to lactation x and estimated as number present at lactation x divided by the number alive at first lactation. The stayability at first lactation was taken as unity and hence $L_0 = 1.0$. $L_x = \frac{n_x}{n_o} = P_x L_x - 1$, where, n_x = number of cows surviving at lactation x and n_0 = number of cows at first lactation.

Lactation-specific herd structure: Lactation-specific herd structure was calculated as described by Greer *et al.* (1980).

a. Age specific distribution of cow (p_x) : It is probability of a cows remaining in the herd that are of each lactation and estimated as $P_x = \frac{L_x}{\Sigma L_x}$, such that $\Sigma p_x = 1.0$.

b. Age-specific loss (q_x) : It is probability of cows being lost from herd that are of each lactation and estimated as $q_x = Q_x L_x$, such that $\Sigma q_x = 1.0$.

Expected herd life (E_x) : This is the number of additional years that an animal of lactation x is expected to remain in the herd E_x more years and it was estimated as the sum of probability of an animal of a given lactation remaining in the herd (P_x) through each succeeding lactation up to the last lactation. Thus,

$E_x = P_x + P_x P_{x+1} + P_x P_{x+1} P_{x+2} + \ldots\ldots P_x P_{x+1} P_{x+n}$ (Ahmed *et al.* 1992).

RESULTS AND DISCUSSION

Influence of age groups on disposal of female calves and of parity order on disposal of adult cows: Chi-Squares statistics revealed that both age groups and parity orders have highly significant influence on disposal of female calves and adult cows, respectively. Age group wise and parity order wise Chi-Squares values for incidence of disposal of female calves and adult cows shown in Table 1 and 2, respectively.

Age group/ lactation specific herd dynamics in Sahiwal cattle: Age specific survival rate, disposal rate and stayability of female calves up to AFC is shown in Table 3 and lactation specific herd dynamics of adult cows is shown in Table 4.

Survival rate (P_x) and disposal rate (Q_x): The results revealed that survival rate in female calves up to AFC was lowest during 0–1 mo. of age (85.9%), then showed increasing trend up to 9–12 mo. of age (98.1%). Lowest survival rate at 0–1 mo. of age group may be attributed to highest mortality due to pneumonia and gestro-enteritis reported in this age group. Comparatively lower survival rate in 12 mo. to AFC group may be attributed to higher culling rate due to poor growth and reproductive performance observed in this age group, which became possible after full expression of physical attributes.

Table 1. Chi-squares values for disposal of female calves in various age groups

Effect (Age groups)	df	Disposed from herd
Overall	5	168.69**
0–1	1	58.45**
1–3	1	8.81**
3–6	1	15.11**
6–9	1	10.58**
9–12	1	26.83**
12-AFC	1	48.92**

** Significant (P<0.01); * Significant (P<0.05).

Table 2 Chi-squares values for disposal of adult cows in various parity orders

Effect (parity orders)	df	Disposed from herd
Overall	10	44.99**
1	1	21.82**
2	1	0.05
3	1	0.63
4	1	2.59
5	1	6.37*
6	1	2.04
7	1	1.34
8	1	0.60
9	1	8.50**
10	1	0.43
11	1	0.62

** Significant (P<0.01); * significant (P<0.05).

Table 3. Age specific survival rate, disposal rate and stayability of female calves up to AFC

Age group (mon.)	N	Survival rate (P_x)	Disposal rate (Q_x)	Stayability (L_x)
0–1	830	0.859	0.141	1.000
1–3	713	0.957	0.043	0.859
3–6	682	0.966	0.034	0.822
6–9	659	0.961	0.039	0.794
9–12	633	0.981	0.019	0.763
12-AFC	621	0.939	0.061	0.748

Analysis of lactation specific herd dynamics of adult cows revealed survival rate as 82.0 % in the first lactation. Hence the loss rate was 18.0 %. Survival rate decreased continuously from first to fifth lactation, and thereafter no definite trend of survival rate was observed. Inconsistent trend of survival rate after fifth lactation may be attributed to less number of cows remained at subsequent lactations in the herd. However some workers reported lower estimates of survival rate than present study in different crossbreds (Singh 2001, Kumar *et al.* 2013), while, higher estimates for survival rate than present findings were reported by Shahi and Kumar (2013) in Sahiwal cows. These differences in survival rate and disposal rate may be attributed to differences in breed groups and culling policies adopted at different farms.

Stayability (L_x): The results showed that the probability of an animal to survive in the herd decreased with the increase in the age groups of female calves up to AFC and number of lactations in adult cows. Taking 1.0 stayability

Table 4. Lactation specific herd dynamics for adult cows

Lactation No.	N	Survival rate (P_x)	Disposal rate(Q_x)	Stayability (L_x)	Herd structure		Expected herd life (E_x)
					Present in herd (p_x)	Disposed from herd (q_x)	
1	473	0.820	0.180	1.000	0.278	0.180	2.594
2	388	0.729	0.271	0.820	0.228	0.222	2.162
3	283	0.703	0.297	0.598	0.166	0.178	1.965
4	199	0.673	0.327	0.421	0.117	0.137	1.794
5	134	0.627	0.373	0.283	0.079	0.106	1.664
6	84	0.655	0.345	0.178	0.049	0.061	1.655
7	55	0.655	0.345	0.116	0.032	0.040	1.527
8	36	0.667	0.333	0.076	0.021	0.025	1.333
9	24	0.458	0.542	0.051	0.014	0.027	1.000
10	11	0.636	0.364	0.023	0.006	0.008	1.182
11	7	0.857	0.143	0.015	0.004	0.002	0.857
≥12	6	0.000	1.000	0.013	0.004	0.013	0.000

at the beginning of first lactation as the base, it was observed that the stayability was 0.421 at fourth lactation, 0.076 at eighth lactation and 0.015 at 11th lactation. These results revealed that only 42.1, 7.6 and 1.5% of cows retained in the herd during respective lactations. However, some workers reported lower estimates of stayability than the present findings (Singh 2001, Kumar *et al.* 2013, Shahi and Kumar 2013).

Lactation-specific herd structure: The results revealed that more than one-fourth (27.82%) of total herd comprised the first calvers and the remaining 22.8% belonged to the females of second lactation. It was observed that 78.99% of total females present in herd belonged to first 4 lactations and less than 3% females belonged to 9 and above lactations, which indicated that this herd of Sahiwal mostly comprised younger cows. These findings were almost similar to findings of Singh (2001) and Kumar *et al.* (2013).

The probability of cows being disposed from the herd due to their death and culling was 0.18 at first lactation, which means 18% of cows were leaving the herd by the end of first lactation, accordingly, replacements are required to maintain the herd size. The pattern of lactation specific loss of cows was inconsistent over the lactations and this is most likely the result of management of the herd. Results revealed that more than 2/3rd of the total females (72%) of first lactation left the herd by the time they completed fourth lactation. The reason could be the culling of old/low producing cows due to higher availability of young replacement heifers. The results suggested that optimum productive life was around four lactations in the present herd of Sahiwal breed. The farm results of the present study need to be compared with the field level observations on productive life of the breed. The lactation specific loss rates in Sahiwal cows observed in present study were lower than the ones reported in earlier studies for different crossbreds (Singh 2001, Kumar *et al.* 2013).

Expected herd life (E_x): Expected herd life was 2.59 lactations at the end of first lactation, this means that a cow belonging to first lactation was expected to remain in the herd for 2.59 lactations more and then it showed declining trend up to ninth lactation. After ninth lactation the trend was inconsistent. Lower estimates of expected herd life than the present study were reported by Singh (2001) and Kumar *et al.* (2013). Whereas, Shahi and Kumar (2013) reported higher estimates of expected herd life as 3.14 lactations at the end of first lactation. Differences in estimates of expected herd life in the different studies could be due to differences in breed groups and managemental practices adopted at different farms. Kumar *et al.* (2013) also observed declining trends in expected herd life along with the increase in parity order.

The overview of results suggested that among female calves lowest survival rate was during 0–1 mo. of age group, which may be attributed to higher mortality observed in this group. Therefore, there is need for proper care and management of calves especially in this age group to minimize losses of calves at an early ages. Among adult cows it was observed that 78.99% of total females present in herd belonged to first 4 lactations which indicated that this herd of Sahiwal mostly comprised younger cows. The probability of cows being lost from the herd due to their disposal was 0.18 at first lactation, indicating that 18.0% replacements are required to maintain the herd size constant.

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