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Adaptation of buffalo calves to a new automatic milk feeder

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ABSTRACT
Rational heifer management in buffalo rearing is of paramount importance. There are no studies in the literature dealing with automatic feeding in individual boxes for buffalo calves. This study aims to deepen knowledge in this area and to evaluate the ability of buffalo calves to adapt to a mobile automatic feeder through data provided by the system's monitoring software. Data were collected on 3 different groups of 15 buffalo calves in succession with each other. The data on the daily feeding quantity and volume showed that 95.67 % of the calves were fed within the first day of stall in the automatic feeder. During the first 72 h in the calf house, the calves were fed from 2.49 ± 1.21 meals per day with an average feeding rate of 0.24 ± 0.06 L/min. The average daily milk intake was 3.57 ± 0.26 L/d, while the average milk intake during the first 72 h was 10.7 ± 0.77 L. The buffalo calves, therefore, showed themselves to be able to adapt to this type of feeding, making use of its advantages.

Section: RESEARCH PAPER

Keywords: buffalo calves; automatic milk feeder; adaptation

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1. INTRODUCTION

Buffalo livestock in Italy is a small reality in comparison to the large population numbers of many east Asian countries, but it is an important reality in economic terms, both for workers' occupation and as an example of typical Italian produce in the world. In addition, the Italian Buffalo is the first in the world for genetics, applied technologies, the monitoring of pathologies and the hygiene and quality of products [1]. In most Italian buffalo farms, and especially in the Campania region, which has approximately 308,523 [2] buffalo heads, while in Italy the total number is 407,027 [2], calves are removed from their mothers shortly after calving, housed individually or in groups and fed, with whole or reconstituted milk, with manual feeding systems (MMF) through open buckets or bottles [3]. Farms traditionally use limited milk feeding plans, providing calves with 10 % of their BW (age and body weight) in milk per day [4]. Reference [5] states that this type of feeding plan promotes early intake of solid feed, thus enabling fast weaning and reduced rearing costs. Studies done on buffalo calves [6] have demonstrated the short and long-term benefits of pre-weaning with high milk feeding programs (20 % of the calves' body weight), that include a gradual reduction of milk to stimulate calves to solid feed intake [7]. These gradual pre-weaning feeding programs are difficult to implement with MMF feeding systems [8]. The disadvantages of MMF lie in the inability to return useful information, such as the amount of milk intake, feeding times and speed of intake. In this regard several studies, carried out during the pre-weaning phase of bovine calves, have shown that these high milk content feeding programs with gradual reduction are, on the other hand, easily implemented with the use of automatic milking feeder (AMF) systems for group-housed calves [9]-[12].

AMFs allow a wide variety of feeding metrics to be tracked for each calf, including daily milk consumption, speed of milk consumption and number of visits. Two different studies [13] and [14] have stated that this management strategy has the advantage of facilitating the ability to feed more milk per day (4 ± 2 meal/d) than MMF systems (2 meal/d) and increasing the physical-social benefits per calf [15]. According to reference [16], reconstituted milk is a perishable feed and, especially in hot weather, with MMF management, it is altered, and the hygienic aspect may be deficient. AMF management, with instantaneous preparation of the feed and isolation of the feed from the external environment, results in a preservation of the hygienic health parameters of the reconstituted milk and, therefore, an improvement in terms of animal welfare for the calves.

Reference [17] on bovine calves explains that they spend a period (5 days) housed individually, where they are trained to suckle the teat, before moving to group housing with MFA.

However, [18], [19], state that calves housed in groups (≥7 calves) have a higher incidence of respiratory disease and mortality [20] than calves housed in individual stalls and that, in addition, it may be more difficult to detect sick calves in group housing systems [21]. Reference [17] also found that only 27 % of all bovine calves drank voluntarily from the feeder within 24 hours and that a decrease in milk intake was noted for the first few days after the introduction into the group pen. This adaptation period, with the decrease in milk intake and the stress of entering a new social group, would seem to put calves at risk of health problems [22]. Several studies are reported in the bibliography in which attempts have been made to optimize the adaptation of bovine calves to AMFs by promoting health, growth and labour efficiency [8], [23], [24], but there seems to be no studies on the adaptation of buffalo calves to AMFs. The aim of this work is to evaluate the adaptation of buffalo calves to the innovative AMF with single stall housing by analysing the adaptation rates over 24 h, 48 h and 72 h. The number of meals taken, the sucking rate per meal and the quantity of milk taken per feed per calf will also be evaluated over these 3 days.

2. MATERIALS AND METHODS

The study was conducted on a livestock farm (112 m above sea level) in Campania, a region in southern Italy. The farm occupies a land area of about 130 hectares. It has a hard of 1178 buffaloes and to the best of our knowledge it is the only farm in the world that introduced the AMF for buffaloes calves in single boxes. The calf-nurse is new, and it was constructed with the introduction of AMF. The entire surface was divided into two sectors, each of them of 229.42 m². In each sector 32 buffaloes calves were accommodated.

The boxes, made of galvanized iron, (1.6 m × 1.2 m dimensions) are arranged head-to-head in a 16 + 16 pattern to allow the calves to look at each other and promote their socialization [25]. Each stall is equipped with a bucket for fresh water and a bowl for solid food (1.3 kg/d). Milk is prepared by the 'Calf Rail' automatic feeder (Förster-Technik), as shown in Figure 1 (left) and administered via the robotic arm (Figure 1, right). This process occurs four times a day with an interval of 6 hours between feedings [26]. The milk replacer (Sprayfo Bufalino HP65) contained 24.5 % CP and 25 % fat, with a concentration of 180 g/L of (18 % solid) at 40 °C. The feeding schedule chosen by the farm, high milk content with gradual reduction, provided that from day d0 (entry into the heifer) to day d3 (3th day in the heifer), the animals had 1.5 L/meal of milk available. A waiting time of 2.3 min was set for the robotic arm; if the animal did not start feeding, the software recorded a refusal and continued with the feeding of the next calf. The average temperature inside the heifer house recorded was 18 ± 4 °C and the relative humidity less than 60 %.

3. DATA COLLECTION AND ANALYSIS

The study was conducted in the period March-July 2022 in which 3 independent groups of 15 calves (G1; G2; G3) were analysed. The calves were chosen randomly for each group, with a total of 45 calves analysed in total. At birth, calves were fed colostrum for the first 5 days of life and then transferred to individual Calf Rail pens. The average weight of the calves at day d0 was 43.41 ± 1.94 kg for group G1, 42.86 ± 1.86 kg for group G2 and 43.13 ± 1.92 kg for group G3, respectively. The raw variables (feeding time, amount of milk per meal, sucking rate and refusals) that the Calf Rail management software stored for

Figure 1. Vario Smart Förster-Technik feeder (left) and Calf Rail robotic arm (right).

each calf per day were evaluated. The information recorded by the software per calf lasted 24 h, so each day and for the duration of the trial it was recorded by us and exported to Microsoft Excel for processing. This data extraction process allowed the detection and removal of any outliers before calculating the variables under study, such as, the percentage of calves fed in 24, 48 h and 72 h; the number of meals taken and the amount of milk taken per calf in the first 3 d in the heifer. Statistical analysis was performed by means of R Studio software (version 4.2.2). The results obtained from the comparison of the three groups were validated with one way ANOVA test (Analysis of variances). Statistical significance of the differences observed among mean values was assessed using Tukey multiple comparisons of means with a 95 % confidence level. Before analysis, normality and homogeneity of variance of data were checked by using the Shapiro-Wilks test and Levene test.

4. RESULTS AND DISCUSSION

To assess the adaptation of buffalo calves to AMF, a total of 45 calves were tested, divided into three groups.

The adaptation of buffalo calves to AMF was assessed by calculating the percentage of self-feeding during the first three days of entry into the calf house. In Table 1 were showed the results.

During 24 h, group G1 and G3 had an adaptation of 100 %, i.e. each calf fed within 24 h of entering the heifer calf house; group G2 had an adaptation of 93.33 %, i.e. of the 15 calves only one did not feed within 24 h. During 48 and 72 h, all calves in the three groups had at least one feed. The rate of adaptation was not statistically different among the three groups of 15 buffaloes calves examined.

The 96.67 % of the calves made their first voluntary feed within 24 h of entering the calf house. The learning ability of the AMF system by the buffalo calves proved to be higher than that observed in another study on bovine calves [27] for which the percentage of independent feeding within the first day of in-calf stall was 27 %. The AMF analysed, provides for an arrangement of calves in individual stalls with the possibility of visual interaction; therefore, the result obtained could be justified by the "learning theory" [25], [28], [29] which states that calves learn faster by observing each other.

Table 2 shows the results for the average number of daily feedings in the 3 groups of calves analysed.

The average number of feeds per calf per day for the groups G1, G2 and G3, in the first 3 days of stalling in the heifer cowshed, was 2.5 ± 0.19 n/d was significantly ($P < 0.05$) higher than 2 n/d, which is the average number of feeds per calf per day in a heifer cowshed with MMF. On Day 1, an average number of feeds per calf per day of 2.4 ± 0.20 n/d was found for the 3

Table 1. Feeding percentage of buffalo calves in the first 3 days in the automatic calf stall.

Group	Percentage of self-fed calves		
	Day 1	Day 2	Day 3
G1	100 %	100 %	100 %
G2	93.33 %	100 %	100 %
G3	100 %	100 %	100 %

Table 2. Average number of daily feedings.

Group	Average number of daily feedings [n]		
	Day 1	Day 2	Day 3
G1	2.5 ± 1.3	2.6 ± 1.2	2.8 ± 1.1
G2	2.1 ± 1.3	2.5 ± 1.0	2.5 ± 1.1
G3	2.4 ± 1.3	2.6 ± 1.3	2.7 ± 1.2

Table 3. Average feeding speed.

Group	Average feeding speed [L/min]		
	Day 1	Day 2	Day 3
G1	0.24 ± 0.06	0.24 ± 0.06	0.26 ± 0.06
G2	0.21 ± 0.06	0.24 ± 0.04	0.24 ± 0.07
G3	0.24 ± 0.04	0.25 ± 0.05	0.27 ± 0.07

Table 4. Average daily milk quantity.

Group	Average daily milk quantity [L/d]		
	Day 1	Day 2	Day 3
G1	3.47 ± 0.32	3.72 ± 0.37	3.93 ± 0.30
G2	2.71 ± 0.47	3.48 ± 0.40	3.62 ± 0.42
G3	3.67 ± 0.59	3.74 ± 0.57	3.76 ± 0.54

groups. On Day 2 and Day 3, an average daily meal per calf of 2.5 ± 0.10 n/d and 2.7 ± 0.15 n/d, respectively, was observed. The 3-day averages were statistically different ($P < 0.05$).

Group G1 and G3 had a significantly higher feeding rate on the first day of stall (+19.4%) than group G2. This could be explained by the fact that on the first day of stall, in G2 one calf did not feed in the first 24 h. On the second and third day of stall there was no statistically significant difference ($P > 0.05$) in the average number of feeds per calf between the 3 groups. The results show a daily increase in the average number of feeds per calf, in fact, in both G1, G2 and G3, the average number of feeds carried out on the first day was significantly lower ($P < 0.05$) than the average number of feeds carried out on the third day of observation. Specifically, in the G1 group from day 1 to day 3 there was a 12 % increase in voluntary feeding, in the G2 group a mean increase in voluntary feeding of 19 % and in the G3 group a mean increase of 12.5 %. These results indicate that buffaloes' calves became accustomed to automatic feeding by Calf Rail early on and progressively increased the number of voluntary feedings per day. According to [30], the increase in the number of daily self-feedings in addition to increased adaptability could be related to the calves' growth and increased voracity.

Table 3 shows the results of the average sucking rate recorded in the 3 observation groups during the first 3 days of stall. The average daily sucking rate in the 3 groups observed in the first 3 days of stall in heifer rearing was 0.24 ± 0.02 L/min. The lowest sucking rate was recorded in group 2 on day 1, and was 0.21 ± 0.06 L/min, while the highest was recorded in group 3 on day 3 and was 0.27 ± 0.07 L/min.

On day 1, an average sucking rate per calf of 0.23 ± 0.01 L/min was recorded for the 3 groups, and on day 2 and day 3 an average sucking rate per calf of 0.24 ± 0.01 L/min and 0.26 ± 0.02 L/min respectively. The mean sucking rates per calf of the 3 days were statistically different ($P < 0.05$).

The G1 and G3 groups had a significantly higher (+14.3 %) mean feeding rate on the first day of stall than the G2 group. This result could also be related to the non-feeding of a calf in group 2 during the first 24 h of stall. On day 2 and day 3 of stall, there was no statistically significant difference ($P > 0.05$) between G1, G2 and G3 in sucking rate per calf.

In both G1, G2 and G3 there was a mean percentage increase in sucking rate from day 1 to day 3 of 12.2 %. There are no comparative experiments in the bibliography for buffalo calves with respect to this figure for both MMF and AMF feeding systems. In a study conducted in Denmark on Holstein-Friesian calves [31], it is reported that with automatic feeding systems for groups of 12 and 24 calves, the average daily sucking rate for calves over the entire pre-weaning period (80 days) was 0.30 ± 0.02 L/min and 0.397 ± 0.02 L/min, respectively.

The sucking rate of the lesser group was therefore comparable to that found in the present study on the buffalo breed in the first 3 days of stall, this result is further confirmation of the possible adaptability of buffalo calves to this new single-stall reconstituted milk feeding technology.

Table 4 shows the results of the milk intake of the 3 groups of calves during the first three days of observation in the heifer stall. The average daily milk intake per calf in the first 72 h of in-calf stall was 3.6 ± 0.26 L/d.

The lowest average daily milk intake per calf was recorded in group 2 on day 1 and was 2.71 ± 0.47 L/d, while the highest was recorded in group 1 on day 3 and was 3.93 ± 0.3 L/d.

On day 1 an average amount of milk intake per calf of 3.3 ± 0.45 L/d was recorded for the 3 groups, on day 2 and day 3 an average amount of milk per calf of 3.65 ± 0.45 L/d and 3.57 ± 0.42 L/min respectively. The averages of milk intake per calf over the 3 days were statistically different ($P < 0.05$).

The G1 and G3 groups had a significantly higher (+31.3 %) mean amount of late intake per calf in the first 24-hour stall than the G2 group. There was no statistically significant difference ($P > 0.05$) between G1, G2 and G3 in the mean amount of milk intake per calf on the second and third day of stall.

In both G1, G2 and G3 there was a mean percentage increase in the amount of milk taken in per calf from day 1 to day 3. Specifically, in the G1 group there was an average increase in milk consumed from day 1 to day 3 of 13.26 %, in the G2 group there was an increase in milk consumed from day 1 to day 3 of 19.92 % and in the G3 group there was an average increase in milk consumed of 5.8 %. The results appear to be consistent with the quantity of meals taken per day per calf and the rate of milk sucking per day per calf, confirming an increasing trend of adaptation of the calves as the days pass.

5. CONCLUSIONS

In conclusion, these initial results would seem to demonstrate that buffalo calves can adapt well to an automatic single stall-feeding system, with 95.65 % of calves feeding on the first day of stalling. During the first 3 days of stalling in the calf house, it was also seen that the average number of voluntary feedings per day by the calves was higher than 2 in all 3 observation groups and that the sucking rate was comparable to that recorded in other studies on buffalo calves. The number of self-feedings and the amount of milk intake also increased from day 1 to day 3, demonstrating the effective growth of the calves and thus their adaptation to this new technology of feeding reconstituted milk.

The use of this new technology allows farmers to rear a large number of calves without having management difficulties and decreasing the number of labour hours, while always having data available for monitoring and efficient calf management. This study shows the preliminary results of a larger trial, in which the efficiency of the AMF applied to Mediterranean buffalo will be evaluated, depending on the operational and functional parameters of the machine, analysing the performance of the system also in terms of energy consumption, operational capacity and cost. This new technology can bring huge benefits to farmers in terms of quality and quantity of production, and larger farms could quickly adopt this solution to lower their farm's labour costs. However, it remains to be seen what effects this technology can have on the different species reared and the sustainability of this type of system compared to those currently most in use.

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REFERENCES

[1] V. Tufarelli, M. Dario, V. Laudadio, Diet composition and milk characteristics of Mediterranean water buffaloes reared in Southeastern Italy during spring season, Livestock Research for Rural Development 20(10) (2008). Online [Accessed 11 November 2023]
http://www.lrrd.org/lrrd20/10/tufa20165.htm
[2] ISTAT 2020, 7° Censimento Generale Agricoltura. [In Italian]
[3] C. Medrano-Galarza, S. J. LeBlanc, T. J. DeVries, A. Jones-Bitton J. Rushen, A. M. de Passillé, D. B. Haley, A survey of dairy calf management practices among farms using manual and automated milk feeding systems in Canada, Journal of Dairy Science 100(8) (2017), pp. 6872-6884.
DOI: 10.3168/jds.2016-12273
[4] P. K. Singh, M.L. Kamboj, S. Chandra, A. Kumar, N. Kumar, Influence of weaning on growth, health and behaviour of buffalo (Bubalus bubalis) calves, Indian J. Anim. Res. 53(5) (2019), pp. 680-684.
DOI: 10.18805/ijar.B-3546
[5] M. A. Khan, D. M. Weary, M. A. G. von Keyserlingk, Invited review: Effects of milk ration on solid feed intake, weaning, and performance in dairy heifers, J. Dairy Sci. 94(3) (2011), pp. 1071–1081.
DOI: 10.3168/jds.2010-3733
[6] W. Abbas, S. A. Bhatti, M. S. Khan, N. Saeed, H. M. Warriach, P. Wynn, D. McGill, Effect of weaning age and milk feeding volume on growth performance of Nili-Ravi buffalo calves, Italian Journal of Animal Science, 16(3) (2017), pp. 490-499.
DOI: 10.1080/1828051X.2017.1291282
[7] M. A. Khan, H. J. Lee, W. S. Lee, H. S. Kim, S. B. Kim, K. S. Ki, J. K. Ha, H. G. Lee, Y. J. Choi, Pre- and postweaning performance of Holstein female calves fed milk through step-down and conventional methods, J. Dairy Sci. 90(2) (2007), pp. 876–885.
DOI: 10.3168/jds.S0022-0302(07)71571-0
[8] S. D. Parsons, M. A. Steele, K. E. Leslie, D. L. Renaud, T. J. DeVries, Investigation of weaning strategy and solid feed location for dairy calves individually fed with an automated milk feeding system, J. Dairy Sci. 103(7) (2020), pp. 6533–6556.
DOI: 10.3168/jds.2019-18023
[9] M. W. Jorgensen, A. Adams-Progar, A. M. de Passillé, J. Rushen, S. M. Godden, H. Chester-Jones, M. I. Endres, Factors associated with dairy calf health in automated feeding systems in the Upper Midwest United States, J. Dairy Sci. 100(7) (2017), pp. 5675–5686.
DOI: 10.3168/jds.2016-12501
[10] C. Medrano-Galarza, J. Rushen, A. M. de Passille, A. Jones-Bitton, T. J. DeVries, S. J. LeBlanc, D. B. Haley, A survey of management practices regarding manual and automated milk feeding systems for dairy calves in Canada, J. Dairy Sci. 100(8) (2017), pp. 6872–6884.
DOI: 10.3168/jds.2016-12273
[11] E. Vasseur, F. Borderas, R. I. Cue, D. Lefebvre, D. Pellerin, J. Rushe, K. M. Wade, A. M. de Passillé, A survey of dairy calf management practices in Canada that affect animal welfare, J.Dairy Sci. 93(2) (2010), pp. 1307–1315.
DOI: 10.3168/jds.2009-2429
[12] J. H. Costa, M. C. Cantor, H. W. Neave, Symposium review: Precision technologies for dairy calves and management applications, J. Dairy Sci. 104(1) (2021), pp. 1203–1219.
DOI: 10.3168/jds.2019-17885
[13] A.Huuskonen, H. Khalili, Computer-controlled milk replacer feeding strategies for group-reared dairy calves, Livest. Sci. 113(2-3) (2008), pp. 302–306.
DOI: 10.1016/j.livsci.2007.06.017
[14] B. A. Roth, E. Hillman, M. Stauffacher, N. M. Keil, Improved weaning reduces cross-sucking and may improve weight gain in dairy calves, Appl. Anim. Behav. Sci. 111(3-4) (2008), pp. 251–261.
DOI: 10.1016/j.applanim.2007.06.007
[15] M. B. Jensen, L. Munksgaard, L. Mogensen, C. C. Krohn, Effects of housing in different social environments on open field and social responses of female dairy calves, Acta. Agric. Scand. 49(2) (1999), pp. 113–120.
DOI: 10.1080/090647099424178
[16] V. De Paula, A. M. de Passille, D. M. Weary, Effects of early social environment on behavioral responses of dairy calves to novel events, J. Dairy Sci. 95(9) (2012), pp. 5149–5155.
DOI: 10.3168/jds.2011-5073
[17] A. Y. Tamime, Milk processing and quality management, Blackwell Publishing Ltd, United Kingdom (2009), ISBN 9781405145305, pp. 195-196.
[18] T. R. Wilson, S. J. LeBlanc, T. J. DeVries, De B. Haley, Effect of stall design on dairy calf transition to voluntary feeding on an automatic milk feeder after introduction to group housing, J. Dairy Sci. 101(6) (2018), pp. 5307–5316.
DOI: 10.3168/jds.2017-14011
[19] C. Svensson, P. Liberg, Effect of group size on health and growth rate of Swedish dairy calves housed in pens with automatic milk-feeders, Prev. Vet. Med. 73(1) (2006), pp. 43–53.
DOI: 10.1016/j.prevetmed.2005.08.021
[20] C. Svensson, K. Lundborg, U. Emanuelson, S. O. Olsson, Morbidity in Swedish dairy calves from birth to 90 days of age and individual calf-level risk factors for infectious diseases, Vet. Med. 58(3-4) (2003), pp. 179–197.
DOI: 10.1016/S0167-5877(03)00046-1
[21] W. C. Losinger, A. J. Heinrichs, Management practices associated with high mortality among preweaned dairy heifers, J. Dairy Res. 64(1) (1997), pp. 1–11.
DOI: 10.1017/S0022029996001999
[22] N. Steenkamer, Alternative housing systems for veal calves, their effect on welfare and performance and their economic feasibility, in: Welfare and husbandry of calves: Current topics in veterinary medicine and animal science. (editor) J. P. Signoret. Martinus Nijhoff Publishers, Leiden, the Netherlands, 1982, ISBN: 978-90-247-2680-6, pp 226–234.
[23] A. M. de Passillé, M. Rabeyrin, J. Rushen, Associations between milk intake and activity in the first days of a calf's life and later growth and health, Appl. Anim. Behav. Sci. 3970 (2014), pp. 1–6.
DOI: 10.1016/j.applanim.2014.10.002
[24] M. A Steele, J. Rushen, A. M. de Passillé, Advancements in automated feeding for calves: Where we are today and where we'll be tomorrow, WCDS Advances in Dairy Technology 27 (2015), pp. 49-59. Online [Accessed 11 November 2023]

https://wcds.ualberta.ca/wcds/wp-content/uploads/sites/57/wcds_archive/Archive/2015/Manuscripts/Chapt%2004%20-%20Steele.pdf
[25] H. Hepola, Milk feeding system for dairy calves in groups: effect on feed intake, growth and health, Appl. Anim. Behav. Sci. 80(3) (2003), pp. 233-243.
DOI: 10.1016/S0168-1591(02)00214-9
[26] H. Gleitman, J. Gross, D. Reisberg. Learning, in: Psychology. 8th (editor). W.W. Norton and Company Inc. New York, 2011, ISBN: 978-0393932508, pp 258– 298.
[27] F. Zerbe, M. C. Schlichting, Drinking behaviour and activities of rearing calves kept in groups and fed with an automatic-milk-feeder, Proceedings of the International Congress on Applied Ethology Berlin 1993: 3rd joint meeting, pp. 483-486.
[28] M.Fujiwara, J. Rushen, A.M. De Passillé, Dairy calves' adaptation to group housing with automated feeders, Appl. Anim. Behav. Sci. 158 (2014), pp. 1-7.
DOI: 10.1016/j.applanim.2014.06.011
[29] E. K Miller-Cushon, T. J. DeVries, Effect of social housing on the development of feeding behavior and social feeding preferences of dairy calves, J. Dairy Sci. 99(2) (2016), pp. 1406–1417.
DOI: 10.3168/jds.2015-9869
[30] C. Svensson, M. B. Jensen, Short Communication: Identification of Diseased Calves by Use of Data from Automatic Milk Feeders, J. Dairy Sci. 90(2) (2006), pp. 994–997.
DOI: 10.3168/jds.S0022-0302(07)71584-9
[31] M. B. Jensen, Computer-controlled milk feeding of dairy calves: The effects of number of calves per feeder and number of milk portions on use of feeder and social behavior, J. Dairy Sci. 87(10) (2004), pp. 3428–3438.
DOI: 10.3168/jds.S0022-0302(04)73478-5