EFFECT OF HATCHERY, GENOTYPE, MONTH OF HATCHING AND NUMBER OF EGGS IN ONE HATCHING UNIT ON HATCHABILITY OF HEN, GOOSE AND DUCK EGGS

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Abstract

The research was based on the national poultry hatching database, supplied by the Department of Animal Registration and Breeding Organization of the Hungarian National Food Safety Authority. Summarizing our previous works, the evaluations were extended to hen, goose and duck species - altogether 17 breeds and 27 hybrids -, 16146 hatching units, about 274.3 million eggs in year 2010. The effect of hatchery, genotype, month of hatching and number of eggs in one hatching unit on hatchability was analyzed by univariate analysis of variance (GLM). Phenotypic correlation coefficients were calculated between hatchability, hatching time and number of eggs in one hatching unit. The corrected overall mean values of hatchability of eggs of different poultry species were as follows: hen 82.96%, goose 61.56% and duck 64.59%. The differences between the genotypes in case of each species were significant. The meat and liver type hybrids showed lower hatchability than the mixed-use genotypes. The hatchability of goose eggs in summer months was almost 10% lower, than the mean value of the population. The hatchability of large units was approximately 8-10% better, than that of smaller units. Low, and significant correlation (r = -0.17-0.27; P<0.01) was found in respect of the examined parameters. Based on the results it can be stated that, the longer is the hatching time, the worse is the hatchability of poultry eggs.

Key-words: genotype, hatchability, hatching time, hatching unit

Összefoglalás

A Szerzők a NÉBiH Állattenyésztési Igazgatóság, Tenyésztés Szervezési és Teljesítményvizsgálati Osztálya által rendelkezésre bocsátott országos baromfikeltetési adatbázist dolgozták fel. Jelen munkát - a korábbi eredményeket összegezve - a 2010-es évre, három fajra (tyúk, lúd és kacsa), ezen belül 17 fajtára és 27 hibridre terjesztették ki. A munka során így összesen 16146 keltetési tételhez (kb. 274,3 millió tojáshoz) tartozó kelési idő és ugyanennyi keltethetőségi adat állt a rendelkezésükre. A keltethetőséget befolyásoló számos tényező közül a keltető üzemnek, a genotípusnak, a keltetési hónapnak és az egy tételben keltetett tojások számának hatását vizsgálták. A tényezők befolyását a tulajdonságokra többtényezős variancia-analízissel értékelték. A kelési idő, a keltethetőség, valamint az egy tételben keltetett tojások száma között fenotípusos korrelációs együtthatókat határoztak meg. A tojások keltethetőségének korrigált főátlaga a következő volt: tyúk 82,96%, lúd 61,56%, kacsa 64,59%. A genotípusok közti különbségek minden esetben szignifikánsak voltak. A hús- és májtípusú hibridek rosszabb keltethetőséget mutattak, mint a vegyes hasznosítású genotípusok. A lúdtojások keltethetősége a nyári hónapokban mintegy 10%-kal rosszabb volt az éves átlagnál. A nagy tételben keltetetett tojások keltethetősége 8-10%-kal jobb volt annál, mint amit a kisebb tojásszámú tételek esetén tapasztaltak. A vizsgált paraméterek között jellemzően laza kapcsolatokat találtak (r = -0,17-0,27;). Az eredmények alapján úgy tűnik, a keltetési idő hosszabbodásával a különböző baromfi fajok tojásainak a keltethetősége romlik.

Kulcsszavak: genotípus, kelési idő, keltetési tétel, keltethetőség

Introduction and literature review

Hatchability of fertile eggs is a formal, physical, chemical and biological property that - with an adequate hatchery technology - allows normal development of the embryo, and hatching of a vital chick from the egg. The hatchability is a complex trait, which may depend on the regular shape and the chemical composition of eggs, the proportion of each ingredient in the egg, and in fact on the genotype of the embryo (Horn, 2000). Hatchability is affected by a number of hereditary and environmental factors. Such factors are the type of parent stock, inbreeding and cross-breeding, the time that parent stocks spent in production, the weight of the eggs, the quality of the eggs (shell thickness, shape, pollution etc), the incubation temperature, egg storage time before incubation, and the feed quality of parent birds respectively (Butler, 1991; Oloffs et al., 1997; Bogenfürst, 2004; Peruzzi et al., 2012). The factors listed above are also under the influence of a number of genetic and environmental factors, regardless of genetically determined viability and vitality of the embryo. Generally, laying and mixed-use types show a better hatchability of eggs, than meat, or liver types.

Van de Ven et al. (2009) found, that the hatchability of fertile eggs in different technological circumstances was 93.67-95.53% for the Cobb 500 broiler, and 95.76-97.60% for the Ross 308 broiler respectively. In the study of Ulmer-Franco et al. (2010) the size of eggs influenced significantly the hatchability of Cobb 500 broilers. O'Dea et al. (2006) found during the hatching of Hubbard Hi-Yield Hybrid eggs, that hatchability was changing with the increasing age of the parent stock. Reijrink et al. (2009) reported that the duration of storage time before incubation affected the percentage of hatching of Cobb broilers.

In the study of Dale Gillette (1977) the Emden goose eggs showed 73.4% hatchability. Hatchability of eggs from Italian geese was between 68.1-75.6% in the study of Wang et al. (2002). According to Bednarczyk and Rosinski (1999), the seasons have a significant impact on the hatchability of Italian goose eggs. They found hatchability over 80% in March, April and May, while in July it was only about 60%, concerning fertile eggs.

Sauveur and de Carville (1986) found that average fertility of the Pekin duck eggs was 95%, and the hatchability was between 78-81 %. According to Sarpong and Reinhart (1985), the duck eggs hatchability increased when the eggs were sprayed during the time of hatching. According to Chowdhury et al. (2004), the season effect is very significant on the hatchability of duck eggs. El-Hanoun et al. (2012) found that the age of parent stock affects the hatchability of Peking duck eggs. Yuan et al. (2013) found significant differences between hatchability of plain and stripe patterned Peking duck eggs.

Based on the literature it can be stated that the hatching parameters of eggs produced by domestic fowl, domestic goose and domestic duck species are influenced by a number of factors. Using the knowledge above the aim of our work was to study the effects of hatchery, genotype, month of hatching and number of eggs in one hatching unit on hatchability. We have to emphasize that our study concentrated primarily on data communication, presentation and on the objective comparison of the "raw" data of registration books.

Material and methods

The research was based on the national poultry hatching database, supplied by the Department of Animal Registration and Breeding Organization of the Hungarian National Food Safety Authority. Summarizing our previous works (Bene et al., 2013, 2014), the evaluations were extended to hen, goose and duck species - altogether 17 breeds and 27 hybrids -, 16146 hatching units. Hatching data of about 274.3 million eggs were analyzed in year 2010.

The hatchability was calculated by using the following formula: (Horn, 2000).

$$\text{hatchability (\%)} = \frac{\text{viable day old chicks (pcs)}}{\text{total number of eggs being put into the incubator (pcs)}} \times 100$$

Among the influencing factors the effect of hatchery, genotype, month of hatching and number of eggs in one hatching unit was examined on hatchability. Hatching unit means one hatching cycle, namely the number of eggs being put into the incubator(s) at the same time in one hatchery. Based on the size of hatching units (number of eggs in one hatching unit) different groups were formed. These, as well as the basic statistical parameters calculated in our work are shown in Table 1 for the various species. The hatching month was determined by the starting date of incubation of eggs.

The effects of factors on hatchability were examined by univariate analysis of variance (General Linear Model, GLM) for the three species separately. During our research the hatchery, genotype, hatching month, and number of eggs in one hatching unit were considered as fixed effects. The used three models were written as follows:

$$\hat{y}_{ijkl} = \mu + H_i + G_j + M_k + I_l + e_{ijkl}$$

(where $\hat{y}_{ijkl}$ is the hatchability of hen, goose or duck eggs, which hatched in „i" hatchery, in „j" genotype and in „k" month with „l" unit size; μ = overall mean value; H_i = the effect of hatchery; G_j = the effect of genotype; M_k = the effect of hatching month; I_l = the effect of number of eggs in one hatching unit; e_{ijkl} = residual).

In those cases, where the F-test showed significant difference, Tukey-test (for different number of elements) was used to reveal the differences between levels of factors.

Phenotypic correlation coefficients were calculated on hatching time, hatchability and number of eggs in one hatching unit for each species separately.

Preparation of data was done with the help of Microsoft Excel 2003 and Word 2003 programs. SPSS 9.0 (1998) statistical software was used for the univariate analysis of variance and correlation analysis.

Table 1. Basic statistical parameters of the examined database

Parameters	Hatching database			
	Hen	Goose	Duck	Total
Total number of hatching units (N)	8625	3829	3692	16146
Hatching unit groups*:				
1	2203	499	868	3570
2	2015	1240	792	4047
3	1710	793	892	3395
4	1058	482	500	2040
5	779	305	245	1329
6	447	510	150	1107
7	413	-	245	658
Least amount of eggs in one hatching unit (pcs)	11	6	291	6
Most eggs in one hatching unit (pcs)	231000	21180	36454	231000
Average number of eggs in one hatching unit (pcs)	27433	2337	7772	12514
Total eggs inlaid in hatchers (rounded to thousand pcs)	236611	8948	28695	274254
All hatched eggs - number of day old chicks (rounded to thousand pcs)	181088	5586	19805	206479
Hatchability (%)	^{a}75.02	^{b}60.69	^{c}66.81	P<0.01
- s	13.08	15.86	12.71	
- cv%	17.44	26.13	19.02	
- minimum	0.03	1.75	3.12	
- maximum	100.00	100.00	91.90	
Hatching time (day)	^{a}21.61	^{b}30.07	^{c}28.40	P<0.01
- s	0.51	0.49	0.50	
- cv%	2.38	1.61	1.76	
- minimum	19.00	28.00	26.00	
- maximum	24.00	32.00	30.00	

treatments without the same superscript differ significantly (P<0.05)
*number of eggs in hatching unit group are as follows: hen: 1. ≤4999, 2. 5000-19999, 3. 20000-34999, 4. 35000-49999, 5. 50000-64999, 6. 65000-79999, 7. 80000≤; goose: 1. ≤500, 2. 500-1499, 3. 1500-2499; 4. 2500-3499, 5. 3500-4499, 6. 4500≤; duck: 1. ≤3999, 2. 4000-6499, 3. 6500-8999, 4. 9000-11499, 5. 11500-13999, 6. 14000-16499, 7. 16500≤

Results and discussion

The effects of the studied factors on hatching of eggs laid by hens, domestic ducks and domestic geese, and the percentage of each factor in the phenotype are presented in Table 2. The impact of all factors demonstrate P<0.01 significance level in the case of all three species.

Importance order of these factors was different species by species. Regarding domestic fowl the role of the examined factors on hatching was as follows: number of eggs in one hatching unit had dominant effect (65.83%), hatchery (17.77%), genotype (8.89%) and hatching month (3.73%) had smaller role. In contrast, regarding domestic geese species the influence of hatching month (36.54%) and hatchery (34.22%) on hatchability was nearly the same, and the number of eggs in one hatching unit (17.66%) and genotype (10.76%) had smaller role. In the case of domestic duck species, genotype (39.34%) was the most influential factor on hatching, followed by hatchery (31.76%), the number of eggs in one hatching unit (19.49%) and hatching month (8.52%).

Table 2. The effect and rate of different factors on the hatchability

Factor	Hen		Goose		Duck	
	P	%	P	%	P	%
Hatchery	<0.01	17.77	<0.01	34.22	<0.01	31.76
Genotype	<0.01	8.89	<0.01	10.76	<0.01	39.34
Hatching month	<0.01	3.73	<0.01	36.54	<0.01	8.52
Number of eggs in one hatching unit	<0.01	68.53	<0.01	17.66	<0.01	19.49
Error	-	1.07	-	0.82	-	0.89
Total	-	100.00	-	100.00	-	100.00

Hatchability showed significant differences between the individual hatcheries in all of the three species. The difference between hatcheries showing minimum and maximum hatchability levels was 20-35%. The lowest hatchability was found in those hatcheries, where the average hatching time was the longest.

Hatchability of different species and genotypes is shown in Table 3. Observing domestic fowl, the hatchability of the New Foxy Chick (95.74%) and the Red Master S757 (91.58%) was exceptional. Their results were 10% higher than the average of the population (82.96%). Among mixed-use types the New Hampshire (88.52%), while among meat hybrids the Hubbard JA57 (89.65%) showed the best results. The lowest level of hatchability (75.78%) was found in the case of the Shaver Rusticbro meat type hybrid. Comparing the results, the levels of hatchability we found, were either lower or the same as the levels presented in the scientific literature. Van de Ven et al. (2009) and Ulmer-Franco et al. (2010) observed much higher levels of hatchability in the case of Ross 308 and Cobb 500. Meanwhile O’Dea et al. (2006), Elibol and Brake (2008), and Reijrink et al. (2009) compared different Hubbard and Ross hybrids and found very similar hatchability levels as we did.

Observing domestic goose genotypes, the best hatchability (71.69%) was experienced in the Hungarian Lowland White type, the rate was much (10%) higher than the average of the goose population (61.56%). There were some other types with remarkable levels of hatchability, such as the Golden Goose W hybrid (68.11%), the White Hortobágy (67.74%), and the Bábolna Emden White (67.14%). The Anabest G liver type hybrid showed the lowest (55.26%) hatchability level. The hatchability levels being revealed in our observations were lower than those can be found in the scientific literature (Dale Gillette, 1977; Bednarczyk and Rosinski, 1999; Wang et al., 2002).

Table 3. The hatchability of eggs of different genotypes

Species	Type, breed or hybrid	Genotype	Hatchability±SE (%)
Hen	Mixed type hen breeds	Transylvanian Naked Neck	80.39±2.32
		White Hungarian	83.87±3.34
		Plymouth White	84.84±3.86
		Partridge Color Hungarian	80.92±3.52
		Speckled Hungarian	79.24±2.36
		New Hampshire	88.52±3.70
		Yellow Hungarian	84.75±3.24
	Mixed type hen hybrids	Bábolna Tetra-H	80.68±1.09
		Red Master S757	91.58±1.42
		Shaver Avicolor	81.94±1.24
		Shaver Farm	80.19±0.68
		Shaver Farm Master	79.14±1.14
	Meat type hen hybrids	Cobb 500	81.85±0.74
		Cobb Sasso 150	83.01±2.17
		Hubbard Flex	79.25±0.86
		Hubbard JA57	89.65±2.57
		Hubbard F15	79.34±1.33
		New Foxy Chick	95.74±1.83
		Ross 308	79.54±0.69
		Shaver Master Gris	83.48±1.17
		Shaver Redbro	81.46±0.88
		Shaver Rusticbro	75.78±2.56
Goose	Mixed type goose breeds	Babat Hungarian Upgraded	59.18±2.08
		White Hortobágy	67.74±1.27
	Meat type goose breeds	Hungarian Lowland White	71.69±1.40
		Bábolna Emden White	67.14±1.11
		Orosháza Hungarian	55.76±1.59
	Liver type goose breeds	Babat Grey Landes	56.51±1.14
		Bábolna Grey Landes	65.76±2.32
		Kolos Grey	56.00±1.65
		Orosháza Grey	59.80±1.32
	Meat type goose hybrids	Golden Goose W	68.11±1.29
		Grimaud G35	60.33±1.95
		Kolos White	62.55±1.43
		Lippitsch	62.09±0.98
	Liver type goose hybrids	Anabest G	55.26±1.24
		Gourmaud SI 14	55.32±1.22
		Maxipalm	61.66±0.76
Duck	Meat type duck breed	Szarvasi K-94	67.24±0.71
	Meat type duck hybrids	Cherry Valley Super M3	64.60±0.72
		Gourmaud ST5 Medium	66.84±1.66
		Gourmaud ST5 Heavy	69.21±1.92
		Grimaud Star 53	61.69±1.10
		Wiesenhof Vital	57.97±0.81

Comparing domestic duck genotypes, the highest hatchability level (69.21%) was experienced in the case of Gourmaud ST5 Heavy hybrid. The Szarvasi K-94 breed (67.24%) and the Gourmaud ST5 Medium hybrid (66.84%) also had remarkable hatchability levels. The Wiesenhof Vital meat type hybrid had the worst result (59.97%). Our experienced hatchability levels were either similar (Chowdhury et al., 2004; El-Hanoun et al., 2012), or lower (Sarpong and Reinhardt, 1985; Onbaşılar et al., 2011) than those we found in the references.

The effect of hatching month on hatchability is presented in Table 4 and Figure 1. Regarding domestic fowl there was only 2.33% difference between the two months showing minimum and maximum hatching rate.

Table 4. Hatchability according to hatching month

Hatching month	Hen		Goose		Duck	
	Mean	SE	Mean	SE	Mean	SE
January	^{a}82.13	0.89	^{ab}64.71	0.78	^{a}67.31	0.76
February	^{a}81.93	0.85	^{a}65.67	0.68	^{ab}66.97	0.73
March	^{bc}83.19	0.84	^{a}65.64	0.68	^{cde}64.78	0.74
April	^{d}84.26	0.85	^{bc}63.60	0.66	^{cf}63.65	0.76
May	^{cd}83.94	0.87	^{d}58.78	0.66	^{bde}65.50	0.76
June	^{abe}82.65	0.93	^{e}51.97	0.76	^{cdf}63.84	0.82
July	^{ab}82.13	0.94	^{e}52.63	1.04	^{g}61.33	0.81
August	^{abc}82.93	0.95	^{df}59.30	1.07	^{fg}62.07	0.85
September	^{abcd}83.02	0.97	^{bfg}62.29	1.28	^{fg}62.05	0.88
October	^{cde}84.02	0.99	^{acg}64.11	1.34	^{ae}65.99	0.91
November	^{abc}82.86	0.99	^{acg}64.16	1.14	^{ae}65.75	0.89
December	^{abc}82.48	1.01	^{ac}65.81	1.16	^{ae}65.87	0.91
Corr. overall mean value	82.96	1.94	61.56	0.46	64.59	0.53
P	<0.01		<0.01		<0.01	

treatments without the same superscript differ significantly (P<0.05)

Hatchability in case of domestic goose species were the lowest in summer months, namely in June and July (51.97-52.63%, respectively). Hatchability rate were significantly (P<0.01) higher in the winter, spring and summer months. Between the two months with extreme values the difference was remarkable 13.84%. A rate of 70% of the eggs in the examined 3829 hatching units was hatched in the first five months of the year. Our results are consistent with the statements of Bednarczyk and Rosinski (1999), thus the season has a great impact on the hatchability of goose eggs. Observing hatchability of duck eggs, the lowest rates were found in summer, especially in July and August (61.33-62.07%, respectively). Our results are similar to the findings of Chowdhury et al. (2004), and Kamar (1961), thus the month of hatching has significant effect on the hatchability of duck eggs.

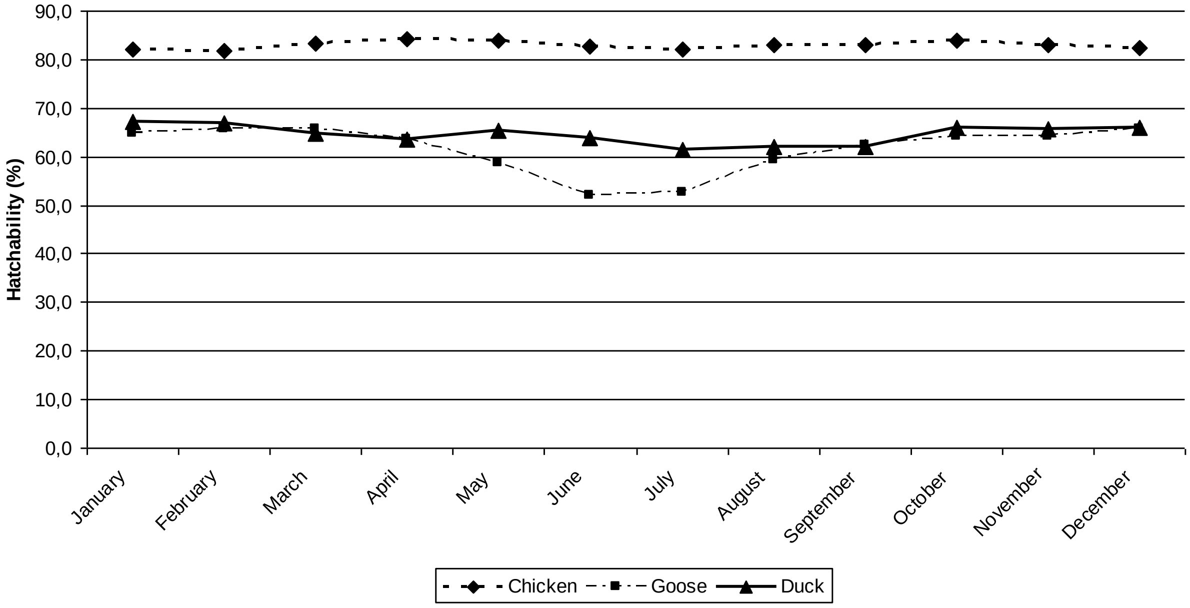

Figure 1. The hatchability in different months

Hatchability linearly increased with the number of eggs in one hatching unit concerning all poultry species (Table 5). It can be concluded that hatchability of eggs in larger units, possibly in large scale conditions, is 8-10% higher than in smaller units. These results are similar to the statements of Heier and Høgasen (2001).

Table 5. The hatchability according to number of eggs in one hatching unit

Hatching unit group*	Hen		Goose		Duck	
	Mean	SE	Mean	SE	Mean	SE
1	a76.23	0.75	a56.40	0.72	a60.09	0.63
2	b78.78	0.83	b60.15	0.55	b61.73	0.67
3	c82.23	0.86	b61.00	0.59	c63.58	0.66
4	d84.64	0.89	c63.50	0.72	d65.18	0.71
5	e85.75	0.93	c64.77	0.86	e67.31	0.85
6	e86.95	1.01	c63.51	0.73	de66.48	1.03
7	e86.14	1.03	-	-	e67.76	0.94
Corrected overall mean value	82.96	1.94	61.56	0.46	64.59	0.53
P	<0.01		<0.01		<0.01	

treatments without the same superscript differ significantly (P<0.05)
*number of eggs in hatching unit group are as follows: hen: 1. ≤4999, 2. 5000-19999, 3. 20000-34999, 4. 35000-49999, 5. 50000-64999, 6. 65000-79999, 7. 80000≤; goose: 1. ≤500, 2. 500-1499, 3. 1500-2499; 4. 2500-3499, 5. 3500-4499, 6. 4500≤; duck: 1. ≤3999, 2. 4000-6499, 3. 6500-8999, 4. 9000-11499, 5. 11500-13999, 6. 14000-16499, 7. 16500≤

None of the poultry species showed any significant correlations between the number of eggs in one hatching unit, hatching time and hatchability (Table 6). The correlation coefficients obtained were statistically reliable, but they only show a very loose relationship (r= -0.17-0.27; P<0.01). Our results, parallel with the findings in the references (Ichione, 1972; Ulmer-Franco et al., 2010), suggest that hatchability is decreasing with the increase of hatching time.

Table 6. The calculated correlation coefficients

Correlation coefficients		Hatching time			Hatchability		
		Hen	Goose	Duck	Hen	Goose	Duck
Number of eggs in one hatching unit	Hen	**0.23			**0.13		
	Goose		**0.10			**0.18	
	Duck			**-0.08			**0.27
Hatching time	Hen				**-0.16		
	Goose					**-0.17	
	Duck						**-0.15

**P<0,01

Conclusions

The following statements can be settled after analyzing 16146 hatching unit data of altogether 44 genotypes - 17 breeds and 27 hybrids - of three poultry species.

The overall mean values of hatchability are as follows: domestic fowl 82.96%, domestic goose 61.56% and domestic duck 64.59%, respectively. Based on our results it is presumable that hatchability can be optimal in the case of all tested genotypes if the hatching environment and technology, and the hatching equipment are appropriate.

The hatchery had significant effect on hatchability in the case of all poultry species. The incubation is a technologically very carefully programmed process, during which a number of parameters (temperature, humidity etc.) are changed at specific manner in the specific phases. Our database included the data of numerous hatcheries. All of them might have differed from one another in either the level of technology and management, or the settings, or the programming of hatching time.

Similarly to the literature information, the mixed-use genotypes showed better hatchability than meat-, or liver-type hybrids. The reason for this may be that the type of meat and liver hybrids have been selected primarily for meat, or liver production, and less attention has been devoted to reproduction. It is well known that there are negative correlations between the traits of meat- and liver-production and reproduction.

It can be concluded that hatchability of eggs in larger units is 8-10% higher than in smaller units. Hatching large number of eggs at the same time requires large scale conditions, industrial technology and incubators, in which the environment of hatching can be easily regulated. The technological conditions of small scale farms are less appropriate. It is also possible that the smaller farms receive lower quality hatching eggs for incubation than large-scale hatcheries.

Hatchability in case of domestic goose species was determined primarily by hatching month. During the summer months - especially in June and July - the hatchability was almost 10% lower than the average of the population, and it was about 15% lower than in the late winter and early spring period. This is probably maybe caused by the seasonality of reproduction of the goose species. Geese are originally migratory birds, and the growing length of daylight will result in a regression of the gonads (so called "photorefracter" phase), which would result in reduction of quantity and quality of germ cells, which ultimately leads to lower hatchability. Besides, intensive hatching egg production is predominant in chicken production, relatively frequent in duck and rare in goose, so environmental effects are the highest in goose hatching egg production, increasing the seasonality. These results are entirely consistent with the existing literature information (Péczely et al., 1984, 1993).

The results of our research suggest that hatchability is decreasing with the increase of hatching time.

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