Labour in Swedish Intensive Beef Cattle Production

Physical Work Environment and Motivation

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Abstract

Red veal and young bull production are the two main intensive beef finishing systems in Sweden and utilise practically all male calves from the dairy and suckler cow herds.

This thesis examined labour input and physical working conditions in the two systems in order to identify factors influencing these parameters. Data collection was mainly based on questionnaires, complemented by observations and interviews on farm visits, and related to the most common work tasks performed during different stages of the finishing period. Motivating factors among the Swedish intensive beef cattle producers were examined to analyse how individual orientations of motivation can help understanding farmers' working conditions.

Total time required per calf in red veal production (n=31) was 5.5, 1.9 and 2.0 h/calf for small, medium and large farms, respectively. This corresponded to a labour efficiency of 1.5, 0.6 and 0.6 min/calf/day. Labour efficiency on young bull farms (n=101) purchasing calves at median ages 21, 61, 121 and 180 days was 0.76, 0.94, 0.64 and 0.69 min/bull/day, respectively. No significant difference was found in labour efficiency between the four different finishing models on young bull farms. A possibility to improve labour efficiency by up to 63% was found when comparing the farms with the 25% highest and 25% lowest labour inputs. An effect of scale on labour input was found up to unit sizes of 550 red veal calves and 450 young bulls per year.

The overall perceived physical strain was rated moderate exertion level. Cleaning tasks and handling of young bulls were rated with the highest physical strain. The prevalence of perceived MSD was 51% and 65% in red veal and young bull farmers, respectively. MSD symptoms were most frequently reported in upper extremities and the back. Feeling stressed and worried, working in an unpleasant work climate, high demands on the daily work pace and a high risk of injuries were reported by more than 20% of the 59 red veal and 98 young bull farmers surveyed. Work-related injuries were reported by 20% and 39% of red veal and young bull farmers, respectively. Swedish young bull and red veal producers with large, work-efficient farms were economically orientated, but just as highly motivated by several intrinsic values as those on small farms, indicating an unprecedented degree of multidimensionality.

Identified measures of improvement of labour input and physical working conditions mainly related to frequently performed work tasks, animal handling, fragmentation of farm, and to improved facilities in the quarantine houses where proportion of labour input and the level of physical strain was typically high.

Keywords: calf, work load, work efficiency, questionnaire, rating scale, hazard.

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Dedication

To
A living countryside

At vide
hvad man ikke ved,
er dog en slags
alvidenhed

Knowing what
Thou knowest not
Is in a sense
Omniscience
Piet Hein (1905-1996)

Contents

List of Publications

This thesis is based on the work contained in the following Papers, referred to by Roman numerals in the text:

I Bostad, E., Swensson, C. and Pinzke, S. (2010). Labour use in Swedish production of red veal. *Journal of International Farm Management* 5(3): 1-23. http://www.ifmaonline.org/pdf/journals/Vol5_Ed3_Bostad_etal.pdf.

II Bostad, E., Swensson, C. and Pinzke, S. (2011). Labour input in specialist beef bull production in Sweden. *CIGR Journal* 13(3): 1-21. http://cigrjournal.org/index.php/Ejounral/article/view/1920.

III Bostad, E., Swensson, C. and Pinzke, S. (2013). Physical working conditions in young cattle production in Sweden. *Journal of Agricultural Safety and Health* 19(1): 19-35.

IV Bostad, E., Swensson, C. and Pinzke, S. (2013). The multidimensional Swedish intensive beef cattle farmer (submitted).

Papers I-III are reproduced with the permission of the publishers.

My contribution to the Papers included in this thesis was as follows:

I Planned the study, performed data collection, analysed the data and wrote the Paper in collaboration with co-authors.

II Planned the study, performed data collection, analysed the data and wrote the Paper in collaboration with co-authors.

III Planned the study, performed data collection, analysed the data and wrote the Paper in collaboration with co-authors.

IV Planned the study, performed data collection, analysed the data and wrote the Paper in collaboration with co-authors.

Abbrevations

AV	The Swedish Work Authority
CAP	Common Agriculture Policy
CR-scale	Category-rate scale
EC	European Union Commission
EEA	European Environment Agency
FAO	Food and Agriculture Organisation of the United Nations
FH	Finishing house
ILO	International Labour Organisation of the United Nations
IQR	Interquartile range
LF	Large-scale farms
MF	Medium-scale farms
MSD	Musculoskeletal disorder
PCA	Principal component analysis
PW	Pre-weaned (calves fed milk)
PWS	Physical work strain index
Q1	25% quartile
Q3	75% quartile
QH	Quarantine house
r	Correlation coefficient
RV	Red veal farms
SD	Standard deviation
SEK	Swedish crowns. 1 SEK = 0.1142 EURO (5/8/2013)
SF	Small-scale farms
TMR	Total mixed ration
W1	Weaned calves purchased at 61 days of age
W2	Weaned calves purchased at 121 days of age
W3	Weaned calves purchased at 183 days of age
YB	Young bull farms
SEPA	Swedish Environmental Protection Agency

1 Background

This thesis is based on studies of labour inputs and physical work conditions in Swedish intensive beef cattle production. The studies are related to the most common work tasks, and limited to the work performed inside or in close relation to the animal houses. As a complement to technical explanations, individual orientations of motivation among the farmers are used to help explain working conditions on farms with intensive beef cattle production.

1.1 Considerations on beef production

The production of beef is of several dimensions, with both beneficial and challenging aspects, leading to different conflicts of interest, particularly in terms of competition for food and land use and environmental impact (Hocquette & Chatellier, 2011). Ruminants are dependent on fibrous plant material to maintain proper rumen function (Mertens, 1977), and have thus a unique capacity to transform cellulose-based plant material into products for human consumption. Keeping grazing livestock is essential for the purposes of maintaining semi-natural grasslands, high biodiversity and an open landscape (Emanuelsson, 2008; Hessle *et al.*, 2007; Kumm, 2005), which are among the environmental goals on national level and within the European Union (EU) (EEA, 2013; SEPA, 2013).

Beef production and biodiversity

A varied agricultural landscape is one of the 16 main Swedish environmental quality goals (SEPA, 2013). The number of cattle in decreasing on both national and EU level (Hessle & Kumm, 2011; Hocquette & Chatellier, 2011), and under-grazing and abandonment of land through reduced use of pastures is an increasing threat to fulfilling the goal of having a varied agricultural landscape (Hessle & Kumm, 2011).

Beef production and environmental impact

A second Swedish environmental quality goal aims at a *reduced climate impact in agriculture* (SEPA, 2013). According to Steinfeld *et al*. (2006), nearly 20% of global greenhouse gas (GHG) emissions come from livestock production. The carbon footprint per kg output is higher in beef production than in dairy production (Gill *et al.*, 2010). The highly potential GHG methane (CH_4) is produced during enteric fermentation in ruminants and is emitted mainly through the oesophagus. The higher the digestibility of the feed, the lower the methane emissions from the rumen, but the dilemma is that this does not exploit the capacity of ruminants to digest coarse vegetation. Emissions of the even more potential GHG nitrous oxide (N_2O) from manure add to the climate impact of ruminants (Saggar *et al.*, 2004).

Excreted nitrogen (N) and phosphorus (P) are two other major concerns for the livestock sector, while N use efficiency is also highly related to GHG production (Olesen *et al.*, 2006). Life cycle analysis (LCA) is a widely used method to examine the environmental impact of agricultural products (Henriksson *et al.*, 2011; Beauchemin *et al.*, 2010; de Vries & de Boer, 2010; Nguyen *et al.*, 2010; Cederberg & Stadig, 2003) and to identify strategies for improvement. Among important mitigation strategies are optimising feed rations for increased digestibility and improved N use efficiency, grazing and strategies for handling and use of manure (Hermansen & Kristensen, 2011; Kristensen *et al.*, 2011; Beauchemin *et al.*, 2010; Nguyen *et al.*, 2010; Olesen *et al.*, 2006).

Beef production and rural development

A third major Swedish environmental quality goal is to aim for s*atisfactory profitability in agriculture.* The longer rearing time for cattle compared with other meat increases the price of beef, and the level of beef consumption is therefore highly dependent on the economic strength of the consumer (OECD-FAO, 2013; Hocquette & Chatellier, 2011). Political decisions have a high impact on beef production (Hocquette & Chatellier, 2011; Salevid & Kumm, 2011), *e.g*. an economic analysis of 841 Swedish beef cattle farms found that the average dependence on subsidies was about 40% (Manevska-Tasevska *et al.*, 2013).

The food industry is the fourth largest of the manufacturing industries in Sweden. Within the food industry, the bread and flour sector has the largest number of employees, but the meat and meat products sector is the largest in terms of turnover (Swedish Board of Agriculture, 2012c). The food industry is important for employment possibilities in all counties of Sweden, unlike the other three major manufacturing industries (Swedish Board of Agriculture, 2012c). The exact employment effect of agriculture is difficult to quantify (Swedish Board of Agriculture, 2008b) but the chain of services linked to a farm and its products is of significant importance for the whole rural society (Hocquette & Chatellier, 2011; Millen *et al.*, 2011; Alston, 2007). Around 10% of rural employment is within the agriculture sector and for every farmer at least two other non-farming full-time jobs are generated (Swedish Board of Agriculture, 2008b).

Beef consumption and human health

To date there are no recommendations from the Swedish National Food Agency on limiting the intake of red meat (meat from ruminants and pigs). However, with an average weekly consumption of 400 g pure red meat and 200 g processed meat (Amcoff *et al.*, 2012), the Swedish population is close to the dietary recommendations issued by the World Cancer Research Fund (WCRF). Due to the increased risk of colorectal cancer connected with consumption of red meat, as observed in several studies, the WCRF recommendations to individuals are limited to a maximum of 500 g per week with very little, if any, processed meat (WCRF, 2012). A recent Nordic report on the nutritional effects of reducing the intake of red meat to the WCRF public health goal of 300 g per week found no dietary consequences in terms of nutritional deficiency (Tetens, 2013).

Beef production and workers health

Farmers and farm workers are exposed to a number of risks and health hazards potentially causing physical health problems and psychological stress. A range of illnesses, such as respiratory diseases, dermatological disorders, physical hazards such as trips and falls, and musculoskeletal disorders (MSD) due to awkward working postures, heavy loads and repeated strain during manual work are related to agricultural work (Fathallah, 2010; Kolstrup, 2008; Kolstrup *et al.*, 2006; Pinzke, 2003; Holmberg *et al.*, 2002; Walker-Bone & Palmer, 2002). Beef cattle for finishing are large animals weighing up to 800 kg at slaughter. Cattle handling is a dangerous activity and, despite general under-reporting, is one of the activities worldwide most frequently leading to occupational injuries (Day *et al.*, 2009; Davis & Kotowski, 2007; Pinzke & Lunqvist, 2007). A high level of stress and concern among farmers has been attributed by several authors to different factors, such as financial stress, time pressure, long working hours, and stress related to increasing level of rationalisation (Sanne *et al.*, 2004; Aptel *et al.*, 2002; Gregoire, 2002). Furthermore, as farms expand, the farm manager requires new leadership skills from having been more used to working alone previously. This can be another stressor both for the farmer and farm workers, as noted *e.g.* by Kolstrup & Hultgren (2011).

1.2 Swedish legislation

1.2.1 Work Environment Act

The Swedish Work Environment Act came into force in 1977 and has been continuously amended since then, with the latest revision in 2011. The legislation provides protection for all employed workers by preventing ill health and injuries during work. Initially the main focus of Swedish workplace legislation was on the physical factors leaving employees at risk, but the reform leading to the Act of 1977 also included psychosocial aspects. Thus technical equipment, work organisation and job content must maintain an overall good working environment in terms of providing a positive working situation through stimulating work tasks, encouraging social relations and personal development. The worker should be able to influence the design of his/her working situation and have possibilities to make changes for improvement. The work environment must be in context with current social and technical developments. For the self-employed there is a modified regulation of the Act, so *e.g.* preventing injuries such as falls or unhealthy work postures are areas where the self-employed are not regulated.

1.2.2 Animal Protection Act

The Animal Protection Act and the Animal Welfare Ordinance (APA, 1988) applies to the welfare of domestic animals, laboratory animals and other animals kept in captivity. The legislation state that the animals shall be treated well and be protected from unnecessary suffering and disease. Animals shall be given sufficient feed and water and adequate care, and feed and water must be of good quality and appropriate for the particular species. Animals shall be housed and handled in an environment that is appropriate for animals, promoting their health and permitting natural behaviour.

Specific regulations for cattle/calves (SJVFS, 2010) state that calves shall be group housed after the age of eight weeks. Pens for calves up to the age of one month shall be provided with litter bedding or similar material. Calves less than 6 months cannot be tethered, roughage must be freely accessible from week two, and no restrictions can be made on the iron content in feed or water. Purchased calves must be kept separate from older calves for a minimum five-week quarantine period. This applies unless the production volume is less than 50 calves per year, all calves are bought from the same farm, or calves are bought at more than 4 months of age.

2 Introduction

2.1 Beef production and consumption numbers

The European Union (EU-27) is the world's third largest producer of beef, after Brazil and the USA. Due to high competition from net exporting countries, the production of beef in EU-27 has decreased in the past two decades. In the coming decade, production volume is projected to stabilise or continue to decrease slightly and produce prices are projected to marginally increase (OECD-FAO, 2013). Brazil is the country forecast to have the largest positive net trade within the next decade. On a global basis, the consumption of beef is predicted to grow at a rate of 1.5% per year, from 6.50 to 6.87 kg per capita, and beef production will increase by nearly 15%. The increase will occur on all continents, but the EU-27 countries will have a slight decrease in beef consumption, from 11.21 (2012) to 11.06 kg per person and year (2021) (OECD-FAO, 2013).

Beef production in a Swedish perspective

The majority of the cattle (~90%) are found in the southern (Götaland) and central (Svealand) parts of Sweden (Swedish Board of Agriculture, 2012b). In 2012 there were 4,968 dairy and 14,593 beef farms (Swedish Board of Agriculture, 2012b). At the end of 2012, the number of cattle in Sweden was 1,443,584 (Swedish Board of Agriculture, 2013d), an 11% decrease since the year 2000. Among these, there were 345,527 dairy cows and 178,296 suckler cows, a decrease in the number of dairy and beef cows by 19% and 16%, respectively, since the year 2000. The average number of cattle per herd in 2011 was 46 on a beef farm and 146 on a dairy farm (70 dairy cows). Of these, 12% of the dairy farms (n=5361) and 16% of the beef farms (n=15,565) were organic (Swedish Board of Agriculture, 2012d).

Sweden had a 52.3% self-sufficiency of beef in 2012 (Lukkarinen & Öberg, 2013). During the past three decades (1980-2011), total consumption of beef in Sweden has increased from 16.9 to 26.3 kg per person and year (Swedish Board of Agriculture, 2013b).

As in most EU countries except Ireland and the United Kingdom (EC, 2001), the majority of Swedish bull calves are entire. The distribution among categories of the 390,840 cattle slaughtered in 2012 is shown in Figure 1 (Swedish Board of Agriculture, 2013c).

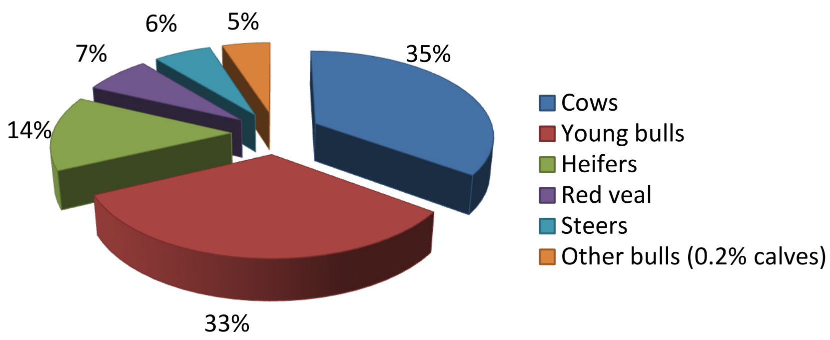

Figure 1. Categories (%) of cattle slaughtered in Sweden, 2012 (based on statistics from Swedish Board of Agriculture (2013c).

During 2012, production of beef in Sweden was 9.2% lower than in the same period in 2010 (Swedish Board of Agriculture, 2013c). The downward trend began in January 2012, following a year when an increased number of bulls aged over 12 months was slaughtered (Figure 2). This was when direct payment of the male premium in the EU for bulls and steers (≥185 kg carcass weight) was phased out, to be included in the single farm payment based on production in the previous 12 months. The Swedish beef market was thus highly affected by abolition of the male premium, with effects on number of head slaughtered and producer prices both before and after abolition. Also the price of live calves was affected and increased considerably during 2010 when the demand for calves was high.

During the period 2007-2013, the producer price for young bulls varied between 22.25 SEK per kg at a minimum in 2007 and 34.68 SEK per kg at a maximum in February 2013 (SLS, 2013). The beef production continued to decrease in the beginning of 2013, but the market has now (summer 2013) stabilised somewhat and meat prices are currently 7.4% higher than during the previous 12 months. The price of live animals has also increased again, since a drop during 2012, by about 15% relative to the previous 12-month period (SLS, 2013).

The production of red veal (calves aged <12 months) in Sweden is based on contracts between the farm and the abattoir, and has therefore remained relatively stable in terms of production numbers (Figure 2).

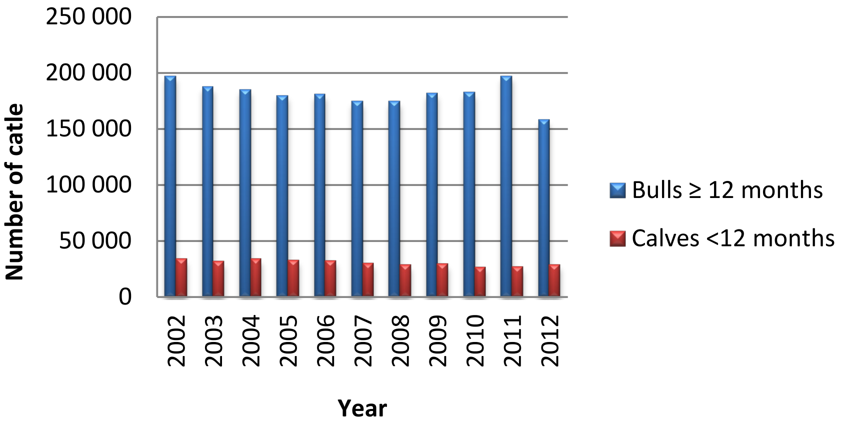

Figure 2. Number of bulls aged ≥12 months and calves <12 months slaughtered in Sweden between 2002 and 2012 (based on statistics from Swedish Board of Agriculture (2013c).

2.2 Intensive beef cattle production in Sweden

2.2.1 Production systems

The red veal and young bull production are the two main sectors of intensive finishing of young cattle in Sweden, and play a large role in utilising practically all male calves from dairy and suckler cow production. The finishing of calves and bulls is based on group housing in intensive indoor systems according to the animal welfare legislation. The feed is generally grass silage and concentrates, fed separately or in a total mixed ration (TMR). Other crops, such as maize, are also used in the silage, mainly depending on farm location and crop production in the area (Arnesson *et al.*, 2009).

Red veal production

Red veal production is based on calves primarily from the dairy industry (Swedish Holstein and Swedish Red breeds). It is mainly bull calves that are reared, with a few heifer calves. The calves are generally purchased at 2-9 weeks of age, either pre-weaned or weaned (at ages >8 weeks). The national average slaughter age of red veal of Swedish Holstein breed during the first six months of 2013 was 10.9 months, with carcass weight close to 160 kg (Taurus, 2013a). A carcass weight between 120-161.9 kg generally falls within the category with the highest payment from the abattoir (SLS, 2013). The average slaughter weight slightly increased before January 2012 due to some meat retailers selling red veal at a higher weight (>185 kg) to obtain the male premium.

The short rearing period, young age of the animals and mixing of calves from many different herds place high demands on farm management. According to the regulations for livestock mentioned earlier (SJVFS, 2010), newly arrived calves are kept in quarantine before being moved for the last months of finishing. All boxes shall be cleaned, disinfected and dried between the batches of calves and all animal houses shall be cleaned at least once a year. A typical rearing period of red veal is illustrated in Figure 3.

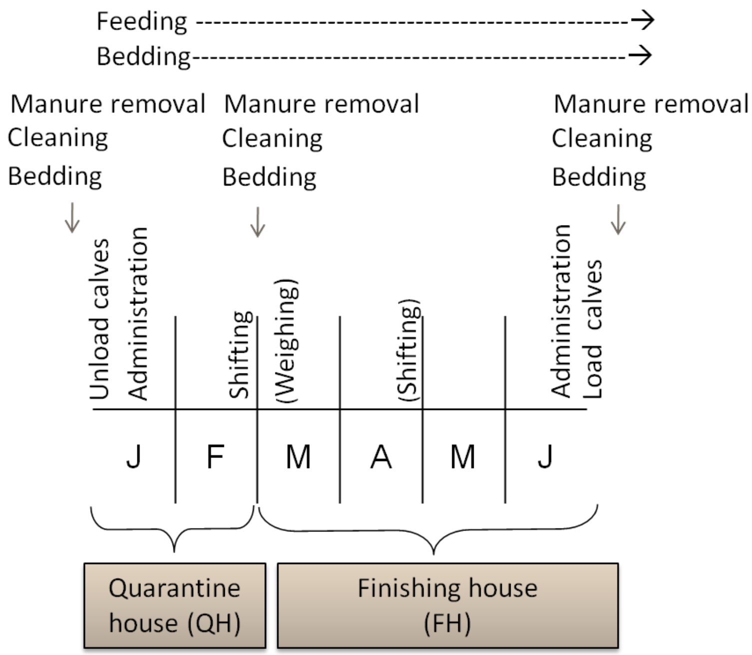

Figure 3. Schematic figure illustrating an example of one batch of weaned calves purchased at 8 weeks of age in January and sold at 8 months in June. The figure includes two months in the quarantine house and four months in the finishing house and shows typical work tasks. Note the continuity of work tasks as several batches typically are run simultaneously throughout the year.

Young bull production

Swedish young bull production is also to a large extent based on finishing bull calves from the dairy industry, as about 65% are dairy breeds (Swedish Board of Agriculture, 2013c). However, this is also the most common way of finishing beef breed bull calves from suckler herds. Within finishing of dairy breed bulls, similarly to calves intended for red veal production, the calves are purchased either before or after weaning, *i.e.* at 2 weeks or ~9 weeks. The national average slaughter age of dairy breed bulls is 19.3 months, with carcass weight close to 310 kg (Taurus, 2013a). Calves from suckler herds are born in the spring, grazed on summer pasture and generally sold on in late autumn, at an average age of 6-7 months. Most beef breed bulls fattened in Sweden are cross-breeds, with a national average slaughter age of 18.3 months and carcass weight close to 340 kg (Taurus, 2013a). The work tasks in young bull production are overall similar to red veal production as shown in Figure 3, but generally performed during a longer period of finishing.

Trading of calves

The calves are traded through meat marketing agencies or bilateral contracts between dairy and finishing farmers, or are kept and finished on the farm of origin. To purchase pre-weaned calves requires the beef farmer to have dairy farms close by, as transport of calves less than 14 days old must be limited to ≤50 km. There are no national statistics to date describing the trading and transportation of calves between farms. An analysis of the Swedish cattle industry in 2011 found that the majority of calves (86%) were traded only once before slaughter, *i.e.* transported from farm of origin to the finishing farm (Swedish Board of Agriculture, 2012d).

Regulations for animal protection and disease control

In addition to the EU Council directives on rearing and finishing of calves (97/2/EC, 1997; 97/182/EC, 1997) intensive beef cattle production in Sweden is regulated by national standards regulated from the Animal Protection Act (APA, 1988). From the beginning of the 1990s, many studies were related to the new EC animal welfare directives on housing and feeding systems in veal production. These directives specified higher levels of group housing and minimum levels of space for the veal calves to move and lie down freely. Furthermore, to allow proper rumen development and avoid digestive diseases, veal calves should receive a minimum amount of structure feed, have a minimum intake of iron and be housed in daylight between 9 a.m. and 5 p.m.

The physiological aspect of rumen function in calves fed different amounts of structure feed was issued by *e.g* Matiello *et al*. (2002) and Morisse *et al*.

(2000). As supplementation of solid feed often lead to a darker carcass colour (Beauchemin *et al.*, 1990), the traditional veal carcass evaluation measures (pale colour, high tenderness and leanness) were expected to be impaired by the new directives. Studies reported no impairment in carcass and meat quality, but rather the opposite, that growth rates and conformation scores were higher and sensory properties unaffected or better (Cozzi *et al.*, 2002; Xiccato *et al.*, 2002). However, Andrighetto *et al.* (1999) found that an increase in redness of the meat resulted in lower rating by a consumer panel.

Grouping of calves was found to have no effect or to increase (Xiccato *et al.*, 2002; Andrighetto *et al.*, 1999) or decrease (Hanekamp *et al.*, 1994) daily growth of calves (g/day) compared with raising calves in single pens. The incidence ratio of respiratory diseases and the mortality rate were found to be higher in group housing of calves due to higher contamination rates, but lower if the group housing was in open houses with natural ventilation (Hanekamp *et al.*, 1994).

The opportunity for locomotion and social behaviour is of great importance for the welfare of the calves (Hanekamp *et al.*, 1994; Neindre, 1993), and the EC directives on group housing were overall supported by the literature. Moreover, group housing is reported to be preferable due to the lower labour requirement per calf (Kung *et al.*, 1997). Hanekamp *et al.* (1994) stress the importance of particularly good farmer skills when rearing group-housed calves, and housing of calves in groups has been described in terms of different management factors such as feeding strategy, disease prevention and group dynamics (Pedersen *et al.*, 2009; Svensson & Liberg, 2006; Hepola, 2003; Hänninen *et al.*, 2003).

Economic aspects and labour cost

Profitability in Swedish beef production is generally characterised as vulnerable to political decisions and constrained by high operation costs, low prices and reduced EU income support (Manevska-Tasevska *et al.*, 2013). According to the 2011 Swedish Farm Economic Survey, which delivers annual data to the Farm Accountancy Data Network (FADN), beef cattle farmers achieved lower net income and a reduced gross margin in 2011 compared with 2010 (Swedish Board of Agriculture, 2013a). The continually decreasing number of cows in the country is another obstacle to domestic beef production (Kumm, 2006). According to studies performed on behalf of the Swedish meat trade organisation (Svenskt Kött, 2013), seven out of ten consumers claim to prefer Swedish meat. However, with no increase in domestic beef production, the rapid increase in beef consumption per capita during recent decades has been covered by imports. Figures from Agri Benchmark, the global network of agricultural economists and specialists, confirm that the situation in Swedish beef production is not unique in Europe (Deblitz, 2009). According to a standard cost estimation guide presented for December 2012 published by the national beef cattle extension service (Taurus, 2013b), less than 200 SEK is left to cover the cost for labour, depreciation and buildings in young bull production.

In a recent study of performance on 6,481 Swedish livestock farms (of which 806 were beef cattle farms) in the FADN, beef farms (suckler cow and finishing farms) were found to have the highest potential for improving their technical efficiency (TE) (Manevska-Tasevska *et al.*, 2013). Technical efficiency is output (revenue)-orientated and aims at achieving higher output without increasing input costs (Farrell, 1957). With a TE of 83%, beef farms had 17% potential for improvement, in comparison with 10% for crop, pig and dairy farms (TE = 90%). A higher proportion of cattle farms compared with other livestock enterprises were within the lower TE interval of 60-79%, and the lowest minimum value of TE (22%) was also found on beef cattle farms. Beef cattle farms had the highest change in TE since 2005 among all farms and the highest total improvement in labour productivity (11.2%) during the decade analysed, but a high level of heterogeneity was still present. The sensitivity to sudden changes in feed prices was particularly detrimental to total farm efficiency. The study also revealed that diversified farms had higher TE, presumably owing to a higher possibility to adjust to changes in the market (Manevska-Tasevska *et al.*, 2013).

The meat prices do not only vary between years, as described earlier. The producer price also varies between farms. Agribeef, the Swedish representative in Agri Benchmark, showed that during 2011 the average price level per kg meat on a sample of 15 farms with intensive finishing of beef varied between 27-34 SEK for bulls of dairy breed and 32-39 SEK for bulls of beef breed (Agribeef, 2011).

In the conventional production systems for beef farming in Sweden, wages are high relative to the kg carcass weight produced per hour worked compared with other large beef-producing countries, and therefore place Sweden among the countries with high costs for labour. According to Deblitz (2009), the opportunity cost of imputed family labour is typically high in many European beef finishing family farms. The exact labour cost relative to total input costs is therefore more difficult to estimate compared with other input factors, and differs between farms depending on the level of hired labour and the level of family labour. Data from selected farms show that the returns from the market and the government together in most cases cannot cover the opportunity costs, which to a large extent are made up of opportunity labour costs (Deblitz, 2009).

Kumm (2006) points out how the price of meat fell from 30 SEK to 23 SEK per kg during the period 1989-2005 while at the same time the cost of hired labour nearly doubled, from 100 SEK to 170 SEK per hour. The current labour cost is an estimated 209 SEK/hour (Agriwise, 2013), and wages of farm workers are generally low compared with those in other occupations (SCB, 2003). Labour costs for hired agricultural workers are expected to continue to rise as a result of the increased need for specialist expertise as farms expand (Kumm, 2006). Increased wages along with increasing costs for land, machinery, buildings and feed, means that many farmers find it too expensive and uncertain to expand (Charroin *et al.*, 2012; Hageberg, 2012). As wages off-farm is generally higher, O'Brien *et al*. (2006) investigated the possibilities to reduce labour input in dairy farms to improve the scope for off farm work.

2.3 Labour input

Labour studies in young cattle production

When estimating the labour input in present cost guides for Swedish young cattle producers, a labour input of 1 min/calf/day has typically been used as a rule of thumb (Taurus, 2009). This estimate is based on smaller domestic studies, and the number of peer-reviewed publications on labour inputs in systems for finishing young cattle is low. However, Taurus, the Swedish beef cattle extension service, recently performed a detailed survey of labour inputs on eight beef cattle farms and found that those on the two beef finishing farms studied averaged 0.77 min/calf/day (Taurus, 2012). Using the same methodology as Taurus (2012), Håkansson & Rungegård (2012) examined the labour inputs on 10 specialist beef finishing farms in Sweden, eight of which produced between 150-750 bulls per year of dairy and beef breed and two of which produced 45-50 bulls annually. The daily labour input varied between 0.33-1.1 min/calf/day for nine of the 10 farms, while one farm producing 148 bulls annually had a labour input of almost 2 min/bull/day. In a Danish study, labour use in quarantine areas on 14 farms averaged between 0.5-1.75 min/calf/day for daily tasks including milk feeding. The farms produced between 400-1300 calves per year (Dalgaard *et al.*, 2007). Danish finishing house animals in a similar study of 13 farms required an average of 16 sec/calf/day, ranging from 5 to 37 seconds of daily work per calf (Dalgaard, 2009).

Peer-reviewed publications on labour input for calf rearing during the milk feeding period in dairy production is to some larger extent available. An

American study on labour input and calf performance using different milk feeding and management methods in a dairy herd identified an average daily time requirement for group-housed calves of slightly less than 1 min/calf (Kung *et al.*, 1997). O'Brien *et al*. (2006) reported a labour input on Irish dairy farms ranging between 1.2 min/calf/day and 5.4 min/calf/day, respectively, on farms categorised as the 20% most and 20% least efficient in the study. The average number of calves was 26 and 30, respectively. Another Irish study found an average daily labour input of 2.1, 1.7 and 1.8 min/calf within small, medium and large dairy herds with different calf rearing methods (Gleeson *et al.*, 2008). A general feature of previous studies is that feeding tasks account for the majority of the labour input, and that herd size and differences in technology and housing systems are main factors influencing total labour use.

Labour studies in other livestock enterprises

A number of studies on operator minutes per cow in dairy enterprises have been published, in particular related to the processes of milking, feeding and housing (Næss & Bøe, 2011; Gustafsson, 2009; Hedlund, 2008; O'Brien *et al.*, 2007; Ferris, 2006; O'Brien *et al.*, 2006; Hansen, 2000; O'Shea *et al.*, 1988). These studies have been important in quantifying the labour requirement related to specific work tasks, milking facilities and technologies, as well as the logistics of cows and work routines pre- and post- milking.

Suckler cow operations are typically characterised by a variation in labour-intensive periods throughout the year (Madelrieux & Dedieu, 2008; Fallon *et al.*, 2006; Leahy *et al.*, 2004) compared with intensive finishing of beef, where season does not have the same effects on changes in labour requirements. Comprehensive labour studies in dairy and suckler cow enterprises are useful for beef cattle production. Efficient logistics and handling of animals, feed, bedding and manure are by many means transferable to beef cattle finishing, as well as time studies on the management and care of the dairy calf. Nevertheless, the knowledge base of specialist beef finishing during different stages of production is in need of broadening and extension.

Labour efficiency as an effect of animal welfare and production parameters

Does low labour input always equal efficient labour, and can it be linked to psychological values varying between farmers? Barkema *et al*. (1999) identified two groups of management styles among 300 Dutch dairy farmers, which they described as 'clean and accurate' or 'quick and dirty'. The authors found that farmers working accurately rather than quickly also had more hygienic conditions and a lower bulk milk somatic cell count compared with the quick-working farmers. Norwegian dairy herds with more dirty cows also tend to have lower labour input (Næss & Bøe, 2011). Furthermore, they found a tendency for farmers agreeing with the statement ‘animals experience physical pain as humans do’ to have higher labour inputs. It is obvious that labour efficiency should lead to increased control of production and should not involve a risk of reduced supervision, reduced animal performance and increased mortality rates. Rather, efficient work should optimise the utilisation of resources, and lead to the farmer feeling satisfaction, pride and a desire to perform.

2.4 Work environment

Research on how human factors and psychology affect employee turnover, performance and productivity in the work place was first initiated in the early 20th century (Morgan, 2006). The psychologist Elton Mayo was a pioneer within research on organisational theory dealing with the emotional needs of employees at work, resulting in the famous Hawthorn studies (1924-1933). Since then, physical, psychosocial and organisational conditions in the work place have grown into a comprehensive field of research and development (Morgan, 2006), legislated and supervised by work environment authorities. The Swedish Work Authority, which was founded in 2001, performs supervision and preventive work to reduce the risks of ill-health and injuries in the work situation. For closer and more local management, occupational health and safety services at company level offer evaluations and advice for improvement of work places where more than five people are employed.

2.4.1 Work environment factors

In 2011 the number of people in Sweden aged between 16-64 years reached 6 million. Of them, just above 4.5 million were employed (Swedish Work Authority, 2012). A sample of approximately 16,000 Swedish employees aged between 16-64 years is examined every second year to analyse the trends in work environments on a national level. The most recent study (2011) revealed overall satisfaction with the work situation of 70% for females in the working population and 80% for males. Where significant changes were found, they were positive. For example, the number of workers having to lift 15 kg or more continuously decreased during the period 1996-2011 (Swedish Work Authority, 2012). However, exposure to negative factors was still found. For example, the level of varied work tasks had decreased, particularly among men, from 61% in 1989 to 50% in 2011, and 30% of employed males were exposed to high levels of noise during at least 25% of their work time.

Despite a general trend for larger livestock herds, a higher degree of mechanisation and less manual work during the past four decades (Coolman, 2002), exposure to physically demanding work environment factors are still commonly found in agriculture. These include heavy lifting and carrying, repetitive movements and difficult work postures (Kolstrup & Hultgren, 2011; Douphrate *et al.*, 2009a; Pinzke, 2003; Walker-Bone & Palmer, 2002; Pinzke *et al.*, 2001). In a Swedish study of 657 farmers and 657 non-farmers Holmberg *et al.* (2002) found that farmers reported significantly higher physical work load, more vibrations, more difficult working positions, longer work days and longer sleep hours than the non-farmers. Furthermore, the farmers also reported to have worked a higher number of years in the current job and 63.4% of the farmers had not been on a vacation during the previous year compared to 8.7% of the non-farmers.

The increased use of tractors instead of manual work has shifted the risk factors from heavy burdens to whole body vibrations and twisting and turning of the back and neck when looking backwards at the field or the attached equipment (Davis & Kotowski, 2007). Tractor age contributes to the exposure to vibrations (Gomez *et al.*, 2003), which might be particularly relevant on livestock farms, where a new tractor might not be the highest investment priority due to the shorter hours of use compared with *e.g.* on arable farms.

Links between physical and psychosocial work environment aspects of farming are described in the literature. In a health study of 17,295 Norwegian workers, Sanne *et al.* (2004) reported a higher level of depression among farmers compared to non-farmers. Longer daily work hours, high levels of physical strain and low income were among the factors explaining the mental stress reported by the farmers. Gregoire (2002) studied how perceived stress in farming situation can lead for example to reduced social contact with other farm colleagues, while Aptel *et al*. (2002) discussed the complex role that psychological stress might play in the incidence of musculoskeletal disorders.

2.4.2 Musculoskeletal disorders

Musculoskeletal disorders (MSD) are physical health problems involving disorders or diseases of the locomotive system, *e.g*. muscles, nerves, tendons, joints, cartilage and spinal discs (Hagberg *et al.*, 1997). Awkward work postures, lifting heavy burdens and repetitive strain are among the most common factors behind work-related disorders in terms of musculoskeletal problems (Fathallah, 2010). MSD can also be caused by acute injuries (Davis & Kotowski, 2007), but it is the results of exertion over time that are normally incorporated in the term. Work-related MSD are the most prevalent occupational diseases on both national and EU level. They are not only painful, but are also associated with a high economic impact to the company, through absences and reduced productivity, and to society as a whole (EU-OSHA, 2013; Widanarko *et al.*, 2011; Kirkhorn *et al.*, 2010; Swedish Work Authority, 2010). Work-related MSD are defined as where the work environment and performance of the work are proven to significantly contribute to the causation of disease (Hagberg *et al.*, 1997). In this thesis, perceived MSD refer to musculoskeletal pain, ache or discomfort in the locomotive system.

Prevalence of MSD

Agriculture is a sector with a high prevalence of MSD symptoms (Fathallah, 2010; Kirkhorn *et al.*, 2010; Kolstrup *et al.*, 2006; Stal *et al.*, 1999). Studies of different Swedish livestock enterprises have shown that 84-86% of dairy farm workers (Kolstrup *et al.*, 2006; Gustafsson *et al.*, 1994), 91% of riding instructors (Löfqvist *et al.*, 2009) and 78% of pig farm workers (Kolstrup *et al.*, 2006) report musculoskeletal symptoms. Osborne *et al.* (2010) found a lower 12-month prevalence of perceived MSD when studying different Irish farm enterprise groups specialising in crops, dairy or beef cattle. Here, a perceived prevalence of 57% was reported, with no differences between the farm enterprise groups. In a study of 266 farmers in Kansas a 60% prevalence of perceived MSD-symptoms was reported. Two thirds of the respondents raised beef cattle with an average of approximately 200 head per farm. Shoulder pain was strongly associated with the job factor working with animals, while neck pain was strongly associated with lifting and carrying heavy materials (Rosecrance *et al.*, 2006). Overall, symptoms of MSD in the low back, hip, knee, upper extremities and neck is commonly associated with farm work (Walker-Bone & Palmer, 2002).

Among the general working population in Sweden surveyed in 2011, 22% of females and 17% of males reported work-related MSD during the previous 12 months, corresponding to approximately 860,000 of the working population aged 16-64 years (Swedish Work Authority, 2012). In contrast to the trend on EU level (EU-OSHA, 2013), this comprises a continuous reduction of 29% of the employed population since 2003 according to national studies performed every second year since 1989. Due to the high correlation to physical work environment factors, blue collar workers are more at risk of developing MSD than white collar workers. For white collar workers the most common work-related disorders relate to stress and psychosocial factors (Swedish Work Authority, 2012).

2.4.3 Occupational injuries

Work places in Sweden are generally considered safe, but although there has been a continuous improvement over time, working in agriculture and the construction sector carries a higher risk (Swedish Work Authority, 2011). The frequency of fatal injuries in the period 2007-2010 was 3.3 cases per 100,000 self-employed, compared with 1.2 cases per 100,000 employees (Swedish Work Authority, 2011). Agriculture is a typical self-employment profession and in Sweden incidents and injuries are most commonly caused by animals (70% of all injuries), followed by machine handling and construction work . Farm injuries involving cattle are often severe (Douphrate *et al.*, 2009b). The exact number of injuries on an annual basis in agriculture is difficult to assess, since many incidents are not reported to the Swedish Work Environment Authority. Pinzke & Lundqvist (2007) investigated the number of non-reported injuries in agriculture, and found that only approximately 400 out of 5,000 injuries (8%) during the year 2004 had been registered by the Work Environment Authority. A similar level of under-reporting occurs worldwide (Day *et al.*, 2009; Davis & Kotowski, 2007; Solomon, 2002). Occupational accidents impose a high cost on Swedish society, accounting for 2-3 billion SEK every year (Swedish Work Authority, 2010). Because of the high level of uncertainty regarding the number of injuries and the actual costs related to them, the numbers cannot be exactly confirmed. Since 2012 the Swedish Work Environment Authority has enabled electronic reporting of occupational injuries, which may facilitate an increase in the number of non-fatal cases reported in future.

Risk factors for occupational injury

Langley & Morrow (2010) listed some of the various activities that livestock handlers are involved in, and also discussed how few livestock farmers look upon cattle farming as a dangerous activity. The number of hours worked, not having attended farm training courses and a low overall income were among the risk factors for work-related injury found in an Australian study of 252 cases of farm injuries (Day *et al.*, 2009). Similarly, Alwall Svennefeldt (2013) found that Swedish farmers who participated in a farm safety study had higher awareness of potential hazards. The farmers admitted to having challenged safety sometimes, which might affect the behaviour of the employees and supports the findings by Day *et al.* (2009) that employees are at higher risk of injuries than the farm owner. Cattle given positive contact by the stockperson develop a reduced fear of humans and have been found to be less difficult to handle. The easier calves are to handle, the lighter the work load and thus the lower the risk of injuries (Lensink *et al.*, 2001; Boivin *et al.*, 1992).

2.5 Motivating factors

Organisational theory has gone through a journey of change from the drudgery of work at the beginning of the industrialisation process to the high attention to management of human resources today. Workers (whether employed or self-employed) are motivated not only by a reasonable wage, but also by personal fulfilment and pleasure at work. Farming is a self-employed business closely associated with a choice of lifestyle. Like any other business, farming is carried out for commercial reasons, but a range of non-economic practices also play a considerable role (Hansson *et al.*, 2012; Maybery *et al.*, 2005; Bergevoet *et al.*, 2004; Willock *et al.*, 1999; Austin *et al.*, 1998). Within both commercial and intrinsic goals, a range of decisions are influenced by the personal motivation of the individual farm manager. Gasson (1973) made an early classification of values relating to farming into four different orientations, although some are more or less overlapping and some closer to goals than values:

- *Instrumental values:* Farming is viewed as a means of obtaining maximum income and security in pleasant working conditions.
- *Social values:* Farming is carried out for the sake of interpersonal relationships in work; gaining recognition, prestige, keeping a family tradition, respect from the farming community.
- *Expressive values:* Farming is valued as a means of self-expression or personal fulfilment in feeling pride of ownership, exercising special abilities, the chance to be creative and original.
- *Intrinsic values:* Farming is valued as an activity in its own right; enjoyment of work, preference for a healthy, outdoor farming life, value in hard work, independence, control in a variety of situations.

Motivation, attitudes and values are formed from individual experiences and are typical determinants of personal goals. Achieving a goal demands a certain behaviour and the Theory of Planned Behaviour (Ajzen, 1991) is a model used to predict behaviour within many disciplines. In terms of understanding behaviour as a measure of farming strategies, farm productivity or animal performance, studies of farmers' individual motivation, attitudes and values are an important complement to economic studies (Edwards-Jones, 2006). In this thesis we expected to find high rankings for economic values among farmers whose work efficiency was higher and whose working environment less strenuous. Conversely, high rankings for intrinsic values with less demand for leisure time, having positive attitudes to physical work and appreciating being close to nature were expected among farmers with more labour-intensive or physically strenuous working conditions.

3 Aims of the thesis

3.1 General aim

To achieve an efficient and safe Swedish intensive beef cattle production by identifying measures to increase labour efficiency, reduce strain and injuries.

3.2 Specific aims

- Analyse labour inputs during common work tasks.
  - Identify factors with influence on labour inputs.
- Analyse physical working conditions related to specific work tasks.
  - Identify factors with influence on physical working conditions.
- Analyse motivating factors among farmers.
  - Identify motivating factors influencing labour inputs and physical working conditions.

4 Structure of the thesis

This thesis comprises several aspects of labour in Swedish intensive beef cattle production. Papers I and II analyses labour inputs and factors with influence on labour efficiency. The physical work environment among farmers is analysed in Paper III, and results are related to the analyses in Papers I and II. In Paper IV individual orientations of motivation among the farmers are analysed and used to help explain working conditions revealed in Papers I-III (Figure 4).

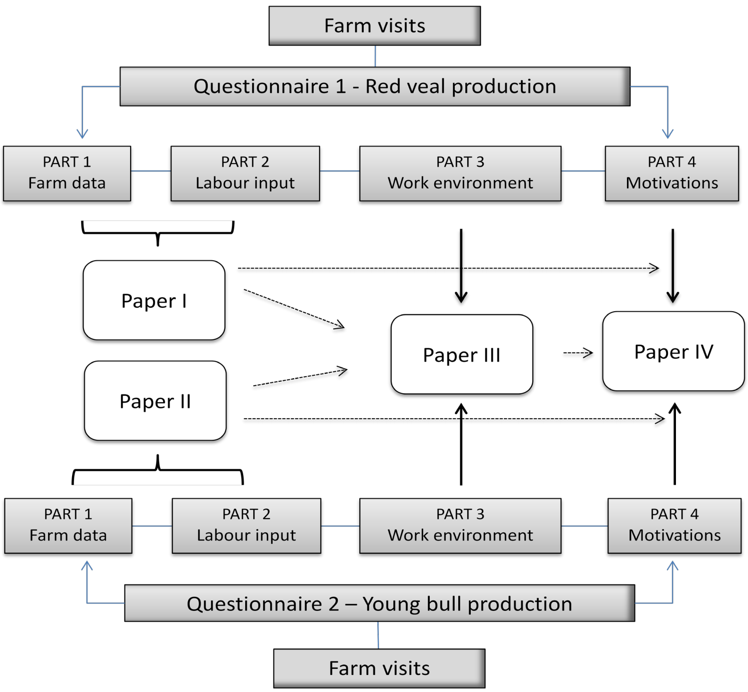

Figure 4. Structure of the thesis and the contributions of Papers I-IV.

5 Materials and methods

5.1 Materials

Papers I-IV are based on data obtained by questionnaires and visits to farms producing red veal calves and young bulls. A summary of the response rates, the categories included in Papers I-IV and the main areas studied within the Papers are given in Table 1.

Table 1. *Total number of farms, number of participating farms, participant rates (%), number of farm visits, and inclusion in respective papers within different size categories of Swedish red veal (2008) and young bull farms (2009), and the main areas studied in Papers I-IV*

Farm type/ farm size category[1]	Participating farms/ total farms (n)	Participant rate (%)	Farm visits (n)	Papers (I-IV)	Main area of study
Red veal					
21-99	25 / 80	31	2	III, IV	Paper III: Physical strain, MSD prevalence, work environment factors, injuries.
100-499	16 / 30	53	5	I, III, IV	Paper IV: Motivating factors, correlations to Papers I-III.
500-1,500	18 / 21	86	5	I, III, IV	Paper I: Labour input according to size categories.
Young bulls					
100-199	64 / 186	34	1	II, III, IV	Paper II: Labour input according to calf purchase age.
200-399	34 / 48	71	3	II, III, IV	
400-960	3 / 7	43	3	II, III, IV	

[1]Farm size categories according to the number of red veal or young bulls finished per year.

5.1.1 Samples

The Swedish Board of Agriculture provided us with two separate registers covering all farms having sold young cattle within the carcass category of either red veal or young bulls. Data were from 2007 for farms finishing red veal calves (n=1716, range 1-1,500 calves) and from 2008 for farms finishing young bulls (n=9921, range 1-800 bulls).

Red veal farm sample (Paper I)

Farms from the records with annual production of 100-1,150 calves/year (median= 486 calves/year) were studied. Overall response rate was 67%.

Red veal farm sample (Papers III and IV)

Papers III and IV included farms from an initial phase of selecting farm samples, *i.e.* all farms producing 21 or more red veal calves (n=155) in 2007. Among these, the median unit size was 53 calves per year. The overall response rate to the questionnaire was then lower (45%), because only 25 responses out of 80 farms produced 21-99 calves.

Young bull farm sample (Papers II, III and IV)

To study the labour input on farms rearing young bulls as an essential source of income (at least 25% of full-time), questionnaires were sent to the 241 farms producing 100 or more bulls annually during 2008 (median= 190 bulls/year). Overall response rate was 41%.

Geographical distribution of farms

Participating farms represented the distribution of farms from agricultural regions all over Sweden (Figure 5).

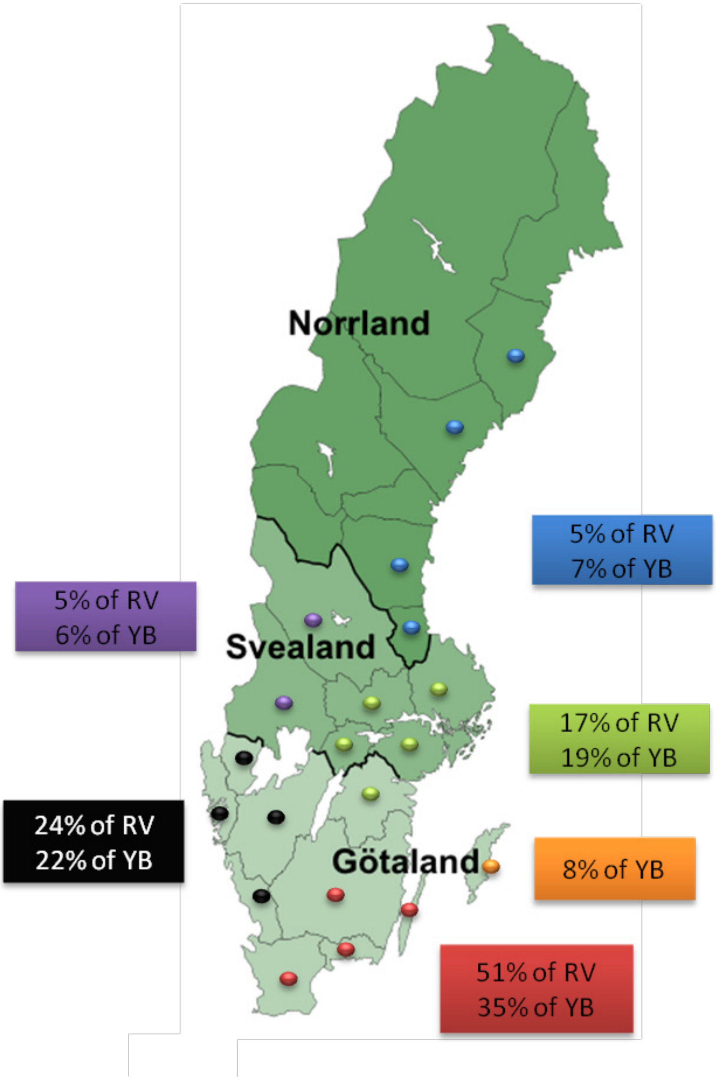

Figure 5. Map showing the geographical distribution of farms included in Papers I-IV (% of responding farms producing red veal (RV) and young bull (YB), respectively). Dots are representing counties (with no respect to number of farms) within the southern (Svealand), central (Götaland) and northern (Norrland) parts of Sweden.

5.2 Methods

5.2.1 Questionnaires

Two semi-structured questionnaires, mainly with closed questions, were designed for the studies of red veal and young bull production. Both questionnaires were posted together with a covering letter, followed by postal reminder/s and, for red veal producers, also phone reminder/s. All respondents received an instant lottery ticket worth €2.5.

The questionnaire consisted of four parts addressing the topics described in the following sections below. The respondents were instructed only to enter the labour input, perceived strain and repetitiveness related to tasks that they mainly performed and only those regarding themselves. The possibility to add an option or leave a comment was used in several of the questions.

Background data

The first part consisted of questions concerning the demographics of the individual farmer and background information about the beef production. These included: Gender and age of the farmer, number of employees and own off-farm employment; number of calves or bulls produced per year, the origin of the calves or bulls, whether beef production was organic or conventional and whether there were other lines of production on the farm.

Technical data about the farm considered: type of housing system/s, using closed questions with options representing the most common Swedish housing systems for quarantine and finishing purposes. Similarly, the strategies for feeding, bedding and manure removal in quarantine and finishing houses were recorded using options with the most common techniques and strategies. In addition, farmers were asked about the latest year of investing in a new building or renovation and the type of this building.

Animal background data considered: breed and slaughter weight of the breeds, whether purchased calves were weaned or not; the age of calves at purchase and slaughter; the number of calves in different houses; and the length of the rearing period in each animal house. This was essential information for further use in the calculation of labour inputs.

Labour input and work tasks (Papers I-III)

The farmers specified the duration of the pre-defined work tasks in minutes or hours in relation to how often they performed the work tasks, *i.e.* per day, week, month or year. Work time was multiplied with the number of workers performing the task.

The work tasks investigated in the questionnaire on labour inputs are briefly described in Table 2. Nine of these were analysed and presented in Paper I and 11 work tasks were analysed in Paper II. Labour input for the work task 'labour management' was not further analysed. This task was found to be of little relevance for both types of farms, as the employees also worked with tasks not related to young cattle finishing. Furthermore, work time for medical or veterinary care was not analysed in Paper I due to low response rate. However, the average weekly time required for medical or veterinary care on red veal farms was presented and analysed in relation to assessed physical strain in Paper III. In this context it was directly related to the physical strain and thus did not have an obvious effect on results presented on an overall basis.

Table 2. *Description of the 12 work tasks investigated in the questionnaire used in Papers I-III, of which four were analysed separately for the rearing period in quarantine and finishing houses*

	Area of study	
	Quarantine house (batches[1] ~2 months)	Finishing house (batches[1] ~4-13 months)
Feeding	Loading and supplying the animals with feed: concentrates, roughage and milk.	Loading and supplying the animals with feed: concentrates and roughage.
Bedding	Transporting and spreading fresh straw in the pens.	Transporting and spreading fresh straw in the pens.
Manure removal	Removal of the deep litter between batches.	Scraping of yards, cubicles, and slatted floors. Removal of the deep litter between batches.
Cleaning	High-pressure cleaning of group pens between batches.	High-pressure cleaning of group pens between batches.
	Quarantine and finishing house (batches[1] ~6-15 months)	
Unload calves	Unloading of purchased calves off vehicle and into pens.	
Shifting	Relocating or regrouping calves.	
Weighing	Moving destined calves up through the weighbridge and back.	
Veterinary/medical care	Veterinary or on-farm medical care of calves and bulls.	
Marking	Marking of slaughter mature bulls.	
Load calves/bulls	Loading finished calves/bulls onto vehicle.	
Administration	Paperwork/computer work.	
Labour management	Management of employees.	

[1] Batches refer to the average length of the rearing period on which the labour studies are based.

The work tasks were developed to consider the activities directly connected to the animal houses. Labour inputs for unpredicted tasks, maintenance and repair of farm equipment and outdoor seasonal work were thus not included. Depending on different strategies, *e.g.* for feeding, this could include a start and end time in a nearby building when mixing feed rations. In general, however, we proposed that the labour inputs were reported for work tasks that were prepared for in advance, *e.g.* bedding using straw bales stored close by. Hence, the time required to fetch bales of straw from a site far away from the animal house was not included. To end the section about labour inputs, the red veal farmers were asked to what extent labour efficiency was important for the economic outcome on their farm. The results are not shown in Paper I, and space did not allow this concluding question to be used in Paper II.

Work environment (Paper III)

Perceived physical exertion in relation to each pre-defined work task was assessed by the farmers using the Borg category (C) ratio (R) scale, *i.e.* the CR-10 scale (Borg, 1990, 1998), ranging from 0 (none at all) to 10 (extremely strong physical exertion). The levels of exposure had familiar verbal descriptions of physical exertion in addition to the intensity levels from 0 to 10, as described in Table 3.

Table 3. *Borg CR-10 scale for rating perceived physical exertion*

Rating	Description
0	None at all
0,5	Extremely weak
1	Very weak
2	Weak
3	Moderate
4	Somewhat strong
5	Strong
6	
7	Very strong
8	
9	
10	Extremely strong

Work environment factors

In the third part of the questionnaire, the farmers rated their overall perception of eight physical and psychosocial work environment factors on a 1-4 scale (bad, less good, good, very good). These factors were principally inspired by Kolstrup *et al.* (2006) and Kristensen (2001). The factors were on a general level for a broad perspective of some common factors in everyday work, as described in Table 4.

Table 4. *Work environment factors analysed in the study of red veal and young bull production*

Work environment factors			
Physical		Psychosocial	
Factor	Description	Factor	Description
Climate	Temperature, humidity, draught or dust.	Work tasks	Allotment of work tasks, teamwork, variety in work.
Noise and illumination	Level of noise from animals and equipment. Intensity of light during work.	Work pace	Work pace and time pressure during everyday tasks .
Physical strain	Exposure to heavy burdens.	Social network	Contact and cooperation with co-workers and neighbours.
Potential hazards	Risk of injuries.	Stress	Stress and concern.

Musculoskeletal symptoms

Perceived symptoms of musculoskeletal disorders (MSD) were assessed in nine different body parts clustered into three main categories: (1) lower extremities (foot/ankle, knee, hip), (2) back (lower and upper back), and (3) upper extremities (hand/wrist, elbow, shoulder and neck). The symptoms of MSD were defined in the questionnaire as perceived pains, aches or discomfort in these body parts during the previous 12 months. The farmers with symptoms of MSD were asked to give their overall assessment of the relationship between perceived MSD and the work in young cattle production on a 1-4 scale (not at all, not particularly, fairly high, and high).

Work-related injuries

Injury was reported through closed questions regarding where the injury took place (quarantine house, finishing house, or other house section), under what circumstances (animal handling or mechanical work tasks), and the severity in terms of medical examinations and number of days absent from work.

Physical Strain Index

To quantify the physical exposure experienced by the farmers, a physical work strain PWS index (Kolstrup *et al*., 2006) was determined for each pre-defined work task on the basis of the labour input and frequency of work tasks (Papers I and II), according to equation 1:

$$PWS_i = \frac{t_i \times p_i}{t_{tot}} \qquad (1)$$

where:

t_i = hours per week working with work task i
p = level of physical exertion (Borg CR-10 scale)
t_{tot} = hours per week working with all predefined work tasks.

Motivating factors (Paper IV)

The farmers were asked to rank 21 different items on a Likert scale from 1-5 (unimportant, of little importance, moderately important, important, very important). A similar methodological framework to that employed by Bergevoet *et al*. (2004) was used with some modifications and addition of items to apply to Swedish production systems for growing and finishing cattle. These modifications and added items are marked with an asterisk in Table 5.

Table 5. *The different items farmers were asked to rank, according to how motivating or important each item was in the Swedish intensive young cattle production*

Items of motivation	
Earn respect from my colleagues	The farm is modern
Enjoy my work	The farm is innovative
Hold in trust for future successors	The farm is environmental
Have sufficient leisure time	The farm is run by the family
Maintain landscape values	The farm is large
Opportunity for physical work*	The farm is organic
The free and autonomous life*	The farm is highly productive
The work with animals	The farm is a second source of income*
Gain as high an income as possible	Farm diversification[2,]*
Produce a safe and high quality product	
Opportunity for creativity and original solutions*	
The farm contributes to nature conservation[1,]*	
Contribute to a positive image of my professional group	

*The item was added or modified in comparison with the items used in Bergevoet *et al*. (2004). [1]The item was only used in the study of motivating factors among red veal producers. [2]The item was only used in the study of motivating factors among young bull producers.

5.2.2 Field studies

To gain a deeper understanding of their working conditions, during our visits to the different animal houses on study farms, farmers were asked about their experiences and perceptions of the labour inputs and physical work environment depending on the type and construction of the animal buildings, techniques and equipment. The farms were contacted according to calf production numbers, beginning with the largest farm. Twelve red veal farms, of which 10 were large-scale (500-1,150 calves per year) and two were small-scale (~100 calves per year), as well as seven medium-large young bull farms (200-960 bulls per year) were visited. The young bull farmers were particularly busy, and as three of the red veal farms visited also produced young bulls (100 to 300 bulls per year), only seven bull farms were visited. The farmer or main worker involved in the predefined tasks was interviewed according to the questionnaire so that data from both studies were comparable and could be analysed in the same dataset.

5.2.3 Statistical analysis

The detailed statistical analysis is described in the individual Papers I-IV.

Farm categorisation

Red veal farms were categorised after calf production numbers (unit size) reported in the questionnaire as small-scale farms (SF) = 100-399 calves/year (n=14); medium-scale farms (MF) = 400-699 calves/year (n=11) and large-scale farms (LF) = 700-1,500 calves/year (n=9). Labour inputs were analysed for 31 farms (61%), due to incomplete details regarding work time during each work task in three questionnaires.

Young bull farms were categorised after the average age of the calves at purchase, reflecting different finishing models: (1) Pre-weaned (PW), 7-61 days (n=30), (2) weaned (W1), purchase age 56-92 days (n=45), (3) weaned (W2), purchase age 107-168 days (n=15) and (4) weaned (W3), purchase age 180-365 days (n=79). The median age of calves at purchase and slaughter in farm categories PW and W1 typically reflected finishing beef bulls of dairy breed, W2 combined dairy and beef breeds and W3 finished beef breed bulls.

Labour input

Labour inputs were analysed and presented per day or batch (rearing period) as efficiency measures on a total basis for all work tasks and for each individual work task. The results were presented for the respective rearing periods in the quarantine (QH) and finishing house (FH). Kruskal-Wallis and Mann Whitney test and Spearman’s correlation of ranked variables was performed using Minitab ver. 16.1 (Minitab Inc., 2010)

Work environment

Descriptive data were presented for work environment factors, perceived physical strain, labour input (hours per week), PWS index and perceived symptoms of MSD. Effects of type of production, farm size and farmer age on perceived physical strain during the predefined work tasks were tested through the non-parametric Kruskal-Wallis and Mann-Whitney tests and Spearman’s correlation of ranked variables in Minitab ver. 16.1 (Minitab Inc., 2010). Work environment factors were analysed using the one-proportion test, and the effects of production type, farmer age and farmer gender on the prevalence of MSD were analysed using cross-tabulation with Fisher’s exact test.

Motivating factors

The results for the 21 statements were analysed using descriptive statistics in the statistical software Minitab ver. 16 (Minitab Inc., 2010) and primarily presented as mode (most frequent number), individual and pooled rankings into three categories (unimportant, moderately important, important), as mean scores can hide internal rankings essential for the interpretation of results. The results from red veal and young bull production were analysed and presented as one.

The dataset of items was reduced through Principal Component Analysis (PCA) and factor analysis with varimax rotation of the variables. Item analysis with Cronbach’s alpha was performed to determine the overall reliability and the reliability between items and the degree of internal consistency for all items included. An inter-item correlation matrix was used to display the strength of the relationship between every pair of items.

To identify whether the motivating factors could predict working conditions in terms of work efficiency (‘≤median labour input per calf or bull in FH’ versus ‘>median labour input per calf or bull in FH’), perceived work strain (‘≤mean strain’ versus ‘>mean strain’), prevalence of musculoskeletal symptoms (MSD) (‘Yes’ or ‘No’), injuries (‘Yes’ or ‘No’), farmer age (‘≤median farmer age’ versus ‘>median farmer age’) and farm size (<median farm size’ versus ‘≥median farm size’), the median scores of items only loading on one of the six orientations of motivation from the reduced dataset were analysed using the Kruskal Wallis test.

6 Summary of results

The detailed results are presented in Papers I-IV.

6.1 Farm data

6.1.1 Characteristics of respondents and farms

The total number of farms was 160. The majority (83% and 92% in red veal and young bull production, respectively) of the respondents were male. An overview of background data on respondents and farms is shown in Table 6.

Table 6. *Main characteristics of responding farmers, farms and red veal/young bull stocks*

	Production	
	Red veal (n=59) median (range)	Young bull (n=101) median (range)
Farmer age (years)	47.2 (31-68)	46.6 (27-66)
Young cattle per year (head)	200 (21-1,500)	190 (100-960)
Arable land (ha)	103 (25-500)	-
Latest year of building (year)	2003 (1991-2008)	2004 (1978-2009)
Additional livestock enterprises	Suckler cows, young bulls, pigs, dairy.	Suckler cows, heifer, red veal, sheep, dairy.
Additional production enterprises	Crop production, machinery contracting, forestry.	Crop production, machinery contracting, forestry.
Origin of calves/bulls (% of farms)		
Meat marketing agency	44	19
Neighbouring farms	22	20
Own herd	6	4
Combined origins	28	57
Pre-weaned calves (% of farms)	32	30

6.1.2 Farm layout and housing

Housing structure was similar overall between red veal and young bull production (Table 6). The largest difference was that most red veal farms operated with a quarantine house system, whereas farmers buying calves >4 months of age generally only used finishing houses. When a QH was used, the rearing period was seven-eight weeks and the median number of calves in the QH ranged between 40 and 95 for both production enterprises (Table 7 & Table 8). Almost all (~90%) farms used only one type of housing system in the QH, mainly full litter group pens.

For finishing houses, about 65% used only one housing system and about 35% of the farms utilised buildings with up to three different housing systems. In red veal production these were primarily full straw litter pens (38%), combined straw litter pens with an alley (tractor or mechanically scraped) along the feed table (29%) or slatted floor pens (23%). In young bull production these could be a combination of a newly built loose house with cubicles, a house with straw litter pens and scraped alleys in the feeding area and a building with slatted floor group pens. At the extremes, two young bull farms reported using five different FH systems.

6.1.3 Production data

Red veal production

Age of calves at purchase and slaughter, length (days) of the rearing period in the quarantine (QH) and finishing house (FH), and total length of rearing period according to farm unit size (SF, MF and LF) are presented in Table 7.

Table 7. *Age of calves (median and inter quartile range, IQR) at purchase and slaughter, and length of rearing period in the quarantine (QH) and finishing house (FH) on small (SF=100-399 calves/year), medium (MF= 400-699 calves/year) and large farms (LF=700-1,150 calves/year)*

	n[1]	Age at purchase (d)	Age at slaughter (d)	Rearing period (d)		
				QH	FH	QH+FH
		median (IQR)	median (IQR)	median (IQR)	median (IQR)	median (IQR)
SF[2]	12	54 (34)	267 (65)	42 (28)	189 (70)	219 (79)
MF[3]	11	56 (9)	244 (23)	56 (30)	132 (68)	193 (49)
LF	8	61 (7)	244 (38)	42 (14)	150 (42)	192 (48)

[1]Number of farms [2]Quarantine houses were not used on three farms in the SF farm category; [3]Quarantine houses were not used on one farm in the MF farm category.

Young bull production

Age of calves at purchase and slaughter, length (days) of the rearing period in the quarantine (QH) and finishing house (FH), total length of rearing period and number of bulls finished per year according to the four models of young bull finishing (PW, W1, W2 and W3) are shown in Table 8.

Table 8. *Characteristics of farms for the finishing models PW, W1, W2 and W3*

	Farm characteristics					
	n[1]	Min	Q1	Median	Q3	Max
Calf purchase age (days)[2]						
PW	30	7	14	21[a]	51	61
W1	45	56	61	63[b]	76	92
W2	15	107	122	122[c]	153	168
W3	79	180	183	183[d]	214	365
Rearing period QH (days)						
PW	29	14	39	56	70	140
W1	34	28	35	56	63	172
Rearing period FH (days)						
PW	30	274	386	426[a]	459	587
W1	45	214	368	402[a]	452	549
W2	15	214	305	336[b]	397	442
W3	79	62	229	275[c]	305	427
Total rearing time (days)						
PW	30	386	449	474[a]	507	636
W1	45	321	418	456[b]	475	549
W2	15	214	305	362[c]	397	442
W3	77	62	237	275[d]	305	427
Slaughter age (days)						
PW	30	427	485	519[a]	538	671
W1	45	397	488	519[a]	549	610
W2	15	366	442	488[ab]	534	564
W3	76	381	427	458[b]	488	763
No. of beef bulls/year						
PW	30	90	150	200	300	900
W1	45	100	120	150	200	960
W2	15	90	125	190	250	430
W3	79	90	120	180	250	960

[1]Number of farms. [2]*PW* = pre-weaned calves; *W*1 = purchase age 56-92 days; *W*2 = purchase age 107-168 days; *W*3 = purchase age 180-365 days.
[abcd]Values (within columns) with different superscripts are significantly different (P<0.05).

6.2 Labour input in intensive cattle production (Papers I-II)

The detailed results of the studies of labour inputs are presented in Papers I-II.

6.2.1 Red veal production

The red veal farmers' personal evaluation of work efficiency revealed that eight farmers (28%, 5 replies missing) considered the correlation between work efficiency and the economic outcome in the red veal production to be very high. A 'quite high' relationship was reported by 55% of the farmers, while 14% and 3% considered it to be quite low and very low, respectively.

Total labour input

Labour input in red veal production is presented in Table 9. Overall daily labour was 3.5-4.4 h/day, corresponding to 24.5-31 h/week on the basis of a 7-day week. Medium and large size farms had significantly lower daily labour input per calf than small farms. Total time per calf was 5.5, 1.9 and 2.0 h for small (SF), medium (MF) and large (LF) farms, respectively (Table 9). This corresponded to a labour efficiency of 1.5, 0.6 and 0.6 min/calf/day.

The 25% most efficient farms required 0.8, 0.5 and 0.3 min/calf/day, respectively (not shown in tables). The variation between the 25% most and the 25% least labour efficient farms indicated a possibility to increase labour efficiency on SF, MF and LF by 63%, 42% and 43%, respectively. Labour input per day was higher in FH than in QH, but with the lower amount of calves in QH, labour input per calf was generally proportionally higher.

Labour inputs for pre-defined work tasks

Results of labour inputs for each pre-defined work task are presented in Table 10. Feeding tasks required 59%, 60% and 56% of total labour on SF, MF and LF, respectively. This was also the most frequent work tasks, with a majority (80%) of the farmers in the study having once or twice daily feeding routines. Only 6% of the farms used a total mixed ration (TMR), thus the majority of farms fed roughages and concentrates separately.

Bedding tasks required 23%, 15% and 17% of total labour on SF, MF and LF, respectively. Manual bedding was most common on SF, with 67% and 81% of QH and FH, respectively.

Cleaning and manure removal tasks required 9% and 10% of total labour input on SF and MF, respectively and 5% of total labour input on LF. At 61 % of the farms quarantine houses were washed once a month or every fifth week, followed by 13 % washing every second month. The remaining 26% washed 1-4 times a year.

The labour patterns in the quarantine and finishing house for feeding, bedding, manure removal and cleaning were relatively similar between unit size categories. A scale-effect on labour efficiency could be found on these tasks. However, tasks related to animal handling and administration consumed proportionally higher labour inputs per calf as farm size increased, *i.e.* 10%, 15% and 20% of total labour input on SF, MF and LF (Table 9). A number of MF farms had high labour inputs in QH, resulting in a higher proportion of labour requirement in this house section compared to farms within the SF and LF-categories (Table 9). An example of distribution of labour inputs per work task during a rearing period on large red veal farms (LF) is illustrated in Figure 6.

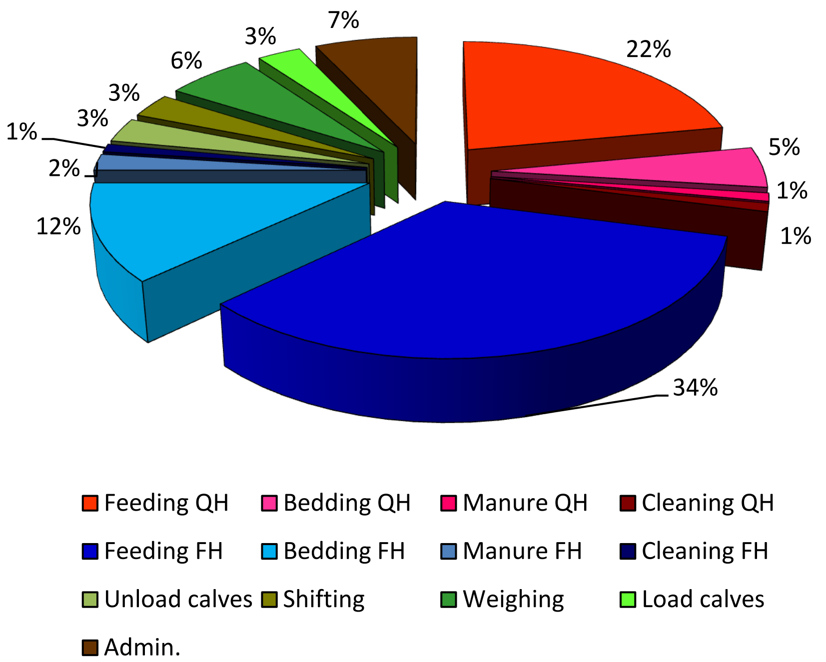

Figure 6. Distribution of labour inputs per calf (% of total) during the entire finishing period for the nine pre-defined work tasks on large red veal farms (LF). Diagram colours in red, blue and green/brown represent labour inputs in QH, FH and for common tasks, respectively.

Table 9. *Total labour inputs in quarantine house (QH), finishing house (FH) and tasks common for QH and FH in red veal production for small (SF), medium (MF) and large (LF) farms, producing 100-399, 400-699 and 700-1,150 calves/year, respectively*

	Labour input														
	SF					MF					LF				
	n[1]	Q1	Median	Q3	%	n[1]	Q1	Median	Q3	%	n[1]	Q1	Median	Q3	%
Daily labour input[2]															
QH *(h/day)*	9	0.9	1.5	2.5	41[3]	10	1.3	1.4	2.3	40[3]	8	1.0	1.2	2.4	35[3]
FH *(h/day)*	12	1.2	1.8	2.9	49[3]	11	0.7	1.6	2.4	46[3]	8	1.1	1.5	2.5	44[3]
Common tasks *(h/day)*	12	0.2	0.4	1.8	10[3]	11	0.4	0.5	0.6	14[3]	8	0.6	0.7	1.1	21[3]
Total labour input (h/day)	12	2.4	3.6	5.8	-	11	2.6	3.5	4.5	-	8	2.6	4.4	5.2	-
Daily labour efficiency															
QH *(min/calf/day)*	9	1.4	2.4[b]	3.5	-	10	0.6	1.1[a]	1.3	-	8	0.5	0.6[a]	1.0	-
FH *(min/calf/day)*	12	0.8	1.2[b]	1.5	-	11	0.2	0.4[a]	0.5	-	8	0.2	0.3[a]	0.4	-
Common tasks *(min/calf/day)*	12	0.09	0.15	0.40	-	11	0.07	0.10	0.12	-	8	0.08	0.10	0.16	-
Total labour efficiency															
QH *(min/calf/batch)*	9	80.0	118.9[b]	226.2	35[4]	10	31.2	64.8[a]	76.8	0.48[4]	8	22.7	33.3[a]	43.7	31[4]
FH *(min/calf/batch)*	12	133.9	185.3[b]	298.1	55[4]	11	25.3	48.7[a]	92.8	0.36[4]	8	36.6	53.6[a]	62.7	49[4]
Common tasks *(min/calf/batch)*	12	22.5	33.6[b]	71.3	10[4]	11	14.8	20. 3[a]	22.3	0.15[4]	8	15.4	21.4[b]	30.0	20[4]
Total (h/calf/batch)	12	3.6	5.5[b]	9.6	-	11	1.7	1.9[a]	2.9	-	8	1.2	2.0[a]	2.1	-

[1]Number of farms. [2]All labour data refer to work time for 9 pre-defined work tasks, and do not include work time *e.g.* for supervision, medical treatment of calves and infrequent unforeseen tasks. [3]relative amount of daily labour input specific to house section ('QH',' FH' and 'common tasks'). [4]relative amount of total labour input per calf specific to house section ('QH',' FH' and 'common tasks'). [ab]Values (within rows) with different superscripts are significantly different ($P<0.05$).

Table 10. *Total labour inputs (min/calf/batch) during 9 pre-defined work tasks in quarantine house (QH), finishing house (FH) and tasks common for QH and FH in red veal production for small (SF), medium (MF) and large (LF) farms, producing 100-399, 400-699 and 700-1,150 calves/year, respectively*

Work task	Labour input (min/calf/batch)																	
	SF						MF						LF					
	n[1]	Q1	Median	Q3	mean	%[2]	n[1]	Q1	Median	Q3	mean	%[2]	n[1]	Q1	Median	Q3	mean	%[2]
Quarantine house																		
Feeding	9	56.0	71.4[b]	143.7	108.3	0.22	10	12.0	43.1[a]	57.0	37.1	0.32	8	7.6	24.3[a]	33.5	23.7	0.22
Bedding	8	8.5	20.7[b]	93.3	31.0	0.06	10	5.1	8.6[a]	46.7	12.6	0.06	8	2.7	5.3[a]	9.0	6.5	0.05
Manure	9	2.2	4.7[b]	21.0	11.1	0.01	10	1.9	4.5[b]	8.1	7.9	0.03	8	0.6	0.8[a]	3.8	2.1	0.01
Cleaning	9	0.9	3.1[b]	5.6	3.6	0.01	9	1.2	2.9[a]	6.7	4.9	0.02	8	0.8	1.3[a]	1.7	1.9	0.01
Finishing house																		
Feeding	12	69.9	122[b]	229.4	170.1	0.37	11	11.2	38.1[a]	63.7	39.6	0.28	8	8.6	37.6[a]	51.2	37.6	0.34
Bedding	10	29.5	54.5[b]	72.1	64.6	0.17	10	7.0	12.8[a]	17.8	14.1	0.09	8	6.8	13.6[a]	19.9	15.0	0.12
Manure	11	5.4	16.2[c]	26.5	26.3	0.05	11	2.6	4.0[b]	5.1	4.1	0.03	8	1.7	2.1[a]	2.9	2.2	0.02
Cleaning	10	2.5	6.9[b]	9.1	7.9	0.02	9	0.8	2.3[a]	4.3	3.0	0.02	6	0.8	1.1[a]	3.7	2.0	0.01
Common tasks																		
Unload	12	1.6	4.0	26.7	11.2	0.01	11	0.7	2.8	7.3	3.8	0.02	8	1.3	2.8	7.8	4.0	0.03
Shifting	10	2.2	3.3	18.1	8.4	0.01	6	1.6	2.9	5.8	3.6	0.02	8	0.8	3.5	6.8	3.9	0.03
Weighing	8	5.6	13.0	19.0	18.8	0.04	6	3.6	5.7	8.1	5.8	0.04	5	3.8	6.2	7.9	5.9	0.06
Load	12	2.5	6.2[b]	10.9	9.1	0.02	10	2.0	3.2[a]	6.7	4.3	0.02	8	1.6	2.8[a]	3.4	2.5	0.03
Administration	9	4.9	7.8	19.0	12.6	0.02	10	4.8	6.1	9.7	8.7	0.05	6	5.1	7.5	20.9	12.0	0.07

[1]Number of farms; [2]Relative amount of total labour input per calf specific to work task; [ab]Values (within rows) with different superscripts are significantly different (*P*<0.05)

6.2.2 Young bull production

The study of labour inputs on young bull farms analysed different finishing models according to calf purchase ages, as described in Table 8.

Total labour input

Daily labour input per young bull is presented in Table 11. Overall daily labour input was between approximately 1.0 and 2.0 hours in the quarantine house and around 2.0 to 2.5 h in the finishing house. The common tasks non-specific to the quarantine or finishing house required 0.2-0.4 h/day. Finishing models did not affect daily labour input per bull. Total labour input per bull was 6.4, 7.1, 4.0 and 2.7 hours, respectively, for the four different finishing models PW, W1, W2 and W3. This corresponded to a labour efficiency of 0.76, 0.94, 0.64 and 0.69 min/bull/day in PW, W1, W2 and W3, respectively.

The variation between the 25% most and the 25% least labour efficient farms on the four finishing models indicated a possibility to increase labour efficiency by 51%, 54%, 58% and 59%, respectively. The period in quarantine represented about 12% of total rearing time and approximately 20% of total labour input on the two finishing models operating with quarantine houses (PW and W1). Labour inputs exceeded 1 min/bull/day for 30%, 42%, 40% and 36% of PW, W1, W2 and W3, respectively.

Labour inputs for pre-defined work tasks

The detailed labour inputs for each of the 11 pre-defined work task in young bull finishing are presented in Paper II.

Feeding required the highest proportion of work time, with 65-78% of total time depending on finishing period. Bedding tasks were mechanised on most farms, which was reflected by high work efficiency (≤0.1 min/bull/day in finishing houses). Work time for manure handling was highly variable from farm to farm. Manual scraping of manure from lying areas /cubicles once or twice daily contributed to a high labour input for manure handling tasks.

PW farms had higher labour input during unloading of calves compared to the other finishing models. Work time for shifting bulls was highest on farms finishing dairy bulls, and was significantly lower for farms purchasing calves >183 days of age and thus having a shorter rearing period. Labour inputs for weighing bulls were between about 6 and 7 min/bull, ranging from 3.5 min/bull for the 25% most labour efficient farms up to 13.2 min/bull for the 25% least labour efficient farms. Medical treatment of dairy calves required a significantly higher amount of labour than beef calves purchased after 183 days of age. Labour input for administrative tasks required approximately 1% of total labour.

Table 11. *Daily labour input per bull in the quarantine and finishing house and during continual tasks non-specific to house section. PW = pre-weaned, purchase age 7-61 days; W1= purchase age 56-92 days; W2 = purchase age 107-168 days; W3 = purchase age 180-365 days*

	Labour input					
	n*	Min	Q1	Median	Q3	Max
Quarantine house (min/bull/day)						
PW	29	0.39	1.00	1.37	1.71	3.51
W1	33	0.35	0.91	1.36	2.13	7.20
Finishing house (min/bull/day)						
PW	30	0.12	0.39	0.60	0.91	1.73
W1	44	0.16	0.47	0.65	1.11	2.28
W2	14	0.30	0.36	0.56	1.04	1.44
W3	78	0.12	0.34	0.59	1.00	2.76
Continual tasks (min/bull/day)						
PW	28	0.03	0.06	0.09	0.14	0.32
W1	45	0.01	0.06	0.11	0.18	0.56
W2	14	0.01	0.06	0.07	0.13	0.32
W3	71	0.01	0.06	0.10	0.16	0.37
Work efficiency (min/bull/day)						
PW	30	0.21	0.54	0.76	1.10	1.86
W1	45	0.22	0.65	0.94	1.40	2.50
W2	15	0.31	0.48	0.64	1.13	1.80
W3	79	0.18	0.46	0.69	1.11	3.01
Total time (h/bull)						
PW	30	1.85	4.80	6.40[a]	8.55	12.82
W1	45	1.70	4.81	7.13[a]	10.44	18.80
W2	15	1.70	2.62	4.00[b]	7.05	8.42
W3	79	0.62	1.90	2.72[b]	4.56	14.51

*Number of farms. [ab]Values (within columns) with different superscripts are significantly different (P<0.05).

6.2.3 Factors influencing labour efficiency

Red veal production

An increase in farm size from 550 to 1,150 calves/year had no effect on labour input per calf (r = -0.045). As a result, labour efficiency was not different between MF and LF.

A high level of manual work increased the labour input, as also operating with a variety in housing systems and techniques within farms. A general increase in mechanisation level was found with increased farm size, but as a result of large variations in techniques within farms, bedding tasks on LF were still performed manually in 38% of QH and 25% of FH.

Within the LF category, the 25% farms with the highest work efficiency were identified by typically operating few buildings centrally located on the main farm, facilitating efficient loading, unloading and shifting of calves, concentrated weighing and limited transportation between houses.

Reduced frequency of work tasks showed to improve labour efficiency.

Young bull production

The relationship between labour efficiency and beef bull unit size was evident as unit size increased up to 450 bulls per year. Thus, there was a similar interaction between farm size and labour efficiency to that found for red veal farms.

The everyday maintenance of loose house cubicles was in several cases shown to have an overall higher total effect on labour inputs than the handling of straw (bedding and deep litter removal).

Feeding a total mixed ration (TMR, n=34) required 0.30 min/bull/day and separate feeding of grass silage and concentrates (n=33) required 0.51 min/bull/day (P=0.046). Farms operating with TMR were significantly larger, with 200 bulls in the finishing house (range 100-600), whereas farms feeding roughage and concentrates separately reared 150 bulls in the finishing house (range 44-400).

Slatted floor group pens in the finishing house required 0.47 min/bull/day, followed by straw-bedded pens with or without paved alleys (0.51 and 0.58 min/bull/day, respectively), while loose cubicle systems required 0.70 min/bull/day.

Rearing pre-weaned calves was expected to have the highest labour input. However, total labour inputs per day in the quarantine and finishing houses and continual tasks indicated no effect of calf age at purchase on labour efficiency.

6.2.4 Comparing labour inputs in red veal and young bull production

The labour inputs required per cattle in Papers I and II were overall comparable, although they proportionally added to the total labour input in different amounts. Feeding required about 1.0 min/cattle/day in QH and 0.3-0.4 min/cattle/day in FH. Bedding required about 0.2 min/animal/day in QH and 0.1 min/cattle/day in FH. Manure handling and cleaning tasks were more labour-consuming per bull than per red veal calf; in Paper II consumed labour was comparable to the results for SF in Paper I, despite SF farms only managing half the number of cattle than that on young bull farms.

Unloading calves from the truck required 2.8-4 min/cattle in both production systems, apart from PW and W1 bull farms, which was presumably due to these farms transporting the calves in private trucks and thus requiring a longer time. Each young bull required a longer total time for shifting, between 4.0-11.5 minutes compared with 3.3-3.5 minutes per red veal calf, presumably a combination of the young bulls being larger animals and a longer rearing period. Proportional to total labour input, the labour input for shifting required about 2% of total labour input per cattle.

Weighing required about 6 min/animal and this resulted in a proportionally higher labour input for weighing on red veal farms (6%) than on young bull farms (2%). Loading cattle onto the truck required 20-30% more time for young bulls, resulting in 3.1-4.5 min/bull compared with 2.0-3.0 min/calf. Administration work required about 5-6 minutes per cattle and thus was also proportionally more labour-consuming per red veal calf (2-7%) than per young bull (1%) due to differences in length of finishing period.

Field study

The farm visits confirmed the variety in work patterns and facilities between farms. With a total of seven of eight red veal farms in the LF category being visited, these could be studied in detail and differences in labour efficiency could be explained in depth. The young bull farms visited were unfortunately not as comparable as the large red veal farms due to a larger variety in farm size, purchase age and young bull rearing period.

6.3 Working conditions in intensive cattle production (Paper III)

6.3.1 Work environment factors

The farmers were generally content with the allotment of work tasks and they were not severely affected by noise, dust, insufficient illumination or high physical work strain (Table 12). They were also generally content with their social network and cooperation with neighbours and friends. However, some factors were scored remarkably low by the farmers. Feeling stressed and worried about beef production was rated "less good" or "bad" by 27.1% of the red veal farmers and by 41.6% of the young bull farmers. Furthermore, the risk of being injured during work was accentuated by more than 26.5% of the young bull farmers, while 8.8% considered the situation to be "very good." Assessed potential hazards in red veal production were significantly lower. More than 20% of young bull producers reported an unsatisfactory work climate ("less good" or "bad"), with uncomfortable levels of temperature, draught or humidity. A similar proportion (20%) of red veal producers reported the daily work pace as a discomfort factor, compared with slightly less (18%) of the young bull producers.

Figure 7 – 10 demonstrate examples of the working conditions including labour inputs and perceived work strain reported for feeding and bedding at some of the farms participating in the field study.

Table 12. *Work environment factors[1] rated on a scale of 1-4 (bad to very good) by red veal (RV)[2] and young bull producers (YB)[2]*

	Work environment factors															
	Climate		Noise, dust, illumination		Physical strain		Potential hazard		Work tasks		Work pace		Social network		Stress	
Rating	RV (%)	YB (%)	RV (%)	YB (%)	RV (%)	YB (%)	RV (%)	YB (%)	RV (%)	YB (%)	RV (%)	YB (%)	RV (%)	YB (%)	RV (%)	YB (%)
Bad	3.4	**1.0**	1.7	1.0	3.4	2.0	1.7	**2.0**	1.7	1.0	**5.1**	2.9	3.4	6.1	**6.8**	**5.9**
Less good	11.9	**20.6**	8.5	13.7	11.9	8.8	6.9	**24.5**	10.3	11.9	**15.3**	15.7	6.8	9.1	**20.3**	**35.6**
Good	66.1	56.9	71.2	56.9	67.8	72.5	74.1	64.7	67.2	63.4	57.6	64.7	66.1	61.6	59.3	43.6
Very good	18.6	21.6	18.6	28.4	16.9	16.7	17.2	8.8	20.7	23.8	22.0	16.7	23.7	23.2	13.6	14.9
Average[3]	3.0 (0.7)	3.0 (0.7)	3.1 (0.6)	3.2 (0.6)	3.0 (0.7)	3.0 (0.6)	3.1[b] (0.6)	2.8[a] (0.6)	3.1 (0.6)	3.1 (0.6)	2.9 (0.8)	3.0 (0.7)	3.1 (0.7)	3.0 (0.8)	2.8 (0.8)	2.7 (0.8)

[1]Climate = temperature, humidity, draught; noise = level of noise from animals and equipment; dust = exposure to dust during work; illumination = intensity of light during work; physical strain = exposure to heavy burdens; potential hazard = risk of injuries; work tasks = teamwork, allotment of work tasks, and variety in work; work pace = pace required to manage everyday tasks; social network = contact and cooperation with co-workers and neighbours; and stress = level of stress and worry related to the beef production.

[2]RV = red veal producers (n = 59), and YB = young bull producers (n = 101; n = 100 for work tasks and stress, and n = 99 for social network). Results in **bold** represent factors for which more than 20% of the farmers reported concern or discomfort.

[3]Average of 1-4 rating (standard deviations in brackets). [a,b]Values within rows with different superscripts are significantly different ($P<0.05$).


Figure 7. Finishing house, large farm. The roughage is fed by tractor. Perceived work strain: Weak. Labour input: 0.15 min/calf/day.


Figure 8. Finishing house, large farm. The roughage is fed by tractor and manually. Perceived work strain: Weak. Labour input: 0.19 min/calf/day.


Figure 9. Finishing house, large farm. The bedding is spread from above the bulls. Perceived work strain: Moderate. Labour input: 15 min/day (0.04 min/calf/day).


Figure 10. Quarantine house, large farm. The roughage is fed manually. Perceived work strain: Moderate. Labour input: 0.75 min/calf/day.

6.3.2 Physical work strain

The results of the perceived physical strain reported by the farmers are shown in Table 13 and Table 14. The overall perceived physical strain was rated at a moderate exertion level (2.6-2.8 on Borg's C-R-scale) (Table 14). However, the variation was high, in particular on red veal farms, with scores ranging from none/extremely weak to extremely strong for 7 out of 13 work tasks. Age of farmer was not found to be correlated with perceived physical strain (r = 0.14 and -0.11, respectively, in red veal and young bull production). Farm size had no effect on perceived physical strain except for bedding tasks in QH on red veal farms, where farmers finishing more than 500 calves reported significantly *higher* physical strain than farmers on smaller farms (not shown in table).

Cleaning was estimated as the overall most physically demanding work task, with average scores ranging up to 3.9 on the CR-10 scale (4 = quite strong) (Table 13). This accounted for both quarantine and finishing houses. Shifting and weighing of young bulls was rated moderate-fairly strong (3.3-3.6), while red veal farmers rated the physical exertion at a moderate level (2.9). Both unloading and loading of animals was perceived as significantly more strenuous on young bull farms than on red veal farms. Veterinary care scored similarly on average, but had a higher range of exertion level on red veal farms than on young bull farms. Effects of the combination of perceived physical strain, duration and repetitiveness of the pre-defined work tasks were as follows:

- Bedding in quarantine and finishing house were ranked similarly for both production types, but required more labour in both QH and FH in red veal production. PWS was therefore also significantly higher.
- Cleaning in QH on red veal farms required longer work time and higher perceived strain resulting in a significantly higher PWS index than in young bull production.
- Feeding the older bulls in the finishing house was not perceived as very strenuous, but with the high number of animals the labour input was significantly higher, as was PWS.
- Shifting of young bulls consumed more labour resulting in significantly higher PWS than shifting red veal calves.
- Loading young bulls was perceived significantly more strenuous than loading red veal calves, but required lower labour input.
- Weighing was considered rather strong physical exertion by young bull farmers and moderate by red veal farmers and had the highest PWS index of animal handling tasks.

Table 13. *Descriptive values of perceived physical exertion (Strain), number of hours worked per week (h/week), and average PWS index associated with feeding, bedding, manure handling and cleaning in quarantine and finishing houses on red veal and young bull farms. Presented as mean, standard deviation (SD), minimum and maximum values*

	Red veal						Young bulls					
		Strain[1]			h/week	PWS		Strain[1]			h/week	PWS
	n	Mean (SD)	Min.	Max.	Mean (SD)	Mean (SD)	n	Mean (SD)	Min.	Max.	Mean (SD)	Mean (SD)
Quarantine house												
Feeding	35	2.5 (1.5)	0.0	7.0	7.3 (5.3)	0.85 (0.80)	61	2.6 (1.2)	0.5	6.0	7.2 (6.5)	0.62 (0.50)
Bedding	32	3.0 (1.5)	0.5	8.0	2.1^{b} (1.7)	0.33^{b} (0.55)	54	2.8 (1.4)	0.0	7.0	1.6^{a} (1.5)	0.16^{a} (0.15)
Manure	33	2.5 (1.9)	0.0	10.0	1.2 (1.7)	0.15 (0.29)	55	2.6 (1.8)	0.0	10.0	0.8 (0.9)	0.09 (0.13)
Cleaning	33	3.9 (2.0)	1.0	10.0	0.6 (0.7)	0.10^{b} (0.13)	56	3.6 (1.5)	0.0	8.0	0.4 (0.5)	0.05^{a} (0.04)
Finishing house												
Feeding	53	2.3 (1.3)	0.0	5.0	6.6^{a} (5.5)	1.00^{a} (0.81)	93	2.3 (1.2)	0.0	5.0	11.3^{b} (6.7)	1.23^{b} (0.82)
Bedding	49	2.7 (2.2)	0.0	10.0	2.9 (2.7)	0.70^{b} (0.96)	68	2.4 (1.7)	0.0	4.0	2.9 (2.9)	0.35^{a} (0.32)
Manure	49	2.0 (2.5)	0.0	6.0	1.3 (1.6)	0.19 (0.42)	81	1.7 (1.3)	0.0	10.0	2.0 (2.9)	0.18 (0.23)
Cleaning	47	2.7 (2.2)	0.5	10.0	0.4^{a} (0.5)	0.08 (0.11)	83	3.7 (1.6)	0.0	10.0	0.9^{b} (3.6)	0.12 (0.25)

^{a,b}Values within rows followed by different lowercase letters (a, b) are significantly different (P<0.05);
[1]Perceived physical exertion based on the CR-10 scale: 0 = none at all, 0.5=extremely weak, 1=very weak, 2= weak, 3=moderate, 4=quite strong, 5=strong, 7=very strong, and 10=extremely strong.

Table 14. *Descriptive values of perceived physical exertion (Strain), number of hours worked per week (h/week), and average PWS index associated with animal handling tasks on red veal and young bull farms. Presented as mean, standard deviation (SD), minimum and maximum values*

	Red veal						Young bulls					
		Strain[1]			h/week	PWS		Strain[1]			h/week	PWS
	n	Mean (SD)	Min.	Max.	Mean (SD)	Mean (SD)	n	Mean (SD)	Min.	Max.	Mean (SD)	Mean (SD)
Animal handling												
Unload	47	2.2^{a} (1.0)	0.0	4.0	0.7 (0.8)	0.09 (0.10)	83	2.6^{b} (1.3)	0.0	6.0	0.8 (0.8)	0.14 (0.22)
Weighing	26	2.8 (1.8)	0.5	10.0	1.1 (1.0)	0.11 (0.08)	47	3.6 (1.4)	1.0	7.0	0.9 (1.0)	0.21 (0.31)
Shifting	40	2.9 (1.8)	0.5	10.0	0.6 (0.6)	0.08^{a} (0.08)	83	3.3 (1.1)	0.0	6.0	0.8 (0.9)	0.12^{b} (0.11)
Veterinary care	45	3.1 (1.9)	0.5	9.0	0.3 (0.3)	0.06 (0.07)	73	2.9 (1.3)	0.5	5.0	0.3 (0.3)	0.04 (0.05)
Marking		-	-	-	-	-	36	2.5 (1.5)	0.0	7.0	0.4 (0.4)	0.03 (0.03)
Load	53	2.4^{a} (1.6)	0.0	10.0	0.5^{b} (0.5)	0.08 B (0.09)	88	3.0^{b} (1.3)	0.5	7.0	0.35^{a} (0.4)	0.05 A (0.06)
Total (all work tasks)	57	2.6 (1.2)			25.6 (12.8)	2.70 (1.4)	93	2.8 (0.8)			30.7 (13.8)	2.52 (0.9)

[a,b]Values within rows followed by different lowercase letters (a, b) are significantly different (P<0.05); P=0.069 for uppercase letters (A, B). [1]Perceived physical exertion based on the CR-10 scale: 0 = none at all, 0.5=extremely weak, 1=very weak, 2= weak, 3=moderate, 4=quite strong, 5=strong, 7=very strong, and 10=extremely strong

6.3.3 Musculoskeletal symptoms

Symptoms of MSD in any part of the body during the previous 12-month period was reported by 51% of the red veal producers and by 65% of the young bull producers (*P*=0.07; Table 15). The prevalence of perceived MSD was assessed by both red veal and young bull farmers/workers as being highest in the upper extremities (28% and 46%, respectively) and in the back (27% and 43%, respectively). MSD in the upper extremities were significantly higher among young bull producers, and MSD experienced in the back comprised in particular lower back symptoms, with a tendency for higher prevalence among young bull producers (*P*=0.06). Of the MSD reported in the lower extremities, knee symptoms were most prevalent and tended to be higher among young bull producers (*P*=0.08). Musculoskeletal problems were considered by 10% of the respondents from both production types not to bear any relationship at all to their work in young cattle production.

Table 15. *Prevalence and anatomical area of perceived musculoskeletal symptoms (MSD) during the previous 12-month period reported by red veal producers and young bull producers*

		Responses, *n* (%)	
		Red veal producers (n = 59)	Young producers (*n* = 98)
Discomfort in any body part		30 (51)[A]	64 (65)[B]
Upper extremities	Neck	10 (17)	22 (22)
	Shoulder	12 (20)	23 (23)
	Elbow	7 (12)	13 (13)
	Hand/wrist	6 (10)	15 (15)
	Clustered[1]	17 (28)[a]	45 (46)[b]
Back	Upper back	6 (10)	11 (11)
	Lower back	14 (24)[A]	37 (38)[B]
	Clustered[1]	16 (27)	42 (43)
Lower extremities	Hip	4 (7)	9 (9)
	Knee	10 (17)[A]	25 (26)[B]
	Foot/ankle	4 (7)	9 (9)
	Clustered[1]	12 (20)	32 (33)
Work-related[2]	Not at all	3 (10.0)	6 (9.8)
	Not in particular	10 (33.3)	26 (42.6)
	Fairly high	15 (50.0)	26 (42.6)
	High	2 (6.7)	3 (4.9)

[1]'Clustered' denotes prevalence of MSD reported within the groups upper extremities, lower extremities, or back. [a,b]Values (within rows) followed by different letters are significantly different (P<0.05); 0.05<P<0.1 for uppercase letters (A, B). [2]'Work-related' denotes the farmers' assessed levels of relationship between perceived MSD and the work in production of red veal or young bulls.

Farm size and farmer age did not have any effect on perceived MSD. The median age of the farmers reporting MSD (47.0 and 48.5 years for red veal and young bull farmers, respectively) was similar to that of the farmers reporting no MSD (47.5 years for both production types). In an analysis of the red veal and young bull farms producing ≥100 cattle/year (Table 16), the following risk factors were found to be particularly important in young bull production:

- Farmers reporting MSD had significantly higher labour input.
- Farmers reporting MSD tended to report higher average physical strain (p=0.08).

- Farmers reporting MSD in upper extremities reported significantly higher average physical strain.

Table 16. *Effect of farmer age, farm size, labour input and physical strain on overall MSD-prevalence and symptoms of MSD in upper extremities on red veal (RV) and young bull (YB) farms*

	Farmer age (median year)		Farm size (no. of cattle/year)		Labour input[1] (min/calf/day)		Physical strain (CR-scale 0-10)	
MSD	RV	YB	RV	YB	RV	YB	RV	YB
Yes	45.0	47.0	500	150	0.47	0.68	3.00	3.00
No	47.5	49.5	450	170	0.56	0.50	2.75	2.75
P-value						<0.05		0.08
Upper extremities								
Yes	44.0	47.0	300	150	0.45	0.68	2.75	3.11
No	48.0	47.0	535	170	0.56	0.58	2.92	2.70
P-value								<0.05

[1]Labour inputs in finishing houses (FH) are used for comparison between production systems.

6.3.4 Occupational injuries

Work-related injuries were reported by 20% and 39% of the respondents from red veal and young bull farms, respectively. In 96% and 89% of cases, respectively, these injuries were related to working with the animals and were most frequently associated with bedding, weighing and shifting between boxes or from box to transport vehicle. In 33% and 21% of the red veal and young bull cases, respectively, medical care was needed, and in 25% and 26% of the cases, respectively, the farmer needed to be off work for periods of up to 90 days (median = 7) for red veal farmers and 122 days (median = 7) for young bull farmers. Only 5% of the injuries reported occurred on red veal farms with herds smaller than 100 calves per year, but there was no effect of farm size on injuries on red veal farms within the size range 100-1,150 calves per year or young bull farms (range 100-960 bulls per year).

6.4 Motivation in intensive beef cattle production (Paper IV)

6.4.1 Ranking of motivating items

The results on farmers' motivation factors are described in detail in Paper IV. The farmers ranked the items '*produce a safe and high quality product*', '*enjoy my work*' and '*gain as high an income as possible'* as the most motivating items in intensive beef cattle production. All three top items were ranked 5 as the most frequent number (mode = 5). A further 16 items had mode = 4, indicating that a range of items were motivating and important for a majority of the farmers surveyed. Among the most popular items were "*the free and autonomous life*" and "*the farm is highly productive*", ranked 4 or 5 by 87.4% and 84.3%, respectively. The two items '*the farm is large'* and '*opportunity for physical work*' were moderately important (mode = 3). The only item not at all motivating for the majority of the farmers was '*the farm is organic'* (mode = 1), which was assessed to be of little or no importance by 82.7% of the respondents.

6.4.2 Multivariate analysis

The PCA and factor analysis reduced the variables to six factors with underlying explanations of the items. These factors were named '*Contemporary*', '*Close to nature*', '*Lifestyle*', '*Relationships*', '*Economic*' and '*Organic*' according to the items with high loadings on the factor. The factor 'Contemporary' was described by items relating to the needs of the human individual for personal growth and self-realisation. This factor thus represented the expressive values described by Gasson (1973) (see also section 2.5), but here in terms of modern farming with awareness of environmental concerns and consumer expectations. The factor 'Close to nature' was described by items relating to the typical enjoyment of nature, as the conservative life as a farmer with responsibility for animals and the environment. The factor 'Lifestyle' represented the traditional motivations of the independent, versatile farmer. The two latter categories together represented the typical intrinsic orientation of values described by Gasson (1973), e.g. with enjoyment of a healthy, outdoor work life, control in a variety of situations and value in hard work. The factor 'Relationships' was described by items relating to the social values of interpersonal relationships in work, gaining respect and recognition from the surroundings. The motivation items related to income, productivity, farm size and keeping an inheritance for future successors were instrumental items underlying the 'Economic' factor. The factor 'Organic' was named after the only item with no correlations to other items. This factor did not have a clear relationship to the classic orientations of motivation described in the literature.

The total mean score of items loading on the 'Lifestyle' factor (4.01) was significantly higher than for the 'Economic' factor (3.82). The 'Organic' factor was lowest ranked, with mean score 1.88.

6.4.3 Predicting working conditions

Farmer age, physical work strain or having been subjected to an occupational hazard could not be predicted by any orientation of motivation.

The values of typical entrepreneurial farmers with large farms and high work efficiency only differed from those of less typical entrepreneurial farmers on very few ideas. The farmers with higher labour efficiency valued the free and autonomous life, the opportunity for creativity and original solutions, the environment and the family life *etc.* as highly as the less work efficient farmers. Items with significant effect on behaviour are summarized below.

Labour efficiency

Farmers with higher work efficiency tended to rank expressive and instrumental orientations of motivation higher than farmers with lower work efficiency. The farmers with the highest work efficiency were particularly motivated by '*the farm is modern*' and '*have sufficient leisure time*'. The categories of intrinsic values could not predict an effect on work efficiency, but the most work-efficient farmers were found to be significantly less motivated by the individual items '*opportunity for physical work*' and '*maintain landscape values*', and also tended to rank '*the work with animals*' lower.

Musculoskeletal symptoms

Among farmers reporting symptoms of perceived MSD in the previous 12 months, expressive and instrumental values were less motivating. Instead, intrinsic values tended to be more motivating among these farmers. The specific item '*to gain as high an income as possible*' was ranked significantly lower by farmers reporting MSD, and '*opportunity for physical work*' was significantly more motivating among farmers reporting MSD than among farmers not reporting MSD.

Farm size

On farms above median size (finishing >486 red veal calves or >190 young bulls/year) the farmers were overall more motivated by expressive and instrumental orientations of motivations than on smaller farms. More specifically, they ranked the items '*the farm is large*' and '*the farm is modern*' higher, and the larger farm owners also tended to be more positive towards the item '*the farm is organic*'.

7 Discussion

7.1 Materials and methods

Our first study investigated red veal production (Papers I, III and IV), followed by a study of young bull production initiated approximately one year later (Papers II, III and IV). As young beef farming overall does not have any typical seasonal changes in labour requirement, the time interval between these two studies was not believed to have any effect on the results.

7.1.1 Sample and response rate

Red veal and young bull enterprises were chosen because they are the two main production systems of intensive finishing of cattle in Sweden. Through obtaining records from the Swedish Board of Agriculture, we were able to reach all farms having sold cattle in the previous year. However, farms expanding substantially or newly established may have been excluded, as the further selection of farms from the register was based on size. All farms in the register were chosen, allowing all types of farms and farm managers to participate and thus reducing the risk of selection bias.

The overall response rates of 45% (red veal production) and 42% (young bull production) were less than the general norm of at least 55% participation in postal surveys (Baruch, 1999). However, categorisation of the farms depending on size showed a large variation in response rate between the size categories (Table 1). It should thus be kept in mind when interpreting the data that medium- and large-sized red veal farms and medium-sized young bull farms were represented by 67-86% of the respondents, thus including farms with considerably higher annual production than the average Swedish beef producer. Use of statistics from the previous year meant that some farms had changed their production, *e.g.* increasing, decreasing or ceasing production. Several of these farms responded with the updated information, but some may also have been among the non-respondents. Our perception of the general reason for non-response, despite the use of different techniques to achieve a satisfactory response rate (reminders, lottery ticket), was limited time for completion of the questionnaire. These assumptions are confirmed to be among appropriate reasons for non-response by *e.g.* Kolstrup & Hultgren (2011) and Pennings *et al*. (2002). The questionnaires were distributed during March and April, a period with impending seasonal work in the most parts of Sweden, which might have affected the response rate negatively (Pennings *et al.*, 2002). Furthermore, during the farm visits, the farmers explained to receive numerous of postal questionnaires every year. Difficulties for the farmers in finding time for participating in studies was also reported by Taurus (2012) in a study of labour input on Swedish beef cattle farms.

A drawback when performing studies on a large sample with limited time and financial resources is the lower possibility to contact and engage the farmers before the study and thereby probably achieve higher response rates. Furthermore, by choosing all farms within a certain size category to potentially participate in the studies, we did not have the time or financial scope to go into depth and extract production data. However a different problem would have appeared during in-depth studies, namely the variation in market, production, climatic conditions and calf illnesses with time, which would have required a study following the same farms over a period of several years. Nevertheless, farms within either red veal or young bull production generally had a common target carcass weight and conformation, and parallels and comparisons in labour productivity could therefore be drawn between farms.

Farmer age and gender were similar between the production types, with a median age of 47.2 and 46.6 years in the two production systems, and the vast majority of respondents (83% and 92% in red veal and young bull production, respectively) being male. Only 15% of private agricultural holdings were owned by females in 2007 (Swedish Board of Agriculture, 2008a), which might explain why male respondents dominated to such a large extent in our studies.

7.1.2 Methods

The data in this thesis were obtained through questionnaires and were based on the farmers' assessments of labour input, physical working conditions and motivation factors. The farmers had a 3-4 week deadline and thus the possibility to consider the answers before the survey was returned. The use of questionnaires always involves a risk of certain biases that might be avoided in an structured interview (Oppenheim, 2000). A questionnaire requires fewer resources than structured interviews for the information gathering and transcription processes. Using a questionnaire also ensures that the questions are asked in exactly the same way. On the other hand, there is no simple way for the respondent to ask in the case of misunderstanding, even if, as in our case, contact information was provided. In interviews, the farmers might have felt less openness to discuss questions related to perceived strain and other attitudes toward their work environment. However, during the farm visits, our experience was that the farmers were comfortable and no less open, resulting in highly comparable data from both the postal surveys and the farm visits. Our experience from the current study was that the questionnaires gave the farmers an opportunity to consider the questions during their farm work and then complete their answers when convenient, thereby reducing recall bias. Næss & Bøe (2011) also found estimated labour input reported from the farmers to be reliable in a study of labour input in dairy production.

Recall bias is another limitation when using questionnaires and self-reporting methods. In Paper III we discussed the fact that recently experienced physical strain is likely to be rated more severe than an earlier experience, while a period of stress can also increase the perception of the strain or musculoskeletal problems (Kuorinka *et al.*, 1987). There may also be a systematic bias if the respondent has pain or injury, resulting in a higher exposure-response relationship than the true value, as found by Balogh *et al.* (2004).

Different work time measurement techniques have been described in labour studies, such as observing the worker by use of a handheld computer (Schrade *et al.*, 2005) using digital stopwatches (Ferris *et al.*, 2008; Gleeson *et al.*, 2007) or keeping a work journal (Gillespie *et al.*, 2008; Gleeson *et al.*, 2008; O'Brien *et al.*, 2006; Schrade *et al.*, 2005; Leahy *et al.*, 2004). The use of a questionnaire would not be expected to be as accurate as when using on-farm measurements, but the main reason for using questionnaires was that on-farm measurements are particularly difficult on beef cattle farms. The time interval between many of the work tasks on beef cattle farms could be several days, compared with *e.g.* pig or dairy farms, where more work tasks are performed on a daily basis. On-farm measurements would therefore have required a large number of farm visits on a smaller sample of farms, whereas questionnaires enabled us to cover a larger sample of the population. The use of a questionnaire was validated by the results showing good consistency throughout Papers I-IV.

Interpretation of results

All work tasks were not performed on every farm, which would have influenced the total labour input and the total strain measured, and thus affect the variation between farms. Furthermore, not all farms had a QH, which decreased the labour input per calf considerably and presumably also the impact on total physical exertion. The large variations in the material are the reason why we chose to present the data using medians and quartiles.

The subjective assessment of the physical work strain using the CR-10 scale could have been complemented by objective methods via posture observations, *e.g.* OWAS (Karhu *et al.*, 1977), REBA (Hignett & McAtamney, 2000) and PATH (Buchholz *et al.*, 1996), and by force assessments (*e.g.* inclinometry, goniometry and EMG) in order to achieve more accurate values of the work exposure. However, the main interest in this thesis was to explore how farmers experienced their working environment.

Field studies

All farm visits were important for the general understanding of the heterogeneity among intensive beef cattle farms, and were used to confirm the reliability of the findings from the questionnaire.

Scale interpretation

To investigate the farmers' apprehension of work environment factors, we intentionally avoided a neutral option on the 1-4 scale to oblige the respondents to make a judgment. Retrospectively, the scale could be found to be unbalanced toward "good." First, the scale provided "very good" as the top anchor and "bad" as the bottom anchor, because "bad" was assessed to be poor enough to describe an unsatisfactory work environment. Second, the scale had two negative and two positive anchors, but unfortunately used "less good" instead of "quite bad." The farmers actually rated their working environment positively overall, but we believe that most farmers interpreted the anchor "less good" as equal to "quite bad," and therefore we did not see any substantial effect from the unbalanced scale on the final results.

The CR-10 scale used in this study (Borg, 1998; Borg, 1990) is a validated and widely used method within various sectors for different ergonomic evaluations identifying work- or exercise-related musculoskeletal problems (Li & Yu, 2011; Day *et al.*, 2009; Østensvik *et al.*, 2008). In addition to recall bias discussed earlier, psychosocial issues should be kept in mind when interpreting the results from a rating scale. In the case of the CR-10 scale, the impression of physical work exertion can be over- or underestimated, *e.g.* influenced by personal emotions and attitudes toward the actual question (Borg, 2008). The fact that the respondents were self-employed might therefore have caused either underestimation, to express dissatisfaction with their current situation in the sector, or overestimation, to express satisfaction with their own farm and its facilities.

The results of the Likert scale used in the study of motivating factors (Paper IV) may have been biased due to socially desirable answers, whereby respondents answer what is socially desired, and also to the central tendency theorem, where they tick the middle alternative (here 3) instead of rejecting or accepting the item. For this reason, a value of 3 was presented individually and not pooled with values of 4 and 5. Furthermore, the questionnaire made use of descriptions above the numerical scale to facilitate that the middle alternative was read as 'moderate' and not as 'neutral'. However, more alternatives should preferably be used to get a more nuanced result.

A dilemma in the further analysis of behaviour studies related to ranked motivation (Paper IV) is that they might not correlate to the actual situation on the farm. For example, the positive correlation between a modern farm and lower work efficiency might be a result of the dilemma where a farm might be modern, but the farmer still ticks that it is moderately important to him. The same phenomenon was found for the motivating item '*to have a large farm*', where some of the largest farms actually ticked the importance level 'low'.

Another dilemma in interpreting the data as predictors of behaviour is the multidimensional farmer being so positive to each item. As an example, we did not find any indicators of the high level of stress or the high rates of injury found in Paper III, as 99.2% of the farmers reported to enjoy their work and only one item regarding the actual work situation ('opportunity for physical work') was rated low by one of four farmers.

7.2 Labour input

Papers I and II in this thesis provide data on labour inputs which have not previously been described in detail for the two production systems of red veal and young bull production in Sweden. The results describe how labour inputs specified per work task and per house section add to the total labour input and how it changes depending on production enterprise, farm size and finishing model.

Results from the category of smaller red veal farms displayed an overall higher rearing time and particularly high variation between farms. The variation within size categories of red veal farms decreased with increased red veal unit size. Besides the effects of scale, it is reasonable to believe that the prerequisites on the farms included in the SF-category (100-399 calves/year) were particularly heterogeneous compared to the MF and LF-categories, where the level of specialisation was higher. Due to a rearing period of approximately six months, a farm producing 100 calves per year would typically manage approximately half the number of calves at the same time. Likewise, the largest farm in SF-category might rear approximately 200 calves at the same time, thus a considerable difference from managing 50 calves.

Labour inputs were comparable between production enterprises, but some typical features were found, for example that rearing red veal farms involved a proportionally higher labour input for animal handling tasks than rearing young bulls. Furthermore, expansion in farm size required more time for animal handling and administration tasks. O'Brien *et al*. (2007) also found that increased unit size do not automatically increase labour efficiency for every work tasks. Direct animal handling such as shifting cattle requires a certain amount of time per animal and cannot be rationalised to a minimum. These proportions are not surprising, as the differences in rearing periods and sizes of animals naturally influence the labour requirement. However, as farms of different sizes and categories have different challenges, the results can be a useful tool when planning an investment or in evaluation of current production, pointing out the different fields of priority according to farm type, farm size and logistical needs.

Medium-sized red veal farms had a proportionally higher labour input in the quarantine house. It is not known exactly what gave rise to these results, but one explanation might be higher labour input for milk feeding of pre-weaned calves on some farms. Taurus (2012) and Hedlund (2008) found that milk feeding consumed a majority of the time spent on calf care. However, in Paper II we did not find that pre-weaned calves increased labour input, and it may also be related to an overall more labour consuming system. Some farms might have expanded without improving their facilities overall and thereby have experienced a lower effect of labour productivity in the quarantine house than is typically expected when the number of calves is increased. Thus, to repay investments it is important that labour saving technology accompanies farm expansion.

The trend for utilising several buildings and techniques was observed on the large farms visited, which might explain why the effect of scale on labour efficiency stagnated already on medium-sized farms. Farm heterogeneity has high influence on the results and the development of more uniform work methods would assist in increasing the labour efficiency. This was evident on red veal farms, as a weak correlation (0.4) was found on farms with high labour efficiency in QH and in FH. A high level of heterogeneity among Swedish beef cattle farms, including suckler farms, was also pointed out by Taurus (2012) and Manevska-Tasevska *et al*. (2013). Manevska-Tasevska (2013) also found that the factor with the highest influence on technical efficiency on Swedish beef cattle farms was farmer age, as younger farmers (although less experienced) were more efficient. Age was not found to have influence on any of the parameters analysed in this thesis.

Quarantine house

Utilising older buildings with no or low opportunity cost is very important for many beef producers (Kumm, 2006). However, with fewer calves in QH labour in this house section consumed up to 48% of total labour input. Supervision of smaller calves is a highly important part of the daily work, but the variations in labour efficiency between farms indicate possibilities for increased labour efficiency without jeopardising calf health and performance. This applies particularly for frequent tasks, such as feeding, which in older buildings was commonly done manually by a wheel barrow, using the old feed table. Using automatic concentrate feeders and moving the feeding place from a narrow feed table centrally placed in the house to where it could be accessed with a front-loader, showed considerable effects on the labour requirement on the field study farms. In a recent study of labour input in small cubicle dairy houses (mean herd size 38.0 ± 14.5 cows), Næss & Bøe (2011) found that small, rebuilt dairies had high labour inputs, but found no difference in labour inputs among large rebuilt or newly build dairies. Evaluating potential improvements in labour-saving strategies of existing facilities, and the labour costs versus investment costs, would not only aim to limit the costs but also to reduce work strain.

In Papers I and II, rearing periods in QH were seven to eight weeks. As rearing period has a strong influence on total labour input, one suggestion could be to plan the design of boxes so groups of calves can be shifted directly after the five weeks of quarantine. The location of the QH is also important, as having several cattle houses far away from the farm centre involves additional labour input, as well as costs related to transportation.

Purchase age

In Paper I the sample of farms was so small that the labour input for farms purchasing pre-weaned calves was not specified. However, in Paper II, no difference was found in labour efficiency between farms rearing pre-weaned (PW) or weaned (W1) calves. The main difficulty with purchasing pre-weaned calves is the high risk of infectious diseases, mainly diarrhoea and respiratory diseases which will affect calf performance later in life, and also increase mortality risk (Svensson *et al.*, 2003). These diseases, particularly respiratory diseases, may also be found even on farms buying weaned calves, and treatment frequency on a national level was 26% in 2009 (Wallgren *et al.*, 2011). No data on calf disease and mortality rates were extracted in this thesis, but recent data (2011) on calf mortality on a national level show that calf mortality rates within a month of birth were 3% and 2.4% for Swedish Holstein and Swedish Red Cattle, respectively. For the most common beef breeds calf mortality varied between 1.4-1.9% (Swedish Board of Agriculture, 2012a). Mortality is by Wallgren *et al.* (2011) calculated at a cost of 1,500 SEK per calf, and thus a high cost for the beef cattle farmer. Costs for calves with an average incidence of 26% respiratory diseases are calculated to 1,000 SEK per calf or 250 SEK per batch. Medical treatment is typically needed in the period after purchase, and extra labour input required for medical treatment is calculated to approximately 20 min/calf. Prevalence of diarrhoea in calf herds was 7% in 2009 and estimated to require an extra labour input of 1 h/calf (Wallgren *et al.*, 2011).

A recommendation on purchasing pre-weaned calves cannot be made based on our studies, but further studies to increase knowledge on rearing calves depending on purchase age and the optimal management for healthy calves would most likely benefit both the beef finishing and the dairy industry. Managing the calf from an early age could shorter the rearing period utilising the growth potential of the calf, reduce input costs, and optimise the use of resources and facilities by giving space to new calves. It would also be expected to lower the environmental impact per calf. A general perception during our field studies was that, either for calf purchases from dairy or suckler cow production, increased goal setting and cooperation between calf seller and calf buyer was desired.

Housing and techniques

Housing systems and level of mechanisation differed not only between farms, but even within farms. The large variation in facilities and time management among farms is not exclusive to Swedish beef cattle producers, but has been reported for several other types of farm (Gleeson *et al.*, 2008; Fallon *et al.*, 2006; Schrade *et al.*, 2005; Leahy *et al.*, 2004). In Paper II we looked deeper into the labour requirement depending on housing systems. The labour requirement in loose house cubicle systems was 0.70 min/bull/day, which was 0.19 min/calf/day more than in straw-bedded systems with paved alleys. We pointed out the importance of considering the overall higher total effect on labour input of manual scraping of cubicles versus the handling of straw in straw-bedded systems. It should be added, however, that the labour input for handling of straw and manure outside the building was not included in the analysis. Furthermore, the cost and availability of straw is important in the choice of building, as large amounts of straw are recommended for a wellfunctioning housing system with straw bedding (Swedish Board of Agriculture, 1995).

We also found that farms using the feeding strategy ‘total mixed ration’ (TMR) spent 0.30 min/bull/day, compared with 0.52 min/bull/day on farms with separate feeding of concentrates and roughage. The farms using TMR were larger, which was assumed to have influenced the results. However, in a study of labour input on Swedish dairy farms, Gustafsson (2009) found an effect of farm size on milking tasks but that feeding tasks were not more efficient as herd size increased. This was in line with findings reported by Hedlund (2008), where feeding TMR to dairy cows in 13 Swedish herds (mean 192 cows; range 80-445) required 0.12-0.94 min/cow/day, and was not affected by increased farm size. In a Norwegian study of smaller dairy herds, the method of feeding roughage (TMR or separately) was not found to have an influence on the labour input (Næss & Bøe, 2011). Deeper knowledge is needed on the economical benefits of different feeding systems in intensive cattle production, in terms of labour input and effect of scale.

Farm size

The results from Papers I and II revealed a scale-effect on labour efficiency up to approximately 500 cattle per year in both production systems. Manevska-Tasevska *et al*. (2013) suggested that to increase technical efficiency in 806 Swedish beef cattle farms studied, increased farm size was not essential. Rather, farmers should invest in technological development. This confirmed our findings that scale effects on labour efficiency were hindered by heterogeneity in levels of mechanisation and housing systems as well as a high level of fragmentation on some farms. Næss & Bøe (2011) showed how changes in labour input on dairy farms was dependent on the capacity of the technique. Labour input decreased with increased herd size on farms using milking parlours, while it was constant on farms using automatic milking system (AMS).

7.3 Working environment

7.3.1 Work environment factors

Overall, the red veal and young bull producers surveyed agreed on the most unpleasant work environment factors, but not the potential hazards, which were assessed as being significantly higher when working with young bulls. The various factors with low scores in this study had significant links between them. Feeling stressed and worried when working in conditions with high demands on the daily work pace and a high risk of injuries is undeniably an unfortunate combination of factors for a safe and healthy work environment. The underlying elements of a negative score for work environment factors related to stress, potential hazards, uncomfortable work climate, and unpleasantly high daily work pace were not found in detail in this study. Deeper studies are needed to investigate the areas that farmers find most problematic and identify the effects of these work environment factors on the farmers' health.

7.3.2 Physical work strain

Physical work strain was presented for the two production systems irrespective of farm size and age of calves at purchase. The overall perceived strain reported by red veal and young bull farmers was rated a moderate, and similar to the workload assessed by Swedish dairy and pig farmers (Kolstrup *et al.*, 2006). None of the work tasks in quarantine houses was rated below 2.5, indicating an overall higher level of work load in quarantine than in finishing houses.

The most physically demanding work task was cleaning, but the work task with the highest PWS index was feeding. The high PWS found for feeding relates to its repetitiveness and the frequent exposure to physical exertion. Attention must thus be given to the fact that repetitive as well as strenuous activities are risk factors for developing MSD in the body parts affected. To reduce the risk of developing musculoskeletal problems it could be suggested to evaluate measures to reduce the frequency of feeding tasks and obviously to apply feeding techniques that require a strain as low as possible. Cleaning was typically monthly performed, and was thus not so repetitive, but is a very important task in intensive beef finishing, particularly on farms operating with quarantine houses. Cleaning tasks were also by Taurus (2012) found to be the most labour consuming tasks among the less frequently performed tasks in Swedish red veal farms finishing approximately 400 calves/year. Improvements of the physical working conditions during cleaning should thus be taken into particular consideration.

Overall physical work strain index (PWS) was similar to the results from Swedish dairy and pig farms (Kolstrup *et al.*, 2006), who also found highest PWS for the most labour consuming work tasks. With a higher labour requirement for bedding tasks in red veal production, PWS was also significantly higher than in young bull production. This is presumably related to the overall lower level of mechanisation in red veal production and the higher number of animals managed. The higher perceived physical strain during bedding in QH on large farms, indicate a problematic daily work load on these farms and systems for less strenuous bedding should be adapted.

Bedding was the task where injuries were most frequently reported. The injuries were not reported from a certain time interval, and the high level of mechanisation for bedding on young bull farms might be a result of the high risks associated with this task.

Handling of calves and bulls during weighing, shifting, and veterinary care was physically demanding (2.8 to 3.6 on the CR-10 scale). The higher variation in perceived physical strain for veterinary care in red veal production is presumably due to a overall higher need for medical treatment here than in young bull production, where calves are purchased of up to six months of age.

The size of the animal during handling tasks had an obvious effect on the perceived physical strain, as unloading and loading of animals were both significantly more strenuous on young bull farms. However, it should be stressed that even though young bulls are considerably larger, red veal calves weigh between 300 and 400 kg at the end of the finishing period and are therefore a significant size to handle for the farm worker. Shifting and weighing were also tasks where injuries were frequently reported. As discussed earlier, labour efficiency for animal handling tasks does not automatically increase with increased farm size, and to reduce work strain and injury risk this aspect must not be neglected when planning for animal handling procedures on expanding farms. The results show that the farmers are more or less continuously exposed to physical exertion in any of the body parts during a work day. It is interesting that according to the results for the work environment factors, the farmers were satisfied overall with the level of physical exertion in their work. Pinzke (2003) similarly found that milking was among the most strenuous tasks on dairy farms, but also the work task that the farmers enjoyed the most.

7.3.3 Musculoskeletal symptoms

The prevalence of musculoskeletal symptoms (MSD) was lower than reported from other livestock sectors in Sweden, but more similar to the studies by Osborne *et al*. (2010) and Rosecrance *et al*. (2006) mentioned earlier, and to studies of Swiss dairy farmers (68% prevalence) (Kauke *et al*., 2010). The lower prevalence of MSD found in this study of young cattle than in other livestock sectors farming might be related to the higher variety of work tasks among beef cattle producers than in other large-scale livestock enterprises. The duties are generally not as monotonous as beef cattle production has not followed the same trend toward very large herds requiring a high level of specialisation among employees. Furthermore, the work tasks in beef farming can to a larger extent be performed with tractors, machines and automatic feeders compared with conventional milking or certain work tasks in a pig house (Kolstrup *et al*., 2006), or a horse stable (Löfqvist *et al*., 2009), and thus reduce the physical exertion to a minimum.

The reported MSD prevalence might also be affected by the predominance of male respondents. Gender differences related to physical working conditions and perceived MSD, *i.e*. that females are more prone to report MSD, have been found to be significant in several studies, (Howard *et al*., 2005; Stal & Englund, 2005; Karlqvist *et al*., 2002; Gustafsson *et al*., 1994). Only 10% of farmers reporting some kind of musculoskeletal discomfort in the present study rejected the possibility of a relationship between MSD and work in young cattle production, indicating a need for further studies within the areas with the highest risk of developing MSD.

The prevalence of perceived MSD symptoms was highest in the upper extremities and the back (particularly the lower back). Among the lower extremities the highest prevalence was in the knee. This is in line with other, more comprehensive studies of perceived MSD among agricultural workers, reporting a high prevalence in the lower back, hip, knee and upper extremities (Osborne *et al*., 2010; Holmberg *et al*., 2002; Walker-Bone & Palmer, 2002; Hildebrandt, 1995). The questionnaires in this thesis were not designed to analyse perceived symptoms of MSD from the nine anatomical areas in relation to a certain work tasks. However, it can be presumed that the prevalence of MSD symptoms in the upper extremities is strongly related to the repetitive tasks of feeding and bedding on low-mechanised farms, as it causes the back to be bent and twisted, as found in an posture analysis of dairy workers (Perkiö-Mäkelä & Hentilä, 2005) as well as workers in horse stables (Löfqvist *et al*., 2009) during bedding. The feed and bedding was in one or more cattle houses on several of the studies farms distributed with a farm fork. Furthermore, some farmers described how they rolled round bales of straw or lifted square bales of straw into the pen, which can be assumed to place a high load on the upper extremities and the knees. Considering the work tasks in beef production, kneeling or working while bending the legs could be assumed not to be as frequent as for example during milking or during castration of piglets (Kolstrup *et al*., 2006).

7.3.4 Occupational injuries

The proportion of farmers reporting injuries in the study was 20% for red veal producers and 39% for young bull producers. A significantly larger number of young bull farmers (26.5%) than red veal farmers (8.6%) reported unacceptably high potential hazards in their working environment. The high number of reported injuries confirms the high risk of being injured when working with bulls. However, despite the high number of reported injuries, the working environment in terms of potential hazards was assessed as "good" or "very good" by the majority of the farmers (91% and 75% of red veal and young bull farmers, respectively). A similar phenomenon was found in perceptions of the general level of physical strain and needs deeper investigation, but it can be speculated that farmers are so accustomed to being exposed to risks and physical exertion that they underestimate the strain and hazards of their working conditions. Lindahl *et al.* (2013) accentuate that carelessness when working with animals should not be accepted among farm owners and workers. This is an important issue for further investigations in order to understand why the health disorder and injury rate in the livestock sector remains high while other sectors show decreasing numbers of incidents.

Despite the drive to reduce injuries on farms by the agriculture industry itself, insurance companies and government initiatives since the 1940s (Swedish Board of Agriculture, 2007), injury rates are not decreasing considering the reduction in number of farms. The pattern is similar all over the world, as fatality rates in agriculture remain high while other industries have seen a continuous decrease.

In the United States the trend in differences in fatality injury rates between agriculture and other occupations is similar to that in Sweden, though the rate is much higher than in Sweden (28.7 compared with 3.4 per 100,000 workers). Handling animals, primarily cattle and horses, is among the three leading causes of injuries in US agriculture (together with handling of machinery and falls) (Dogan & Demirci, 2012). Australian agriculture has a three- to four-fold fatal injury rate than the workforce in general.

A very important aspect of farm occupational injuries is that in contrast to most other industries, on most farms inexperienced people and even children are involved or have access, and thus are at increased risk. In a report based on Swedish statistics from 2000-2008, Lindahl *et al.* (2009) point out that children (0-18 years old) are generally given too much responsibility in agriculture. Activities with the highest frequency of injuries among children are handling horses (46%), tractors and agricultural machinery (20%). Every year in Sweden, 2-4 of these cases are fatal (Lindahl *et al.*, 2009).

According to the websites of the Swedish Farmers' Organisation (LRF) and the large Swedish construction company, Skanska, the future goals for occupational injuries are quite different. LRF's goal is to halve the number of injuries, whereas Skanska has a goal of no injuries at all. Could we somehow put higher pressure on the farm industry today? Are we expecting too little? Do we really think that to have a few injuries is the common standard and "all right"? A report by the Swedish Board of Agriculture (2007) on identifying actions to reduce the number of injuries on farms concluded that there was no need for stricter legislation, but rather for risk information and advisory services on a close-to-farm basis.

During our farm visits, many of the red veal and young bull farmers described how they occasionally walked into the pens to provide some contact with the calves. To save labour, reduce strain and injuries this might be a worthwhile task on which to spend saved labour, but as the calves grow it would require a building planned for making inspections in boxes. Thus, planning for work safety must be included at the initial phase of construction or reconstruction of animal buildings. Farmers should not have to compromise their safety and health due to economic factors when planning for new investments.

7.4 Motivating factors

The study on motivating factors was initiated on the basis of a hypothesis that all farmers not necessarily are driven to work as efficiently as possible. Therefore, motivation factors among Swedish farmers with intensive beef production were investigated to determine whether different categories of factors identified could be used to predict the behaviour of the farmers. We expected to find that for example intrinsic values were ranked higher by farmers with a lower labour efficiency. A motivation of not wanting to optimise work could have different reasons, for example due to farmers not feeling like changing their work, believing it would lower the time for inspection of animals. There might be also a financial reason for keeping labour-demanding strategies in old buildings, as there will be no financial loss if the enterprise has to be terminated. This requires farmers to work without payment, but if there are no successors, it may be the only way to continue farming until retirement.

The study revealed, as expected, a more positive attitude towards physical work and a lower emphasis on leisure time among farmers with lower work efficiency. Work efficiency thus not only relates to the possibility to invest in technical equipment, but also to the decisions made by the individual farmer. The results also indicated that the farmers who were overall more motivated by non-economic values would most likely expose themselves to a higher amount of physical work, resulting in a higher work load and thus a higher risk of developing MSD. The results were therefore to a large degree in accordance with previous literature. However, economically orientated farmers were not significantly less motivated by the intrinsic motivation factors. The values of typical entrepreneurial farmers with large farms and high work efficiency only differed from those of less entrepreneurial farmers on a few individual items.

They valued the free and autonomous life, the opportunity for creativity and original solutions, the environment and the family life *etc*. as highly as the less entrepreneurial farmers, indicating a difficulty in placing farmers into typology-boxes.

The higher ranking of the item '*the farm is highly productive*' compared to the item '*the farm is large*' might indicate that the farmers do not see farm expansion as the ultimate measure of productivity, even if they need to expand to keep up with agricultural policies. Recent studies in productive agricultural countries such as Denmark and France on the conflicts between increased productivity and difficult farm viability displayed that attempts to achieve economies of scale increased production costs per hectare by 20-30% rather than lowering them (Charroin *et al.*, 2012; Hageberg, 2012). Items concerning the family and future succession were somewhat surprisingly among the five bottom ranked items, and had weak loadings on several factors. Most farms, both in Sweden are family run, meaning that the successors come from within the family. Furthermore, the item '*hold in trust for future successors*' was assessed as very important by 26.6%, while 18.9% farmers assesses the item '*the farm is run by the family'* as very important. These two items could be assumed to be strongly correlated, and the explanation for the weak correlation might be that the farmers are motivated to run the farm in an economically sustainable way, but they are reluctant to have expectations on their children to continue farming. The farmers in the present study scored high on environmental values, but low on organic farming, typically seen as more environmentally friendly than conventional farming. This has a natural explanation in the fact that none of the farms in the study was organic and in the generally low rate of organic red veal or young bull production in Sweden, despite a higher price for organic meat. The farmers valued the item '*enjoy my work*' highly, which corresponds to findings in a study of 5,049 Swedes between 18-74 years of age that after being healthy, it is most important to feel happy at work (Wise Group AB, 2012). Retrospectively, specific items about how the farmers valued health and physical work conditions in their work with intensive beef production should have been added to the study in Paper IV.

Increased knowledge is needed about why farmers are so dedicated to their occupation, as we found in Papers III and IV. Consumers are demanding more and more information about where their meat (and food in general) comes from, and as the number of farms continuously decreases, there is likely to be an increased need to understand farmers and their working conditions with the high responsibility and commitment in the management of 'common goods'. To understand animal production, knowledge about the multidimensional aspects of livestock farming needs to be established and distributed.

8 General conclusions

This thesis comprises the first descriptive study of labour inputs and physical working conditions during the most common work tasks in Swedish intensive beef cattle production. The thesis also presents novel findings on motivating factors among the intensive beef cattle producers and on methods to understand how motivation can help the understanding of farmers' working conditions. The main findings are listed below.

- Labour efficiency in red veal production was not significantly increased by herd size once the unit size exceeded 550 red veal calves or 450 young bulls per year.

- Labour efficiency in young bull production was not significantly different on farms finishing bulls from median purchase age 21, 63, 122 and 183 days to 17.0, 17.0, 16.0 and 15.0 months of age. The results indicate that purchasing pre-weaned calves can reduce total labour input and lower the length of the finishing period.

- The variation found in labour efficiency on small, medium and large red veal farms between the 25% most and 25% least labour efficient farms indicate possibilities to increase labour efficiency by 63%, 42% and 43%, respectively.

- The variation found on the four finishing models of young bull production between the 25% most and 25% least labour efficient farms indicate possibilities to increase labour efficiency by 51%, 54%, 58% and 59%, respectively.

- Identified measures to increase labour efficiency were to increase mechanisation in daily work tasks, lower the level of farm fragmentation, reduce the frequency of work tasks, apply similar strategies between animal houses and plan for strategic handling of animals, particularly as farm extends. Measures for improvements in design and mechanisation level in quarantine houses were suggested, due to a low number of animals, short batch period and higher work load in this house section.

- Work environment factors with more than 20% negative scores were ‘feeling stressed and worried’, ‘unpleasant work climate’, ‘high demands on the daily work pace’ and a ‘high risk of injuries’.

- Work related injuries were reported by 20% and 39% of the respondents from red veal and young bull production, respectively. Bedding, shifting and weighing of cattle were most frequently associated with injuries.

- The prevalence of perceived MSD was higher than the general Swedish working population, but lower than often reported from studies of livestock enterprises. The prevalence was assessed as being highest in the upper extremities and the back.

- Cleaning of calf houses was assessed as the most physically demanding work task followed by handling of young bulls.
    - Feeding tasks in young bull production and bedding tasks in red veal production were repetitively performed and thus need special attention despite a weak to moderate strain.
    - Despite strenuous tasks, the farmers were satisfied overall with the level of physical exertion in their work, and 75% of the farmers were moderately to highly motivated by the possibility of physical work.

- The Swedish beef and red veal farmers ranked both economic and non-economic values highly, but some differences could be identified:
    - Intrinsic items were ranked more highly by farmers with higher daily labour inputs per cattle, having smaller farms and reporting higher perceived prevalence of musculoskeletal symptoms.
    - Large farms valued economic and expressive items of motivation more highly than smaller farms, and economic and expressive motivation also tended to predict higher work efficiency.

8.1 Practical implications

The results from Papers I-IV provide deeper knowledge about the work in Swedish intensive beef cattle production. The results of labour inputs provide data which can be used in benchmarking and evaluation of labour patterns on individual farms. This can be in planning processes of new investment in buildings or technology, or in identifying areas of optimisation in existing facilities. The separation of labour inputs in quarantine and finishing houses and defined for each of the most common work tasks provide possibilities to identify target areas for priority and improvement.

Strong control over input costs decreases the vulnerability of the enterprise to political and economic trends. More time for planning and decision making in the enterprise can facilitate frequent interaction with relevant agents within agriculture, so farmers can be better informed about the current market in terms of demands, prices and interests. Increased labour efficiency can free up time to facilitate diversification or off-farm employment. Improved labour efficiency can also improve the scope for family life, physical exercise and social activities outside the farm.

The results of physical work environment can be used in evaluation of physical strain during specific work tasks during different stages of the beef production, and to increase the awareness of risk factors for developing MSD. An increased awareness of the everyday work situation will facilitate in identifying problematic areas at an early stage.

The reported number of injuries is a number that would not be accepted in any other occupation, and the results are an important contribution to a continuous preventive work against occupational injuries in agriculture.

Farms have a high responsibility and commitment in *e.g.* environmental, animal welfare and food quality aspects, thus not only commercial but also cultural, societal and historical values are closely linked to agriculture. Increased knowledge about farmers' individual driving forces is thus essential in the overall understanding of their working situation.

9 Future research

Labour input related studies

More research is needed to increase the knowledge of labour input in Swedish intensive beef cattle production for increased competitiveness and future attractiveness. Specifically:

- Work time requirement and calf performance related to different feeding strategies and feeding techniques.
- Work time requirement related to different housing systems and building design, particularly optimal design of quarantine houses.
- Work time requirement related to management strategies of group housed calves depending on calf purchase age.
- Work time requirement and calf performance related to different frequency of work tasks.
- Measures to achieve a more cost-efficient finishing of young cattle through closer collaborations between the farm of origin and the finishing farm.

Work environment studies

More research is needed in the development towards improved physical working conditions in Swedish intensive beef cattle production. Specifically:

- Further analysis of the specific work tasks with high perceived physical strain identified in this thesis
- To analyse the underlying elements of the work environment factors that farmers found most problematic in this thesis: hazards, stress, work pace and an unpleasant climate.

- To identify measures to improve problematic areas of the work environment and how to implement strategies for improved safety and health among farmers and their employees.

Studies on motivation factors

More research is needed to understand the multidimensionality of farmers as a complement to technical studies. Specifically:

- Investigate to what extent farmers consider their personal motivation to be influencing individual control of work efficiency, working environment and farming strategies.
- Investigate how farmers' driving forces can be utilised to increase the competitiveness of the enterprises.

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