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Advantages and disadvantages with outdoor hutches as housing system for calves and their future effect on the replacement heifer

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Fördelar och nackdelar med kalvhyddor som inhysningssystem samt framtida effekt på kvigan

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Sammanfattning

Denna litteraturstudie har undersökt hur utomhushyddor för inhysning av mjölkkraskalvar kan ha positiv och negativ påverkan på kalven och eventuell framtida effekt på kvigan. Många vetenskapliga studier har visat att en god uppfödning av mjölkkraskalven är av stor vikt för att få fram en lönsam mjölkko. Den nyfödda mjölkkraskalven blir inom sina första dygn separerad från kon för att inhysas ensam eller i grupp med andra kalvar. Där ska den dricka mjölk från hink eller dia från artificiella spenar. Under de första månaderna ska den leva här men kan också bli sammanförd med andra kalvar. Att hålla kalvar i utomhushyddor under denna period kan ha många fördelar. Senare kommer kvigkalven att betäckas eller insemineras och bära sin första kalv. När dräktigheten når sitt slut går kvigan igenom sin första kalvning och blir diad eller mjölkad sin första producerade mjölk. Därefter går kvigan in i mjölkkobesättningen och blir en del av den största inkomstbringande djurgruppen på mjölkgården. För att få de bästa förutsättningarna med sig för detta är uppfödningen av stor vikt. En frisk kalv har en högre daglig tillväxt och växer till en högre vikt och kroppsstorlek än en kalv som varit sjuk under sin uppväxt. Kvigan kommer sannolikt att producera mer mjölk vid första och kommande laktation om hon inte var sjuk som kalv. I Sverige idag håller många mjölkproducenter kalvarna inomhus i ensambox, innan de flyttas till en större gruppbox, även den inomhus. Inhysning utomhus i kalvhyddor, där ventilation och luftfuktighet är naturlig, kan vara ett hälsosammare alternativ för kalvar. Nackdelar med denna inhysningsform finns också och är tillsammans med fördelarna presenterade i denna litteraturstudie.

Abstract

This study has investigated how outdoor hutches for housing dairy heifer calves will have negative and positive effects on calf development. Many studies have shown that an optimal rearing of the young calf is of great importance to up bring a profitable dairy cow. The dairy calf and growing heifer is subject for a great scientific interest. Within its first days the young animal will be separated from the dam. Then during a few months it will be kept individually or collectively with other calves and drink milk from buckets or suckle from artificial teats. Housing calves in hutches during this period can have many advantages. Later she will be impregnated and carry her own calf. When her pregnancy comes to its end she will in only a day go through her first calving and get milked or suckled her first produced milk. Thereafter she will enter the most important income bringing part of the dairy farm. To get the optimal prerequisites for the lactation period, the rearing is of great importance. A healthy calf will have a higher average daily gain, and grow to a higher weight and stature. The heifer is more likely to have a higher milk yield at first and future lactations if she was not ill as a calf. Many dairy producers in Sweden keep calves in pens inside a stable. Housing outside in hutches, where ventilation and humidity is natural, can be a healthier alternative for calves. Some disadvantages from housing calves outside in hutches do exist and is also discussed.

Introduction

In a beef cow production the calf is generally housed with the dam and feeds from her. On a dairy farm the milk from the cow is not intended entirely for her calf, but for being sold and made profit from. The calf is instead reared by the human. In what way this is conducted is diverse.

The mean herd size of dairy cattle is increasing globally with no exception for Swedish herds (International Farm Comparison Network, 2007; Jordbruksverket, 2012). This increases the demand of replacement heifers in most farms. Many properties of the heifer are of economic value when the heifer becomes a dairy cow. Age at first calving, udder health and animal health, milk yield and feed efficiency is important parameters for the economics of dairy production (Andersson, 1996; Pettersson et al., 2001). The link between an optimal rearing of the calf and an economically profitable cow is being scrutinized by the dairy cattle industry. The feeding of colostrum, milk or milk replacers, age and procedures at weaning and the genetic capacity of the calf and of course housing systems from birth to first breeding and onwards to first calving is important rearing components (Davis & Drackley, 1998). Housing is interesting since a variety of systems is used and also because new systems, such as the individual outdoor hutch are increasing in popularity in Sweden. A recent thesis by Nilsson (2012) investigated the effect on calf health after changing from indoor housing in insulated barn to outdoor hutches. The health unambiguously improved outside. My literature study aims to discuss advantages and disadvantages from using calf hutches in dairy herds. It will also investigate how housing in hutches might influence the replacement heifer. References have been made to international studies, peer-reviewed papers, books and short interviews.

Literature Study

From calf to cow

In figure 1, time periods in the life of a dairy cow with housing systems most used in Sweden is shown. Information on systems in general and during which period the hutch can be favourably used has been collected from studies by Marcé et al. (2010) and Pettersson et al. (2001).

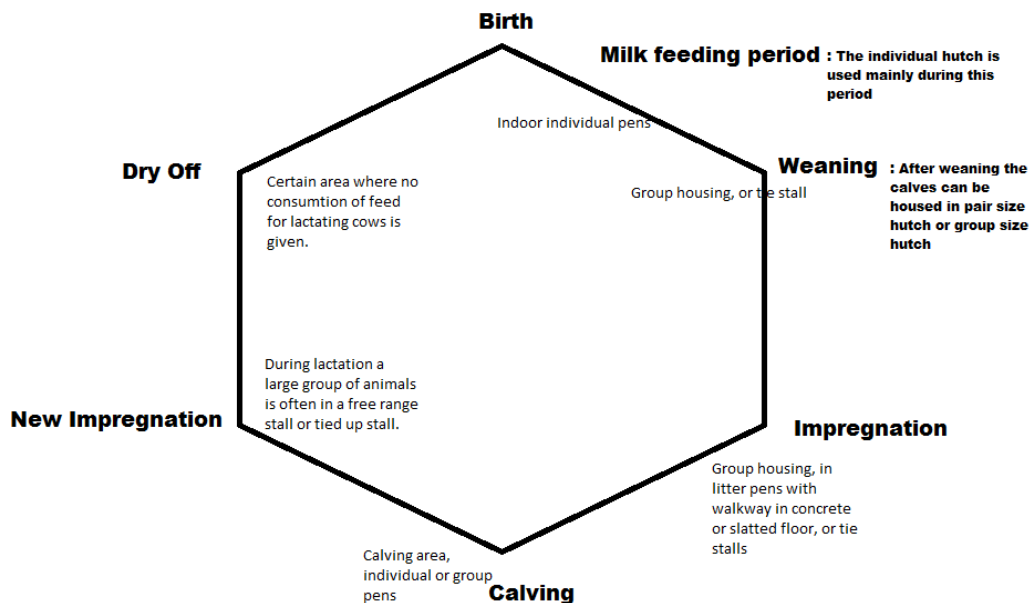


Figure 1. This hexagon shows important events in the life of a dairy cow, from birth to first and further lactations.

During the first period of age comprising the period until weaning the animal is referred to as a neonatal calf or calf. In what way the dairy calf is reared and with what course of actions is diverse across Europe and also within the countries (Marcé et al., 2010). In Sweden the predominant system for calves up to two weeks of age is individual indoor pens (Marcé et al., 2010; Pettersson et al., 2001). Outdoor hutches for calves was yet only used by approximately 3 percent of Swedish dairy herds when an investigation of housing systems for calves was published in 2010 (Marcé et al., 2010). Indoor individual pens can be situated along with other animals of varying age or in a separate barn. At two to three weeks of age, the calf in many farms is moved to a group pen, which rationalizes the work for each calf (Marcé et al., 2010). Other farmers choose to keep calves individually for an average of eight weeks before moving calves together in a group pen. Feeding can be done automatic with mixers and computerized recognition of individual calves. Feeding can also be manually with buckets and caretakers managing the distribution or at ad lib. with different kinds of milk feeders. Calves can be fed milk, acidified milk or milk replacers or acidified milk replacers (Weber Nielsen & VandeHaar, 2007). From weaning to impregnation and to first calving the female calf is referred to as a heifer. When she gives birth to her first calf and enters her first period of lactation she becomes a dairy cow. Around weaning and until first calving different systems can be used including certain grazing period or periods (Bach et al., 2009; Pettersson et al., 2001). During all periods the animal needs certain attention, managing and housing. Legal restrictions, traditions and farm specific factors interact and make the outcome of the housing system chosen for the young animals (Andersson, 1996).

The outdoor hutch system

Commercial outdoor hutches are a fairly new housing system for Swedish dairy calves that is gaining increasing interest by farmers. Outdoor pens for preweaned and weaned calves have been evaluated now and in the past in Sweden (Nilsson, 2012; Gauffin & Ringmar, 1988). In the thesis by Gauffin and Ringmar (1988), homemade outdoor hutches for calves were evaluated. In the thesis it is stated that outdoor hutches for rearing calves in Sweden was, at that time, uncommon. However, hutches was widely used, e.g. in the United States (Gauffin & Ringmar, 1988). One indication of an increased interest in hutches in Sweden is the installation of outdoor hutches during the winter of 2012/2013 at the dairy cow facility of the Swedish University of Agricultural Sciences (SLU).

The plastic outdoor calf hutch origins from North America, where it has been used commercially since the 1970's (Hoshiba, 1986; Otterby & Linn, 1981). The commercial hutch comes in different shapes and sizes. From individual and pair-size hutches to group size, which can fit 4-20 calves (Davis & Drackley, 1998; Calf-Tel, 2015; Gådsby Iglu AB, 2015). An outside enclosure can be added to the hutch to extend the living area. Thus a simple hutch or a hutch with an open air enclosure is available. Hutches from different brands and in varying price-range are available on the market. The commercial type of the outdoor hutch in polyethylene or fiberglass, has made it easier for farmers to house calves outside since no homemade constructions have to be made. The material of commercial hutches is also easy to clean and might be sturdier than homemade options (Davis & Drackley 1998). Macaulay et al. (1995) made a comparing study on 30 Holstein calves, during their first 8 weeks of life, randomly assigned to 3 different outdoor systems. The study compared conventional wooden hutches, enclosed moulded polyethylene domes, and

thermomolded opaque polymer hutches with ridge-top ventilation systems. The conclusion was that no difference in growth, feed intake, blood physiology, and behaviour was seen (Macaulay et al., 1995). Thus the authors state that there is no great difference in calf performance due to hutch type.

In warm climates the hutch provides shade and sun protection. In cold weather the hutch keeps slightly higher temperature than outside and provides protection to wind (Hill et al. 2010). The hutch fulfils the recommendation of keeping calves individually with visual contact with other calves (Bach et al., 2009). When Marcé et al. (2010) assessed the risk factors for the main infectious calf diseases in different housing types, outside hutches gave a lowered risk, compared to most housing systems, from birth to weaning. However Hill et al. (2011) found that airborne bacteria concentrations were lower in inside nursery pens, naturally ventilated and with fans during summer months, than in outside hutches either individual or group hutches with four calves. Different conclusions on outside hutches in different types of studies make it difficult to evaluate the profits or losses from their use. Below some advantages and disadvantages of using hutches as calf housing is listed and explained.

Advantages of housing in hutches

Many advantages from housing calves in outdoor hutches have been shown in studies on calf management. From early studies (Waltner-Toews et al. 1986; Jorgensen et al. 1970; Davis et al., 1954) significant results on the advantages of housing calves in hutches versus inside pens and stalls are found. Also recent studies show positive effects from hutches as housing (Marcé et al. 2010, Nilsson, 2012).

Health

Bacteria concentration in feces, illness and mortality amongst calves has been proved to be lower in outdoor hutches than inside barns (Tomkins et al., 1994; Quigley et al., 1994; Nilsson, 2012). These are all health advantages that are of importance to the farmer (Davis & Drackley, 1998). In Eastern Ontario, Canada, Holstein bull calves housed outside in hutches or housed inside in elevated stalls was studied. If a calf suffered from illness, such as scours, respiratory problems or high rectal temperature it was treated with antibiotics or a special treatment for scours. In average the hutch calves required one treatment per calf during their first 49 days of life while inside barn calves was treated in average 3.5 times per calf (McKnight 1978). A lower number of treatments of calves kept in outside hutches were also seen in the study by Tomkins et al. (1994). As well, the severity of scouring was less in those calves kept in hutches. Hutches as housing system gave a lowered risk of common calf infectious diseases when Marcé et al. (2010) assessed risk factors connected to housing of calves.

When new facilities for calves was built at Nötcenter Viken in Falköping, Sweden, a study was made to compare the new housing to the older isolated barn with natural ventilation (Nilsson, 2012). The new housing consisted of individual hutches for calves up to 10-17 days. After that age calves are kept in group hutches of 10-14 calves. Of calves housed outside in hutches 36.8% were reported ill compared to 63.7% for calves kept inside in pens.

Pneumonia was a common diagnose and as many as 56% of calves in the inside stable was reported to have pneumonia while only 25% of the calves kept outside were diagnosed with pneumonia. A significant difference in cases of diarrhoea was found between calves housed outside and calves housed inside. Outside calves had a rate of 21.3% diarrhoea cases. The rate in inside barn calves was 30.5% for diarrhoea. The rate of mortality was 3.5 % in the inside pen and 3.1 % in the outside hutches. Studies that support these, fairly recent, results range from 1950's to today (Davis et al., 1954; Hill et al., 2011).

The individual hutch keeps calves separated and prevents pathogens to spread from contact. The hutch that is situated outside provides fresh air for the calf, which is a great advantage, since pathogenic bacteria is in low concentrations in the open air (Hill et al., 2011). Contaminants in the air is not circulated and shared by all calves. Ola Shultzberg (2013) believes that hutches are more likely to provide a low pathogenic environment and a very good air quality than other facilities (2013 personal message). He states that it seems easier to attain a good health status outside.

Environment

The calf generally tolerates lower temperatures but can be sensitive to hot climates and humid surroundings. The stress of being warm is said to be greater than being cold (Hill et al. 2011). Calves kept in hutches during winter months, where temperatures reached as low as -12° C, have been reported to have a higher average daily weight gain (ADG) than calves kept inside a warm barn, with a steady temperature of 20° C (Tomkins et al. 1994). This study was made in Wisconsin, USA.

An obvious advantage in hutches with outside enclosures is the separation of calves with maintained visual contact. This prevents disease transmission between calves from touching licking or suckling at one another. The visual contact is a social interaction which is needed for the welfare of the animals (Rushen et al., 2008). In Sweden it is required for calves to have physical contact with other calves or livestock (Jordbruksverket, 2014).

Disadvantages of housing in hutches

Disadvantages from housing calves in hutches have also been proved. These should be considered and taken into account when deciding what housing system will be used for raising dairy calves.

Growth

In a comparative study of an indoor nursery and outdoor hutches, where calves were housed from the age of 2 days until 56 days of age, average daily weight gain (ADG) of calves housed indoors was 6 percent higher. Final weight gain (56 days) was highest for calves kept in indoor pens and lowest for calves in hutches (Hill et al. 2011). If bedding material in the hutch was sand even lower average daily gain was measured. Final body weight was lowest for calves raised in an outside hutch bedded with sand, compared to hutches bedded with straw and inside nurseries bedded with sand or straw. In a trial concerning calf performance during summer and winter

season in Eastern Ontario, Canada, calves in outside hutches during the winter months grew slower than calves in inside an insulated barn (McKnight, 1978). However during the summer season one year earlier calves housed outside had significantly greater ADG than the calves inside. According to Pettersson et al. (2001) housing in hutches can give a lower average daily gain and feed efficiency. In a Norwegian study (Næss et al. 2007) it was found that average daily weight gain of calves 2-4 weeks old reared in hutches ranged from 0 g/day to 900 g/day.

Bedding

Studies on bedding material in outside hutches are few, but show that hygienic quality can be a problem compared to inside pens. The bedding material in hutches had a lower dry matter content than the bedding in an inside nursery when Hill et al. (2011) evaluated bedding material and housing. If straw was used as bedding its dry matter content was 83% inside and 78% outside, if sand was used dry matter content was even lower outside, 71%. Hutches and sand was a poor combination. Calves housed in outside hutches with sand as bedding had more days with abnormal feces, lower intake of a solid feed mix and a lower ADG compared with calves housed inside bedded with straw. During some mornings it was also observed that calves were possibly colder when kept outside on sand, in comparison with those bedded with straw outside or inside the barn.

If hutches are not sheltered from wind and precipitation the main opening of the hutch can allow bedding to get wet. Snow shovelling and cleaning hutches from wet bedding material will be necessary. The bedding material should at all times be kept dry (Davis & Drackley, 1998). According to a study on insects in bedding of outdoor calf hutches (Shmidtman et al., 1991) straw as bedding can promote occurrence of fly larvae in the hutch. The study investigated the frequency of two fly species. Straw as bedding held the most maggots in outside hutches. Sawdust was the bedding material recommended for outside hutches during summer months to keep fly invasion low and to provide calves with satisfactory bedding.

Cost

A large cost with only long term benefits is labour cost for care taking and managing calves. The Norwegian study by Næss et al. (2007) shows that average daily labour time for calves outside in hutches could be 1.2 min/calf but could increase to 3.6 min/calf if certain attention to calves was needed. Also weather conditions could imply certain work which would prolong labour time. Precipitation during winter such as snow, hail and rain can constitute a hardship for caretakers, and prolong daily maintenance. Labour time was measured in the study by McKnight (1978), it was shown that inside kept calves took in average half the time to care for than those outside in hutches. The cost of feed will also be affected if feed efficiency is lower outside. As mentioned above, ADG can be lower outside, and this will give higher cost for feed.

Environment

A study that shows how bacteria concentration was larger in hutches is that made by Hill et al. (2011). Here, bacteria concentrations (cfu/m³) measured outside in hutches were more than 6 times higher than inside a naturally ventilated nursery. Behaviour in hutch kept calves due to outside environment, which is disadvantageous, was seen by Næss et al. (2007). During windy winter days (-4 to -7° C and wind speed 4-12 m/s) calves did not leave the inside area of the

hutch. This means that no food or water was consumed. Calves were instead herded to reassure eating and drinking. Young calves, 3 weeks and under, was seen shaking when eating in the outside area. Temperatures were -4 to -7 ° C and wind speed 4-12 m/s. The same study experienced freezing of milk in the pipes from milk feeders. Thus these outside hutches had problems during winter (Norway).

Future effects on the heifer from housing during calfhood

Waltner-Toews et al. (1986) made important studies on relations between housing and health of calves and heifers. Their research showed that housing of calves and heifers will affect performance and health of the adult animal. Later research, by Heinrichs et al. (2005) has made it more evident that housing along with other management factors will affect calf body condition and future performance. Two extensive studies by Heinrichs et al. (2005) and Heinrichs & Heinrichs (2010) on calf factors and their effects on first-time lactation and future lactations show interesting results. Life time production was not affected by heifer weight at first calving. But first lactation production was affected by this and also from illness before four months of age. When trying to bring up a dairy cow for a high milk production, a healthy start in life seems to be of importance. The studies state that days with respiratory disease or scours during the first four months affected first lactation production and later lactation production negatively. Also weight and age at first calving affected both first and later lactations. First lactation production of a heifer was negatively affected by days of illness as a young calf. A young calf was in these studies defined the period from birth to four month of age. Heinrichs et al. (2005) concludes that a proper managing and rearing of neonates and young calves is important since events and handling in early life can have long-term impacts on later life of the heifer. Housing factors that affect health and growth of calves will have affect up to first calving and first lactation. Heifers that calve at about twenty-four months of age and not much later are economically preferable. Due to costs for feed during non-pregnancy, space, care taking, and possible veterinary costs it will be more profitable to get heifers pregnant in good time in order to shorten the rearing time (Hoffman & Funk, 1992). It is concluded by Hoffman and Funk (1992) that reducing costs on dairy farms can be achieved by shortening the time before first calving for heifers. According to research on Holstein calves in New York dairy herds, heifers that as calves had no respiratory illness calved 6 months earlier than did calves that suffered from respiratory illness (Correa et al., 1988). In the earlier studies by Waltner-Toews et al. (1986) ill calves treated for scours were more likely to calve at an age of 30 months or older. Calves that had suffered from pneumonia during their first 3 months of life were more likely to die after this period than did calves not ill and treated for respiratory illness.

Discussion

This literature review shows that different and sometimes contradictory results concerning management of calves and outdoor hutches are found in scientific papers. Many studies made before the 21st century had greater ADG and feed efficiency and fewer ill calves when observing calves outdoors in hutches compared to those housed in stables (Jorgensen et al., 1984, Davis et al., 1953, McKnight, 1978). More recent studies more often show opposite or both positive and negative results from housing calves in hutches. In the comparative study by Hill et al. (2011), the nursery was superior in many measurements. Many parameters of measuring was far more satisfactory in the inside nursery. However, the hutches in this study might not have been

managed ideally. Was there perhaps different ways of tending to the calves outside and inside? In the field study on housing calves and its residual effects on health and growth, it is stated that a poor indoor environment compared with a superior outdoor facility will unquestionably be less favourable (Hill et al., 2011). The authors also discuss older scientific studies and argue that barns used in these might have been poorer in ventilation and hygienic conditions than modern new ones.

There might be great variation within the same type of housing between farms. Bedding material, feeding routines, ventilation, and access to fresh water are all part of the housing system and will all affect any type of facility. Any farmer who is keen on caring and managing animals with the highest possible care, will achieve good results from most housing systems (Schultzberg, 2013). Therefore studies that have used several farms in their material, such as Heinrichs et al. (2005) might have had different conditions in the same housing type. Straw as bedding material in the pen (inside box or outdoor hutch) was shown to have positive effects on calves in a study by Hill et al. (2011). Sand as bedding in the hutch or pens gave slightly lower average daily gain, intake of concentrate, feed efficiency and days with normal feces. The calves who grew heaviest and biggest, measured by hip width, was calves in an inside pen bedded with straw. This means that straw as bedding, whether it is outside in pens, or inside, is a good bedding material, which will affect the calf and further the heifer, positively. Therefore availability of straw should be a factor to consider if hutches should be used as calf housing.

In the thesis by Gauffin and Ringmar (1988), insect problems in the hutches during the summer months are addressed. Potent pesticides and special insecticide ear disks are recommended. Earlier studies such as this might have prerequisites that are not legally allowed today. The climate in which studies of hutches has been performed might require means to keep hutches functional, such as pesticides. If the system does not function without these means it is crucial that all applicators of the system have, and will in the future have, access to such. The hutches in this study were far more enclosed than the plastic hutch. A higher temperature inside the hutch than inside a commercial polyethylene hutch is most likely to have been attained. Thus all outdoor systems are not comparable. It might be interesting to further investigate not only outdoor vs. indoor housing but also outdoor vs. outdoor, since a variety of hutch types can be used. If the decision to house calves outside is made based on results from scientific studies also studies which investigate differences in such systems should be considered. However, from the study of three housing types, all outdoors, no differences was found amongst calves (Macaulay et al., 1995). Still, since a range of shapes and sizes, and possibilities to position calf hutches exist, more studies need to be taken into account or be made.

First lactation milk production is affected by illness as a calf (Heinrichs et al., 2005) which according to some studies (McKnight, 1978; Marcé et al., 2010) is not as frequent amongst calves housed outdoors. Also body weight of the heifer at first calving affected first-lactation. Since calves have been proved to have lower ADG outside, calves could take longer time to reach a desired weight for mating or artificial insemination. This means that a higher age at first calving could occur for calves reared in hutches. Death and culling is proven to be affected by housing factors (Waltner-Toews et al., 1986). It is evident that housing outside in hutches will affect the heifer and her being more or less profitable as a dairy cow. Cost for purchase of hutches, care taking outside and a lower feed efficacy can affect the total cost of the upbringing of the dairy

heifer. If she is healthy and has as early first calving this can reduce cost and lead to a higher first lactation production. Many studies that compares outside housing to inside housing shows a lower degree of illness (Nilsson, 2013), treatments (McKnight. 1978) and deaths of calves in outside hutches. However they still do exist and it is important to know that this system is not flawless. One must still fight disease and death rate amongst calves housed outside in hutches. Hutches cannot be considered a safe investment in order to eliminate sick calves; it is no “quick-fix” (Distriktsveterinärerna Tomelilla, 2015).

Conclusion

The rearing of the dairy calf is globally different and different housing systems are in use (Marcé et al, 2010). Which housing system for calves any given farm should use is not perfectly clear. A poor indoor environment exchanged for outdoor hutches will probably improve calf health. The outdoor system will obviously not improve the calf health if inappropriately managed. Many advantages can be achieved from housing calves in outdoor hutches if managed properly. Some disadvantages with outdoor hutches can be costly and can be difficult to avoid. From this study some proof of how healthy calves have a higher chance of becoming profitable dairy cows has been presented.

References

- Andersson, T. 1996. Rekryteringskvigor för mjölkproduktion - uppfödningens betydelse för produktion. Thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden.
- Bach, A., Ahedo, J., Ferrer, A. 2009. Optimizing weaning strategies of dairy replacement calves. *Journal of Dairy Science* 93, 413-419.
- Calf-Tel, Hampel Animal Care, 2015. www.calf.tel.com
- Correa, M.T., Curtis, C.R., Erb, H.N., White, M.E. 1988. Effect of calthood morbidity on age at first calving in New York Holstein herds. *Preventive Veterinary Medicine* 6, 253-262.
- Davis, C. L., Drackley, J. K. 1998. *The Development, Nutrition, and Management of the Young Calf*. Ames, Iowa: Iowa State University Press. 179-206.
- Davis, L.R., Autrey, K.M., Herlich, H., Hawkins, G.E. 1954. Outdoor individual portable pens compared to with conventional housing for raising dairy calves. *Journal of Dairy Science* 37, 562-570.
- Distriktsveterinärerna. Juni 2015. Tomelilla. Personligt meddelande. Jordbruksverket
- FOKUS Mjölkkons hälsa och produktion. Februari 2013. Svensk Mjolk. www.svenskmjolk.se
- Gauffin, E., Ringmar, E. 1988. Hyddor till spädkalvar – en pilotstudie under vintern 1987/1988 I Uppland. Thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden.
- Gårdby Iglu AB, 2015. www.gardsbyiglu.se
- Heinrichs, A.J., Heinrichs, B.S., Harel, O., Rogers, G.W., Place, N.T. 2005. A Prospective Study of Calf Factors Affecting Age, Body Size, and Body Condition Score at First Calving of Holstein Dairy Heifers. *Journal of Dairy Science* 88, 2828-2835.
- Heinrichs, A.J., Heinrichs, B.S. 2011. A prospective study of calf factors affecting first lactation and lifetime milk production and age of cows when removed from the herd. *Journal of Dairy Science* 94, 336-341.
- Hill, T.M., Bateman II, H.G., Aldrich, J.M., Schlotterbeck, R.L. 2011. Comparison of housing, bedding and cooling options for dairy calves. *Journal of Dairy Science* 94, 2138-2146.
- Hoffman, P.C., Funk, D.A. 1992. Applied dynamics of dairy replacement growth and management. *Journal of Dairy Science* 75, 2504-2516.
- Hoshiba, S. 1986. Environmental characteristics of calf hutches. Department of Agricultural Engineering, Faculty of Agriculture, Hokkaido University. Japan.
- International Farm Comparison Network (IFCN) Dairy Report. 2007. <http://www.ifcnnetwork.org/extern/downloads/pdf/DR07-web.pdf>
- Jordbruksverket. 2014. Kalvning och kalvar. Sverige. www.jordbruksverket.se.
- Jordbruksverket. 2012. Sveriges officiella statistiska meddelanden, Antal företag med mjölkkor efter besättningsstorlek i juni 2012. Sverige. www.jordbruksverket.se.
- Jorgensen, L.J., Jorgensen, N.A., Schincoethe, D.J., Ownes, M.J. 1970. Indoor versus outdoor calf rearing at three weaning ages. *Journal of Dairy Science* 53, 813-816.
- Macaulay, A.S., Hahn, G.L., Clark, D.H., Sisson, D.V. 1995. Comparison of calf housing types and tympanic temperature rhythms in Holstein calves. *Journal of Dairy Science* 78, 856-862

- Marcé, C., Guatteo, R., Bareille, N., Fourrichon, C. 2010. Dairy calf housing systems across Europe and risk for calf infectious diseases. *Animal* 4:9, 1588-1596.
- McKnight, D.R. 1978. Performance of newborn dairy calves in hutch housing. *Canadian Journal of Animal Science* 58, 517-520.
- Naess, G., Solheim Hansen, H., Dagunn, O.M., 2007. Utendørs oppdrett av kalver i iglo-system. Proceedings from the conference Calf Management, Norway, 117-125.
- Nilsson, A. 2013. Calf health before and after change of housing system - isolated barn vs. Hutches. Thesis. Swedish University of Agricultural Sciences, Skara, Sweden.
- Otterby, D.E and Linn, J.G. 1981. Advances in nutrition and management of calves and heifers. *Journal of Dairy Science* 64, 1365-1377.
- Pettersson, K., Svensson, C., Liberg, P. 2001. Housing, feeding and management of calves and replacement heifers in Swedish dairy herds. *Acta vet. scand.* 42, 465-478.
- Quigley, J.D., Martin, K.R., Bemis, D.A., Potgieter, L.N.D., Reinemeyer, C.R., Rohrbach, B.W., Dowlen, H.H., Lamar, K.C. 1994. Effects of housing and colostrum feeding on serum immunoglobulins, growth and fecal scores of Jersey calves. *Journal of Dairy Science*
- Rushen, J., de Passillé A.M., von Keyserlingk, M.G., Weary, D.M. 2008. *The welfare of cattle.* Springer Science & Business Media. The Netherlands.
- Schmidtman E.T. 1991. Suppressing Immature House and Stable Flies in Outdoor Calf Hutches with Sand, Gravel, and Sawdust Bedding. *Journal of Dairy Science* 74, 3956-3960.
- Schultzberg, Ola. Mars 2013. Personligt meddelande. Leg. veterinär. Växa Sverige.
- Tomkins, T., Sowinski, J., Drackley, J.K. and J. K. 1994. The influence of energy level in milk replacer on performance of male Holstein calves raised in two different environmental conditions. *Journal of Animal. Science* 72 (Suppl. 2):49.
- Waltner-Toews, D., Martin, S., Meek, A.H et al. 1986. The effect of early calfhood health status on survivorship and age at first calving. *Canadian Journal of Veterinary Research* 50, 314-317.
- Weber Nielsen, M.S., VandeHaar, M.J. 2007. Group housing and feeding of calves. *Michigan Dairy Review.* Departement of Animal Science.

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