Labour input in specialist beef bull production in Sweden

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Abstract: Labour input was investigated on 101 Swedish beef bull farms, representing 42% of all farms rearing 100-800 bulls annually in 2007. Work time studies were performed through questionnaires, supplemented by field studies on a smaller set of farms. Young bulls were of dairy or beef breed, purchased from age 7 to 365 days by specialist producers and finished to an average age of 17 (dairy breed) and 15.5 months (beef breed) and carcass weight 300 and 330 kg, respectively. Farms with different models of finishing, depending on calf age at purchase, were categorised into four groups as: 1) Pre-weaned, 7-61 days purchase age (PW), 2) weaned, 56-92 days purchase age (W1), 3) weaned, 107-168 days purchase age (W2) and 4) weaned, 180-365 days purchase age (W3). Total median labour input per bull for pre-defined work tasks was 6.4, 7.1, 4.0 and 2.7 hours, respectively, for these four different finishing models. Labour efficiency in the four models was 0.76, 0.94, 0.64 and 0.69 min/bull/day, respectively, i.e. with no difference in labour efficiency between farms rearing pre-weaned calves (PW) or calves weaned from 2-3 months of age (W1). No differences were found in total daily labour efficiency (min/bull/day) within the quarantine house and finishing sections, or in tasks common to both sections. Feeding was the most labour-intensive task, requiring 65-78% of daily labour input. Feeding time was not strongly affected by technique, but was shortest on farms operating with total mixed ration (TMR) (0.30 min/bull/day) (p=0.046). However, farms operating with TMR were also significantly larger, with 200 bulls (range 100-600) in the finishing house compared with 150 bulls (range 44-400) on farms feeding roughage and concentrates separately (labour input 0.52 min/bull/day). The effect of housing system on labour input for daily tasks was examined on the 65% of farms utilising only one type of housing system in the finishing house. Systems with slatted floor group pens (concrete or rubber flooring) had the lowest work time requirement (0.47 min/bull/day), followed by straw bedded pens with or without paved alleys (0.51 and 0.58 min/bull/day, respectively) and loose house cubicle systems (0.70 min/bull/day). A non-linear relationship was found between labour efficiency and bull unit size. Variations in work efficiency for finishing 100-200 bulls/year ranged from 0.2-3.0 min/bull/day in the finishing house, indicating possibilities for increased labour efficiency related to factors other than unit size. Labour input per bull was not significantly affected by unit size from 450 bulls/year (0.4 min/bull/day) to 960 bulls/year (0.3 min/bull/day), possibly indicating the highest level of labour efficiency achievable in Swedish beef bull production at present.

Keywords: calf, finishing cattle, work time, work efficiency, questionnaire

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1 Introduction

Challenges within the livestock sector such as declining produce prices and competitive imports place high demands on beef cattle producers to maintain economic sustainability. Swedish beef bull and steer producers will experience phasing-out of the male premium from January 2012 in line with the EU common agricultural policy (CAP), and therefore increasing productivity is essential to maintain competitiveness. Along with feed, animal stock and buildings, labour is

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one of the major production costs in cattle finishing, making up around 25-30% of invested costs (www.agriwise.se).

Only 27% of Swedish farmers currently work full-time on the farm, without any outside income (SJV, 2011). A Norwegian study of 2953 farm owners by Loewe (2003) reported that 40% worked full-time on the farm. Combined dairy and beef farmers were found to work the longest hours, on average 57 hours/week, to manage both enterprises. However, 60% of farmers stated that they would prefer to concentrate on farm work alone if farm revenues were acceptable and gave a better return on time invested. Increased labour efficiency is key to increased productivity and diversification linked to the farm, while it would also improve the scope for supplementary off-farm employment. The opportunity cost for labour may be the extra time for planning and decision making in the enterprise. With time for frequent interaction with relevant agents within agriculture, farmers could be better informed about the current market in terms of demands, prices and interests. A study on the effect of managerial capacity on different efficiency measures in Swedish dairy farms found that the most important factor in optimising productivity was to decrease input costs (Hansson, 2008a). Optimal use of labour is related to allocative efficiency, an efficiency measure aimed at combining inputs at the lowest production cost possible (Farrell, 1957). By improving the allocative efficiency, farmers would also be more likely to make decisions to improve the technical efficiency through increased outputs. Similarly, an improved labour pattern can free up time for valuable exchanges of experiences with other farmers or engagement in study groups, keeping the farmer updated and further educated. Efficient use of labour will not only increase economic sustainability, but also provide better opportunities for increased family life or social activities outside the farm. The agricultural sector is facing lower availability of hired or family labour (SJV, 2009) and improved working conditions for both farmers and farm staff is believed to be a significant measure for attractiveness to future successors and rural employment.

Aspects of labour use and organisation for competitive and sustainable animal production have been widely discussed (e.g. Benjamin, 2006; Ferris et al., 2006; O'Brien et al., 2006; Gleeson et al., 2008; Madelrieux et al., 2009; Quendler et al., 2009; Cournut and Chauvat, 2010). However, to our knowledge very few publications focus on the labour requirement in beef bull production. Farm advisors calculating profit contributions for Swedish beef cattle producers use a work time of 1 min/bull/day as a rule of thumb (Taurus, 2011). In a recent study of labour use on Swedish red veal farms of different sizes, median daily labour input for common, pre-defined tasks was 1.5, 0.6 and 0.6 min/calf/day for smaller (100-399 calves/year), medium (400-699 calves/year) and larger scale (700-1150 calves/year) farms (Bostad et al., 2010). Kung et al. (1997) measured a labour input of <1 min/calf/day to manage automatically milk and starter-fed dairy calves kept in groups, whereas calves individually housed in hutches and manually fed required 10 min/calf/day.

Swedish beef bull production is based on finishing bull calves from the dairy industry (Swedish Holstein and Swedish Red) and/or beef calves from suckler cows (mostly cross beef breeds). The calves are bought through meat marketing agencies or bilateral contracts between dairy farmers and beef cattle producers, or are finished on the farm of origin. By law, to prevent cross-infection and spread of diseases, calves under the age of four months and bought from more than one farm must be kept in quarantine in separate groups for a minimum five-week period before being moved for the last months of finishing (SJV, 2007). Within dairy calf finishing, two typical main forms can be distinguished: Farms purchasing 1) pre-weaned (1-8 weeks) or 2) weaned calves (~9 weeks), in 2010 reared to 18.8 months of age as a national average (Taurus, 2011). Suckler calves are generally purchased in late autumn (October-December) 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 17.5 months. However, for pure breeds slaughter age is in the range of 16.8 months for bulls of the heavy Limousin breed to 18.4 months for the lighter Hereford breed (Taurus, 2011). A fourth model is an intermediate form, where calves are bought aged between 4 and 6 months.

The choice of finishing model is dependent on a number of factors such as facilities on the farm, possible contracts and availability of calves. Calves are very sensitive to infections during the first weeks of their life (Svensson et al., 2003). Therefore in the present study we assumed that farms purchasing calves after weaning save work time in the quarantine house compared with those purchasing pre-weaned calves, even if age at slaughter is similar. The objectives of the present study were to investigate the current use of labour in Swedish beef bull production on farms with different finishing models and to identify factors with major influence on labour input and work efficiency.

2 Materials and methods

Records of all Swedish farms producing beef bulls during 2007 (n=9921) were obtained from the Swedish Board of Agriculture (SJV) in June 2008, under rules of confidentiality. The unit size ranged from 1 to 800 bulls per year, with average production of 15.1 bulls per year. The typical family farm is still very evident in Sweden and 89% of agricultural firms are registered as private businesses. Of these, 64% have their major occupations off-farm, and another 9% have important income from a subsidiary occupation (SJV, 2011). Thus, only 27% have their main employment on farms, explaining the highly skewed distribution of production unit sizes. To study the labour input on farms rearing beef bulls as an essential source of income, the commonly estimated work time is 1 min/bull/day (Taurus, 2011). A farm producing 100 bulls per year is thus estimated to spend about 2 hours per day (25% of full-time) on pre-defined tasks, including preparing and finishing up the daily work. Using a lower limit of farms spending 25% of full-time (450 h/year) on beef bull production, the 241 farms in Sweden producing 100 or more bulls annually (mean 174 bulls/year) were chosen from the register for further studies.

2.1 Farm classification

The selected farms were classified according to calf purchase age into four groups reflecting typical finishing models on Swedish farms: 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 beef breed bulls. As weaning age slightly differed between farms, the calf age distribution in groups PW and W1 overlapped around the age of 56-61 days.

2.2 Questionnaire

A modified version of a semi-structured questionnaire used in a previous labour study on Swedish red veal production (Bostad et al., 2010) was posted together with a covering letter in late April 2009 to the 241 farms with annual production of minimum 100 bulls. The questionnaire began with questions on farm structure and facilities, such as unit size, finishing model, breeds, type of buildings and housing and mechanisation level. Farmers were then asked to assess the work time requirement for 11 pre-defined tasks (as defined in Bostad et al., 2010) and the frequency of performance of these tasks. The tasks enquired about were common daily and non-daily on-farm tasks performed within, or strongly connected to, the animal house (Figure 1). Farmers were asked to return the completed questionnaire within 4 weeks.

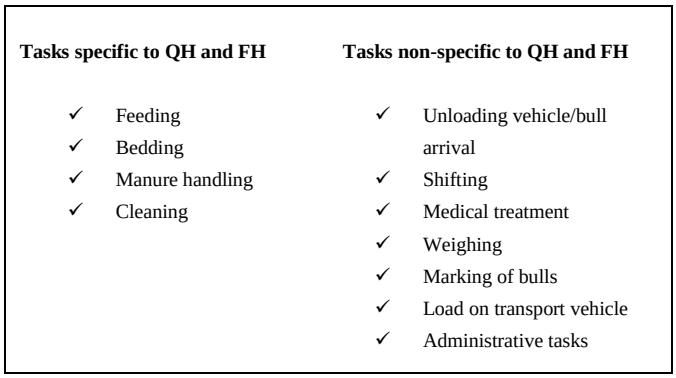

Figure 1 Common pre-defined work tasks in beef bull finishing where labour input was studied during the period in the quarantine house (QH) and the finishing house (FH)

2.3 Field study

To gain a deeper knowledge of the labour patterns on different farms and facilities, seven larger farms rearing 700-960 bulls/year and two farms with 200-500 bulls/year were contacted for farm visits with interviews. These farms were chosen and contacted according to beef bull unit size and due to failure to respond to the questionnaire, starting with the largest farms, until a sufficient number of farms had consented to participate in the study. The farmer or main worker involved with the pre-defined tasks was interviewed about topics addressed in the questionnaire so that data from both studies were comparable and could be analysed in the same dataset.

2.4 Labour efficiency measurements

Work time requirements related to 'feeding', 'bedding', 'manure removal' and 'cleaning' were parallel tasks, analysed separately for the period in the quarantine house (QH) and the finishing house (FH). Labour input for continual, non-daily animal handling tasks that were not strictly specific to quarantine or finishing house were analysed in relation to the rearing period as a whole (Figure 1). Labour efficiency in minutes/bull/period was analysed with the dependent factors calf age at purchase and farm size. The results are presented in a five-number summary, including minimum, lower and upper quartiles, median and maximum values.

2.5 Statistical analysis

Differences in labour use in min/bull/day or min/bull/batch were analysed by the Kruskal-Wallis test (non-parametric analysis of variance) in Minitab® Statistical Software, ver. 16.1 (Minitab Inc, 2010). The effect of calf age of purchase was tested using the Mann-Whitney test (non-parametric t-test) and that of dependent factors using Spearman's correlation of ranked variables.

In total, 111 farms responded (46% response rate). However, incomplete details regarding work time in five questionnaires and five farms reporting that they had stopped production resulted in 42% representation of beef bull farms. Among the responding farms, some had increased their production up to 960 bulls per year and three farms had reduced their production to 90 bulls per year. Labour inputs were analysed for 101 farms, whereof 68 farms provided data on two different applied models of finishing, i.e. purchasing calves at different ages, and were thus represented in more than one finishing model. Farms buying calves above 4 months of age typically only operated with finishing houses. Only six of these farms reported keeping calves in quarantine, and data from these are therefore not presented.

3 Results and discussion

3.1 Characteristics of respondents and farms

The characteristics of beef bull production within the four models of finishing (calf purchase age, annual production level, length of rearing period and slaughter age) are shown in Table 1. The number of bull calves in the quarantine house was significantly higher in PW than W1, but the number of bulls in the finishing house (160-220 bulls) was similar for all categories. Purchase of bull calves at 3-4 months of age (W2) was the least common model of finishing, and also a category where the larger farms managing >430 bulls in the finishing house were not represented. The overall average slaughter age was 1.8 and 2.0 months lower than the national average for dairy and cross-breed bulls, respectively (Table 1). This might reflect the fact that the sample of data represented only farms finishing bulls on a relatively large scale. The average age of responding farmers was 46.6 years (SD 9.9; range 27-66 years), whereof 10% were female. This was slightly

lower than the official proportion of 15% female farmers in Sweden (SJV, 2010), and presumably considerably lower than the true share (LRF, 2009). In all, 70% of the farms combined beef bull production with other animal enterprises, such as heifer rearing, dairy or sheep production, which is also typical for Swedish livestock farms. Of the respondents, 30% bought pre-weaned calves. As regards sources, 19% of the farms bought calves through the meat marketing agency, 20% bought calves from neighbouring farms and 4% finished calves from their own herd, but the majority of farms (57%) combined calves from two or more sources. No national statistics are available on how Swedish beef bull finishing farms are distributed according to source of beef calves or age of calves at purchase.

The median year of latest investment in a new building or conversion of a former building for beef bull production was 2004 (range 1978-2009). Around 90% of the farms with quarantine houses used only one type of housing system, mainly straw litter pens, while 64% of the farms used only one type of housing system for finishing (number of buildings unknown). A further 34% of the farms used buildings with two or three different housing systems, such as 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 farms reported using five different housing systems. This reflects typical utilisation of existing buildings and facilities in Swedish beef cattle production, where production units vary greatly in size in comparison with the more specialist dairy, pig and poultry production. By law, pre-inspection of the construction plans for animal houses designed for a certain number of animals is required according to the Swedish regulations on Animal Welfare (SJV, 2007). The annual number of applications for such pre-inspections of building plans reflects the current willingness to make larger investments in the livestock sector. The top investment period in buildings for finishing cattle, and also dairy production, was in the period 2005-2007, followed by a reduction in number of cases until 2010. During 2009-2010, cases of pre-inspection of buildings for less than 40 cattle (*n*=237) were as common as cases for more than 80 cattle (*n*=225) (SJV, 2010).

Overall, a total mixed ration (TMR) was used in the finishing house by 53% of the farms, whereof 3 farms operated with both separate feeding and TMR, and 47% fed roughage and concentrates separately, both feedstuffs typically ad libitum. Where bedding was supplied, the material was mainly straw and mechanically handled. Manure handling in buildings with straw bedding was performed by tractor. In loose house cubicles, solid floors with automatic scrapers were most common, but in the majority of buildings this was supplemented with once or twice daily manual scraping of cubicles. A major clean-out was generally done once every year in the finishing house, except for systems with slatted floors, where cleaning was performed more frequently. In the quarantine house, feed and bedding were generally manually distributed, mainly due to older buildings not being constructed for highly mechanised operations. Manure was typically removed with tractors of various models. Cleaning tasks were frequent in the quarantine house, typically between every six-week batch.

Table 1 Characteristics of farms with different finishing models

	Farm characteristics					
	n*	Min	Q_1	Median	Q_3	Max
Calf purchase age (d)						
PW	30	7	14	21[a]	51	61
*W*1	45	56	61	63[b]	76	92
*W*2	15	107	122	122[c]	153	168
*W*3	79	180	183	183[d]	214	365
No. of beef bulls/year						
PW	30	90	150	200	300	900
*W*1	45	100	120	150	200	960
*W*2	15	90	125	190	250	430
*W*3	79	90	120	180	250	960
No. of bulls in quarantine house						
PW	29	30	46	70[a]	105	200
*W*1	34	15	25	40[b]	60	180
No. of bulls in finishing house						
PW	30	100	150	220	308	800
*W*1	45	44	127	160	223	850
*W*2	15	100	125	180	300	450
*W*3	79	65	128	200	250	850
Period in quarantine house (d)						
PW	29	14	39	56	70	140

*W*1	34	28	35	56	63	172
Period in finishing house (d)						
PW	30	274	386	426[a]	459	587
*W*1	45	214	368	402[a]	452	549
*W*2	15	214	305	336[b]	397	442
*W*3	79	62	229	275[c]	305	427
Slaughter age (d)						
PW	30	427	485	519[a]	538	671
*W*1	45	397	488	519[a]	549	610
*W*2	15	366	442	488[ab]	534	564
*W*3	76	381	427	458[b]	488	763
Total rearing time (d)						
PW	30	386	449	474[a]	507	636
*W*1	45	321	418	456[b]	475	549
*W*2	15	214	305	362[c]	397	442
*W*3	77	62	237	275[d]	305	427

Note: *PW* = pre-weaned calves; *W*1 = purchase age 56-92 d; *W*2 = purchase age 107-168 d; *W*3 = purchase age 180-365 d.

*n=number of farms.

[abcd]Values (within columns) with different superscripts are significantly different (P<0.05).

3.2 Labour input

3.2.1 Total labour input

Total labour input per bull was 6.4, 7.1, 4.0 and 2.7 h/bull for the four farm categories, respectively corresponding to labour efficiency of 0.76, 0.94, 0.64 and 0.69 min/bull/day (Table 2). Total labour input per day in the quarantine and finishing houses and continual tasks indicated no effect of calf age at purchase on labour efficiency. The interquartile range (IQR) representing the 25% most efficient and the 25% least efficient farms was from approximately 3 h/bull (W3) to 6 h/bull (W1). With current wages of SEK 190 per hour (EUR 21), the lowest and highest IQR corresponded to a difference in labour costs of EUR 56 and EUR 118 per bull, respectively. As a comparison, the male cattle premium is at present approx. EUR 160. The large variations in labour efficiency between farms are not specific to beef bull production, but have been described in other cattle enterprises such as suckler beef farms (Leahy et al., 2004; Fallon et al., 2006) and Swedish dairy farms (Gustafsson, 2009).

Table 2 Daily labour input per bull in quarantine and finishing house and during continual tasks non-specific to house section

	Labour input					
	n*	Min	Q_1	Median	Q_3	Max
Quarantine house (min/bull/d)						
PW	29	0.39	1	1.37	1.71	3.51
*W*1	33	0.35	0.91	1.36	2.13	7.2
Finishing house (min/bull/d)						
PW	30	0.12	0.39	0.6	0.91	1.73
*W*1	44	0.16	0.47	0.65	1.11	2.28
*W*2	14	0.3	0.36	0.56	1.04	1.44
*W*3	78	0.12	0.34	0.59	1	2.76
Continual tasks (min/bull/d)						
PW	28	0.03	0.06	0.09	0.14	0.32
*W*1	45	0.01	0.06	0.11	0.18	0.56
*W*2	14	0.01	0.06	0.07	0.13	0.32
*W*3	71	0.01	0.06	0.1	0.16	0.37
Quarantine house (min/bull)						
PW	29	21.34	40.71	76.81	102.4	249.6
*W*1	33	9.9	33.5	73.5	129.8	416.4
Finishing house (min/bull)						
PW	30	59.5	175.7	245.1	348.7	535.7
*W*1	44	73.2	169.2	288.2	495.5	1041.9
*W*2	14	89.4	124.2	184.6	403.4	457.7
*W*3	78	27	92.3	135.9	260	798.9
Continual tasks (min/bull)						
PW	28	16.1	28.84	44.66	75.32	131.2
*W*1	44	6.04	26.05	42.78	67.76	203.7
*W*2	14	5.11	22	29.52	41.25	67.8
*W*3	71	1.28	16	25.67	41.44	124.5
Total time (h/bull)						
PW	30	1.85	4.8	6.40[a]	8.55	12.82
*W*1	45	1.7	4.81	7.13[a]	10.44	18.8
*W*2	15	1.7	2.62	4.00[b]	7.05	8.42
*W*3	79	0.62	1.9	2.72[b]	4.56	14.51
Work efficiency (min/bull/day)						
PW	30	0.21	0.54	0.76	1.1	1.86
*W*1	45	0.22	0.65	0.94	1.4	2.5
*W*2	15	0.31	0.48	0.64	1.13	1.8
*W*3	79	0.18	0.46	0.69	1.11	3.01

Note: *PW* = pre-weaned; *W*1= purchase age 56-92 d; *W*2 = purchase age 107-168 d; *W*3 = purchase age 180-365 d.

*n=number of farms.

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

Rearing pre-weaned calves was expected to have the highest labour input, but there was no significant effect on labour input per bull between rearing calves from a median age of 21 days (0.76 min/bull/day) or 61 days (0.94 min/bull/day). The majority of the farms buying pre-weaned (PW) calves of dairy breed were instead able to shorten the rearing period relative to farms purchasing weaned calves (Table 1). This suggests that with good calf management, young calves gain advantages from early arrival on the farm through increased daily growth, despite the health risks at very young ages (Svensson et al., 2003). The work requirement on W1 could be related to the higher age of the bulls in the quarantine

area, as they need more feeding and bedding and are thus as time-consuming overall as younger calves.

Daily labour input for the pre-defined work tasks was between approx. 1.0 and 2.0 hours in the quarantine house and around 2.0 to 2.5 h in the finishing house (Table 3). The less frequently performed tasks non-specific to the quarantine or finishing house (Figure 1) required 0.2-0.4 h/day.

Table 3 Daily labour input in quarantine and finishing house and during continual tasks non-specific to house section

	Daily labour input						
	n*	Min	Q_1	Median	Q_3	Max	%[i]
Quarantine house (h/day)							
PW	29	0.44	0.92	1.70[a]	2.6	4.7	37
*W*1	29	0.2	0.53	0.90[b]	1.9	4.8	22
Finishing house (h/day)							
PW	30	0.61	1.41	2.5	3.25	8	54
*W*1	44	0.34	1.5	2.5	3.1	8	68
*W*2	14	0.58	1.25	1.73	3.13	4.3	89
*W*3	78	0.34	1.4	2.1	3.1	10.11	87
Continual tasks (h/day)							
PW	28	0.2	0.29	0.39	0.8	1.81	8
*W*1	44	0.05	0.24	0.35	0.63	3.4	10
*W*2	14	0.12	0.16	0.22	0.48	0.8	11
*W*3	71	0.07	0.2	0.3	0.56	1.38	13

Note: *PW* = pre-weaned; *W*1 = purchase age 56-92 d; *W*2 = purchase age 107-168 d; *W*3 = purchase age 180-365 d.

*n=number of farms; [i]=Relative amount of daily labour input.

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

3.2.2 Work tasks specific to quarantine and finishing house

The period in quarantine represented about 12% of total rearing time (Table 1) and approximately 20% of total labour input (Table 4). Feeding required the highest proportion of work time in both the quarantine and finishing house, followed by bedding tasks. The higher labour input for bedding in quarantine among W1 farms could be explained by the need for higher amounts and more frequent additions of bedding for older calves. Total labour input for manure handling in the quarantine house was not affected by the age of calves at purchase. The high variation between PW farms on labour input for cleaning could be related to a higher demand for sanitation when purchasing pre-weaned calves, and is also a measure of stockmanship. Previous studies have shown a positive effect on veal calf performance if the farmer has a positive attitude to cleaning tasks (Lensink et al., 2001).

Table 4 Labour input during pre-defined tasks in quarantine houses

	Labour input in quarantine house					
	n*	Min	Q_1	Median	Q_3	Max
Feeding (min/bull/d)						
PW	28	0.27	0.64	1	1.3	3
*W*1	33	0.15	0.6	0.9	1.4	6
Bedding (min/bull/d)						
PW	25	0.04	0.09	0.14[a]	0.19	0.56
*W*1	31	0.01	0.14	0.21[b]	0.38	1.33
Manure handling (min/bull)						
PW	25	0.53	2.1	4.59	7.87	80
*W*1	31	0.83	2.58	4.13	8.81	80
Cleaning (min/bull)						
PW	26	0.42	1.04	2.66	6.5	12.6
*W*1	30	0.5	1.15	2	3.6	15.02

Note: *PW* = pre-weaned calves; *W*1 = purchase age 56-92 d.

*n=number of farms

[ab]Values (within rows) with different superscripts are significantly different (P<0.05).

Feeding tasks in the finishing house consumed between 72-95 min/day (Table 5). Bedding tasks were highly mechanised on most farms, as reflected by the high work efficiency. Work time for manure handling was highly variable from farm to farm, and was only notably different on W1 and W2. Several of the farmers in these categories carried out manual scraping of manure from lying areas once or twice daily. As an example, a 30-min daily routine equalled 54 min/bull on W1, while another farm that reported spending 1 hour in the morning and 1 hour in the evening spent a total of 458 min/bull.

Table 5 Labour input during pre-defined work tasks in the finishing house

	Labour input in finishing house					
	n*	Min	Q_1	Median	Q_3	Max
Feeding (min/bull/d)						
PW	29	0.06	0.27	0.43	0.80	1.20
*W*1	44	0.12	0.33	0.49	0.90	1.36
*W*2	14	0.15	0.24	0.40	0.88	1.20
*W*3	77	0.08	0.25	0.40	0.63	1.64
Bedding (min/bull/d)						
PW	19	0.01	0.06	0.07	0.10	0.20

*W*1	29	0.01	0.04	0.08	0.26	0.75
*W*2	10	0.01	0.03	0.07	0.14	0.21
*W*3	63	0.01	0.06	0.11	0.19	0.75
Manure handling (min/bull)						
PW	20	2.70	7.52	15.38	31.82	60.74
*W*1	34	0.90	10.00	25.40[b]	82.10	457.5
*W*2	11	3.64	7.41	21.68	29.80	89.51
*W*3	68	0.66	4.53	8.19[a]	27.03	274.5
Cleaning (min/bull)						
PW	27	1.90	5.10	9.10	13.40	388.4
*W*1	39	1.00	4.10	6.00	10.63	62.74
*W*2	13	1.34	5.15	5.87	11.60	13.55
*W*3	65	0.74	2.60	4.55	7.61	38.34
Unloading truck (min/bull)						
PW	27	0.60	2.60	16.55[a]	26.14	61.14
*W*1	40	0.30	3.50	11.00[a]	26.53	64.29
*W*3	13	0.50	1.40	3.25[b]	5.55	16.80
*W*4	67	0.10	1.50	3.94[b]	10.50	38.57
Shifting (min/bull)						
PW	26	2.60	5.82	8.80[a]	19.80	40.76
*W*1	43	1.60	5.00	11.50[a]	21.70	94.11
*W*3	12	1.40	3.41	7.84[a]	13.10	17.60
*W*4	59	0.71	2.23	4.00[b]	7.90	57.60
Weighing (min/bull)						
PW	11	1.90	3.95	6.50	13.20	35.78
*W*1	19	1.40	4.50	6.92	13.10	68.29
*W*3	8	2.90	3.50	6.37	10.40	21.92
*W*4	34	0.90	3.50	5.93	8.80	38.60
Marking (min/bull)						
PW	9	0.22	2.00	2.00	3.83	6.50
*W*1	15	1.10	4.60	4.60	7.50	31.37
*W*3	7	2.90	3.40	4.61	8.80	21.92
*W*4	31	0.87	2.50	4.80	8.73	38.60
Loading onto truck (min/bull)						
PW	26	0.70	1.94	4.22	5.70	32.50
*W*1	43	0.40	2.50	4.51	6.40	12.00
*W*3	13	1.60	2.50	3.25	5.30	16.80
*W*4	69	0.40	2.10	3.10	5.00	18.00
Medical treatment (min/bull)						
PW	22	1.00	3.35	4.93[a]	6.83	23.00
*W*1	35	0.30	1.73	3.20[a]	6.54	20.00
*W*3	12	0.90	1.72	3.40[a]	4.34	8.50
*W*4	50	0.04	0.80	1.50[b]	3.45	6.90
Administration (min/bull)						
PW	28	1.51	3.68	6.41	10.84	22.76
*W*1	42	0.60	4.10	6.80	13.90	101.30
*W*3	13	1.68	3.70	5.03	11.20	22.22
*W*4	69	0.64	2.60	4.62	9.44	68.63

Note: *PW* = pre-weaned calves; *W*1 = purchase age 56-92 d; *W*2 = purchase age 107-168 d; *W*3 = purchase age 180-365 d.

*n=number of farms

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

3.2.2 Work tasks non-specific to quarantine and finishing house

Work time related to the non-daily work tasks were equivalent to 1.4-2.8 hours/week or 6-12 hours/month as shown in Table 3. As regards total labour input per bull required for these tasks (Table 6) PW farms had the expected effect of increased labour during unloading of calves, as they are often transported with private trucks. 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. Median labour input for weighing bulls was between 6 and 7 min/bull, ranging from 3.5 min/bull for the 25% most efficient farms up to 13.2 min/bull for the 25% least efficient. However, that finding should be interpreted in relation to the low number of farms (n=41) weighing the bulls. Even fewer (n=31) marked the bulls as they reached slaughter age and were ready to be sold. The labour input for this task was 2-5 min/bull, but it is seemingly an efficient way of selecting bulls without having to group new individuals before transportation where intact groups are not slaughtered in the same week and thus maintain the ordinations within the group of individuals familiar to each other (Mounier et al., 2005; Raussi et al., 2005; Mounier et al., 2008). Medical treatment of dairy calves required most likely a significantly higher amount of labour than beef calves purchased after 183 days of age. As regards labour input for administrative tasks they were of the more labour demanding non-daily tasks with no difference between the finishing models.

Table 6 Labour input during pre-defined continual tasks

	Labour input during tasks non-specific to QH or FH					
	n*	Min	Q_1	Median	Q_3	Max

The results of labour input in the present study are restricted to the 11 pre-defined tasks, and the median for finishing models PW and W1 was already close to the rule of thumb of 1 min/bull/day (Taurus, 2011). Furthermore,

labour input exceeded 1 min/bull/day for 30%, 42%, 40% and 36% of PW, W1, W2 and W3, respectively. Therefore, including the time spent preparing and finishing up after the work day and time spent on unforeseen tasks, it is possible that the labour requirement is underestimated in calculations for many farms.

3.3 Effect of beef bull unit size

The international trend during recent decades for fewer but larger production units has also been evident in Swedish beef cattle production. The relationship between herd size and economic efficiency is widely discussed and cited (e.g. Langvatn 1960; Hall and LeVeen, 1978; Bravo-Ureta and Rieger, 1991; Tauer and Mishra, 2006). A decrease in cost per output is often observed as farm or herd size increases, but there is no evidence that only the largest farms can be competitive if use of resources is optimised. Findings by Hansson (2008b) and Gustafsson (2009) show the importance of knowledge of the different factors that need improvement during the expansion of a dairy farm.

The beef bull farms that responded to our questionnaire were categorised into four sets according to existing unit size: I) 90-150 bulls (n = 70, IQR 44), II) 170-250 bulls (n = 43, IQR 50); III) 280-350 bulls (n = 20, IQR 44); and IV) >400 bulls (n = 14, IQR 200). The median age of calves at purchase for categories I-IV was 92, 107, 76 and 105 days, respectively, and slaughter age was 488, 503, 519 and 488 days. The relationship between labour efficiency and beef bull unit size was particularly evident as the latter increased from 100 to 350 bulls per day, but was also characterised by large variations between the farms within these size categories. The very large variations within farms producing 100-200 bulls per year, ranging from 0.2 min/bull/day to 3.0 min/bull/day in the finishing house (median 0.8 min/bull/day), indicate that within farms of these sizes there are important factors other than herd size affecting labour efficiency. The relationship observed here followed a typical pattern described by Langvatn (1960) of an evident increase in efficiency on smaller farms up to 450 bulls/year, beyond which labour input per bull was not significantly affected by unit size (0.4 min/bull/day) compared with farms producing 960 bulls/year (0.3 min/bull/day). This is possibly close to the highest level of labour efficiency in Swedish beef bull production at present. Gustafsson (2009) found an effect of farm size on milking tasks but that feeding tasks were not more efficient as herd size increased, which is also in line with findings reported by Hansson (2008b).

The number of bulls in the quarantine house on PW farms was nearly double that on W1 farms (Table 1), but an effect of unit size could not be found for the work in the quarantine house. The buildings used as quarantine houses are often older, low cost buildings with poor logistics and are thereby more labour-demanding. With an increase in unit size, the working day also became longer. Total labour input per bull was 6.1, 4.8, 3.4 and 2.8 h/bull for the four unit size categories, respectively. The daily labour requirement (Table 3) also reflects the effect of unit size, as 25% of the smallest farms had between 123 and 150 bulls in the finishing house while the 25% largest farms managed between 229 and 300 bulls daily. Daily work time in the finishing house increased with farm size from 1.7 h/day (category I) for the smallest group of farms to 3.5 hours/day for the largest (category IV). Approximately 2.5 hours per week were spent on the common, continual tasks of animal handling and administration tasks in farm size categories I and II, whereas categories III and IV spent 5 hours/week on these tasks. However, labour efficiency for animal handling and administration work was not affected by farm size, requiring 1.0 min/bull/week in all farms size categories. This confirms findings in a labour study of red veal calf production (Author et al., 2010), and illustrates the importance of proper animal handling systems as farms are extended, as well as the increasing administration burden on today's farmers.

3.4 Effect of housing and mechanisation level

The rearing period in the finishing house was only different between farm size categories in terms of number of days. In all, 67 farms (64%) operated with one housing system, whereof 11 had loose cubicle houses, 22 slatted floor houses, 25 buildings with straw-bedded group pens with scraped alleys, 7 houses with full litter

boxes, 1 tie stall and 1 unknown type of housing. Time requirement for feeding per day was not affected by housing type, with labour inputs from 0.3 to 0.4 min/bull/day. The only exception was in the tie stall and the unknown building type, where feeding required 0.6 and 1.6 min/bull/day, respectively. Systems with slatted floor group pens had the lowest work time requirement (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. Straw-bedded systems are recognised as positive in terms of animal hygiene, health and welfare (SCAHAW, 2001; Absmanner et al., 2009), while deep litter systems are typically dependent on straw being available at a reasonable cost and are often also associated with increased labour demand (e.g. Tuyttens, 2005). However the everyday maintenance of loose house cubicles was in several cases shown to have an overall higher total effect on labour input than the handling of straw (bedding and deep litter removal), indicating a need for thorough evaluation of the labour costs versus the cost of the housing system.

Feeding total mixed ration (TMR, n=34) required 0.42 min/bull/day and separate feeding of grass silage and concentrates (n=33) required 0.63 min/bull/day (p=0.046). However, the labour-saving effect of TMR cannot be totally confirmed, as 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). Feeding TMR means that the rumen pH is more stable throughout the day, facilitating microbial fermentation and reducing the risk of feed-related metabolic diseases. The use of TMR is therefore generally considered productivity-enhancing and labour-saving (Gordon et al., 1995; Keane et al., 2006). However studies on finishing cattle have shown no significant effect of TMR on animal performance, carcass traits or labour efficiency (Caplis et al., 2005; Ferris et al., 2006). It is therefore crucial to consider the facilities and possibilities of decreased labour input versus possible performance improvements on the individual farm before changing to a new feeding system.

3.5 Frequency of task

The bulls were fed twice daily in most (70%) quarantine houses, and in 52% of finishing houses. Compared with farms feeding once daily, farms with twice daily feedings had 38 and 120 minutes higher labour input per bull in quarantine and finishing house, respectively. Bedding tasks were more frequently performed in the finishing house (daily basis) than the quarantine house (weekly basis). Overall, 51% of farms handled bedding material daily or every second day. Once or twice daily bedding tasks increased total labour input per bull by 6 and 20 min per bull in the quarantine and finishing house, respectively, compared with performing bedding tasks every second day. As also found in a study of Irish suckler beef farms by Fallon et al. (2006), frequency of tasks had a large effect on the total labour input and is an essential factor to consider when labour costs are analysed and work is being organised on the individual farm.

4 Conclusion

Total median labour input per bull for pre-defined tasks was 6.4, 7.1, 4.0 and 2.7 hours respectively, for the four different finishing models studied. The wide variation between the 25% most and the 25% least efficient farms indicates possibilities for improvements in the efficiency and competitiveness of Swedish beef bull production. Furthermore, the rule of thumb of 1 min/bull/day commonly used in profit contribution calculations might be an underestimated in many cases. This work time study revealed that farm productivity could be increased by purchasing pre-weaned calves instead of buying the calves weaned at 2-3 months of age. The time-saving loose house systems spent a surprisingly high amount of labour on daily manure removal duties. The weak effect on labour efficiency of using TMR must be recognised when planning for labour-saving feeding strategies.

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