Lactation curves for milk yield, fat, and protein content in Slovenian dairy sheep

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ABSTRACT: Lactation curves for daily milk yield, fat, and protein content in three dairy sheep breeds were estimated by the repeatability animal model using test-day records. A total of 38 983 records from 3068 ewes of Bovec, Improved Bovec, and Istrian Pramenka breeds, collected between the years 1994 and 2002, were analysed. The three-trait repeatability animal model included breed and lambing season as fixed. The stage of lactation within each breed was modelled by the modified Ali-Schaeffer's lactation curve. Parity and litter size were used as covariates in quadratic and linear regression, respectively. Common flock environment, additive genetic effect, permanent environment over lactations as well as within lactation were treated as random. The average daily milk yield was 1090 g in Bovec, 1010 g in Improved Bovec, and 731 g in Istrian Pramenka breeds. Overall means for fat and protein content were 6.59 and 5.53% for Bovec, 6.22 and 5.33% for Improved Bovec, and 7.20 and 5.63% for Istrian Pramenka. Breed, lambing season, stage of lactation, parity, and litter size significantly ($P < 0.001$) affected all three observed milk traits, with the only exception of parity in fat and litter size in protein content. The shape of lactation curves for daily milk yield in Bovec and Improved Bovec breeds fitted well to the general lactation curve in dairy sheep. Daily milk yield was increasing in the first month of lactation and decreasing thereafter. In Istrian Pramenka, the shape of lactation curve was more or less atypical, with daily milk yield decreasing almost throughout the entire lactation. Lactation curves for fat and protein content were opposite to the lactation curves for daily milk yield in all three breeds.

Keywords: dairy sheep; milk traits; test-day records; lactation curves

Three dairy sheep breeds are mainly used in Slovenia: the autochthonous Bovec (B) and Istrian Pramenka (IP) breeds and the Improved Bovec (IB) breed. B breed is the most numerous dairy breed in the country (3500 sheep) which is bred in the western part of Slovenia around the town of Bovec and Trenta valley. IP (1150 sheep) is reared in the Karst region and in the south-western part of Slovenia. IB breed originates from the native B sheep which was improved with East Friesian sheep and is also bred mainly in the western part of Slovenia. B and IP breeds are reared in the traditional way. The climate as well as rearing conditions are diverse but local breeds are well adapted to the environment where they are reared. All three breeds are mostly used to prevent overgrowing of the agricultural land.

Production of the sheep milk is seasonal in our country due to the seasonal fertility of the breeds. Ewes lamb mainly from February to April. After a two-month suckling period, milking of the ewes starts and it lasts until autumn. Milk is mainly processed into cheese, yoghurt, and curd which are the main sources of the income in all three dairy breeds. Milk yield and its composition are influenced by breed, age of the ewe, litter size, nutrition, health of the animals, environment, stage of lactation, etc. Among these factors, the stage of lactation is very significant (Pavić et al., 2002; Oravcová et al., 2006, 2007; Kuchtík et al., 2008).

Two types of lactation curves can be found in sheep to describe the effect of stage of lactation on milk traits. The first one is common to rich environment or the intensive production systems. Daily milk yield (DMY) is increasing from lambing to the peak of lactation appearing three to five weeks ahead. Thereafter, it is gradually diminishing toward the end of lactation with different persistence, depending on rearing conditions, breed, and individual animal (Ploumi et al., 1998; Ringdorfer and Pöckl, 2004; Oravcová et al., 2006). The second type (Cappio-Borlino et al., 1997a, b; Ringdorfer and Pöckl, 2004), known as an atypical lactation curve, appears in ewes kept in poor environment or in the extensive production systems. DMY is reducing from the start toward the end of lactation. Indeed, no peak is expressed in these lactations. Cappio-Borlino et al. (1997a) and Oravcová et al. (2006) investigated lactation curves within parity and acquired lower and earlier peak with better persistence in the first than in later parities. This fact is due to a maturation process of mammary gland (Stanton et al., 1992), which is still in progress during the first lactation.

The shape of lactation curves is reversed for milk components. Under intensive circumstances, fat (FC) and protein (PC) contents are declining shortly after lambing (Ploumi et al., 1998). The lowest point is reached approximately a week earlier than the peak in DMY. Afterwards, FC and PC are increasing until the end of lactation. Cappio-Borlino et al. (1997a, b) described the atypical lactation curve for milk components, which appeared in barren environment, showing the lowest point at lambing and increasing thereafter.

Milk production is a function of the stage of lactation, usually measured in the number of days in milk (Swalve, 1995). The most common approach in lactation curve modelling is to fit suitable function of time, $y = f(t)$, to test-day records. In dairy cows, Koçak and Ekiz (2008) studied the suitability of seven different mathematical models on DMY records. Most of the studies in dairy sheep focus only on lactation curves for DMY (Torres-Hernandez and Hohenboken, 1980; Cappio-Borlino et al., 1997b; Fuertes et al., 1998; Macciotta et al., 1999; Manalu et al., 2000; Ruiz et al., 2000; Bilgin et al., 2010), but only a few for DMY, FC, and PC (Hassan, 1995; Cappio-Borlino et al., 1997a; Brežnik, 1999; Oravcová et al., 2006, 2007).

In the earlier study in Slovenia, Brežnik (1999) modelled the stage of lactation by a simple quadratic regression due to the lack of records at the beginning of lactation. Since the work of Brežnik (1999), the number of test-day records has substantially enlarged, especially in the first two months of lactation. The lactation curves were investigated for DMY, FC, and PC under new circumstances in three Slovenian dairy sheep breeds by a repeatability animal model. Also, the differences in the lactation curves among breeds were assessed.

MATERIAL AND METHODS

Data for DMY, FC, and PC from Bovec (B), Istrian Pramenka (IP), and Improved Bovec (IB) breeds were provided by the Slovenian breeding program for small ruminants. They were collected between the years 1994 and 2002, according to standard ICAR regulations by A4 method (ICAR, 2005). Milk samples were collected between days 5 and 244 after lambing. DMY was constrained to at least 50 g. Records were deleted if FC did not fall between 1.5 and 18.0% and PC between 2.0 and 13.0%. A few records after parity 10 were omitted as well. Only complete records without missing data were analyzed and at least three test-days per lactation were required to be included. After editing, 6.73% out of 41 794 records were discarded. The analyzed test-day records (38 983) belonged to 3068 ewes from 36 flocks in total.

The majority of test-day records (26 587, Table 1) was collected in breed B, which is also the most important dairy sheep breed in Slovenia. The number of records was considerably smaller in breeds IB (6414) and IP (5982). The distribution of records throughout the lactation was different among breeds. In general, all three breeds had a low number of records in the first month of lactation due to suckling period and in the last month of lactation, where only the best animals and/or animals from the best flocks were still milked. Test-day records in breed B were mainly collected between the second and the sixth month of lactation, while in the other two breeds, records were mainly collected during the third and the sixth month of lactation due to a longer suckling period.

The following multi-breed repeatability animal model (Equation 1) was applied for DMY, FC, and PC (y_{ijklmn}):

$$y_{ijklmn} = B_i + S_j + \sum_{q=1}^{4} b_{iq} x_q + b_5(z_{ijklmn} - \bar{z}) + b_6(z_{ijklmn} - \bar{z})^2 + b_7(w_{ijklmn} - \bar{w}) + fym_k + a_{il} + p_{il} + l_{ilm} + e_{ijklmn} \quad (1)$$

$$x_1 = x_{ijklmn}/150,\ x_2 = (x_{ijklmn}/150)^2$$
$$x_3 = \ln(150/x_{ijklmn}),\ x_4 = (\ln(150/x_{ijklmn}))^2 \quad (2)$$

Fixed part of the model included breed (B_i) with three levels and lambing season as year-month of lambing interaction (S_j) with 63 levels. Due to the seasonal production systems, the first and last months of lambing were checked for the number of records and joined with adjacent ones, if the

Table 1. Descriptive statistics by breeds according to the month of lactation

Breed/month of lactation	*N*	(%)	Daily milk yield (g)	Fat content (%)	Protein content (%)
Bovec (B)					
1	1 076	4	2 308 ± 963	4.52 ± 1.32	4.66 ± 0.49
2	4 636	17	1 821 ± 741	5.36 ± 1.00	4.67 ± 0.51
3	5 217	20	1 340 ± 588	5.97 ± 1.03	4.87 ± 0.54
4	5 252	20	938 ± 448	6.63 ± 1.16	5.31 ± 0.67
5	4 873	18	680 ± 354	7.32 ± 1.36	6.03 ± 0.94
6	3 585	14	526 ± 294	7.96 ± 1.56	6.79 ± 1.19
7	1 447	5	465 ± 286	7.96 ± 1.64	6.88 ± 1.25
8	501	2	569 ± 286	7.53 ± 1.75	6.58 ± 1.06
B total	26 587	100	1 090 ± 743	6.59 ± 1.60	5.53 ± 1.14
Improved Bovec (IB)					
1	123	2	2 058 ± 1 064	3.98 ± 1.17	4.62 ± 0.44
2	486	8	1 819 ± 792	5.13 ± 0.96	4.65 ± 0.53
3	980	15	1 410 ± 584	5.47 ± 0.85	4.84 ± 0.46
4	1 142	18	1 140 ± 454	5.75 ± 0.88	4.97 ± 0.52
5	1 154	18	908 ± 357	6.15 ± 0.94	5.21 ± 0.58
6	1 109	17	745 ± 304	6.57 ± 1.01	5.46 ± 0.67
7	856	13	607 ± 286	7.21 ± 1.14	6.02 ± 0.89
8	564	9	471 ± 259	7.90 ± 1.36	6.58 ± 1.06
IB total	6 414	100	1 010 ± 611	6.22 ± 1.32	5.33 ± 0.87
Istrian Pramenka (IP)					
1	266	4	1 127 ± 555	4.83 ± 1.45	4.95 ± 0.44
2	510	9	1 095 ± 498	5.75 ± 1.26	4.93 ± 0.44
3	1 051	18	934 ± 378	6.54 ± 1.11	5.16 ± 0.54
4	1 225	20	772 ± 321	7.06 ± 1.15	5.41 ± 0.59
5	1 199	20	666 ± 298	7.41 ± 1.20	5.70 ± 0.64
6	966	16	500 ± 260	8.00 ± 1.36	6.06 ± 0.83
7	552	9	413 ± 246	8.61 ± 1.70	6.61 ± 1.13
8	213	4	364 ± 212	9.10 ± 1.85	6.90 ± 1.24
IP total	5 982	100	731 ± 408	7.20 ± 1.62	5.63 ± 0.90

number was insufficient (less than 20 observations). Stage of lactation, parity, and litter size were treated as covariates. Stage of lactation (x_{ijklmn}) was modelled by Ali-Schaeffer's lactation curve (Ali and Schaeffer, 1987) with four regression coefficients nested within breed. Independent variables (Equation 2) x_1, x_2, x_3, and x_4 were transformations of the stage of lactation. Because lactations are shorter in sheep than cows, a constant of 305 was replaced by 150. Parity (z_{ijklmn}) and litter size (w_{ijklmn}) were modelled with a simple quadratic and linear regression, respectively.

Common flock environment effect (fym_k), additive genetic effect (a_{il}), permanent environment effect over lactations (p_{il}), and permanent environment effect within lactation (l_{ilm}) were fitted as random. Random part of the model is more precisely described by Komprej et al. (2009).

Statistical analysis of the data was initially performed using GLM (General Linear Model) pro-

Table 2. Coefficient of determination for individual effects in milk traits (in %)

Effect/milk trait	Daily milk yield	Fat content	Protein content	Degrees of freedom
Breed	3.38	3.07	0.69	2
Season of lambing	5.31	3.14	5.35	62
Stage of lactation	51.35	39.52	47.58	12
Parity	1.62	0.06	0.03	2
Litter size	0.38	0.13	0.01	1
Total	62.04	45.92	53.66	79

cedure in SAS (SAS 2001), where the fixed part of the model was developed. Covariance components were estimated by restricted maximum likelihood (REML) as applied in VCE 5 (Kovač et al., 2002) by the three-trait (DMY, FC, and PC) repeatability animal model. The analysis was performed for all three breeds together, due to the small data sets in IB and IP breeds (Komprej et al., 2009).

RESULTS AND DISCUSSION

The average DMY over lactations was the highest (1090 g; Table 1) in breed B. Breed IB had lower average DMY (1010 g), unexpectedly, which is mainly a consequence of a longer suckling period in the first two months of lactation. In addition, IB ewes have in general higher maintenance requirements which are not met under barren environment. The lowest average DMY among all breeds had IP breed (731 g). In all three breeds, the average DMY was decreasing from the first to the last month of lactation. The average level of FC was 6.59% in breed B (Table 1), 6.22% in IB, and 7.20% in IP breed. FC was increasing from the beginning toward the end of lactation in all three breeds. The lowest average PC was observed in IB (5.33%) and the highest in IP breed (5.63%). Also, PC was increasing from the first to the last month of lactation. Standard deviation was reducing in DMY and enlarging in FC and PC as the lactation progressed.

Fixed effects of the model were significant in all three observed milk traits ($P < 0.001$), with the only exception of parity in FC and litter size in PC. As concerns the particular effects (Table 2), all the three milk traits were the most affected by the stage of lactation. Coefficient of determination for this effect was 51.35% for DMY, 39.52% for FC, and 47.58% for PC. All other effects contributed to a much smaller variation in the observed milk traits when added in the model with all other effects. This fact is in accordance with Swalve (1995), who says that modelling of days in milk is crucial in test day models, while other effects are of lesser extent. A significant ($P < 0.05$) or highly significant ($P < 0.001$) effect of the stage of lactation on DMY, FC, and PC was confirmed also by Pavić et al. (2002) in Travnik sheep, by Oravcová et al. (2006, 2007)

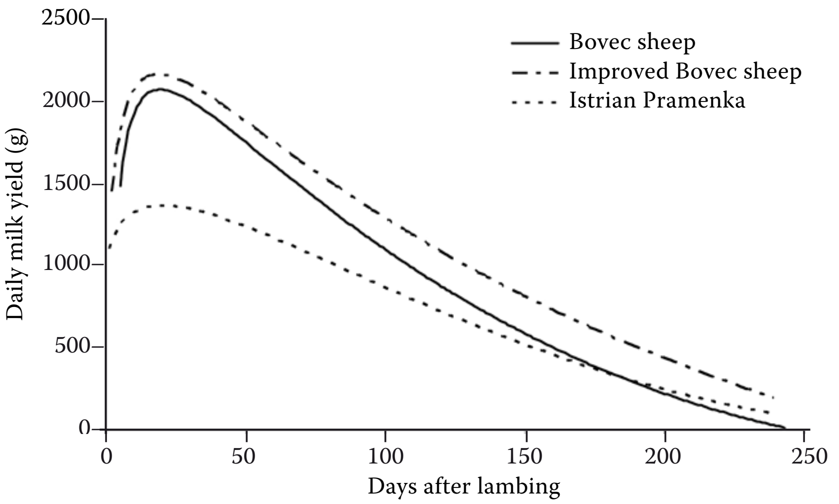

Figure 1. Lactation curves for DMY

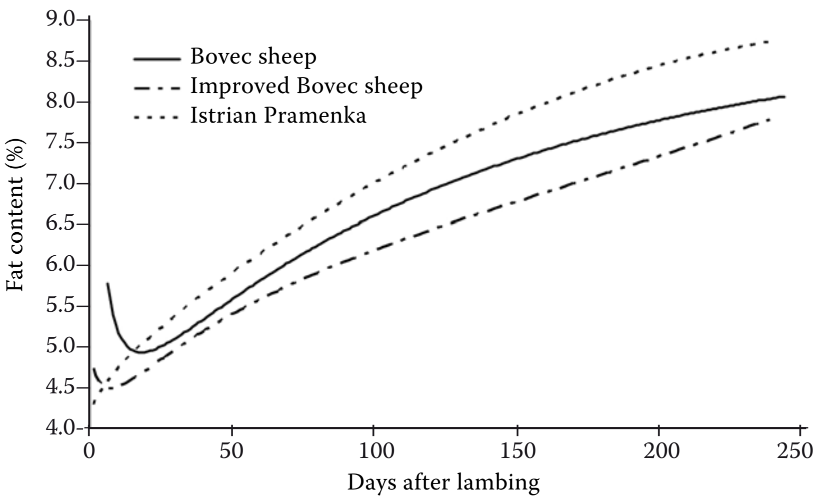

Figure 2. Lactation curves for milk FC

in Tsigai, Lacaune, and Improved Valachian sheep, and by Kuchtík et al. (2008) in East Friesian sheep.

Stage of lactation, nested within breed, was modelled with modified Ali-Schaeffer's lactation curve (Ali and Schaeffer, 1987). As expected, DMY was increasing from the beginning to the third (breed B) or forth (breed IB) week of lactation (Figure 1) and decreasing after the peak was reached. Both breeds showed a typical lactation curve in DMY. Regarding the average DMY by month of lactation of these two breeds presented in Table 1, where B breed had higher DMY in the first two months after lambing than IB breed, the estimated lactation curves (Figure 1) showed a higher milk production level in IB in comparison to B breed throughout the entire lactation. The reason for the difference could be in a lack of records at the beginning of lactation and thus in overestimation of the average DMY. FC was declining after lambing in B and IB breeds (Figure 2), while it was steadily increasing toward the end of lactation. In B breed, the minimum was reached in the third week of lactation, coinciding with the peak of DMY. The minimum of FC in IB breed was reached in the first week of lactation, earlier than the peak of DMY. The level of FC in B breed was higher than in IB for the entire lactation. PC was also reducing from the beginning to the fourth week of lactation in breed B and to the third week of lactation in breed IB (Figure 3). After reaching the minimum, an ascending phase followed in both breeds. The minimum in PC in breed B appeared a week later in comparison to the peak in DMY and the minimum in FC. In IB breed, the minimum in PC coincided with the peak in DMY, while it appeared a week later than the minimum in FC. The level of PC in B breed was higher in comparison to IB breed for the entire lactation.

The typical shape of lactation curves in dairy sheep was reported by Hassan (1995) for DMY and FC in Ossimi sheep, by Cappio-Borlino et al. (1997a) for PC in Val del Belice sheep, by Cappio-Borlino et al. (1997b) for DMY in Sarda sheep, by

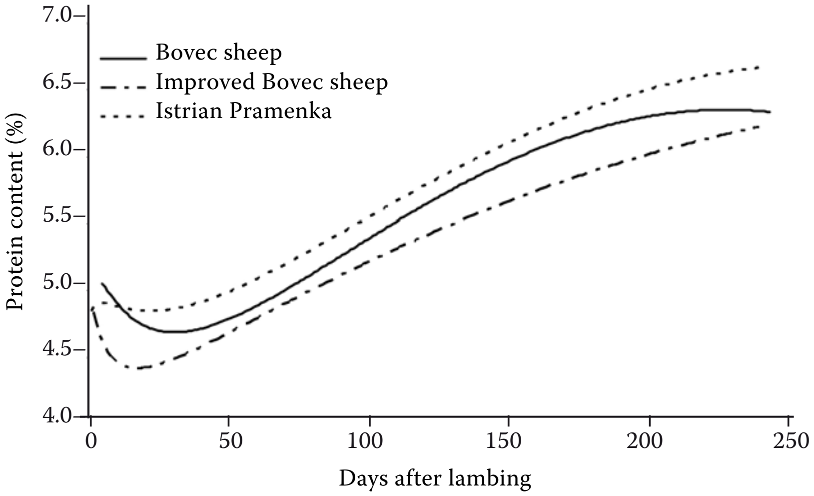

Figure 3. Lactation curves for milk PC

Fuertes et al. (1998) for DMY in Churra sheep, by Ringdorfer and Pöckl (2004) in Austrian mountain sheep, by Oravcová et al. (2006, 2007) for DMY, FC, and PC in Tsigai and Lacaune sheep and for DMY and PC in Improved Valachian sheep, and by Bilgin et al. (2010) for DMY in Morkaraman sheep. Some authors mentioned that these dairy sheep were supplemented with concentrates during milking, so they were kept in rich environment. The milk production level in B and IB breed was higher than in Spanish Churra breed (Gonzalo et al., 1994) and Slovak Tsigai, Improved Valachian, and Lacaune breeds (Oravcová et al., 2006). For FC and PC, the level of lactation curve in our breeds was lower in comparison to Churra breed. Fuertes et al. (1998) studied only DMY in Churra breed, where the shape of lactation curve was similar to B and IB breed, but the production level of Churra breed was lower in comparison to the two breeds. Milk production level of the two breeds was also higher than in Boutsico sheep (Kominakis et al., 2002). The level of lactation curves for FC in our B and IB breeds was slightly higher in comparison to Lacaune breed, but lower in comparison to Tsigai breed observed by Oravcová et al. (2007). For PC, the level of lactation curves in our B and IB breeds was more similar than that in Lacaune and Tsigai breeds.

Due to small amount of records in early lactation, simple quadratic regression was applied for Slovenian dairy sheep by Brežnik (1999) which sufficiently described the peak and declining phase of the lactation curve. When lactation curves for milk traits in the three Slovenian dairy sheep breeds were estimated without a random part of the model (Komprej et al., 2003), DMY in B and IP breeds has started to increase since the 200th day of lactation, while FC and PC were decreasing at the same time. The fact proved to be a consequence of drying practice, when milking was stopped earlier at low producing animals or even flocks. Only the best animals and/or the best flocks were still milked at the very end of lactation.

A considerably high increase in DMY was obtained in B (almost 600 g) as well as in IB (700 g) breed at the beginning of lactation (Figure 1). The reduction in DMY from the peak to the end of lactation was almost 100% in B breed (2077 to 13 g) and 91% in IB breed (2170 to 194 g). In Boutsico breed, adapted to harsh environmental conditions in the highland and mountain areas of north-western Greece (Kominakis et al., 1998), DMY fell by 70% (879 to 235 g) between the 24th and the 248th day of lactation (Kominakis et al., 2002).

FC in B breed decreased around 1% in the first two weeks of lactation (Figure 2), while it was steadily rising toward the end of lactation reaching around 8%. In IB, the decrease of FC after lambing was much smaller, it was less than 0.25%. FC was then increasing toward the end of lactation, to almost 8%. PC was also reducing from the beginning to the fourth week of lactation in breed B and to the third week of lactation in breed IB (by about 0.4%; Figure 3). After reaching the minimum, an ascending phase followed in both breeds, thus PC exceeded 6.3% in both breeds at the end of lactation.

Between the 45th and the 150th day of lactation, DMY in B breed decreased by 70% (1411 to 467 g) and DMY in breed IB fell by 60% (1929 to 807 g). Gonzalo et al. (1994) also noticed a 70% decrease (1755 to 547 g) in DMY for Spanish Churra breed in the same period of lactation. FC rose by 35% (5.40 to 7.30%) in B breed and by 28% (5.20 to 6.65%) in IB breed between the 45th and the 150th day of lactation. An increase of PC was 27% (4.73 to 6.00%) in B and 23% (4.60 to 5.65%) in IB breed. In Churra breed, Gonzalo et al. (1994) confirmed higher (40%) increase in FC (5.96 to 8.20 %) and lower (20%) increase in PC (5.69 to 6.85%) in the same period. Churra breed, raised in North-Western Spain, is well suited to the continental climate with long severe winters, very short springs and hot dry summers. A similar decrease of DMY and an increase of PC in Churra breed were later observed also by El-Saied et al. (1998c).

Traditional rearing technology in breed B, kept in the western part of Slovenia, and climate conditions can explain the relatively fast decrease of DMY after the peak of lactation curve is reached. Bovec sheep are kept in flocks up to 30 animals, rarely breeders decide to rear over 100 sheep in a single flock. Soon after lambing, ewes go to the pastures near the stables in April, where the quality of pasture is moderate due to dry winters without rainfall. Growth conditions for grass are even worse, therefore ewes do not cover their high nutrient requirements for the maintenance and milk yield. Additionally, breeders take a half of the ewes to the mountain pastures in June, where they stay until September. Due to relatively long walk during grazing at the mountain pastures, milk yield usually decreases, which also affects DMY and its composition. Some breeders with large flocks keep the animals in lowland. The husbandry in these flocks is more intensive, so sheep are often fed concentrates as an addition beside pasture, hay or grass silage. Considering traditional rearing conditions, the production level in B breed seems to be relatively high. Also Gabiña and Ugarte (2001) reported that Manchega, Churra, and Latxa dairy sheep from Spain had medium milk yield due to the extensive or semi-extensive production systems.

The German East-Friesian breed was used to improve the local B breed in order to obtain higher milk production. East-Friesian breed is known for high milk yield and prolificacy in its native country (Boyazoglu, 1991; Maijala and Terrill, 1991). East Friesian sheep are highly specific animals which do poorly under extensive and large flock conditions. As seen from Figure 1, IB breed had slightly higher DMY through lactation than B, even though we expected a larger difference in DMY. IB is reared also in the western part of Slovenia. In more intensive rearing conditions with rich feeding, the IB breed could probably be more productive. The average DMY of IB breed was 1010 g with 6.22% FC and 5.33% PC (Table 1), while the average DMY of the purebred East-Friesian breed studied by Hamann et al. (2004) was 2330 g with 5.81% FC and 4.98% PC.

The lactation curve in IP breed (Figure 1) seems to be similar to the atypical lactation curve. Precisely, DMY in IP breed was slightly increasing after lambing to the peak, which appeared a week earlier and was much smaller than in IB and B breeds. Then, DMY was gradually diminishing toward the end of lactation. The decrease in DMY in this breed was slower than in B and IB breeds. FC (Figure 2) in this breed was rising through the entire lactation. PC (Figure 3) was more or less constant at the beginning of lactation, but later it was steadily increasing.

Lactation curves for DMY and FC in IP breed had more or less atypical shape, similar to the ones observed in Valle del Belice dairy sheep by Cappio-Borlino et al. (1997a), Improved Valachian dairy sheep observed by Oravcová et al. (2007), and in Awassi and Tushin dairy sheep observed by Bilgin et al. (2010). This shape also appeared in a part of the Sarda breed population (Cappio-Borlino et al., 1997b). Actually, 30–50% of lactations in Sarda breed are reported to be atypical (Cappio-Borlino et al., 1995; Carta et al., 1995). The atypical lactation curve for DMY was found also in German Improved Fawn goats (Bömkes et al., 2004). It is specific for the extensive production systems, where nutrition of the ewes is insufficient in the last third of gestation period and also after lambing. As mentioned before, IP breed is reared mainly in the extensive production systems of Karst and Istria regions, where the quality of pasture and hay is relatively low. Nutrition of the ewes is often not balanced to their requirements for the specific production level, especially in the periods when ewes are more productive. Ringdorfer and Pöckl (2004) found out that the average DMY in Austrian mountain sheep depended on hay quality and the amount of concentrate added to the diet. Lower quality of hay (7.65 MJ of metabolisable energy, 117 g of crude proteins vs. 8.80 MJ of metabolisable energy, 134 g of crude proteins) and smaller amounts of concentrate (5 and 30% vs. 55% of total ratio) were also related to a lower feed intake, which was reflected in lower DMY. The average DMY of sheep fed a lower amount of concentrate was decreasing immediately after lambing, and the lactation curve of these sheep had an atypical shape. The lactation curves in IP breed were not of the same height in comparison to Valle del Belice (Cappio-Borlino et al., 1997a), Sarda (Carta et al., 2001), and Awassi and Tushin breeds (Bilgin et al., 2010). The daily milk production level was lower in IP compared to the Valle del Belice and Sarda breeds, while it was higher than in Awassi and Tushin breed. For FC, the level in IP breed was lower than in Valle del Belice and Sarda breeds in the first half of lactation, while later, it was higher than in the other two breeds. Our IP breed had similar height of the lactation curve for FC than Improved Valachian sheep studied by Oravcová et al. (2007). The level of PC in IP breed was similar to Valle del Belice and Sarda breeds in the first months of lactation. Later, PC in IP breed was diminishing to a lesser extent than in Valle del Belice and Sarda breeds. The husbandry in our IP breed, as well as in Valle del Belice from south-western Sicily, Sarda from Sardinia, and Awassi and Tushin from Turkey, is typically extensive. Animals are kept outdoors on pastures, supplementation is occasional and their diet is not balanced according to the stage of production.

In IP, DMY was decreasing from almost 1400 g at the peak of lactation curve to 100 g toward the end of lactation (Figure 1). The decrease made 93%. FC (Figure 2) in this breed rose by more than 100% (4.23 to 8.74%). PC (Figure 3) increased by 38% (4.85 to 6.67%) throughout the lactation. In comparison to other milk breeds, DMY in IP breed fell the most from the peak to the end of lactation. DMY in Valle del Belice breed declined by 50%

(2000 to 1000 g) between the first and the seventh month of lactation (Cappio-Borlino et al., 1997a). In Sarda breed (Cappio-Borlino et al., 1997b), DMY decreased by 75% (2000 to 500 g) between the first and the seventh month of lactation. Later analysis of Sarda's breed milk yield by Carta et al. (2001) showed a 63% reduction of DMY (1515 to 558 g), 26% FC increase (6.12 to 7.73%), and 17% PC increase (5.27 to 6.16%) between the first and the seventh month of lactation.

In all observed milk traits, the shape of lactation curves in breeds B and IB was in accordance with the general (typical) lactation curve for dairy sheep. DMY was increasing in the first month of lactation and it was decreasing thereafter. Contrary, FC and PC were reducing from lambing for some weeks after and then they were increasing towards the end of lactation. The lactation curves of IP breed were more or less similar to the atypical lactation curves of Valle del Belice, a part of Sarda sheep population, and Awassi and Tushin sheep. While DMY was decreasing during the lactation period, FC and PC were increasing simultaneously.

The typical extensive husbandry is known in Slovenian dairy sheep. In our study, DMY declined quite fast after lambing. Nevertheless, the production level in B breed seemed to be relatively high. In better rearing conditions, IB breed could produce more milk.

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