Animal welfare in Mexican dual-purpose cattle herds in the tropics - with focus on feeding and housing

Djurvälfärd hos nötkreatursbesättningar i kombinerad mjölk- och köttproduktion under tropiskt klimat i Mexiko - med inriktning på inhysning och foder

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1 Summary

Chiapas is a state in the southeast of Mexico where the climate is tropical, both humid and dry. The predominant cattle production system found is dual-purpose, which on every productive cycle produces both milk and meat. Growing concern about animal welfare can be seen among consumers, who expect their food to be produced with respect to the animals and their welfare. Animal welfare assessment on farm is needed to inform animal unit managers about the welfare status on their farm and to identify areas in need of improvement. Strategies for improving animal welfare can thereafter be implemented which is an important step in the work for improving the quality of animal products. In this study we conducted welfare assessments on 34 farms, located in San Pedro Buena Vista, using a modified Welfare Quality® Assessment protocol for cattle to suit this kind of small-scale production in the tropics. The protocol from Welfare Quality® is based on the five freedoms from the Farm Animal Welfare Council and is based on the welfare principles Good Feeding, Good Housing, Good Health and Appropriate behaviour. This study focuses on Good feeding and Good housing. The main findings were that absence of prolonged hunger and absence of prolonged thirst were the areas where improvements are necessary for better animal welfare. Housing was good according to the protocol since there is very little infrastructure on these farms and no housing is needed. The animals are kept on extensive pastures most of the time and a better way of assessing this kind of housing would be needed to get a better understanding of the actual welfare. There is also a need to create a method to properly assess thermal comfort since heat stress is more common in the tropics than in thermal climates, where the original WQ® protocol was developed. Further studies should focus on feed management to improve Good Feeding. Providing knowledge to the farmers is important to find alternative management practices that is economically feasible to both increase their productivity and animal welfare.

2 Sammanfattning

Chiapas är en delstat i sydöstra Mexiko med tropiskt klimat. Den dominerande nötdjursproduktionen är kombinerad mjölk- och köttproduktion där varje produktionscykel genererar mjölk dagligen och kött när tjurkalvar avvänjs. Djurvälfärd inom animalieproduktionen är något som fler och fler konsumenter blir medvetna om och de förväntar sig därför att denna produktion tar hänsyn till både djuren och deras välfärd. För att förbättra djurvälfärden är det viktigt att informera djurägare om hur välfärden är på deras gårdar för att hitta orsaker till eventuell försämrad djurvälfärd som sen kan förbättras. Denna studie utförde välfärdsbedömningar på 34 gårdar i San Pedro Buena Vista med hjälp av ett anpassat ”Welfare Quality® Assessment protocol for cattle” för denna typ av produktion. Detta protokoll är baserat på de fem friheterna från ”Farm Animal Welfare Council” och består av välfärdsprinciperna ”Bra utfodring”, ”Bra inhysning”, ”Bra hälsa” och ”Normalt beteende”. Fokus för denna studie är ”Bra utfodring” och ”Bra inhysning”. De viktigaste slutsatserna var att välfärdskriterierna ”Frånvaro av långvarig hunger” och ”Frånvaro av långvarig törst” var de områden där förbättringar behövs för bättre djurvälfärd. Inhysningen var bra enligt protokollet eftersom det är väldigt lite infrastruktur på dessa gårdar, där det till exempel inte finns något behov av byggnader. Djuren inhyses på extensiva beten större delen av dygnet och en bättre metod för att bedöma denna typ av inhysning skulle behövas för att bättre förstå den verkliga djurvälfärden. Det behövs också en metod för att bedöma den termiska komforten eftersom värmestress är vanligare i tropikerna jämfört med det termiska klimat, där originalet av WQ protokollet har utvecklats. Framtida studier bör fokusera på att förbättra utfodringen. Slutligen är det viktigt att tillhandahålla kunskap till djurägarna för att hitta alternativa sätt att förvalta djuren som är ekonomiskt genomförbara och som kan förbättra både djurvälfärd samt produktivitet.

3 Introduction

Cattle are an essential part of human society. They provide us with food, clothing, fuel, draft power and companionship. Cattle use resources that are of little or no value to humans and they constitute a genetic insurance since future events may favour different genotypes (Phillips, 2002; Webster, 2005). Mexico is placed among the ten biggest beef and milk producers worldwide (Rojo-Rubio *et al.*, 2009) and cattle production is found in nearly all of Mexico's climatic environments. The production system chosen, and cost of it, is dependent on climate. Productivity of a given production system varies from region to region (Peel *et al.*, 2010). Cattle production is one of the most important livestock activities in the rural areas of Mexico. Most of the national territory is dedicated to this production and it uses most of the agricultural supplies, forage resources, agricultural by-products and agro-industrial by-products (Rojo-Rubio *et al.*, 2009).

3.1 Small-scale dual-purpose cattle production in Mexico

The main suppliers of beef and milk are found in the tropical zones of Mexico and they are mainly found in the developing regions (Rojo-Rubio *et al.*, 2009). As reported by Rivera (1989) the majority of dual-purpose systems in the tropics use undefined crossing schemes with *Bos indicus* (maternal line) and *Bos taurus* (paternal line) as an attempt to obtain the highest hybrid vigour (cited by Rojo-Rubio *et al.*, 2009). This combines the high milking potential and early maturing of European breeds with adaptability to conditions of nutrients and limiting health factors from zebu and local breeds (Blake, 2004). The animals are managed in dual-purpose systems which can be described as producing, on every productive cycle, milk daily and beef when calves are being weaned. The milk is either used for self-consumption or sold to local markets and calves are after weaning sold to local feedlots or for export (Rojo-Rubio *et al.*, 2009).

Most of the milk collected from small-scale dual-purpose farms is marketed as raw milk or as cheese made by small processors (Améndola *et al.*, 2006). Dual-purpose production systems are insufficient in meeting the demand for milk due to population growth and urbanization. However, specialized intensive cattle production systems are, according to Magaña Monforte *et al.* (2006), less viable due to their high production cost and limited resources of water. The water resources are being overloaded when there is a high pressure in usage; housing of cattle and growing of crops requires high water consumption (Magaña Monforte *et al.*, 2006). This results in a higher risk of water pollution and the intensive systems are therefore not the best alternative for increasing the production due to the limited sustainability. Dual-purpose production systems have a good reason for increasing their participation in Mexico's milk production due to their usage of available natural resources as pastures, water and by-products which gives low cost in comparison to usage of external feed/concentrates (Magaña Monforte *et al.*, 2006).

Milk production systems vary extremely across agro-ecological zones but most of them are dependent on the availability of range or pasture land which is used both for grazing and feed production (Bennett *et al.*, 2006). Feed forms the largest input to most milk production systems while support services, such as for animal health, are essential to ensure achieved and maintained productivity. Small-scale farms are dependent on availability of land area, water and productivity of the animals (Bennett *et al.*, 2006). Milk is a source of both nutritious food products and a regular income. Milk production in

developing countries plays a key role in the household food security. On the other hand, crop farming and meat production give periodic income returns. Dairying is therefore an important benefit for the farmers to support an appreciation and gradual adoption of saving and loan approaches (Webster, 2005; Bennett *et al.*, 2006). Small-scale dairy production in rural areas of Mexico is a major source for employment, serving as a tool for development and alleviation of rural poverty (Espinoza-Ortega *et al.*, 2007). Access to family related labour has shown to be a crucial factor for small-scale dairy production providing profitability and competiveness. Its economic importance is directly related to herd size; larger herds give better profitability (Posadas-Dominguez *et al.*, 2014). However, these small-scale farms lack capital, infrastructure and equipment (Améndola *et al.*, 2006). The level of organization and integration is low and there is a lack of regular channels for commercialization of their products. Otherwise, they could obtain higher prices for their products, pay lower prices for inputs, receive regular technical advice and have easier access to credit with preferential rates (Améndola et al., 2006). Nevertheless, market oriented small-scale dairying has the potential to increase household income, reduce income losses and generate employments in processing and marketing (Bennett *et al.*, 2006). Farmers might not have the time or proper training to research market demands and consequently, they are not aware of what is needed. One mechanism to improve this is to create farmer groups that can improve bargaining power and inform farmers of market needs and demands (Bennett *et al.*, 2006). The Genesis farmer organization in Veracruz, Mexico serves as an example of this (Absalón-Medina *et al.*, 2012a), aiming to seek possible improvements in farm outcomes through officially recognized rural entities that qualify for more support and advice from the government. The members of this organization have responded to professional advice by investing in producing their own forage with higher quality (which is rare for Mexican dual-purpose farmers), and replacing or adding grass and legume species to the natural available forage (Absalón-Medina *et al.*, 2012a).

3.1.1 Feeding, housing and management

The majority of Mexican dual-purpose farms keep their cattle on continuous grazing of tropical grasses and this is the primary nutrient resource. Native pastures provide low cost nutrients but grass quality can be constrained by seasonal changes. It is therefore common to provide the animals with supplementary feeding during the dry season to uphold production (Juárez-Lagunes *et al.*, 1999; Montiel *et al.*, 2007; Pedraza-Beltrán *et al.*, 2012). The pastures consist mainly of native, improved and naturalized grasses with low productivity (Rodriguez-Romero *et al.*, 2004). These tropical grasslands constitute 80 % of the Mexican subtropical farm areas and according to Salas-Reyes *et al.* (2015) these have a low impact on the environment, when compared to agriculture. The extensive pasture based systems have advantages like a great diversity of perennial crops. Another benefit is that excreta deposition from cattle falls directly on the soil, representing an organic fertilization, which reduces the need for external input of fertilizers. It has also a positive effect for the economy of farmers as cost for feeding and fertilization is reduced, at least during the rainy season. The dry season can, on the contrary, be hard for the farmers when the need of feed supplements increases together with the cost of production of milk and beef (Salas-Reyes *et al.*, 2015).

When Juárez-Lagunes *et al.* (1999) analysed tropical forage grasses from southeast of Mexico results showed that availability of metabolizable protein would limit the milk pro-

duction in dual-purpose systems since microbial growth was limited by ruminally available protein, rather than carbohydrates (Juárez-Lagunes *et al.*, 1999). Forage production during the dry season and droughts does not satisfy nutritional requirements for maintenance, growth and milk production (Rodriguez-Romero *et al.*, 2004). To decrease the negative effects of low forage availability, most critically during dry season, farmers must use energy and protein supplementation to compensate the low digestible forages containing high fibre and low nitrogen level. Protein supplementation can either be as non-protein nitrogen, such as urea, or as rumen bypass proteins (Castillo *et al.*, 1999; Rodriguez-Romero *et al.*, 2004). Usage of relatively inexpensive agricultural by-products is important to profitable livestock production and one example is giving up to 20 % coffee pulp in concentrates for milking cows to maintaining productivity but lowering costs for concentrates (Pedraza-Beltrán *et al.*, 2012).

Feed also has an important impact on reproduction and productivity. Absalón-Medina *et al.* (2012a) studied dual-purpose herds in Veracruz, Mexico, showing energy deficits among dry cows and immature cows. Cows were typically smaller and underweight for their age which limits feed intake capacity, milk production and the probability of returning to ovarian cyclicity postpartum. The animals display longer calving intervals and less milk production per cow over their productive lifetime. But high quality harvested forage increased milk yields and when diets from first parturition accurately supported cow growth and tissue construction, to achieve desirable body weight, milk production in second and third lactation was improved by up to 60 %. When supplemented diets contained legume forages at first calving, it was predicted that productivity would increase by up to 80 %. The study concluded that these farmers have large incentives to increase milk sales by implementing nutritional management strategies (Absalón-Medina *et al.*, 2012a; Absalón-Medina *et al.*, 2012b). A greater production can therefore be achieved by improving nutritional and reproductive management of the herds.

Since the dual-purpose production in Mexico often uses crosses of *Bos indicus* and *Bos taurus* (Montiel *et al.*, 2007) and the calves get to suckle the cows (Orihuela, 1990; Rojo-Rubio *et al.*, 2009) it would be interesting to find if the suckling affects the productivity. Calves are commonly allowed to suckle restrictively where they are tethered beside the cow to stimulate milk let-down and after milking they get to suckle the cow for a limited period of time (Orihuela, 1990). *Bos indicus* cattle have shown a higher need of the presence of calves for milk ejection and according to Orihuela (1990) the highest milk yield from *Bos indicus* cows is received when being in physical contact and suckled by their calves. Studies with the cross *Bos indicus*/*Bos taurus* also shows the same result, compared to non-suckling (Fröberg *et al.*, 2007). Beside the higher milk yield, Fröberg *et al.* (2007) found that the udder health also was improved with restricted suckling.

3.1.2 Sustainability

There are several definitions of sustainability. One simplistic definition is that the use of a resource is sustainable if it does not constrain future use of the resource. The bottom line of sustainability is simultaneous achievement of economic feasibility, social responsibility or justice, and environmental quality (Peterson, 2013). So a future long term viability of small-scale production systems is that they are sustainable in relation to the environment, social structures and economy.

Mexican agriculture is developing into a more competitive context and there is hence a need to find areas of weakness and to assess the current sustainability. This could in a second step determine opportunities for improvement which may help to develop research and policies (Fadul-Pacheco *et al.*, 2013). Dual-purpose cattle farms are, according to Salas-Reyes *et al.* (2015), moderately sustainable with economy as the limiting factor which therefore has opportunities for improvement. This type of system is mainly located in developing regions and characterized by being found in poor environments using low-technology which consequently leads to productive levels considered as low (Rojo-Rubio *et al.*, 2009; Nahed-Toral *et al.*, 2013). These farms may be considered as unproductive and inefficient. Nevertheless, their low use of external inputs and high utilization of local resources may make this production sustainable in economic, agro-ecological and socio-territorial terms (Nahed-Toral *et al.*, 2013; Salas-Reyes *et al.*, 2015). Magaña Monforte *et al.* (2006) points out that a rearrangement in the use of resources should be done to make profitable and sustainable systems. The potential for increasing the milk production in dual-purpose systems lies in the management of available resources, such as soil, water, forages, cheap by-product feeds, the existing animal population and technology currently in use. Milk from this production is according to Magaña Monforte *et al.* (2006) cheaper when compared to milk produced from other, more intensive, systems in Mexico. However, the dual-purpose production system has several challenges like the lack of information about costs and bioeconomical benefits from different proposed technologies (Magaña Monforte *et al.*, 2006).

There are examples of dual-purpose cattle production that seems to have positive future prospects with opportunity for improvement. According to Garcia-Martinez *et al.* (2015) dual-purpose farms in the dry tropical southwest of Mexico show a dynamism in structure, management and administration. The farms showed significant changes in land use and there were greater tendency of having extensive cattle management, efficient use of land and introduction of breeds that fit the existing geography (Garcia-Martinez *et al.*, 2015). The producers increased their commitment for caring and maintaining the environment and available resources. This was a result from the pursuit of economic benefits, product quality, value added products and growth potential. Their commitment afforded a better perception as a cattle producer, and in order to increase their income for improving the living conditions for their families, they diversified their activity (Garcia-Martinez *et al.*, 2015).

Sustainability of animal production in relation to animal welfare is the moral to maintain continuous development in harmony with nature. The animal producers have the duty to play the role as moral stewards, since they are responsible for animals' welfare, due to humanity's moral obligations towards other living creatures. Animals are sentient creatures and production systems resulting in poor welfare are unsustainable since it is unacceptable for society (Szücs *et al.*, 2009; Broom, 2010). In addition, poor animal welfare also results in poor meat quality, which may impose negative economic implications on the beef industry failing to meet the expectations of consumers. Milk production can also be affected by poor welfare and economic advantages can be found if the welfare is improved. It is therefore of importance to create an environment for minimizing livestock discomfort and enhance productivity. There is however some situations where improved welfare leads to reduced profit for the farmer (Fraser, 1997; Ndou *et al.*, 2011).

3.2 Cattle welfare

All definitions of animal welfare have to include three elements; emotional state of the animal, biological function and ability of showing normal patterns of behaviours (Manteca *et al.*, 2009). The Five Freedoms is a framework for animals kept by humans to define ideal states rather than standards for acceptable welfare (Farm Animal Welfare Council, 2009). To provide good welfare attention to the five freedoms must therefore be given (Webster, 2005). Welfare Quality® (2009) built their four welfare principles on these five freedoms;

1. Freedom from Hunger and Thirst - by ready access to fresh water and a diet to maintain full health and vigour
2. Freedom from Discomfort - by providing an appropriate environment including shelter and a comfortable resting area
3. Freedom from Pain, Injury or Disease - by prevention or rapid diagnosis and treatment
4. Freedom to Express Normal Behaviour - by providing sufficient space, proper facilities and company of the animal's own kind
5. Freedom from Fear and Distress - by ensuring conditions and treatment which avoid mental suffering
   (Farm Animal Welfare Council, 2009)

The minimum level of what is acceptable for the adequate welfare of cattle is not established (Phillips, 2002). Consequently, it is a moral decision that commonly is taken by people with different backgrounds, previous experience, age, etc. Modern cattle have shown similar behaviour patterns as their wild relatives. Human selection in the breeding process has had little impact on the behaviour which suggests that intensive housing systems may have deficiencies that need further investigation (Phillips, 2002).

3.2.1 Feed and water provision

The most important aim in feeding cattle is to maintain constant and good conditions in the rumen, which can be negatively affected by a variety of conditions. Abnormal rumen fermentation and digestion can lead to inappetence, acidosis, bloat, displaced abomasum or lameness induced by laminitis (Phillips, 2002; Webster, 2005). Incidents of pain, hunger, maternal anxiety or illness affects rumination together with oestrus and parturition times. The longer rumination is interrupted or delayed, the harder it gets for resuming the activity (Fraser, 1997).

The welfare principle “Good feeding” by Welfare Quality® (2009) constitutes of the welfare criteria absence of prolonged hunger and absence of prolonged thirst. Prolonged hunger and thirst results in poor welfare due to increased stress levels, reduced fitness, immunosuppression, disease and loss of body condition. This consequently leads to inadequate biological functioning which is likely to be an unpleasant emotional state (Webster, 1995; Kariazakis & Tolkamp, 2011). Good indicators where welfare of a cattle herd may be compromised by digestion and metabolism disorders are observations of body condition and the prevalence of production disorders (Webster, 2005). Hunger and thirst are according to Webster (1995) two of the most basic and unceasing motivating desires for animals. Pleasure arises when anticipating that feed will arrive and when eating. Suffering can on the contrary occur directly when feed is absent and indirectly when the animal is prevented from performing behaviours that are anticipated to provide them with feed (Webster, 1995). There are four major criteria to ensure good feeding; adequate provision of all essential nutrients, chemical composition and physical form of feed which

is consistent with stable digestion, feed and opportunity for foraging which allows achievement of oral satisfaction and minimizes the risks of disturbed behaviours, together with feed being free from harmful substances (Webster, 2009).

Cattle evolved primarily as grazing and browsing animals, which means that they harvest their feeds from grasses, legumes and maize stove (grazing) or shrubs and trees (browsing). The wild ancestors of domestic cattle lived mainly in forest fringes where there are shrubs and bushes that can be browsed (Phillips, 2002). Availability of feed diversity is essential for animals to meet their particular nutritional needs and consume substances improving their health. At the same time, this also gives the opportunity to cope with toxins since certain feed combinations have potential to alter the negative effects of toxins. Nature has in the evolutionary diets of animals provided temporal and spatial compositional variety. Manteca *et al.* (2008) therefore suggest that choice of diet is necessary for animals to have the freedom of expressing their normal behaviour and to reduce levels of stress. This could enable the uniqueness of individual animals to be manifest to promote animal welfare and performance which could increase production profitability (Manteca *et al.*, 2008).

Hunger may result in malnutrition, undernutrition, or both (Kariazakis & Tolkamp, 2011). Feed that have unbalanced nutrients can cause malnutrition and it can occur due to a mismatch between farming practices providing a diet for the "average" animal. The individual animal's nutritional needs are though depending on sex, age, stage of growth or reproduction, previous nutritional history etc. (Manteca *et al.*, 2008; Kariazakis & Tolkamp, 2011). On the other hand, undernutrition reflects insufficient supply of nutrients (Kariazakis & Tolkamp, 2011). Undernutrition can for example occur at pasture when forage conditions are poor (Phillips, 2002; Manteca *et al.*, 2009) and feed intake is limited by the rate that cattle can physically harvest and consume the grass (Webster, 2005). The low nutritive value of pasture will in many cases be inadequate to sustain maintenance requirements for cattle and mobilization of body reservoirs will hence occur. The welfare problem for these animals is the metabolic needs for energy and nutrients. This can to some point be compensated by having dormant grasses for the satisfaction of foraging behaviour and physiological rumen fill. There is however a risk of starvation if the rumen is full of grass containing high levels of indigestible lignin (Webster, 2005; Webster, 2009). Fibrous feeds generates greater heat increment of digestion which makes concentrate feed ingredients more preferable in the humid tropics (Phillips, 2002). Nevertheless, since concentrate feed ingredients are required for human consumption fibrous feed are common (Phillips, 2002).

Diseases might be more common during drought since cattle search for feed sources and might eat plants that can be poisonous to them (Phillips, 2002). Providing both mineral and fodder supplements, for energy and protein, can during draughts be crucial for the cattle. But also other fodder supplements which provides energy and protein. Urea might be used as an inexpensive source of nitrogen but caution must be taken since excessive amounts will be toxic (Phillips, 2002).

Prolonged thirst can occur when animals are given water of poor quality or when drinking facilities are insufficient or inadequate. Thirst reduces feed intake and may result in dehydration. (Manteca *et al.*, 2009). When water supplies falls under the point of what is required in the area feed shortages and loss of productivity occur in grazing herds (Phillips, 2002). Cattle need to drink at least two to four times a day, depending on the temperature,

feed type, production of milk and drought resistance of the cattle. There is also a difference in the need of water intake between *Bos taurus* and *Bos indicus,* the latter being more tolerant to higher temperatures and have capacity to conserve water more efficiently (Fraser, 1997; Phillips, 2002). If grazing is situated far from available water, cattle can spend a few hours at the water point and drink several times. But if the availability of water is enough and close they will drink more frequently which benefits the ruminant digestive tract in keeping a stable osmolarity (Phillips, 2002).

3.2.2 Housing and management

Housing is rather an economic necessity for farming than being a physical necessity for cattle (Phillips, 2010) except for very cold and damp climates. The welfare principle "Good housing" from Welfare Quality® (2009) constitutes of the welfare criterias comfort around resting, thermal comfort and ease of movement. If animals have the option to choose they would prefer enriched environments to barren ones and open areas instead of enclosed ones (Manteca *et al.*, 2008). Access to pasture offers a complex and enriched environment resembling the natural habitat (Waiblinger, 2009). Cattle reared under extensive conditions benefit from the absence of behavioural restriction (Petherick, 2005). Providing pasture gives greater areal availability compared to keeping cattle indoors on smaller areas which can cause more aggression and injuries than pasture rearing (Phillips, 2002). Animals are able to perform more physical activities on pasture and the stress of being too close to other animals is reduced. Inside air might be of poor quality and contain higher amounts of ammonia, for example, which cattle out on pasture is not exposed to in the same amount. On the contrary, flies and other insects are more common on pasture than indoors and animals need to be more active to counteract with the flies (Phillips, 2002).

Genotypes that are adapted to the environment and feeds with low nutritional value are preferable for the animal welfare when reared on pasture (Petherick, 2005). The same applies to animals that have a higher tolerance to thermal stress and parasites. But the low management input can be inferior with good animal welfare, when the animals are not under supervision as much as they would be if housed indoors (Petherick, 2005), together with the risks of inclement weather, parasites, poor walking tracks, long walking distances, poor quality pasture and predation (Rushen, 2008; Waiblinger, 2009). Extensive conditions requires provision of shelter during temperatures over 24°C and when temperature-humidity index (THI) exceeds 70 (Silanikove, 2000). Thermal comfort and the relationship between animals and their thermal environment can be explained using the concept of thermoneutral zone (Manteca *et al.*, 2009). This concept is defined as the range of ambient temperatures which provides a feeling of comfort and reduces stress. Temperatures defining the thermoneutral zone are dependent on breed and even between animals of the same breed if they have been raised in different environments (Manteca *et al.*, 2009). There are also breed differences between *Bos taurus* and *Bos indicus* since the latter is more tolerant to hot pasture conditions (Phillips, 2002). Production level and feeding influences the response to the thermal environment; which consists of the interaction between air temperature, relative humidity, ventilation and flooring together with solar radiation (Manteca *et al.*, 2009).

Cattle spend about one third of their life lying down and resting to recuperate and digest their food. Cattle prefer to lie down when ruminating, but if the weather is bad they often choose to stand or walk around slowly (Fraser, 1997; Phillips, 2010). Cattle out on pasture

prefer grazing on level, lowland ground where there is opportunity to lie down and rest (Phillips, 2002). Inadequate resting increases the risk of lameness and, since animals are often strongly motivated to rest, preventing them to do so might cause distress (Manteca *et al.*, 2009).

3.3 Animal welfare assessment

The word "welfare" refers to the condition of an individual in relation to its environment (Broom, 1991). Welfare is a multidimensional concept and contains both physical and mental health factors such as physical comfort, absence of hunger and disease and the possibility to perform motivated behaviour (Welfare Quality®, 2009). Indicators of poor welfare are both difficulty and failure to cope with the environment (Broom, 1991). Poor welfare and suffering often occur together, but not in all cases. It is therefore important that the scientific definition of welfare is not entirely based on subjective experiences and moral considerations. Welfare is a characteristic of an animal and not something that is provided to it. Understanding about the preferences of an animal is valuable information when considering what conditions are likely to result in good welfare. This followed by direct measurements of the animal's condition to assess the welfare and improve it, both when considering animal management practices and legislation. Since animals may use a variety of methods trying to cope with their environment it is important to use a variety of measures to assess their welfare (Broom, 1991).

Consumers expect that products from animals are being produced associated with proper welfare. The overall "food quality concept" is therefore partly based on the animal welfare (Blokhuis *et al.*, 2003; Welfare Quality®, 2009; Broom, 2010). The public is demanding more legislation to protect animals (Broom, 2009) ensuring a minimum animal welfare level. Many countries have animal welfare legislation and/or private animal welfare schemes (Lundmark *et al.*, 2014). But since ethical values differ between countries it is expected that animal welfare also vary in relation to levels set up in the legislation, even though there is scientific information about how different procedures or situations will affect animal welfare. Hence, there is a need to define concepts used in animal welfare legislations to minimize variations in possible interpretations (Lundmark *et al.*, 2014). One important factor for long term improvement of the animal welfare is to educate those who use or have responsibility for animals. They should receive adequate education and training in biological functioning of animals, including ways in which their welfare might be made better or worse. In many countries retailers' codes of practice have had the main effect on welfare of farm animals although both laws and ethical codes are needed (Broom, 2009; Szücs *et al.*, 2009).

The animal welfare legislation and/or private animal welfare schemes needs to include both input requirements (housing and management) such as feed, water, maximum stocking density, biosecurity and management requirements, and requirement related to animal-based measures (Blokhuis *et al.*, 2008; Blokhuis *et al.*, 2010). For accurately discussing the animal welfare and make comparisons between different situations it is necessary to base it on well-defined and clear objective evaluations (Franchi *et al.*, 2014). A reliable scientific method of assessing animal welfare is needed to inform animal unit managers about the welfare status on their farm and to identify areas in need of improvement. Strategies for improving animal welfare can thereafter be implemented which is an important step in the

work for improving the quality of animal products (Szücs *et al.*, 2009; Welfare Quality®, 2009).

The Welfare Quality® Assessment protocol for cattle (WQ® protocol) uses animal-based measures (for example behaviour, fearfulness, health or physical condition) that are turned into welfare criteria that, according to animal welfare science, reflect what is meaningful to the animals (Welfare Quality®, 2009). The animal-based measures include the effects of variation in how the farm is managed and the animal interactions. If resource and management measures are correlated to the animal-based measures they can contribute to the welfare assessments to identify risks to the animal welfare and thereafter find areas of improvement opportunities. However, animals differ in experiences and temperament which may lead to some individuals experiencing the same environment differently. Alternatively, the same environment may be managed in a different way. The WQ® protocol is therefore based primarily on animal-based measures and secondly on resource and management measures when no feasible animal-based measures are available to assess a welfare criteria (Welfare Quality®, 2009).

The WQ® protocol from Welfare Quality® (2009) is, however, suited for European production where cows are kept indoors in intensive systems, hindering its application in other types of cattle enterprises. Franchi *et al.* (2014) adapted a WQ® protocol for Brazilian dairy farms where animals are kept out on pastures in semi-intensive systems. The authors found the original WQ® protocol useful, provided that the assessors are trained before the assessment and that the protocol was adapted on some points to be feasible to the Brazilian dairy sector. However, one important thing missing in the protocol was the thermal comfort evaluation, which has not been properly developed yet for cattle raised outdoors under tropical conditions (Franchi *et al.*, 2014). Examples of other species studied with the Welfare Quality® Assessment Protocols are broiler chickens in Brazil (Souza *et al.*, 2015), water buffaloes in Italy (De Rosa *et al.*, 2015) and pigs in Spain (Temple *et al.*, 2011).

3.4 Societal factors affecting the production and animal welfare

According to Bayvel and Cross (2010) animal welfare issues are usually portrayed by the media as having simple, single perspective solutions. The reality is more complex since animal welfare is multifactorial and many factors needs to be considered when aiming for improving the animal welfare in a country. Welfare of animals receives low priority in the developing world, according to Ndou *et al.* (2011), originating from factors such as traditional customs and beliefs, sub-standard handling facilities and lack of information in animal handling. As mentioned in section 3.3 consumers, educated animal keepers and legislation are important societal factors for the animal welfare. Bayvel and Cross (2010) argues that animal welfare issues must take into account scientific, ethical and economic issues together with religious, cultural and international trade policy considerations. Changes of governmental policies for animal welfare needs to be applied gradually recognising the constraints on the animal keeper. Stakeholders involved in the animal welfare debate includes industry and producer groups, science bodies, animal welfare non-governmental organizations, veterinarians and legal professions (Bayvel & Cross, 2010). Generating an active dialogue between scientists and society is essential to meet the justified demands of stakeholders and consumers (Blokhuis *et al.*, 2003).

Import from developed countries has increased in Mexico and the local farmers receive little governmental support which expose them to compete with highly protected (subsidized) agricultural systems in developed countries (Améndola *et al.*, 2006). A special law for animal welfare does not exist in Mexico but it is mentioned in Ley Federal de Sanidad Animal (2012) which is primarily about keeping animals healthy and without any diseases to protect humans from harm. The law defines animal welfare as a set of activities aimed at providing comfort, tranquillity, safety and security of the animals during their breeding, maintenance, transport and slaughter (Ley Federal de Sanidad Animal, 2012).

3.5 Aim

This study is part of a project aiming in strengthening Mexican small-scale dual-purpose cattle production. Welfare is a part of sustainability and the project's aim is to show the proper care and animal welfare of the production system. Future hopes is that this can be useful to strengthen the production on the world market. The specific study (sub-project) presented in this MSc thesis aims to examine how the welfare is, according to "Good feeding" and "Good housing" from Welfare Quality® (2009), in dual-purpose herds reared under tropical conditions in Chiapas, Mexico. Other societal factors are also considered together with a perspective of the sustainability of the farms. This to get an overall picture of what is affecting the animal welfare and what needs to be improved for a better animal welfare.

4 Material & methods

The study was performed on 34 small-scale dual-purpose cattle farms in San Pedro Buena Vista, located in the municipality of Villa Corzo in the state of Chiapas, Mexico, at 15°47' N and -92°29' W. The climate in the region is hot and sub-humid with summer rainfall. The study was conducted during the rainy season from June 30th to July 23rd 2015 (weekends excluded). Four students were involved, two Mexican and two Swedish. Two farm visits were conducted each day, except for June 30 and July 2 due to complications finding the second farm. Each farm was visited by at least one Mexican student and at least one Swedish student.

4.1 Farms

Farm visits were organized weekly. Members of the local farmer association were asked to participate in the study and they also gave further suggestions for other farmers that might be interested in participating too. The farms' main focus is milk production but male calves and old cows are also used to produce meat, typically sold to the local market. Most of the farms delivered their milk to a local cheese factory where route directions to the farms were given every morning by the manager. The farm visits were in the morning during the daily milking, between 7-12 a.m. The farms worked in general under the same system; cows came from pasture to the milking parlour, calves were allowed to suckle 5 seconds-2 minutes before hand milking (to stimulate milk let down) and after milking (residual milk). When all the lactating cows had been milked the animals were let out on pasture. The majority of the farms kept the cows at pasture until morning milking the next day. Some farms kept the calves together with the cows while some farms kept them on separate

pastures, where calves and cows only met at milking. The herd size ranged from 7 to 90 cows, with approximately 2/3 of the farms ranging between 15 and 35 cows. Herds were mostly composed of crossbred animals (*Bos taurus* x *Bos indicus*).

4.2 Structured interviews

In order to collect information about the farms in the study, an interview protocol was developed by Adalinda Hernandez and can be seen in Appendix B. The questions were designed to obtain specific information about the farms' feeding, management procedures and infrastructure. Structured interviews with the farmers were done by two veterinary students from Universidad Nacional Autónoma de México (UNAM), Mexico, who exposed every farmer to the same questions. The idea with having structured interviews are, according to Bernard (2006), to control the input that triggers the interviewed people's responses so that their output can be reliably compared between interviews. The interviews were performed face-to-face and all of the interviewed were expected to get all the questions to avoid questions left unanswered. Face-to-face interviews also have the advantages that you know who answers the questions and the interviewer can fill in and explain if the interviewed did not understand the question (Bernard, 2006). Interviews were primarily made with the owner and secondly with the worker responsible of milking the cows, who often was in closer contact with the animals. A short presentation about the assessor (Swedish student) and interviewer (Mexican student) was given before the interview started together with information of what the welfare study was about and why the farmers were interviewed. Since these farmers were valuable to work with in future projects the interviewers needed to make the interviewed feel comfortable. It was therefore some variation in the interviews in which order the questions were asked and some variation due to that two different persons were carrying out the interviews.

4.3 Animal welfare assessments

Animal welfare assessments were based on the Welfare Quality® Assessment protocol for cattle with some modifications to fit small-scale and extensive production systems with dual-purpose cattle (see Appendix A). Table 1 shows the main welfare principles with their welfare criteria that was included in the study.

Table 1. Welfare principles and criteria copied from the WQ® protocol (Welfare Quality®, 2009) A=animal-based measures, R=resource-based measures, M=management-based measures

Welfare principles	**Welfare criteria**	
Good feeding	1	Absence of prolonged hunger (A)
	2	Absence of prolonged thirst (R)
Good housing	3	Comfort around resting (A)
	4	Thermal comfort (R)
	5	Ease of movement (R)
Good health	6	Absence of injuries (A)
	7	Absence of disease (A & M)
	8	Absence of pain induced by management procedures (M)
Appropriate behaviour	9	Expression of social behaviours (A)
	10	Expression of other behaviours (R & M)
	11	Good human-animal relationship (A)
	12	Positive emotional state (A)

Review and testing of the modified WQ® protocol were made by the assessors in April 2015 before the study was conducted in Mexico. The test-herd was dairy cows in an intensive European production at SLU's research farm; The Swedish Livestock Research Centre, Uppsala, Sweden.

The study included animal, management and resource-based measures to obtain an overall assessment of the animal welfare. Animals observed during animal welfare assessments were adults (cows and bulls). Calves were only included when maternal behaviour was observed. One Mexican student and two agronomy students from the Swedish University of Agricultural Sciences (SLU), Sweden, did the animal welfare assessment by observing the herd according to the modified WQ® protocol. Observations were made during 1.5 hour at the milking parlour and for 0.5 hour after the adult animals had been let out on pasture. Binoculars were used during observations on pastures. Animals were not touched and the assessors observed the animals from a place where they affected the animals' behaviour as little as possible. Animals' attention to the assessors were only highlighted when performing the avoidance distance.

4.3.1 Modifications for small-scale productions with dual-purpose cattle

Measures added to the WQ® protocol were notes about which type of water point existed at the farm and where the water point was; if there were any in the milking parlour and/or on the pasture. For the welfare criterion "Thermal comfort", temperature and humidity for each study day was simply noted as given by The Weather Channel, LCC, taken from the weather application in iPhone®. Measures that were included from the original WQ® protocol, but changed in the method of measuring, were in the welfare criterias "Absence of disease" and "Comfort around resting". The number of coughs and time needed to lie down were not measured on individual animals. The results are instead given for the whole herd and the sample size might have exceeded 25 animals if the herd was bigger.

After ten farms an extended behaviour study was performed, focusing on calf-cow interactions and sexual behaviours between bull and cows. The results of this study will be reported by Edstam (in prep.). Measures for welfare criteria not included from the original WQ® protocol are as follows; 5.1.2.3, 5.1.4.2, 5.3, 6.1.1.2, 6.1.2.1, 6.1.2.3, 6.1.3.2, 6.1.4.2 and 6.3 (as seen in Welfare Quality® (2009)). The work with developing the modified protocol and the overall assessment results will be further reported by Hernandez *et al.* (in prep.).

4.3.2 Assessing feeding, housing and management

For measuring the welfare principle "Good feeding" assessors performed body condition scoring, for the criterion "Absence of prolonged hunger" on a representative sample of 15 animals with the grades very lean, normal and very fat. "Absence of prolonged thirst", was assessed by noting down type of water point used and cleanliness of the water. Available water points were checked at pasture and in the milking parlour. The water point (if it was a trough) was measured in centimetres and split by number of adult animals having access to that water point giving available centimetres at water point per animal.

Three criteria were included in "Good housing"; "Comfort around resting" included time (seconds) needed to lie down, number of animals colliding with housing equipment during lying down, number of animals lying partly or completely outside the lying area/shade and cleanliness of the animals. "Thermal comfort" included maximum and minimum temperature (°C) and average humidity (%). The last, "Ease of movement", included pen features according to live weight but length and width was not measured. Measures of animals lying partly or completely outside the lying area/shade and animals colliding with housing equipment during lying down was not applicable on the farms since there were no housing equipment and observations took place early in the morning (no sun).

4.4 Data analysis

Calculation of body condition scores was performed according to the statistics included in the WQ® protocol (Welfare Quality®, 2009). The result is represented by a number from 0 to 100 and the farms are divided in four categories according to their score; Excellent (80.1-100), Enhanced (60.1-80), Acceptable (20.1-60), and Not classified (0-20).

Percentage of very lean cows/farm was analysed according to if water was available at the milking parlour, how the feed was stored, number of cows in milk production and milk yield (kg/cow/day). Both number of cows in milk production and milk yield were classified in three farm groups. The classifications and number of farms in each classification are demonstrated in table 2. Since the data can not be considered normal distributed statistical analysis was performed using Kruskal-Wallis (H_0: the population medians are all equal versus H_1: the medians are not all equal) in Minitab® version 17.2.1. P-values presented are "adjusted for ties".

Table 2 Classification and number of farms (parentheses) in each classification group

Cows in milk production (herd size)	Small: 5-14 (8)	Medium: 15-32 (20)	Large: 33-90 (5)
Milk yield (kg/cow/day)	Low: 4.6-5.9 (13)	Medium: 6.0-9.0 (11)[1]	High: 9.1-12.0 (8)
Feed storage	Clean and dry place; feed storage only (5)	Clean and dry place; shared with other stuff (12)	Uncontrolled place (17)
Water available at milking parlour?	Available (18)	Not available (16)	-

[1] Consistent with results from Montiel *et al.* (2007) and Rojo-Rubio *et al.* (2009)

Temperature-humidity index (THI) was calculated with the equation; $THI = 1.8 \times T_a - (1 - RH) \times (T_a - 14.3) + 32$, as described by Kibler (1964) where T_a is the average ambient temperature in °C and RH is the average relative humidity as a fraction of the unit. Two calculations were made using the average minimum temperature in the first and average maximum in the second. Other examples of studies using this method are in Bouraoui *et al.* (2002) and Gantner *et al.* (2011).

5 Results

5.1 Cattle production in Chiapas, study farms

The majority of the farm owners were males (32 of 34 farms) and the majority of employees, if the farm had any, were males. Average number of employees was 2 employees/farm and it ranged from 0-6. The education level of farm owners and employees is illustrated in figure 1. A total of 65 farm owners and employees were interviewed. Sixty percent of the owners and employees had finished elementary school and three farm owners (5 %) had university degrees of Doctor in Veterinary Medicine. There was though 25 % of the owners and employees with unknown education level.

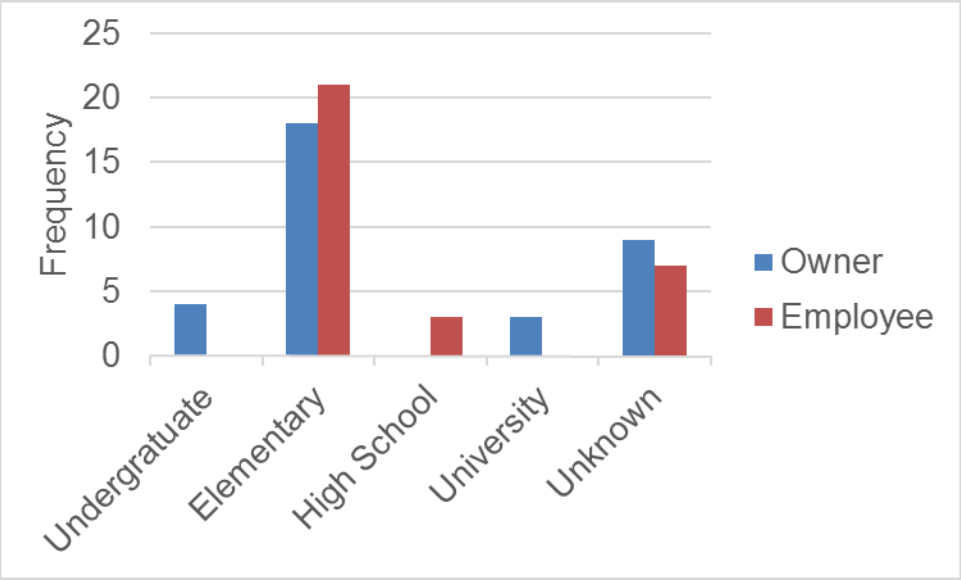

Figure 1. Education level of interviewed farm owners and employees.

The number of milking cows ranged between 5-90 animals with an average of 24 animals in milk production/farm. Average milk production, according to the farmers, ranged between 4.67-12.00 litres/cow/day with an average of 7.45 litres/cow/day. Milk production characteristics are shown in Table 3.

Table 3. Milk production characteristics of studied farms

	Minimum	Median	Mean value	Maximum
Number of animals in milk production	5	18	24	90
Average milk production (kg/cow/day)	4.67	7.00	7.45	12.00

5.1.1 Feed and water provision

5.1.1.1 Feed

The main feed source for the cows was native grass, for example Cuban grass, grown freely on natural extensive pastures. One farmer was partly cultivating his pasture and another farmer used pasture as the only feed. The majority of the farms gave non-organic supplemental feed, produced in the local feed mill. Cows were allowed to eat while they

were being milked and feed rations were not individual based. Some farms gave extra feed after finishing milking. The feed mix used contained maize, poultry bedding from broiler production (increase nitrogen intake), sorghum, sugar cane and dried grass. The mix did not have a standardized recipe and feed ingredients were consequently changing during the year. Figure 2 illustrates how the farmers stored their feed. Half of the farmers stored their feed in a clean and dry place while the other half did not have any special place for feed storage. Most of the farmers gave mineral and vitamin supplements to their animals.

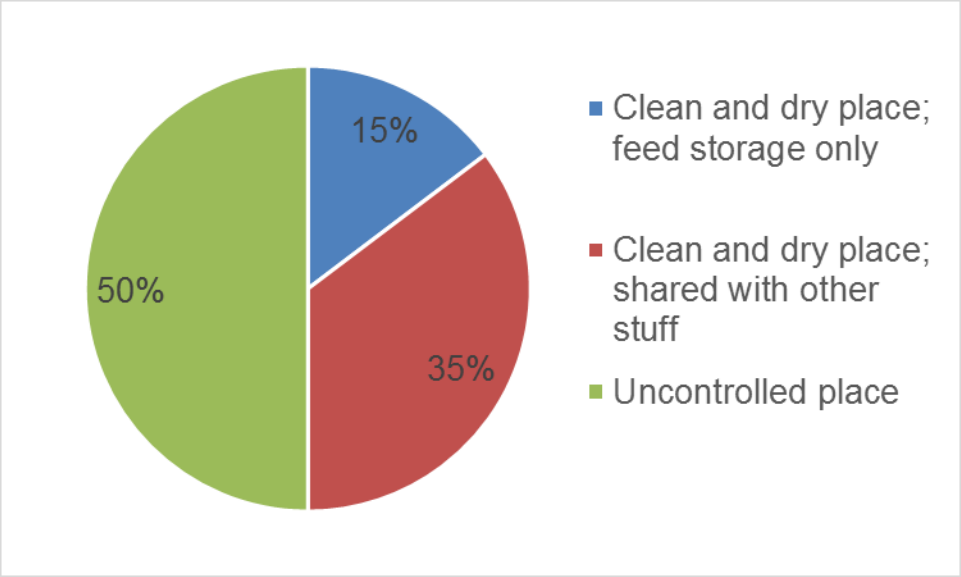

Figure 2. Place of feed storage at studied farms.

Available commercial feed used on three farms was "Campileche", which is a protein feed costing 200 MXN for 40 kg. One unit of "Campileche" corresponds to three units of poultry litter. The ingredients of "Campileche" are; crushed grains, grounded grain products, vegetable oils, urea, alfalfa, citrus by-products, sugar cane molasses, vegetable fats, calcium orthophosphate, calcium carbonates and sodium chloride. The feed also contains vitamins (A, D3, E) and minerals (iron, manganese, copper, iodine, selenium, zinc, cobalt). Nutrient content of "Campileche" can be seen in table 4 showing that the feed contains at least 18.0 % protein, 3.5 % fat and a maximum of 15.0 % fibre. Two of the farmers combined the local feed mix, containing poultry litter, with "Campileche" while the third farmer only used "Campileche" as supplemental feed.

Table 4. Given nutrient and ingredient content from a sack of Campileche

Guaranteed analysis (análisis garantizado) %	
Protein (min)	18.00 %
Fat (min)	3.50 %
Fibre (max)	15.00 %
Humidity (max)	12.00 %
Ash	10.00 %
Nitrogen-free extract	41.50 %

5.1.1.2 Water provision

Water sources were found in both the milking parlour and pasture. Available water at the milking parlour was found on 53 % of the farms and provided in troughs. Trough was the most common water source observed (figure 3) and was mostly found at the milking parlour, but also out on pasture. In total, troughs were found on 23 farms (71 % of all the farms) and the mean value for water provision was 16.2 cm/animal. Troughs were also found in combination with other water sources; rivers and ponds, which were only found on pastures. Observed cleanliness of each water source is illustrated in figure 4 showing that rivers were mainly considered as clean while ponds and troughs was partly dirty. The only water source considered as dirty was trough at two farms.

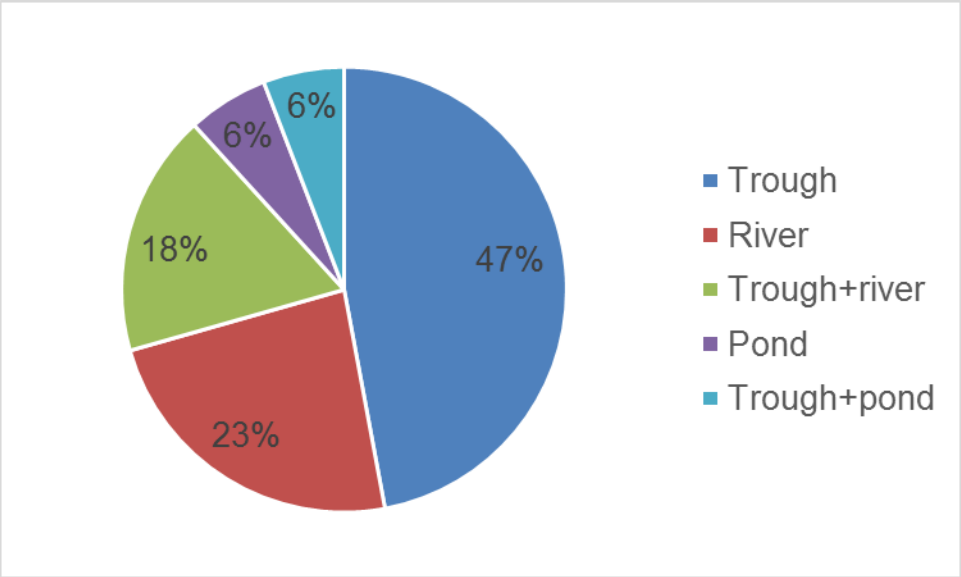

Figure 3. Observed water sources; either use of one type or a combination of two types.

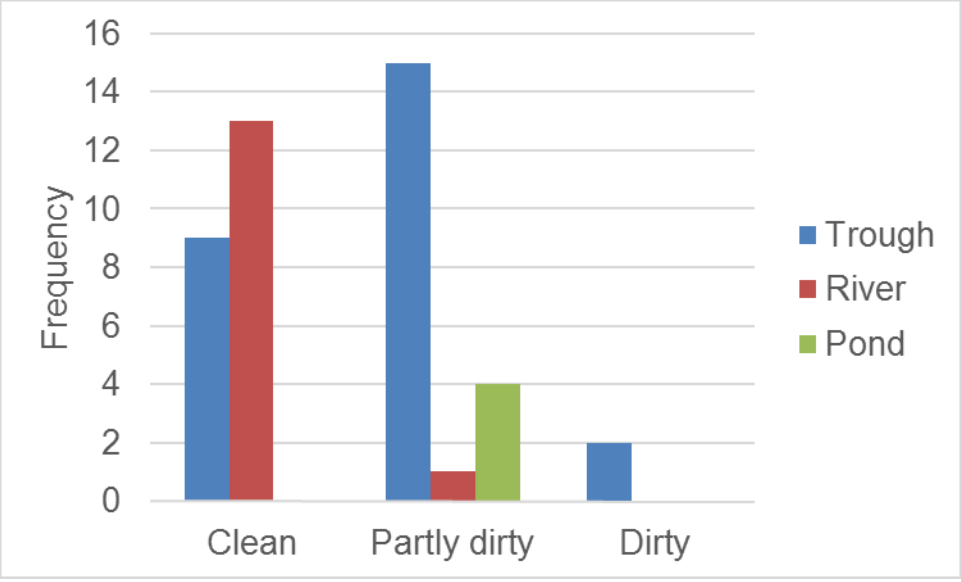

Figure 4. Observed cleanliness of used water sources.

5.1.1.3 Body condition score

Results of the body condition scores for the 34 farms were ranging between 7-80 % of very lean cows/farm (figure 5). Average body condition score was 63 % normal and 37 % very lean cows (figure 6). No cows were classified as very fat.

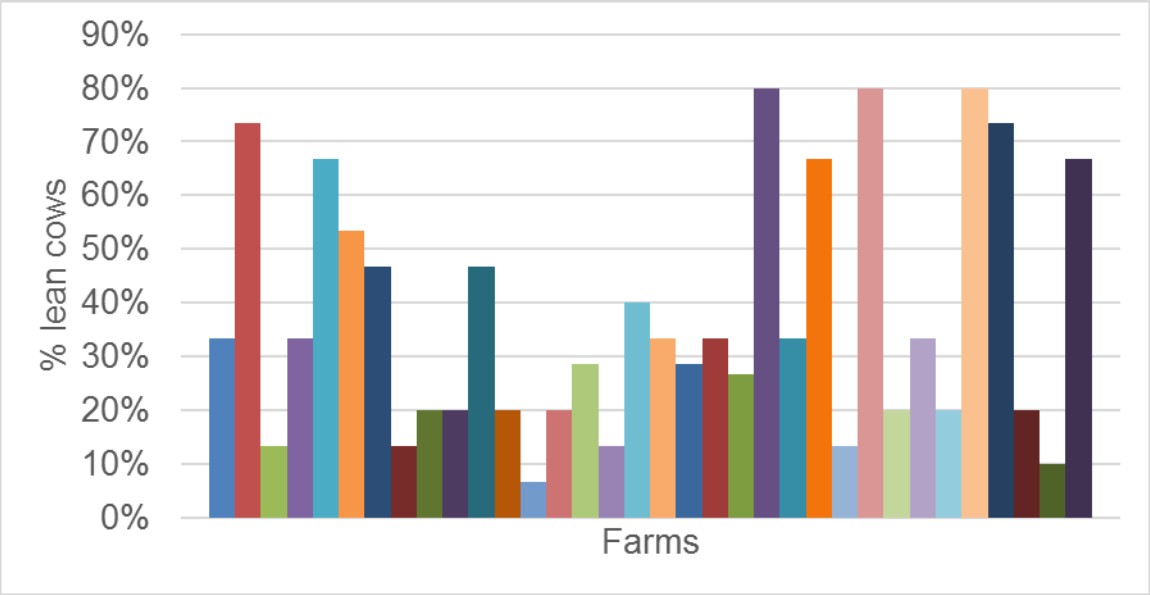

Figure 5. Percentage of the body condition score very lean (%) cows for all the 34 studied farms.

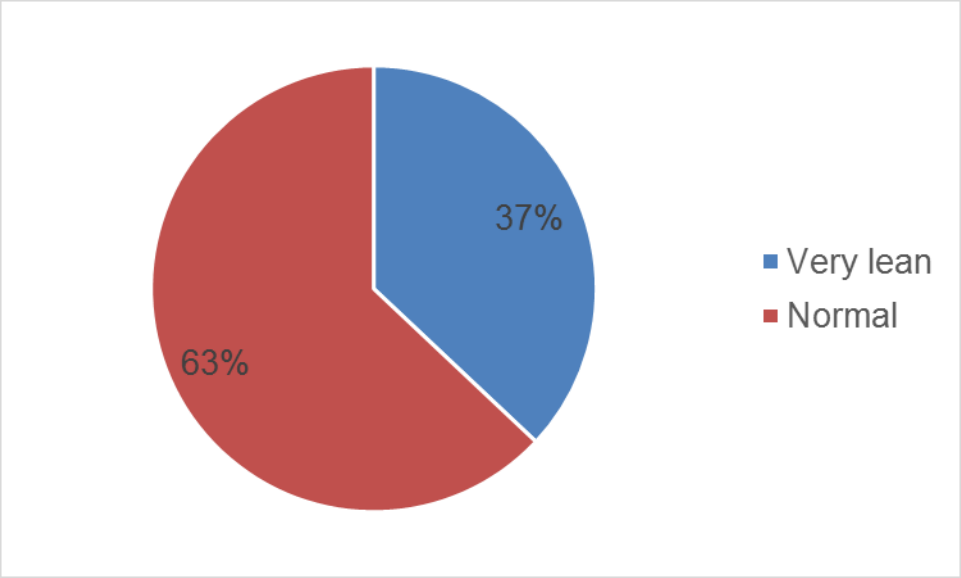

Figure 6. Average body condition scores for all studied farms.

The results from analysing "Absence of prolonged hunger" according to Welfare Quality® (2009) are presented in figure 7. The majority (53 %) of farms were classified as "Acceptable" (the welfare of animals is above or meets minimal requirements). The rest of the farms were classified as "Not classified" (the welfare of animals is low and considered

unacceptable). No farms scored "Enhanced" (the welfare of animals is good) or "Excellent" (the welfare of the animals is of the highest level).

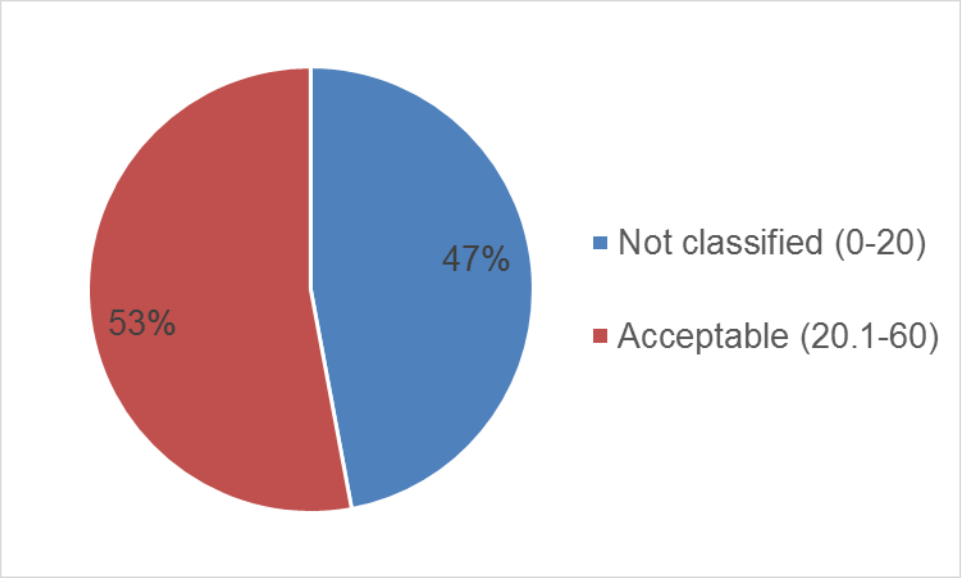

Figure 7. Body condition results for the farms where two of the four categories from Welfare Quality® (2009) was found.

When performing statistical analysis, using Kruskal-Wallis, groups (table 2) were compared according to their body condition scores (very lean). The results did not show any significance (p-values < 0.05), as seen in table 5. There is a tendency that water available at milking parlour might have an effect on the farms' body condition scores (p-value 0.056).

Table 5. Result from analysing % very lean cows with factors divided in 2-3 groups

Response	Factor	Number of factor groups	p-value
Body condition score: % very lean cows	Water available at milking parlour	2	0.056
	Milk yield	3	0.541
	Cows in milk production	3	0.817
	Feed storage	3	0.132

5.1.2 Housing and management

Animals were kept on extensive pastures which were located near the milking parlour. Faeces were used as fertilizer. Every farm had at least one bull together with the cows throughout the day. The most common reproduction method was having the bull together with the cows at pasture (uncontrolled natural mating), but one farm was controlling the natural mating and another farm used artificial insemination.

Time needed to lie down was observed on 20 farms (figure 8). The lowest average for one farm was 3.7 seconds and the highest was 7 seconds. The average time needed to lie down, for the 20 farms, was 4.7 seconds. The majority (73 %) of farms scored 100 % clean animals (figure 9). Three farms had 7 % dirty animals, one farm had 10 % and five farms had more than 10 % dirty animals. The farm with dirtiest animals had 27 % dirty animals.

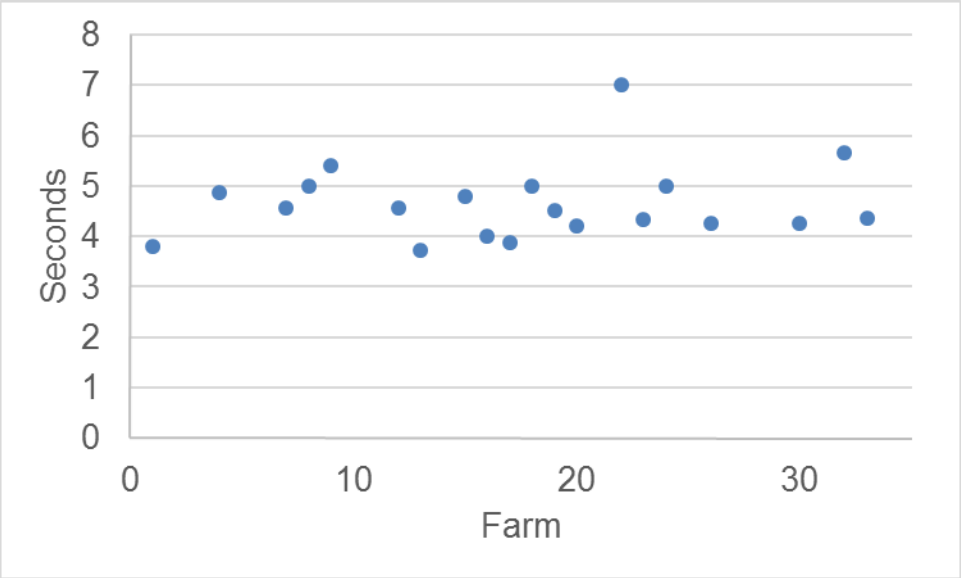

Figure 8. Mean duration of time needed to lie down (seconds)/farm (20 farms).

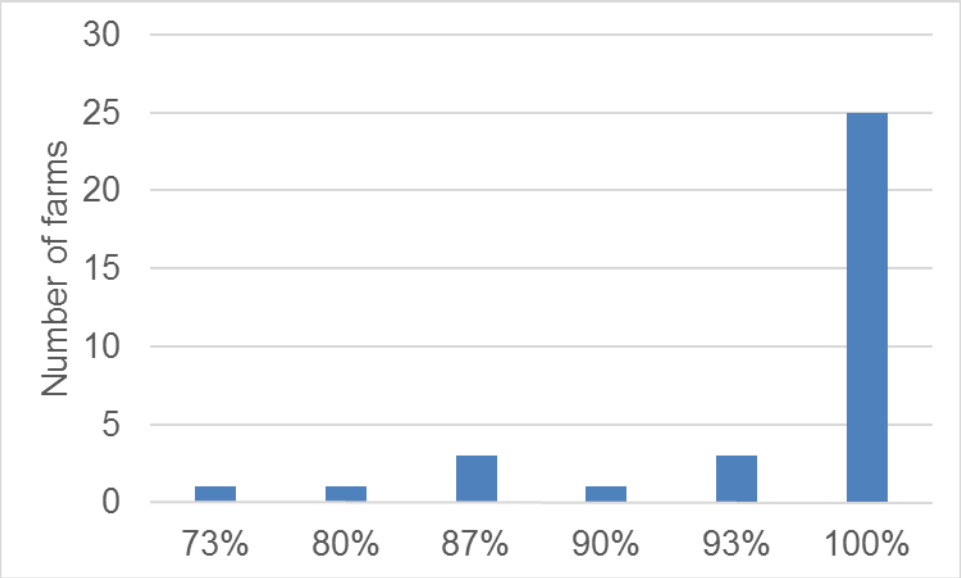

Figure 9. Cleanliness score for all the studied farms (100 % = all the animals were clean).

Thermal comfort is illustrated in figure 10. Daily temperature ranged between 19.0-34.0 °C with an average of 20.5-30.6 °C (minimum-maximum) and humidity ranged between 62-95 % with an average of 87 %. Using the THI calculation from Kibler (1964) results in THI values 68.1, average minimum °C, and 84.9, average maximum °C. Data from three days is missing; June 30, July 15 and July 16.

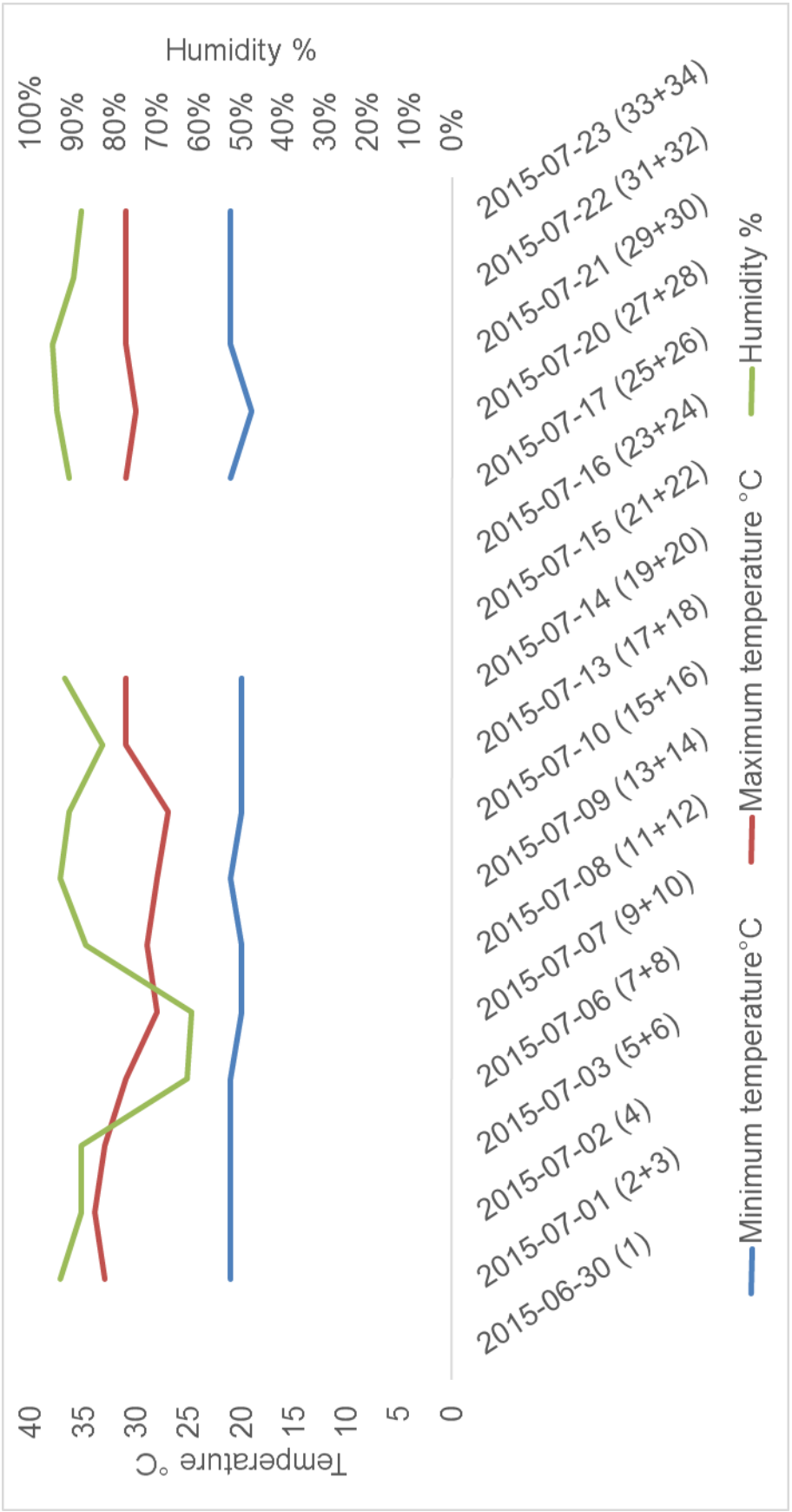

Figure 10. Humidity, minimum and maximum temperature for the whole study days. Date and studied farm(s) in brackets on x-axis. Broken lines means missing data (3 days missing).

6 Discussion

6.1 Small-scale dual-purpose cattle production in San Pedro Buena Vista

The states situated in the southeast of Mexico are characterized by having the highest proportion of poor people in the country (Nationalencyklopedin, 2015). People typically work in agriculture and the lack of basic services is still common in the region. Illiteracy, weak administration and high levels of unemployment contribute to the slow development of these states. Chiapas is one of the poorest states of Mexico and in the year of 2008 nearly 77 % of the residents lived below the poverty line (Nationalencyklopedin, 2015). Additionally, the population has increased from 438 843, in 1910, to 4 796 580 in 2010 (INEGI, 2011) resulting in a higher demand of food and economic resources. In response to these new necessities, the cattle population in Chiapas has also augmented (Nahed-Toral *et al.*, 2013). Forty percent of the population in the state are engaged in farming (Nationalencyklopedin, 2015). Of Chiapas total cattle production Villa Corzo produces 5.76 % of the milk and 3.73 % of the meat (INEGI, 2011).

6.1.1 Feeding, housing and management

Animals are reared under extensive system and kept at pasture along the day. The only livestock facility consists in the milking parlour, which was the only housing the farms had. Milking parlours were generally of a standardized construction (example seen in figure 11) with some farms having flooring of concrete and a building consisting of a roof, walls and feed bunkers.

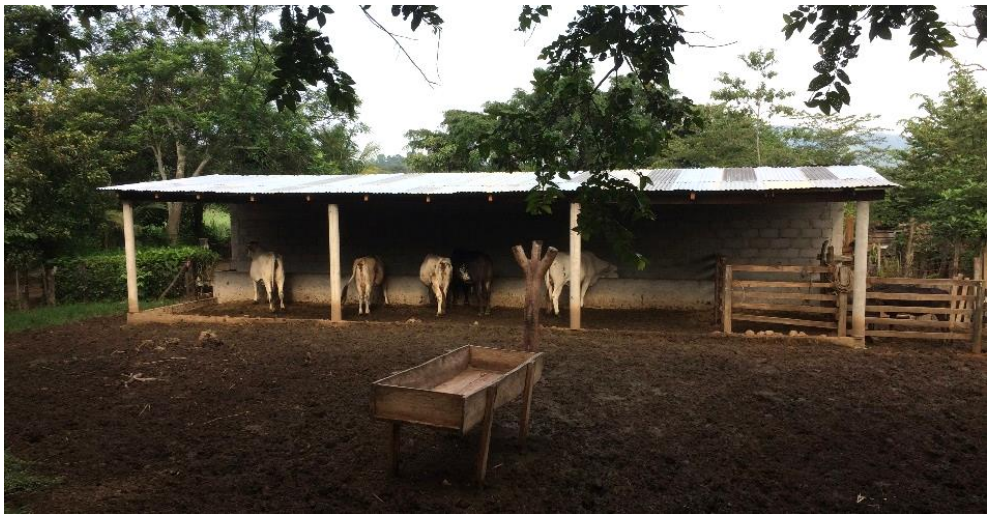

Figure 11. A milking parlour seen from the outside. Where there is not a concrete flooring there is dirt floor. Milking pen to the left.

Some farmers tied the cows among other cows and some had a special milking pen (figure 12), which reduced disturbance from other cows and the cow, being milked, had the supplemental feed for herself. *Bos indicus* breeds has a more difficult milk let down (Orihuela, 1990) and for this reason it is a common practice to utilise oxytocin injections routinely. The cows were hand milked which provides a surrogate stimulus in the udder

facilitating milk let down and this stimulus is not present when using milking machines (Phillips, 2002). The provision of supplemental feed as a reward during milking may help the cows to overcome any repulsion, together with the physiological stimulus and presence of their calves (Phillips, 2002).

Figure 12. Typical appearance of the milking pen (seen from the inside) when cow and calf are tied beside each other while the cow is being milked.

The trend of land use change in Chiapas is, according to Nahed-Toral *et al.* (2013), that maize fields are being converted to pastures. The production of crops in Chiapas consists mainly of grain maize, pasture, beans, sugar cane and sorghum. In the place where this study was undertaken, the majority of crops consist of grain maize and beans (INEGI, 2011). Feed mix ingredients is therefore locally available. The majority of farmers in this study did not sow their pastures, letting native species to grow without any management, which is consistent with the statistics from INEGI (2011).

Both humid and dry tropical climates can be found in Chiapas (Améndola *et al.*, 2006; Peel *et al.*, 2010). This can determine the quality and quantity of forage; being poorer in the dry tropics and especially notorious during the dry season (Peel *et al.*, 2010). Rainfall is therefore an important factor when determining the quantity and quality of grasses in tropical pastures. In a study conducted in the south of Mexico, introduced grasses had greater production in dry matter yields than native grasses (Lopez-Gonzalez *et al.*, 2015). Growing of pastures can therefore have good influence on productivity since the native pastures in the study area probably contains low dry matter. The best would be if the farmers had access to educated advisory but, according to Absalón-Medina *et al.* (2012a), there is lack of timely, reasonable cost forage analysis services which limits knowledge about the current situation and potential options.

6.1.1.1 Poultry litter as feed

Animal excreta contains nutrients and sources of digestible energy which can be recycled in the use as a feedstuff for cattle. Some reasons for using animal excreta for feeding might be feed deficiency and lower cost than traditional feeds, making it a cheap source of nitrogen (Flachowsky, 1997). Poultry litter have according to Smith and Wheeler (1979) high nutritional and economical value when used as a protein feedstuff source since production animals have performed well consuming diets containing poultry litter (Smith & Wheeler, 1979). In a study by Absalón-Medina *et al.* (2012a), poultry bedding was used and consisted of rice hulls, manure, feed waste and feathers.

Farmers in this study used a locally produced feed mix where maize silage/grain was commonly found. Maize are though low in both crude protein and minerals so poultry bedding was used in the feed mix to nutritionally upgrade and balance the feed (Smith & Wheeler, 1979). There is though a need in having valid nutritional compositions of excreta products to formulate balanced diets (Smith & Wheeler, 1979). Feed type provided to the poultry and bedding material used are examples that influences the digestibility and energy content of the excreta (Flachowsky, 1997). However, when formulating diets containing poultry litter there is the risk of toxicity when feeding in excess. Silanikove and Tiomkin (1992) found that high amounts (>10 kg/day) of poultry litter fed to beef cows was associated with severe emaciation and higher mortality. Blood analysis showed that these cows suffered severe liver damage. Cows fed with lower amounts (3 kg/day) appeared healthy but Silanikove and Tiomkin (1992) believed that the amount given was sufficient to possibly cause liver damages. Ammonia not utilized in the rumen by microorganisms is absorbed into the blood and converted into urea in the liver. This is an energy consuming process and the metabolic burden of excessive amounts of ammonia, together with low metabolizable energy intake, is believed to cause damage in the liver (Silanikove & Tiomkin, 1992). However, farms in this study appeared to use the local feed mix in amounts that would provide the animals with less than 3 kg/day of poultry litter and it is believed that this was not critically harmful to the animals. Nevertheless, the farmer using "Campileche" were under the impression that the change from poultry litter has resulted in fewer sick animals and medical treatments. Also, poultry litter was bad for cheese quality, which is important since higher profitability of the production is necessary to obtain higher profits. Another farmer (Doctor in Veterinary Medicine) said that the risk for tuberculosis and coccidiosis was higher when feeding cattle with poultry litter. Problems with diarrhoea was also something he said increased with increased feeding of poultry litter. It is of importance not to overfeed with poultry litter, but since the feed mix is not in standardized there are difficulties for farmers who desire balanced diets to their animals.

To sum up the use of poultry litter; most farmers agreed that they wanted to decrease the use of poultry litter or have other options for supplemental feed ingredients. "Campileche" was considered expensive so poultry litter was primarily used for better economy. It is therefore of interest if further studies can be made to find alternative feed options. Coffee is for example grown in Chiapas which can benefit the cattle production with valuable by-products, as shown by Pedraza-Beltrán *et al.* (2012).

6.1.2 Sustainability of the production

The concept of sustainability includes numerous factors and this study has not included all of them. Further studies are needed to give a complete picture of the sustainability of these farms. A small proportion of farms have access to roads in good condition, running water, and electricity which limits implementation of innovations, improvement of facilities and equipment, and development of the production systems in general (Nahed-Toral et al., 2013). The social importance of these dual-purpose farms is that they provide the household with food, income and sometimes results in employment, which helps the alleviation of poverty (Espinoza-Ortega et al., 2007). It was not unusual to find that employees were family related to the farm owner. In a study by Nahed-Toral et al. (2013) farmers considered that at least one of their family members would take over the cattle production, which provided 40 % of the family income.

Economy is the main factor limiting the sustainability of dual-purpose farms (Salas-Reyes et al., 2015). The sale of animals, for example, involves passing through several levels of intermediaries in the supply chain (Nahed-Toral et al., 2013). This study did not investigate the chain from the farm to the consumer but if there are several intermediaries the farmer association can work together to negotiate for better pricing. Financial loss can also occur if thieves are killing the animals at pasture to steal the body parts containing most meat, which was told by one farmer. Ways of increasing the farmer's profitability and knowledge, of how to improve and why, is important. The potential of increasing the production lies in the management of resources which is already available in the local area (Magaña Monforte *et al.*, 2006). However, increasing the production does not automatically lead to increased profitability. The cost for increasing the feed management input (feed supplementation and water provision) should be less than the income provided by the potential increased production. Better marketing of their products could however rise the income of the production instead of focusing on increasing the farms' output quantity. The cows are raised under natural conditions out on pasture, which looks good to a consumer who cares about animals being reared in their natural habitat. Better information channels reaching the farmers about companies interested in buying this kind of extensively produced milk could favour the milk prize and income of the farmer.

Ethical concerns are arising about using land for growing feed for cattle when there are a growing human population that in the future is expected to be undernourished (Phillips, 2010). This future scenario might result in rangelands for cattle used today to be converted to land for human food production (Phillips, 2010). Broom (2010) suggests that systems should be developed in which animals consume plant material rather than feed that could be utilized by humans. Farms in this study were using natural water resources and extensive natural pastures, which compared to agriculture have a low impact to the environment (Nahed-Toral *et al.*, 2013; Salas-Reyes *et al.*, 2015), and the feed supplementation consisted mostly of ingredients which humans can not consume and digest. Also, excreta fall directly on the soil and if it is spread at most of the pasture fertilizers are not needed. Villa Corzo has since 2000 increased their reforested areas and the plantation of trees (INEGI, 2011). Forestry and grazing together provides a variety of goods and services to society. Using this management may, according to Nahed-Toral *et al.* (2013), be classified as giving a cleaner production, since it is an approach of adaptation to and mitigation of climate change. Forestry also provides a variety of environmental services like; fixation of atmospheric nitrogen to the soil and regulation of emissions (carbon, nitrous oxide and methane), nutrient recycling and restoration of degraded soils,

biodiversity conservation, protection of watersheds, improvement of water quality, and connectivity among ecosystems (Nahed-Toral *et al.*, 2013). Farmers could therefore, if they have the knowledge and economy, favour their future production by increasing the forest in their pastures. As mentioned before; dry periods constitute challenges for the pastures and considering overgrazing in these periods are of importance if the pastures are to be maintained. Overgrazing might temporarily satisfy the nutritional requirements of undernourished animals but is not sustainable in the long run since plant growth capacity is likely to be reduced (Phillips, 2002). Dry season also results in higher production cost since feed supplementation increases in the need (Castillo *et al.*, 1999; Salas-Reyes *et al.*, 2015). The production is therefore critically affected during dry season and further studies should be done during the dry season to get an overall picture of the production and the animal welfare.

6.2 Cattle welfare at study farms - feeding, housing and management

Using the modified WQ® protocol from (Welfare Quality®, 2009) was in general applicable on these farms when assessing the animal welfare. There are though seasonal effects on the animals' welfare due to the variable climate throughout the year. This study was conducted during the rainy season, for example, so the welfare of animals is believed to be quite different during dry season. The protocol could be adjusted to various seasons for better assessing the welfare status during different seasons. Other modification suggestions to the WQ® protocol, regarding Good Housing, are found in section 6.2.2.

6.2.1 Good feeding

6.2.1.1 Absence of prolonged hunger

The major weakness, according to the overall assessment made by Hernandez *et al.* (in prep.), was the welfare criteria absence of prolonged hunger at studied farms. Almost half (47 %) of the farms scored "Not classified" which can be described as the welfare of animals is low and considered unacceptable. No cows were found to be considered as very fat and very lean cows was 37 % on an average farm. Body condition scores for very lean cows ranged between 7-80 % on farms which seem to be a critical situation when compared with studies in Dutch dairy herds (de Vries *et al.*, 2013); 0-29 %, and European beef bull farms (Kirchner *et al.*, 2014); 0-7 %. Comparisons of these studies should though have in mind that the herd sizes were larger; ranging from 41-700 beef bulls in Kirchner *et al.* (2014) and a median of 67 cows in the study of de Vries *et al.* (2013), than in this study ranging between 7-90 cows with a median of 18 cows. One single animal therefore constitutes a bigger proportion compared to if this study would have been conducted with larger herds.

Low body condition scores could be due to low nutritional content in the native grasses (Phillips, 2002; Rodriguez-Romero *et al.*, 2004; Manteca *et al.*, 2009) together with that the quantity and quality of provided feed supplementation are not fulfilling the cows' nutritional needs. A study by Cozzi *et al.* (2009) concluded that welfare problems related to feeding on Italian beef farms was low fibre content in feed and inadequate space at the feed trough. Space for feed seemed adequate at study farms since pasture was the largest component of the cows' feed ration. There are some other factors, as seen in section 3.2.1, for good welfare that is provided to studied animals; foraging behaviour, physiological

rumen fill and natural feed diversity. Inadequate rumen fill was probably not the problem since there was a high forage production at pasture during the study time. However, the grasses were possibly high in fibre which could result in starvation, if the cows do not receive adequate feed supplementation and their body condition scores are deteriorating. The size of the pastures could probably have a great impact on the animals' body condition scores since walking long distances was sometimes necessary to reach milking parlours and water sources, as similarly reported for Brazilian dairy herds (Franchi *et al.*, 2014). Nevertheless, if feed samples were analysed information could be provided to see if the cows' nutritional needs are being satisfied or not and if the farmers can do something different in their feed management to increase the cows' body condition. One should though have in mind that composition of feeds is changing during the year when analysing the feeds. Record keeping of individual animals could help to see where the cows are in their lactation, which provides information about the nutritional needs of individual cows. If, for example, one cow is in her early lactation (high yielding) the farmer can, preferably, provide that cow with extra feed.

6.2.1.2 Absence of prolonged thirst

Absence of prolonged thirst was placed among the welfare criteria with the lowest scores (Hernandez *et al.*, in prep.). Available water at milking parlour was easy to observe and 53 % of the farms supplied their animals with water at the milking parlour. The statistical analysis performed in this study (see section 4.4 & 5.1.1.3) found a tendency, p-value 0.056, that there might be differences in % very lean cows between the two groups; available water and no available water at the milking parlour. It is therefore a possibility that body condition might be influenced of the availability of water in the milking parlour. Further studies are however needed to see if water availability at milking parlour has a significant effect on body condition scores and where there are most lean cows; farms with available water or no available water at milking parlour.

Cattle need to drink at least two times a day (Phillips, 2002) and cows had probably the opportunity to do that since they were producing milk. Due to large pastures it was hard to identify all the natural water sources on pasture, enabling the possibility that available water could be higher than observed. The breed mix is better than a purebred *Bos taurus* in conserving water (Fraser, 1997; Phillips, 2002) but to be sure that the animals receive adequate water the farmers should look at the possibilities to increase available water, most necessarily during hot and dry seasons. There are examples from this study were one cow stood on her knees bending down to drink from a urine gutter (at milking parlour) and other cows drinking from a muddy puddle (after being let out on pasture), which might not have happened if the animals had adequate access to water at the milking parlour. Increasing available water might however be hard since, according to Phillips (2010), climate change will bring significant water shortages in drought prone regions which might limit the cattle production further. Also Franchi *et al.* (2014) found difficulties for farmers in the tropics to provide their dairy cows with water in adequate quantity and quality.

6.2.2 Good housing

6.2.2.1 Comfort around resting & Ease of movement

Ease of movement scored, on the other hand, the highest score due to lack of interiors in the buildings/milking parlours (Hernandez *et al.*, in prep.) and out on pasture. Intensive

Italian beef production (Cozzi *et al.*, 2009) had limited space allowance as their main welfare problem but cows observed in this study did not collide with housing interior. Cleanliness of the animals was easy to evaluate and 64 % of the farms was scored 100 % clean animals with an average of 3 % dirty animals for all the farms, compared to 15 % in a study by Kirchner *et al.* (2014).

6.2.2.2 Thermal comfort

The original WQ® protocol is designed for intensive European cattle production systems. As for Franchi *et al.* (2014), the welfare criterion thermal comfort are missing in this study which is of greater importance for the animal welfare in tropical regions. An alternative to assess thermal comfort is to have a thermometer for noting the temperature and what kind of weather (sunny, cloudy, rainy) it is in the beginning and the end of the study time. If the animals have access to shade it might be interesting to know if it is natural or artificial and the approximate size of it. It is also of importance to know if animals have access to shade during sun hours to ease heat stress (Silanikove, 2000).

Shelter is important during temperatures over 24°C and THI is over 70 (Silanikove, 2000). Given THI calculations (Kibler, 1964) and guidelines, provided by Silanikove (2000), does not include breed differences. Adaptability to heat differs (Fraser, 1997; Phillips, 2002; Manteca *et al.*, 2009) and for more accurately concluding about how THI values in this study are applicable on *Bos indicus*/*Bos taurus* cows one could include the breed mix as a factor in the calculations. However, this study showed a THI of 84.9, using average maximum temperature, and that temperatures could be up to 34 °C which advises that shelter should be provided to the animals. Shade could be provided, for example, by putting up a tarpaulin if the pasture does not have trees providing enough shelter. But as mentioned in section 6.1.2 Villa Corzo is increasing the tree and shrub cover which provides shade for regulating climate stress. This also favours the pasture conditions with improved nutrient provisioning, efficiency of fodder use, and improvement of pasture production and quality (Nahed-Toral *et al.*, 2013).

6.2.2.3 Additional modification suggestions

The welfare principle "Good housing" was hard to assess in this study due to absence of infrastructure. Ways of evaluating this welfare principle is therefore in a need of modification to fit this kind of production and to better assess the animal welfare. As a suggestion the protocol can add measurements on the environment these animals are reared; pasture and milking parlour. Besides the thermal comfort and access to shade, other factors which can be considered in the protocol are the condition of the pasture land (muddy or dry and clean) and if there are objects or plants, reachable for the animals, which are potentially harmful or poisonous. Milking parlours were generally free of trash but sometimes there were objects reachable for the cattle. Mostly plastic, blown by the wind.

6.2.3 What affects the animals' welfare and what can be done to improve it?

Factors that seem to influence animal welfare at studied farms are economy, climate and availability of natural resources. Politics could favour the dual-purpose production with subsidies (Améndola *et al.*, 2006), which was not received at the study time. The farmer association has though the opportunity to work together for strengthening their production and seek possible ways to qualify for governmental support and advice, as the example

from Absalón-Medina *et al.* (2012a). Changed feed management might constitute an economic risk but if the farmers had enough money, they might have prioritized giving lean animals more feed since starvation formed a risk of mortality. On the other hand, altered feed management to gain higher milk yields could put animal welfare at risk if the cows are producing more than they are physically durable of. But increasing the body condition should be of interest for studied farms to provide better animal welfare and to reduce the risk of starvation, especially during dry seasons.

There was also a feeling that education level might have influenced animal welfare. If knowledge of feed management and animal welfare is lacking, there might be some farmers not considering very lean animals as a problem for their production. Most of the farmers seem to wish the best for their animals, but limited knowledge can still be a relevant factor. Educational workshops can for example alter information constraints if alternative feed management means higher risk. Improved feed management could favour improved reproduction, higher productivity and reduce environmental impact (Magaña Monforte et al., 2006; Absalón-Medina et al., 2012b). Also the production of heifers would benefit from it if they receive a healthy rearing without nutritional deficiencies. The educated farmers can, as a suggestion, help other farmers through the local farmer association. Also the universities involved in this study could provide with information since there is an interest in continue working with these farmers. The farmers should receive information why animal welfare is important and how a better animal welfare at their farms could benefit their production. Animal welfare are also affected by traditional customs and beliefs (Ndou *et al.*, 2011) and old farmers might stick to "how it is and how it has always been done". Generational change, allowing younger talents to become farmers, have potential to increase the awareness of animal welfare. For example, due to availability improvements of internet and information.

Knowledge of how farmers should take care of their animals are important if improvements of the animals living conditions are desired. One example for improving the animal welfare is to develop a system for self-evaluation, like an example from Austria by Ofner *et al.* (2007). The aim of this is to enable farmers to personally check their animal housing systems against given standards and it is important that they understand the measures to be able to act with personal responsibility. Hopefully this will lead to better awareness of animal welfare issues and advice how to improve the state of the animal welfare would be included in the manuals (Ofner *et al.*, 2007). This would maybe be a future alternative for the farmers in the study area to have the possibility to raise their animal welfare. But this demands that someone develops this kind of self-evaluation for their production system and that the farmers have internet access to the document. This is also a situation where the farmers' association and the universities would be helpful.

6.3 Methodological reflection

6.3.1 Structured interviews

Two people were performing the interviews which might have affected the interviews. The language was hard for the Swedish students to understand and they could not participate in the interviews. Valuable information might have been missed in the transfer between different persons involved and the Swedish students did not have the capacity to validate if the farmers were actually asked all questions at each occasion. Furthermore, there is always

a risk that the results are based on assumptions rather than explicit answers, because of preconceptions related to what "everybody else does and how things are always done here". Collection of data, for example milk yield and number of cows in milk production, was done by interviewing the farmers since there were no available production data. This information might consequently not be 100 % correct since it is their own estimate of their production. Farmers were asked about used feeds and different answers were given for the same local feed mix. In addition; one farm visit showed that the feed mix did not, at that moment, contain one specified ingredients (sugarcane) which demonstrates that the feed mix from the local mill was not standardized.

6.3.2 Animal welfare assessments

The animal welfare assessments were also performed by three people which might, at times, have performed the assessments differently. Time has also changed regarding how the assessments were done, even if the WQ® protocol were tested in Sweden before the study was conducted in San Pedro Buena Vista. Not all the assessors have been on the same farms and valuable information from some farm might have been missed. Due to large pastures and long walking distances the assessment of water points on pasture was performed in different ways. If long distance to water point farmers were asked if they had a water point at the pasture and type of water point were noted. Most of the farms water source at pasture were however assessed.

6.3.3 Data analysis

Apart from the descriptive analyses, this study is limited with respect to conducted data analyses and no highly significant differences were found between the categories analysed. A larger study might have provided more extensive data with normal distribution, allowing for more advanced analyses. A statistical analysis was only performed where there were results for every farm, for example body condition scores or access to water at the milking parlour. Using Minitab might seem too basic but should be okay for a master thesis with a small data set. It would have been interesting to compare body condition scores between farms using "Campileche" instead of supplemental feeding with poultry litter, but this was not possible since there was just one farmer that used only "Campileche" as supplement feed. To study the effects of "Campileche" a whole study can be made with larger groups of animals eating different feeds. Another analysis not performed is if body condition scores were affected by the age or education of the animal keeper. The reason for this analysis not being performed is that quantity of feed given to animals, when being milked, is missing. The calculations for THI can be considered as an approximation and the results could be different if other, more accurate, measuring methods and calculations had been used.

6.4 Conclusion

Further studies are needed to give a complete picture of the sustainability of these farms. However, it can be concluded that the utilization of local resources is high and the use of external fertilizers is low. Using a modified Welfare Quality® Assessment protocol for cattle can be useful when assessing the welfare on small-scale dual-purpose cattle farms in the tropics. There is still a need to create a method to properly assess the welfare principle "Good housing" since these farms do not house their cows indoors. A method for assessing the welfare criteria "thermal comfort" has not been established yet and there is a need to further develop this criterion since farms located in the tropics withstand high humidity and temperatures. "Good feeding" was the welfare principle that got the lowest score in the overall assessment. Both absence of prolonged hunger and absence of prolonged thirst are in need of improvement. There is lack of information in this study for concluding how the feed used, and the quantity of it, are affecting the body condition scores. A further study where feeding and body condition are analysed together is therefore suggested to find alternative feed management to improve the animal welfare. The water provision is also in need of improvement since it is believed to be inadequate to satisfy the animals' needs, most critically during dry seasons. Economy is believed to be one main reason for the feed management. Alternative feed supplements and ways of increasing the water provision, which are economically feasible and available in the area, are of interest to find. Education could be a way of enhancing the farmers' knowledge and if the farmers work together in the farmer association they could help each other to strengthen their production.

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9 Appendix

9.1 Appendix A. Modified Welfare Quality® Assessment protocol for cattle

9.1.1 Good feeding

Absence of prolonging hunger

Title	Body condition score		
Scope	Animal-based measure: family-farm system cows		
Sample size			
Method description	View the animal from behind and from side in the loin, tail head and vertebrae. Animals must not be touched but only watched. Animals are scored with regard to four criteria as follows;		
	Body region	Very lean	Very fat
	Cavity around tail head	Cavity around tail head	Tail head cavity full and folds of fatty tissue present
	Loin	Visible depression between backbone and hip bones (tuber coxae)	Convex between backbone and hip bones (tuber coxae)
	Vertebrae	Ends of transverse processes distinguishable	Transverse processes not discernible
	Tail head, hipbones, spine and ribs	Tail head, hip bones (tuber coxae), spine and ribs visible	Outlines of fat patches visible under skin
	Individual level: 0 –Regular body condition 1 –Very lean 2 –Very fat		
Classification	Herd level: Percentage of very lean cows Percentage of very fat cows		
Optional additional information	Based in dual purpose breeds		

Absence of prolonged thirst

Title	Water provision
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	All water points in question are assessed within the area of the animal unit where behavioural observations have been made. Check the type of the water points per area of study, and count the number of animals per area. In the case of open troughs, measure the length of the trough. In the case of bowls with reservoirs, bowls, nipple drinkers or drinkers with balls/antifrost devices, count the number of water points.
Classification	Group level: Number of animals and number of each type of water points. Length of troughs in cm.

Title	Cleanliness of water points
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	All water points in question are assessed within the area of the animal unit where behavioural observations have been made.

	Check the cleanliness of the water points with regard to the presence of old or fresh dirt on the inner side of the bowl or trough as well as staining of the water. Water points are considered as clean when there is no evidence of crusts of dirt and/or decayed food residues. Note that some amount of fresh food is acceptable. In case of natural water points consider water aspect, odour and colour, and whether it is still or running water.
Classification	Group level: 0 –Clean: drinkers and water clean at moment of inspection 1 –Partly dirty: drinkers dirty, but water fresh and clean at moment of inspection or only part of several drinkers clean and containing clean water. 2 –Dirty: drinkers and water dirty at moment of inspection

Title	Number of animals using the water points
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	All water points in question are assessed within the area of the animal unit where behavioural observations have been made. Count the number of animals in the area of study that have access to the water points.
Classification	Group level: Number of animals in the area of study having access to the water points

9.1.2 Good housing

Comfort around resting

Title	Time needed to lie down
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	This measure applies to all adult animals, and applies to all observable “lying down” movements (minimum sample size of 6 or 8 is required). Time needed to lie down is recorded continuously according to the following method: time recording of a lying down sequence starts when one carpal joint of the animal is bent and lowered (before touching the ground). The whole lying down movement ends when the hind quarter of the animal has fallen down (touched the ground) and the animal has pulled the front leg out from underneath the body. Record the time needed to lie down. Observations in large spaces should be divided in segments with not more than 25 animals per segment. Total net (overall) observation in the farm (together with social behaviour). Minimum duration of observation per area/segment is 10 minutes. Individual level: Duration of lying down movement in seconds
Classification	Group level: Mean duration of lying down movement in seconds

Title	Animals colliding with housing equipment during lying down (Only if applies)
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	This measure applies to all adult animals kept in confined spaces. It considers all lying down movements for which time needed to lie down has been recorded (minimum sample size of 6 is required).

	A collision is defined as occurring during lying down; the cow collides with or contacts housing equipment with any part of the body (usually hind quarter or side). The collision is obviously seen or heard. Collisions with housing equipment are recorded continuously in the focus segment. The duration of a lying down movement is only taken when undisturbed by other animals or human interaction and, in case of cubicles and littered systems, if it takes place on the supposed lying area. Observations take place in segments of the barn. Individual level: 0 –No collision 2 –Collision
Classification	Herd level: Percentage of animals colliding with housing equipment (i.e. score 2)

Title	**Animals lying partly or completely outside the lying area/shade**
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	In confined spaces: Assess the number of animals which are lying and how many of them are lying with their hind quarter on the edge of the cubicle or the deep littered area (edge markedly pressing into the hind leg of the animal), lying with hind quarter (both hind legs) or completely outside the supposed lying area (cubicles, deep littered area). Observations take place in segments of the observation area. Animals lying partly/completely outside the lying area are recorded at the start and at the end of each segment observation. In open spaces: Assess the number of animals which are lying and how many of them are lying with their hind quarter outside a natural or artificial shade. Group level: Number of animals lying Number of animals lying partly/completely outside lying area/shade
Classification	Herd level: Percentage of animals lying partly/completely outside lying area/shade out of all lying animals

Title	**Cleanliness of the animals**
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	From a distance not exceeding 2 m, one side of the focal animal is examined including as much of the underbelly as is visible but excluding head, neck and legs below the carpal joint and hock (tarsal joint), respectively. **Evaluations under pasture conditions will have to take place at a minimum of 5 mts using a pair of binoculars to accurately assess their welfare. The conditions under pasture make it rather difficult to assess them closer.** The criterion for cleanliness is the degree of dirt on the body parts considered: • covering with liquid dirt • plaques: three-dimensional layers of dirt Random selection of the side of the animal observed (left or right) has to be ensured. To prevent biased results, the side selection has to be done before the examination. In

	most cases, the side which is seen first when approaching the animal can be chosen. Individual level: 0 –Less than 25% of the area in question covered with plaques, or less than 50% of the area covered with liquid dirt 2 –25% of the area in question or more covered with plaques, or more than 50% of the area covered with liquid dirt
Classification	Herd level: Percentage of dirty animals (score 2)

Thermal comfort

This part is quite important as heat dissipation in animals in the tropics should have to be measured, the presence of trees, shades made by humans as opposed to natural shades will need to be accounted for. Useful measurement could be THI (temperature, humidity index) of the black globe thermometer.

Ease of movement

Title	Pen features according to live weight (Only if applies)
Scope	Animal-based measure: family-farm system cows
Sample size	Animal unit
Method description	The length and width of the pens is measured. The number of animals in each pen is counted. The average weight of the cattle is estimated in each pen in categories of 100 kg (e.g. 200, 300, 400… kg).
Classification	Group level: Length/width in m and Number of animals and Estimated weight of the animals in kg (per 100 kg)

9.1.3 Good health

Absence of injuries

Title	Lameness
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	Lameness describes an abnormality of movement and is most evident when the animal (and so the legs) is in motion. It is caused by reduced ability to use one or more limbs in a normal manner. Lameness can vary in severity from reduced mobility to inability to bear weight. Assess the animal for presence of one of the indicators mentioned below, according to the description for either standing or moving animals. Indicators in moving animals: Irregular foot fall Reluctance to bear weight on a foot Uneven temporal rhythm between hoof beats Weight not borne for equal time on each of the four feet Indicators in standing animals: Resting a foot (bearing less/no weight on one foot). Frequent weight shifting between feet (“stepping”), or repeated movements of the same foot Standing on the edge of a step Individual level: 0 –No evidence of lameness: animals showing none of the indicators listed above

	2 –Evidence of lameness: animals showing one indicator in the case of either moving or standing animals
Classification	Herd level: Percentage of not lame animals (score 0) Percentage of moderately lame animals (score 1) Percentage of severely lame animals (score 2)

Title	**Integument alterations (hairless patches and lesions/swellings)**
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	Integument alternations are defined as hairless patches and lesions/swellings. Assess one side of the animal for integument alterations. Hairless patches and lesions/swellings are counted in accordance with the criteria provided below: Only skin alterations of a minimum diameter of 2 cm at the largest extent are counted. Hairless patch • Area with hair loss • Skin not damaged • Extensive thinning of the coat due to parasites • Hyperkeratosis possible Lesion/swelling • Damaged skin either in form of a scab or a wound • Dermatitis due to ectoparasites • Ear lesions due to torn off ear tags • Completely or partly missing teats From a distance not exceeding 2 m, three body regions on one side of the assessed animal have to be examined with regard to the criteria listed above. Evaluations under pasture conditions will have to take place at a minimum of 5 mts using a pair of binoculars to accurately assess their welfare. The conditions under pasture make it rather difficult to assess them closer. These body regions are scanned from the rear to the front, excluding the bottom side of the belly and the inner side of the legs, but including the inner side of the opposite hind leg. Random side selection (left or right) has to be ensured. To prevent biased results, the side selection has to be done before the examination. In most cases, the side which is seen first when approaching the animal can be chosen. In the case of more than 20 alterations per category only ">20" is noted. The maximum (“>20”) is also given if the area affected is at least as large as the size of a hand. If there are different categories of alterations at the same location (e.g. swelling and lesion at one leg joint) or adjacent to each other (e.g. around hairless patch with a lesion in its centre) all these alterations are counted. Individual level: Number of hairless patches Number of lesions/swellings

Classification	Herd level: Percentage of animals with no integument alteration (no hairless patch, no lesion/swelling) Percentage of animals with mild integument alterations (at least one hairless patch, no lesion/swelling) Percentage of animals with severe integument alterations (at least one lesion/swelling)
Optional additional information	For the calculation of scores, this measure is taken into account as the total number of counts from all body regions. However, for advisory purposes more detailed information may be necessary.

Absence of disease

Title	Coughing
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	Coughing is defined as a sudden and noisy expulsion of air from the lungs. The number of coughs is counted using continuous observations, in the case of very large areas, in segments. Per segment not more than 25 animals should be assessed on average. Total net observation time is 120 minutes. Recording of coughs is carried out together with social behaviour and resting behaviour observations.
Classification	Herd level: Mean number of coughs per animal in 15 min.

Title	Nasal discharge
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	Nasal discharge is defined as clearly visible flow/discharge from the nostrils; it can be transparent to yellow/green and often is of thick consistency. Animals are scored with regard to the nasal discharge criteria. Individual level: 0 –No evidence of nasal discharge 2 –Evidence of nasal discharge
Classification	Herd level: Percentage of animals with nasal discharge (score 2)

Title	Ocular discharge
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	Ocular discharge is defined as clearly visible flow/discharge (wet or dry) from the eye, at least 3 cm long. Animals are scored with regard to the ocular discharge criteria. Individual level: 0 –No evidence of ocular discharge 2 –Evidence of ocular discharge
Classification	Herd level: Percentage of animals with ocular discharge (score 2)

Title	Hampered respiration
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	Hampered respiration rate is defined as deep and overtly difficult or laboured breathing. Expiration is visibly supported by the muscles of the trunk, often accompanied by a pronounced sound. Breathing rate may only be slightly increased. Animals are scored with regard to the criteria for hampered respiration. Individual level: 0 –No evidence of hampered respiration 2 –Evidence of hampered respiration
Classification	Herd level: Percentage of animals with hampered respiration (score 2)

Title	Diarrhoea
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	Diarrhoea is defined as loose watery manure below the tail head on both sides of the tail, with the area affected at least the size of a hand. Animals are scored with regard to the criteria of diarrhoea. Individual level: 0 –No evidence of diarrhoea 2 –Evidence of diarrhoea
Classification	Herd level: Percentage of animals with diarrhoea (score 2)

Title	Bloated rumen
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	Bloated rumen is defined as a characteristic “bulge” between the hip bone and the ribs on the left side of the animal. Animals are scored with regard to the criteria of bloated rumen. Individual level: 0 –No evidence of bloated rumen 2 –Evidence of bloated rumen
Classification	Herd level: Percentage of animals with bloated rumen (score 2)

Title	Mortality
Scope	Animal-based measure: family-farm system cows
Sample size	Animal unit
Method description	Mortality is defined as the ‘uncontrolled’ death of animals as well as cases of euthanasia and emergency slaughter. The animal unit manager is asked about the number of animals which died on the farm, were euthanized due to disease or accidents, or were emergency slaughtered during the last 12 months. Additionally the average number of animals with a weight of more than 200 kg live weight in the animal unit is asked. Farm records may also be used.
Classification	Herd level

	Percentage of animals dead, euthanized and emergency slaughtered on the farm during the last 12 months.

Absence of pain induced by management procedures

Title	Disbudding/dehorning
Scope	Animal-based measure: family-farm system cows
Sample size	Animal unit
Method description	The animal unit manager is asked about the disbudding/dehorning practices on the farm with regard to the following: • Procedures for disbudding calves or dehorning cattle • Use of anaesthetics • Use of analgesics
Classification	Herd level: 0 –No dehorning or disbudding 1 –Disbudding of calves using thermocautery 2 –Disbudding of calves using caustic paste 3 –Dehorning of cattle and 0 –Use of anaesthetics 2 –No use of anaesthetics and 0 –Use of post-surgery analgesics 2 –No use of analgesics

Title	Tail docking
Scope	Animal-based measure: family-farm system cows
Sample size	Animal Unit
Method description	The animal unit manager is asked about tail docking practices on the farm with regard to the following: • Procedures for tail docking • Use of anaesthetics • Use of analgesics
Classification	Herd level: 0 –No tail docking 1 –Tail docking using rubber rings 2 –Tail docking using surgery and 0 –Use of anaesthetics 2 –No use of anaesthetics and 0 –Use of analgesics 2 –No use of analgesics

Title	Castration
Scope	Animal-based measure: family-farm system cows
Sample size	Animal unit
Method description	The animal unit manager is asked about castration practices on the farm with regard to the following: • Procedures for castration • Use of anaesthetics • Use of analgesics
Classification	Herd level: 0 –No castration 1 –Castration using rubber rings 2 –Castration using Burdizzo

	3 –Castration using surgery and 0 –Use of anaesthetics 2 –No use of anaesthetics and 0 –Use of analgesics 2 –No use of analgesics

9.1.4 Appropriate behaviour

Expression of social behaviours

Title	Agonistic behaviours	
Scope	Animal-based measure: family-farm system cows	
Sample size		
Method description	Agonistic behaviour is defined as social behaviour related to social hierarchy and includes aggressive as well as submissive behaviours. Here, only aggressive interactions are taken into account. Assess the occurrence of the behaviours listed below. Areas with more than 25 animals are divided into 2 or more segments, which will be observed for 10 min each. Animals with a weight between 200 and 350 kg and animals with more than 350 kg live weight are observed proportionally to their presence within the observation time. Observations should always be approximately randomly distributed across the area and also within the weight categories. Total net (overall) observation time is 120 minutes. Minimum duration of observation per segment is 10 minutes. Agonistic behaviours are recorded using continuous behaviour sampling always taking the animal carrying out the action (actor) into account. Interactions between animals in different segments are recorded if the head of the animal carrying out the action (actor) is located in the focus segment.	
	Parameter	Description
	Head butt	Interaction involving physical contact where the actor is butting, hitting, thrusting, striking or pushing the receiver with forehead, horns or horn base with a forceful movement; the receiver does not give up its present position (no displacement, see definition below).
	Displacement	Interaction involving physical contact where the actor is butting, hitting, thrusting, striking, pushing or penetrating the receiver with forehead, horns, horn base or any other part of the body with a forceful movement and as a result the receiver gives up its position (walking away for at least half an animal-length or stepping aside for at least one animal-width). Penetrating is defined as an animal forcing itself between two other animals or between an animal and barn equipment (e.g. at feeding rack, at water trough). If after a displacement neighbouring animals also leave their feeding places but physical contact as described above is not involved, this reaction is not recorded as displacement.
	Chasing	The actor makes an animal flee by following fast or running behind it, sometimes also using threats like jerky head movements.

		Chasing is only recorded if it follows an interaction with physical contact. If, however, chasing occurs in the context of fighting then it is not counted separately.
	Fighting	Two contestants vigorously pushing their heads (foreheads, horn bases and/or horns) against each other while planting their feet on the ground in 'sawbuck' position and both exerting force against each other. Pushing movements from the side are not recorded as head butt as long as they are part of the fighting sequence. A new bout starts if the same animals restart fighting after more than 10 seconds or if the fighting partner changes.
	Chasing-up	The actor uses forceful physical contact (e.g. butting, pushing, and shoving) against a lying animal which makes the receiver rise.
	Before starting and after finishing the behaviour observation in the area/segment the number of animals present in the area/segment has to be counted. In the case of multiple segments, animals which are found lying, standing or feeding across the boundaries of segments are counted in the section where the main part of their body is situated. Note that agonistic and cohesive behaviours are recorded at the same time and therefore the number of animals at the start and the end of each observation period is only recorded once. Group level: Number of animals in the area/segment at the start and the end of each observation period. Number of aggressive behaviours per area/segment and observation period. Duration of observations	
Classification	Herd level: Mean number of aggressive behaviours per animal and hour	

Title	**Cohesive behaviours**
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	Cohesive behaviour is defined as behaviour promoting group cohesion. Assess the occurrence of the behaviours listed below. Areas with more than 25 animals are divided into 2 or more segments, which will be observed for 10 min each. Animals with a weight between 200-350 kg and animals with more than 350 kg live weight are observed proportionally to their presence. Observations should always be approximately randomly distributed across the area and also within the weight categories. Total net (overall) observation time is 120 minutes. Minimum duration of observation per area/segment is 10 minutes. Cohesive behaviours are recorded using continuous behaviour sampling always taking the actor into account. Interactions between animals in different segments are recorded if the actor's head is located in the focus segment. Before starting and after finishing the behaviour observation in the area/segment the number of animals present in the area/segment has to be counted. In the case of

	multiple segments, animals which are found lying, standing or feeding across the boundaries of segments are counted in the section where the main part of their body is situated.	
	Parameter	Description
	Social licking	The actor touches with its tongue any part of the body (head, neck, torso, legs, and tail) of another group mate except for the anal region or the prepuce. If the actor stops licking for more than 10 s and then starts licking the same receiver again, this is recorded as a new bout. It is also taken as a new bout, if the actor starts licking another receiver or if there is a role reversal between actor and receiver.
	Horning	Head play with physical contact of two animals: The animals rub foreheads, horn bases or horns against the head or neck of one another without obvious agonistic intention. Neither of the opponents takes advantage of the situation in order to become a victor. It is taken as a new bout if the same animals start horning after 10 seconds or more or if the horning partner changes.
	Note that agonistic and cohesive behaviours are recorded at the same time and therefore the number of animals at the start and the end of each observation period is only recorded once. Group level: Number of animals in the area/segment at the start and the end of each observation period. Number of cohesive behaviours per area/segment and observation period. Duration of observations.	
Classification	Herd level: Mean number of cohesive behaviours per animal and hour	

Good human-animal relationship

Title	Avoidance distance
Scope	Animal-based measure: family-farm system cows
Sample size	
Method description	Test at least half of the animals in the study area. The animals selected for the behavioural observations should be included. Place yourself on the feed bunk at a distance of 3 meters (if possible) in front of the animal to be tested. The head of the animal has to be completely past the feeding rack / neck rail over the feed. If you do not have 3 meters in front of the animals in which to approach them, then choose an angle of up to 45 degrees with the feeding rack, and start at a distance of 3.5 meters. If a distance of 3.5 meters is not possible, continue with the assessment but note down the maximum distance possible on the recording sheet. Make sure that the animal is attentive or is taking notice of your presence. If an animal is not obviously attentive, but also not clearly distracted, it can be tested. A way to attract the animals' attention is to make some movements in front of them (at the starting position). Approach the animal at a speed of one step per second and a step length of approximately 60 cm with the arm held overhand at an angle of approximately 45° from the body. When approaching, always direct the back of the hand toward the animal. Do not look into the animal's eyes but look at the muzzle. Continue to walk towards the animal until signs of withdrawal occur, or until you can touch the

	nose/muzzle. Withdrawal movement is defined as the following behaviours: the animal moves back, turns the head to the side, or pulls back the head trying to get out of the feeding rack; head shaking can also be found. In the case of withdrawal the avoidance distance is estimated (= distance between the hand and the muzzle at the moment of withdrawal) with a resolution of 10 cm (300 cm to 10 cm possible). If withdrawal takes place at a distance lower than 10 cm, the test result is still 10 cm. If you can touch the nose/muzzle, an avoidance distance of zero cm is recorded. Make sure that the hand is always closest to the animal during the approach (not the knee or the feet). Especially when getting close to animals that are feeding or have their heads in a low position, bend a little in order to try to touch them. Note that neighbouring animals react to an animal being tested and so should be tested later on. In order to reduce the risk of influencing the neighbour's test result, every second animal can be chosen. Retest animals at a later time if the reaction was unclear. Individual level: 0 –The assessor can touch the animal 1 –The assessor can approach closer than 50 cm but cannot touch the animal 2 –The assessor can approach within 100 to 50 cm 3 –The assessor cannot approach as close as 100 cm
Classification	Herd level: Percentage of animals that can be touched Percentage of animals that can be approached closer than 50 cm but not touched Percentage of animals that can be approached as closely as 100 to 50 cm Percentage of animals that cannot be approached as closely as 100 cm

Positive emotional state

Title	Qualitative behaviour assessment							
Scope	Animal-based measure: family-farm system cows							
Sample size	Animal unit							
Method description	Qualitative Behaviour Assessment (QBA) considers the expressive quality of how animals behave and interact with each other and the environment, i.e. their 'body language'. Select between one and eight observation points (depending on the size and structure of the farm) that together cover the different areas of the farm. Decide the order to visit these observation points, wait a few minutes to allow the animals to return to undisturbed behaviour. Watch the animals that can be seen well from that point and observe the expressive quality of their activity at group level. It is likely that the animals will initially be disturbed, but their response to this can be included in the assessment. Total observation time should not exceed 20 minutes, and so the time taken at each observation point depends on the number of points selected for a farm:							
	Number of observation points	1	2	3	4	5	6	7	8
	Duration of observation per observation point in minutes	10	10	6.5	5	4	3.5	3	2.5
	When observation at all selected points has been completed, find a quiet spot and score the 20 descriptors using the visual analogue scale (VAS). Please note that scoring is not done during observation, and that only one integrative assessment is made per farm.							

	Each VAS is defined by its left 'minimum' and right 'maximum' point. 'Minimum' means that at this point, the expressive quality indicated by the term is entirely absent in any of the animals you have seen. 'Maximum' means that at this point this expressive quality is dominant across all observed animals. Note that it is possible to give more than one term a maximum score; animals could for example be both entirely calm and entirely content. To score each term, draw a line across the 125 mm scale at the appropriate point. The measure for that term is the distance in millimetres from the minimum point to the point where the line crosses the scale. Do not skip any term. Please be aware when scoring terms that start with a negative pre-fix, such as unsure or uncomfortable, as the score gets higher, the meaning of the score gets more negative, not more positive. The terms used for QBA are: Active, Indifferent, Nervous Relaxed, Frustrated, Boisterous Uncomfortable, Friendly, Uneasy Calm, Bored, Sociable Content, Positively occupied, Happy Tense, Inquisitive, Distressed Enjoying, Irritable
Classification	Herd level: Continuous scales for all body language parameters from minimum to maximum

9.2 Appendix B. Collection of farm data - interview protocol

Production

Inventory of animals	
Total of animals:	

Milk production	
Average milk production kg/cow/day:	
Number of animals in milk production:	
Hygiene at milking:	
Main purchasers of milk:	

Beef production	
Number of animals/month:	
Main purchasers of beef:	

Medical care

Veterinary assistance		
Regular veterinary assistance	Occasional veterinary assistance	No veterinary assistance

Procedures and frequency	
Vaccination (specify):	
Internal deworming	
External deworming	
Curative care	

Procedure applied by	Veterinary	Owner	Worker
Vaccination			
Deworming			
External deworming			

Procedure	Analgesia		Place		Applied by		
	Yes	No	Specific place	Anywhere	Veterinary	Owner	Worker
Castration							
Dehorning							
Disbudding							
Tail docking							
Hoof trimming							
Ear tagging							
Tattoo							
Branding iron							
Supernumerary nipple removal							
Nose ring							
Other (Specify):							

Reproductive assistance

Reproductive assistance		
Free natural mating	Controlled natural mating	Artificial insemination (A.I.)

Food

Food source			
Own production	Local production	National production	Foreign production
Organic		Non-organic	
Non-processed		Processed	

Food storage		
Clean and dry place designated to food storage only	Clean and dry place shared with any other stuff	Uncontrolled place

Waste management

Faeces disposal	
Faeces disposal in open spaces	
Faeces disposal in milking parlour	
Faeces disposal in pens	
Corpses' disposal:	
Other organic waste disposal:	
Inorganic waste disposal:	

Infrastructure

Milking parlour		
Automatic milking machine	Partial automatic milking machine	Manual milking

Infrastructure	
Night pens:	
Infrastructure for shade:	
Infrastructure for heat dissipation:	
Infrastructure for cleanliness:	
Livestock crush:	
Silo:	

Farm accessibility

Distance from purchasers:	
Distance from slaughterhouse:	
Paved road:	

Farm facilities

Farm clothes		
Special for farm	Spare change clothes brought by workers	Everyday clothes brought by workers
Farm vehicles:		

Farm owner

Age:	
Sex:	
Education:	
Time dedicated to farming:	
Time being a farmer:	

Workers

Number:	
Age:	
Sex:	
Education:	
Family related:	
Experience:	

Other

Any additional information about the farm:

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