ACTA *Acta Sci. Pol., Zootechnica 12 (1) 2013, 21–32*

THE EFFECT OF SELECTED NON-GENETIC FACTORS ON KEY FERTILITY INDICES IN HIGH-YIELDING MONTBÉLIARDE COWS

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Abstract. The aim of the study was to analyse the effect of non-genetic factors on fertility in high-yielding Montbéliarde cows. The length of the rearing period for the Montbéliarde heifers in the herd analysed was found to depend on their origin and on the season in which they were born. Their average age at first calving was 908 days, with imported heifers calving for the first time on average 168 days later than native heifers. Heifers born in autumn months gave birth earliest, while those born from March to May calved latest. The acclimatization process may have negatively affected reproductive performance, as longer calving-to-first-service intervals (CFSI), service periods (SP), calving-to-conception intervals (CCI), and calving intervals (CI) were noted in the imported cows. Delayed first calving in heifers significantly increased the calving-to-first-service interval. In successive lactations a general downward trend was observed in the length of CFSI, SP, CCI and CI. Reproductive efficiency was significantly reduced by 305-day milk yield exceeding 10 000 kg FPCM. Hence, in the case of record productivity in the Montbéliarde breed, as in Holstein-Friesians, reduced fertility must be expected.

Key words: cows, fertility indices, high yield, Montbéliarde

INTRODUCTION

Since 1993 milk yield per cow has been systematically increasing in Poland. In 1993 the average yield of evaluated cows was 3935 kg of milk, and in 2011 it

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exceeded 7000 kg for the first time. In 2011 the increase in yield in comparison with the previous year was 155 kg of milk (from 6980 to 7135), while the number of cows in the active population increased by 2%. The increase in the Montbéliarde population was much greater (18.7%), and their yield in 2011 was 7093 kg [PFCB&DF 2012].

The increasing production potential of dairy cows can negatively affect reproductive indices [Bronicki and Dembiński 1996, Lucy 2001, Sawa et al. 2002, Westwood et al. 2002, Bogucki et al. 2007, Borkowska and Januś 2009, Koeck et al. 2010]. Reproductive problems are particularly severe in high-yielding cows, whose lactation yield often exceeds 10 000 kg of milk [Bogucki et al. 2007]. These problems result from the fact that the nutritional needs of the cows are not adequately met in the early lactation period. The reproductive system is first to react to any type of irregularities. Symptoms observed include prolongation of the period between calving and the appearance of the first post-calving oestrus, less pronounced external signs of oestrus, silent oestrus, ovulatory disorders, reduced conception rate, prolonged oestrus cycles, and poor oocyte quality [Bronicki and Dembiński 1996, Sawa et al. 2002, Strzetelski et al. 2003, Jaśkowski et al. 2006].

Fertility maintained at the proper level positively affects genetic improvement efforts, milk yield, and the profitability of milk production [Kowalski 2010]. Reproductive disorders are the most important health problem in dairy cattle after mastitis, which means that a substantial proportion of cows are eliminated from the herd before achieving their full production potential [Januś and Borkowska 2006, Kowalski 2010]. In a population of dairy cows analysed by Sawa et al. [2002], 64% of cullings were due to infertility.

Changes in reproduction indices in high-yielding cows are influenced by a number of factors, mainly non-genetic (nutrition, care, rearing of heifers, production levels, and herd organization and management) [Litwińczuk et al. 2004, Nogalski 2004, Bilik and Strzetelski 2006, Januś and Borkowska 2006, Bogucki et al. 2007, Kowalski 2010, Sawa and Bogucki 2011]. One factor reducing reproductive efficiency is ineffective oestrus detection [Bilik and Strzetelski 2006]. There has been a tendency to inseminate cows too soon after calving in order to improve certain reproductive indices, which takes place at the cost of the rest period [Juszczak and Hibner 2000]. Reproductive efficiency is influenced to a lesser degree by genetic factors [Januś and Borkowska 2004, Litwińczuk et al. 2004]. Kruk et al. [2010] report that fertility disorders are only about 10% determined by genetic factors.

The aim of the study was to analyse the effect of non-genetic factors on changes in reproductive indices in high-yielding Montbéliarde cows.

MATERIAL AND METHODS

The study was carried out on the farm MONTAGRO sp. z o.o., which in 2011 kept 248 Montbéliarde cows with average milk yield per cow of 9782 kg of milk, containing 3.36% fat and 3.49% protein [PFCB&DF 2012]. The cows were kept in free-stall housing on deep litter and fed total mixed rations (TMR).

Data were obtained from the SYMLEK data base: the date of birth of each cow, the dates of their calvings and dry periods, the dates of first service after calving and successful service, and the number of services per conception. Based on these data the following fertility indices were calculated: age at first calving (AFC), calving-to-first-service interval (CFSI), service period (SP), calving interval (CI), calving-to-conception interval (CCI) and services per conception (SC). Data were also collected on standard lactation yield, which was converted to FPCM (fat and protein corrected milk) according to the following formula [Subnel et al. 1994]:

$$\text{FPCM (kg)} = [0.337 + 0.116 \times \text{fat (\%)} + 0.06 \times \text{protein (\%)}] \times \text{milk (kg)}$$

For the statistical evaluation, analysis of variance using the least squares method was performed with SAS software [2006]. Significance of differences was determined by Scheffe's test. Two-way analysis was used to evaluate the effect of origin (imported – brought from France to Poland in December 2005 and at the beginning of 2006 as heifers in their 7th-8th month of pregnancy, and native – born and reared in Poland) and season of birth (spring – March-May, summer – June-August, autumn – September-November, and winter – December-February) on the age of the heifers at first calving. The remaining fertility indices (CFSI, SP, CI, CCI, SC) were analysed taking into account the following factors:

– origin (imported, native);
– age (in days) at first calving ($\leq$ 823; 824–915; 916–1038, > 1038);
– calving number (1, 2, 3, > 3);
– standard lactation yield (kg FPCM) ($\leq$ 8000, 8001–10 000, > 10 000).

The frequency of occurrence of different service period lengths (none, 1–24 days, 25–72, 73–98 and > 98 days) was also determined for the factors taken into account in the analysis. The significance of the effect of the factors was estimated using the χ^2 test of independence.

RESULTS AND DISCUSSION

Calving age in heifers is a factor that determines lifetime production parameters in dairy cows (fertility, milk yield, milk performance efficiency) [Pirlo et al. 2000, Majewska et al. 2002, Nogalski 2004, Krężel-Czopek and Sawa 2008, Gołębiewski and Brzozowski 2009]. In 2011 the average age at first calving of Montbéliarde cows in Poland was 873 days [PFCB&DF 2012]. In the herd analysed in the present study, the Montbéliarde heifers gave birth on average at the age of 908 days, i.e. in about their 30th month of life (Table 1). Trela [2003] reports that the standard age at first calving for this breed is 33 months, which means that the rearing period for the heifers in the herd analysed was 3 months shorter. In a study by Koç [2011], heifers of this breed gave birth at the age of 952 days. Gołębiewski and Brzozowski [2009] found that Montbéliarde heifers gave birth for the first time when they were 912 days old.

Milk production in the Montbéliarde heifers most frequently began within the age range of 916–1038 days (109 cows – 32.9% of the total). The percentage of heifers whose first calving took place at the age of 824–915 days was 1.2% lower (31.7%). Calving at $\leq$ 823 days was noted in 71 cases (21.5%), while age at first calving exceeded 1038 days in 46 heifers (13.9%).

The results presented in Table 1 show that the reproductive life of the heifers on the farm analysed began earlier than in the French herds. A younger age at first calving reduces the costs of rearing the heifer, which account for about 15–20% of all milk production costs [Nogalski 2004]. Among the heifers born and reared in Poland, a combined 79.1% calved at an age not exceeding 823 days or between 824 and 915 days. In only 2 (1.3%) cases were births noted at an age exceeding 1038 days. The imported heifers calved for the first time on average 168 days later ($P \leq 0.01$), and the highest percentage by far (45.8%) gave birth at an age of 916–1038 days.

Heifers born in autumn months calved at the earliest age, and those born in spring months at the latest age. The difference between these groups (99 days) was significant at $P \leq 0.01$. The age at first calving for heifers born in autumn (873 days) also differed from the average calculated for the summer (924 days). A marked association was observed between season of birth and age at first calving. The earliest calvings (up to 823 days) and those in the range of 824-915 days were most often noted in heifers born in winter months (25.4% and 47.3%, respectively), which may suggest that their somatic development was more rapid and they attained the body mass and condition necessary for reproduction earlier. A study by Kuczaj [2004] found that development of calves born in winter was most advanced as early as the first few days of life. Age at first calving between 916 and 1038 days was most frequently noted in heifers born in autumn and summer (42.0% and 38.6%, respectively), while the highest percentage of births at > 1038 days was noted in the heifers born in March–May.

The indicator considered to be most important for evaluating fertility in dairy herds is calving interval (CI). In 2011 the calving interval in the active population of Montbéliarde cows was 413 days, and the calving-to-conception interval was 123 days [PFCB&DF 2012]. Table 2 shows that the Montbéliarde herd analysed in the study was characterized by higher values for these traits; average CI was 441 days and CCI was 158 days. Changes in these indices were significantly ($P \leq 0.01$ and $P \leq 0.05$) affected by three of the four factors taken into account in the statistical analysis. Fertility was not significantly influenced by the age of the cows at first calving. However, the highest values for both of these indices were noted in the case of heifers that calved at the age above 1038 days.

Table 1. Age at first calving (days) of Montbéliarde heifers according to their origin and season of birth
Tabela 1. Wiek przy pierwszym wycieleniu (dni) jałowic montbéliarde w zależności od pochodzenia i sezonu urodzenia

Factor – Czynnik	Number of cows Liczba krów	Age at first calving Wiek przy I wycieleniu		Number (%) of heifers calving at different ages Liczba (%) jałowic cielących się w wieku				Value for χ^2 test Wartość testu χ^2
		LSM	SE	≤ 823	824–915	916–1038	> 1038	
Origin – Pochodzenie								
– imported – importowane	168	997^{A}	8.59	10 (6.0)	37 (22.0)	77 (45.8)	44 (26.2)	102.7*
– native – krajowe	163	829^{B}	7.98	61 (37.4)	68 (41.7)	32 (19.6)	2 (1.3)	
Season of birth Sezon urodzenia								
– spring – wiosenny	69	972^{Aa}	13.61	12 (17.4)	26 (37.7)	16 (23.2)	15 (21.7)	29.0*
– summer – letni	88	924^{Ab}	10.22	21 (23.9)	17 (19.3)	34 (38.6)	16 (18.2)	
– autumn – jesienny	119	873^{B}	9.21	24 (20.2)	36 (30.2)	50 (42.0)	9 (7.6)	
– winter – zimowy	55	881^{AB}	13.24	14 (25.4)	26 (47.3)	9 (16.4)	6 (10.9)	
Total and average Ogółem i średnio	331	908	6.74	71 (21.5)	105 (31.7)	109 (32.9)	46 (13.9)	–

Averages designated with different letters differ significantly: capital letters – $P \leq 0.01$, lower case letters – $P \leq 0.05$.
Średnie oznaczone różnymi literami różnią się istotnie: wielkie litery – przy $P \leq 0,01$, małe litery – przy $P \leq 0,05$.
*value for the χ^2 test significant at $P \leq 0.01$ – wartość testu χ^2 istotna przy $P \leq 0,01$.

A factor that significantly ($P \leq 0.01$) influenced fertility traits was the origin of the cows. In those imported from France, CFSI, SP, CCI and CI were longer by 28, 53, 80 and 79 days, respectively. These results indicate that the acclimatization process may have negatively affected the reproductive performance of the imported cows. According to Trela [2003], Montbéliarde cattle imported from France to Poland adapt well to their new conditions after living in them for a long period of time. First calving at an age exceeding 1038 days significantly lengthened the calving-to-first-service interval (to 96 days). This index was lowest (70 days) when age at first calving was 823 days or less. When the first calving occurred at the age of 824–1038 days, the length of the calving-to-first-service interval was 80–82 days. In a population of high-yielding Black-and-White Holstein-Friesian cows, first calving delayed to 915 days had a significant negative effect on fertility indices in subsequent reproductive periods [Borkowska et al. 2012].

Table 2. Fertility indices taking into account the effect of the factors analysed
Tabela 2. Wielkość wskaźników płodności krów w obrębie analizowanych czynników

Factor – Czynnik	n	Length of periods (days) – Długość okresów (dni) LSM (SE)				SC* – IU* LSM (SE)
		CFSI* PP*	SP* OU*	CCI* OMC*	CI* OMW*	
Origin – Pochodzenie						
– imported – importowane	570	96^{A} (1.91)	80^{A} (4.55)	176^{A} (4.69)	459^{A} (4.64)	2.07^{A} (0.06)
– native – krajowe	282	68^{B} (2.81)	27^{B} (6.70)	96^{B} (6.90)	380^{B} (6.83)	1.65^{B} (0.08)
Age at first calving; days Wiek przy I wycieleniu; dni						
– ≤ 823	86	70^{A} (4.41)	62 (10.49)	135 (10.8)	417 (10.69)	1.92 (0.13)
– 824–915	290	80^{A} (2.34)	46 (10.1)	127 (5.75)	410 (5.69)	1.79 (0.07)
– 916–1038	326	82^{a} (2.40)	57 (5.70)	139 (5.88)	423 (5.82)	1.90 (0.07)
– > 1038	150	96^{Bb} (3.60)	47 (8.55)	143 (8.82)	427 (8.72)	1.84 (0.011)
Calving number Kolejne wycielenie						
– 1	290	109^{A} (2.57)	90^{Aa} (6.11)	201^{A} (6.30)	485^{A} (6.23)	1.98 (0.08)
– 2	225	77^{B} (2.81)	38^{B} (6.70)	116^{B} (6.91)	398^{B} (6.83)	1.81 (0.08)
– 3	178	76^{B} (3.32)	56^{b} (7.90)	131^{Ba} (8.14)	415^{Ba} (8.05)	1.93 (0.10)
– > 3	159	66^{B} (3.60)	30^{B} (8.57)	96^{Bb} (8.84)	380^{Bb} (8.74)	1.73 (0.11)
Milk yield in 305 days; kg FPCM Wydajność mleka za 305 dni; kg FPCM						
– ≤ 8000	288	87^{a} (3.02)	43^{a} (7.19)	129^{A} (7.41)	412^{a} (7.33)	1.69^{A} (0.09)
– 8001–10 000	256	77^{b} (2.64)	47^{a} (8.2)	125^{A} (6.46)	409^{A} (6.40)	1.77^{A} (0.08)
– > 10 000	308	82 (2.47)	69^{b} (5.87)	154^{B} (6.05)	437^{Bb} (6.00)	2.12^{B} (0.07)
Total and average Ogółem i średnio	852	91 (1.54)	66 (3.31)	158 (3.67)	441 (3.63)	1.95 (0.04)

Averages within a factor designated with different letters differ significantly: capital letters – $P \leq 0.01$, lower case letters – $P \leq 0.05$.
Średnie w obrębie czynnika oznaczone różnymi literami różnią się istotnie: wielkie litery – przy $P \leq 0{,}01$, małe litery – przy $P \leq 0{,}05$.

* CFSI – calving–to–first–service interval – PP – przestój poциążowy.
SP – service period – OU – okres usługi.
CCI – calving–to–conception interval – OMC – okres międzyciążowy.
CI – calving interval – OMW – okres międzywycieleniowy.
SC – services per conception – IU – indeks unasienień.

Analysis of the effect of lactation number showed a general downward trend in the length of CFSI, SP, CCI and CI. No pattern was observed with respect to services per conception. The average values ranged from 1.73 to 1.98 and the differences were statistically insignificant. The most favourable values for all indices were calculated for cows calving for the fourth time or more (66, 30, 96 and 380). The longest CFSI, SP, CCI and CI were noted in primiparous cows: 109, 90, 201 and 485 days, respectively, which was longer than the recommended lengths. Shortening of successive intervals between calvings in Montbéliarde cows was observed by Behmaram and Aslaminejad [2010]. Krzyżewski et al. [2004] report that prolonged CI is beneficial in primiparous cows, as it enables the young animals to more rapidly attain full maturity and the proper condition for the next calving.

The indices expressed in days decreased with successive calvings. The exception was CI, CCI and SP after the second calving. The differences between the extreme values were 43 (CFSI), 60 (SP) and 105 (CCI and CI) days. Some of the differences between groups were significant ($P \leq 0.01$ and $P \leq 0.05$). This is not consistent with results of other studies [Sawa et al. 2004, Hare et al. 2006, Borkowska et al. 2012], which found that fertility indices became significantly less favourable in successive lactations.

The values for the fertility indices were also dependent on standard lactation yield (FPCM). Yield exceeding 10 000 kg of milk was found to significantly reduce fertility in comparison with cows whose yield was $\leq$ 8000 or 8001–10 000 kg FPCM – by 22–26 days in the case of SP, 25–29 days for CCI, and 25–28 days for CI. Services per conception increased from 1.69 to 1.77 to 2.12. A negative effect of increasing yield on fertility in cows was also observed by Sawa and Bogucki [2011].

According to Sawa et al. [2004], calving-to-first-service interval should last from 40 to 70 days, but cows with lactation yield exceeding 10 000 kg of milk need at least 100-120 days of rest. The average calving-to-first-service interval in the present study ranged from 77 to 87 days, depending on milk yield. Dillon et al. [2003] report that the period between calving and first insemination was significantly shorter (64.9 days) in Montbéliarde cows than in Holstein-Friesian cows (71.5 days). It should be emphasized that in high-yielding cows this interval comes at a time of high milk yield, so the question of the optimal time for the first service after calving is of particular importance. It has been demonstrated [Westwood et al. 2002] that pregnancy after the first service was confirmed 1.46 times more often in cows whose first ovulation occurred 31–53 days after calving than in those whose ovulation took place before the 21st day of lactation. Thus in Montbéliarde cows producing over 10 000 kg FPCM in standard lactation, the 82-day calving-to-first-service interval may have been too short and thus negatively affected the other fertility indices. The number of services per conception (2.12) in the case of the highest milk production may have resulted from excessive metabolic load in the cows. According to Dymnicki et al. [2003], a high number of services per conception may result from inadequate preparation of the reproductive tract for implantation of an embryo, despite external signs of oestrus. Poor fertility indices may also be due to a negative energy balance in the early lactation period.

The service period, together with the calving-to-first-service interval, is part of the calving-to-conception interval. This period, during which the success of the services is evaluated, should be as short as possible. Pregnancy was noted after the first insemination in nearly half (47.4%) of cases (Table 3). When one service was not sufficient, service periods were most frequently (26.6%) over 98 days. The frequency of different values for this trait was significantly influenced by the cows' origin, calving number, and FPCM yield in 305 days of lactation, but was not affected by age at first calving. Pregnancy was confirmed after the first service in 40.9% of cases in imported cows, and in 60.6% of cases in native cows. The longest service periods (> 98 days) were noted more often (by 17.7%) in imported cows, while 1.6% more service periods of 24 days or less were observed in native cows. The first service was most often successful after the second calving (51.6%) and in cows with 305-day lactation yield of 8000–10 000 kg FPCM (51.2%). Service periods lasting 1–24, 25–72 and 73–98 days were least frequent (3.8%, 6.9% and 3.4%, respectively) after the first calving in comparison with subsequent calvings, while SP > 98 days were the most frequent (36.9%). A similar pattern was observed in the case of the frequency of different service period lengths in the case of cows with the lowest yield. Increasing FPCM yield was accompanied by an increase in the proportion of service periods of 1–24, 25–72 and 73–98 days.

CONCLUSIONS

To sum up, the length of the rearing period of the Montbéliarde heifers was dependent on their origin and the season in which they were born. The average age at first calving was 908 days, while in the imported heifers first calvings took place 168 days later than in the native heifers. Heifers born in autumn gave birth earliest, and those born in spring calved latest. The acclimatization process may have negatively affected reproductive performance, as longer calving-to-first-service intervals and service periods were noted in the imported cows, as well as higher values for CCI and CI. Delayed first calving significantly lengthened the calving-to-first-service interval in the cows. An overall downward trend was observed in the length of CFSI, SP, CCI and CI in successive lactations. A 305-day yield of over 10 000 kg FPCM had a significant ($P \leq 0.01$ and $P \leq 0.05$) negative effect on reproductive efficiency expressed as SP, CCI and CI. Hence in the case of record productivity in the Montbéliarde breed, as in Holstein-Friesians, reduced fertility must be expected.

Table 3. Frequency of different service period lengths taking into account the effect of the factors analysed
Tabela 3. Frekwencja różnych wartości dla okresu usługi w obrębie analizowanych czynników

Factor – Czynnik	n	Number (%) of service periods of different lengths (days) Liczba (%) okresów o różnej długości; dni					Value for χ^2 test Wartość testu χ^2
		None Brak	1–24	25–72	73–98	> 98	
Origin – Pochodzenie							
– imported – importowane	570	233 (40.9)	42 (7.3)	82 (14.4)	29 (5.1)	184 (32.3)	38.5*
– native – krajowe	282	171 (60.6)	25 (8.9)	31 (11.0)	12 (4.3)	43 (15.2)	
Age at first calving; days Wiek przy I wycieleniu; dni							
– ≤ 823	86	40 (46.5)	3 (3.5)	14 (16.3)	4 (4.6)	25 (29.1)	15.3
– 824–915	290	156 (53.8)	26 (9.0)	36 (12.4)	14 (4.8)	58 (20.0)	
– 916–1038	326	142 (43.6)	28 (8.6)	44 (13.5)	16 (4.9)	96 (29.4)	
– > 1038	150	66 (44.0)	10 (6.7)	19 (12.7)	7 (4.6)	48 (32.0)	
Calving number Kolejne wycielenie							
– 1	290	142 (49.0)	11 (3.8)	20 (6.9)	10 (3.4)	107 (36.9)	53.4*
– 2	225	16 (51.6)	23 (10.2)	37 (16.5)	10 (4.4)	39 (17.3)	
– 3	178	75 (42.1)	18 (10.1)	24 (13.5)	10 (5.6)	51 (28.7)	
– > 3	159	71 (44.7)	15 (9.4)	32 (20.1)	11 (6.9)	30 (18.9)	
Milk yield in 305 days; kg FPCM Wydajność mleka za 305 dni; kg FPCM							
– ≤ 8000	288	145 (50.3)	12 (4.2)	34 (11.8)	10 (3.5)	87 (30.2)	20.4*
– 8001–10 000	256	131 (51.2)	25 (9.8)	36 (14.0)	14 (5.5)	50 (19.5)	
– > 10 000	308	128 (41.6)	30 (9.7)	43 (14.0)	17 (5.5)	90 (29.2)	
Total – Ogółem	852	404 (47.4)	67 (7.9)	113 (13.3)	41 (4.8)	227 (26.6)	–

* value for the χ^2 test significant at P ≤ 0.01 – wartość testu χ^2 istotna przy P ≤ 0,01.

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WPŁYW WYBRANYCH CZYNNIKÓW POZAGENETYCZNYCH NA WARTOŚCI PODSTAWOWYCH WSKAŹNIKÓW PŁODNOŚCI WYSOKOWYDAJNYCH KRÓW RASY MONTBELIARDE

Streszczenie. Celem pracy była analiza wpływu czynników pozagenetycznych na płodność wysokowydajnych krów rasy montbeliarde. Wykazano, że długość odchowu jałowic rasy montbeliarde w objętym analizą stadzie zależała od ich pochodzenia i sezonu urodzenia. Średni wiek przy I wycieleniu wynosił 908 dni, przy czym u jałowic importowanych pierwsze porody odbywały się przeciętnie o 168 dni później. Najwcześniej cieliły się jałówki urodzone w miesiącach jesiennych, a najpóźniej – urodzone od marca do maja. Proces aklimatyzacji mógł mieć negatywny wpływ na użytkowość rozpłodową, bowiem u krów importowanych stwierdzono dłuższy okres przestoju poporodowego (PP) i usługi (OU) oraz okresu międzyciążowego (OMC) i międzywycieleniowego (OMW). Opóźnianie pierwszego wycielenia jałowic istotnie wydłużało okres spoczynku płciowego krów. W kolejnych laktacjach obserwowano tendencję do skracania PP, OU, OMC i OMW. Wydajność za 305 dni powyżej 10 tys. kg FPCM istotnie pogarszała sprawność rozrodu. Zatem przy rekordowych wydajnościach także u krów rasy montbeliarde należy liczyć się z obniżeniem płodności.

Słowa kluczowe: krowy, rasa montbeliarde, wskaźniki płodności, wysoka wydajność

Accepted for print – Zaakceptowano do druku: 16.01.2013