ISSN: 2456-2912
VET 2024; 9(1): 1384-1387

www.veterinarypaper.com
Received: 28-11-2023
Accepted: 04-01-2024

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Effect of age at calving and lactation order on milk yield per kg of live body weight in Vrindavani cows under institutional farm conditions

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Abstract
The current investigation analyzed a dataset spanning 12 years (from 2007 to 2018) focusing on 1252 lactations of Vrindavani cows raised at the Cattle and Buffalo Farm, specifically within the Livestock Production and Management Section of ICAR-Indian Veterinary Research Institute in Izatnagar (Bareilly), Uttar Pradesh, India. The assessment aimed to understand the milk yields per kilogram of live body weight (MY/BW) by calculating the ratio of monthly milk yields (MMY) during a lactation period to the corresponding average monthly live body weights (MLB) of milch cows within the 1-15th months of lactation. To investigate the impact of age at calving (ACC), the study categorized the data into five age at calving classes (ACC1: ≤1095 days; ACC2: 1096-1460 days; ACC3: 1461-1825 days; ACC4: 1826-2190 days; and ACC5: ≥2191 days). Additionally, the study considered lactation orders (LO) ranging from 1st to 10th lactations. The findings revealed that both lactation order and age at calving class exhibited highly significant to significant effects (p≤0.01/0.05) on milk yields per kilogram of live body weight in Vrindavani cows. In essence, the results underscore the importance of age at calving and lactation order in influencing the efficiency of milk production in Vrindavani cows. The observed variations suggest that strategic management practices, considering these factors, could contribute significantly to optimizing milk yields in the breed. This study not only provides insights into the dynamics of milk production in Vrindavani cows but also lays the groundwork for implementing targeted strategies to enhance overall productivity in similar dairy farming setups.

Keywords: Age at calving, lactation order, milk yield per kg of live body weight, Vrindavani cows

Introduction
The country is facing an acute shortage of feeds and fodders for livestock (green fodder: 35.6%, dry fodder: 10.95% and concentrate: 44%, Vision, 2030, IGFRI). Almost 50% of the livestock population is underfed or hungry. This in turn, creates hurdles in expression of true genetic potential of an animal too. It is also well established that under inferior environmental (including feeding) conditions, superior genotypes are more adversely affected as compared to inferior ones. The possible ways to cope up with prevailing situation could either be a reduction (up to almost 50%) in the current livestock population or reduction in the dry matter (DM) requirements per animal without adversely affecting its milk production efficiency. Further, the intensity of the problem is severed due to the fact that most of the genetic improvement programmes are aiming at higher milk yields ignoring live body weights of milch animals. Usually, at the time of selection of milch animals for future use, an animal yielding higher milk yield per day or in a lactation is given weightage over an animal with lower respective yields, ignoring their live body weights. Higher live body weights require higher DM to fulfil their daily nutritional needs. Traditionally, the selection of milch cows has primarily focused on lactation yields, often overlooking the significance of live body weights. Nonetheless, the live body weight of a cow plays a crucial role in the economic aspect of milk production. Heavier cows necessitate a larger quantity of dry matter compared to their lighter counterparts, impacting the overall efficiency of milk production per unit. In light of this, the current study aimed to evaluate the milk production efficiency of Vrindavani cows. Instead of solely considering total milk yield, the assessment focused on milk yield per kilogram of live

body weight. This metric was calculated by dividing monthly milk yields by the corresponding monthly live body weights. Additionally, the study explored the influence of age at calving class and lactation order on this efficiency in Vrindavani cows. The objective was to gain a holistic understanding of factors affecting milk production in this specific breed, with the ultimate goal of optimizing efficiency and sustainability in dairy farming practices.

Materials and Methods

The research conducted during the 2017-18 period delved into a comprehensive analysis of 12 years' worth of data (spanning from 2007 to 2018) pertaining to 1252 lactations of Vrindavani cows at the Cattle and Buffalo Farm within the Livestock Production and Management Section of ICAR-Indian Veterinary Research Institute in Izatnagar (Bareilly), Uttar Pradesh, India. Relevant data concerning monthly milk yields (MMY) and monthly live body weights (MBW) were meticulously gathered from available records and current data on milch cows. To evaluate the milk yield per kilogram of live body weight (MY/BW) throughout the entire lactation period (1st to the last month, i.e., 15th month) in Vrindavani cows, the study employed a calculation method. This involved dividing the monthly milk yields in a given lactation by the respective average monthly live body weights of milch cows. The study further delved into the impact of age at calving class and lactation orders. The data were organized into five age at calving classes (ACC 1: ≤1095 days; ACC 2: 1096-1460 days; ACC 3: 1461-1825 days; ACC 4: 1826-2190 days; and ACC 5: ≥2191 days). Additionally, the information was categorized based on lactation orders ranging from the 1st to the 10th lactation. This meticulous approach aimed to capture a nuanced understanding of the interplay between age at calving, lactation orders, and milk production efficiency in Vrindavani cows, contributing valuable insights to the field of dairy farming.

Results and Discussions

The effect of lactation order (LO) was highly significant ($p \leq 0.01$) on 4th, 5th, 6th, 10th, 11th and 12th month's MY/BW and significant ($p \leq 0.05$) on 13th and 14th month's MY/BW, whereas, non-significant effects were seen on rest of the MY/BW's (Table 1 & Fig 1). The MY/BW gradually increased from 1st month to 3rd month of lactation beyond it which declined gradually towards the end of lactation. Considering LO, the MY/BW were gradually increased from 1st to 4th LO beyond which it declined in successive lactations. Many research workers had reported significant effect of lactation order on different production traits in cows and buffaloes and Auradkar (1999) [2] reported significant effect of lactation order on milk yield per day of lactation length. Thakur and Singh (2001) [6] reported significant effect of parity on lactation milk yield. Afzal and Zhila *et al.* (2011) [9] reported significant effect of parity on milk production.

The effect of age at calving class (ACC) was highly significant to significant ($P \leq 0.01/0.05$) on most of the MY/BW's except, its non-significant effects on MY/BW's during 10th, 13th, 14th and 15th months (Table 2 & Fig 2). The MY/BW were gradually increased from 1st ACC (≤1095 d) to 3rd ACC (1461-1825 d)/4th ACC (1826-2190 d). Then there was decline in MY/BW. As the age enhances, MY/BW also increased up to 3rd/4th ACC, but then it declined. It may be due to the fact that in initial ages live body weights were smaller and comparatively milk yields were better, hence, MY/BW were gradually increased in initial ages. As the age further enhances, milk yield gradually decreased with comparatively increased live body weights, which resulted into decreased MY/BW values.

The peak profitability of Vrindavani cows, raised for milk production, is observed during the 3rd and 4th age at calving class (ACC) intervals (1461-1825 and 1826-2190 days), as indicated by MY/BW values. Beyond this point, profitability gradually diminishes. Similarly, lactation order exhibits heightened milk production efficiency up to the 3rd lactation, after which it experiences a decline. This decline may be attributed to the increase in age or lactations, resulting in higher live body weights, a phenomenon supported by Rios *et al.* (2013). In dairy animals, advanced stages of production are often associated with decreased milk production as live body weights increase. The elevated live body weights may stem from the deposition of muscular body fat or slight growth. While heavier cows demand increased dry matter (DM) intake in the form of more feeds and fodder, this doesn't necessarily translate into proportionally higher milk yields. This scenario becomes economically unfavorable for dairy farmers as these animals consume more resources while exhibiting lower milk production efficiency. Consequently, these animals can become unprofitable for farmers. Genetically, heavier cows, in line with Veerkamp's findings in 1998, have higher feed requirements, posing challenges to economic sustainability. This aligns with the notion that there is a close genetic correlation between milk yield and feed intake. In contrast, smaller-sized animals may prove more advantageous for long-term production. Although they may yield comparatively less milk than larger counterparts, their input requirements, such as feeds, fodders, housing, and space, are lower. This indicates that smaller-sized animals could be a more economically viable option for dairy farmers, aligning with a sustainable and cost-effective approach to dairy farming practices.

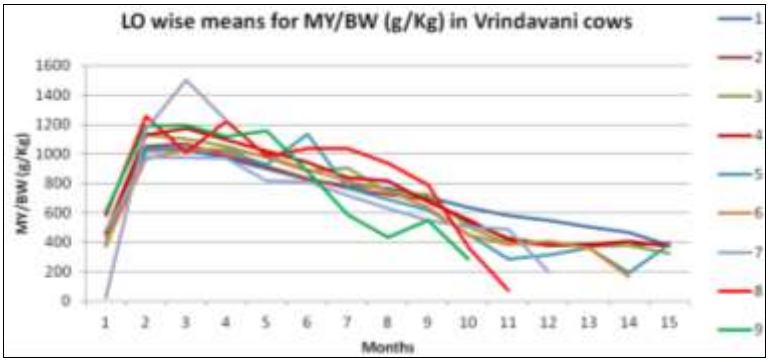

Fig 1: Lactation order wise means for milk yield per kg of live body weights in Vrindavani cows

Table 1: Lactation order wise means for milk yield per kg of live body weights (g/kg) in Vrindavani cows

Particulars	Milk Yields Per Kg of Live body Weights (g/Kg) during months														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Overall means	425.182 ±9.756 (1179)	1058.111 ±14.406 (1150)	1064.363 ±13.616 (1139)	1002.569 ±9.306 (1101)	928.538 ±9.167 (1075)	865.394 ±14.148 (997)	802.023 ±14.024 (956)	752.076 ±10.181 (923)	696.383 ±14.209 (880)	572.485 ±9.818 (807)	494.671 ±12.775 (640)	478.832 ±15.763 (422)	458.665 ±16.405 (258)	429.155 ±18.361 (156)	375.715 ±19.637 (98)
Lactation Orders	NS	NS	NS	**	**	**	NS	NS	NS	**	**	**	*	*	NS
1	396.516 ±14.750 (492)	1026.069 ±27.913 (485)	1030.765 ±20.230 (488)	969.277 ±13.623 (475)	898.132 ±13.585 (470)	831.038 ±12.893 (438)	783.888 ±12.784 (428)	766.602 ±16.619 (404)	706.667 ±13.143 (393)	636.665 ±14.366 (375)	583.373 ±19.872 (322)	548.930 ±22.089 (248)	504.884 ±20.350 (163)	464.642 ±23.063 (103)	378.530 ±24.719 (72)
2	455.445 ±19.551 (289)	1054.824 ±21.496 (278)	1069.294 ±34.985 (277)	985.793 ±18.520 (262)	914.600 ±17.836 (256)	835.820 ±17.266 (240)	767.860 ±18.519 (227)	725.230 ±17.579 (223)	689.168 ±30.478 (206)	531.849 ±20.211 (180)	430.965 ±22.297 (145)	384.374 ±28.856 (84)	373.513 ±38.245 (47)	379.142 ±41.227 (24)	393.545 ±51.849 (11)
3	441.704 ±25.570 (178)	1128.944 ±28.776 (175)	1099.666 ±25.590 (164)	1050.175 ±24.601 (168)	975.897 ±23.582 (161)	882.634 ±22.107 (148)	902.875 ±77.211 (142)	742.825 ±20.027 (138)	724.238 ±65.485 (138)	507.647 ±23.856 (124)	390.532 ±27.629 (84)	385.511 ±31.936 (45)	389.902 ±46.333 (26)	376.666 ±63.869 (15)	324.792 ±60.599 (8)
4	468.776 ±32.980 (117)	1130.916 ±33.121 (110)	1172.819 ±35.965 (108)	1097.188 ±32.220 (104)	1019.010 ±31.298 (100)	942.930 ±28.042 (94)	837.452 ±27.814 (83)	817.152 ±46.124 (81)	677.072 ±28.169 (74)	552.071 ±32.205 (66)	415.699 ±31.268 (52)	380.674 ±53.857 (28)	386.567 ±80.271 (15)	404.813 ±40.607 (8)	375.360 ±22.881 (6)
5	373.574 ±40.978 (58)	1034.087 ±47.706 (57)	1044.057 ±44.286 (57)	1017.974 ±42.230 (50)	927.958 ±44.598 (50)	1137.655 ±262.680 (43)	768.851 ±37.078 (44)	691.043 ±38.843 (46)	618.510 ±41.319 (41)	457.957 ±39.167 (36)	283.961 ±41.306 (24)	310.877 ±63.857 (11)	364.733 ±46.168 (5)	192.457 ±80.100 (4)	386.364 (1)
6	390.799 ±70.746 (26)	964.505 ±79.654 (27)	1029.835 ±83.258 (26)	1032.205 ±65.751 (24)	986.805 ±72.583 (24)	895.949 ±65.302 (19)	818.822 ±64.817 (20)	748.940 ±58.855 (21)	638.961 ±63.255 (18)	449.501 ±74.434 (18)	386.042 ±92.769 (9)	404.107 ±192.381 (5)	362.403 ±45.736 (2)	166.183 ±26.410 (2)	–
7	482.258 ±112.214 (13)	978.768 ±137.222 (12)	973.573 ±145.674 (12)	970.969 ±135.023 (11)	819.084 ±129.384 (9)	812.182 ±120.978 (10)	719.579 ±128.386 (8)	629.438 ±142.934 (6)	550.672 ±84.509 (6)	505.988 ±153.469 (5)	491.114 ±243.548 (3)	198.000 (1)	–	–	–
8	579.738 ±126.512 (2)	1255.417 ±342.083 (2)	1010.503 ±278.303 (3)	1222.316 ±102.226 (3)	987.436 ±20.377 (2)	1037.106 ±30.417 (3)	1035.721 ±11.971 (2)	937.118 ±189.444 (2)	789.460 ±93.120 (3)	368.482 ±147.232 (2)	69.863 (1)	–	–	–	–
9	610.145 ±175.098 (3)	1189.142 ±280.224 (3)	1195.999 ±301.012 (3)	1119.836 ±299.216 (3)	1156.603 ±302.634 (3)	882.857 ±386.190 (2)	587.541 ±192.459 (2)	433.095 ±293.095 (2)	547.727 (1)	284.091 (1)	–	–	–	–	–
10	22.917 (1)	1169.136 (1)	1502.500 (1)	1229.091 (1)	–	–	–	–	–	–	–	–	–	–	–

Conclusion

The age at calving and lactation order had significant effects on milk yields per kg of live body weights in Vrindavani cows. The Vrindavani cows reared for milk production were more efficient and economical milk producers at 3rd/4th age at calving classes (1461-1825 /1826-2190 d) and at 3rd lactation order, based on milk yields per kg of live body weights, beyond which, their economic values gradually declined.

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