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Labour in suckler cow herds – a study on enterprises in southern Sweden

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ABSTRACT
This study aimed at examining labour demand in Swedish suckler cow operations grazing biodiverse semi-natural grasslands. Labour time was successfully recorded by 49 randomly selected farmers and their employees using an application in their mobile phone to register time for different labour tasks every 8th day for one year, crop production excluded. Median labour time for all herds was 17 hours/cow/year with a general lower workload per cow for large herds compared to small herds. Labour demand during the grazing period was however more dependent on the structure of pastures than herd size. The calving period was the most labour-intensive period, whereas supervision on pasture was the most time-consuming task both during the grazing period and the entire year. Large variations among herds indicates that there are often great opportunities for achieving a decreased labour time, not the least in small herds.

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Labour time; work efficiency; workload; suckler cow; beef production; pasture fragmentation

Introduction

As in many countries in the European Union (EU), Swedish beef suckler cow herds are small (European Commission, 2022; Swedish Board of Agriculture, 2022). The average herd size of suckler cows in Sweden has increased from only 6 to 22 cows from year 1985 to 2022, while the number of herds is relatively unchanged. The labour demand per cow is correlated with herd size where larger herds generally are more labour efficient than smaller ones (Paul et al., 2004; Schrade et al., 2005), at least up to a certain size (Langemeier et al., 2004). Furthermore, farm fragmentation has a negative effect on efficiency (Fallon et al., 2006).

A lot of former Swedish dairy enterprises have changed their operation to suckler cows, which can explain why a lot of Swedish suckler cow herds are small. Of the Swedish suckler herds, 60% have 1–49 cows while only 2% of the enterprises have more than 100 suckler cows (Swedish Board of Agriculture, 2021a). Many suckler cow enterprises, especially the small ones, use buildings, machines, land and manpower which have been released when ceasing the dairy production. Those resources often have low or no opportunity cost, why the profitability can be acceptable even though the working time per cow sometimes is high. However, cheap existing resources will run out sooner or later. When investment in new buildings and machinery and market-related wages are required, then low labour demand per cow is necessary to achieve profitability (Kumm, 2006). In general, labour is one of the largest costs in suckler cow enterprises (Agriwise, 2022).

Labour demand in Swedish indoor beef production with intact bulls has previously been studied by Bostad et al. (2011). They found that labour demand per bull was not significantly affected by unit size from large (450 bulls reared/year; 0.4 min/bull/day) to very large (960 bulls reared/year; 0.3 min/bull/day) but they found that labour demand per animal were higher in smaller herds. Previous studies of labour demand in suckler cow herds are lacking in Sweden. However, based on practical experience from suckler herds, the daily labour requirement per suckler cow and replacement heifer in different herd sizes has been estimated (Nelson, 2002). The result indicates that the labour requirement per cow is halved when the herd size is increased from 20 to 150 cows. In larger herds, the time required per animal decreases with a slower rate than for smaller herds (Nelson, 2002). Production calculations for spring-calving suckler cows in Sweden typically uses labour demand of 12 or 15 hours/cow/year as a rule of thumb, and have done so for decades, while labour demand for dairy production has decreased rapidly (Agriwise, 2000, 2022; Gård & Djurhälsan, 2022).

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Labour demand in suckler cow herds has been measured in other countries with varying results. Fallon et al., (2006) found labour demand per suckler cow and year to be 6.7 hours in Ireland, when including feeding, cleaning, animal husbandry, farm maintenance and farm management. Labour demand was found to be much higher in Switzerland, where the animal husbandry included grassland maintenance, loading and driving cattle to and from alpine pastures, with an average of 66 hours/cow/year (Schrade et al., 2005). The average labour demand for British suckler cows was estimated to be between 10.8 and 34.8 hours/cow/year excluding feed production (Redman, 2020). Another British study distributed suckler cow operations after financial performance. They found the labour time per cow (with calf and 0.2 replacement heifer) including feed production, management of pasture and buildings and administration to be 16.6 hours per cow in the third of herds with the largest labour demand (average 54 cows). The labour time in the average labour demanding herds (90 cows) was 10.9 hours, whereas it was 9.2 hours per cow in the third of the herds having the lowest labour demand (101 cows) (Agriculture and Horticulture Development Board, 2016). These international studies show a huge variation in labour demand per cow, and the last one states work demand is much lower in large, profitable herds than in small herds with lower economic result. These large, profitable herds have significantly lower labour demand per cow than what is assumed in the Swedish suckler cow calculations cited above.

Suckler cows are often kept on biodiverse semi-natural pastures, where their grazing maintain the ecological, culture-historical, recreation and amenity values of these lands (Pykälä, 2005; Hanauer, 2015; Eriksson, 2022). The values of these lands are due to the long-standing continuous grazing-management, and occasional mowing, and they are therefore location-bound. They tend to be small and scattered, and thereby expensive to maintain, not the least due to high labour demand (Cederberg et al., 2018). Small herds in combination with small-scaled, scattered mosaic pastures is one reason for the mearge profitability in Swedish beef cattle production (Government Offices of Sweden, 2004), not the least as Swedish wages and cost of living are generally high compared to many other countries (OECD, 2018).

There is a long-lasting trend of decreasing numbers of small suckler cow enterprises, caused by the retirement of older farmers, while the younger generation at the farm finds profitability too small to continue with this production (Swedish Board of Agriculture, 2021a; Swedish Board of Agriculture, 2022). Many of the small suckler cow operations that still exist are family-based and dependent on off-farm work, which decreases the labour available at the farm. For existing suckler cow herds to carry on and new farmers taking over when older farmers retire, the enterprise must be able to provide acceptable labour remuneration per hour and therefore low labour demand per cow is necessary (Swedish Board of Agriculture, 2022). By adopting good techniques and/or practices, small farms can improve their competitiveness without growing in size (Sheng et al., 2015). Low labour demand per cow also makes it easier to combine a small suckler cow herd with off-farm work. It is therefore important to find working methods that decrease labour demand in suckler cow operations, both to increase the possibility to create larger herds for full-time enterprises, and to facilitate having off-farm employment on small suckler cow enterprises.

The aim of this study was to examine labour demand in Swedish suckler cow operations with different conditions regarding herd size and structure of pasture, and to demonstrate possibilities to reduce labour demand per cow.

Material and method

Selection of farms

Farmers with beef cow operations were recruited for the study by using an official register of all Swedish cattle herds at the Swedish Board of Agriculture. An invitation letter was sent to a random selection of 247 suckler cow enterprises with ≥20 suckler cows, performed by Swedish Board of Agriculture, in a radius 300 km from Skara, southwestern Sweden, in February 2019. All selected herds had to have loose housed or outdoor wintering systems to be part of the study, hence, herds in tied-up systems were excluded. The aim was to find similar numbers of enterprises within the herd sizes 20–50, 51–100 and >100 cows per farm. In the first round, 30 positive responses were received. After a reminder to the initial 247 invited enterprises, contact with a further 100 randomly selected farms from the official register, and one last reminder addressed only to farms with >100 cows were undertaken. After these actions, 68 enterprises (response rate 20%) were willing to participate in the study. Twenty-two of these farms had 20–50 cows, 26 farms had 51–100 cows and 20 farms had >100 cows.

Each of the enterprises were visited by the main author before entering the study and background farm data was collected by the help of a questionnaire (Appendix 1). The questions concerned structure of the farm, i.e area of pasture and arable land, calving time, number of workers etc. Some variables used in the analyses were calculated from those data. One such variable was median distance from the farm to animals on pasture, both on a group level and to individual animals in different pasture enclosures. The other variable was median distance from farm to paddock. Of the 68 visited farms, 51 entered the study and 49 completed the whole study period (Figure 1). The enterprises that participated had 20–280 suckler cows (18 farms with 20–50 cows, 17 with 51–100 cows and 15 with >100 cows) and the overall median herd size was 72 cows.

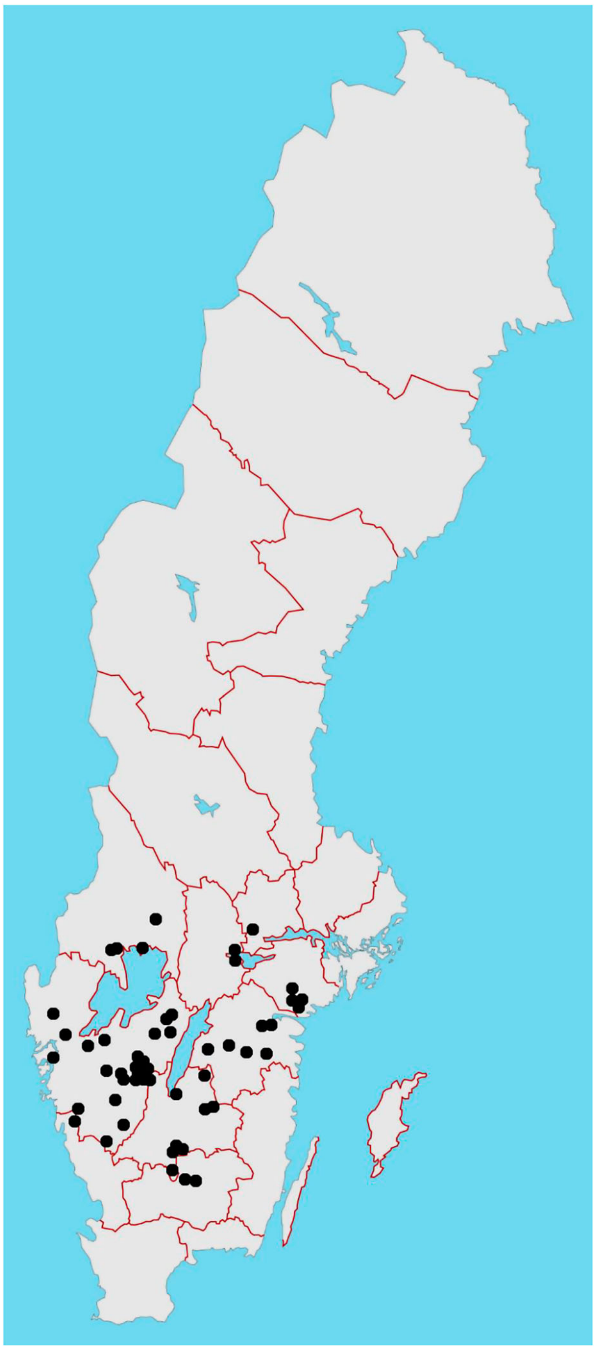

Figure 1. Location of investigated suckler cow enterprises in southern Sweden where labour time was measured.

Time logging of labour

The data collection on each enterprise aimed at measuring the workload during all seasons of the year and all days of the week, including weekends. In agricultural time studies it is important to incorporate weekends because family labour might carry out a disproportionately large part of their farming tasks during weekends (Abeyasekera and Lawson-McDowall, 2001). The starting time of the data collection varied from February 2019 to

Table 1. Definition of categories of work at investigated suckler cow enterprises. Maintenance = maintenance of buildings and machinery.

Category of work	Definition	Recurrent	Seldom
Administration	Planning, accounting, labour management and further education e.g. courses or study visits at other farms. From when you start the activity/ arrive at the place until the activity/event is over (not travel time).	X	X
Bedding	From straw is picked up or, if straw is stored far away, when entering the farmyard. Finished when work is done.	X	
Cleaning	Mucking out from barns and cleaning e.g. water bowls, feeding table and wash barn. From entering the barn until the work is done.	X	X
Feeding	From the start of the tractor/ feeding equipment until the work is completed. If feedstuff is stored far away the time begins when entering the farmyard.	X	
Fencing	Looking over and maintenance of existing fences, but not fencing new pastures. Starts when picking up equipment and leave the farm and lasts until being back to the farm again.	X	X
Maintenance	Buildings and machinery related to suckler cows. From when you start until the work is done and the equipment is put back again.	X	
Supervision indoor	Supervision and handling of housed cattle in barns, e.g. assistance at calving, marking calves and treatment of sick animals. From entering the barn until the work is done.	X	X
Supervision on pasture	Supervision of cattle at pasture, changing pasture enclosures and oversight of water, salt and mineral supplements. From leaving farmyard until being back again.	X	X

December 2019. All persons working in the enterprise logged their labour time with the cows, breeding bulls and replacement heifers in real-time during one whole day every 8th day for 12 months. Three of the enterprises measured all their animal-related labour on own initiative every day continuously, two of them for 365 days and one enterprise for 180 days. Labour with finishing cattle was not included in the study. The farmers/employees were asked to allocate their time recordings into eight different labour categories (Table 1). The categories were all animal-related tasks. Hence, work with e.g. crop production, maintenance of pasture or forestry was not included. Labour was logged in an application called 'A time logger' (©aLoggers 2019) in the person's smart phone and sent for further compilation by email to the author.

Estimates of labour time of seldom tasks

When using time logging every 8th day there is a risk of both missing or overestimating labour time for labour-intensive work occurring just once or a few times per year, in this study defined as 'seldom tasks'. To correctly incorporate the seldom tasks, the farmers were asked to estimate labour time for such tasks. The defined seldom tasks were study visits, meetings and courses (belonging to work category Administration), emptying straw beds and high pressure washing the barn (belonging to work category Manure handling), repair and inspect existing fence (belonging to work category Fencing), pregnancy test, hoof trimming, deworming, clipping and trade of livestock (belonging to work category Supervision indoor), and time for turning-out cattle to pasture and housing them for the winter-feeding period including transports (belonging to category Supervision on pasture).

Data on common, recurrent, work was analysed as it was collected, but for seldom tasks there was sometimes missing or double data, leading to this work time having to be processed before analysing. At the three farms where all work time was logged continuously everyday (365, 365 and 180 days, respectively), this data was used also for the seldom tasks (data defined as 'true'). If a seldom task at the other farms had been completely covered by every 8th daytime logging, this data was used (defined as 'recorded'). If a seldom task had been partly covered, it was possible to use an estimate based on knowledge of the proportion of work that had been done (for instance if one straw bed was emptied in eight hours, two beds would take 16 hours), this data was used (defined as recorded). If the seldom task had not been covered by the time logging at all, but estimated by the farmer in the questionnaire, this data was used (defined as 'farmer's estimate'). If both time log and estimate were lacking for a seldom task, a prediction was made by applying multilinear regression, using predict model in R version 4.1.3 (R Core Team, 2022) based on the workload on the other farms with similar conditions. In prediction for seldom tasks, number of cows was most often included, whereas the other variables in the model differed among the specific seldom tasks. For estimation of labour time for the seldom task emptying straw beds, labour time in barns with straw beds were included, while the model for estimate of labour time for deworming, trade of livestock and high pressure washing the barn included type of housing system. Models for estimation of time for fencing, turn-out on pasture and housing did not include number of cows. Instead, time for fencing was predicted from number of paddocks, hectares of pastures and median numbers of animals per paddock. Turn-out on pasture and housing of animals included number of animal groups, median number of groups and number of barns. Distribution of seldom tasks, independent of type of time estimate, was in average across farms 1.2 hours per cow, corresponding to 7% of the total labour time.

Periods

In the data analyses, the year was divided into three periods: calving period, grazing period and indoor non-calving period. The ranges of the periods were individually defined for each farm. Calving period was defined as starting on the day the first calf was born and lasting until the day when the last calf was born. Calving during summer grazing was regarded as grazing period, because so few calvings occurred during the grazing period. The start of the grazing period was defined as the day the cattle were turned out to pasture and lasted until the day when the cattle were housed again. For out-wintering cattle the grazing period ended when they were put in to their winter enclosure. The indoor non-calving period started on the day of housing and lasted until the day of turn-out to pasture, except during the period of calving.

Median daily amount of labour per work category and cow in each of the enterprises was calculated as well as the total labour in each of the three periods (calving period, grazing period and indoor non-calving period), and for the entire year.

Statistical data analyses

Statistical analyses were done in R and RStudio (R Core Team, 2022; RStudio Team, 2022). Correlations between variables were investigated using correlations and principal component analysis (PCA) (Le et al., 2008; Kassambara and Mundt, 2020). The correlation graph shows significant correlations from a t-test on the Pearson correlation coefficient at a significance level of 0.05. With the given number of replicates, the cut-off for significance is a correlation below −0.29 or above 0.29. A regression model on herd size and total labour time was done using a logarithmic model $y = \log10(x)$, where $y =$ labour time per cow and year and $x =$ number of cows. Model assumptions were checked using diagnostics graphs for normally distributed residuals and homoscedasticity (equal variance independent of the level of the explanatory variable). Finally, case-selection based on five farms, with ≤100 cows and with residuals in each end that diverged most from the regression line, were picked out for further analysis. The five farms furthest below the line had least labour time per cow and the five farms highest above the line had largest labour time per cow.

Results

Description of labour time

There was a large variation in labour time among suckler cow farms. In herds with 20–50 cows, labour time varied from a minimum value of 11.6 hours/cow/year to a maximum value of 40.6 hours/cow/year. In herds with 51–100 cows, the workload varied in a range from 9.7 to 41.9 hours/cow/year, and in herds with >100 cows the labour time varied from 7.9 to 28.5 hours/cow/year. The large distribution in labour time among farms is shown in Table 2. The annual median labour time was 17 hours per cow, corresponding to 2.8 minutes per cow and day.

Largest daily labour demand was found during the calving period (median 91 days) and least labour time during the indoor non-calving period (median 101 days). Although the animals usually were kept indoor in the same systems during these two periods, labour time for feeding, bedding and manure handling increased during the calving period (Table 2).

The single most time-consuming labour task across the year was supervision of animals and water supply on pasture (Table 2), corresponding to almost half of the total labour time during the grazing period (median 173 days). However, for the 75th percentile in herds with 20–50 cows, manure handling was the most time-consuming task across the year.

The labour time was unevenly distributed over the year, not only among the three studied periods (calving period, grazing period, and indoor non-calving period), but also among single weeks. This is illustrated with data from one of the farms, where the labour time was recorded every day during the investigated year (Figure 2). This enterprise shows a variation in workload from 0.9 minutes per cow during week 24 (on pasture) to 11.9 minutes per cow during week 44 (indoor), when all animals had been housed and, in addition to the daily tasks, pregnancy testing (supervision indoor) and a study visit (administration) was also undertaken.

Correlations and regression

Year

Farms with low daily labour time per cow across the entire year, generally spent less time at every single task whereas farms with large labour time spent more time on every task. The most important factors for the daily labour time per cow across the year, were number of cows (r: −0.37) and mechanical bedding (labour time and mechanical bedding r: −0.33; labour time and manual bedding r: 0.35) (Figure 3(a)). Manual bedding was in turn positively correlated with time spent on manure handling (r: 0.34), administration (r: 0.31) and maintenance (r: 0.29). Number of cows was negatively correlated with time spent on manure handling (r: −0.38) and time spent on supervision on pasture (r: −0.35).

Calving period and indoor non-calving period

Similar to the labour time across the year, the daily labour time per cow during calving and indoor non-calving periods, was negatively correlated to the number of cows (r: −0.36 and −0.33 for calving period and indoor non-calving period, respectively) (Figure 3 (b,d)). During the indoor non-calving period, the labour time per cow was also negatively correlated with number of employees (r: −0.31) and mechanical bedding (r: −0.31), and positively correlated with manual bedding (r: 0.43).

For the calving period, the number of cows was positively correlated with number of barns (r: 0.36). For the indoor non-calving period, the number of cows was positively correlated with length of calving period (r: 0.47), annual working unit (AWU) (r: 0.66) and number of employees (r: 0.56).

Grazing period

Although a negative correlation between number of cows and daily labour time spent on supervision on pasture was found on a yearly basis, no correlation between daily labour time and herd size could be

Table 2. Labour time (min) per suckler cow and day (25th, 50th and 75th percentile) of different work categories in Swedish suckler enterprises of three different herd sizes (n = no. of herds) during the calving period, the grazing period, the indoor non-calving period and yearly. Maintenance = maintenance of building and machinery, supervision ind. = supervision of animals indoor and supervision pas. = supervision of animals and water supply on pasture.

	Herd sizes, cows	20–50 (*n* = 16)			51–100 (*n* = 19)			>100 (*n* = 14)		
	Percentile	25	50	75	25	50	75	25	50	75
Period	Work category									
Calving	Administration	0.11	0.14	0.25	0.11	0.16	0.25	0.10	0.15	0.30
	Bedding	0.12	0.31	0.93	0.30	0.67	0.98	0.11	0.19	0.24
	Feeding	0.44	0.90	1.50	0.32	0.60	1.01	0.36	0.67	0.83
	Fencing	0.00	0.00	0.03	0.00	0.00	0.34	0.00	0.01	0.13
	Maintenance	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.06
	Manure handling	0.12	0.32	1.18	0.14	0.41	0.73	0.05	0.21	0.42
	Supervision ind.	0.90	1.18	1.66	0.46	0.90	1.28	0.47	0.77	1.30
	Supervision pas.	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.04
	Total labour	**3.28**	**4.18**	**5.26**	**2.09**	**3.41**	**3.99**	**1.77**	**2.45**	**3.07**
Grazing	Administration	0.05	0.14	0.38	0.11	0.19	0.27	0.08	0.12	0.14
	Bedding	0.00	0.00	0.01	0.02	0.04	0.11	0.00	0.00	0.02
	Feeding	0.06	0.11	0.34	0.07	0.15	0.25	0.03	0.06	0.14
	Fencing	0.17	0.54	0.90	0.25	0.52	0.97	0.11	0.25	0.36
	Maintenance	0.00	0.00	0.02	0.00	0.03	0.23	0.00	0.02	0.27
	Manure handling	0.44	0.57	1.00	0.29	0.35	0.51	0.23	0.34	0.41
	Supervision ind.	0.00	0.04	0.18	0.02	0.09	0.22	0.01	0.05	0.30
	Supervision pas.	1.33	1.65	2.10	1.17	1.42	1.75	0.81	0.98	1.35
	Total labour	**2.63**	**3.41**	**4.38**	**2.23**	**3.17**	**4.32**	**1.57**	**1.93**	**2.50**
Indoor non-calving	Administration	0.06	0.13	0.22	0.10	0.14	0.22	0.07	0.09	0.13
	Bedding	0.07	0.30	0.51	0.20	0.35	0.63	0.14	0.18	0.23
	Feeding	0.45	0.92	1.33	0.41	0.52	1.00	0.33	0.41	0.83
	Fencing	0.00	0.00	0.02	0.00	0.00	0.13	0.00	0.00	0.12
	Maintenance	0.00	0.00	0.27	0.00	0.02	0.22	0.00	0.01	0.05
	Manure handling	0.17	0.43	0.98	0.16	0.29	0.45	0.04	0.08	0.41
	Supervision ind.	0.27	0.41	0.71	0.17	0.42	0.51	0.13	0.23	0.35
	Supervision pas.	0.00	0.00	0.04	0.00	0.00	0.01	0.00	0.00	0.00
	Total labour	**1.85**	**2.25**	**4.78**	**1.75**	**2.40**	**2.89**	**1.23**	**1.42**	**1.69**
Year	Administration	0.09	0.15	0.27	0.12	0.20	0.30	0.09	0.12	0.19
	Bedding	0.10	0.18	0.39	0.13	0.27	0.46	0.09	0.09	0.13
	Feeding	0.31	0.65	0.80	0.24	0.42	0.65	0.21	0.36	0.49
	Fencing	0.08	0.24	0.43	0.19	0.30	0.57	0.12	0.15	0.26
	Maintenance	0.01	0.06	0.12	0.01	0.08	0.23	0.00	0.02	0.18
	Manure handling	0.29	0.55	0.99	0.26	0.37	0.51	0.17	0.24	0.33
	Supervision ind.	0.34	0.40	0.62	0.24	0.44	0.58	0.24	0.36	0.62
	Supervision pas.	0.63	0.79	0.93	0.52	0.71	0.84	0.37	0.45	0.66
	Total labour	**2.71**	**3.40**	**4.32**	**2.12**	**3.01**	**4.05**	**1.72**	**1.92**	**2.51**

found when analysing this correlation for the grazing period separately.

Total daily labour time during the grazing period was positively correlated to time spent on supervision on pasture (*r*: 0.84), fencing (*r*: 0.73) and manure handling, mostly composing of emptying straw beds (*r*: 0.51) (Figure 3(c)). Some labour time during the grazing period was spent on supervision indoors (Table 2), e.g. of single housed sick cows.

The regression line (Figure 4) shows that the annual total labour time per suckler cow generally decreased with increasing herd size, but the distribution around the regression line was large, and largest in the herds with fewer cows. The variability explained by the model (17%) is in the range what can be expected in this kind of studies. For a tenfold increase in herd size from 20 to 200 cows, labour time decreased from 25.0 to 13.5 hours per cow. Nonetheless, in herds with more than 250 cows the decline in labour time per cow and year tended to cease. It should also be noted there were several small herds which had less labour demand per cow and year than larger herds.

Comparisons between farms with particularly low and particularly high labour consumption

Comparison of the five farms with ≤100 cows having least and most labour time (Figure 4) showed that farms with large labour time spent time on most tasks, compared to farms with least labour time, but especially on maintenance of buildings and machinery, feeding and bedding (Figure 5). The median of the daily work-load of the farms with the least labour time was 23, 48, 40 and 36% of the workload at the five farms with the largest labour time during calving period, grazing period, indoor non-calving period, and across the entire year, respectively.

At the five farms with the low workload, four of the farmers worked off-farm, whereas only two farmers worked off-farm in the group with the high workload.

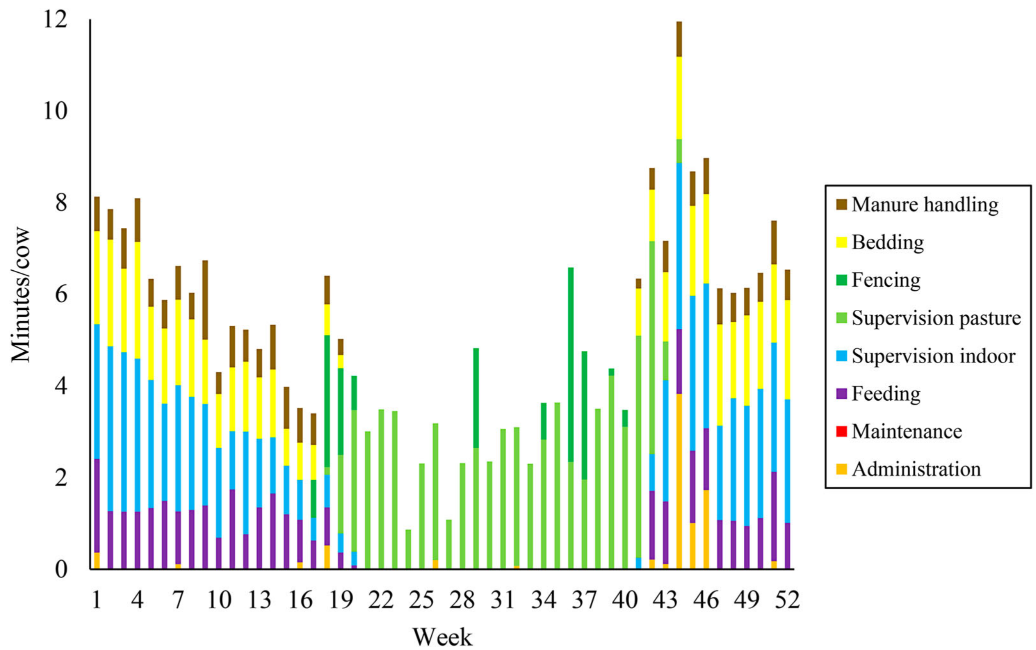

Figure 2. Labour time (min) per cow and week during a year logged continuously every day in a Swedish beef suckler cow farm with 69 cows, representative of the studied farms. Maintenance = maintenance of building and machinery, supervision pasture = supervision of animals and water supply on pasture.

Farms with low workload had one barn as a median, whereas farms with high workload had two barns. Both farm groups had cubicle housing as well as straw bed barns where the most common feeding strategy was to put silage bales on the feeding table. The median length of calving period was 61 days on the farms with low workload and 121 days on the farms with high workload.

Farms with a low workload had a median of five animal groups on pasture whereas farms with a high workload had three groups. The median value of the maximum distance from the farm centre to the pasture paddocks was four kilometres for farms with a low workload and seven kilometres for farms with a high workload (Appendix 2).

Discussion

The results of this study show that there is a large distribution in labour demand per cow and year (from 7.9 to 41.9 hours) among beef suckler cow herds in southern Sweden (Table 2 and Figure 4). A similar large distribution has also been found in Irish suckler cow production (Leahy et al., 2004; Fallon et al., 2006) and in Swedish indoor finishing bull production (Bostad et al., 2011). The five small farms (≤100 cows) with the least labour time per cow and day (furthest below the regression line, Figure 4) diverged most in workload compared to the five small farms with the largest labour time during the grazing period (Figure 5). In spite of having more animal groups on pasture, the farms with the least labour spent only 23% of the labour time that the farms in the high labour group spent during the same period.

Short SD (2001) categorized suckler cow operations both as being 'retirement and residential/lifestyle farms' and family farms of various sizes. These lifestyle farms studied by Short SD (2001) were part-time operations with small herds, less than 50 cows and having relatively high labour demand per cow. Nevertheless, these farms were generally profitable due to low total operating costs per cow stemming from having owned pasture resources to feed the animals. Short SD (2001) stated that suckler cow production tends to fit well into lifestyle farming compared to finishing cattle. The motivation for a lifestyle farmer in a Swedish context might not always be to achieve high labour efficiency, but rather an interest in animals and traditions, to be able to use existing resources or keeping biodiverse semi-natural grasslands around the residence open (Setten, 2002; Nitsch, 2009). A possible higher proportion of lifestyle farms in the present study on suckler cows than in the study on indoor finishing cattle of Bostad et al. (2011) might explain the larger dispersion in labour time in the suckler cow study.

Even in situations where labour efficiency is desirable, minimizing labour time is not the only goal. How the labour is distributed across the year and hence can be

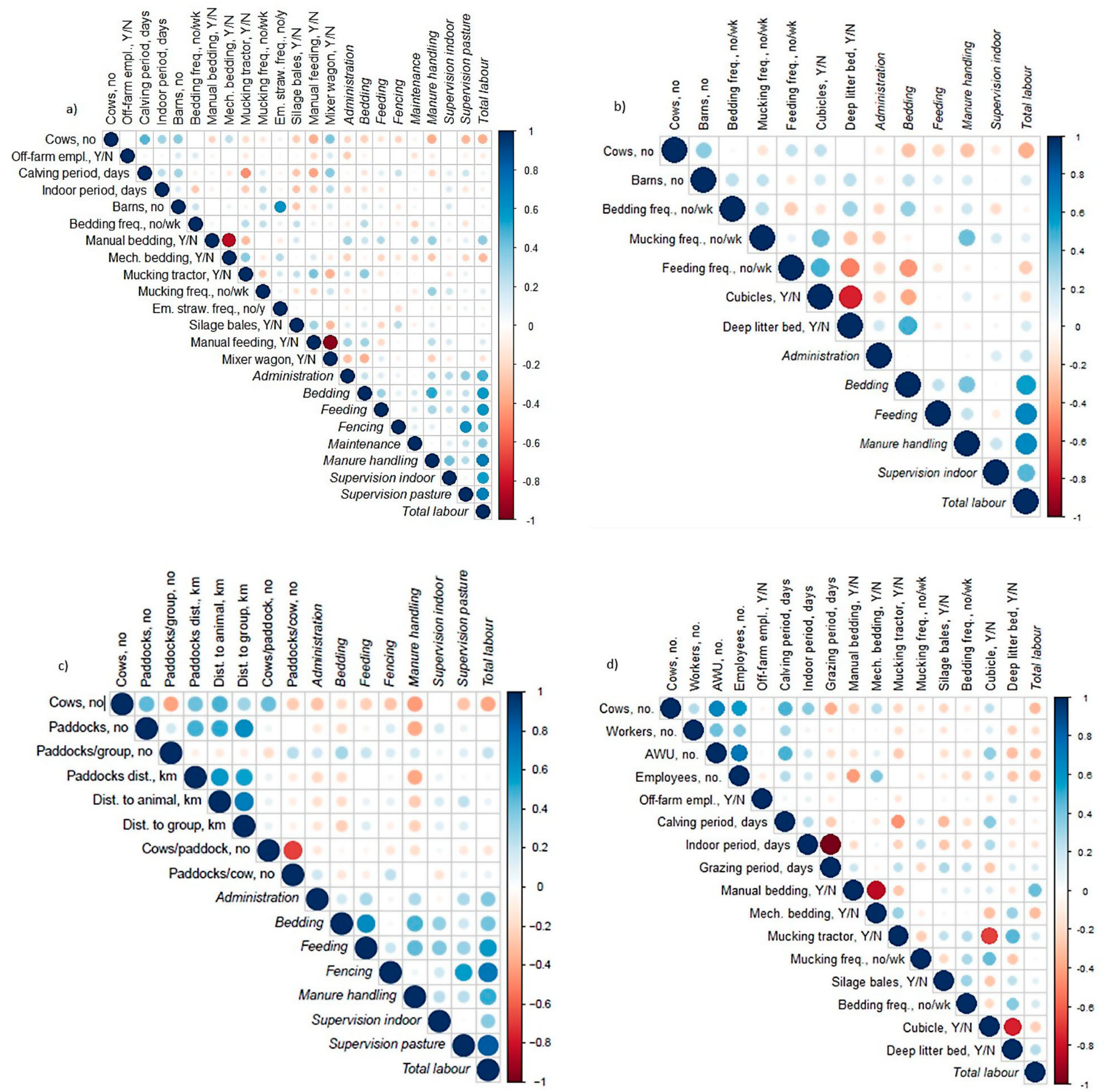

Figure 3. (a–d) Correlation matrixes for on-farm parameters (upright) and daily labour time (Italic) for (a) entire year, (b) calving period, (c) grazing period and (d) indoor non-calving period. Positive correlations are displayed in blue and negative correlations in red colour. Colour intensity and size of the circle are proportional to the correlation coefficients. Y/N = yes/no, freq. = frequency, dist = distance, AWU = annual working unit, off-farm empl. = off-farm work, both for owner and/or employees, mech. bedding = mechanical bedding and, em. straw freq. = emptying straw bed, no of times straw beds are mucked out during the year maintenance = maintenance of buildings and machinery.

combined with other engagement on and off the farm also needs to be considered (Figure 2). The large dispersion in labour time indicates an opportunity for improvements of competitiveness and efficiency in Swedish suckler cow production, where both lifestyle farms and very large, labour effective herds could be motivated.

The annual labour time per cow in the present study decreased along with an increasing herd size, which is in accordance to other studies (Short SD, 2001; Nelson, 2002; Schrade et al., 2005; Bostad et al., 2011; Agriculture and Horticulture Development Board, 2016). Based on all investigated herds, the annual labour time per cow is estimated to 25 hours for herds with 20 suckler cows, 17 hours for herds with 100 cows and 14 hours for herds with 200 cows (Figure 4). The shape of the regression curve for labour demand as a function of herd size (Figure 4) is similar to the one developed

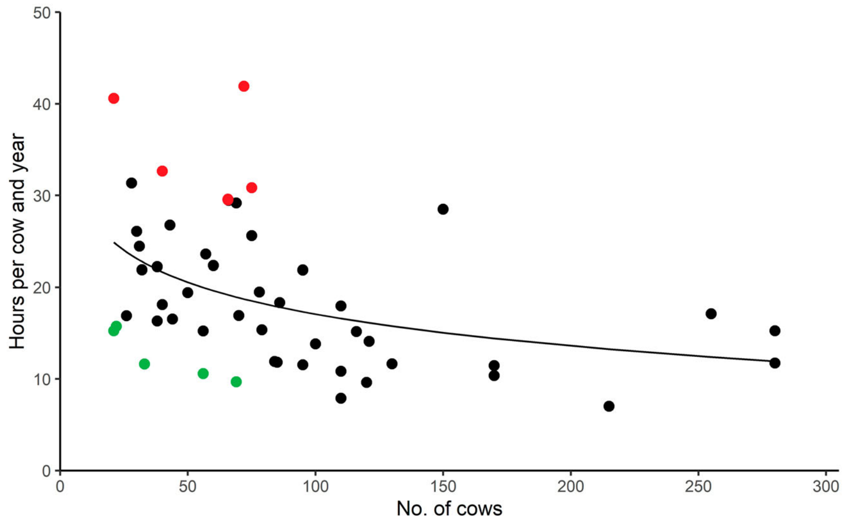

Figure 4. The points show labour time (hours) per suckler cow and year related to size in 49 Swedish beef operations. The logarithmic regression function has the form $y = 40–11.5 \times \log10(x)$, $R^2 = 0.17$, p-value <0.01. Five farms diverging most from the regression line are marked in green colour (below the line, least labour time) and red colour (above the line, largest labour time).

from a Swedish advisor's experiences up to 200 cows, but on a higher level of labour demand (Nelson, 2002). This discrepancy could partly be explained by the fact that our estimate includes labour time for administration, fencing, and maintenance of building and machinery, unlike the Nelson study. For herds larger than 200 cows, the curve from Nelson (2002) continues to fall while the largest herds in the present study have higher labour demand than both Nelson's estimate and the most labour efficient herds with 50–130 cows. The high workload in our largest herds could either indicate a decline in size advantage or be an artefact due to a low number of observations.

For housed beef cattle, a decreasing economies of scale previously has been explained by Bostad et al., (2011) and Finneran and Crosson (2013), who stated that when the optimum herd size has been reached, structural changes are better than scale changes for reaching further efficiency. This is in line with the results of our study, where herd size was positively correlated to number of barns during the calving period. Furthermore, the five small farms (≤ 100 cows) with the least labour time, compared to the regression line (Figure 4), had a median of one barn only, whereas the five small farms with most labour time had a median of two barns.

Although herd size in the present study was negatively correlated with labour demand per cow for the calving period and the indoor non-calving period, no effect of herd size was found on labour demand per cow during the grazing period. Instead, labour demand during the grazing period was more dependent on pasture fragmentation, as it was positively correlated with the time used for supervision on pasture and on fencing. Time spent on supervision of animals, water and fences on pasture was of great importance for the overall workload, as this was the single most time-consuming task across the year (Table 2). The suckler cows in the study grazed many small grasslands, scattered in the landscape between forests and arable land. Swedish livestock usually graze the same paddock continuously throughout the grazing period or is rotated among two or three paddocks with a few weeks' interval. The transport of cows to and between paddocks, and in some cases transports of water, were often over long distances, as well as the workers' transportation during animal supervision. The five small herds (≤100 cows) with the lowest workload per cow, compared to the regression line, had a median distance to the pasture of four kilometre, whereas the five small herds with the largest workload had a distance of seven kilometres. There was also a positive correlation between distance to paddocks with time spent on animal supervision indoors (Figure 3(c)). This could be explained by cattle being ill or needing extra supervision for some other reason, when the farmer is more inclined to keep them at home instead of on pasture if the distance to the paddock is long. Labour efficiency due to a large herd size during indoor periods were counter-acted by scattered location of and long distances to pasturelands during the grazing period. It might seem inconsistent that herd size was negatively correlated with time spent on supervision on pasture on a yearly basis, but not during the specific grazing period. This divergence is most likely because large herds in general have shorter grazing periods than smaller herds.

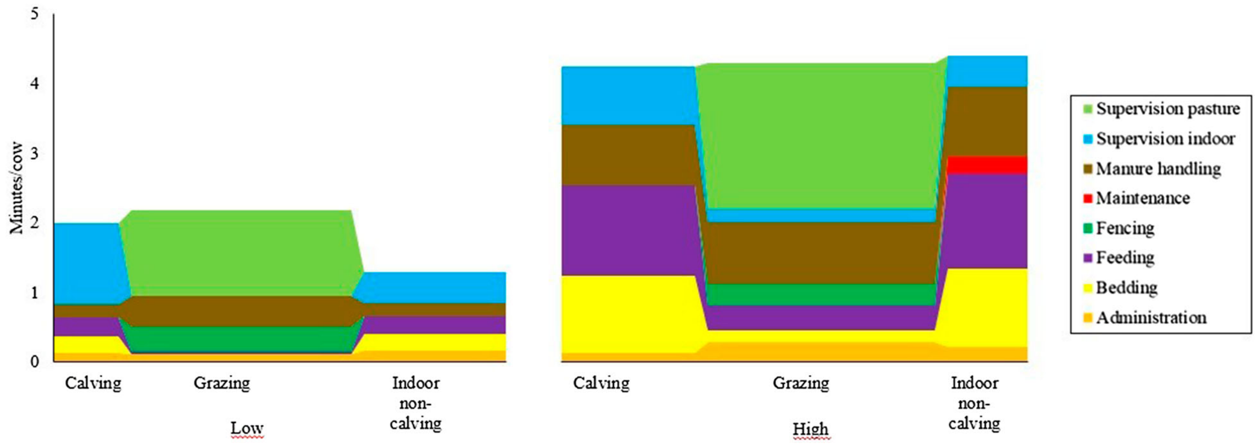

Figure 5. Median labour time (min) per suckler cow and day for the five farms with the least and the largest workload respectively, estimated as the largest deviation downwards vs. upwards from the regression line in Figure 4, in Swedish beef enterprises with ≤100 cows during calving, grazing and indoor non-calving period respectively, allocated into eight various tasks.

Fragmentation of pastureland has been noticed by other studies to decrease labour efficiency (Leahy et al., 2004; Fallon et al., 2006; Cederberg et al., 2018). For example, farmers interviewed by Cederberg et al. (2018) estimated labour time spent on supervision on scattered semi-natural pastures to be double when grazing one-hectare-paddocks compared to when grazing five-hectare-paddocks. Hence, due to variables related both to indoor and grazing periods, there are reasons to believe that the effect of herd size is not as large as was previously expected (Nelson, 2002).

Although there was a general negative correlation between herd size and labour time per cow, some small herds were also shown to have a low labour time per cow. The overall labour demand at the five small herds (≤100 cows) with the lowest workload was about half of the workload at the five small herds with the largest workload (Figure 4). A majority of these small farms with a low labour time per cow worked outside the farm, whereas the ones with a high workload did not. Work with the cattle may have a high opportunity cost for those who have a well-paid job outside the farm, whereas farmers who have no other work than the cattle may lack other income-generating work in certain parts of the year and hence it does not matter if the animal husbandry takes a little longer. When comparing full-time farmers with part-time farmers, Fallon et al. (2006) found part-time farmers to be more labour efficient than full-time farmers. Short SD (2001) also found that part-time lifestyle suckler cow farming could be labour efficient. In the present study we did not find any correlation between proportion of off-farm work and labour time for all the farms studied. Socio-economic factors, such as farmer's need of income-generating occupation, age and time in profession, as well as the quality of farm facilities, were not investigated, but could have influenced the result (Fallon et al., 2006).

Hence, the variation in labour demand suggests that relatively small and labour efficient herds, in combination with off-farm work, may sometimes be a good way to reach a satisfactory work/life balance compared to building up a herd that is very large for Swedish conditions.

In other countries (Leahy et al., 2004; Fallon et al., 2006; Agriculture and Horticulture Development Board, 2016) the labour demand per cow is generally lower than on most of the farms in the present study, but not always lower than the most labour efficient ones. The generally higher labour demand in Sweden may be due to the fact that Swedish production is generally small-scale, having a long indoor period and lacks both a long tradition of suckler cow production and large coherent pastureland. Hence, land structure and climate conditions affect labour demand and other costs, resulting in Swedish farmers having a higher total costs for beef production compared to other countries (Government Offices of Sweden, 2004). It should be noted that the herds in the present study on average were four times larger (88 cows) than the Swedish average suckler cow herd (22 cows); (Swedish Board of Agriculture, 2022). Schrade et al. (2005) reported larger annual labour demand in Swiss suckler cow herds (on average 38 hours routine work per cow including fencing and water supply on pasture) than in the previous study, which can be explained by a large demand in the Swiss alps, i.e. for travelling.

Maintaining a national Swedish suckler cow herd is important not only for food production, but also for preserving the biodiverse semi-natural grasslands, since almost half of that area is grazed by suckler cow operations (Swedish Board of Agriculture, 2021a). A prerequisite for long-term continued suckler cow operations is that they are profitable. During the last decades, structure rationalization has been high in dairy and pig operations, but not in beef production, and especially not in the suckler cow operations (Swedish Board of Agriculture, 2022). Family farm incomes are lower in Swedish beef production than in dairy and pig production (Swedish Board of Agriculture, 2021b). This is partly due to the costs in beef production having increased more than revenues during the last decades and especially the labour costs (Agriwise, 2000, 2022). Labour is one of the largest costs in suckler cow operations, accounting for approximately 20% of the total costs (Agriwise, 2022). Compensation to the owner for labour time and invested capital in beef production is lower than wages paid for employees (Swedish Board of Agriculture, 2021b). Therefore, is it of great importance to decrease labour demand in suckler cow production.

As previously discussed, supervision of animals, water and fences during the grazing period was found to be the most time-consuming task across the entire year, and the fragmentation of the pastures is a reason for the high workload. By creating larger coherent paddocks out of small scattered semi-natural grasslands and adjacent forestland and marginal arable land, the cattle can be kept in larger but fewer groups and the labour time hence be reduced (Holmström et al., 2018, 2021). Such arrangement has proved to be profitable (Holmström et al., 2018, 2021; Kumm and Hessle, 2020).

In spite of a similar structure of pastureland and animal group sizes, supervision of animals during the grazing period had a labour demand 2.5 times larger in the present study than in a previous Irish study (Fallon et al., 2006). This divergence can be explained by the fact that daily inspection of every single animal is mandatory due to the Swedish animal welfare regulation (Swedish Board of Agriculture, 2019). The actual time spent on supervision on pasture might even have been higher. If someone else than the farmers and their employees supervised the animals or fences, for example, a neighbour, this labour was not recorded. Furthermore, farmers commented that they do not always regard animal supervision as work, but leisure time, as they combined the work with walking the dog, etc. We did not ask the farmers whether all animals were supervised daily (as the Swedish law prescribes) or not. If they had, the time spent on supervision on pasture would have been much higher than presented (Högberg, 2021). At present, daily manual surveillance of every single animal is compulsory by the Swedish animal welfare regulation (Swedish Board of Agriculture, 2019). If animal surveillance achieved by digital sensors would be allowed, labour time spent on animal supervision would in future be possible to reduce by using new innovative decision support systems with remote surveillance of animal behaviour and welfare (Högberg, 2021). If supervision of suckler cows could be decreased from daily to twice a week, it would decrease the labour input by between 1.7 and 4.3 hours/cow/year.

Feeding was the most time-consuming task during the indoor non-calving period, similar to results on the farms studied by Schrade et al. (2005) and also finishing beef operations studied by Bostad et al. (2011), where feeding and bedding accounted for the highest labour demand. The tasks took longer time per animal for the suckler cow herds in our study than for the finishing cattle studied by (Bostad et al., 2011), which might derive from different herd sizes and the use of different types of barns and/or degree of mechanization.

The result from this study shows that for total annual labour time, mechanical bedding is of great importance in order to save labour time, which is similar to the results in other studies (Fallon et al., 2006; Bostad et al., 2011; Veysset et al., 2015).

In accordance with previous studies on finishing beef and suckler cows (Fallon et al., 2006; Bostad et al., 2011), we had expected that a higher frequency of feeding, bedding and manure handling would increase the total workload on the farms, but no such effect was found (Figure 3(d)). This is most likely due to a statistically confounding effect of higher frequencies and degrees of mechanization being positively correlated to herd size. A similar (confounding) effect might be in play for the structure of barns. Bostad et al. (2011) found that farm fragmentation increased labour demand in finishing beef production. As previously stated, the five small farms with the least labour time per cow had one barn, whereas the five small farms with the most labour time had two barns as a median. However, no correlation between labour time and number of barns was found on an annual basis when analysing all farms. Probably the size advantage of larger herds counteracted the extra work brought on by using several barns, so that larger herds with many barns still had less labour time than smaller herds. The declining size advantage for very large herds discussed above (Figure 4) could however be partly due to building fragmentation.

We found that the largest daily labour demand occurred during the calving period, which is similar to what Fallon et al. (2006) and Leahy et al. (2004) found in Irish herds. However, our study showed an average daily labour time per cow 10 times higher than Fallon et al. (2006), despite the larger average herd size in the present study. Large Swedish suckler cow herds often have two calving seasons, one during spring and one during autumn, whereas the study by Fallon et al. (2006) mainly was conducted on spring calving suckler-beef systems. The divided calving season is implemented in order to lower the daily work load during the labour-intensive period, to increase the use of the barn and to decrease risks of infection when spreading the calving period (Leahy et al., 2004).

In accordance with the calving period being the most labour-intensive period, we found that the small farms (≤100 cows) with lowest labour time per cow often had a short calving period (61 days compared to farms of similar size having the largest labour demand where the calving period was 121 days). No correlation between length of calving period and labour time could however be found. These inconsistent results are probably due to a confounded effect between herd size and length of calving period as larger herds generally had a longer calving period.

In this study we did not investigate how or if the farms used observation cameras or calving indicator equipment during the calving period, if they grouped the cows according to calving date, or if they practised night feeding, which leads to a higher probability of calvings to occur during daytime (Lowman et al., 1981). All these measures have previously been identified as good labour-saving practices during the calving period (Leahy et al., 2004; Fallon et al., 2006).

The response rate of this study was 20%. There might have been a selection bias due to the number of non-participants, but there was unfortunately no way to compare these with the participants. Our perception of the general reason for non-responding was a lack of time for the farmers.

According to Bostad et al. (2011) to underestimate labour time is more common than to overestimate it. In our study, especially the supervision on pasture and work with fencing might have been under-estimated as previously discussed. Some other tasks might also have been under-estimated. When comparing the on forehand estimates of seldom tasks from the interview, for instance mucking out straw beds, with the recorded actual labour time, some low figures in the former data source was found, indicating under-estimation.

Based on the results, it can be concluded that the median labour demand was 17 hours/cow/year, but varied greatly among farms, not only between herd sizes but also within herd size, with a variation from 7.9 to 41.9 hours. Herd size was negatively correlated with labour time per cow during the calving period and indoor non-calving period, but not during the grazing period when the cows often were allocated into groups and grazing fragmented pastureland. Supervision of animals, water and fences on pasture was the most time-consuming task across the year, whereas the calving period was the most labour-intensive period. The results show that labour demand of housed cattle can be reduced by mechanical bedding and having a short calving period. Even if there is a generally smaller labour demand per cow in larger herds, we conclude that small herds can be as efficient as larger ones.

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References

Abeyasekera, S. & Lawson-McDowall, J. (2001). *Computerising and Analysing Qualitative Information from a Study Concerning Activity Diaries* (Chatham: Natural Resources Institute).

Agriculture and Horticulture Development Board. (2016). Beef: Cost of production benchmarks - suckler herds. Accessed 13 June 2022, available at: https://ahdb.org.uk/beef-cost-of-production-benchmarks/suckler-herds.

Agriwise. (2000). Agriwise-SLU. Accessed 9 June 2022, available at: http://www.agriwise.org/Databoken/index_oldfiles_12.aspx.

Agriwise. (2022). Agriwise - Smart kalkylering. Accessed 5 April 2022, available at: https://www.agriwise.se/web.

Bostad, E., Swensson, C. & Pinzke, S. (2011). Labour input in specialist beef bull production in Sweden. *Agricultural Engineering International: CIGR Journal*, 13(3). Accessed 9 May 2018, available at: http://cigrjournal.org/index.php/Ejounral/article/view/1920.

Cederberg, C., Henriksson, M. & Rosenqvist, H. (2018). Ekonomi och ekosystemtjänster i gräsbaserad mjölk- och nötköttsproduktion. Chalmers tekniska högskola, Göteborg: Instutitionen för rymd-. geo- och miljövetenskap.

Eriksson, O. (2022). Coproduction of food, cultural heritage and biodiversity by livestock grazing in Swedish semi-natural

grasslands. *Frontiers in Sustainable Food Systems*, 6. Accessed 28 October 2022, available at: https://www.frontiersin.org/articles/10.3389fsufs.2022.801327.
European Commission. (2022). Database Eurostat. Accessed 28 February 2022, available at: https://ec.europa.eu/eurostat/web/agriculture/data/database.
Fallon, R. J., Leahy, H., O'Riordan, E. G. & Ruane, D. (2006). *A Study of Time and Labour Use on Irish Suckler Beef Farms* (Dunsany: Teagasc). Accessed 28 February 2022, available at: https://t-stor.teagasc.ie/handle/11019/1133.
Finneran, E. & Crosson, P. (2013). Effects of scale, intensity and farm structure on the income efficiency of Irish beef farms. *International Journal of Agricultural Management*, 2 (4), 1–12.
Gård & Djurhälsan. (2022). Accessed 5 April 2022, available at: https://www.gardochdjurhalsan.se/.
Government Offices of Sweden. (2004). Genomförandet av EU:s jordbruksreform i Sverige/ Implementation of the EU agricultural reform in Sweden. Accessed 16 November 2017, available at: http://www.regeringen.se/rattsdokument/departementsserien-och-promemorior/2004/01/ds-20049/.
Hanauer, M. (2015). Comparative Ecological and Functional Analysis of Grazing Systems. Regensburg: Der fakultät für Biologie und Vorklinische Medizin; Accessed 5 October 2022, available at: https://epub.uni-regensburg.de/33329/1/Dissertation_Maria%20Hanauer.pdf.
Högberg, N. (2021). *Sensing the worms - automated behaviour monitoring for detection of parasitism in grazing livestock*. Dissertation. Uppsala, Sweden: Swedish University of Agricultural Sciences, available at: https://publications.slu.se/?file=publ/show&id=111607.
Holmström, K., Hessle, A., Andersson, H. & Kumm, K.-I. (2018). Merging small scattered pastures into large pasture-forest mosaics can improve profitability in Swedish suckler-based beef production. *Land*, 7(2), 58. doi:10.3390/land7020058
Holmström, K., Kumm, K.-I., Andersson, H., Nadeau, E., Segerkvist, K. A. & Hessle, A. (2021). Economic incentives for preserving biodiverse semi-natural pastures with calves from dairy cows. *Journal for Nature Conservation*, 62, 126010. doi:10.1016/j.jnc.2021.126010
Kassambara, A. & Mundt, F. (2020). Factoextra: Extract and visualize the results of multivariate data analyses, available at: https://CRAN.R-project.org/package=factoextra.
Kumm, K.-I. (2006). Scenarios for profitable beef and lamb production. ResearchGate. Accessed 15 May 2017, available at: https://www.researchgate.net/publication/242112192_Vagar_till_lonsam_not-_och_lammkottsproduktion_Scenarios_for_profitable_beef_and_lamb_production.
Kumm, K.-I. & Hessle, A. (2020). Economic comparison between pasture-based beef production and afforestation of abandoned land in Swedish forest districts. *Land*, 9(2), 42. doi:10.3390/land9020042
Langemeier, M. R., McGrann, J. M. & Parker, J. (2004). Beef cattle handbook: Economies of size in cow-calf production. Accessed 24 April 2017, available at: http://www.iowabeefcenter.org/bch/CowCalfEconomySize.pdf.
Le, S., Josse, J. & Husson, F. (2008). FactoMineR: An R package for multivariate analysis. *Journal of Statistical Software*, 25 (1), 1–18. doi:10.18637/jss.v025.i01
Leahy, H., Ruane, D. J., O'Riordan, G. E. (2004). An investigation into the impact of farm labour use on Irish suckler beef farms. In: Dublin: 20th Annual Conference AIAEE, pp. 519–530.
Lowman, B. G., Hankey, M. S., Scott, N. A., Deas, D. W. & Hunter, E. A. (1981). Influence of time of feeding on time of parturition in beef cows. *The Veterinary Record*, 109(25–26), 557–559.
Nelson, B.-O. (2002). Kalkylmodell för nötköttsproduktion. Ängelholm: Skogs- och lantarbetsgivareförbundets analysgrupp.
Nitsch, U. (2009). Bönder, myndigheter och naturbetesmarker. Uppsala: Centrum för biologisk mångfald, Swedish University of Agriculture; Accessed 5 April 2023, available at: https://www.slu.se/globalassets/ew/org/centrb/cbm/dokument/publikationer-cbm/cbm-skriftserie/skrift23.pdf.
OECD. (2018). Innovation, agricultural productivity and sustainability in Sweden. oecd-ilibrary.org. Accessed 12 May 2022, available at: https://read.oecd-ilibrary.org/agriculture-and-food/innovation-agricultural-productivity-and-sustainability-in-sweden_9789264085268-en.
Paul, C., Nehring, R., Banker, D. & Somwaru, A. (2004). Scale economies and efficiency in U.S. agriculture: Are traditional farms history? *Journal of Productivity Analysis*, 22(3), 185–205. doi:10.1007/s11123-004-7573-1
Pykälä, J. (2005). Cattle grazing increases plant species richness of most species trait groups in mesic semi-natural grasslands. *Plant Ecology*, 175(2), 217–226. doi:10.1007/s11258-005-0015-y
R Core Team. (2022). R: A language and environment for statistical computing. Accessed 31 May 2022, available at: https://www.R-project.org/.
Redman, G. (2020). *John Nix Pocketbook for Farm Management for 2021* (Leicestershire: Agro Business Consultants Ltd). www.thepocketbook.co.uk.
RStudio Team. (2022). RStudio: Integrated Development for R, available at: http://www.rstudio.com/.
Schrade, S., Keck, M., Schick, M. & Krause, M. (2005). Determination of working-time requirement in suckler cattle farming using a combination of recording methods. Accessed 27 February 2022, available at: https://www.semanticscholar.org/paper/Determination-of-working-time-requirement-in-cattle-Schrade-Keck/c3aab12d821c13a47c7b9aae4ab782bb7de5eb1b.
Setten, G. (2002). *Bonden og landskapet* (Trondheim: Geografisk institutt, Norges teknisk-naturvitenskapelige universitet). Accessed 5 April 2023, available at: https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/265231/123952_FULLTEXT01.pdf?sequence=1.
Sheng, Y., Zhao, S., Nossal, K. & Zhang, D. (2015). Productivity and farm size in Australian agriculture: Reinvestigating the returns to scale. *Australian Journal of Agricultural and Resource Economics*, 59(1), 16–38. doi:10.1111/1467-8489.12063
Short SD. (2001). *Characteristics and Production Costs of U.S. Cow-Calf Operations* (Washington, DC: U.S. Department of Agriculture, Economic Research Service). Accessed 24 April 2017, available at: https://www.ers.usda.gov/publications/pub-details/?pubid=47151.
Swedish Board of Agriculture. (2019). SJVFS 2019:18: Statens jordbruksverks föreskrifter och allmänna råd om nötkreaturshållning inom lantbruket/The regulations and general advice of the Swedish Board of Agriculture about

cattle farming in agriculture. Jönköping, Sweden. Accessed 6 April 2023, available at: https://lagen.nu/sjvfs/2019:18.

Swedish Board of Agriculture. (2021a). Den vanligaste besättningsstorleken för kor för uppfödning av kalvar är 25-49 kor. Jordbruket i siffror. Accessed 9 June 2022, available at: https://jordbruketisiffror.wordpress.com/2021/11/10/den-vanligaste-besattningsstorleken-for-kor-for-uppfodning-av-kalvar-ar-25-49-kor/.

Swedish Board of Agriculture. (2021b). The farm economics surveys (JEU) 2021. Accessed 16 March 2023, available at: https://jordbruksverket.se/om-jordbruksverket/jordbruksverkets-officiella-statistik/jordbruksverkets-statistikrapporter/statistik/2023-02-24-jordbruksekonomiska-undersokningen-2021.

Swedish Board of Agriculture. (2022). Statistics Sweden. Accessed 27 February 2023, available at: https://jordbruksverket.se/om-jordbruksverket/jordbruksverkets-officiella-statistik/jordbruksverkets-statistikrapporter/statistik/2022-07-05-jordbruksstatistisk—sammanstallning-2022.

Veysset, P., Lherm, M., Roulenc, M., Troquier, C. & Bébin, D. (2015). Productivity and technical efficiency of suckler beef production systems: Trends for the period 1990–2012. *Animal*, 9(12), 2050–2059. doi:10.1017/S1751731115002013