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The adoption of good practices of handling improves dairy calves welfare: Case study

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ABSTRACT. The aim of this study was to assess the effect of the adoption of a set of good practices of handling on dairy calves welfare. Data were retrieved from the records of a commercial farm, considering three periods: Conventional handling (CH, 12 mo.), transitional period (TP, 4 mo.), and good practices handling (GPH, 12 mo.). During CH calves were kept in individual pens, milk-fed in open pails and subjected to abrupt weaning; while during TP and GPH they were kept in groups, milk-fed in nipple-pails, brushed for 5 min. once a day, and subjected to progressive weaning. TP was assumed as a training period necessary for GPH implementation. The percentages of calves treated with antibiotics and numbers of deaths per month were used as indicators of calves welfare. Statistical analysis was performed using a logistic regression model to compare the number of deaths per month between CH and the other periods. Chi-square test was used to compare the percentage of animals treated with antibiotics per month. Results showed that CH had a higher risk of calf's death then TP and GPH, as well as a higher percentage of animals treated with antibiotics. In conclusion, the adoption of good practices of handling improved dairy calves welfare.

Keywords: antibiotic use; mortality rate; progressive weaning; tactile stimulation.

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Introduction

The welfare of farm animals has been the object of interest of many researchers, particularly in situations where the animals are directly dependent on basic care provided by human beings, as is the case of dairy calves (Adamczyk, 2018; Mota-Rojas et al., 2020). Previous reports have shown a wide range of mortality rates among dairy calves, from relatively low (⩽5.0%: Gulliksen, Lie, Løken, & Østerås, 2009; Cruz et al., 2011; Walker et al., 2012, McCorquodale et al., 2013, Urie et al., 2018; Hyde et al., 2020) to extremely high (⩾10.0%: Moran, 2011; McCorquodale et al., 2013; Mahendran et al., 2017; Reimus, Alvåsen, Emanuelson, Viltrop, & Mõtus, 2020).

Such variations have been explained by the effect of breed or genetic groups (Davis, Norberg, & Fogh, 2020) and meteorological conditions (Stull et al., 2008, Roland, Drillich, Klein-Jöbstl, & Iwersen, 2016), as well as by the differences in raising and handling conditions (Botteon, Botteon, Santos Júnior, Pinna, & Lóss, 2008; Moran, 2011; Walker et al., 2012; Barry et al., 2019). For example, in a study carried out by Abuelo, Havrlant, Wood, and Hernandez-Jover (2019) in Australian dairy farms, only 19.5% of the colostrum samples analysed (n = 221) meet the standards of satisfactory IgG concentration (>50 g L^{-1}) and microbiological quality (total bacteria and total coliform counts lower than 100,000 and 10,000 cfu mL^{-1}, respectively); and the results of Stull et al. (2008) showed that calf mortality increases when the average daily temperature are less than 14ºC and higher than 24ºC, and that, under the meteorological condition in which the study was carried out, rain was not an important predictor of mortality.

Infectious diseases, particularly diarrhoea and pneumonia, are characterized as the main causes of dairy calf morbidity and mortality (Gulliksen et al., 2009; Beaver, Meagher, von Keyserlink, & Weary, 2018; McConnel et al., 2019). However, there is little information on the prevalence of these diseases in Brazilian dairy cattle herds. In one of the few studies published on the subject, Botteon et al. (2008) reported a 19.75% (range: 18.2 to 24.2%) frequency of dairy calves with diarrhoea among 63 herds in the Paraiba Valley, Brazil. The results of a long-term study (carried out from 2000 to 2009) in dairy herds in Rio Grande do Sul State, Brazil (Cruz et al., 2011) showed high prevalence of diarrhoea (mean 23.7%) and pneumonia (mean 16.8%) in

dairy calves. Additionally, Fruscalso, Olmos Antillon, and Hötzel (2020) reported that the main cause of calf mortality was diarrhoea, being responsible for more than 40% of deaths.

One strategy used to reduce spreading infectious diseases among dairy calves is to maintain them in individual pens, without any possibility of physical contact (McGuirk, 2008; Gulliksen et al., 2009). This is a common practice in Brazilian dairy farms, where small outdoor shelters, commonly called "casinhas tropicais", are used to keep a calf isolated from each other (Vinholis, Tupy, Pedroso, Primavesi, & Bernardi, 2006). However, according to Costa, von Keyserlingk, and Weary (2016) the social isolation has a negative impact on dairy calves welfare; being suggested by the authors that the best way to deal with the higher risk of spreading infections, when keeping dairy calves in group housing, is by the adoption of appropriated management, instead isolating them.

It should also take into consideration that using open-pails to milk-feed dairy calves increases the risk of harming their welfare, since they are not able to express proper suckling behaviour, which lead to motivational and physiological disturbances, characterized by the expression of cross-suckling abnormal behaviour (de Passillé, 2001) and by precluding oesophageal groove to close, which is essential for proper milk digestion (Martín-Alonso, Cal-Pereyra, Fernández-Caso, & Gonzáles-Montaña, 2019).

To the best of our knowledge, no studies have been conducted assessing the effects of adopting a set of good handling practices on the welfare of dairy calves. Thus, the aim of this study was to evaluate the effects of adopting of a set of good practices of handling (control of the colostrum ingestion, group housing, milk-feeding in nipple-pails, brushing during suckling, and progressive weaning) on the welfare of dairy calves raised under a commercial dairy farm in Brazil.

Material and methods

This study was approved by the Committee of Ethical Use of Animals of the Faculty of Agricultural and Veterinary Sciences, UNESP, Jaboticabal, São Paulo State, Brazil (Protocol number 17310/15).

The study was conducted with the data file of a commercial dairy farm located in the municipality of Taiaçu, São Paulo, Brazil (21º08'40" S and 48º30'45'' W, average altitude of 565 m above sea level), by considering the frequencies of treatments with antibiotics and calves losses during a period of 2 years and 4 months, comprising data from before (12 mo., n = 511), during (4 mo., n = 128) and after (12 mo., n = 420) the adoption of good practices of calves handling as a routine. Months within periods were assumed as replications.

During the first 12 months of data records calves were handled in a conventional way (conventional handling, CH), staying with their mothers during the first 24 hours of life, suckling colostrum directly from them (without any control of the quality and amount of colostrum ingested); and navels were treated within the first 12 hours after birth by immersion in 10% iodine solution. From the 2nd to the 30th day of life calves were housed in individual pens (1.5 m² calf^{-1}, with 10 cm of sawdust or straw as bed) installed in a shed; during the first 2 days of this period, they received colostrum (ad libitum) in bottle; and from the 4th day old, they were fed with a commercial milk replacer (Sprayfo Violet®) in open-pails, receiving 4 L of milk replacer per day (divided in two meals) until weaning. On the 31st day of life, calves were moved to outside and housed in "casinhas tropicais" (installed under the shade of coconut palms and on a sand bed), being tied to them with a 1.2 m. Weaning was carried out in an abrupt way, when they were around 70 days old. Handling procedures were carried out with few interactions with calves.

During the following 4 months of the study period (transitional period, TP), farm staff was trained to adopt a set of good practices of handling, when the following handling procedures started to be adopted: Calves remained with their mothers during the first 24 hours of life, but an additional offer of high quality colostrum (tested using a colostrometer) were supplied in bottles, assuring the ingestion of 2 L of colostrum up to 6 hours after birth, plus 2 L up to 12 hours. The navels were treated within the first six hours after birth, also with total immersion in a 10% iodine solution; and from the 2nd to the 30th day of life, the calves were housed in larger individual pens (3.0 m² calf^{-1}), besides having access to a paddock between feed meals (except on rainy days), where they were able to socialize and play. From the 4th day of life, the calves were milk-fed with the same milk replacer and the same amount but, in this case, using nipple-pails, allowing the calves to suckle. Calves were brushed for five minutes during morning milk-feed and, from the 31st day of life, they were moved into paddocks (*Cynodon* spp.) with free access to water and shade, where they stayed in groups of 6 to 8 animals until weaning. Calves were weaned gradually (see Table 1 for details), completing weaning when

reaching 70 days of life and 70 kg of body weight (when a calf did not reach the minimum body weight, it continued receiving 1 L of milk day^{-1} until reaching it).

We assumed that after the TP, the adoption of the good practices of handling was already integrated in the farm handling routine; then, the following 12 months of the data records was assumed as a new period (good practices of handling, GPH). In all periods (CH, TP, and GPG) calves had free access to hay and concentrate (with 18% crude protein) throughout milk-feeding period.

Table 1. Protocols adopted for milk-feeding dairy calves from birth to weaning according to the handling procedure: conventional handling (CH) and good practices of handling (GPH).

Calf age (days)	CH (number of meals)	GPH (number of meals)
1st day of life	Allowed to suckle the cow, no control of colostrum ingestion	Allowed to suck the cow, assuring the ingestion of 2 L of colostrum up to 6h of life plus 2 L up to 12h
From 2nd to 3rd	Colostrum *ad libitum* (2)	Colostrum *ad libitum* (2)
From 4th to 20th	4 L of milk replacer (2)	6 L of milk replacer (2)
From 21st to 55th	4 L of milk replacer (2)	4 L of milk replacer (2)
From 56th to 60th	4 L of milk replacer (2)	3 L of milk replacer (2)
From 61st to 65th	4 L of milk replacer (2)	2 L of milk replacer (2)
From 66th to 70th	4 L of milk replacer (2)	1 L of milk replacer (1)
Amount of milk replacer ingested per calf	264 L	264 L

Statistical analysis

To control the effect of seasonal influences, comparisons between CH and GPH were conducted for the same months of the year.

The fixed effects of handling procedures (CH, TP, and GPH) on the likelihoods of calf death were analysed using restricted maximum likelihood (REML). A logistic regression model with the probit link function (for an adjacent normal distribution) and with a binomial distribution of the response variables was applied by using the GENMOD procedure in SAS (SAS Institute Inc., Cary, NC), CH was set as the reference class. The Chi-Square test was used to compare the relative frequencies of antibiotic use between CH, TP, and GPH.

Results and discussion

The mortality rate per month from birth to weaning was extremely high (18.79%) before the adoption of the good practices of handling (CH), reducing expressively after their adoption, dropping to 7.81% (58.4% reduction) during TP (when the good practices of handling was still being implemented) and to 5.24% when GPH were already implemented in the farm routine (72.1% reduction). The results of the statistical analysis sustained these reductions with high probability, showing that the risk of calf mortality was significantly lower ($p < 0.005$) after the adoption of good practices of handling (TP and GPH), when the odds ratio for calves death, which were reduced to less than half when compared to the value estimated in CH (reference class), as shown in Table 2.

Table 2. Number of calves (N), relative and absolute frequencies of calf deaths, and respective odds ratio, confidence intervals, Chi-Square, and P-values, according to the periods (CH = conventional handling, TP = transition period, and GPH = good practices of handling).

Periods	N	Calf death % (N)	Odds ratio ± SE	95% Confidence intervals	Chi-Square	P values
GPH	420	5.24 (22)	0.24 ± 1.27	0.15 – 0.39	33.71	<0.0001
TP	128	7.81 (10)	0.37 ± 1.41	0.18 – 0.72	8.31	0.0039
CH	511	18.79 (96)	RC	RC	-	-

The same tendency was observed when considering the percentage of calves treated with antibiotics, dropping from 68.1% per month in CH, to 45.7% in TP and 34.2% in GPH ($p < 0.001$ for both), indicating a reduction of 32.9% and 49.8%, respectively, after the adoption of the good practices of handling. No statistically difference was observed between the percentages of calves treated with antibiotics in TP and GPH (Figure 1).

The big standard errors found in this study were due to uncontrolled environmental factors, e.g., the birth season, which has effects on the quality of the colostrum and the prevalence of diarrhoea and pneumonia (Gulliksen et al., 2009), and survival of dairy calves (Zhang et al., 2019).

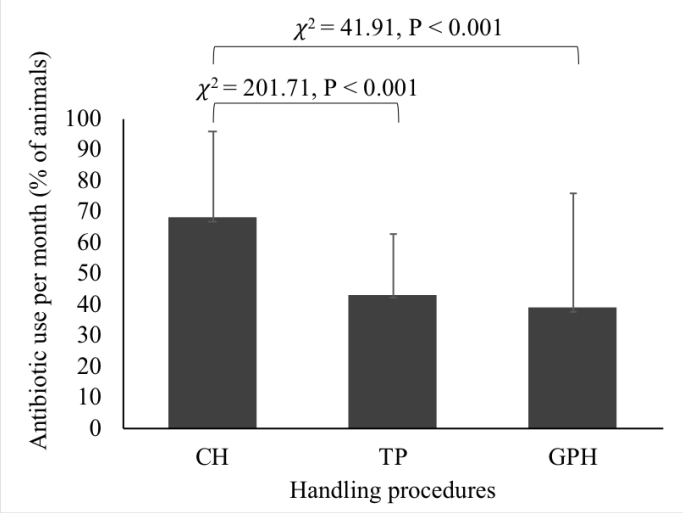

Figure 1. Means (and respective standard errors) of the monthly frequencies of antibiotic use in dairy calves, assessed from the 2nd to the 70th day of life, according to handling procedure (CH = conventional handling, TP = transition period, and GPH = good practices of handling).

Thus, for both indicators, CH showed the worst situation, indicating that the adoption of the set of good practices of handling evaluated in this study contributes to the reduction of calf losses and health problems in dairy herds, reducing the costs with veterinary care and the financial loss with calves deaths, which have an expressive impact on the dairy farms economic performance (Demir, Aydin, & Ayvazoğlu, 2019). These results challenge the expectation that just keeping dairy calves in individual pens is sufficient to reduce the risk of infectious disease transmission, making clear that there is a need for more investment and attention to define the proper handling procedures for dairy calves. For example, as reported by von Keyserlingk and Weary (2011) it is difficult to maintain a good standard of hygiene in collective facilities when compared to individual pens, but it is likely that the adoption of GPH implemented in this study would facilitate this, by allowing the calves to spend a period of time outside, in paddocks, mostly from 30 days of age, when they stayed all time on pasture.

It also should be taken into account that, despite of being acknowledged as essential to assure proper passive immunity through colostrum ingestion (Hulbert & Moisá, 2016), the calf's first meal was not under the control of calves' caretakers before the adoption of GPH procedures. Thus, there is a high probability that the action of offering an adequate amount of good quality colostrum in the first six hours after birth in bottles was crucial to reduce the number or severity of health problems and, consequently, the number of calves deaths, as previously reported by Swensson, Lundborg, Emanuelson, and Olsson (2003).

Despite of the importance of early identification of diseases to ensure good welfare for dairy calves (Mahendran et al., 2017), it is well known that it is not an easy task for dairy farmers (Whay, Main, Green, & Webster, 2003). This limitation may have been overcome after the adoption of GPH procedures, since it promoted a closer contact between handlers and calves, mainly when carrying on the tactile stimulation. This is because the closeness would facilitate the recognition of subtle changes in respiratory rate, stool consistency, and behaviour (e.g., signs of apathy and loss of appetite), which are signals of health problems, enabling handlers to adopt early care or treatments to solve them. In addition, it should be also taken into account that tactile stimulation can have a positive effect on calves' immune responses, as reported for rats (Solomon, Levine, & Kraft, 1968) and human infants (Ang et al., 2012). Therefore, our results oppose the notion that promoting physical isolation of dairy calves is sufficient to maintain them in good health, suggesting that the promotion of a closer contact with their caretakers is a better strategy to prevent or minimize disease severity.

Results from previous studies also indicated that the use of open-pails to milk-feed of dairy calves increase the risk of harming their welfare, since under such conditions calves are not able to express proper suckling behaviour, resulting in motivational and physiological disturbances, characterized by the expression of cross-suckling (abnormal) behaviour (de Passillé, 2001) and when the oesophageal groove close incompletely (Martín-Alonso et al., 2018). Thus, it is likely that using nipple-pails after the GPH adoption has contributed to reduce calves frustration (de Passillé, 2001), and to improve milk digestion, either by preventing milk from being fermented in the rumen (Kaba, Abera, & Kass, 2018) or by enhancing the production of digestive

enzymes (stimulated by suckling), which reduce the risk of osmotic diarrhoea caused by milk fermentation in the intestines (Quigley lll, Drewry, Murray, & Ivey, 1997).

Similar approach can be used when assessing the effect of gradual weaning. Previous results (Khan et al., 2007; Steele et al., 2017) indicated that its (singly) adoption leads to less stress and better calves performance; then, it can be assumed that it had also an important role in the promotion of calves welfare after the adoption of GPH procedures.

It is clear that we were not able to identify which one of the GPH procedures adopted in this study had the greatest positive impact on calf health and welfare, but we can hypothesize that the proximity between calves and their caretakers (which included physical contact), played an important role in reducing health problems and calves' deaths. Therefore, in a moment that the automation of livestock husbandry is replacing stockpeople work, further research is needed to check the importance of the close contact between humans and dairy calves on animal welfare and performance.

Conclusion

We conclude that the adoption of a set of good practices of handling (by combining the control of colostrum ingestion control, use nipple-pails, tactile stimulation, group housing, and progressive weaning) improved dairy calves' health and survival, resulting in a direct positive economic impact for milk producers due to the significant reduction in the costs of veterinary care and economic losses related to calf mortality.

The results also allow to conclude that isolating dairy calves, by raising them in individual pens, is not enough to ensure good health and survival if a set of good practices handling is not jointly adopted.

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References

Abuelo, A., Havrlant, P., Wood, N., & Hernandez-Jover, M. (2019). An investigation of dairy calf management practice, colostrum quality, failure of transfer of passive immunity, and occurrence of enteropathogens among Australian dairy farms. *Journal of Dairy Science*, *102*(9), 8352-8366. DOI: https://doi.org/10.3168/jds.2019-16578

Adamczyk, K. (2018). Dairy cattle welfare as a result of human-animal relationship – a review. *Annals of Animal Science*, *18*(3), 601-622. DOI: https://doi.org/10.2478/aoas-2018-0013

Ang, J. Y., Lua, J. L., Mathur, A., Thomas, R., Asmar, B. I., Savasan, S., Buck, S., Long, M., & Shankaran, S. (2012). A randomized placebo-controlled trial of massage therapy on the immune system of preterm infants. *Pediatrics, 130*(6), 1549-1558. DOI: https://doi.org/10.1542/peds.2012-0196

Barry, J., Bokkers, E. A. M., Berry, D. P., Boer, I. J. M., McClure, J., & Kennedy, E. (2019). Associations between colostrum management, passive immunity, calf-related hygiene practices, and rates of mortality in preweaning dairy calves. *Journal of Dairy Sciences*, *102*(11), 10266-10276. DOI: https://doi.org/10.3168/jds.2019-16815

Beaver, A., Meagher, R. K., von Keyserlink, M. A. G., & Weary, D. M. (2018). A systematic review of the effects of early separation on dairy cow and calf health. *Journal of Dairy Science*, *102*(7), 5784-5810. DOI: https://doi.org/10.3168/jds.2018-15603

Botteon, R. C. C. M., Botteon, P. T. L., Santos Júnior, J. C. B., Pinna, M. H., & Lóss, Z. G. (2008). Frequência de diarreia em bezerros mestiços sob diferentes condições de manejo na região do médio Paraíba – Rio de Janeiro e Minas Gerais. *Brazilian Journal of Veterinary Research and Animal Science*, *45*(2), 153-160. DOI: https://doi.org/10.11606/issn.1678-4456.bjvras.2008.26712

Costa, J. H. C., von Keyserlingk, M. A. G., & Weary, D. M. (2016). Invited review: Effects of group housing of dairy calves on behavior, cognition, performance and health. *Journal of Dairy Science*, *99*(4), 2453-2467. DOI: https://doi.org/10.3168/jds.2015-10144

Cruz, C. E. F., Raymundo, D. L., Cerva, C., Pavarini, S. P., Dalto, A. G. C., Corbellini, L. G., & Driemeier, D. (2011). Records of performance and sanitary status from a dairy cattle herd in southern Brazil. *Pesquisa Veterinária Brasileira, 31*(1), 1-9. DOI: https://doi.org/10.1590/S0100-736X2011000100001

Davis, R. B., Norberg, E., & Fogh, A. (2020). Estimation of genetic parameters for young stock survival on beef x dairy crossbred calves. *Animal*, *14*(3), 445-451. DOI: https://doi.org/10.1017/S1751731119002386

de Passillé, A. M. (2001). Sucking motivation and related problems in calves. *Applied Animal Behaviour Science*, *72*(3), 175-187. DOI: https://doi.org/10.1016/S0168-1591(01)00108-3

Demir, P. A., Aydin, E., & Ayvazoğlu (2019). Estimation of the economic losses related to calf mortalities Kars Province, in Turkey. *Kafkas Universitesi Veteriner Fakultesi Dergisi*, *25*(3), 283-290. DOI: https://doi.org/10.9775/kvfd.2018.20471

Fruscalso, V., Olmos Antillon, G., & Hötzel, M. J. (2020). Dairy calves' mortality survey and associated management practices in smallholding, pasture-based herds in southern Brazil. *Preventive Veterinary Medicine, 175*. DOI: https://doi.org/10.1016/j.prevetmed.2019.104835

Gulliksen, S. M., Lie, K. I., Løken, T., & Østerås, O. (2009). Calf mortality in Norwegian dairy herds. *Journal of Dairy Science*, *92*(6), 2782-2795. DOI: https://doi.org/10.3168/jds.2008-1807

Hulbert, L. E., & Moisá, S. J. (2016). Stress, immunity and the management of calves. *Journal of Dairy Science*, *99*(4), 3199-3216. DOI: https://doi.org/10.3168/jds.2015-10198

Hyde, R. M., Green, M. J., Sherwin, V. E., Hudson, C., Gibbons, J., Forshaw, T., Vickers, M., & Down, P. M. (2020). Quantitative analysis of calf mortality in Great Britain. *Journal of Dairy Science*, *103*(3), 2615-2623. DOI: https://doi.org/10.3168/jds.2019-17383

Kaba, T., Abera, B., & Kass, T. (2018). Esophageal groove dysfunction: a cause of ruminal bloat in newborn calves. *BMC Veterinary Research*, *14*(1), Article 276. DOI: https://doi.org/10.1186/s12917-018-1573-2

Khan, M. A., Lee, H. J., Lee, W. S., Kim H.S., Kim, S. B., Ki, K. S., Ha, J. K., Lee, H. G., & Choi, Y. J. (2007). Pre- and postweaning performance of Holstein female calves fed milk through step-down and conventional methods. *Journal of Dairy Science*, *90*(2), 876-885. DOI: https://doi.org/10.3168/jds.S0022-0302(07)71571-0

Mahendran, S. A., Booth, R., Beekhuis, L., Manning, A., Blackmore, T., Vanhoudt, A., & Bell, N. (2017). Assessing the effects of weakly preweaning health scores on dairy calf mortality and productivity parameters: cohort study. *Veterinary Record*, *181*(8), 196. DOI: https://doi.org/10.1136/vr.104197

Martín-Alonso, M. J., Cal-Pereyra, L. G., Fernández-Caso, M., & Gonzáles-Montaña, J. R. (2019). Anatomy, physiology, manipulation and veterinary applications of the reticular grove. Review. *Revista Mexicana de Ciências Pecuárias*, *10*(3), 729-755. DOI: https://doi.org/10.22319/rmcp.v10i3.4453

McConnel, C. S., Nelson D. D., Burbick, C. R., Wilson, E. A., Klatt, C. T., & Moore, D. A. (2019). Clarifying dairy calf mortality phenotypes through postmortem analysis. *Journal of Dairy Science*, *102*(5), 4415-4426. DOI: https://doi.org/10.3168/jds.2018-15527

McCorquodale, C. E., Sewalem, A., Miglior, F., Kelton, D., Robinson, A., Koeck, A., & Leslie, E. (2013). Short communication: Analysis of health and survival in a population of Ontario Holstein heifer calves. *Journal of Dairy Science*, *96*(3), 1880-1885. DOI: https://doi.org/10.3168/jds.2012-5735

Moran, J. B. (2011). Factors affecting high mortality rates of dairy replacement calves and heifers in the tropics and strategies for their reduction. *Asian-Australasian Journal of Animal Sciences*, *24*(9)*,* 1318-1328. DOI: https://doi.org/10.5713/ajas.2011.11099

Mota-Rojas, D., Broom, D. M., Orihuela, A., Velarde, A., Napolitano, F., & Alonso-Spilsbury, M. (2020). Effects of human-animal relationship on animal productivity and welfare. *Journal of Animal Behaviour and Biometeorology*, *8*(3), 196-205. DOI: https://doi.org/10.31893/jabb.20026

Quigley III, J. D., Drewry, J. J., Murray, L. M., & Ivey, S. J. (1997). Body weight gain, feed efficiency, and fecal scores of dairy calves in response to galactosyl-lactose or antibiotics in milk replacers. *Journal of Dairy Science*, *80*(8), 1751-1754. DOI: https://doi.org/10.3168/jds.S0022-0302(97)76108-3

Reimus, K., Alvåsen, K., Emanuelson, U., Viltrop, A., & Mõtus, K. (2020). Herd-level risk factors for cows and calf on-farm mortality in Estonian dairy herds. *Acta Veterinaria Scandinavica*, *62*(15)*,* 1-15. DOI: https://doi.org/10.1186/s13028-020-0513-x

Roland, L., Drillich, M., Klein-Jöbstl, D., & Iwersen, M. (2016). Invited review: Influence of climatic conditions on the development, performance and health of calves. *Journal of Dairy Science*, *99*(4), 2438-2452. DOI: https://doi.org/10.3168/jds.2015-9901

Solomon, G. F., Levine, S., & Kraft, J. K. (1968). Early experience and immunity. *Nature*, *220*, 821-822. DOI: https://doi.org/10.1038/220821a0

Steele, M. A., Doelman, J. H., Leal, L. N., Soberon, F., Carson, M., & Metcalf, J. A. (2017). Abrupt weaning reduces postweaning growth and is associated with alterations in gastrointestinal markers of development in dairy calves fed an elevated plane of nutrition during the preweaning period. *Journal of Dairy Science*, *100*(7), 5390-5399. DOI: https://doi.org/10.3168/jds.2016-12310

Stull, C. L., Messam, L. L. McV., Collar, C. A., Peterson, N. G., Castilho, A. R., Reed, B. A., ... VerBoort, W. R. (2008). Precipitation and temperature effects on mortality and lactation parameters of dairy cattle in California. *Journal of Dairy Science*, *91*(12), 4579-4591. DOI: https://doi.org/10.3168/jds.2008-1215

Swensson, C., Lundborg, K., Emanuelson, U., & Olsson, S-O. (2003). Morbidity in Swedish dairy calves from birth to 90 days of age and individual calf-level risk factors for infectious diseases. *Preventive Veterinary Medicine*, *58*(3-4), 179-197. DOI: https://doi.org/10.1016/S0167-5877(03)00046-1

Urie, N. J., Lombard, J. E., Shivley, C. B., Kopral, C. A., Adams, A. E., Earleywine, T. J., ... Garry, F. B. (2018). Preweaned heifer management on US dairy operations: Part V. Factors associated with morbidity and mortality in preweaned dairy heifer calves. *Journal of Dairy Science, 101*(10), 9229-9244. DOI: https://doi.org/10.3168/jds.2017-14019

Vinholis, M. M. B., Tupy, O., Pedroso, A. F., Primavesi, O., & Bernardi, A. C. C. (2006). *Avaliação dos impactos econômicos sociais e ambientais de tecnologias da Embrapa Pecuária Sudeste: Casinha tropical: abrigo móvel individual para bezerras* (Documentos, 58). São Carlos, SP: Embrapa Pecuária Sudeste.

von Keyserlingk, M. A. G., & Weary, D. M. (2011). Opportunities and challenges in dairy calf housing and management for the next decade. *Proceeding of the 2011 Cornell Nutrition Conference for Feed Manufacturers*. Ithaca, NY: Cornell University.

Walker, W. L., Epperson, W. B., Wittum, T. E., Lord, L. K., Rajala-Schultz, P. J., & Lakritz, J. (2012). Characteristics of dairy calf ranches: Morbidity, mortality, antibiotic use practices, and biosecurity and biocontainment practices. *Journal of Dairy Science*, *95*(4), 2204-2214. DOI: https://doi.org/10.3168/jds.2011-4727

Whay, H. R., Main, D. C. J., Green, L. E., & Webster, A. J. F. (2003). Assessment of the welfare of dairy cattle using animal-based measurements: Direct observations and investigation of farm records. *Veterinary Record*, *153*(7), 197-202. DOI: http://dx.doi.org/10.1136/vr.153.7.197

Zhang, H., Wang, Y., Chang, Y., Luo, H., Brito, L. F., Dong, Y., ... Liu, L. (2019). Mortality-culling rates of dairy calves and replacement heifers and its risk factors in Holstein cattle. *Animals*, *9*(10), 1-11. DOI: https://doi.org/10.3390/ani9100730