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Economic assessment of small-scale mountain dairy farms in South Tyrol depending on feed intake and breed

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ABSTRACT

Dairy mountain farms are economically disadvantaged due to small farm size and high production costs. However, these farms are of importance for the preservation of traditional landscapes and biodiversity, especially when they are managed extensively. The present study compares the economic situation of mountain dairy farms in South Tyrol that differ with respect to the amount of concentrates fed (low-input vs. high-input) and the breed used (Tyrolean Grey vs. Brown Swiss). The calculations show that low-input farms have lower variable costs but similar fixed costs and lower revenues compared to high-input farms. As a result, high-input farms are economically superior to low-input farms in terms of income per farm, per ha and per kg energy-corrected milk. Regarding the breeds, farms using the local breed Tyrolean Grey can compete with farms using the high-yielding breed Brown Swiss when subsidies are considered because of special payments for an endangered breed. The dominance of high-input farms can be explained with economies of scale and the milk to feed price ratio of about 1.8. Thus, the currently paid high milk price makes it economically worthwhile to produce as much milk as possible. The results thus point to the risk of intensification or abandonment of small mountain farms. In order to improve their economic situation and thus maintain small and low-input mountain dairy farms, it might be an option to connect subsidies with the feeding strategy and farm structure, pay premiums for value-added milk products or use taxes for concentrated feed to support extensive farms.

HIGHLIGHTS

- Low-input farms achieve lower farm income
- Only small differences in farm income between breeds
- Herd size and milk yield per cow are decisive for farm income

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Profitability; feed-intake; farm system; mountain farming

Introduction

Changing market conditions, technological progress and economic pressure have led to a steady consolidation and intensification of dairy production in the last decades (Tilman et al. 2002). In addition, milk production has shifted to more profitable regions while in disadvantaged ones, such as mountain areas, a high percentage of agricultural land has been abandoned (MacDonald et al. 2000; Tasser et al. 2007). However, dairy mountain farms are of great importance as the pasturing of animals and forage production prevents reforestation (Tasser et al. 2007). This in turn has positive impacts on the environment and biodiversity but also ensures preservation of traditional landscape and increases the region's attractiveness for population and tourism (Bernués et al. 2011; Battaglini et al. 2014).

The main challenges for mountain farmers are the limited possibility to expand the herd size to benefit from economies of scale (MacDonald et al. 2000) as well as the high workload and production costs due to steep slopes and altitudes (Lips 2014). As a result, the economic situation is often worse compared to dairy farms located in plain areas (Kirner and Gazzarin 2007; EC 2008) and causes mountain farmers to abandon or intensify milk production (MacDonald et al. 2000; Battaglini et al. 2014). Due to the limited areas, farmers can only increase milk yield through feeding higher amounts of concentrates and the use of high yielding breeds (MacDonald et al. 2000; Caviglia-Harris 2005). Both intensification strategies may lead to a loss of ecosystem services mainly because intensive farms cultivate less grassland (Sturaro et al. 2009).

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Table 1. Criteria for the selection of the dairy farms for the four different groups.

	Low-input Tyrolean Grey (L-TG)	Low-input Brown Swiss (L-BS)	High-input Tyrolean Grey (H-TG)	High-input Brown Swiss (H-BS)
No. of farms	13	12	14	19
Breed	Tyrolean Grey	Brown Swiss	Tyrolean Grey	Brown Swiss
Concentrates (kg/day)[1]	≤3.5 kg	≤4.5 kg	≥6.0 kg	≥7.5 kg

[1]On average per lactating cow.

In addition, high-yielding breeds are often not appropriate for grazing on mountain pastures but need more concentrated feed (Zollitsch et al. 2016). Thus, intensification of dairy production in mountain areas is accompanied with negative environmental consequences (Cozzi et al. 2006; Battaglini et al. 2014). However, profitability and farm income will be decisive for the survival of (mountain) farms (Bragg and Dalton 2004; Gellrich and Zimmermann 2007) and several studies show that intensive systems superior extensive ones in terms of profitability (Soder and Rotz 2001; Alvarez et al. 2008; Wilson 2011). Extensive milk production is only more economical if it is connected to a clear reduction of production costs and working time (Ramsbottom et al. 2015; Gazzarin and Schmid 2017), which is difficult to accomplish in most mountain regions (Lips 2014). To the best of our knowledge, there is only one study comparing the economic situation of extensive and intensive strategies of mountain dairy farming. Cozzi et al. (2006) show that extensive farms achieve higher net incomes due to lower costs for extensive production. However, herd sizes of the analysed farms (34 vs. 54 lactating cows) are larger than average mountain dairy farms, which limits the significance for small farms. In addition, a study by Pretto et al. (2009) shows that traditional local breeds are economically disadvantaged compared to high-yielding breeds (Holstein Friesian) due to lower milk yields and can only achieve a similar income per cow if the milk is marketed for a higher price, e.g. for the production of a special cheese. Nevertheless, no study compared the profitability of small mountain farms dependent on feed intake and breed. However, this is of great interest as these factors can be influenced by farmers to increase productivity and profitability but have several consequences for the environment and the preservation of traditional mountain farms. Therefore, the aim of this study is to analyse the income per farm, per ha and per kg energy-corrected milk (ECM) produced as well as the workload and farmer's attitudes towards their situation and future of farms located in the Italian Alps (Province of South Tyrol). South Tyrol is situated in the very northern part of Italy and is characterised by mountains with only 14% of its land area below an altitude of 1000 m, 49% between 1000 m and 2000 m and 37% above 2000 m.a.s.l. (Südtiroler Landesverwaltung 2017). Milk production is an important agricultural industry and dominated by small farms with on average 13 cows per farm (Südtiroler Landesverwaltung 2017). Thus, this area is a good example to analyse the economic situation of small-scale mountain dairy farms.

The analysed farms were grouped according to the amount of concentrates fed (low vs. high) and the breed used (Tyrolean Grey vs. Brown Swiss). The number of high-yielding breeds is rising in South Tyrol what might indicate an increase in intensification (Südtiroler Landesverwaltung 2017). The study results offer the possibility of deducing recommendations for future policies regarding the maintenance of small-scale extensive dairy farms in mountain areas. This is of great importance, as intensive milk production not only has negative consequences for the environment but also contradicts the public idea of mountain farming and might lower the regions attractiveness for tourists (Gazzarin and Schmid 2017; Faccioni et al. 2019).

Material and methods

All farmers voluntarily participated in the survey and the anonymity of participants is guaranteed during the whole study.

Data collection

In order to compare the profitability of strategies for small-scale dairy farms in mountain areas, which differ in terms of intensification, the farms included in this study were selected according to the amount of concentrates fed to lactating cows and the breed used. Therefore, we set a maximum amount of concentrated feed per day and lactating cow for the extensive farms and a minimum amount for the intensive farms depending on the breed so that four groups were defined (Table 1). For the breeds, we chose Tyrolean Grey and Brown Swiss to compare a local dual-purpose and a high yielding breed that are commonly used in South Tyrol (Sennereiverband 2017).

In addition, all farms have a farm size between seven to 22 cows, are located above at least

700 m.a.s.l. (metres above sea level) and participate in routine milk control. The selection was based on a survey that was completed by almost all South Tyrolean dairy farmers in the year 2016 and was validated during farm visits. In some cases, there had been differences with respect to the amount of concentrates fed to lactating cows so that these farms did not fit to the defined limits. Farmers who fed less or more concentrate than the chosen limits or used mixed breeds were excluded from the survey.

In total 58 out of 70 farms visited remained in the sample. The farms were visited from October 2017 to May 2018 and were interviewed with respect to their economic situation, farm structure, and husbandry and feeding system. To measure the economic situation, farmers indicated all revenues and expenses related to milk production as well as their investments in machines in the last 15 years and in buildings for the last 30 years. When investments are also used for other purposes, farmers were asked to estimate the share of use in milk production. In addition, we used data from milk records to calculate the energy corrected milk yield per cow and farm using the formula by Weiß (2001).

Furthermore, 5-point Likert-scales were used to measure farmers opinion about the relation of work effort and farm income, the probability that they will still produce milk in ten years and if they want to change milk yield per cow in the near future. These statements can give further insights into the relationship between the risk of farm abandonment and the economic situation of farms. In addition, farmers estimated the time that is needed for all the work inside the stable (Poulopoulou et al. 2018). Therefore, they should consider all family members who work in the barn. Farmer's work effort for manure application is not included in this calculation. Working time for forage production was also not taken into account but we used a formula by Peratoner et al. (2010) to estimate the costs for forage production. For this estimation, machine costs and labour costs were considered and the calculation is based on the farms altitude and steepness of slopes. As costs for machinery are already included in the cost accounting, we only considered 50% of the estimated costs for economic analysis as Peratoner et al. (2010) state that about half of the total costs result from work effort.

Calculation of profitability

All economic data refer to the year 2016 and are expressed in euro (€) or eurocent (c) unless otherwise stated. Full cost accounting was done for each farm and in average for each of the four groups. The calculated income was further used to compute the hourly wage for the work inside the stable. Variable and fixed costs as well as gross margin and net income were calculated. Variable costs are characterised by the direct link to the production volume and comprise all feed costs, costs for veterinary, insemination, stock replacement, claw care, litter, transport, pasture seeding and fertiliser. Costs that are not directly influenced by the output are named fixed costs and are related to buildings and machines such as depreciation, repairs and maintenance, power and fuel as well as insurance fees or fees for memberships and costs for hired labour and phone. The allocation of costs as variable or fixed followed Ramsbottom et al. (2015). All revenues (milk and animal sales as well as fodder and manure sales) minus variable costs calculated the gross margin and gross margin minus fixed costs results in farm income.

For comparative purpose, all revenues and costs were divided by the managed grassland area (ha) and the milk yield (ECM). These parameters were chosen because grassland area is a limiting factor for the farmers' expansion and the amount of milk produced is directly related to the amount of concentrate supplementation what is the main distinctive feature for the classification as low or high-input farm in our study. Therefore, the economic analysis was done per kg ECM, per ha and per farm to detect factors that are responsible for the profitability. For a better overview, only the most important cost factors are shown in detail, whereas costs with a low amount are summarised as others. In the total costs, however, all costs are included. The income per farm was further used to calculate the remuneration for the farmer's workload which is a further indicator of profitability and can be used for the comparison of different production branches.

Share of milk derived from roughage

It is known that the share of milk that is derived from roughage could affect the profitability and cows' health (Kiefer et al. 2015). Thus, the share of roughage used for milk production was calculated by using the formula (1) of Weiß (2001) and differences between the farms were analysed.

$$\left(\frac{7\ \text{MJ NEL}}{\text{kg concentrate}} \times \frac{\text{concentrate in tons}}{\text{cow and year}} \times 100\right) - \left(\frac{\frac{7\ \text{MJ NEL}}{\text{kg concentrate}} \times \frac{\text{concentrate in tons}}{\text{cow and year}}}{3.2} \times 100\right) \quad (1)$$

Thereby, the amount of net energy lactation in mega joule (MJ NEL) was adapted for the respective

Table 2. Descriptions of farms by group.

Item	Farm groups			
	L-TG	L-BS	H-TG	H-BS
Meter a.s.l.	1145 (345)	1298 (289)	1283 (267)	1148 (255)
Lactating cows, no.	12.1 (2.8)	10.3 (2.7)	12.6 (3.5)	12.6 (3.2)
Young cattle, no.	5.6 (4.1)	4.3 (2.7)	5.2 (3.8)	3.2 (2.9)
Rearing own cattle, %	100	100	85.7	63.2
ECM/cow and year, kg	4191 (349)	4906 (678)	5871 (712)	7739 (1111)
ECM/farm and year, kg	47,402[a] (13,730)	49,352[a] (17,399)	74,082[b] (24,372)	100,588[c] (39,673)
Full-time, %	53.8	41.7	71.4	78.9
Loose housing, %	15.4	8.3	7.1	42.1
Grassland, ha	11.0 (4.6)	10.4 (3.7)	11.4 (4.9)	7.8 (1.8)
Days of grazing	102.3 (70.1)	76.7 ± 47.7	52.1 (56.8)	21.6 (30.0)
Concentrate/ cow and day, kg	3.3 (0.9)	3.6 (1.5)	6.4 (0.8)	8.0 (1.2)
Roughage-derived milk, %	44.5 (11.8)	49.4 (13.2)	20.1 (14.1)	25.4 (10.7)

L-TG: low input Tyrolean Grey; L-BS: low input Brown Swiss; H-TG: high input Tyrolean Grey; H-BS: high input Brown Swiss; Meter a.s.l.: meter above sea level; ECM: energy-corrected milk. Means; standard deviation in brackets.

concentrate that was used by the farmer. The energy value differed between 7.0 and 7.3 MJ NEL.

Statistical analysis

We use Analyses of variance (ANOVAs) to test for significant differences between the group means. Post hoc tests were further used to find out which groups differ significantly. Therefore, the groups' means were tested for homogeneity of variance with the Levene's test. If variances were homogenous, Gabriel's test was used whereas Games Howell's test was used when variances were heterogeneous. All significant levels are related to $p < .05$.

ANOVAs and post hoc tests were also used to find significant differences regarding revenues, costs and farm structure among the 20% of all 58 farms achieving the lowest and highest profit per kg ECM and per farm, respectively. All analyses were done using IBM Statistics SPSS 25.

Results

Farm characteristics

All farms are family businesses and sell their products by cooperatives. Table 2 shows the farm descriptions of the four studied groups. Farms of all groups were located above 1000 m.a.s.l. Except for the group L-BS, the majority worked as full-time farmers. We found that the dominant husbandry system was the tie-stall for all groups, even though the group H-BS has a relatively high percentage of loose housing. Days of pasture decrease with an increasing intensification level from L-TG to H-BS, while concentrates/cow and day and ECM/cow and year increase with increasing intensification level.

Economic performance

Table 3 shows that farm income without subsidies is negative for both extensive groups and similar and positive for both intensive groups with 5638€ and 5993€. When subsidies are considered, intensive farms are still more profitable compared to extensive ones but farms using Tyrolean Grey are in a better economic position compared to farms using Brown Swiss. It also turns out that farms using Tyrolean Grey have higher revenues for sold cows. Furthermore, it can be seen that variable costs per farm and year are lowest for low-input farms and highest for high-input farms using Brown Swiss, whereas fixed costs are also clearly higher for this group but similar for all other groups. Workload per day and year is similar between all groups, leading to higher remunerations per working hour for intensive farms.

Income incl. subsidies per kg ECM is highest for the H-TG farms with 18.3 c/kg followed by L-TG, H-BS and L-BS farms. Variable costs per kg ECM are similar for all groups whereas fixed costs are clearly lower for high-input farms due to higher milk yield (Table 4). This leads to a cost advantage of 10 c/kg ECM for the intensive farms. When it comes to income per ha, high-input farms using the breed Brown Swiss are leading. This is mainly because these farms cultivate less grassland. Nevertheless, H-TG farms achieve almost similar income per ha and manage most ha grassland (11.4 ha) (Table 5).

However, there is a high variation of income within all groups.

Comparison of farms with lowest and highest income

Table 6 shows the main differences between the farms with the highest and the lowest income per kg ECM, per ha grassland and per farm. We found that farms

Table 3. Revenues, costs and income by group in €.

Item	Farm groups			
	L-TG	L-BS	H-TG	H-BS
Revenues	39,241^{a} (12,033)	34,672^{a} (11,317)	55,988^{b} (15,219)	68,132^{b} (26,156)
Milk	24,877^{a} (7368)	26,240^{a} (9613)	41,609^{b} (15,193)	56,992^{c} (26,064)
Sold cows	4033^{a} (1874)	2305^{b} (1160)	5162^{a} (3545)	4910^{a} (2568)
Subsidies	10,331^{a} (6237)	6126^{b} (2141)	9218^{ab} (3545)	6192^{b} (3323)
Variable costs	15,964^{a} (8402)	15,249^{a} (3545)	22,766^{b} (7322)	29,308^{c} (10,808)
Concentrates	4442^{a} (2748)	3909^{a} (2193)	10,190^{b} (3951)	12,972^{c} (4712)
Forage production[1]	7414^{a} (4164)	7,153^{ab} (2143)	7281^{a} (2718)	5395^{b} (1186)
Silage	15^{a} (55)	158^{a} (548)	121^{a} (309)	1182^{b} (2229)
Veterinary	491^{a} (572)	554^{a} (417)	1156^{b} (751)	1375^{b} (941)
Insemination	649^{ab} (195)	584^{a} (161)	942^{ab} (642)	914^{b} (463)
Stock replacement	1023 (2330)	1237 (1815)	942 (1961)	3808 (3366)
Other	1645 (1938)	1320 (641)	1732 (1218)	2675 (3200)
Gross margin	30,690 (9837)	26,575 (9641)	40,503 (11,260)	44,219 (19,856)
Fixed costs	18,341 (7850)	17,479 (6653)	18,965 (7215)	27,112 (8830)
Machinery and building upkeep	4282 (2543)	3259 (1712)	3409 (1657)	5612 (3962)
Building depreciation	1924^{a} (2528)	2253^{a} (2181)	2402^{a} (2623)	4716^{b} (4442)
Machine depreciation	4378^{a} (3569)	5,052^{ab} (3,517)	5,196^{ab} (3, 103)	7,764^{b} (5,902)
Insurance	1744 (1282)	1689 (646)	1887 (970)	2480 (1447)
Fees and consulting	5189 (2899)	5059 (3214)	5760 (3626)	5110 (2641)
Other	337 (543)	25 (87)	200 (406)	551 (550)
Summed costs	34,305^{a} (14,623)	32,729^{a} (8156)	41,731^{a} (12,532)	56,420^{b} (17,639)
Income				
Excl. subsidies	−344 (8571)	−453 (6914)	5638 (8523)	5993 (16,714)
Incl. subsidies	5987 (8063)	2673 (8046)	14,856 (7117)	11,388 (17,130)
Workload (h)				
Per year	1959^{a} (432)	1852^{a} (419)	2042^{a} (716)	1963^{a} (670)
Per day	5.37^{a} (1.19)	5.08^{a} (1.15)	5.60^{a} (1.96)	5.38^{a} (1.84)
Payment/working hour				
Excl. subsidies	−.67^{a} (4.87)	−.32^{a} (4.21)	2.35^{b} (3.91)	3.25^{a} (8.78)
Incl. subsidies	3.01^{a} (3.70)	1.09^{a} (4.60)	7.39^{b} (2.75)	6.74^{b} (8.42)

L-TG: low input Tyrolean Grey; L-BS: low input Brown Swiss; H-TG: high input Tyrolean Grey; H-BS: high input Brown Swiss.
$^{a-c}$Means within a row with different superscripts differ ($p < .05$); Standard deviation in brackets.
[1]Estimated according to Peratoner et al. (2010), includes labour costs only.

Table 4. Revenues, costs and income per kg ECM in €-Cent.

Item	Farm groups			
	L-TG	L-BS	H-TG	H-BS
Revenues	83.7^{a} (15.6)	73.4^{a} (8.8)	76.4^{a} (11.4)	68.1^{a} (5.9)
Milk	54.6^{a} (3.7)	55.2^{a} (4.2)	56.6^{a} (3.0)	55.1^{a} (3.9)
Sold cows	8.9^{a} (4.1)	4.8^{b} (2.6)	7.7^{ab} (6.1)	4.9^{b} (2.7)
Subsidies	22.6^{a} (12.8)	13.4^{b} (5.0)	13.7^{b} (7.2)	6.9^{c} (4.5)
Variable costs	32.5^{a} (9.9)	32.7^{a} (7.7)	31.5^{ab} (8.1)	29.5^{b} (7.1)
Fixed costs	37.7^{a} (12.9)	37.9^{a} (13.3)	26.6^{b} (8.3)	29.1^{b} (9.7)
Summed costs	70.2^{a} (18.1)	70.6^{a} (18.7)	58.1^{b} (12.7)	58.6^{b} (11.2)
Income				
Excl. subsidies	−.9^{a} (18.2)	−0.6^{a} (18.2)	4.5^{b} (10.1)	2.5^{b} (12.9)
Incl. subsidies	13.6^{ab} (19.6)	2.8^{a} (18.1)	18.3^{b} (7.0)	9.5^{b} (13.1)

ECM: energy-corrected milk; L-TG: low input Tyrolean Grey; L-BS: low input Brown Swiss; H-TG: high input Tyrolean Grey; H-BS: high input Brown Swiss.
$^{a-c}$Means within a row with different superscripts differ ($p < .05$); Standard deviation in brackets.

Table 5. Revenues, costs and income per ha grassland in €.

Item	Farm groups			
	L-TG	L-BS	H-TG	H-BS
Revenues	3013^{ab} (1223)	3074^{a} (1450)	4461^{b} (1187)	8073^{c} (2624)
Milk	2449^{a} (799)	2734^{ab} (1368)	3947^{b} (1151)	7369^{c} (2463)
Sold cows				
Subsidies	947^{a} (456)	619^{a} (193)	881^{a} (357)	840 ^{a} (514)
Variable costs	1582^{a} (987)	1555^{a} (432)	2103^{a} (497)	3830^{b} (1212)
Fixed costs	1851^{a} (950)	1926^{a} (1153)	1852^{a} (756)	3581^{b} (1276)
Summed costs	3430^{a} (1825)	3481^{a} (1509)	3953^{a} (1124)	7403^{b} (2145)
Income				
Excl. subsidies	−17^{a} (879)	−7^{a} (823)	508^{ab} (699)	670^{b} (1921)
Incl. subsidies	530^{ab} (749)	212^{a} (872)	1389^{bc} (583)	1510^{c} (1873)

L-TG: low input Tyrolean Grey; L-BS: low input Brown Swiss; H-TG: high input Tyrolean Grey; H-BS: high input Brown Swiss.
$^{a-c}$Means within a row with different superscripts differ ($p < .05$); standard deviation in brackets.

with the lowest income per kg ECM achieve slightly higher revenues but have more than twice as high fixed costs. It becomes further evident that for all parameters low-input farms are mainly among the farms with the lowest income whereas only two L-TG farms are among the farms with the highest income per ECM, one L-TG farm achieves a high income per farm and one L-BS farm is among the farms with the highest income per ha. Thus, farms with lowest income are characterised by a lower milk yield per cow, a higher percentage of roughage in the feed ration and more pasture days per year.

Farmers' satisfaction and attitudes

Table 7 shows that dairy farmers in all groups tend to disagree that the payment is in a good relation to the work effort. However, farmers with an intensive milk production are more satisfied with their remuneration and are more certain that they will still produce milk

Table 6. Comparison of the 20% of farms that achieve the lowest or highest income per kg ECM, per farm and year and per ha grassland in terms of economic indicators, group affiliation, feeding and husbandry.

	Per kg ECM, c			Per farm, €			Per ha grassland		
Item	<20%	>20%	All	<20%	>20%	All	<20%	>20%	All
Economy									
Revenues incl. subsidies	75.4	70.7	74.7	43,264	78,017	51,802	5678	8831	5861
Variable costs	37.6	24.9	31.3	24,334	27,241	21,829	3021	3174	2438
Concentrates	10.0	10.0	11.2	8917	15,521	8513	1102	1430	973
Forage production	16.2	7.2	11.1	6664	6350	6667	807	676	689
Veterinary	1.3	1.0	1.3	875	1165	954	115	135	110
Stock replacement	4.0	1.2	2.5	3549	2334	1960	420	346	237
Fixed costs	46.4	19.3	32.2	26,380	24,030	21,186	3285	2815	2433
Building depreciation	6.2	3.4	4.3	4844	5074	3454	7873	5084	3022
Machine depreciation	15.9	4.2	9.1	7154	5138	5824	7873	5849	5824
Insurance	4.6	1.7	3.0	2860	1994	2008	332	232	229
Fees and consulting	8.9	4.3	8.5	5367	4640	5273	693	492	586
Summed costs	83.9	44.2	63.6	50,714	51,271	43,019	6302	5982	4869
Income excl. subsidies	−5.4	18.4	−.3	−1,807	20,486	1636	−465	2185	164
Income incl. subsidies	−.5	26.5	11.1	−495	27,641	9473	−30.3	2848	992
Farm group affiliation, n									
L-TG	6	2		3	1		3	0	
L-BS	4	0		5	0		5	1	
H-TG	0	3		0	3		0	3	
H-BS	2	6		4	7		4	8	
Further determinants									
Herd size, n	11.5	13.6	12.0	10.9	15.2	12.0	11.1	14.3	12.0
ECM/year and cow	4753	7020	5886	5637	7501	5886	5593	7609	5886
Pasture days, n	96.7	22.7	58.1	67.1	31.0	58.1	70.4	28.3	58.1
Percentage of roughage, %	41.1	31.6	33.3	38.6	27.7	33.3	37.4	30.0	33.3
Concentrates per day, kg	4.2	6.7	5.6	4.9	7.5	5.6	5.0	7.3	5.6

ECM: energy-corrected milk; L-TG: low input Tyrolean Grey; L-BS: low input Brown Swiss; H-TG: high input Tyrolean Grey; H-BS: high input Brown Swiss.

in ten years compared to farmers using an extensive strategy. The agreement that milk will still be produced in 10 years correlates with the satisfaction of the financial remuneration ($r = 0.430$, $p = .001$).

Discussion

Farm structure

Mountain dairy farms are of high importance for the local economy and the maintenance of traditional landscapes (Battaglini et al. 2014). The results of the present study confirm that dairy farming is a full-time business for more than half of the visited farmers indicating that milk production is an important industry with respect to the provision of employment. However, the proportion of full-time dairy farmers is lower throughout South-Tyrol (30%; Sennereiverband 2017) but similar in other alpine regions (Streifeneder et al. 2007). Mountain dairy farmers are further of high importance for the conservation of grassland as farmers use on average more than 10 ha for hay production and pasturing. This is mainly true for farms using the local breed Tyrolan Grey and farms that are more extensive. Thus, from an ecological view extensive farms using local breeds make a greater contribution in terms of ecosystem services what is in line with previous studies (Bernués et al. 2011; Marini et al. 2011; Sturaro et al. 2009; Gazzarin and Schmid 2017).

Economic performance

However, dairy farms in mountain regions are confronted with many peculiarities, which also affect the economic situation. Existing studies revealed that mountain farming is linked to higher production costs compared to dairy farms located in plain areas (Kirner and Gazzarin 2007; EC 2008; Lips 2014). This is consistent with our findings: for all farm groups we found that costs per kg ECM (between 58.1 c/kg and 70.6 c/kg) are clearly higher compared to average production costs in Germany (36.5 c/kg), France (36.8 c/kg) or Italy (30.5 c/kg) (Gołaś 2017). Especially fixed costs per kg ECM are higher compared to other countries and can be seen as the main disadvantage of small-scale mountain farms what is in line with previous studies (MacDonald et al. 2007; Lips 2014). The situation is even worse for low-input farms, for which fixed costs are about 10 c/kg ECM higher, due to a lower quantity of milk produced. Profitability per ha is highest for H-BS farms due to the lowest percentage of grassland managed by these farms. In contrast, H-TG farms manage most grassland and achieve similar income per ha. For high-input farms, income per ha is only slightly lower compared to what Suisse mountain dairy farms generate (Gazzarin and Schmid 2017).

In total, all parameters show that high-input farms outperform low-input farms in terms of profitability – except income per ECM for which L-TG farms achieve

Table 7. Farmers' satisfaction with and attitudes towards their economic situation and future farm decisions.

Do you agree/think that …	Farm groups			
	L-TG	L-BS	H-TG	H-BS
relation of payment to workload is good?[1]	4.08 (0.99)^{ab}	4.58 (0.67)^{a}	3.50 (1.09)^{b}	3.84 (0.81)^{b}
you will still produce milk in 10 years?[1]	2.62 (0.77)^{a}	2.58 (0.79)^{a}	2.00 (0.68)^{ab}	1.89 (0.99)^{b}
you will change milk yield per cow?[2]	3.15 (1.49)^{a}	3.00 (0)^{a}	3.00 (0)^{a}	2.84 (0.89)^{a}

L-TG: low input Tyrolean Grey; L-BS: low input Brown Swiss; H-TG: high input Tyrolean Grey; H-BS: high input Brown Swiss.
[a,b]Means within a row with different superscripts differ ($p < .05$); standard deviation in brackets.
[1]5-point-Likert scale from 1="Yes, absolutely" with 3="Partly" to 5="No, absolutely not".
[2]5-point-Likert scale from 1="Much less milk" with 3="Equal milk yield" to 5="Much more milk".

higher incomes than H-BS farms. However, when it comes to income per ha or farm the results are conclusive. Thus, our result contrasts the finding of Cozzi et al. (2006) that extensive mountain dairy farms gain higher farm income. However, the results might not be comparable as their study was conducted in another region (Altopiano dei Sette Comuni, Northern Italy). Furthermore, the farms analysed by Cozzi et al. (2006) used different breeds (Rendena, Pezzata Rossa and Bruna Italiana in extensive farms and Friesian and Browns in intensive farms) and had larger herd sizes (35 in extensive and 54 lactating cows in intensive farms), which in addition differed between the extensive and intensive farms. Therefore, intensive farms in their study had higher costs due to larger buildings and more machinery. In our study, farm structure for extensive and intensive farms is similar among the groups and herd sizes are smaller. The different findings underline the influence of farm structure and regional conditions on profitability.

One regional characteristic in the Province of South Tyrol is the milk to feed price ratio of about 1.8. This value might also explain the clear dominance of high-input farms with respect to farm income. Hemme (2015) states that a milk to feed price ratio higher than 1.5 makes intensive milk production more gainful. The fact that in South Tyrol the milk price (Ø 54 c/kg ECM) is much higher than costs for purchased high energy feed (Ø 30 c/kg) can also be the rationale for the result that farms with highest farm income show the smallest percentage of milk derived from roughage (27%). This value is clear below the recommendations of dairy nutrition experts (Kiefer et al., 2015). However, de Oliviera et al. (2010) also indicate that with the current prices in South Tyrol a concentrate intake per cow and day of more than 8 kg might be most profitable. Additionally, hay produced in South Tyrolean mountains is of low quality (Peratoner et al. 2010) and it is known that the cows response to concentrate supplementation is higher when roughage contains low energy (Hanrahan et al. 2018).

Regarding the breeds the results show that farms using the local breed Tyrolean Grey can compete with the high yielding breed Brown Swiss. Especially H-TG farms seem to combine the merits of dual-purpose breeds (higher revenues from cattle sale and lower replacement costs due to longer productive life; Evans et al. 2004; Dal Zotto et al. 2007) and further profit from economies of scale caused by higher milk yield (MacDonald et al. 2007). In addition, farms using Tyrolean Grey benefit from higher subsidies due to a larger share of grasslands and the additional support of Tyrolean Grey cattle as this breed is listed as endangered (Bittante 2011).

However, the high standard deviations for all parameters and all groups suggest that the feeding strategy or breed used is not sufficient to draw conclusions about profitability (Shadbolt 2008). Nevertheless, the comparison of the farms with the lowest and highest income underlines the economical superiority of high-input farms. Farms achieving the highest income have significantly larger herd sizes, produce more milk per cow, feed more concentrates and keep their cows less often on pastures. The finding that milk yield per cow and number of dairy cows per farm are of strong influence for the income per farm is in line with findings by Wilson (2011). Considerable cost saving would be necessary to make farms with lower milk yield competitive to intensive ones (Alvarez et al. 2008; Ramsbottom et al. 2015; Hanrahan et al. 2018) but this was not realisable for the analysed farms.

To summarise, the results show that under current conditions feeding large amounts of concentrates is economically advantageous for South Tyrolean small-scale dairy farmers. This could, however, be linked to problems regarding animal welfare (Manson and Leaver, 1988), impact on environment and landscape (Strijker 2005; Battaglini et al. 2014), the regions attractiveness for tourists (Battaglini et al. 2014) and public acceptance (Gazzarin and Schmid 2017; Faccioni et al. 2019). Furthermore, a low percentage of roughage used for milk production could lead to less fatty acids in the milk (Borreani et al. 2013).

Due to these negative aspects, extensive mountain farms already receive financial support (EC 2008).

The results of our study confirm that low-input farms are more dependent on subsidies – without financial aid, their income is negative. However, the South Tyrolean system of support is not sufficient to provide low-input farmers with a similar income to that of farmers using an intensive feeding strategy. To support mountain dairy farms feeding less concentrates pricing strategies and governmental direct payments should even more consider differences and particularities on farm level (Caraveli 2000; Strijker 2005; El Benni and Finger 2013). In Switzerland, some direct payments are only paid when the production of milk and meat is based on grassland. In detail, farms receive financial aid from a special direct payment scheme when the annual feed ration consists of at least 85% (in mountain areas; 75% for farms located in flatlands) fresh, ensiled or dried grass fodder and only a maximum of 10% concentrated feed (BLW 2019). In this context, the labelling and marketing of traditionally and locally produced mountain products at higher prices may also be promising (Mitchley et al. 2006; Santini et al. 2013). Another approach to reduce the use of concentrated feed is to introduce taxes on imported feed. Although this would initially increase costs for intensive farms, the tax revenue could be used to provide financial support for extensive farms. Data from Switzerland confirm that high concentrate costs through import taxes as well as corresponding direct payments increase the percentage of domestically produced and grassland based feeding (Mack and Kohler 2019).

Farmers' workload, payment and attitudes

The required working time per farm and year is similar among all farm groups and in line with findings by Poulopoulou et al. (2018). The remuneration per working hour is therefore higher for high-input farms as these farmers achieves higher income with equal work effort. Thus, especially for low-input farmers it could be worthwhile to quit dairy farming and find off-farm work. However, this is dependent on the availability of appropriate jobs and farmers motivation (Zimmermann and Heckelei 2012; Pinter and Kirner 2014). Indeed, for the surveyed farmers there is a general tendency that most of them still want to produce milk in ten years. Nevertheless, high-input farmers are more convinced to continue dairy farming, which is because these farmers are more satisfied with their remuneration. Peel et al. (2016) confirm that the probability to quit farming is related to farmers' wellbeing and income. Thus, the risk of farm exits might be higher for extensive farms (MacDonald et al. 2000; Tasser et al. 2007). Thus, although most farmers state that they do not want to increase milk yield per cow, it cannot be ruled that farmers nevertheless will intensify when they get aware of the economic advantages of intensive farming. Indeed, the most important aim is that the farms financial viability have to be ensured to maintain extensive farms in the long-term (Bragg and Dalton 2004; Gellrich and Zimmermann 2007).

Conclusion

Our findings reveal that high-input dairy farming through feeding high amounts of concentrates pays off economically for South Tyrolean small-scale mountain farmers because the high fixed costs can be thinned by higher milk volume. In addition, the high milk to feed price ratio makes it clearly profitable to produce more milk with purchased feed to cover fixed costs. This leads to higher incomes on farms where the percentage of roughage in the feed ration is below the recommended criterion. The results further show that the local breed Tyrolean Grey can compete with the high-yielding breed Brown Swiss in economic terms and at the same time is more used for grazing on mountain pastures. Nevertheless, economic motivation for extensive dairy farming, with significantly more positive environmental effects, is low, as current subsidies are not sufficient to compensate lower farm income. Although most of the surveyed farmers do not expect changes in their feeding strategies, the question arises of how to prevent intensification or farm exits in the long-term. Deducing from the results of this study, effort should be extended to support extensive farming, mainly when local breeds are used, as these farms manage more grasslands, feed more forage and keep their cows more often on pasture with positive effects for environment, landscape and animals' welfare. In addition, this kind of farming is more in line with the public's expectations and thus extensive farming could lead acceptance rate what is decisive for the future of dairy farming. An adaptation of the milk price to the farming strategy, as it is already done for hay milk, or of paid subsidies could be a worthwhile tool for the conservation of extensive small-scale dairy farms in mountain areas whereas a unified high milk price might have the opposite effect. Steering taxes on concentrated feed might also be an option to strengthen the situation of extensive small-scaled farms, especially, when the tax money was used to cross-finance the extensive farms.

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