Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science

Factors affecting the heifer´s age at pregnancy

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Faktorer som påverkar kvigans ålder vid dräktighet

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Abstract

Several factors affect the heifer´s growth and development, the newborn calf´s feeding of colostrum during its first hours of life is one important factor. The colostrum contains higher amount of immunoglobulins and insulin growth factors compared to matured milk. A high intake of immunoglobulins from colostrum results in a high blood concentration of immunoglobulins until the age of eight months. This leads to a lower incidence of diseases that can affect the growth and development negatively. Diarrhea is the most common disease in calves younger than 30 days. An infected heifer calf is three times more likely to calve at an age older than 30 months compared with a healthy calf. At the age of 3-7 months almost half of all heifers get pneumonia which can result in a delay of the first calving with three months.

Every month after the age of 24 months when the heifer has not had her first calf is unnecessary rearing cost which can affect the producer´s economy negatively. This review showed that access to roughage and concentrate, the intake and quality of colostrum, feeding intensity, diarrhea, pneumonia, housing system and the possibility of estrus detection affect the heifers age of first calving. All factors can be regulated by the producer. If first calving occurs at the age of 24 months and the heifer has attained the right weight this will result in an improved economy.

Sammanfattning

Flera faktorer påverkar kvigans tillväxt och utveckling, den nyfödda kalvens utfodring av råmjölk under de första levnadstimmarna är en viktig faktor. Halten av immunglobuliner och insulinliknande tillväxtfaktorer är högre i råmjölk än i vanlig mjölk. Ett högt intag av immunoglobulin från råmjölk resulterar i en högre koncentration av immunglobuliner hos kalven ända fram tills åtta månaders ålder. Detta leder till lägre uppkomst av sjukdomar vilka annars kan påverka kalvens tillväxt och utveckling negativt. Diarré är den vanligaste sjukdomen hos kalvar yngre än 30 dagar. En kalv som har insjuknat löper tre gånger så stor risk att kalva in efter 30 månaders ålder jämfört med en frisk kalv. I åldern 3-7 månader drabbas nästan hälften av alla kvigor av lunginflammation vilket kan resultera i att kvigan kalvar in tre månader senare än friska kalvar.

Varje månad efter 24 månaders ålder då kvigan inte har kalvat in är en onödig uppfödningskostnad vilket kan påverka producentens ekonomi negativt. Litteraturöversikten visade att tillgång till grovfoder och kraftfoder, mängd konsumerad råmjölk och råmjölkens kvalité, utfodringsintensitet, diarré, lunginflammation, inhysningssystem och möjligheten till brunstkontroll påverkar kvigornas inkalvningsålder och att alla dessa faktorer kan påverkas av producenten. En inkalvningsålder vid 24 månaders ålder och då kvigan har nått rätt vikt leder till bättre ekonomi.

Introduction

Fertility is the basis for milk production and the growth is important to achieve the correct weight at first calving. Not all calves grow up to become heifers able to reproduce, as much as 11.6% of heifers from the 25% best producers in Sweden fail to reproduce (Hallén- Sandgren & Christvall, 2011). Some heifers needs more time to fully mature and attain enough weight for insemination. It is the weight rather than the age that determines the time of sexual maturity. At the age of 12 months the heifer should have attained 40% of adult weight and be sexually mature (Växa Sverige, 2013).

In Sweden, average age of first calving is 28 months. Because the gestation period for a cow is nine months, this means that the average insemination occurs at the age of 19 to 20 months. The general view is that first insemination should occur around the age of 15 months and thereby first calving would take place at the age of 24 months. Since heifers generally are more fertile than cows, only a few inseminations should be required. The producer's vision of first insemination at the age of 15 month differs a lot from the average age of first insemination. The higher age of first calving is very costly for the producer and recruitment of new heifers is one of the highest costs in milk industry (Oskarsson, 2010).

The problems with getting a heifer pregnant might depend on many different factors that occur early in the heifer's life. The calf´s access to colostrum will influence the immune defense and might determine the young heifer's health and growth. The heifer´s time for sexual maturity and weight are strongly correlated and thereby growth is the most important factor to work with. Two common diseases, which give rise to troubles for young calves, are pneumonia and diarrhea. Do these diseases decrease growth and by that, delay the date of insemination? Can they affect the possibility of pregnancy? That weight and sexual maturity are correlated is known but can the amount of body fat affect the possibility of growth and pregnancy?

The purpose of this review is to learn more about these questions and as a result discuss how to increase the number of heifers pregnant and lower the age at first insemination and thereby the age of first calving. This review will focus on the breeds Holstein and SRB, which are the most common breeds within milk production in Sweden.

The heifer´s development

Newborn to the age of three months

The newborn calf can only receive nutrition from the milk, the milk is transported via the esophageal groove directly to abomasum without passing the reticulo-rumen. The esophageal groove is created when muscles from the end of esophagus until the opening of omasum constricts. (Davis & Drackley, 1998). The constriction is stimulated by the calves suckling and is therefore not present in adult animals (Comline & Titchen, 1951). At birth the calf´s forestomach has different proportions compared with the adult animals. Reticulo-rumen stands by birth for 38% of the fore-stomachs total weight, omasum 13% and abomasum 49%. The

abomasum is growing in the same rate as the rest of the body but the development of the other stomachs are affected by the diet. In order to develop the fore-stomachs volume, absorption capacity and musculature, dry feed is required. Both hay and grain are needed. Hay stimulates development of
musculature and volume whereas grain stimulates the absorption capacity (Davis & Drackley, 1998). To acquire fully developed stomachs the calf requires roughage and concentrate from its first week of life (Fungbrant, 2012). An increase of roughage and concentrate increases the growth of microbes, which produce volatile fatty acids (VFA) and the VFAs stimulate growth of the rumen epithelium. By the age of 12-16 weeks the proportions are changed and reticulo-rumen stands for 67% of the fore-stomachs total weight, omasum 18% and abomasum 15% (Davis & Drackley, 1998). The changes can be seen in the picture below which truly indicate how the stomach use is changing. Calves which are not fed with roughage and concentrate will have poorly developed stomachs with smaller papilla (Växa Sverige, 2013), which can result in a reduced growth.

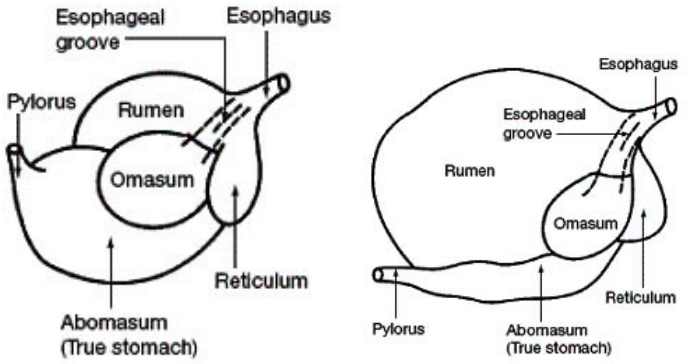

Figure 1. To the left, the calf´s stomach, to the right, the adult animal´s stomach.
From the Ontario veal association (2013).

The time for weaning is regulated by the calf´s weight and should occur at a weight of 100 kg, which usually happens by the age of eight weeks (Fungbrant, 2012). Weaning too early can result in a dip in the calf´s growth (Lindfors, 2000). By the time of weaning there are great changes in the calf´s environment and feed which can stress the calf with diseases as consequence (Hickey et al., 2003).

Three months until pregnancy

In heifers, the puberty usually begin at the age of nine to eleven months (Sejrsen & Purup, 1997) This is because hypothalamus stimulates the production of gonadotropin releasing hormone (GnRH), which stimulates an increased concentration of luteinising hormone (LH) and follicle stimulating hormone (FSH). An increased concentration of LH and FSH stimulates the ovaries´ production of estrogen and progesterone, which in turn stimulates an increased secretion of growth-hormone. During puberty there is a massive body growth, which is indirectly controlled by LH and FSH (Thompson, 2012). A lack of LH and FSH can occur because of a low feed intake and result in a decrease of estrogen and the heifer´s development fades. The estrogen secretion stabilises at the moment the heifer´s energy balance is positive (Durrell, 1955).

The weight at sexual maturity is different between breeds, for example a heifer of the Holstein breed has a weight of 245 kg and a heifer of the breed Swedish Red Breed (SRB) weigh 260 kg (Karlsson & Dieden, 2007). Wathes et al., (2007) shows that heifers who failed pregnancy at the age of 15 months were lighter at nine months of age than those who became pregnant. Moreover had heifers with poor development at the age of six to nine months problems to become pregnant. The feeding intensity is determining for the heifers age at first calving. Van Amburgh et al. (1998), showed that heifers growing 680 g/day had their first calf at an age of 24,5 months, which is optimum. An increased feeding intensity resulted in higher daily gain up to 940 g/day and the age at first calving was reduced to 21 months. The daily growth for heifers with a calculated age of 24 months for first calving is different between breeds. A Holstein heifer should have higher daily growth compared with a SRB heifer.

Table 1. Average recommended daily growth (g/day) for heifers of the breeds Holstein and Swedish Red Breed (SRB). Modified from Svensk Mjölk (2006)

Age	Growth g/day Holstein	Growth g/day SRB
0-3 Months	700	650
3-13 Months	750	700
13-24 Months	800	750

In order to have first calving at the age of 24 months the heifer´s weight should double from birth to weaning (Everitt et al., 2002). To achieve this it requires feed of good quality, good care and no diseases.

Estrus

Estrus is controlled by endocrine hormones from hypothalamus, pituitary, ovaries and uterus. The estrus cycle starts with a release of GnRH from hypothalamus, which stimulates the pituitary´s production of FSH. FSH stimulates growth and maturation of follicles in the ovaries. Matured follicles produce estrogen, which stimulates the brain´s center for estrus and the cow shows signs of estrus. When the concentration of estrogen in blood is high, the hypothalamus will react by signaling to the pituitary to secrete LH which stimulates ovulation. The follicle break because of the ovulation, the broken follicle forms a corpus luteum, which produce progesterone and prevent maturation of new follicles. Thereby pregnancy can remain in the case of fertilisation. If the cow is not pregnant corpus luteum will be broken down after 16 days and the cycle begins again (Eklund, 2011).

The optimum time during estrus for insemination is 12-18 hours before ovulation, ovulation occurs 24-28 hours after the onset of estrus. The time during estrus when insemination is at optimum is in average seven hours and missed estrus is a problem causing the heifers to be older at the age of first calving (Roche, 2006).

Factors affecting growth and development

Colostrum

The intake of colostrum may affect the heifer later in life. A study made by Svensson et al., (2007) showed that heifers fed by hand with colostrum had their first calf earlier than heifers suckling from the cow. This is probably due to the amount of colostrum digested, a high intake of colostrum is secured by hand feeding. Colostrum contains a high amount of energy which is important for calves, since they are born with low energy stores (Quigley & Drewry, 1998). Colostrum also contains higher amount of insulin-growth factors (IGF) and immunoglobulins (Ig) compared with matured milk (Blum & Hammon, 2000).

Immunoglobulins

When foreign substances invade the body, the lymphoid system reacts by producing immunoglobulins (Ig). The calf is born without Ig and depends on the colostrum from the cow to receive those. The calf absorbs Ig through the intestinal epithelium and Ig is then transported by the lymph system to the peripheral circulation. It creates an immunisation that acts until the calf´s specific immune system has matured (Arthington et al., 2000), this occurs at different time depending on the calf´s access to colostrum during it´s first days. Calves fed colostrum produce enough of Ig at the age of four weeks. Calves fed with matured milk during their first days of life lacks immunity until the age of one to two weeks when they start producing enough of their own Ig (Davis & Drackley, 1998).

There are different types of Ig. In colostrum, 85-90% of all Ig is immunoglobulin G (IgG) where IgG1 account for 80-90% of all IgG. The uptake of IgG decreases at the same rate as the permeability of intestinal epithelium is reduced. This occurs with increasing time after calving and thereby time is an important factor for the calf´s concentration of Ig in plasma. The uptake of IgG is most effective during the first four hours after birth. There is still permeability up to 12 hours after birth but after 24 hours no more Ig can be absorbed from the colostrum. The uptake of Ig are affected by the amount of digested colostrum and the colostrum´s level of Ig (Östlund, 2013). After 24-48 hours the concentration of Ig in serum should exceed 10 mg Ig/ ml (Arnold-Larsen, 2011) otherwise the calf will suffer from failure of passive transfer (Godden, 2008). According to Quigley & Drewry (1998), calves with an IgG concentration below 10 mg/ml had twice as high mortality as calves with satisfying IgG concentration. Moreover, a low Ig concentration in serum increases the risk for diseases (Karlsson & Dieden, 2007). Other studies indicate that the major problems with diseases and death of calves depend on insufficient intake of colostrum leading to a colonisation of pathogens in the intestine. This results in an uptake of pathogens instead of immunoglobulins, explaining the low concentrations of IgG in serum, but the main reason for increased mortality is the uptake of pathogens (Stott et al., 1979). Even after the epithelium is closed, Ig is protecting against pathogens in the intestine (Karlsson & Dieden, 2007). On the contrary, Arthington et al., (2000) did not find any significant statistical correlation between diseases and low intake of

IgG. They only saw a tendency of a lower disease rate in the group which received colostrum of higher IgG content.

Klinkon et al., (2008) studied 71 calves from two farms with different IgG concentration in the colostrum. In the first group 33 calves had an IgG concentration below average value, in the second group 38 calves had an IgG concentration above average value. Thereby they had a higher intake of IgG compared with group one. They took blood samples from the calves for 24 weeks and found the greatest differense of IgG concentration in the calves at the age of one week. Moreover calves from group 2 had higher IgG concentration during the whole test period. They also found a correlation between percent diseases and IgG concentration, the first group with low IgG concentration had a higher percent diseases in the group.

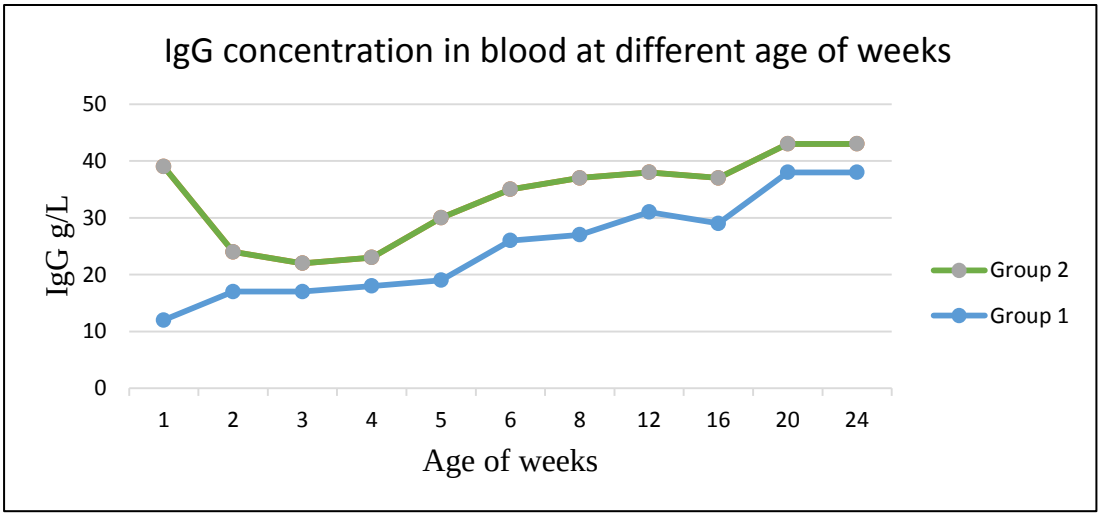

Figure 2. IgG concentration in blood at different age of weeks in heifers, group 1 was fed with colostrum containing a lower IgG concentration than average, group 2 was fed with colostrum containing a higher IgG concentration than average. Modified from Klinkon et al., (2008).

Insulin growth factor

Insulin growth factor 1 (IGF1) is of high concentration in colostrum the first hours after calving and decreases by time. A few days into lactation the concentration of IGF1 is decreased several times lower compared with concentration in colostrum (Burrin, 1997). IGF1 has effects on the development and function of the gastro-intestinal tracts (GIT) by regulating cell proliferation in GI-cells and thereby enhancing intestinal growth (Bühler et al., 1998). This is supported by the existence of IGF1 receptors in different places in the intestine. IGF1 receptors exist mainly in the stomach submucosa and Lamina propria, but also in the small intestine in the crypt enterocytes. Crypt enterocytes are the inwards wrinkled parts of the epithelium around the villi. IGF1 receptors also exist in other cells in the mucosa and in the large intestine (Burrin, 1997). The intake of colostrum is affecting the ability to bind IGF1. Calves at the age of eight days, which received colostrum during their first three days of life, had higher capacity of IGF1 uptake compared with calves fed with milk replacer. Moreover, calves fed with colostrum during their first days of life had higher concentration of glucose in plasma

after feeding compared with calves fed with milk replace (Blum & Hammon, 2000). This indicates that colostrum has a positive effect on calf growth and most likely growth factors like IGF1 play an important role. Wathes et al., (2007) showed that pre-pubertal IGF1 concentrations were strongly correlated with both the growth rate in the age from one to six months and also to the body weight at the age of six months.

Housing system

The housing of the calf can affect the calf´s health and thereby growth and reproduction. Calves in group housing with 10-20 calves per box and with calf feeder runs 2.8 times higher risk for pneumonia compared with calves in small group with 3-5 calves/box and bucket fed. The rates for pneumonia vary in different housing systems. In calves group-housed it was found that 9% of the calves had pneumonia, in small groups this number was 4% and in single/double box only 3.4% had pneumonia. This can be compared with the overall average of 7% Svensson & Pettersson 2000). Moreover, calves that were held in large groups were 3.6 times more likely to suffer from pneumonia at the age 3-7 months compared with calves in other housing systems.

Calves in group housing have lower growth with 25 g/day, which can be explained by the increased disease rate (Pettersson et al., 2000). The increased disease rate may be due to an increase spreading of infections when many calves in different age are mixed in large groups. Also large groups can complicate the finding of sick animals (Svensson & Petterson, 2000). The lower growth can depend on higher competition for the plastic teats. In a study made by Keyserlingk et al., (2004) the ratio teat-to-calf was changed daily from 1:3 to 4:3. This was to see if the number of teats affect the amount digested milk and time at teat. It was shown that when the number of teat changed from 4:3 to 1:3 so did the total time at the teat from 40 minutes/day to 32 minutes/day. The number of times one calf pushed away another from the teat increased from 18 to 41 times and the amount of milk consumption decreased from 14 to 11.4 liters/day. To have one teat on three calves resulted in increased competitive behavior and decreased milk consumed.

Calf hutches have a large positive effect on calf health. Calves in calf hutches together with one or a couple of other calves have the best feed conversion, growth and a minimum of diseases (Davis & Drackley, 1998). In a calf hutch the calves are fed with buckets twice a day.

Diarrhea

Each year 10% of all born heifers die, 52% of all these events of death are caused by diarrhea (Davis & Drackley, 1998). Most cases with diarrhea occur before the age of 30 days and only 58% of the infected calves are found (McGuirk, 2008). The disease is caused by infections from bacteria, virus, and protozoa or due to a limited intake of colostrum during early state of life. Moreover milk in the rumen can cause diarrhea, which can happen if the calf is not suckling properly and thereby the esophageal groove is not stimulated. The calf´s environment, housing and feed, are all factors that can increase the risk of diarrhea. Diarrhea results in mas-

sive loss of water and electrolytes. As much as 83% of total water intake can be lost by faeces, compared with only 5% for a healthy calf. Considering that a calf consist of 75% water, this is a dangerous state which quickly results in dehydration (Davis & Drackley, 1998) and imbalance of electrolytes. Studies made on humans shows that patients suffering from disorder of electrolytes have higher mortality up to five years after recovery (Olsson & Öhlin, 2012). Diarrhea in young animals up until an age of 14 months can lead to deficiency in copper (Castillo-Duran et al., 1988). This results in a depressed reproduction and impaired ovarian function (Smith, 2005).

Calves that are affected of diarrhea during their first three months of life have lower growth rate compared with calves that has been healthy their whole life. If the calf suffers from diarrhea during its first month of life it results in a large weight loss that the calf will not be able to compensate before weaning. At the time of weaning the calf can weigh up to 16 kg less than healthy calves (Wittum & Perino, 1995). The age when the animal get infected affect the severity of the disease. In the two first weeks of life, a delay in the onset of diarrhea of one day decreased the length of the disease with 0.2 days and also increased the average daily gain with 10 g (Virtala et al., 1996).

Waltner-Toews et al. (1985), showed in a study that calves that have been treated for diarrhea are 2.9 times more likely to have a first calving at the age of 30 months or more, compared with healthy calves.

Bovine viral diarrhea virus

Bovine viral diarrhea virus (BVDV) exist in different forms. As many as 70-90% of all infected animals lack symptoms and can thus spread the disease. Young animals are often troubled by acute BVDV resulting in symptoms like diarrhea, fever and anorexia. BVDV inhibits the immune system, therefore the heifer is often affected by other diseases as well (Institute of veterinary virology, 2006). In older animals, the disease can affect reproduction, either by early abortion or inability of becoming pregnant. The time for infection has great influence on what effect the disease will have. Heifers that get infected during the period between insemination and 51 days of pregnancy have lower pregnancy rate compared with heifers that get infected before insemination. Heifers infected before insemination managed to complete the whole pregnancy. BVDV can either affect the oocyte directly by cell damage or indirectly by changing the oocytes environment, which result in impaired survival (Grooms, 2004).

In Sweden, a control program for BVDV started in 1993.This has resulted in a decrease of BVDV. By the end of 2012 only 12 farms were not free from the disease and only three of them were infected (SVA, 2014).

Respiratory disease and Pneumonia

The lungs of cattle are different from those of other animals, they are more flat, smaller relative to body weight and more divided into lobes and lobules. This leads to a decreased gas

exchange compared with many other species. Moreover cattle cannot increase ventilation and gas exchange at increased physiological or metabolic activity. Because of these factors cattle are extra sensitive to diseases that affect the ability of the alveoli (Rångemark-Åkerman 2009). Pneumonia is a problem for 7% of all calves (Svensson & Petterson, 2000). and is often caused by bacteria. Respiratory diseases account for 21-29% and 40-50% of the total morbidity in calves at the ages of 0-3 months and 3-7 months, respectively (McGuirk, 2008; Rångemark-Åkerman, 2009). This means that respiratory disease is the most common disease in heifers older than three months. In cattle, respiratory disease is often the same as an infection in the lower part of the respiratory pathways. This can sometimes result in poor general condition, which is easily discovered. But in many cases, the symptoms are vague and this results in that many cases are missed. Only 50% of all respiratory diseases in calves at the age of 0-3 months are found by the producer. In calves at the age of 3-7 months only 15% of all respiratory diseases are found. Untreated respiratory disease can result in prolonged disease, which strongly affects the growth (Rångemark-Åkerman, 2009).

One study by Warnick et al., (1994) showed that heifers suffering from pneumonia have a delayed first calving with three months. This support the statement by Waltner-Toews et al., (1985) that diseases in calves younger than three months probably affect the age of first calving. The delayed first calving can however be because of genetically and/or immunological problem in the heifer. Also McGuirk (2008) confirmed that pneumonia affect reproduction and growth. Pneumonia is the disease affecting heifer´s growth most. In a study by Virtala et al. (1996), heifers affected by pneumonia before weaning had a reduced daily gain of 1.3 g/day/kg. Heifers infected in the third month of age had a reduced daily gain of 14 g/day. Each additional week with pneumonia resulted in a loss of growth with 0.8 kg (Virtala et al., 1996). After the age of six months the growth is not significant affected by pneumonia (Donovan et al., 1997).

Heifers affected by pneumonia during the first three months of life runs 2.5 times higher risk of dying before first calving compared with healthy heifers (Waltner-Toews, 1985). In the Swedish heifer project 150 calves were dissected and 1/3 of them had died because of pneumonia (Svensson & Pettersson, 2000).

To prevent the occurrence and spread of diarrhea and pneumonia, it is important to:

- keep calving place clean
- clean teats and single pens
- clean group pens before inserting a new calf group
- keep right temperature in the stable, minimum 15 C for newborn calves
- avoid draft, maximum 0,2 m/s
- have feed of good quality
- feed colostrum first four hours of life
  (McGuirk 2008; Pettersson, 2008; Davis & Drackley, 1998).

For pneumonia, it is important to have maximum 80% humidity in the stable. Calves which have had diarrhea have an increased risk to be infected by pneumonia (Pettersson, 2008).

Can body fat affect ovulation?

Several studies on different species, have shown that weight and sexual maturity are strongly correlated. One study showed a correlation between anorexia and decreased estrogen concentration (Robert et al., 1977). In another study, rats were divided into two groups, fed with high or low energy feed, respectively. The groups had first estrus at different times and weights but with the same amount body fat, which could indicate that body fat somehow is affecting ovulation (Frisch et al., 1977). On the other hand a study done by Bronson (1987) showed the opposite. A group of mice were separated in to three groups, one group with hard exercise, one group with restricted food and one control group. The body weight, growth rate and amount of body fat was measured. They found that none of the parameters was critically correlated to ovulation (Bronson, 1987). The adipose tissue can metabolise and store steroids and also affects sex hormone-binding globulin. Because of these qualities it was thought to affect ovulation. But the estrogen concentration produced from the adipose tissue is very low and can probably not have any effects on the body, there is no evidence confirming that the amount of body fat directly affects ovulation (Bronson & Manning, 1991).

One thing that has proven to affect the opportunity to sexual maturity is the body's total energy balance. Studies where glycolysis and fatty acid oxidation was inhibited shows that a lack of these substances directly blocks the estrus cycle. Moreover, insulin is considered to affect estrus positively by supplying the hypothalamus with necessary amino acids for the synthesis of the neurotransmitters norepinephrine and serotonin, which affect the secretion of GnRH. GnRH in turn stimulates an increased concentration of LH. That the availability of substrate and insulin can affect the estrus hormones was confirmed by a study showing an increased concentration of LH in blood after drip was given, containing insulin, glucose and amino acids (Bronson & Manning, 1991).

A study made by Lanyasunya et al., (2005) showed that a low body weight is correlated to low fertilisation rate. By adding more energy and protein, pregnancy rate increased from 42% to 72%. The positive correlation between feed intake and reproductive hormone cycle indicated that too low feed intake disturbs the reproductive hormone cycle.

Economy

Rearing cost for a heifer varies between different producers from 11000 to 30000 SEK/heifer, average is around 15000 SEK, including building cost (McGuirk, 2008; Carlén, 2013). Oskarsson (2010) compiled 25 farms in Sweden with an average age of first calving at 27 months and showed that rearing cost on average was 11388 SEK/ heifer, excluding building costs. A heifer having her first calf at the age of 24 months has paid her rearing cost after two lactations, assumed that the production is 10000 kg milk. A delayed first calving so that the heifer calve at the age of 30 months implies that the cow has paid its rearing cost after 2.5

lactations. The average producing age for a Swedish cow is 2 lactations (Carlén, 2013) to 2.5 lactations (Carlén & Eriksson 2013), this means that a cow having her first calf at the age of 30 months might not be able to pay her rearing cost before culling.

A heifer costs around 14 SEK/day, excluding building cost. Each month after the age of 24 months when the heifer is not pregnant she cost 420 SEK. The average age of first calving is 28 months, this means a loss of 1680 SEK/heifer. It has been shown that the farm with best economical results also have the highest rearing cost/heifer, the god economical result is because of a lower percent new recruitment (Oskarsson, 2010).

Discussion

To understand how different factors can affect the heifer´s development we need an overview of the different development phases. Many factors affect the heifer´s ability to grow and reproduce and the colostrum intake and quality is one of them. The importance of access to colostrum has long been known but lately it has been debated because some studies showed a lack of correlation between diseases and a low intake of colostrum. Arthington et al., (2000) could not find any statistical significant correlation between low intake of IgG and the incidence of diseases. As said in that study, this could depend on the low number of animals attending in the study. I do believe that there is a correlation between low intake of colostrum and high frequency of diseases and poor development of the heifer. Quigley & Drewry (1998), Carlsson & Dieden (2007) and Stott et al., (1979) confirm that the intake of colostrum of good quality with an IgG concentration higher than 10 mg/ml is important for the calf´s future development and immune defense. This was clearly demonstrated in the study made by Klinkon et al., (2008) were calves fed with colostrum containing higher IgG concentration had higher concentration of IgG in the blood until the age of eight months. They also found a negative correlation between colostrum with high IgG concentration and the number diseased animals. Studies like this are necessary since they once again shows the importance of feeding colostrum correctly, this is something that the author have experienced to be insufficient on different farms when milking is prioritised.

Also the environment and feeding can affect the development of the calf, as shown by Davis & Drackley (1998), Fungbrant (2012) and Växa Sverige (2013). Access to roughage and concentrate can strongly affect the development of the stomach. This is something that in the studies is missed. Even though the calf has free access to hay and milk, competition in the group might prohibit smaller and low-ranking calves that are not given access to all kind of feed. The author think that the competition is most important for concentrate consumption if it is given once or twice a day and not with free access. As Keyserlingk et al., (2004) showed in their study, the amount of consumed milk increased when the competition for the teats was nonexistent, there is no reason to believe otherwise about concentrate consumption. If the calf is not given all kinds of feed it will not be able to develop at the same rate as calves in the same age and may also be older by the time for first calving. And I think that an increased

competitive behavior might lead to increased long term stress which can reduce the immune system and thereby affect growth and development negatively.

The farms in Sweden are getting bigger, with more cows. The increased number of calvings at the farm will result in a smaller difference of age between calves group housed. But there is still smaller farms were the difference in age should be considered. I think it can be recommended to divide large boxes, with many calves, into smaller areas so that the calves can be held in smaller groups in the same age. This would probably also reduce morbidity and make it easier to detect sick animals early. Since about half of all pneumonia and diarrhea cases are missed, detection of sick animals is something that the author think should be prioritised. Waltner-Toews et al., (1985) showed in their study that animals treated for diarrhea is 2.9 times as likely to have their first calving after 30 months of age. This means that it costs 2.5 lactation to rear this heifer. Compared with a heifer that has her first calf at the age of 24 months, this heifer costs 2 lactations to rear. One half lactation may sound little but considering that the average producing age of a Swedish cow is 2-2.5 lactations the age of first calving can be determining for the economy.

Diarrhea increases the risk that a heifer will be affected by pneumonia (Pettersson, 2008). This is interesting because the author think it indicates something the author have not found evidence for in any study. Namely, that the onset of a disease can affect the immune system so that the heifer later in life may be more easily affected by other diseases. This makes it even more important to keep healthy heifers since we do not know if the heifer, as a milking cow more easily can be infected by diseases that will affect the milk yield.

As the majority of studies shows, pneumonia has a great affect on the age of first calving. Warnick et al., (1994) showed in their study that heifers that had suffered from pneumonia may have their first calf three months later than healthy heifers. A heifer that has her first calf after the age of 24 months cost 420 SEK/month (Oskarsson, 2010). This means that a heifer with a delayed first calving of three months cost 1260 SEK unnecessarily.

When looking at these numbers it become clear that a good care of the heifers from the first day of life until becoming a milking cow is truly important for the producer's economy. But it should not be forgotten that the farms with the best economic performance also had the highest rearing costs for the heifers. These farms despite high rearing costs may have the best economic result because they have chosen these high costs themselves. They might be aware and have chosen a higher age at first calving and thus the heifer has her first calf when she is fully mature, instead of suffering from diseases and calve despite a low weight. The farms with good financial results are likely to have a lower percentage recruitment of heifers compared with farms with poor economic results.

Conclusion

Access to roughage, concentrate and colostrum, colostrum quality, diarrhea, pneumonia, housing system and possibility to estrus detection are important for the heifer´s development. The producer can affect all these factors. By working preventive against diseases and detecting diseases, early growth can be improved and the heifer´s age of first calving may be lowered and reach 24 months of age.

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