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Breeder line and age affects the occurrence of developmental defects, the number of culled one-day old broiler chicks and their body mass

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Abstract: The objective of this work was to study the reasons for culling one-day old broiler chicks and to examine the relationship between the age and line of the hens and the culled chick's body mass. Hatching eggs and day-old chicks were collected from a commercial flock of the Cobb 500 and Ross 308 broiler lines. The eggs were collected when the hens were 32, 42 and 52 weeks old. The reasons for culling the chicks were assessed immediately after the chicks had been removed from the hatcheries. The four main groups of defects were distinguished, depending on the part of the chick's body. A fifth group covered general developmental defects. Within each group, the structural defects were identified in detail. The statistical analysis was performed in the R project. Amongst 57 600 chicks evaluated, 1042 malformations disqualifying them from further rearing were found in 666. The most frequent developmental defects were associated with the structure of the abdominal wall and umbilical cord: these were found in 155 chicks from the Ross 308 line and in 107 from the Cobb 500 line. In turn, umbilical defects occurred in 95 and 104 chicks from the Ross 308 and Cobb 500 lines, respectively. Abdominal defects were the most common in 107 chicks from the 42-week-old layers and in 89 chicks from the 52-week-old layers. There were also correlations between the age of the parent flock and the following defects: glued down, lack of down on the wings, contorted hips, wry neck and spine, and lack of a wake-up reflex. The average body weights of the Ross 308 and Cobb 500 chicks were 44.00 g and 43.13 g, respectively, but these differences were not statistically significant. However, the age of the broiler breeders (42 or 52 weeks) did affect the chick's body weight ($P \leq 0.05$). The lightest chicks (40.75 g) came from the Ross 308 line (age 42 weeks) and were nearly 4 g lighter than all the other groups. Most relationships between the lines of the layer hens at a particular age and the occurrence of malformations in the chicks were found in the hens aged 32 weeks, which may indicate the need for changes in the management of the eggs from the youngest layers belonging to the different lines.

Keywords: broiler chicks; culling; malformations; Cobb 500; Ross 308

Poland has become the biggest poultry meat producer in the European Union, supplying 2.21, 2.68 and 2.75 million tonnes in 2014, 2015 and 2016, respectively (Agencja Rynku Rolnego 2017). Poultry meat production is focused principally on broiler chickens (81%), rather than turkeys (14%), ducks or geese (5%). Hence, it is imperative to produce broiler chickens of high quality: such chickens are a pointer to the success of the hatchery, as well as the good performance and processing traits.

The quality of the one-day old chicks primarily depends on genetic factors (Hristakieva et al. 2014),

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the biological value of the eggs (Othman et al. 2014) and the handling of the chicks after hatching (Jacobs et al. 2016). Proper maintenance of the parent flock (Paraguassu and Arango 2012), the breeder's age (Nowaczewski et al. 2016), the appropriate nutrition and a high level of welfare guarantees the production of hatching eggs of a high biological value (King'ori 2011). The handling of the eggs during transport, as well as their disinfection and incubation is also important (Jacobs et al. 2016). The hatching eggs should not be stored for long periods of time, as this may result in increased early embryo mortality (Bergoug et al. 2013). Incubation factors, such as humidity, temperature, ventilation and egg movement also influence the quality of the day-old chicks (Ipek and Sozcu 2013).

Nonetheless, even if all of these requirements are met, a small portion of the hatched chicks are still unviable. In hatchery practice, chick quality is judged on a binomial scale (an all-or-nothing question) (Tona et al. 2004), but, in fact, little is known about the criteria used by hatcheries during the culling of chicks (van de Ven et al. 2012). Although most hatcheries do collect data about second-grade chicks, they retain this information for internal company use and do not publish it. Second-grade chicks should be culled, because their chances of survival are minimal. In addition, their presence on the farm may lower production indices and reduce the space and amount of feed for the top-grade ones. Such chicks may also constitute a reservoir of microorganisms, thereby increasing the risk of diseases spreading (Muhammad et al. 2009).

The primary reasons for culling chicks include unhealed navels, abnormal appendages or down defects (Finkler et al. 1998; Tona et al. 2003). Data on this subject appears to be limited. Othman et al. (2014) did not find any association between the egg size, the breeder age and the length of the storage period on the incidence of the developmental defects in Japanese quail (*Coturnix coturnix japonica*). Similarly, Elibol and Brake (2008), who assessed the quality of one-day-old chicks from Ross 308 breeder hens aged 51 and 58 weeks, found no relationship between the hen's age, egg weight and egg position in the setter on the incidence of malformations. Van de Ven et al. (2012) examined the reasons for culling chicks, but their analysis only covered the Ross 308 line in two periods of life (35 and 53 weeks). They also separated the categories of the reasons for culling the chicks including the body parts but did not address the specific defects in each category or the percentage of chicks culled because of a particular defect.

Chick weight at hatching is also an important factor affecting the potential profitability of a flock because it affects the survival and daily gains (Wilson 1991). Many authors (Christensen et al. 2002; Vieira et al. 2005; Yildirim 2005) report that the chick's body weight increases with the breeder hen age and, subsequently, leads to heavier eggs (O'Sullivan et al. 1991; Koppenol et al. 2014). Abudabos (2010) showed that breeder's age affects the body weight of the one-day-old chicks, as well as the rate of fertilisation and hatchability. Elibol and Brake (2008) showed a higher percentage of second-grade chicks hatched from large eggs (weight ± 70 g) obtained from the older laying hens (58 weeks), compared to the laying hens aged 51 weeks. On the other hand, van de Ven et al. (2012) found no association between the Ross 308 age (35 or 53 weeks) and the incidence of the defects. Gualhanone et al. (2012) observed that the age of the breeder flocks did not affect the hatchability parameters.

The aim of this study was to identify detailed reasons for culling one-day-old chicks from the two most popular broiler lines – Cobb 500 and Ross 308 – in three different periods of life and to examine the impact of the breeder's age and the line on the number of culled chicks and post-hatch body weight.

MATERIAL AND METHODS

The study was conducted in one of the largest commercial hatcheries in Poland. Hatching eggs and day-old hatched chicks were collected from a commercial flock of the Cobb 500 and Ross 308 broiler lines. The eggs were collected when the laying hens were 32, 42 and 52 weeks old (beginning, peak and end of laying period, respectively). Both flocks used for the egg collection were maintained under similar and standard environmental and management conditions (Ross and Cobb Breeder Management Guide). Three to four days after being laid, all the eggs were transported to the same hatchery and moved to incubators. The incubation and hatching system were fully automated. A Viscon automatic system was used for the egg transfer, the candling, the selection and vacuum discharge

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of the droppings. On the 11th day of incubation, all the eggs were candled to eliminate any unfertilised eggs and any eggs with dead embryos. On day 18, the eggs were candled again and those with live embryos were transferred to a hatcher. At the end of the incubation, the hatched chicks were recorded and assessed. A full set of documentation was carried out for each hatch (Table 1). The machines used were a Petersime Model 576 setter and a Model 192 hatcher. The respective air temperatures in the setter and hatcher were 37.8 °C and 37.2 °C. The air flow and temperature patterns for these types of machines were described by van Brecht et al. (2003).

The reasons for culling the chicks were assessed immediately after their removal from the hatchers. Randomly selected chicks were assessed for such parameters as navel and umbilical cord quality, down quality, leg confirmation, bright eye, hatching weight and vitality. Four main groups of defects (A–D) were distinguished depending on the part of the body. A fifth group (E) covered general developmental defects. Tables 2, 3 and 4 list the details of the structural defects within each group. The culled chicks hatched from eggs laid by the 42- and 52-week-old breeders were also weighed to the nearest 0.01 gram to determine the relationship between the breeder's line, age and age/line interaction and the chicks' post-hatch body weight.

A statistical analysis was performed in the R project. The statistical significance of the differences in the number of defects of the culled chicks depending on the line (Ross 308, Cobb 500) and belonging to a particular age group (32 weeks, 42 weeks, 52 weeks) was evaluated using the χ^2 test or Fisher's exact test, the latter in the case of small subgroups (less than 5 birds).

The descriptive statistics for the body weight of the chickens were determined by the stat.desc() function available in the pastecs package in the R project. The normality of the above-mentioned variable distribution was evaluated using the Shapiro-Wilk test. The statistical significance of the dependence of the chick's weight on the line (Ross 308, Cobb 500) or membership in a particular age group (42 weeks, 52 weeks) was assessed with the Wilcoxon test for two independent samples and also using the Kruskal-Wallis non-parametric analysis of variance.

RESULTS

The fertility, hatch, and culled chick sets of data for the Cobb 500 and Ross 308 broiler lines in three different laying periods (32, 42 and 52 weeks of life) are shown in Table 1. Fertility was similar in both lines: from 89.11% in the Cobb 500 line in the final stages of laying period to 93.08% in the Ross 308 line at the peak and the end of laying period. The egg hatchability was from 82.63% (52 weeks) to 85.77% (42 weeks) for the Cobb 500 line and from 82.66% (32 weeks) to 88.19% (52 weeks) for the Ross 308 line. The percentage of culling was similar in both lines: from 1.13% to 1.70% in the Cobb 500 line and from 1.22% to 1.46% in the Ross 308 line.

Amongst all the chicks assessed (57 600), 1042 malformations disqualifying them from further breeding were found in 666 chickens – 360 and 306 from the Ross 308 and Cobb 500 lines, respectively.

Table 1. The descriptive statistics of the broods in the Ross 308 and Cobb 500 broiler lines in three laying periods (32, 42 and 52 weeks old)

Breeder line	Breeder age (week)	% of incubated eggs	% of fertilisation*	% of hatchability*	% of hatchability from fertilised eggs	% of culled chicks*
Ross 308	32	14.80	91.11	82.66	90.84	1.22
Ross 308	42	19.24	93.12	85.29	91.71	1.46
Ross 308	52	6.66	93.08	88.19	94.82	1.22
Mean for Ross	–	–	92.44	85.38	92.45	1.30
Cobb 500	32	21.27	92.21	83.99	91.29	1.19
Cobb 500	42	23.68	92.22	85.77	93.01	1.13
Cobb 500	52	14.35	89.11	82.63	92.85	1.70
Mean for Cobb	–	–	91.18	84.13	92.38	1.34

*The influence of breeder line and age group was statistically significant (P-value < 2.2^{e-16})

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Table 2. The occurrence of the types of defects for the Ross 308 and Cobb 500 lines at 32, 42 and 52 weeks of age

Defect group	Type of defect	Defect	Line		*P*-value	Age (weeks)			*P*-value
			Ross 308	Cobb 500		32	42	52	
A – abdominal and umbilical cord defects	unhealed abdominal wall	no	205	199	**0.04**	143	119	142	**0.004**
		yes	155	107		67	107	88	
	unhealed umbilical cord	no	265	202	**0.04**	153	173	141	**0.001**
		yes	95	104		57	53	89	
	eversion of intestines	no	352	304	0.12	208	219	229	0.07
		yes	8	2		2	7	1	
	distended abdomen	no	357	304	1.00	210	223	228	0.33
		yes	3	2		0	3	2	
B – down defects	wet down	no	293	263	0.14	169	186	201	0.12
		yes	67	43		41	40	29	
	poorly formed down	no	284	232	0.39	166	179	171	0.37
		yes	76	74		44	47	59	
	glued down	no	332	270	0.10	184	215	203	**0.011**
		yes	28	36		26	11	27	
	lack of down on wings	no	359	300	0.052	204	225	230	**0.003**
		yes	1	6		6	1	0	
C – leg defects	contorted hips	no	332	274	0.22	203	196	208	**0.001**
		yes	27	32		7	30	22	
	crooked fingers	no	356	304	0.69	210	222	228	0.15
		yes	4	2		0	4	2	
	lividity of joints	no	359	306	1.00	210	225	230	0.65
		yes	1	0		0	1	0	
D – weak chicks	lack of wake-up reflex	no	299	263	0.35	160	196	206	**0.002**
		yes	61	43		50	30	24	
	dead chicks	no	335	298	**0.016**	202	214	217	0.64
		yes	25	8		8	12	13	
	closed eyes	no	357	302	0.70	208	222	229	0.36
		yes	3	4		2	4	1	
	drooping wings	no	359	306	1.00	209	226	230	0.31
		yes	1	0		1	0	0	
E – general developmental defects	lack of eye	no	360	305	0.45	209	226	230	0.31
		yes	0	1		1	0	0	
	monstrosity	no	353	304	0.19	207	221	229	0.13
		yes	7	2		3	5	1	
	wry neck and spine	no	358	299	0.088	209	219	229	**0.026**
		yes	2	7		1	7	1	
	general developmental disorders	no	359	306	1.00	209	226	230	0.31
		yes	1	0		1	0	0	

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Table 3. The number of different types of defects in the Ross 308 and Cobb 500 lines at various ages of the broiler breeders

Defect group	Type of defect	Defect	Ross 308 line of different age			*P*-value	Cobb 500 line of different age			*P*-value
			32	42	52		32	42	52	
A – abdominal and umbilical cord defects	unhealed abdominal wall	no	56	80	69	0.54	87	39	73	**0.001**
		yes	44	67	44		23	40	44	
	unhealed umbilical cord	no	84	113	68	**0.002**	69	60	73	0.09
		yes	16	34	45		41	19	44	
	eversion of intestines	no	100	140	112	**0.033**	108	79	117	0.19
		yes	0	7	1		2	0	0	
	distended abdomen	no	100	144	113	0.11	110	79	115	0.34
		yes	0	3	0		0	0	2	
B – down defects	wet down	no	81	113	99	0.08	88	73	102	**0.047**
		yes	19	34	14		22	6	15	
	poorly formed down	no	84	117	83	0.16	82	62	88	0.8
		yes	16	30	30		28	17	29	
	glued down	no	91	142	99	**0.023**	93	73	104	0.24
		yes	9	5	14		17	6	13	
	lack of down on wings	no	100	146	113	1.00	104	79	117	**0.002**
		yes	0	1	0		6	0	0	
C – leg defects	contorted hips	no	97	131	105	0.068	106	65	103	**0.006**
		yes	3	16	8		4	14	14	
	crooked fingers	no	100	144	112	0.47	110	78	116	0.72
		yes	0	3	1		0	1	1	
	lividity of joints	no	100	146	113	1.00	110	79	117	–
		yes	0	1	0		0	0	0	
D – weak chicks	lack of wake- up reflex	no	69	130	100	**0.001**	91	66	106	0.18
		yes	31	17	13		19	13	11	
	dead chicks	no	93	138	104	0.84	109	76	113	0.39
		yes	7	9	9		1	3	4	
	closed eyes	no	98	146	113	0.36	110	76	116	0.09
		yes	2	1	0		0	3	1	
	drooping wings	no	99	147	113	0.27	110	79	117	–
		yes	1	0	0		0	0	0	
E – general developmental defects	lack of eye	no	100	147	113	–	109	79	117	0.61
		yes	0	0	0		1	0	0	
	monstrosity	no	99	142	112	0.38	108	79	117	0.19
		yes	1	5	1		2	0	0	
	wry neck and spine	no	99	146	113	0.74	110	73	116	**0.002**
		yes	1	1	0		0	6	1	
	general developmental disorders	no	99	147	113	0.27	110	79	117	–
		yes	1	0	0		0	0	0	

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Table 4. The relationship between the age (32, 42 and 52 weeks) of the broiler breeders in the Ross 308 and Cobb 500 lines and the number of specific defect types

Defect group	Type of defect	Defect	Age 32 weeks		*P*-value	Age 42 weeks		*P*-value	Age 52 weeks		*P*-value
			Ross 308	Cobb 500		Ross 308	Cobb 500		Ross 308	Cobb500	
A – abdominal and umbilical cord defects	unhealed abdominal wall	no	56	87	**0.005**	80	39	0.55	69	73	0.94
		yes	44	23		67	40		44	44	
	unhealed umbilical cord	no	84	69	**0.009**	113	60	1.00	68	73	0.83
		yes	16	41		34	19		45	44	
	eversion of intestines	no	100	108	0.49	140	79	0.09	112	117	0.49
		yes	0	2		7	0		1	0	
	distended abdomen	no	100	110	–	144	79	0.55	113	115	0.49
		yes	0	0		3	0		0	2	
B – down defects	wet down	no	81	88	0.99	113	73	**0.006**	99	102	1.00
		yes	19	22		34	6		14	15	
	poorly formed down	no	84	82	0.13	117	62	0.98	83	88	0.87
		yes	16	28		30	17		30	29	
	glued down	no	91	93	0.22	142	73	0.19	99	104	0.92
		yes	9	17		5	6		14	13	
	lack of down on wings	no	100	104	**0.03**	146	79	1.00	113	117	–
		yes	0	6		1	0		0	0	
C – leg defects	contorted hips	no	97	106	1.00	131	65	0.21	105	103	0.30
		yes	3	4		16	14		8	14	
	crooked fingers	no	100	110	–	144	78	1.00	112	116	1.00
		yes	0	0		3	1		1	1	
	lividity of joints	no	100	110	–	146	79	1.00	113	117	–
		yes	0	0		1	0		0	0	
D – weak chicks	lack of wake-up reflex	no	69	91	**0.029**	130	66	0.40	100	106	0.75
		yes	31	19		17	13		13	11	
	dead chicks	no	93	109	**0.028**	138	76	0.54	106	113	0.22
		yes	7	1		9	3		9	4	
	closed eyes	no	98	110	0.22	146	73	0.12	113	116	1.00
		yes	2	0		1	3		0	1	
	drooping wings	no	99	110	0.47	147	79	–	113	117	–
		yes	1	0		0	0		0	0	
E – general developmental defects	lack of eye	no	100	109	1.00	174	79	–	113	117	–
		yes	0	1		0	0		0	0	
	monstrosity	no	99	108	1.00	142	79	0.18	112	117	0.49
		yes	1	2		5	0		1	0	
	wry neck and spine	no	99	110	0.47	146	79	**0.008**	113	116	1.00
		yes	1	0		1	6		0	1	
	general developmental disorders	no	99	110	0.47	147	79	–	113	117	–
		yes	1	0		0	0		0	0	

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The detailed numbers of chicks culled from each line are listed in Tables 2, 3 and 4.

The groups of malformations are presented in Tables 2, 3 and 4. Nearly half (45.68%) of the abnormalities were related to the abdominal and umbilical cord defects. In this group, the most frequent defects were an unhealed navel area (25.14%) and an unhealed umbilical cord (19.10%), whereas a bloated stomach was the rarest malformation (0.48%). Defects of the down were associated most often with the poorly developed down (14.40%) and the wet down (10.56%). Structural leg defects were rare: in this group, twisted hips were the most frequent malformation (5.65%). In the group of weak chicks (14.30%), the largest proportion were those unable to get back on their feet after being placed on their backs (10.36%). General developmental defects were the rarest cause of culling (1.92%).

Table 2 shows the effect of the broiler lines and their age on the incidence of the defects. However, the age of broiler breeders has an impact on the occurrence of the defects in each group (A–E), but not in each sub-group. There was a correlation between the age of the parent flock and the following defects: unhealed abdominal wall and umbilical cord, glued down, lack of down on wings, contorted hips, wry neck and spine and lack of wake-up reflex. The most frequent developmental defect was an unhealed abdominal wall, which was observed in 155 and 107 culled chicks from the Ross 308 and Cobb 500 lines, respectively. Statistically significant differences were also found in the defect group D, where dead chicks occurred more often in the Ross 308 line (25 chicks) than in the Cobb 500 line (8 chicks). Abdominal defects were the most common in chicks from eggs laid by the 42-week old breeders. In turn, defects of the umbilical cord, down and leg defects were the most frequent in the chicks from the eggs laid by the oldest layers (52 weeks).

The impact of the broiler breeders' lines at various ages on the number of culled chicks was also examined (Table 3). Significant relationships were found for the Ross 308 line in group A (unhealed umbilical cord and everted intestines), B (glued down) and D (lack of wake-up reflex). Among the chicks of the Ross 308 line hatched from eggs laid by breeders aged 42 and 52 weeks, umbilical cord defects and down defects were found more frequently than among chicks from eggs laid by the 32-week old birds. In turn, the wake-up reflex was absent much more often among chicks from the youngest breeders. Significant relationships for the Cobb 500 line were found in group A (unhealed abdominal wall), B (wet down and lack of down on wings), C (contorted hips) and E (wry neck and spine). Chicks

Table 5. The descriptive statistics of a chick's body weight (BW) depending on the breeders' line (Ross 308 and Cobb 500) and age (42 and 52 weeks)

Trait	Factor	Descriptive statistics						
		n	minimum	median	maximum	mean	SD	VC (%)
BW	line							
	Ross 308	260	23.35	45.20	58.70	44.00	6.68	15.20
	Cobb 500	196	22.30	43.95	56.65	43.13	6.44	14.93
	total	456	22.30	44.70	58.70	43.63	6.59	15.10
	age							
	42 weeks	226	22.30	43.87	52.25	42.89[a]	6.41	14.95
	52 weeks	230	25.65	45.50	58.70	44.36[b]	6.69	15.10
	line/age							
	Ross 308/42	147	23.35	45.20	55.25	44.04[b]	6.06	13.77
	Ross 308/52	113	25.65	45.40	58.70	43.95[b]	7.44	16.94
	Cobb 500/42	79	22.30	42.00	55.10	40.75[a]	6.52	16.00
	Cobb 500/52	117	30.08	45.50	56.65	44.75[b]	5.88	13.16

n = number of individuals; SD = standard deviation; VC = variation coefficient (expressed as a percentage)
The mean values with statistically significant differences between the groups designated by the line and age are indicated by the different letters (P-value < 0.05)

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hatched from the eggs from the older breeders had an unhealed abdominal wall and leg defects more often, whereas down-related defects were more frequent in the chicks from the eggs laid by the youngest hens. The lack of wing down in the chicks of the Cobb 500 line was observed only among those from the youngest layers (32 weeks).

Table 4 shows the relationship between the line at a certain broiler's age and the number of culled chicks. Most relationships between the line of breeders and their age were found in the 32-week-old breeders. Significant differences between the lines examined at age 42 weeks were found in Group B and E only. No significant differences were found between the different lines at the age of 52 weeks. The disadvantages associated with an unhealed abdominal wall among the chicks from the eggs laid by the youngest breeders were more frequent in the chicks from the Ross 308 line than the Cobb 500 line (44 and 23 chicks, respectively). The opposite situation held in the case of the chicks with umbilical cord defects, which were found in 41 chicks from the Cobb 500 line, but in only 16 from the Ross 308 line. The latter chicks failed to exhibit a wake-up reflex more often, while the Cobb 500 line of chicks had no down on their wings more frequently.

The statistical analysis of the culled chick weight (Table 5) showed that the average body weight of a Ross 308 and a Cobb 500 was 44.00 g and 43.13 g, respectively. These differences were not statistically significant. However, the age of the broiler breeders (42 or 52 weeks) did affect the body weight of the chicks ($P \leq 0.05$), but only so long as the division into the broiler lines is not taken into account. Chicks hatched from the eggs laid by the breeders aged 52 weeks were 1.47 g heavier than those hatched from the eggs from a parent flock aged 42 weeks. Examination of the relationship between the age/line and the weight of chicks showed that the lightest ones were from the 42-week-old Cobb 500 line breeders and that they differed ($P \leq 0.05$) from all the other groups.

DISCUSSION

There are many factors indicating the profitability of poultry production, including the percentage of hatching, the number of culled chicks and their post-hatch body mass. In a well-run hatchery, the percentage of broiler chicken hatchability is 85–90% (Aviagen 2018). In our study, the percentage of hatchlings for both lines was over 82%. Tona et al. (2001) obtained a similar rate of hatching in their research, from 69.34% to 90.89%, at an average of 84.53%. They also found a relationship between the breeder's age and the hatching percentage. The highest hatchability was reported in the Cobb 500 line at the age of 40–42 weeks. However, Abudabos (2010) showed that the best hatchability was obtained from hens at 26 weeks (Cobb 500 line) and 32 weeks (Ross 308 line) of age. Our results were similar to those of Nowaczewski et al. (2016), who demonstrated the best hatchability in eggs laid by hens aged 40 weeks. However, our research indicated that the Ross 308 line at age 52 weeks had the best hatchability. This is in contrast to the results of El Sabry et al. (2013), who did not reveal any age effects on the shell quality and thickness. This may be indicative of a properly balanced feeding regime among the tested hens. On the other hand, many authors showed that the reduced hatchability of the eggs from the older broiler breeders may be caused by many factors, including a larger egg size (Nowaczewski et al. 2016), poorer shell quality (Iqbal et al. 2016) or a deterioration in the albumen quality (Tona et al. 2004).

The percentage of culled chicks should not exceed 2% (Aviagen 2018). In this study, the percentage of culled chicks was 1.15%, which corresponds to the results obtained by van de Ven et al. (2012).

Our research has shown that the most common reasons for culling one-day old chicks are an unhealed navel area and umbilical cord. Similarly, Muhammad et al. (2009) showed that 40% of the chicks were culled due to an unhealed abdominal wall. On the other hand, van de Ven et al. (2012) indicated that the most common causes of culling chicks were their low quality (31.65%) and poor-quality feather development (15.16%). Physical anomalies and leg deformations were rare occurrences (8.78 and 9.04%, respectively). However, Muhammad et al. (2009) reported that the physical abnormalities were the reason for culling 32% of chicks, while weak chicks accounted for 4% of all of the sorted birds. The developmental defects in one-day old chicks are influenced by many factors, including the level of hygiene, and the temperature and humidity during the incubation. *Streptococcus* sp., *Proteus* sp. and *E. coli* strains cause yolk sac and abdominal wall infections

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(Geidam et al. 2007). Too high temperatures produce an unhealed navel area and toe deformation (Du Preez 2007). A temperature of 39.1 °C leads to a low hatch weight, and feathers are bleached and poorly-developed, while a temperature above 40 °C significantly reduces the hatching success and increases the probability of down and leg defects and no wake-up reflex. Excessive humidity, as well as inadequate ventilation and the failure to turn the eggs during incubation, causes abdominal and umbilical cord malformations, wet and sticky down and poor chick quality (Deeming 2005; Bergoug et al. 2013). Because these groups of defects are occurring in the chicks, the incubator's parameters should be improved. A more detailed discussion of the specific defects in the individual chickens depending on the line and age of the laying hens is difficult to carry out because, to the best of our knowledge, these are the first such detailed studies on the developmental defects in one-day-old chicks.

The results obtained in this study, however, correspond with those of other authors (Tona et al. 2003; Tona et al. 2004; Abudabos 2010; King'ori 2011; Alsobayel et al. 2013; Jacobs et al. 2016), who pointed out the relationship between the age of the parent flock and the quality of the hatched chicks. Willemsen et al. (2008) and Nowaczewski et al. (2016) demonstrated that the older the breeder, the greater the incidence of chick body defects, which, thus, reduces the quality of the one-day-old chicks. Tona et al. (2004) stated that chick mortality, with the highest quality and hatchability, was the lowest when the breeders were aged 40 weeks. The deterioration rates of the one-day old chick quality along with the increasing breeder age may be due to the poor shell quality, as calcium absorption decreases with age. Poor shell quality may, in turn, reduce the gas exchange in the egg and increase the risk of bacterial infections, which may lead to embryogenesis disorders (Ulmer-Franco et al. 2010).

The chick's weight at hatching is one of the most important factors affecting the profitability of a flock. In our study, the day-old chicks from the Ross 308 line were heavier than those of the Cobb 500, but these differences were not statistically significant. Such results were not confirmed by Willemsen et al. (2008) and Alsobayel et al. (2013), who reported the impact of the lines of the broiler breeders on the chick's post-hatch body weight. In both studies, the Cobb 500 chicks were slightly heavier than those of the Ross 308 line. Willemsen et al. (2008) showed that the Ross chicks weighed 43 g on average, while those from the Cobb 500 line were 45.9 g. Hristakieva et al. (2014) also revealed a relationship between the broiler strain and the weight of chicks hatched.

We analysed the body weight of the culled chicks only from the 42- and 52-week old breeders, because these birds had already reached their laying peak and somatic maturity. Producers of broiler chicks often prolong the useful life of the layers, as both the egg weight and chick body mass increase with the breeder age. Larger chicks are more desirable because they have a better chance of survival and display better growth (Tona et al. 2004). On the other hand, shell defects are more frequent in the older eggs, and the chicks hatching from them are more likely to have developmental defects (Ulmer-Franco et al. 2010). This study has shown, however, that the age of the broiler breeders (42 or 52 weeks) does affect the chick's body weight, but only so long as the division into the broiler lines is not taken into account. Similar results were reported by other authors, but the differences in the chick's body weight in their studies were greater. Alsobayel et al. (2013) demonstrated that chicks produced by 50–55-week-old breeders were 3.5 g heavier than those of the hens aged 40–45 (48.4 g and 44.9 g, respectively). Even greater differences were reported by Willemsen et al. (2008), who showed that the chicks from the Ross 308 line from the older layers (53 weeks) weighed an average of 47.4 g, while those hatched from eggs from the younger ones (39 weeks) was only 43 g. Examination of the relationship between the age/line and the chick's weight revealed statistically significant differences in the chicks from the 42 week old Cobb 500 line breeders only. Our work indicates, however, that the differences in the body weight are small in both groups, which may indicate the high reproductive potential of these lines, good management conditions and the lack of an evident lowering of the brood parameters and the quality of the chicks obtained from the oldest layers.

To the best of our knowledge, this study is the first such detailed research on the developmental defects of one-day old chicks and was carried out using one parent stock for each line. The feed and breeder management can influence the fertility, but these parameters were not included in the experimental design. However, it seems to us that the size of the experimental group and the fact that we analysed two of the most common broiler lines main-

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tained in an optimal environment that was strictly compliant with the producer's requirements limited the impact of the parent stock on the results.

In conclusion, our research showed that the most frequent reason for culling one-day-old broiler chicks, regardless of the age and laying line, were the abnormalities of the abdominal wall and umbilical cord. It also demonstrated that the majority of the malformations occurred in both lines, regardless of the age of the laying hens. Most relationships between the lines of the layer hens at a particular age and the occurrence of malformations in chicks were found in the youngest hens (aged 32 weeks). However, there was no such correlation between any group of the defects in the oldest hens (aged 52 weeks). These results may indicate the need for changes in the management of the eggs from the youngest layers belonging to the different lines, as they may require slightly different storage conditions than eggs from the older layers. Little appears to be known about this problem, so further research into the reasons for culling chicks is required. Such studies, preferably on a larger scale, may, in the future, reduce the percentage of the chicks eliminated from further breeding and thereby increase the performance of the poultry production.

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