INTEGRATED MANAGEMENT OF TECHNOLOGICAL COMPONENTS IN CALF REARING: A GUIDE FOR THE SUSTAINABILITY OF FAMILY DAIRY FARMING

MANEJO INTEGRAL DE COMPONENTES TECNOLÓGICOS NA CRIAÇÃO DE BEZERRAS: UM GUIA PARA A SUSTENTABILIDADE DA PECUÁRIA LEITEIRA FAMILIAR

MANEJO INTEGRAL DE COMPONENTES TECNOLÓGICOS EN LA CRIANZA DE BECERRAS: UNA GUÍA PARA LA SOSTENIBILIDAD DE LA LECHERÍA FAMILIAR

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J. Reyes Galaviz Rodríguez[1], Arturo Raymundo Peña Vergara[2], Juvencio Lagunes Lagunes[3], René Carlos Calderón Robles[4], Tomas Arturo González Orozco[5], Xochil Gabriela Montalvo Aguilar[6], Patricia Villalobos Peñalosa[7], Luz Marina Hernández Calva[8], Eugenio Villagómez Amezcua Manjarrez[9], Vicente Eliezer Vega Murillo[10], Itziar Eukene Lepe Anasagasti[11]

ABSTRACT

The manual addresses the integrated management of calves in family dairy farming systems, highlighting the importance of proper rearing to ensure sustainability, productive efficiency, and animal welfare. It emphasizes the role of nutrition, health management, housing, and genetic selection as pillars for the development of replacement heifers. The work underscores that inadequate rearing affects herd longevity, productivity, and reproduction. A

[1] Professor in Veterinary Medicine and Zootechnics. Universidad Autónoma de Tlaxcala.
E-mail: jrgrgalaviz@gmail.com
[2] Professor in Veterinary Medicine and Zootechnics. Universidad Autónoma de Tlaxcala.
E-mail: raypeve@gmail.com
[3] Researcher at Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP).
E-mail: juvenciolaguneslagunes@yahoo.com.mx
[4] Researcher at Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP).
E-mail: calderon.rene.inifap@inifap.gob.mx
[5] Researcher at Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP). Centro Experimental del Bajío. Specialist in Technology Transfer in Animal Production.
E-mail: gonzalez.tomas.inifap@inifap.gob.mx
[6] Professor in Veterinary Medicine and Zootechnics. Universidad Autónoma de Tlaxcala.
E-mail: maxigirasol2006@yahoo.com.mx
[7] Research Professor in Veterinary Medicine and Zootechnics. Universidad Autónoma de Tlaxcala.
E-mail: pvillalobosp@uatx.mx
[8] Professor in Veterinary Medicine and Zootechnics. Universidad Autónoma de Tlaxcala.
E-mail: marinahc@yahoo.com
[9] Researcher at Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP). Postgraduate Professor at Facultad de Estudios Superiores Cuautitlán in Animal Reproduction.
E-mail: euginvam@gmail.com
[10] Professor at the Faculty of Veterinary Medicine and Zootechnics. Universidad Veracruzana. Researcher in Animal Genetic Improvement. E-mail: vega.vicente@uv.mx
[11] Professor at the Faculty of Veterinary Medicine and Zootechnics. Universidad Veracruzana. Area of Animal Reproduction. E-mail: ilepe@uv.mx

technological approach adapted to the socioeconomic conditions of each producer is recommended, with low-cost practices that have a high impact on the health and growth of the calves.

Keywords: Calf Rearing. Family Dairy Farming. Sustainability. Rural Economy. Appropriate Technology.

RESUMO

O manual aborda o manejo integral de bezerras em sistemas de pecuária leiteira familiar, destacando a importância de uma criação adequada para garantir a sustentabilidade, a eficiência produtiva e o bem-estar animal. Enfatiza-se o papel da alimentação, do manejo sanitário, do alojamento e da seleção genética como pilares para o desenvolvimento de fêmeas de reposição. A obra ressalta que uma criação deficiente afeta a longevidade, a produtividade e a reprodução do rebanho. Recomenda-se uma abordagem tecnológica adaptada às condições socioeconômicas de cada produtor, com práticas de baixo custo, mas de alto impacto na saúde e no crescimento das crias.

Palavra-chave: Criação de Bezerras. Pecuária Leiteira Familiar. Sustentabilidade. Economia Rural. Tecnologia Adaptada.

RESUMEN

El manual aborda el manejo integral de becerras en sistemas de lechería familiar, destacando la importancia de la crianza adecuada para garantizar la sostenibilidad, la eficiencia productiva y el bienestar animal. Se enfatiza el papel de la alimentación, el manejo sanitario, el alojamiento, y la selección genética como pilares para el desarrollo de hembras de reemplazo. La obra subraya que una crianza deficiente afecta la longevidad, la productividad y la reproducción del hato. Se recomienda un enfoque tecnológico adaptado a las condiciones socioeconómicas de cada productor, con prácticas de bajo costo, pero alto impacto en la salud y crecimiento de las crías.

Palabras clave: Crianza de Becerras. Lechería Familiar. Sostenibilidad. Economía Rural. Tecnología Adaptada.

1 INTRODUCTION

Calf breeding is a fundamental aspect in the livestock industry, as it lays the foundations for the future success of the dairy herd, directly influencing the longevity, production efficiency and reproductive performance of the animals (Heinrichs & Jones, 2016; NRC, 2001). This process not only involves providing basic care such as food and shelter, but also has a significant impact on the health, productivity, and welfare of animals throughout their lives, since poor breeding can predispose to diseases and low productive performance in adulthood (Khan et al., 2011; Weaver et al., 2000).

From the moment of birth, every decision made in raising calves can influence their physical, mental, and emotional development, as well as their ability to produce milk or meat in the future. Key practices such as colostrum management, early nutrition, and health control are decisive in achieving adequate growth and optimal immune system function (Godden, 2008; Drackley, 2008). Therefore, understanding and applying proper breeding practices is crucial to ensure quality and profitability in livestock production.

In this manual, we will explore the importance of calf farming and how a careful and well-planned approach can benefit both animals and producers, improving animal welfare and generating more sustainable and profitable production systems (FAO, 2011; Soberon et al., 2012).

The production of food of animal origin is restricted on a daily basis, which is mainly due to the decrease in the number of animals in production systems, associated with factors such as health problems, low reproductive efficiency and limitations in livestock management and nutrition (FAO, 2011; Thornton, 2010). Within the production systems that provide food for human consumption, milk production occupies an important place due to its high nutritional contribution, especially in proteins of high biological value, vitamins and minerals, as well as its economic and social importance in different regions of the world (Walstra et al., 2006; FAO, 2019).

Likewise, dairy production is characterized by being present at various levels of technification, from extensive and small-scale systems to highly specialized farms, which makes it a key activity for food security and rural development (NRC, 2001; FAO, 2018). This activity is closely associated with agriculture, since it depends on the cultivation of fodder, cereals and other essential inputs for livestock feed, establishing a direct relationship between agricultural productivity and the efficiency of livestock systems (Van Soest, 1994; Herrero et al., 2013).

This agriculture-livestock integration is an important advantage in production units, particularly in rural areas, where producers can make more efficient use of their natural and economic resources. The complementarity between the two activities allows the use of agricultural by-products in livestock feed and the use of manure as organic fertilizer, which facilitates nutrient recycling, reduces feed costs and improves soil fertility (FAO, 2010; Herrero et al., 2013). Likewise, this approach contributes to greater sustainability of the production system, strengthening the family and regional economy and favoring the resilience of production units to adverse conditions (Santiago et al., 2020; Thornton & Herrero, 2015).

The use of technological components in production systems must be in accordance with the availability and proper management of natural resources, both in agriculture and livestock, in order to guarantee the productive efficiency and sustainability of production units (FAO, 2011; Herrero et al., 2010). In milk production systems, the adoption of technology varies considerably due to differences in the technological and socioeconomic level of each production unit, which directly influences management practices, including calf rearing, feeding, health, and reproduction (NRC, 2001; Heinrichs & Jones, 2016).

These differences are closely related to the geographical location of the productive units, since not all of them have the same means of production, such as land area, number of wombs, availability of inputs, infrastructure, as well as applied food, health, reproductive and genetic techniques and procedures (FAO, 2018; Rosas & Villasana, 2022). Likewise, the participation and availability of the workforce, together with the climatological conditions of each region, as well as the tradition and culture of the producers, significantly influence decision-making and the productive performance of dairy systems (Thornton, 2010).

Livestock production units in the country are generally characterized by low use of available technology, which is largely associated with the low level of education of the producer and limitations in the processes of training and technology transfer. In many cases, producers face difficulties in accessing or maintaining training programs due to economic constraints, as well as poor practical application of the knowledge acquired, which limits the increase in their production levels and the improvement in livestock management, including calf breeding (FAO, 2018; INEGI, 2020).

This situation generates a marked heterogeneity in the country's livestock production systems, determined by the geographical location and the productive level of the units. There are from highly technical systems, which contribute more than 50% of the national milk production, to subsistence or family systems that contribute only 9.8% of the total production. In this context, national milk production reached 13,333 million liters, with an increase of 1.7% compared to 2022 (SIAP, 2023). These differences directly influence calves' management, health, nutrition, and development practices, conditioning their future productive performance (Heinrichs & Jones, 2016).

Therefore, it is necessary to base it on the sustainable operation of the livestock production unit, as well as to establish clear criteria in management methods and tools with an approach that guarantees productive efficiency. This implies integrating the production unit into stages of its production cycle, from calf rearing to the adult stage, so that accurate and reliable information is generated that allows the evaluation of the most relevant technical, productive and economic indicators of the system (NRC, 2001; FAO, 2011).

2 HANDLING MODELS

In order to make more efficient use of resources or means of production, it is necessary to implement management models according to the characteristics of each production system, so that they can be adopted and adapted in the management of dairy cattle, particularly in calf breeding (FAO, 2011; Heinrichs & Jones, 2016). Artificial rearing is a transcendental practice in livestock farms, since it allows better control of the feeding, health and growth of calves, optimizing the use of inputs and improving the efficiency of the production system (Drackley, 2008; NRC, 2001).

This type of breeding acquires special relevance in family or backyard systems, where resources are limited and management decisions directly influence the profitability and sustainability of the productive unit. The main objective of artificial rearing is to know and control the productive and sanitary parameters of calves destined for replacement, such as weight gain, age at weaning and body condition, determining factors for their future performance as milk-producing cows (Soberon et al., 2012; Heinrichs & Jones, 2016). In this sense, it should not be forgotten that artificial breeding represents a fundamental link in the country's dairy farming, laying the foundations for the replacement herd and guaranteeing the productive continuity of dairy systems (Rosas and Villasana, 2022).

3 HANDLING OF TECHNOLOGICAL COMPONENTS

The technological components that must be considered in the management of calves for replacement in family dairy production units include a series of simple techniques that can be adapted to the socioeconomic and productive conditions of each system, particularly during the rearing and development phase, which largely determines the future productive performance of the unit (FAO, 2011; Heinrichs & Jones, 2016). These technologies include practices related to feeding, sanitation, housing, colostrum management, and growth monitoring, which can be implemented gradually and at low cost, favoring production efficiency and system sustainability (Drackley, 2008; NRC, 2001).

All of this is intended to guide and strengthen technical knowledge in the breeding and development activities of calves intended for replacement, so that they can be effectively applied and transferred to the country's producers, contributing to improving decision-making and the performance of family dairy systems (Eadie, 2025; Rosas & Villasana, 2022).

4 MANAGEMENT OF THE FEMALE PRIOR TO CALVING

4.1 DIET AND BODY CONDITION

Part of the essential requirements for the success of any dairy unit is to maintain adequate growth and development of the product before calving, since this directly influences the birth of a viable, healthy calf with the potential to become a productive replacement, as long as it receives appropriate management during the rearing phase (NRC, 2001; Heinrichs & Jones, 2016).

In this phase it is recommended that the cow arrives at calving with a body condition of between 3.5 and 4, as well as with an adequate weight, since a deficient or excessive body condition can lead to dystocia, metabolic problems and lower colostrum quality, indirectly affecting the health and performance of the calf (Roche et al., 2009; Overton & Waldron, 2004). This objective is achieved through the implementation of an adequate nutritional program during pregnancy (Figures 1 and 2).

Figure 1

Dairy cattle body condition scheme (NRC, 2001)

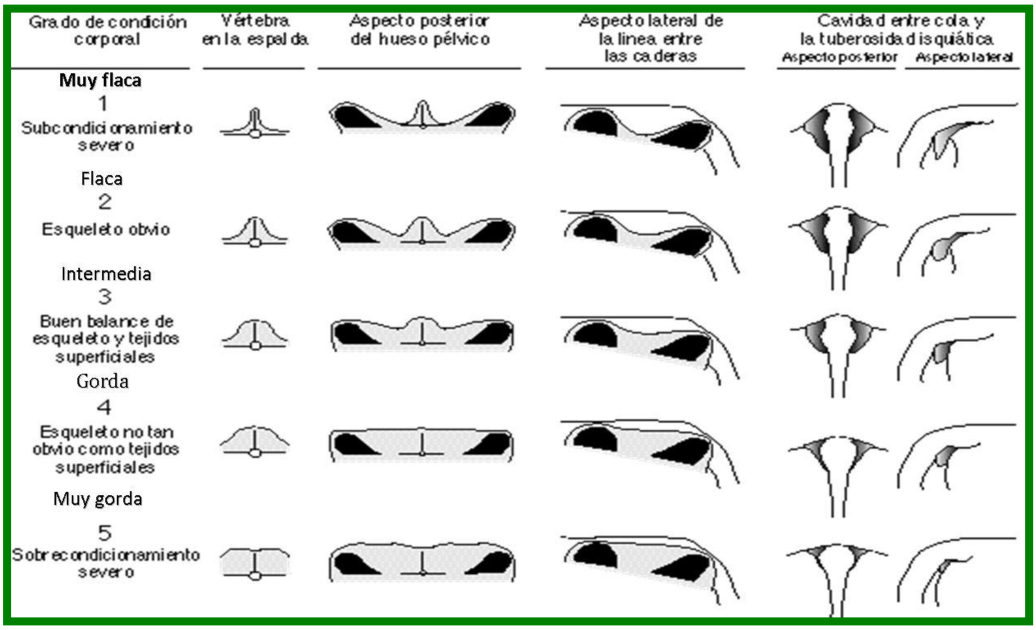
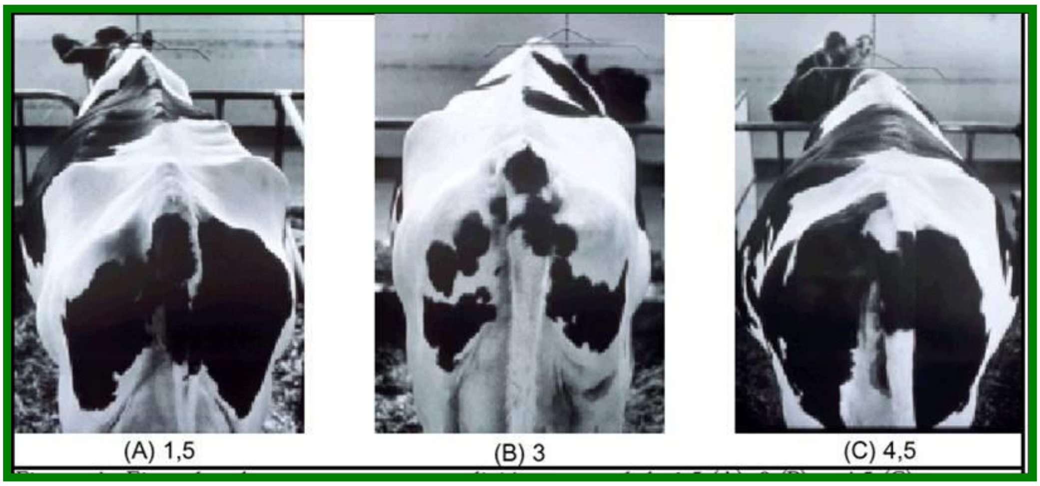


Figure 2

Holstein Cow Body Condition Scale (NRC, 2001)



During gestation, the cow's diet must be optimal to ensure the proper development of the fetus and the correct formation of the udder. The last third of gestation is a critical stage, since approximately 60–70% of fetal growth occurs in this period and the synthesis of colostrum begins, essential for the transfer of passive immunity to the newborn (Godden, 2008; NRC, 2001). At this stage, dry matter intake (SCM) can decrease by up to 30% during the week prior to calving, increasing the risk of a negative energy balance in dairy cows, affecting health, reproduction, and milk production in the following lactation (Grummer et al., 2004; Silva et al., 2023).

Therefore, it is essential to provide a balanced diet that considers good quality foods, including forages, corn silage and concentrates, in addition to guaranteeing water at free access. It is also recommended to reduce the proportion of low-quality stubble and supplement the diet with adequate sources of protein, minerals and vitamins, particularly calcium, phosphorus, magnesium and vitamins A, D and E, which are essential for maternal health and proper calf development (FAO, 2011; NRC, 2001).

4.2 BIRTH MANAGEMENT

Females close to calving should be kept in a pasture or maternity area that is clean, safe and adequately conditioned, since hygiene and management prior to calving play a determining role in the survival of the calf and in the health of the cow. It is essential to take extreme cleaning measures during delivery and avoid exposing newborns to air currents and humid environments, since these conditions increase the incidence of neonatal infections and perinatal mortality, which can exceed 10% in family production units with inadequate management (FAO, 2011; me, 2008).

The size of the paddock and its level of cleanliness directly influence the ease of locating and caring for neonates, especially in extensive or semi-extensive systems. However, it is recommended to group or batch cows by gestation stage to improve calving control and increase efficiency in care, which allows for early detection of reproductive problems and facilitates early intervention in case of complications, such as dystocia (Noakes et al., 2019; me, 2012). Therefore, it is advisable to have maternity spaces where cows close to calving are under constant observation.

During childbirth, the normal physiological phases of the process must be respected, which include the preparation phase, cervical dilation and expulsion of the fetus. Human intervention should be performed only when there are abnormalities in the duration or progression of labor, in order to avoid injury to both the mother and the calf (Arthur et al., 2001; Noakes et al., 2019). Subsequently, expulsion of fetal membranes generally occurs between 3 and 12 hours after delivery; therefore, it is recommended to perform check-ups at the beginning, middle and end of the day to detect timely cases of placental retention, a condition that can affect the reproductive health of the cow and future milk production (Drillich et al., 2006; NRC, 2001).

4.3 MANAGEMENT OF THE NEWBORN

It is crucial to ensure a correct intake of colostrum within the first hours of life, preferably during the first 2 to 4 hours after birth, since it provides passive immunity through immunoglobulins, as well as energy, vitamins and minerals essential for the development and survival of the calf (Godden, 2008; Costa et al., 2021). Poor intake or absorption of colostrum significantly increases the risk of neonatal diseases, early mortality, and poor productive performance in later stages.

In addition to this, it is essential to carry out an initial evaluation of the clinical condition of the newborn animal to guarantee its health and well-being from the first moments of life. During this assessment, various physical and functional aspects are observed to determine if the newborn is in optimal condition or if it requires special attention, such as feeding assistance, stimulation to stand up or timely veterinary intervention (me, 2008; Noakes et al., 2019).

It is recommended to keep records of the behavior of the newborn calf, such as the time it takes to raise its head firmly, the presence of the sucking reflex when inserting a finger into the mouth, the response to external stimuli (reflexes), as well as the interest in the environment, including noise and light. It is also important to record the time it takes to make the first attempt to stand up and approach the mother, since these indicators reflect her vitality and neurological status (Davis & Drackley, 1998; me, 2004).

In addition, it is recommended to perform a complete clinical evaluation at birth, recording physiological parameters such as respiratory rate, heart rate and body temperature, as well as the evaluation of the skin, fur, mucous membranes, lymphatic system and general condition of the newborn. These data allow early identification of alterations such as hypothermia, hypoxia, dehydration or infections, contributing to adequate decision-making in the health management of calves (Davis & Drackley, 1998; Radostits et al., 2007).

4.4 HOUSING OF CALVES

To house or keep calves, the utmost care must be taken, especially during the first weeks of life, since at this stage the chances of contracting diseases are high due to the immaturity of the immune system. The risk of respiratory and digestive diseases increases considerably when housing conditions are not appropriate in terms of hygiene, ventilation, humidity, and temperature (Heinrichs & Jones, 2016; Svensson & Liberg, 2006).

When planning the construction of facilities for the housing of the young, it is necessary to consider the location, orientation and construction materials, in order to ensure adequate environmental conditions that allow optimal levels of humidity and temperature to be maintained, contributing to preserving the health and welfare of the animals. Likewise, the facilities must facilitate the efficient performance of the practices of handling, feeding, cleaning and daily observation of calves (FAO, 2011; Davis & Drackley, 1998).

There are different types of constructions for the housing of the young, which can be closed or semi-closed sheds or sheds, as well as open or outdoor housing, such as portable wooden or plastic corrals. The selection of the type of accommodation depends on the production system, the climatic conditions of the region and the available resources, always seeking to minimize stress and exposure to pathogens (me, 2008; Svensson et al., 2003).

4.5 ENCLOSED OR SEMI-ENCLOSED SHEDS OR SHEDS

In this type of facility, the animals are housed in individual calves that must be roofed and have adequate ventilation, avoiding the formation of direct air currents that predispose to respiratory diseases. Likewise, these facilities should allow easy and frequent cleaning to reduce the microbial load in the environment (Bath et al., 1986; Heinrichs & Jones, 2016).

The individual accommodation in corraleta or calf is usually located approximately 0.30 m above ground level, with dimensions close to 1.50 m in length by 0.70 m in width and 1.20 m in height. In facilities with two rows of calves, the space between the access alley and the kennels should be at least 2 m wide, allowing for the circulation of personnel and the proper handling of the animals (Bath et al., 1986; Davis & Drackley, 1998).

This model of breeding, also known as "individual cage", allows animals to be kept separate, avoiding undesirable behaviors such as sucking the navel or parts of the body between calves (Figure 3). In addition, it helps to reduce the transmission of diseases through faecal contamination or direct contact, which is especially important during the neonatal stage. Individual cages also facilitate individualized feeding, allowing for better control of consumption and a more accurate recording of the growth and health status of each calf (Heinrichs & Jones, 2016; Svensson & Liberg, 2006).

Figure 3

Semi-enclosed individual cages for calf rearing

4.6 OUTDOOR AGEING IN A PORTABLE PEN

This breeding model is characterized by the use of individual portable pens, which are movable and can be moved daily together with the calf, or as often as the weather conditions of the place allow. Among the main advantages of this type of housing is the rapid adaptation of the calf to the environment, as well as the reduction of the risk of diseases associated with the accumulation of humidity and pathogens in the resting area (Galaviz et al., 2000; Heinrichs & Jones, 2016).

The portability of the corral allows it to be changed periodically, which favors that solid and liquid waste is directly exposed to solar radiation, contributing to the natural disinfection of the area and the reduction of the microbial load, which is especially important during the first weeks of the calf's life (FAO, 2011; Galaviz, 2005). This management has proven to be an efficient and low-cost alternative in family or small-scale systems.

When the portable pen is placed inside a paddock, the brood can have daily access to fresh forage, a desirable situation since it stimulates early rumen development and favors voluntary forage consumption, contributing to a more efficient transition from liquid to solid diet (Davis & Drackley, 1998; Galaviz et al., 2000). This type of early stimulation is associated with better productive performance later in the animal's life.

Outdoor housing in an individual, mobile or movable portable corral generally comprises a resting and feeding area of approximately 1.50 m by 2.50 m, and has an area for the feeder for solid feed and a bucket holder located at a height of approximately 0.45 m from floor level (Figure 4). On top, a support is placed for the bottle or container used in the administration of milk, facilitating individual management and control of the consumption of each calf (Galaviz, 2005; Heinrichs & Jones, 2016).

Figure 4

Portable pen for calf rearing

4.7 CALF FEEDING

Adequate feeding is a fundamental factor for the optimal development of calves, as it directly influences their growth, health, feed efficiency and future productive performance. During the first weeks of life, it is recommended to supply good quality breast milk or, failing that, milk substitutes that meet the specific nutritional requirements of the species, ensuring an adequate supply of energy, protein, minerals and vitamins (Davis & Drackley, 1998; NRC, 2001).

In family milk production units, the basis of livestock feed is mainly made up of fodder produced on the small plots of land owned by producers, whose average land holdings area is approximately 1.6 hectares. These systems are characterized by an efficient use of available resources and a strong dependence on local agricultural production for livestock feed, which conditions calf nutritional management strategies (FAO, 2011; Rosas & Villasana, 2022).

In this context, the main forage crops used are corn, alfalfa and oats, which represent the food base of the production system. According to the percentage distribution of the crops managed in these units (Table 1), corn predominates with 52%, followed by alfalfa with 35% and oats with 13%. These forages are considered essential elements in dairy cattle feed, as they provide energy, protein, and fiber necessary for rumen development and proper growth of calves, especially during the transition from liquid to solid diet (Van Soest, 1994; Heinrichs & Jones, 2016).

Table 1

Forage crops predominant in family dairy production units

CROPS	%
Corn	52
Alfalfa	35
Oatmeal	13

5 CALF FEEDING BY AGE STAGE

5.1 NEWBORNS UP TO TWO WEEKS OF AGE

At this stage, calves rely primarily on colostrum for the essential nutrients and passive immunity needed for their survival and initial development. Colostrum is composed of high concentrations of immunoglobulins (mainly IgG), as well as nutrients, maternal leukocytes, growth factors, hormones, and nonspecific antimicrobial factors that protect the newborn during its first days of life (Godden, 2008; McGuirk & Collins, 2004).

There is a selective transport of IgG immunoglobulins from the blood serum to the secretory cells of the mammary gland, which makes it essential to ensure that the calf receives good quality colostrum within the first hours after birth, when intestinal permeability allows the efficient absorption of antibodies. This absorptive capacity decreases dramatically after the first 24 hours of life (Weaver et al., 2000; Davis & Drackley, 1998).

Colostrum also contains growth factors and hormones, including trypsin inhibitory factor, which is found exclusively in colostrum and disappears in mature milk. This factor prevents the degradation of immunoglobulins and other proteins in the calf's gut, favoring the effective transfer of passive immunity (McGuirk & Collins, 2004; Godden, 2008). Therefore, it is recommended to offer fresh, clean and warm colostrum, preferably within the first 2 to 4 hours after birth, ensuring a sufficient volume to cover the immunological requirements of the calf.

5.2 FROM TWO WEEKS TO THREE MONTHS OF AGE

During this stage, calves should be fed a diet that promotes rapid, healthy, and even growth. It is recommended to continue with the supply of breast milk or milk substitutes of good quality, while gradually introducing solid foods into the diet, with the aim of stimulating rumen development (Heinrichs, 2005; Davis & Drackley, 1998).

Early introduction of solid feeds should include commercial starter concentrates for calves, good quality hay, and fresh, clean water available at all times. Concentrated feed intake is critical for rumen papillae development, facilitating a more efficient transition to weaning (Heinrichs & Jones, 2016; NRC, 2001).

The starter concentrate feed should be offered consistently and in small quantities at the beginning. Voluntary consumption of calves increases progressively week after week, so the amount of feed offered can be gradually increased to approximately 500 g per calf per day (Table 2). This feed must meet the nutritional requirements of growing calves, characterized by a high crude protein content (about 20%) and a moderate level of crude fat (2%), which favors the growth and proper development of the digestive system (NRC, 2001; Heinrichs, 2005).

According to information obtained in studies carried out in family dairy cattle production systems and based on the monitoring of production units, where the maximum use of available forage crops by producers is prioritized, a feeding program from birth to 60 days of age is presented below. adapted to the conditions of this type of production systems (FAO, 2011; Rosas & Villasana, 2022).

Table 2

Calf feeding program from birth to 60 days of age

Stage	Colostrum/Whole Milk/Substitute	Food
1 to 3 days	Colostrum (10% of its HP). 4 liters a day in 2 servings 7.00 hrs. and 17 hrs.	
4 to 7 days	Relay to whole milk. 4 liters a day in 2 servings 7.00 hrs. and 17 hrs.	
8 to 14 days	Replacement of milk substitute. 4 liters a day in 2 servings 7.00 hrs. and 17 hrs.	It will offer concentrated starter feed for calves, initial amount of 200 a 250 g / calf / day, at freedom. Offer water at free access.
15 to 21 days	Milk replacer. 5 liters a day in 2 servings 7.00 hrs. and 17 hrs.	Starter concentrate for calves, amount of 500 g / calf / day, at freedom. Water to free access. Offer alfalfa hay (reduced), concentrate:forage ratio 4:1. (3.5:0.125).
22 to 28 days	Milk replacer. 4.5 liters per day in 2 servings 7.00 hrs. and 17 hrs.	Starter concentrate, amount of 750 g / calf / day, at freedom. Water to free access. Continue with concentrate:forage ratio (5.25:0.19).

29 to 35 days	Milk replacer. 4 liters a day in 2 servings 7.00 hrs. and 17 hrs.	Starter concentrate, amount of 1 Kg / calf / day, at freedom. Water to free access. Continue with concentrate:forage ratio (7:0.25).
36 to 56 days	Milk replacer. 3 liters a day in 2 servings 7.00 hrs. and 17 hrs.	Starter concentrate, of 1.75 Kg / calf / day, at freedom. Water to free access. Concentrate:forage ratio (7.5:0.45).
57 to 60 days		Starter concentrate, 2 Kg / calf / day, at freedom. Water to free access. Concentrate:forage ratio (8:0.5).

6 CALF FEEDING BY GROWTH STAGE

6.1 FROM THREE MONTHS TO SIX MONTHS OF AGE

Calves at this stage are in an active phase of growth, so they require a diet that mainly promotes bone and muscle development, as well as the maturation of the digestive system. During this period, the supply of milk or milk substitutes can be continued in those systems where weaning is late; however, it is recommended to gradually reduce the number and frequency of feedings to encourage the transition to a diet based on forages and solid concentrates (Davis & Drackley, 1998; NRC, 2001).

Providing constant access to good quality hay is essential as it supports rumen activity and contributes to voluntary dry matter intake. Concentrates formulated specifically for growing calves should also be included, providing the energy and protein needed to sustain adequate growth rates (Heinrichs & Jones, 2016). In addition, it is essential to ensure an adequate supply of minerals and vitamins, particularly calcium, phosphorus, zinc, copper, and vitamins A, D, and E, in order to meet nutritional needs during this critical stage of development (NRC, 2001; FAO, 2011).

6.2 FROM SIX MONTHS TO FIRST REPRODUCTIVE SERVICE

From six months of age to the first reproductive service, the main objective of nutritional management is to ensure that calves reach the appropriate weight and body condition to begin the reproductive stage without compromising their health or future productive performance. To this end, it is essential to periodically monitor weight and body condition, adjusting the diet according to the growth requirements established for the breed and the production system (Heinrichs, 2005; NRC, 2001).

During this stage, it is recommended to include alfalfa hay or other good quality forages that are not excessively fibrous, in order to maintain adequate energy and protein intake (Table 3). From five to six months of age, the inclusion of corn silage in the ration can be initiated, without exceeding 25% of the total diet, thus avoiding digestive problems and ensuring adequate rumen adaptation (Van Soest, 1994; Heinrichs & Jones, 2016).

It is essential to provide a balanced diet that promotes constant and healthy growth, with an emphasis on the supply of nutrients that support the development of the reproductive system, since poor or excessive growth can delay the age at first service or affect reproductive and productive performance in adult life (Heinrichs, 2005; Rosas & Villasana, 2022).

Table 3

Calf feeding program from 60 days to the pregnant heifer

Stage	Food
Post-weaning to reproductive management 60 days	Growth feed is provided according to their body size, consumption should be 2.0 kg per calf / day, having the feed free, plus alfalfa hay. The ratio of concentrated forage shall be 4:1.3.5 kg
Heifers growing 150 days	It will be 3.0 kg, of growth feed with 16% crude protein, water to free access. Add alfalfa hay or some other forage that is not too fibrous. From five months onwards, corn silage will begin to be included in the ration, not exceeding 25% of the total diet.
Heifers pregnant at 260 days	Concentrated feed with 14% CP will be at a rate of 2.0 kg expressed in dry matter, being approximately 20% of the total required by the animal. The rest will be based on corn silage or other forage that the producer has (oats or hay, pasture), with the remaining proportion of 80% of the dry matter required by the animal. Remembering that the minimum consumption per day will represent 2.5% of dry matter in relation to its live weight.

Source: Author's own.

7 SANITARY MANAGEMENT

Proper sanitary management of replacement heifers is essential to keep them in optimal health conditions and guarantee their correct productive and reproductive performance in the adult stage. To this end, it is necessary to implement a strict sanitary program that includes vaccination and deworming schemes according to each age group of animals, considering the epidemiological conditions of the region and the production system (FAO, 2011; Radostits et al., 2007).

Regardless of the age at which females receive their first reproductive service, it is critical to perform serological testing for diseases that affect the reproductive tract and can lead to miscarriages, infertility, or significant economic losses. These diseases include Brucellosis, Leptospirosis, Bovine Viral Diarrhea (BVD), Infectious Bovine Rhinotracheitis (IBR) and Trichomoniasis, which represent both a health and production risk within dairy production units (OIE, 2019; Radostits et al., 2007).

Likewise, within the health program, preventive vaccination against bacterial diseases of high mortality or economic impact, such as Pasteurellosis or Hemorrhagic Septicemia, Clostridiosis and Derriengue, is recommended, in addition to implementing regular practices for the control of external parasites through tickicidal baths and strategic internal deworming in accordance with the established sanitary calendar (FAO, 2011; Quiroz et al., 2011).

Vaccination is an essential component of herd health programs, contributing to the prevention of infectious diseases and reducing the use of therapeutic treatments. During the application of vaccines, it is important to consider that the main objective is the induction of effective protective immunity; however, this protection is not immediate, as the immune system requires a minimum period of approximately two weeks to develop an adequate immune response, either at the cellular or humoral level (Tizard, 2020; Robers, 2021).

Proper health management of calves from birth and throughout the growth stage, until shortly before the first reproductive service, is essential to ensure their health and well-being throughout their productive life (Table 4). Timely sanitary control reduces the incidence of diseases, improves reproductive efficiency and ensures the obtaining of healthy and productive replacement animals. In this sense, the establishment of specific recommendations by stage of development facilitates monitoring and correct decision-making within dairy production systems (Heinrichs & Jones, 2016; NRC, 2001).

Table 4

Vaccination Schedule in Becerras

Illness	Vaccination	Revaccination	Vaccine type	Purpose	Restrictions
Brucellosis	*Calves 4-6 months. Calf or classic dose. *Animals over 12 months of age who are not vaccinated at an early age. Cow dose RB51 or reduced C-19	*12 months old. Cow dose RB51 or reduced C-19. On a single occasion.	Live vaccine. *RB51 *C-19	* Avoid reproductive problems. Mainly abortions in the last third of gestation.	*Do not vaccinate males. *Preferably do not vaccinate pregnant animals.
Leptospirosis	*Calves 4-6 months. *Vaccination biannually.	*every 6 months	* Bacterin containing serovarieties present in the area or region.	Avoid problems such as embryo resorptions, mummified fetuses, abortions, etc.	*None.
Bovine Viral Diarrhea (BVD)	*Calves 4-6 months. *Annual vaccination.	*Booster at 15-21 days. *12 months.	*Live virus Type I and II. (non-pregnant) *Inactivated virus	Avoid reproductive and digestive problems.	*Do not vaccinate with live virus in pregnant animals.

			Type I and II. (pregnant women)		
Infectious Bovine Rhinotracheitis (IBR)	*Calves 4-6 months. *Annual vaccination. *Booster at 15-21 days.	*12 months.	*Live virus. (non-pregnant) *Inactivated virus. (pregnant women)	Avoid reproductive and respiratory problems.	*Do not vaccinate with live virus in pregnant animals.
Pasteurellosis	*Calves 4-6 months. *Vaccination biannually.	*6 months.	*Bacterins with Toxoid.	Avoiding respiratory problems	*None
Clostridiasis (charcoal, edema, sepsis).	*Calves 4-6 months. *Vaccination biannually.	*6 months.	*Bacterins.		*None
Derriengue	*Annual vaccination. Areas of high prevalence	*12 months.	*Modified live virus	Avoiding problems of bovine rabies	*Preferably do not vaccinate pregnant animals.

7.1 DESIGN OF THE HEALTH PROGRAMME

The design of a vaccination program must consider several factors, with the identification of the main pathogens present in each region being essential. To this end, it is essential to obtain updated information from Veterinary Zootechnicians and official animal health services on diseases affecting livestock in the area of interest. Thus, it is not possible to establish a general vaccination program applicable to all production systems, but it must be adjusted to the specific needs of each herd and integrated into the general livestock management program (Currin et al., 1999; Radostits et al., 2007).

7.2 NEWBORNS UP TO TWO WEEKS OF AGE

During this stage, calves are highly vulnerable to disease due to the immaturity of their immune system. Therefore, it is essential to implement sanitary management measures that minimize the risk of infections, such as ensuring a clean and dry environment for delivery, providing good quality colostrum in adequate quantity and time, and continuously monitoring the health of the newborn to detect early signs of disease (McGuirk & Collins, 2004; Godden, 2008).

7.3 FROM TWO WEEKS TO THREE MONTHS OF AGE

In this phase, calves should receive ongoing health care to prevent disease and support healthy growth. It is recommended to implement a vaccination program that includes protection against highly prevalent respiratory and viral diseases, such as Bovine Viral

Diarrhea (BVD), Infectious Bovine Rhinotracheitis (IBR), Parainfluenza3 (PI3) and Bovine Respiratory Syncytial Virus (BRSV). Likewise, internal and external deworming should be carried out according to a sanitary calendar designed by the Veterinary Zootechnician, in order to control parasites that affect the productive performance and general health of calves (Van Metre et al., 2019; FAO, 2011).

7.4 FROM THREE MONTHS TO SIX MONTHS OF AGE

During this stage of accelerated growth, it is essential to maintain rigorous sanitary management to prevent diseases and promote optimal development. The vaccination program should be continued, making sure to apply booster doses according to the manufacturer's recommendations. In addition, it is important to regularly monitor calf health and address any abnormal clinical signs in a timely manner to avoid growth delays or productive losses (Quigley & Drewry, 1998; Heinrichs & Jones, 2016).

7.5 SIX MONTHS TO SHORTLY BEFORE FIRST REPRODUCTIVE SERVICE

Prior to the first reproductive service, it is essential to ensure that the calves are in optimal sanitary conditions. Regular health check-ups and diagnostic tests should be performed to confirm that they are free of reproductive diseases. Similarly, vaccination and deworming programs should continue to ensure adequate health status before the onset of reproductive life (Van Metre et al., 2019; NRC, 2001).

Animals that do not have these immunizations are vulnerable to infections, which can lead to severe health problems and even calf mortality, directly affecting the profitability and sustainability of the production system (Radostits et al., 2007).

8 MANAGEMENT OF THE OFFSPRING

8.1 DEHORNING

Dehorning is a recommended management practice that should be performed as soon as possible after birth to minimize stress and pain in the pups. It can be carried out by using an electric cauterizer, as it is practical and economical, or by the traditional method of applying caustic pastes directly to the protrusions (Stafford & Mellor, 2005; FAO, 2011).

The main methods include:a) Cauterizer or electric soldering iron, which applies heat directly to the protuberances.b) Cauterizer of red-hot iron, heated to red hot.c) Use of caustic pastes, applied to the horn growth button.d) Cutting of horns in lactating pups, performed with dehorning tweezers or Liess saw and subsequent cauterization.

These procedures should be performed with trained personnel and under hygienic conditions to reduce the risk of infection (Stafford & Mellor, 2005).

8.2 REMOVAL OF EXTRA TITS

The removal of supernumerary teats consists of cutting the accessory teats during the first week of the calf's life, as a preventive measure against mastitis and udder problems during the lactation stage. Prior to the procedure, the asymmetrical tits to be removed should be carefully identified and the area should be disinfected before and after the cut, using clean and disinfected scissors (Radostits et al., 2007; FAO, 2011).

8.3 BODY WEIGHT

Recording technical information, such as date of birth, birth weight, and weaning weight, is a critical activity to assess the genetic potential of offspring and their productive behavior. In females, this information is the basis for the selection of future replacements; in males, it allows the profitability of the ranch to be assessed, since the sale of calves is an important source of income (Heinrichs & Jones, 2016).

Body weight can be recorded using scales or, failing that, using tape measures as a practical alternative in family production units (Galaviz et al., 2000).

8.4 SOMATOMETRY

Somatometry is defined as the measurement of the body and is performed considering three dimensions: body weight expressed in kilograms, height at withers expressed in centimeters (Donovan & Braun, 1987) and body condition rating (CCC), assessed on a scale of 1 to 5 (Edmonson et al., 1989).

The measurement of height at the withers and hips is carried out using a somatometer, which consists of a vertical ruler with a metric scale and a sliding horizontal ruler. This method allows for a simple and reliable assessment of calf skeletal and muscle development over time, especially in farms that do not have a weighing scale (Heinrichs, 2005).

8.5 HEIGHT AT THE WITHERS

Height at withers is an alternative measure used on dairy farms and correlates with the live weight of the animal. As a general reference, it is considered appropriate that approximately 90% of calves should be between 75 and 78 cm tall at the withers at certain stages of growth (Heinrichs & Jones, 2016).

8.6 THORACIC CIRCUMFERENCE

Measuring chest circumference is a simple, economical and practical method of estimating body weight on farms that do not have a scale. This measure serves as a guide to make adjustments, mainly in the feeding management of calves (Table 5). A reference parameter is that 90% of calves maintain a body condition between 2.0 and 2.25 on the scale used (Heinrichs, 2005; NRC, 2001).

Table 5

Equivalences between thoracic circumference and body weight in calves and heifers of dairy breeds

Holstein and Suizo Pardo		Jersey	
Chest circumference (cm)	**Body weight (kg)**	**Chest circumference (cm)**	**Body weight (kg)**
70.0	33	**70.0**	24
72.5	36	**72.5**	28
75.0	39	**75.0**	32
77.5	43	**77.5**	36
80.0	47	**80.0**	41
82.5	51	**82.5**	46
85.0	56	**85.0**	51
87.5	61	**87.5**	57
90.0	66	**90.0**	63
92.5	72	**92.5**	69
95.0	78	**95.0**	75
97.5	84	**97.5**	81
100.0	90	**100.0**	88
102.5	97	**102.5**	95
105.0	104	**105.0**	102
107.5	111	**107.5**	109
110.0	119	**110.0**	117
112.5	127	**112.5**	125
115.0	135	**115.0**	133
117.5	143	**117.5**	141
120.0	152	**120.0**	149
122.5	161	**122.5**	158
125.0	171	**125.0**	167
127.5	180	**127.5**	176
130.0	191	**130.0**	186
132.5	201	**132.5**	196
135.0	211	**135.0**	206
137.5	222	**137.5**	216
140.0	234	**140.0**	226
142.5	245	**142.5**	237
145.0	257	**145.0**	248
147.5	269	**147.5**	259
150.0	281	**150.0**	270
152.5	294	**152.5**	282
155.0	307	**155.0**	294
157.5	320	**157.5**	306
160.0	334	**160.0**	318
162.5	348	**162.5**	331
165.0	362	**165.0**	343
167.5	376	**167.5**	356

170.0	391	**170.0**	370
172.5	406	**172.5**	383
175.0	422	**175.0**	397
177.5	437	**177.5**	411
180.0	453	**180.0**	425
182.5	470	**182.5**	439
185.0	486	**185.0**	454
187.5	503	**187.5**	469
190.0	520	**190.0**	484
192.5	538	**192.5**	499
195.0	556	**195.0**	515
197.5	574	**197.5**	
200.0	592	**200.0**	

Source: Author's own.

8.7 SELECTION OF REPLACEMENTS AND GENETIC IMPROVEMENT

All the technical information that is recorded from the birth of the calf to weaning, such as birth weight, daily weight gain, health status and body condition, forms the basis for identifying the best animals in the herd. These records allow evaluating both individual performance and the efficiency of the management applied during breeding, determining factors for the selection of animals with greater productive potential (Heinrichs & Jones, 2016; VanRaden, 2020).

After the selection of stallions, the selection of the females at weaning represents one of the most important investments in the genetic improvement process of the production unit. In this selection, both the genetic component of the animal and the management to which it was subjected must be considered, since the observed phenotype is the result of the interaction between genetics and environment. Proper management during the rearing stage allows the genetic potential of calves destined for replacement to be expressed (NRC, 2001; Cassell, 2009).

In family milk production units, most replacements come from the herd itself, accounting for approximately 43% of replacement females. This indicates that a significant proportion of calves are destined to replace adult or waste cows, while the rest correspond to calves destined for sale as a source of income. This situation highlights the need to produce animals with good genetic quality and free of diseases, since the permanence of animals with low productive potential or sanitary problems negatively impacts the efficiency and profitability of the production unit (FAO, 2011; Rosas & Villasana, 2022).

For the selection of the best animals in the herd, it is recommended to prioritize the offspring with higher weaning weight and better growth rates, since these indicators are associated with better feed efficiency and greater reproductive and productive performance in adult life. Generally, these calves are the daughters of cows that reached puberty early, gestated more quickly during the mating season, and had higher milk productions, reflecting the influence of the maternal genetic component on the performance of the offspring (Heinrichs, 2005; Ettema & Santos, 2004).

On the other hand, it is not recommended to select calves with poor conformation, poor health history or those from twin births in which the other product was male. The latter, known as freemartin, usually present alterations in the development of the reproductive system and, in most cases, are sterile, so their inclusion as replacements generates economic and productive losses (Roberts, 1986; Padula, 2005).

8.8 WEANING, SELECTION AND DEVELOPMENT OF REPLACEMENT FEMALES

In national livestock, weaning of calves (females and males) is generally carried out around seven months of age; however, because not all calves are born on the same date, it is necessary to estimate the weaning weight adjusted to 205 days, considering calves between 160 and 250 days of age. This adjustment allows for an objective comparison of the performance of the offspring and constitutes a fundamental tool in genetic improvement programs, since it facilitates the selection of animals with the greatest productive potential, particularly those with higher weaning weights (Bagley, 1993; Heinrichs & Jones, 2016). Weight adjustment should be made only in calves within the established age range to avoid bias in the evaluation.

Once the calves with the highest weaning weight have been selected, a second selection is recommended. At this stage, excessively fat calves should be discarded, as they tend to have lower milk production in adult life, as well as those with an excessively large body structure, because this can increase the mature size of the cows in the herd and generate production inefficiencies, especially in systems with limited resources (Ettema & Santos, 2004; NRC, 2001). Through this selection process, farmers ensure that the best animals remain in the herd.

8.9 SELECTION CRITERIA FOR REPLACEMENT FEMALES IN THE DEVELOPMENTAL STAGE

For the producer, the acquisition or breeding of a high-quality replacement heifer represents a strategic investment, since heifers constitute the genetic foundation of the herd. These are expected to become fertile cows, capable of producing one calf per year and remaining productive for a long period (Cassell, 2009).

The process of selecting replacement heifers must consider several stages:

1. Weaning selection,
2. Development from weaning to first mating,

3. Post-mating and first-calving assessment, and
4. Successful repairings.

Heifers that do not meet the established productive and reproductive objectives should be discarded at any time during the process, in order to maintain the efficiency of the system (Heinrichs, 2005; VanRaden, 2020).

The selection of heifers with good body development and rapid conception in their first calf has a positive and lasting impact on the productivity, reproductive efficiency and profitability of the herd (Ettema & Santos, 2004).

8.10 REPLACEMENT FEMALE DEVELOPMENT AND HERD STRUCTURE

A replacement program consists of giving continuity to the body growth and physiological maturation of the offspring, promoting the timely manifestation of puberty, the presentation of the first fertile heat, the first service and, consequently, the first conception at an appropriate age and weight (Day & Anderson, 1998; NRC, 2001).

The objective of the selection of females at first calving is to replace the cows in production that must be eliminated from the herd for reproductive, health or age reasons. To achieve this adequately, it is essential to know the biological and management factors that influence the number of heifers and heifers available annually (FAO, 2011).

Production units generally must internally generate the heifers needed to replace unproductive cows, which implies knowing how many females are required to maintain the size and productive potential of the herd, as well as how many can be destined for sale as additional income (Rosas & Villasana, 2022).

For the development of the herd it is necessary to have information such as:a) Number of animals per batch,b) Current productive and reproductive indicators and future goals,c) Technical records and spreadsheets,d) Carrying capacity of the paddocks (UA),e) Area available for grazing, and f) Cow:male ratio for mating, recommending an approximate ratio of 25 cows per stallion (Radostits et al., 2007).

Herd structure can be affected by calving rate, sex ratio at birth, and mortality and culling rates. Therefore, the number of heifers that remain in the herd results from the balance between generation and sale, considering factors such as mortality, voluntary and involuntary discarding, and age at first calving (Heinrichs & Jones, 2016).

8.11 FEEDING OF REPLACEMENT HEIFERS

One of the main objectives in any livestock production unit is to achieve heifers that cycle at an early age, are easy to calve, produce offspring with good weaning weight and have a long productive life in the herd (Bagley, 1993). Regardless of genotype, body weight is a determining factor for the onset of puberty and reproductive activity, with the first fertile estrus being observed when the calf reaches approximately 40% of its adult weight (Day & Anderson, 1998).

Under conditions of good nutrition, sexual maturity can occur around 11 months of age; however, in tropical regions, heat stress and poor diet quality can delay puberty until 14 or 15 months of age (Villagómez & Fajardo, 1990). A higher growth rate shortens the age to puberty, so feeding from weaning to the first service is decisive for early pregnancy and better productive and reproductive performance (Bagley, 1993).

The National Research Council has established the nutritional requirements of growing cattle considering breed, weight, physiological stage and expected daily gain, which allows the formulation of balanced rations with various ingredients available in each production system (NRC, 2001). There are also commercial supplements that support heifer growth, and their use is especially relevant in times of drought or when the availability and quality of forage is limited (Van Soest, 1994).

8.12 SELECTION OF HEIFERS PER YEAR

To properly assess the physical differences between heifers at one year of age, it is necessary to make adjustments based on the dimensions of the pelvic area, since this measurement allows estimating their relationship with the size of the calf at birth and, therefore, its ability to calve without assistance (Bagley, 1993; Noakes et al., 2019).

The highest number of dystotic births occur in heifers of first calving, with the disproportion between the size of the calf at birth and the dimensions of the mother's pelvic area being the main factor that hinders calving. For this reason, the measurement of the pelvic area is used as a selection and disposal tool to reduce the probability and severity of dystotic births, contributing to improving animal welfare and the reproductive efficiency of the herd (Meijering, 1984; Arthur et al., 2001).

The measurement of the pelvic area, which results from the product of the length and width of the pelvic canal, is carried out by means of a pelvimeter between 320 and 410 days of age of the heifer. This measurement allows estimating whether a heifer at first calving will be able to give birth without help. The most common application is to define a minimum pelvic area; if the value obtained is below the established threshold, the female is discarded as a replacement (Bagley, 1993; Noakes et al., 2019). As a reference, a minimum pelvic area of approximately 150 cm² is recommended for one-year-old heifers with 318 kg body weight and 180 cm² for those weighing close to 400 kg.

8.13 ZOOTECHNICAL PURPOSE

According to the productive objective of the livestock production unit, whether it is the production of calves at weaning or the production of milk and calves, the producer must carefully evaluate the conditions of the environment where the herd will develop, as well as select the breed or cross most appropriate to the production system and the availability of resources (FAO, 2011; Rosas & Villasana, 2022).

In dual-purpose production systems, it is common to recommend crossing specialized European breeds, such as Brown Swiss or Simmental, with Zebu breeds such as Brahman, Nelore, Gyr, or Indobrasil. This type of crossbreeding allows animals with greater rusticity, adaptation to the tropics and an adequate balance between milk and meat production (McDowell, 1985; Madalena, 2008). Under grazing conditions and proper management, females resulting from these crosses can reach lactation peaks close to 20 L of milk, while males destined for meat can reach slaughter weight around two years (Madalena, 2008; FAO, 2011).

8.14 ECONOMIC MONITORING AND EVALUATION

All productive activity must generate profits in order to be sustainable over time. In this sense, milk production units under the family system must also seek profitability, which requires systematic control of the investments made, operating expenses and sales of the products obtained. The implementation of economic records allows for periodic evaluations and to determine whether calf rearing and replacement heifer production are economically viable (FAO, 2011; Heinrichs & Jones, 2016).

8.15 ECONOMIC RECORDS

The economic information of a dairy production unit can be monitored using previously designed formats or through record books that include variables such as assets, purchases and sales. Although the level of detail of the records depends on the size of the company, it is recommended to record the assets at least once a year, while purchases and sales should be recorded as they are made. This control facilitates decision-making, herd growth planning, and evaluation of the profitability of the production system (FAO, 2011; Rosas & Villasana, 2022).

9 DISCUSSION

The use of technological components in family or backyard milk production systems depends fundamentally on the benefit expected by the producers, as well as the capital available to invest in each element susceptible to improvement. In these systems, technological adoption is usually gradual and selective, privileging those practices that have a direct impact on productivity, the reduction of losses and the efficiency of the use of available resources (FAO, 2011; Herrero et al., 2010).

Within each farm, it is necessary to analyse the individual production level of each unit or producer, in order to use it as a reference for decision-making. This analysis allows adjustments to be made aimed at reducing, controlling or redistributing production costs, not only in the area of cattle feed, but also in aspects such as health, reproduction and general management of the herd. In particular, ration adjustment should be based on local forage availability, ensuring that forages are of good quality, as they are the food base of family dairy systems (Van Soest, 1994; Rosas & Villasana, 2022).

In dairy cows with high productive potential, energy and protein requirements are considerably increased, which forces the producer to complement the traditional management of the animal with more precise nutritional strategies. Forages alone are often insufficient to meet the energy and protein demand required to sustain high levels of milk production, especially during peak lactation (NRC, 2001; Heinrichs & Jones, 2016).

The use of concentrates in the dairy cow's ration allows additional sources of energy and protein to be provided, complementing the forages and facilitating the fulfilment of the animal's nutritional requirements. In this way, concentrates become key inputs for the formulation of balanced diets that maximize milk production and improve herd feed efficiency (Khan et al., 2011; NRC, 2001).

However, the amount of concentrate that a cow can receive daily must be directly related to its production level and the economic capacity of the producer, since the excessive use of these inputs significantly increases production costs. The main challenge in family dairy systems is to strike a balance between adequate nutrient supply and cost control, so that production is maintained without compromising the profitability of the production unit (FAO, 2011; Thornton, 2010).

10 CONCLUSION

The purpose of this project was to contribute to the most efficient use of the agricultural and livestock resources available in family dairy systems, so that the producer can clearly define the uses and applications of these resources according to their productive, economic and social needs. In this type of system, the profitability of the production unit is directly supported by the number of animals, the level of production achieved and the purpose of use or marketing of the main product, which is milk (FAO, 2011; Rosas & Villasana, 2022).

The results and recommendations derived from the project show that the gradual and strategic application of technological components in family milk production, adjusted to the different production levels, allows improving the efficiency of the system without compromising the economic viability of the producer. Key aspects such as calf rearing systems, heifer replacement programs, sanitary management, milking hygiene, and forage production and conservation are fundamental pillars for the strengthening of family dairy production units (Heinrichs & Jones, 2016; NRC, 2001).

Likewise, it is concluded that the permanent training of producers and technicians is an indispensable element for the correct implementation of these practices, since it facilitates the adoption of appropriate technologies, improves decision-making and favors the productive and economic sustainability of family dairy systems. In this way, the project meets the proposed objective by providing technical tools that optimize the integral management of the herd, ensure the quality of replacement animals and contribute to the development and permanence of the family dairy in the country (FAO, 2011; Thornton, 2010).

REFERENCES

Arthur, G. H., Noakes, D. E., Pearson, H., & Parkinson, T. J. (2001). Veterinary reproduction and obstetrics (8th ed.). Saunders.

Bagley, C. P. (1993). Nutritional management of replacement heifers. Journal of Animal Science, 71(11), 3155–3163.

Bath, D. L., Dickinson, F. N., Tucker, H. A., & Appleman, R. D. (1986). Dairy cattle: Principles, practices, problems, profits (3rd ed.). Lea & Febiger.

Cassell, B. G. (2009). Using phenotype and genotype in dairy cattle selection. Journal of Dairy Science, 92(1), 404–410.

Costa, J. H. C., Cantor, M. C., & Neave, H. W. (2021). Precision technologies for dairy calves and management applications. Journal of Dairy Science, 104(1), 1203–1219. https://doi.org/10.3168/jds.2019-17885

Costa, J. H. C., von Keyserlingk, M. A. G., & Weary, D. M. (2021). Benefits of colostrum management for dairy calves. Journal of Dairy Science, 104(1), 505–515.

Currin, F. J., Bailey, T., & Bass, T. (1999). Developing vaccination programs for cattle in Virginia. Virginia Cooperative Extension.

Currin, J. F., Whittier, J. C., & Currin, N. (1999). Designing herd health programs. Veterinary Clinics of North America: Food Animal Practice, 15(2), 231–245.

Davis, C. L., & Drackley, J. K. (1998). The development, nutrition, and management of the young calf. Iowa State University Press.

Day, M. L., & Anderson, L. H. (1998). Current concepts on the control of puberty in cattle. Journal of Animal Science, 76(Suppl. 3), 1–15.

Donovan, G. A., & Braun, R. K. (1987). Calf growth and management. Journal of Dairy Science, 70(2), 352–359.

Donovan, G. A., & Braun, R. K. (1987). Evaluation of dairy replacement-rearing programs. Compendium on Continuing Education for the Practicing Veterinarian, 9(4), F133–F139.

Drackley, J. K. (2008). Calf nutrition from birth to breeding. Veterinary Clinics of North America: Food Animal Practice, 24(1), 55–86.

Drillich, M., Beetz, O., Pfützner, A., Sabin, M., Sabin, H. J., Kutzer, P., Nattermann, H., & Heuwieser, W. (2006). Evaluation of a systemic antibiotic treatment of retained fetal membranes in dairy cows. Journal of Dairy Science, 89(2), 627–635.

Eadie, J. (2025). Technological components for calf management in small-scale dairy systems. Technical manual of dairy production.

Eadie, T. (2025). Smarter calf management: How precision tools are redefining dairy success. Dairy Producer.

Edmonson, A. J., Lean, I. J., Weaver, L. D., Farver, T., & Webster, G. (1989). A body condition scoring chart for Holstein dairy cows. Journal of Dairy Science, 72(1), 68–78.

Ettema, J. F., & Santos, J. E. P. (2004). Impact of age at first calving on lactation, reproduction, health, and income in first-parity Holsteins on commercial farms. Journal of Dairy Science, 87(8), 2730–2742.

FAO. (2010). Analysis of integrated systems of agriculture and livestock. Food and Agriculture Organization of the United Nations.

FAO. (2011). Guide to good animal management and welfare practices in dairy farms. Food and Agriculture Organization of the United Nations.

FAO. (2018). Dairy development and livestock systems. FAO Animal Production and Health Series.

FAO. (2019). Milk and dairy products in human nutrition. FAO.

Galaviz, R. J. R. (2005). Panorama and perspectives of livestock production in the state of Tlaxcala. In Memoria del 1er. Forum of Experiences in Research and Transfer of Agricultural and Forestry Technology in the State of Tlaxcala 1999-2003 (pp. 218–225). INIFAP-Tlaxcala.

Galaviz, J. R. (2005). Practical manual for raising calves in family systems. Chapingo Autonomous University.

Galaviz, J. R., López, A., & Hernández, M. (2000). Management and rearing of calves in family dairy production systems. Livestock Technique in Mexico, 38(2), 123–135.

Galaviz, R. J. R., González, O. A. T., Calderón, R. R. C., & Lagunes, L. J. (2000). Guide for raising calves in the family dairy system (Technical Brochure No. 23).

Godden, S. (2008). Colostrum management for dairy calves. Veterinary Clinics of North America: Food Animal Practice, 24(1), 19–39.

Grummer, R. R., Mashek, D. G., & Hayirli, A. (2004). Dry matter intake and energy balance in the transition period. Veterinary Clinics of North America: Food Animal Practice, 20(3), 447–470.

Heinrichs, A. J., & Jones, C. M. (2016). Heifer rearing: A guide to successful dairy replacement management. Penn State Extension.

Heinrichs, A. J. (2005). Raising dairy replacements to meet the needs of the 21st century. Penn State Extension.

Herrero, M., Havlík, P., Valin, H., Notenbaert, A., Rufino, M. C., Thornton, P. K., Blümmel, M., Weiss, F., Grace, D., & Obersteiner, M. (2013). Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. Proceedings of the National Academy of Sciences of the United States of America, 110(52), 20888–20893. https://doi.org/10.1073/pnas.1308149110

Herrero, M., Thornton, P. K., Notenbaert, A. M., Wood, S., Msangi, S., Freeman, H. A., Bossio, D., Dixon, J., Peters, M., van de Steeg, J., Lynam, J., Parthasarathy Rao, P., Macmillan, S., Gerard, B., McDermott, J., Seré, C., & Rosegrant, M. (2010). Smart investments in sustainable food production: Revisiting mixed crop-livestock systems. Science, 327(5967), 822–825. https://doi.org/10.1126/science.1183725

INEGI. (2020). Agricultural Census 2019. National Institute of Statistics and Geography, Mexico.

Khan, M. A., Weary, D. M., & von Keyserlingk, M. A. G. (2011). Effects of milk ration on solid feed intake, weaning, and performance in dairy heifers. Journal of Dairy Science, 94(2), 1071–1081.

Madalena, F. E. (2008). Dairy cattle genetic improvement in developing countries: Lessons from Brazil. Livestock Research for Rural Development, 20(12).

McDowell, R. E. (1985). Crossbreeding in tropical areas with emphasis on milk, health, and fitness. FAO Animal Production and Health Paper.

McGuirk, S. M., & Collins, M. (2004). Managing the production, storage, and delivery of colostrum. Veterinary Clinics of North America: Food Animal Practice, 20(3), 593–603. https://doi.org/10.1016/j.cvfa.2004.06.005

me, J. F. (2004). Managing the dairy cow at calving time. Veterinary Clinics of North America: Food Animal Practice, 20(3), 521–546.

me, J. F. (2008). Managing the dairy cow at calving time. Veterinary Clinics of North America: Food Animal Practice, 24(2), 295–311.

me, J. F. (2008). Prevalence and risk factors for dystocia in dairy cattle—a review. The Veterinary Journal, 176(1), 93–101.

me, J. F. (2012). Managing the dairy cow at calving time. Veterinary Clinics of North America: Food Animal Practice, 28(3), 489–502.

Meijering, A. (1984). Dystocia and pelvic dimensions in cattle. Veterinary Clinics of North America: Large Animal Practice, 6(2), 315–330.

Noakes, D. E., Parkinson, T. J., & England, G. C. W. (2019). Arthur's veterinary reproduction and obstetrics (10th ed.). Elsevier.

NRC (National Research Council). (2001). Nutrient requirements of dairy cattle (7th rev. ed.). National Academies Press.

OIE. (2019). Manual of diagnostic tests and vaccines for terrestrial animals. World Organisation for Animal Health.

Overton, T. R., & Waldron, M. R. (2004). Nutritional management of transition dairy cows: Strategies to optimize metabolic health. Journal of Dairy Science, 87(E. Suppl.), E105–E119.

Padula, A. M. (2005). The freemartin syndrome: An update. Animal Reproduction Science, 87(1–2), 93–109.

Quigley, J. D., & Drewry, J. J. (1998). Nutrient and immunity transfer from cow to calf. Journal of Dairy Science, 81(10), 2779–2790.

Quiroz, H., Figueroa, J., & Ibarra, F. (2011). Veterinary parasitology. Editorial Limusa.

Radostits, O. M., Gay, C. C., Hinchcliff, K. W., & Constable, P. D. (2007). Veterinary medicine: A textbook of the diseases of cattle, horses, sheep, pigs and goats (10th ed.). Saunders Elsevier.

Robers, L., Jorritsma, R., Nielen, M., & Koets, A. (2021). A scoping review of on-farm colostrum management practices for optimal transfer of immunity in dairy calves. Veterinary Sciences, 8, Article 668639. https://doi.org/10.3389/fvets.2021.668639

Robers, M. (2021). Principles of vaccination and immune response in cattle. Veterinary Immunology and Immunopathology, 234, 110–118.

Roberts, S. J. (1986). Veterinary obstetrics and genital diseases (Theriogenology). Edwards Brothers.

Roche, J. R., Friggens, N. C., Kay, J. K., Fisher, M. W., Stafford, K. J., & Berry, D. P. (2009). Body condition score and its association with dairy cow productivity, health, and welfare. Journal of Dairy Science, 92(12), 5769–5801.

Rosas, L. M., & Villasana, L. P. (2022). Adoption of technologies in agri-food production systems: A literature review. RIVAR, 9(26).

Rosas, J., & Villasana, E. (2022). Artificial calf rearing and its impact on the productive efficiency of family dairy systems in Mexico. Mexican Journal of Livestock Sciences, 13(2), 489–502.

Santiago Solano, A. D., Velázquez Contreras, L., Moreno Dena, J. M., & Salazar Solano, V. (2020). Innovation and productive integration in a dual-purpose cattle system in northwestern Mexico. Region and Society.

Santiago, A., López, J., Martínez, R., & Gómez, L. (2020). Agriculture-livestock integration as a strategy for the sustainability of rural production systems. Mexican Journal of Livestock Sciences, 11(3), 745–758.

Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food. (2002). Manual of organization of the technical-consultative commission of grazing coefficients. http://normateca.sagarpa.gob.mx/ArchivosNormateca/manual_3.pdf

SIAP. (2023). Livestock production: Bovine milk. Agri-Food and Fisheries Information Service, Ministry of Agriculture and Rural Development, Mexico.

Silva, F. G., Caseição, C., & Silva, R. S. (2023). Literature review on technological applications to monitor and evaluate calves' health and welfare. Animals, 13(7), 1148.

Silva, M. E., González, F., & Pérez, R. (2023). Nutritional management of antepartum cows and its impact on metabolic health. Revista Mexicana de Ciencias Pecuarias, 14(1), 112–125.

Soberon, F., Raffrenato, E., Everett, R. W., & Van Amburgh, M. E. (2012). Preweaning milk intake and effects on long-term productivity of dairy calves. Journal of Dairy Science, 95(2), 783–793.

Stafford, K. J., & Mellor, D. J. (2005). Dehorning and disbudding distress and its alleviation in calves. The Veterinary Journal, 169(3), 337–349.

Svensson, C., & Liberg, P. (2006). The effect of group size on health and growth rate of Swedish dairy calves housed in pens with automatic milk-feeders. Preventive Veterinary Medicine, 73(1), 43–53.

Svensson, C., Lundborg, K., Emanuelson, U., & Olsson, S. O. (2003). Morbidity in Swedish dairy calves from birth to 90 days of age. Preventive Veterinary Medicine, 58(3–4), 179–197.

Thornton, P. K. (2010). Livestock production: Recent trends, future prospects. Philosophical Transactions of the Royal Society B, 365(1554), 2853–2867.

Thornton, P. K., & Herrero, M. (2015). Adapting to climate change in the mixed crop and livestock farming systems in sub-Saharan Africa. Nature Climate Change, 5, 830–836.

Tizard, I. R. (2020). Veterinary immunology (10th ed.). Elsevier.

Van Metre, D. C., Callan, R. J., & Garry, F. B. (2019). Health management of dairy calves. Veterinary Clinics of North America: Food Animal Practice, 35(1), 1–20.

Van Metre, D. C., Galyean, M. L., & Branine, M. E. (2019). Veterinary medicine: A textbook of the diseases of cattle, horses, sheep, pigs and goats (11th ed.). Elsevier.

Van Soest, P. J. (1994). Nutritional ecology of the ruminant (2nd ed.). Cornell University Press.

VanRaden, P. M. (2020). Genomic selection in dairy cattle. Journal of Dairy Science, 103(1), 1–9.

Villagómez, A. E., & Fajardo, G. J. (1990). Reproductive behavior of zebu cows kept in tropical climate. In T. M. Valdovinos, G. F. Cisneros, & L. H. Barradas (Eds.), X Symposium of Tropical Livestock. Beef Producing Cattle (pp. 63–68). INIFAP, CIFAP-VER.

Villagómez, E., & Fajardo, R. (1990). Factors that affect puberty in heifers in the tropics. Livestock Technique in Mexico, 28(3), 145–152.

Walstra, P., Wouters, J. T. M., & Geurts, T. J. (2006). Dairy science and technology. CRC Press.

Weaver, D. M., Tyler, J. W., VanMetre, D. C., Hostetler, D. E., & Barrington, G. M. (2000). Passive transfer of colostral immunoglobulins in calves. Journal of Veterinary Internal Medicine, 14(6), 569–577.