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How can working time analysis contribute to the production efficiency of dairy farms in mountain regions?

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ABSTRACT

The aim of the present study was to (1) estimate the labour input on loose and tie stall housing dairy farms in South Tyrol; (2) to develop a tool for the extension service available to propose strategies for improving labour productivity. The study performed on 102 dairy farms, half of them with tie and half with loose housing. Daily and non-daily working activities surveyed with a questionnaire. Nine tie stall and 10 loose housing farms were selected for on-site measurements to determine the working time of each activity and validate questionnaire data. Average herd size was 16.3 and 23.2 cows for tie stall and loose housing farms, respectively. Effects of housing type and herd size category on total and single working time were examined. In tie stalls and herd size <10 total working time was estimated as 270 manpower hours (MPh) per cow per year while loose housing and herd size >21 cows required 82 MPh/cow/year. Labour costs were estimated as 34.9 and 19.2 Euro cents per kg of milk for tie and loose housing, while milk production per working hour determined as 56.9 and 86.7 kg/MPh, respectively. The required MPh/cow/year decreased as the herd size increased. Efficient organisation of working time with an increase in herd size might improve production efficiency and sustainability of mountain dairy farming. However, it has to be taken into consideration that because of limited space and the fact that most farmers are only working part time on farm, the improvement of labour management is of higher importance.

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Introduction

In mountainous regions, livestock farming is one of the main pillars that supports the maintenance of the heterogeneous landscapes and contributes to the sustainability of the local biodiversity (Battaglini et al. 2014), while at the same time provide income for local communities. Mountainous ecosystems, although they are under constant pressure due to differentiation of land use management, infrastructure development or global socio-economic transitions, manage to adapt to those changes and maintain the local farming practices (Schermer et al. 2016). Specifically, in alpine areas, studies have shown that livestock farming has been traditionally a key supporter in the maintenance of the local economy, while simultaneously, the development of agritourism activities can contribute to the sustainability of the social structure in those areas (Sturaro et al. 2013). Lately the importance of the development of agritourism, have been clearly recognised since it not only motivates local population to maintain their livestock holdings in the mountainous areas but also leads to an improvement of farmers' incomes without altering the agricultural character of mountainous areas (Streifeneder 2016). Moreover, food originated from those small scale mountain farms with the use of traditional production methods, might be associated with higher quality and nutritional value of the products, promoting at the same time environmental sustainability, landscape biodiversity and animal welfare (Farrugia et al. 2014). However, latest observations in those areas showed that farmland abandonment due to economic, structural, social or other regional factors is increasing (Battaglini et al. 2014). More specifically in alpine areas, the number of farms constantly decreased over the past three decades (1980–2010). In 2010, there has been a significant reduction in cattle farms (–54%) in the seven alpine countries and also a remarkable decline in the number of animals (–23%) (Battaglini et al. 2014). The observed decrease has caused not only environmental consequences but also

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a rapid reduction in the income of the remaining farmers. In comparison to other European countries, the situation in South Tyrol, is more stable (Rinner et al. 2011), since their number has decreased by only 15.9% during the abovementioned period (Streifeneder et al. 2014). Concerning dairy farming, South Tyrol is characterised by small herd sizes while 4886 dairy farms deliver milk to the local processing plants (Sennereiverband Südtirol 2015).

Though loose housing is becoming more and more common in larger farms, tie stalls are still the dominating husbandry system in alpine regions (Sennereiverband Südtirol 2015). In tie stalls, the cow's ability to move freely is restricted, while many other activities through which the animal can express its natural behaviour are restrained. Furthermore, cows spend most of their life in the barn while grazing on alpine areas is becoming less common. This means that performance of the animals is considerably influenced by the housing conditions (Weisz et al. 2011). Since, the barn is the major workplace for farmers, labour efficiency partly depends on the structural arrangement and technical equipment of the buildings, while the high labour intensity led especially larger farmers to change to loose housing. However, due to economic reasons, since altering from tie to loose housing requires capital investment, lack of space availability and to the familiarity with the system and the regular intimate contact with the cows (CIGR 2014), tie stalls are still favoured by many small-scale farmers. Furthermore, the introduction of new technologies, and the alteration from tie stall to loose housing barns, is often only justified if herd sizes can be increased and/or succession planning is ensured. It has to be noted here, that for small scale farms a well-equipped pipeline milking system might be favourable in terms of labour efficiency compared to milking parlours since it requires less labour e.g. for cleaning. On the contrary, the advantages that loose housing offers concerning labour input, is the integration of working activities that require high labour input such as milking and feeding (Schick et al. 2015).

Regardless of the housing systems, farmers in mountainous areas are also facing difficulties concerning the fluctuation in milk prices, which coupled with the increasing labour cost, may force them to abandon their farms. However, in order to prevent the reduction in the number of farms García-Martínez et al. (2009) showed, that the transfer of farm activities to the next generation can be positively related with an increase on farms' herd size, and an improvement to the farmers' social life. However, those parameters, in order to act effectively in the sustainability of mountainous farms, must be combined with an improvement in labour efficiency (Schick 2008). In order to enhance labour productivity, labour resources have to be used efficiently (FAO, IDF 2011). Labour costs constitute, in addition to fixed costs for buildings and machinery, the highest costs in milk production. Consequently, an efficient organisation of work and knowledge of the working time and effort required for the various work processes is the basis for improvements and economic success (Quendler 2011). To date, however, little is known about the working time and effort required on dairy farms with different housing systems in alpine regions. Although there are studies that describe the situation in the farm of the alpine areas concerning productivity (Streifeneder et al. 2014), production and management practices (Stuppner 2016), machinery used (Laur et al. 2011), number of workers employed in livestock and the impact on social indexes (Sturaro et al. 2013), data regarding manpower expenditure are still missing. The aim of the present study was to (1) estimate the labour input on dairy farms with loose and tie stall housing in South Tyrol, Northern Italy and (2) propose strategies for improving labour productivity.

Materials and methods

According to the methodological approach of Auernhammer (1979), a questionnaire was designed to collect data on farm structure, barn management, housing facilities, labour stock, livestock, milking system and routines, manure removal and feeding. The questions were completely standardised (single answer choice from a list or self-completion answers). In addition, farmers were asked to estimate their working time for different activities (milking, feeding, manure removal and bedding, care of young calve and cattle, special tasks such as hygiene or management practices). This procedure allowed a quick though detailed response by the farmers and motivated them to fully complete the questionnaire. Farms were contacted with the help of the South Tyrolean milk association (Sennereiverband Südtirol) and the regional extension service (Bergbauernberatungsring, BRING). Thereby, it could be ensured that the whole region was covered and that a representative number of farms in terms of herd size, management practices and production systems could be surveyed. The questionnaire sent to 226 farmers of which 102 responded, a response rate that estimated as 45%. From the total number of farmers that participated in the survey, 51 had tie stall and 51 loose housing barns.

On-site farm measurements

Among the above-mentioned agricultural holdings that responded to the questionnaires, nine farms with tie stalls and 10 with loose housing were selected for further on-site measurements. Farms with very small and very large herd sizes were excluded as outliers from the selection for on-site measurements. Although the direct measurements require higher effort, they provide accurate information regarding the working procedures in a farm and allow the evaluation of the ability of the farmers to correctly estimate the labour input of their farms. The duration of all the daily and non-daily working procedures measured as described by Von Borstel et al. (2010), was recorded directly by using the stopwatch function from a standard wrist-watch. Single activities are described in detail in Table 1. For the working time estimation, only the indoor activities were included. The activity of hay production or manure application was not included in the recording of farm activities since these activities vary largely between seasons and in order to standardise measurements and to focus on the on farm activities that are directly related to the dairy cows, those activities were excluded. From this, the number of manpower units, i.e. the labour force available, which throughout a full year is equal to 2160 MPh/year, was calculated.

Productivity for tie stall and loose housing in kg/MPh was determined by dividing the total average milk production per year by the estimated working time requirement (MPh/cow/year). The work procedure care of calves and young cattle was ignored for the calculation of productivity as it was done in earlier studies for several reasons (Macuhova and Haidn 2013). The aforementioned activity is largely diversified between farms since the management of replacement varied widely between farms, is independent of the farm size and housing system. For example, calves rearing might be performed in different farms while animals return at first calving. Other farmers, do not raise their own replacement animals, instead buying them as heifers. Additionally, total number of calves in a farm can be raised, partly kept as replacement and partly sold as heifers. In this context, in the studied production system it was not possible to consider the exact time for care of calves and young cattle. Labour cost was determined by assuming a salary of 13.5 € per hour.

Table 1. Description of the working activities and discrimination of each sub-task as classified in dairy farms of the present study.

Working activity	Working activity sub-tasks
Milking	Preparation of milking machine
	Milking
	Milk transport
	Cleaning of milking machine
	Bulk tank transport to the collection point
Feeding	Fodder preparation
	Forage distribution
	Supplementary feed distribution
Manure removal and bedding	Manure removal and bedding
Care of calves and young cattle	Feeding calves and young cattle
	Manure removal and bedding
Special works	Daily special works
	Non-daily special works

The statistical analysis was performed with the use of SAS statistical package version 9.3 (SAS Institute Inc., Cary, NC). A general linear model (GLM) with *post hoc* Tukey test was used to determine the effects of herd size and housing system on total working time requirements per MPh/cow/year and each working activity. For the analysis, three herd size categories were built: <10, 11–20 and >20 dairy cows/farm. When normal distribution was absent, logarithmic transformation was used. Additionally, for farms on which questionnaire and on-site data were available, a *t*-test was applied to test for differences between methods. Results were considered statistically significant at $p < .05$.

Results

The average herd size for both housing systems is emphasised in the representativeness of the sample for the region (Südtiroler Rinderzuchtverband 2016). Tie stall farms had an average of 16.3 cows (min 5; max 43; SD 9.0) while it was 23.2 (min 5; max 65; SD 13.9) in loose housing farms. The average milk production was estimated as 6664 kg/cow/year (min 4500 kg; max 8850 kg; SD 1240 kg) and 7639 kg/cow/year (min 5125 kg; max 10,000 kg; SD 1254 kg) in tie stall and loose housing, respectively. A clear decrease of working time with increasing herd size is visible for tie stall and loose housing in Figures 1 and 2, respectively. Milk yields increased with increasing herd size in both housing systems (Table 2). However, it has to be noted that loose housing farms had a higher milk yield compared to tie stalls, while the increase with increasing herd size was far more pronounced in tie stall farms. Regarding the comparison of working activities in relation to herd size and housing system, the results are presented in Table 2. Concerning the total working hours in both housing systems, the differences clearly demonstrate that tie stalls with a herd size <10 have the higher MPh/cow/year (270.4 ± 13.71 MPh/cow/year) and varied significantly ($p < .05$) from the rest of the estimated categories while loose housing herd size <20 cows have the lowest MPh/cow/year

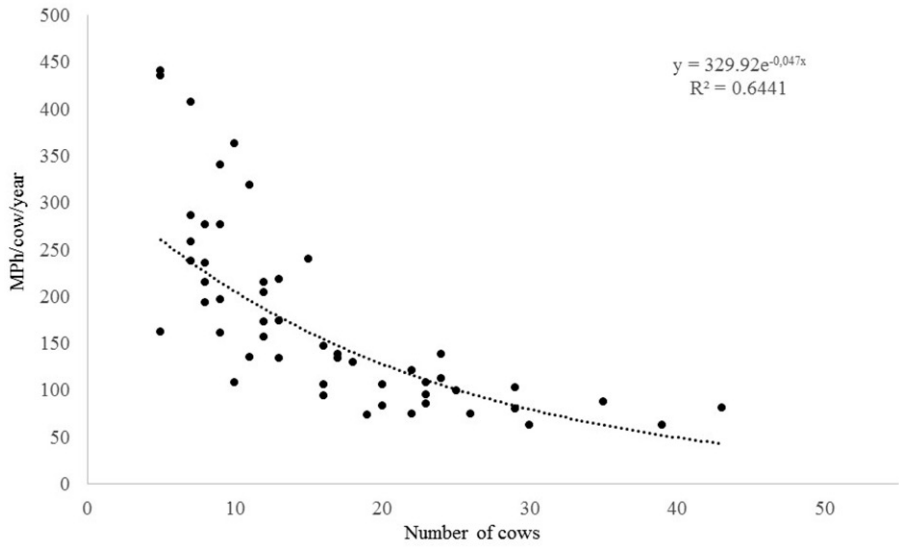

Figure 1. Working time requirement per cow per year for the tie stall housing according to herd size.

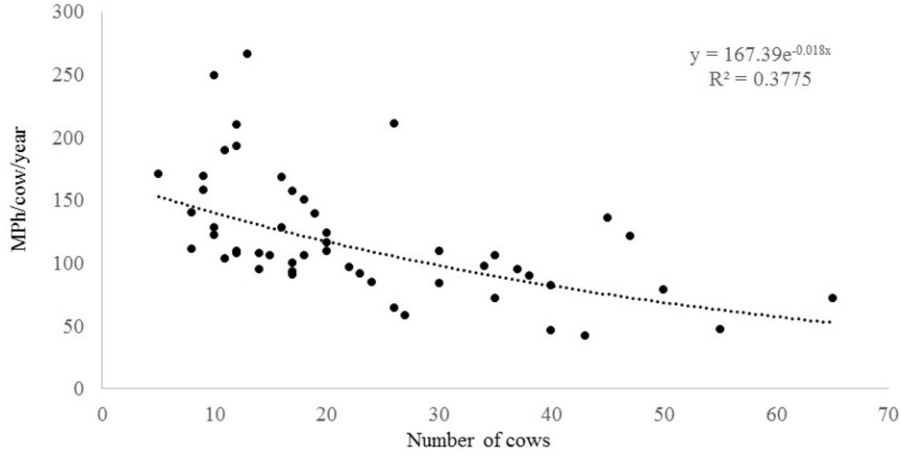

Figure 2. Working time requirement per cow per year for loose stall housing according to herd size.

(82.6 ± 13.32 MPh/cow/year). Similar findings were observed for the single working activities with <10 cows ties stall farms to require the most MPh/cow/year, while herd size >20 of loose housing have the lower demand of MPh/cow/year. It has to be noted that working activity of special tasks was difficult to be estimated since it includes not only daily tasks but also non-daily working activities that occur occasionally.

The average milk production per working hour for tie stalls without taking into consideration herd sizes, was estimated as 57.0 kg/MPh, equalling to labour costs of 34.9 Euro cent/kg, when assuming a salary of 13.5 €/h. For loose housing, milk production per working hour was estimated as 86.7 kg/MPh, thus about 30 kg greater than tie stall farms. Labour costs were consequently 19.2 Euro cent/kg of milk. Similar to milk yield, labour productivity increased with increasing herd size in both systems.

The comparison of questionnaire and on-site measurements for farms, on which both methods were applied, are presented for tie stalls in Table 3 and for loose housing in Table 4. For tie stalls, total working time requirement differed only by 16 MPh/cow/year between questionnaire (164.2 MPh/cow/year) and on-site measurement (148 MPh/cow/year; $p > .05$). Except for special task, no differences between methods were found for the single activities. Concerning loose housing, the total working time was estimated as 112.6 MPh/cow/year for the 10 loose housing farms (Table 4) for questionnaire survey while for the on-site measurements, the total working time estimated as 104.4. For milking it was 60.7 MPh/cow/year, while feeding determined as 27.2 MPh/cow/year, while on

Table 2. Labour input differentiated for single activities given as MPh/cow/year for tie stall ($N = 51$) and loose housing ($N = 51$), separated by herd size category.

		Tie stalls			Loose housing	
Herd size	<10, $n = 17$	11–20, $n = 19$	>20, $n = 15$	<10, $n = 8$	11–20, $n = 25$	>20, $n = 18$
Average milk yield, kg	5939	6879	7214	7764	7369	7958
kg/MPh	27	55	89	60	69	131
Milking	111.6 ± 5.76^{a}	64.5 ± 5.45^{b}	43.8 ± 6.14^{cd}	69.4 ± 8.406^{b}	59.5 ± 4.76^{bd}	33.3 ± 5.60^{c}
Feeding	49.0 ± 4.70^{a}	33.3 ± 4.448^{b}	16.7 ± 5.01^{b}	31.7 ± 6.86^{b}	32.6 ± 3.88^{b}	17.5 ± 4.57^{b}
Manure removal and bedding	32.5 ± 2.47^{a}	17.3 ± 2.33^{ab}	8.4 ± 2.63^{bc}	15.99 ± 3.60^{abd}	10.1 ± 2.03^{bc}	7.7 ± 2.39^{cd}
Care of calves and young cattle	20.9 ± 2.87^{a}	14.8 ± 2.71^{ab}	7.9 ± 3.05^{b}	23.0 ± 4.18^{ab}	17.5 ± 2.37^{a}	13.9 ± 2.79^{ab}
Special tasks	56.3 ± 3.37^{a}	26.9 ± 3.19^{b}	15.6 ± 3.59^{bc}	16.1 ± 4.92^{bd}	15.2 ± 2.78^{cd}	10.2 ± 3.28^{dc}
Total	270.4 ± 13.71^{a}	156.9 ± 12.97^{b}	92.4 ± 14.60^{c}	156.2 ± 19.98^{b}	134.9 ± 11.31^{b}	82.6 ± 13.32^{c}

Different superscripts indicate statistical differences ($p < .05$).

Table 3. Comparison of questionnaire and on-site measurements of labour input differentiated for single activities given as MPh/cow/year of tie stall farms ($N = 9$).

	Questionnaire			Investigated			
	Mean, $\bar{x}$	Min	Max	Mean, $\bar{x}$	Min	Max	p Value
Milking	77.6	43.5	169.5	95.5	60	133	ns
Feeding	32.1	9.6	70.2	17.4	5	59	ns
Manure removal and bedding	10.8	0.6	23.5	9.6	1	36	ns
Care of young calves and young cattle	11.7	3.2	19.1	12.2	0	21	ns
Special tasks	32	6.4	63.3	12.3	2	30	*
Total	164.2	74	286	148	92	242	ns

*$p < .05$.

Table 4. Comparison of questionnaire and on-site measurements of labour input differentiated for single activities given as MPh/cow/year of loose housing farms ($N = 10$).

	Questionnaire			Investigated			
	Mean	Min	Max	Mean	Min	Max	p Value
Milking	60.7	45.4	97.3	60.7	36.7	97.3	ns
Feeding	23.8	17.2	30.8	24.1	17.2	37.7	ns
Manure removal and bedding	9.8	3.3	17.6	11.6	1.5	17.6	ns
Care of young calves and young cattle	10.6	1.6	17.7	7.3	1.6	17.7	ns
Special tasks	7.7	5.2	13.6	0.6	0	4.83	*
Total time	112.6	85	158	104.4	85.0	158.2	ns

*$p < .05$.

site measurements estimated as 60.7 and 23.8 MPh/cow/year, respectively. Accordingly, for the on-site measurements, the working time was estimated as 7.3 and 0.6 MPh/cow/year for manure removal and bedding and special tasks, respectively, while questionnaire data determined as 10.6 and 7.7 MPh/cow/year, respectively.

Discussion

It was the first attempt to estimate labour cost under the present conditions of mountain dairy farming in South Tyrol. The questionnaire survey has been chosen since it was referred in previous studies (Laur et al. 2011) as an accurate and reliable method to collect data regarding the labour activity in livestock farms. This was confirmed by the fact that the results of the questionnaire survey widely agreed with the on-site observations. The relatively high response rate to the questionnaire, compared to other comparable surveys (Fogsgaard et al. 2016), observed in the present research might in a certain extent explain the fact that the farmers show an above average motivation to take advice for a more effective management of their farms. Through the on-site farm measurements, it was also possible to record accurately the individual times for every working activity. Moreover, the farmer could stay focussed on his job without interruptions. Non-daily tasks such as birth assistance or claw trimming, which are not scheduled, are difficult to measure. Thus, on-site measurements were possible only for daily tasks (Schrade et al. 2005).

It was evident from the comparison between questionnaire results and on-site measurements, that it was more difficult for farmers to estimate the single activities, while assessing their total daily labour input was relatively precise. An overestimation can be often explained by the fact, that not all of the daily special works indicated in the questionnaire, were performed on the day the on-site measurement was carried out

on the farm. The underestimation can be attributed to human behaviour, since farmers tend to work more carefully when they are observed during the measurements. The average overestimation is nearly the same as the average underestimation, against an initial assumption, that farmers tend to underestimate their work, because especially simple and fast procedures performed simultaneously with other more time-consuming works. However, it is important for the farmers not only to know the overall working time per day, but also to have information for the single procedures. Based on that, the farmer will be able to detect inefficient work procedures in order to improve efficiency.

The dairy farms that participated in the present study were slightly above the South Tyrolean average regarding both herd size and milk yield (Südtiroler Rinderzuchtverband 2016), while lower compared to the Italian average, which is estimated at 28.8 cows per farm and an average milk yield of 5.555 kg (Eurostat 2015). As mentioned, loose housing farms had an increased milk yield compared to tie stalls. This may be mainly explained by the availability of concentrate feed stations in loose housing barns, which in turn results in higher concentrate intake compared with tie-stall barns, in which concentration is generally provided manually considering that feeding total mixed rations is still not common in small-scale dairy mountain farming. However, in terms of the housing systems, it should be noted that tie stalls are still the dominating systems in alpine small scale farms (Sennereiverband Südtirol 2015), even though larger farms tend to change to loose housing. For example, in Bavaria tie stall housing still represents 41% of the total number of farms (LKV Bayern 2015).

The results of the average working time requirement for tie stalls are below the results obtained from small-sized farms in Switzerland, where the required labour hours were determined as 185.0 MPh/cow/year (Moriz 2007). However, the number of sampled farms in the present survey was lower than that in the abovementioned study. Additionally, it has to be clearly outlined that in the present study, the activities care of calves as well as forage production was not included in the calculation of the total working time, so that estimates vary in this respect from most of the cited studies which included these activities in the calculation. In this context, Van Caenegem et al. (2000) estimated 288 MPh/cow/year in tie stalls and herd sizes up to 16 cows, a number similar to the smallest herd size category of this study. Accordingly, Fischer-Colbrie (2009) found that 184.3 MPh/cow/year required for herd sizes up to 20 cows in Austria. Moreover, Handler et al. (2006) estimated the mean working time requirement for the total work in Austrian dairy farms at 120 MPh/cow/year while herd size was similar to South Tyrolean loose housing farms with a herd size between 11 and 20 cows. For both systems, there was a clear reduction of labour input when farm sizes increased. Moreover, the working time estimated for the majority of small-sized loose housing farms (<10 cows) is similar to the average labour time per cow and year for small herd sizes mentioned in other studies (Moriz 2007; Fischer-Colbrie 2009; Lips 2014). Again, it is pointed out that these values include working time for care of calves and forage production. Regarding the housing type taken into consideration, the small size of South Tyrolean farms, the choice of the tie stall offers the advantage of better and effective management. That fact combined with the option to observe and treat, if needed individual animals, might in long term have a cost effective result in farm management. On the contrary, since the last two decades animal welfare has a crucial role in animal's husbandry and management, while tie stalls are criticised because animals are not able to move freely and express normal behaviour (Cozzi et al. 2008).

Compared to large herd size farms, in Baden-Württemberg, where two separate working time surveys were carried out during different periods, the results of the present study differ significantly. In a study that took place in 2006, data showed that for an average herd size of 91 cows (range 37–393 cows), the required labour time was estimated as 39–69 MPh/cow/year. Accordingly, in 2010, the labour time for an average herd size of 135 cows (range 79–180 cows) was determined as 22–51 MPh/cow/year (incl. manure application) (Laur et al. 2011). However, for small-scale loose housing farms in Bavaria, working times were similarly determined as 31.2–74.6 MPh/cow/year (Macuhova and Haidn 2013). Nevertheless, it has to be mentioned that due to the small number of animals and the different management methods applied in each farm the labour requirement might vary to a high extent. Variations between farms might be on the one hand explained by the fact that the activities care of calves and forage production were not considered in the present calculations and on the other hand by the low effort that the farmers spent to the holding or to the lacking ability to organise the working time effectively. Furthermore, these results can be explained by the fact that those small scale farms are part time farms thus, the available time for handling the daily tasks is limited, while full time farms can organise and manage the daily tasks in a more structured way (Dannenberg and Kuemmerle 2010).

Regarding North Tyrol, Thurner (Thurner J. 2016. Arbeitskreis Milchproduktion Landwirtschaftskammer Tirol [Milk production working group], Personal communication) identified by using work diaries in dairy farms a labour input from 70 to 140 MPh/cow/year in different tie stall and loose housing systems.

Evaluating each working activity independently for tie stall and loose housing, higher labour input values resulted in return for milking, compared to the rest of the working activities in the farm for both systems. Shares for milking were higher than in other studies where milking was estimated about 30% of the total labour input (Macuhova and Haidn 2013). For care of calves and young cattle in tie stalls, which largely depends on the number of cows on the farm, similar values to the ones stated in the literature with 4–6 MPh/reared calf and on average 9 MPh per young animal and year were found. The results of the special tasks are diverging from the ones stated in the literature (Moriz 2007; Schick 2010). This is due to the fact, that many of the studies are not including the non-daily special works to the work procedure special tasks. Especially for loose housing, values differed significantly between survey and on site measurements. One obvious reason for this is the lower number of calves and young cattle in the farms where on-site measurements where performed, which of course lowers the mean in the calculation of labour input in MPh/cow/year. Part of the young cattle on those farms was already on the alpine pastures, when the on-site measurements occurred. Those results are different from the calculated standard labour input determined by Handler et al. (2006) where 25 MPh per animal are required for young female cattle between 0.5 and 1 year. The average time requirement for all the special works in tie stalls is with a value of 56.3 MPh/cow/year for small herd sizes considerably high. Regarding special tasks, it has to be mentioned that the differences obtained can be mainly attributed to the high variability of the work activities included in this category and the high variation that was recorded among the different tasks.

Labour productivity is an important factor that determines the effectiveness of the labour input of a dairy farm, and thus can act as an indicator of its efficiency and performance. The labour productivity per kg of milk was estimated above the EU average, which is determined as 52 kg/MPh (Schick 2010), independent of the housing systems. Moreover, the productivity in South Tyrolean small-sized tie stall farms (<10 cows) is below average production for Austrian farms (40 kg/MPh) with a herd size of 10.5 cows (Schick 2010). Additionally, in comparison to the Swiss farms with an average production of 62 kg milk/MPh for both housing types and a herd size of 21 cows, both housing systems in South Tyrol are well above the Swiss average production. The average production for both housing types estimated for Germany with 40 cows per holding is above the numbers determined for South Tyrolean farms with 90 kg/MPh (Schick 2010). However, in loose housing farms within the largest herd size, category production was estimated as 130 kg/MPh, which can be attributed to the use of the milking systems used at its capacity. Additionally, Zenka et al. (2016) did not found a positive correlation between productivity and farm size in Czech dairy farms, while they attributed the low productivity of the farms that participated in the study in factors related to the lack of the use of mechanisation and management practices. Moreover, as mentioned by Dannenberg and Kuemmerle (2010), small farms have the ability to find alternative sources to maintain their income as a balance for their inability to compete with scale economies. Additionally, in a study conducted by Macuhova and Haidn (2012) in dairy farms in Bavaria, herd size did not have a major effect on labour input. Thus, they concluded that work efficiency could be increased if there is an improvement in parameters related to technology, farm facilities or work management. In the Netherlands, production expansion also attributed in aspects related also to social and environmental factors and not only to financial figures (Samson et al. 2016). In a conceptual model that Samson et al. (2016) developed, they investigated the factors that affect the decision of the farmers to invest in their farm expansion. The results showed that many other parameters apart from economic aspects, such as market condition, national and local policies, farmers' values, could affect decision making.

The estimated differences in production performance between the two systems can mainly be attributed to the different milking systems. Thus, it is clear that with the appropriate management improvements, such as for example with a more efficient organisation of working time and adaptation of new technologies in the farm, labour time can be used more effectively and production output can be increased. However, as mentioned above, those changes related to and influenced by many factors, the farmer can decide and choose the best way to improve their herd's productivity, either by changing animal husbandry practices or making economic investment in the farm equipment. Those conclusions are in accordance with the results of other researchers, who investigated the results of farmers decision to maintain their livestock holding and made the necessary farm investments (e.g.

increase herd size, improve buildings, machinery and management practices). They showed that a good level of farm mechanisation could reduce the percent of physically strenuous tasks from 30% to 16% (Schick et al. 2015). As an outcome, farmers had the opportunity to improve their overall income (Fredrikson et al. 2017) and reduce their labour input, which has in addition a positive effect on farmers' social life (Macuhova and Haidn 2012). Though there are no data available yet, machinery investments, such as for example fodder mixing wagons, in small- and medium-sized farms when not used at its capacity have to be considered critically. In mountain areas, the sustainability of the systems under harsh conditions is related not only to landscape conservation (Schermer et al. 2016), but also to the maintenance of livelihoods in rural areas. Their contribution to the sustainability of the local environment is to some degree already acknowledged by the EU through certain Rural Development Programmes (RDP), but needs further support to motivate farmers to maintain and expand their livestock production (Smit et al. 2015).

According to the Italian institute for studies, research and information on the agricultural market (ISMEA) the production cost of milk for Italy was estimated in 2012 at 57 Euro cent/kg milk while in other countries fluctuates from 35 Euro cent/kg in the UK to 46 Euro cent/kg, in France and the Netherlands (De Roest et al. 2013). Accordingly, the international remuneration per MPh was estimated from 9.2 € to 14.4 € in UK. The remuneration in South Tyrol was determined as 13.5 € for specialised agricultural work forces (Maschinenring Südtirol 2016). Additionally, the price for 1 kg of milk while the average in the middle Europe estimated as 30.8 Euro cent/kg in South Tyrol was 51.0 Euro cent/kg milk (Proplanta 2016). However, if the labour cost is calculated per kg of milk, the costs for cattle breeding, machinery, insurance, electric energy and water, maintenance costs, taxes, social contributions and other costs are summed up, the result was estimated as 49.4 cent per kg milk. If also the depreciation is added, an average value of 61.1 cent per kg milk results. It has however to be noted that in farms with herd size from 5 to 15 cows the price estimated as 75 cent while if the herd size is between 16 and 25 animals then the cost was estimated as 60 cent (Stuppner 2016). It is therefore obvious that even a small increase in herd size has a crucial effect on production costs. All these varying numbers show that a comparison between labour input and economy, even if carried out only for a single region, is a very delicate issue due to the variety of the factors that have to be taken into account. Moreover, economical statements in the present study would be only partly true, since only the manpower units inside the barn were taken into account. Work activities apart from the on farm one, such as fodder production or manure application, were not considered in this study because standardisation on this kind of small scale farms in mountain regions is very low. It also has to be mentioned that care of calves and young cattle is another issue that differs largely between farms, because management of replacement animals is very different. Even if warranted to be included in working time analyses, its assessment has to be considered as critical considering the above mentioned reasons.

Conclusions

The present study provides a detailed overview on the labour input of South Tyrolean tie stall and loose housing dairy farms. Working time requirements were higher for tie stall than for loose housing farms. However, variation within the system was high and largely dependent on farm size. Shares of the activities milking and feeding were amounted more than half of the total working time. Here, the highest potential to increase productivity, such as the adoption of certain milking systems or feeders, despite their costs can be seen. However, the possible investment in machinery should be made under careful examination of the proposed capacity used. Especially, in small- and medium-sized herds, investments will increase labour productivity, but not necessarily farm income if machinery is not used at its capacity. A clear understanding of their working efficiency will allow farmers to better understand the requirements for dairy farming encouraging them to modify working procedures in a way so that sustainability of mountain dairy farming is improved.

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