GENERAL EGG CHARACTERISTICS AND ALTERATION DURING THE EGG-LAYING PERIOD BY GREY PARTRIDGE (*Perdix perdix*)

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ABSTRACT

JÁNOSKA, F. & SÁNDOR, G. (2019): GENERAL EGG CHARACTERISTICS AND ALTERATION DURING THE EGG-LAYING PERIOD BY GREY PARTRIDGE (*Perdix perdix*). *Hungarian Small Game Bulletin* **14**: 171–183. http://dx.doi.org/10.17243/mavk.2019.171
In Hungary, the hand-rearing of winged game, especially pheasant and grey partridge, is a well-known management form of small game management. In the latest decades, the intensive hand-rearing methods are the domineering procedure.

A well-known phenomenon that egg size varies greatly within many avian species. Many kinds of research pointed that variation within species is greatly high but within clutches the flexibility is altered depending on species, clutch size, laying date or sequence of the egg. We have only a few information about winged game species egg mass alterations.

For new information, we manage egg produce stock population in fenced circumstances and these stock populations produce for our investigation hatching eggs. During our investigations we checked the main data of the eggs: laying data, weight, width, length and from these data, we calculated the egg volume and egg shape index as well.

We found in a single clutch the deviation between the smallest and the biggest egg fairly high. We noticed as high as 85.5% deviation between the largest and the smallest egg mass.
From altogether 35 evaluated breeding pairs, egg mass tendency of 17 pairs showed a stagnant trend during egg-laying season. At the same time, from the other 18 breeding pairs, two pairs showed an explicit decreasing, other 16 pairs an explicit growing tendency in egg weight after laying order at a 5% level ($p<0.05$).
These data provide new information about egg production and serve new possibilities for renewing intense technologies of winged game management.

KEY WORDS: grey partridge, egg characteristics, egg mass, laying order, precocial species

ÖSSZEFOGLALÁS

JÁNOSKA, F. & SÁNDOR, G.: ÁLTALÁNOS TOJÁSMÉRET-JELLEMZŐK ÉS MÉRETVÁLTOZÁSOK A FOGOLY (*Perdix perdix*) TOJATÁSI IDŐSZAKA SORÁN**.** Magyarországon a szárnyas apróvad, elsősorban a fácán és a fogoly tenyésztése, közismert formája az apróvad-gazdálkodásnak. Az utóbbi évtizedekben az intenzív tenyésztési eljárások váltak általánossá.

Számos madárfaj esetében közismert, hogy a tojás mérete nagy változatosságot mutat. Számos kutatás igazolta, hogy a fajon belüli változatosság meglehetősen nagy lehet, de a fészekaljon belüli változatosság függ a fajtól, a fészekalj méretétől, a tojásrakás időpontjától és a tojás fészekaljbeli, tojásrakási sorrendjétől. Ugyanakkor meglehetősen kevés információnk van e jelenségről szárnyasvadfajaink esetében.

Mindezek miatt zárttéren tartott fogolyállománytól gyűjtöttünk tojásokat és vizsgáltuk a tojásrakás minden adatát. Feljegyzésre került a fogolypár száma, a tojás keletkezési dátuma, a tojás tömege, szélessége, hosszúsága, majd ez utóbbi két adatból számítottuk a tojás térfogatát és a tojásindexet.

Egy-egy fészekaljon belül viszonylag nagy különbséget detektáltunk a legnagyobb és a legkisebb tojás tekintetében. Szélsőséges esetben a legnagyobb tojás 85,5%-kal volt nagyobb, mint a legkisebb.

A 35 kiértékelt fogolypár esetében 17 párnál stagnáló tendenciát mutattunk ki a tojásméret változása tekintetében. Ugyanakkor 2 pár esetében szignifikáns csökkenő, 16 pár esetében szignifikáns növekvő tendenciát tapasztaltunk a tojásméret változását illetően ($p<0.05$).

Adataink új információkkal szolgálnak a fogoly tojásprodukciójáról és lehetőséget teremtenek a tenyésztési eljárások megújítására is.

KULCSZAVAK: szürke fogoly, tojás adatok, tojás tömeg, megtojás sorrendje, fészekhagyó faj

1. INTRODUCTION

In Hungary, the hand-rearing of winged game, especially pheasant and grey partridge, is a well-known form of small game management. In the latest decades, the intensive hand-rearing methods are the domineering procedure (JÁNOSKA, 2016, BAGI *et al.*, 2018). In the 2017 hunting year, more than 600,000 pheasants and about 12000 partridges were released to hunting territories in Hungary, more than 85% for hunting purposes (CSÁNYI, 2018). During intensive captive rearing, the breeding pairs of grey partridges are usually in the first year of their life. The selected breeding pairs originated from the first artificial hatching of the previous year, that is, the breeding pairs come from the very first eggs of the past capture-breeding population (ANDROVICZ, 2013).

Egg size is a widely studied trait and yet the causes and consequences of variation in this trait remain poorly understood. Egg size varies greatly within many avian species, with the largest egg in a population generally being at least 50% bigger as the smallest, or even twice as large (CHRISTIANS, 2002). Intraclutch egg size variation is probably a mechanism of female birds to modulate reproductive effort and offspring quality (GIBSON & WILLIAMS, 2017), especially by altricial bird species. However, different species showing a dissimilar figure of laying-sequence-specific egg size, e.g. Goldcrest, *Regulus regulus* (HAFTORN, 1986) increase egg size with laying sequence whereas other species (e.g. European Starling, *Sturnus vulgaris*) decrease egg size with laying order (GIBSON & WILLIAMS, 2017). At the same time, by other altricial species, researches found no relation between egg mass and position in the laying sequence, e.g. by blue tit (NILSSON & SVENSSON, 1993).

The brood-reduction hypothesis proposed by LACK (1954, cit. FRIEDL 1993). Lack suggested that, at the time of egg-producing, females usually be impossible to predict food availability during the rearing period. Therefore, females would produce an "optimistic" number of eggs (i.e. as many eggs as young could be reared under optimal environmental conditions). SLAGSVOLD ET AL. (1984) suggested that birds adopting the "brood-reduction strategy" have a small final egg, particularly those birds with large clutches, whereas birds adopting the "brood-survival strategy" have a relatively large final egg, particularly those birds with large clutches.

In many species of passerine birds, egg size increases with the laying order, and this phenomenon is indeed difficult to give a reasonable means of the brood-reduction hypothesis (CLARK & WILSON, 1981; SLAGSVOLD *et al.*, 1984).

Pheasant and grey partridge are precocial bird species. In precocial species, egg-laying and incubation are important stages of reproductive investment and may perform critical energy bottlenecks, particularly in harsh environment conditions (SHI *et al.*, 2019). MAGRATH (1992) advised that egg mass might have a greater effect on chick survival in precocial than altricial species (with relatively little investment in egg production). It is evident, the mass and composition of an egg have a considerable impact on the successful development of the embryo and may influence the subsequent survival of the hatchling (FINKLER *et al.*, 1998), especially in precocial birds. Volume and fresh egg mass are generally highly correlated (REID & BOERSMA, 1990).

Our target was to analyze the egg characteristics, especially the egg mass alteration during laying period in hand-reared grey partridge, a precocial species characterized by fairly large clutches.

2. MATERIAL AND METHODS

Examinations were carried out in four ensuing years (2015-2018) during the reproductive season of grey partridges (March – July) on the Botanical Garden belonging to the University of Sopron. Our breeding stock originated from the very first 150 eggs obtained from *Lenes Breeding Farm* in 2014. Mean birds were chosen from the gaggle each year for the egg-productive season. During winter months, birds were fed entirely wheat grain. From Mid-February wheat was gradually replaced by complete nutrition which contained: 16,4 % crude protein and 11.05 MJ ME and 2.49 % calcium, so that by March 1st, it was the only feed, fed ad libitum.

Partridge pairs were placed in open-air wire cages (1x1 m, respectively). Breeding pairs of partridges we formed about Mid-March. We investigated 21, 6, 16, 12 breeding pairs of grey partridges in 2015-2018, respectively. From these breeding populations, yearly 12, 3, 9 and 11 pairs produced more than 15 eggs/breeding season, so we used in our analysis only the results of these pairs.

When hens started laying we gathered the eggs by late afternoon each day. We marked each egg with a non-toxic permanent marker pen (date of laying, the number of partridge hen). Additionally, we collected eggs in two other breeding farms in Hungary in 2016. In *Kecel Breeding Farm* we measured 47 eggs from 10 breeding pairs, in *Lenes Breeding Farm* 101 eggs form 20 breeding pairs (between 15-22th April, respectively). Because of the methods of egg-producing, we have exact data from each partridge female eggs.

Just after collection eggs were weighed to the nearest 0.01 g with a digital balance. Egg breadth and length we measured with a digital caliper to the nearest 0.01 mm. Egg volume we calculated with the method of HOYT (1979) from the length and breadth of the egg, with some little modification based on our previous research (JÁNOSKA unpubl.). We measured altogether 1515 partridge eggs.

We investigated the relationship between laying order, egg weight, and egg volume. Linear correlation analysis has been used in examining the characteristics of eggs.

3. RESULTS AND DISCUSSION

3.1. GENERAL EGG CHARACTERISTICS

The egg dimensions (**Table 1**) correspond to the data of literature. In some oological collections measured 358 partridge eggs FARAGÓ (2001) in Hungary. He found the average egg is 35.10 X 26.78 mm. In former Czechoslovakia the average egg was found (N=222) 34.99 X 26.45 mm (GLUTZ *et al*., 1973, cit. FARAGÓ 2001). After 13 clutches, altogether 183 eggs found the average egg 34.58 X 26.48 mm CAROLL *et al*., (2020).

Table 1: The egg characteristics (2015-2018)
1.táblázat: A tojások legfontosabb adatai

	N	Mean	SD	Maximum	Minimum
Fresh egg weight (g)	1515	13.44	1.194	17.66	7.40
Length (mm)	1515	34.48	1.458	37.98	27.29
Width (mm)	1515	26.67	0.891	29.07	21.81
Volume (cm^3)	1515	12.37	1.195	15.877	6.73
Shape index	1515	77.439	2.561	88.777	68.057

The following **Table 2-5** we gathered the most important data for each year investigated. Every year except 2016 there were breeding pairs produced no eggs. Some earlier investigations report a similar situation, namely the egg production of gray partridge is erratic (MULLER *et al.*, 1971, CSÁNYI, 1993). The reasons are not sufficiently clear; CSÁNYI (1993) suggested it is a natural phenomenon and affects 6-9% of the artificial breeding population. From our other studies, we hypothesize that some birds do not reach sexual maturity in their first year of life. In our studies with Reeves's pheasants (*Syrmaticus reevesii*), we found in several cases that the male became sexually mature only in his second year of life (JÁNOSKA unpubl.).

Table 2: Egg weight data in 2015
2. táblázat: A tojások tömegadatai, 2015

No of breeding box	N	Mean weight, g	SD	Maximum, g	Deviation from the mean, %	Minimum, g	Deviation from the mean, %
1	30	13.80	0.750994	15.14	9.71	12.31	-10.81
2	24	13.51	1.079223	16.08	19.02	12.00	-11.18
3	18	14.23	1.409873	15.71	10.40	11.87	-16.58
4	28	13.38	0.944669	15.11	12.95	11.13	-16.82
5	30	13.80	1.056668	16.98	23.04	11.49	-16.74
6	15	13.79	1.134527	15.89	15.26	11.81	-14.38
7	3	12.71	0.390366	13.15	3.49	12.20	-3.99
8	24	13.12	0.883679	15.12	15.26	11.30	-13.87
9	13	12.75	0.596174	13.92	9.18	11.46	-10.12
10	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
12	24	13.50	1.029118	15.76	16.74	11.82	-12.44
13	7	13.96	0.365156	14.70	5.30	13.52	-3.15
14	32	13.45	0.757742	15.51	15.32	11.73	-12.81
15	9	14.01	0.619428	14.87	6.14	12.78	-8.78
16	0	0	0	0	0	0	0
17	8	13.08	0.444075	13.80	5.50	12.56	-3.98
18	0	0	0	0	0	0	0
19	15	13.39	0.738034	15.44	15.33	12.35	-7.77
20	33	12.87	1.331249	15.29	18.80	8.24	-35.98
21	23	14.03	0.676932	15.16	8.07	12.41	-11.56

We found in a single clutch the deviation between the smallest and the biggest egg fairly high. After a wide literature review, CHRISTIANS (2002) found great variability in egg size, but approximately 70% of the variation in egg mass was due to variation between rather than within clutches, although there were some cases of extreme intra-clutch egg-size variation. The greatest variability in egg size within a single clutch showed in the crested penguins (*Eudyptes* spp.) that exhibit extreme egg-size dimorphism, with differences of 30±60% between eggs (WILLIAMS, 1990; ST. CLAIR, 1996). In contrast, in some partridge females, we found a similar extreme difference between the smallest and largest egg size. For example, in 2015 by the 20th breeding pair, the smallest and the largest egg were 8.24g and 15.29g, respectively. That means an 85.5% difference (**Table 2**). Also was the difference fairly high in 2017 by the 3rd breeding pair (7.40g vs. 11.26g, 52.2%, **Table 4**).

Table 3: Egg weight data in 2016
3. táblázat: A tojások tömegadatai, 2016

No of breeding box	N	Mean weight, g	SD	Maximum, g	Deviation from the mean, %	Minimum, g	Deviation from the mean, %
1	3	12.84	0.769949	13.48	4.98	11.76	-8.41
2	31	15.13	0.845269	16.87	11.50	12.94	-14.47
3	6	11.77	0.897863	12.71	7.99	10.08	-14.36
4	4	13.42	1.60295	15.27	13.79	10.97	-18.26
5	29	13.08	0.814888	14.93	14.14	10.76	-17.74
6	33	13.52	0.487851	14.64	8.28	12.46	-7.84

Table 4: Egg weight data in 2017
4. táblázat: A tojások tömegadatai, 2017

No of breeding box	N	Mean weight, g	SD	Maximum, g	Deviation from the mean, %	Minimum, g	Deviation from the mean, %
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	40	9.82	0.82881	11.26	14.66	7.40	-24.64
4	27	13.90	0.390965	14.61	5.11	13.04	-6.19
5	35	15.29	0.492767	16.09	5.23	14.29	-6.54
6	14	14.42	0.425365	15.08	4.58	13.70	-4.99
7	46	13.97	0.444719	15.00	7.37	13.24	-5.23
8	23	12.87	0.862019	14.09	9.48	10.85	-15.70
9	19	13.96	0.466339	14.63	4.80	12.65	-9.38
10	13	12.10	0.779274	13.19	9.01	10.67	-11.82
11	0	0	0	0	0	0	0
12	19	13.12	0.414288	13.79	5.11	12.29	-6.33
13	0	0	0	0	0	0	0
14	29	14.82	0.732554	16.48	11.20	12.91	-12.89
15	23	13.9	0.609979	14.74	6.04	12.36	-11.08
16	12	12.25	0.370843	12.81	4.57	11.73	-4.24

However, in both cases, the lightest two eggs were the very first eggs in the clutch (8.24g and 11.09g; 7.40g and 8.21g, respectively). Following research done with the herring gull, PARSONS (1976) hypothesized that an increase in physiological efficiency of the ovaries and oviduct as development passes from the first egg to the following ones may account for the increase in size between the first egg and subsequent ones. Examining the nesting of the Canada goose, LEBLANC (1987) stated: once the optimal level of efficiency has been attained, eggs could be very similar in size; this was the case in most clutches of grey partridge in our investigations.

Table 5: Egg weight data in 2018

5. táblázat: A tojások tömegadatai, 2018

No of breeding box	N	Mean weight, g	SD	Maximum, g	Deviation from the mean, %	Minimum, g	Deviation from the mean, %
1	39	13.31	0.811813	15.36	15.40	11.93	-10.37
2	47	13.11	0.919159	14.97	14.19	11.18	-14.72
3	54	15.28	0.774652	17.66	15.58	13.01	-14.86
4	52	13.66	0.810438	16.55	21.16	12.34	-9.66
5	71	13.41	0.509476	14.66	9.32	12.1	-9.77
6	23	13.73	0.773271	14.67	6.85	11.54	-15.95
7	44	11.63	0.714645	14.08	21.07	10.37	-10.83
8	0	0	0	0	0	0	0
9	37	13.09	0.370129	14.04	7.26	12.38	-5.42
10	20	12.68	0.925157	14.49	14.27	10.7	-15.62
11	66	13.73	0.578476	15.16	10.42	12.56	-8.52
12	22	11.53	0.573505	12.48	8.24	10.18	-11.71

3.2. ALTERATION OF EGG MASS AND VOLUME

From 55 breeding pairs, we appraised 35 pairs produced more than 15 eggs in an egg-producing season. From altogether 35 evaluated breeding pairs, egg mass tendency of 17 pairs showed a stagnant trend during egg-laying season. At the same time, from the other 18 breeding pairs, two pairs showed an explicit decreasing, other 16 pairs an explicit growing tendency in egg weight after laying order at a 5% level ($p<0.05$).

In the first research year (2015) we could evaluate 11 pairs from altogether 21 breeding pairs. From this 11 pairs egg mass of 1 pair showed significantly decreasing, 6 pairs significantly increasing tendency, according to the laying order (**Table 6**).

In the second research year (2016) we could evaluate 3 pairs from altogether 6 breeding pairs. From these 3 pairs, egg mass of 1 pair showed significantly increasing tendency, according to the laying order (**Table 7**).

In the third research year (2017) we could evaluate 9 pairs from altogether 16 breeding pairs. From these 9 pairs, egg mass of 6 pairs showed significantly increasing tendency, according to the laying order (**Table 8, Figure 3-4**).

In the fourth research year (2018) we could evaluate 11 pairs from altogether 12 breeding pairs. From these 11 pairs egg mass of 1 pair showed significantly decreasing, 3 pairs significantly increasing tendency, according to the laying order (**Table 9, Figure 1-2**).

Table 6: Egg mass alteration statistical test, 2015

6. táblázat: Tojástömeg-változás statisztikai próbája, 2015

2015	N	statistically proven	tendency
1	30	NS	increasing
2	24	**S**	increasing
3	18	**S**	decreasing
4	28	NS	decreasing
5	30	**S**	increasing
6	15	NS	increasing
7	3	i.d.	
8	24	**S**	increasing
9	13	i.d.	
10	0	n.d.	
11	0	n.d.	
12	24	NS	increasing
13	7	i.d.	
14	32	**S**	increasing
15	9	i.d.	
16	0	n.d.	
17	8	i.d.	
18	0	n.d.	
19	15	**S**	increasing
20	33	**S**	increasing
21	23	NS	increasing

S: significant in 5% level
NS: non-significant
n.d.: no data
i.d.: insufficient data

Table 7: Egg mass alteration statistical test, 2016

7. táblázat: Tojástömeg-változás statisztikai próbája, 2016

2016	N	statistically proven	tendency
1	3	i.d.	
2	31	**S**	increasing
3	6	i.d.	
4	4	i.d.	
5	29	NS	increasing
6	33	NS	increasing

S: significant in 5% level
NS: non-significant
i.d.: insufficient data

Table 8: Egg mass alteration statistical test, 2017

8. táblázat: Tojástömeg-változás statisztikai próbája, 2017

2017	N	statistically proven	tendency
1	0	n.d.	
2	0	n.d.	
3	40	**S**	increasing
4	27	NS	increasing
5	35	NS	decreasing
6	14	i.d.	
7	46	NS	increasing
8	23	**S**	increasing
9	19	**S**	increasing
10	13	i.d.	
11	0	n.d.	
12	19	**S**	increasing
13	0	n.d.	
14	29	**S**	increasing
15	23	**S**	increasing
16	12	i.d.	

S: significant in 5% level
NS: non-significant
n.d.: no data
i.d.: insufficient data

Table 9: Egg mass alteration statistical test, 2018

9. táblázat: Tojástömeg-változás statisztikai próbája, 2018

2018	N	statistically proven	tendency
1	39	**S**	increasing
2	47	**S**	increasing
3	54	NS	increasing
4	52	NS	decreasing
5	71	NS	increasing
6	23	**S**	increasing
7	44	NS	increasing
8	0	n.d.	
9	37	NS	increasing
10	20	NS	increasing
11	66	NS	increasing
12	22	**S**	decreasing

S: significant in 5% level
NS: non-significant
n.d.: no data

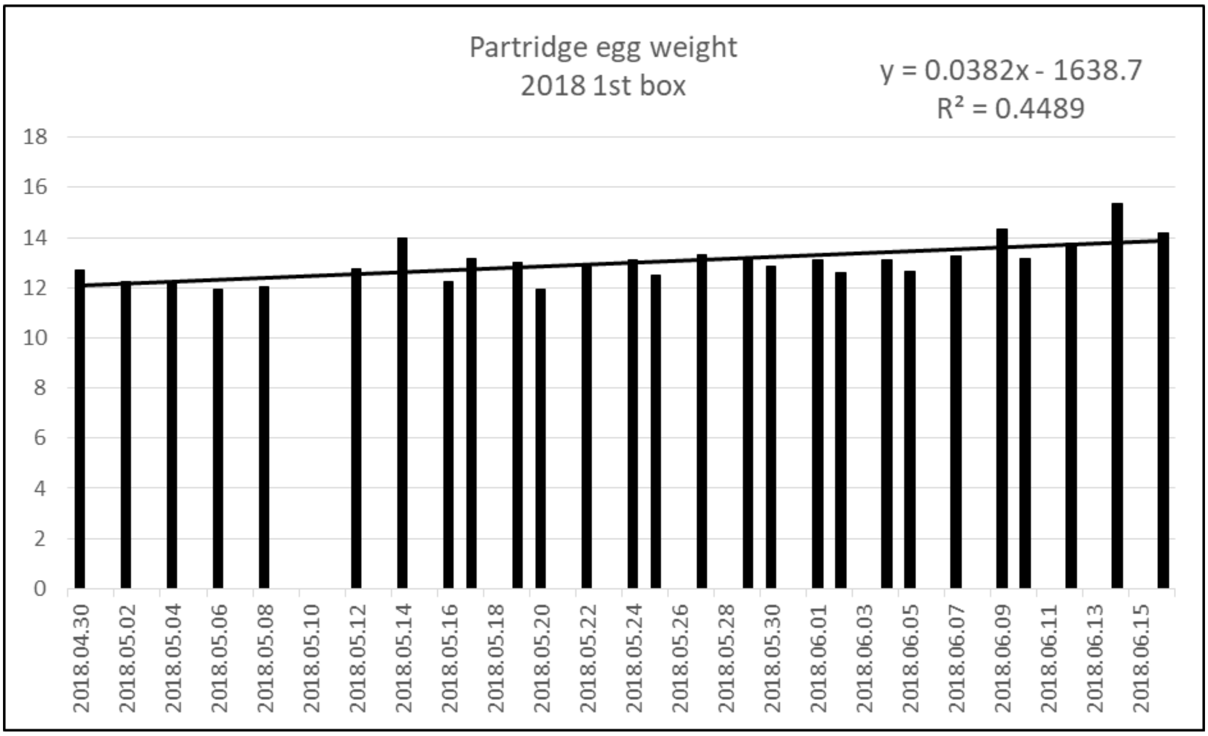

Figure 1: Egg weight alteration in 2018, 1st breeding box

1. ábra: A tojástömeg változása 2018-ban az 1. boxban

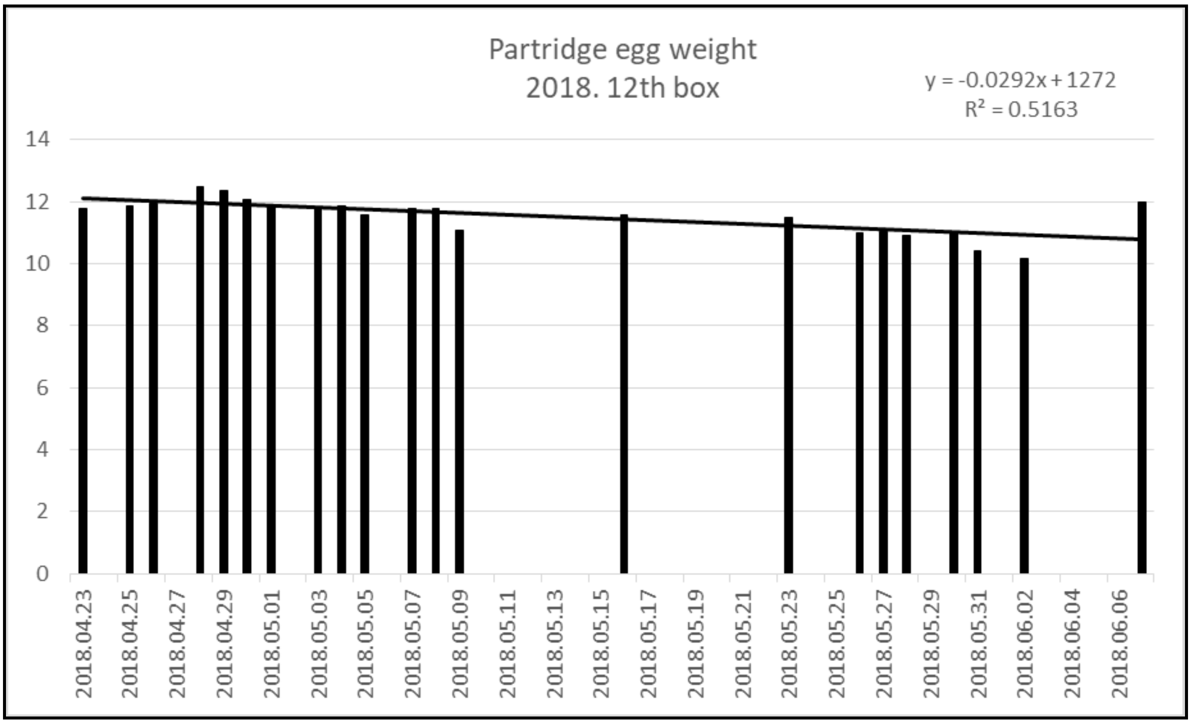

Figure 2: Egg weight alteration in 2018, 12th breeding box

2. ábra: A tojástömeg változása 2018-ban a 12. sorszámú boxban

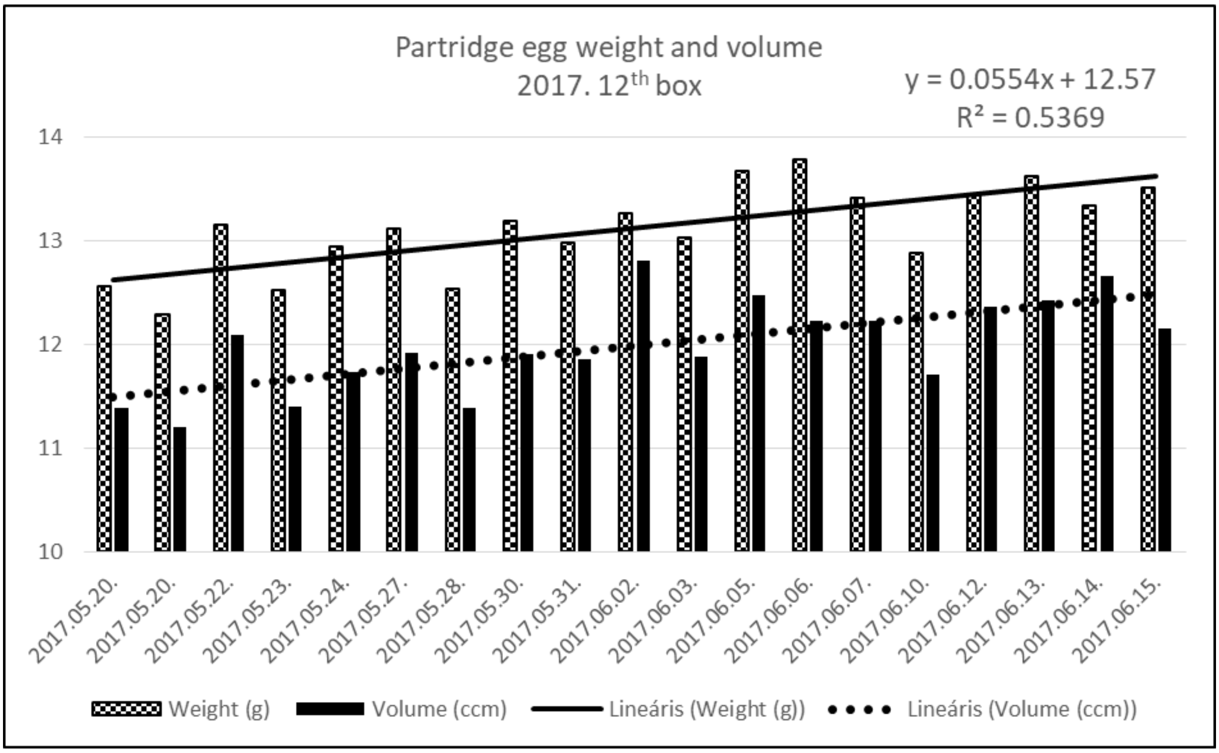

Figure 3: Egg weight and egg volume alteration in 2017, 12th breeding box

3. ábra: A tojástömeg és a térfogat változása 2017-ben a 12. sorszámú boxban

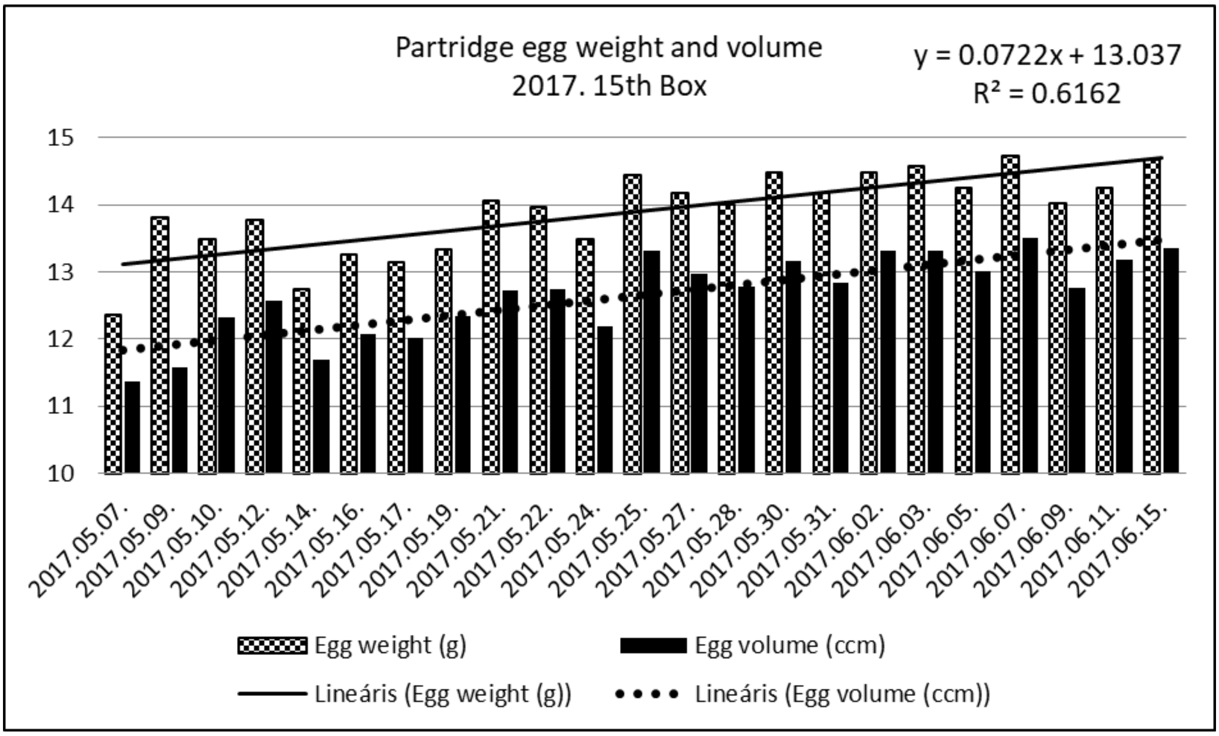

Figure 4: Egg weight and egg volume alteration in 2017, 15th breeding box

4. ábra: A tojástömeg és a térfogat változása 2017-ben a 15. sorszámú boxban

Because egg volume and fresh egg mass are generally highly correlated (REID & BOERSMA, 1990), we can see this phenomenon in **Figure 3-4**, too.

In the literature, there are only a few data about egg mass alteration within years by partridge species. Variation in egg mass and the period between eggs within years was attributable more to variation among individual females by red-legged partridge (*Alectoris rufa*), after CABEZAS-DÍAZ *et al*., (2005). In some Italian research with grey partridge (CUCCO *et al*., 2010), egg characteristics were unrelated to egg position in the laying order, but in this research were measured only the first 20 eggs of each hen.

Investigated the laying gaps by grey partridge, the egg position in the laying order was significantly related to several egg characteristics. In particular, along the laying sequence, there was a significant decrease in egg mass (CUCCO *et al*., 2017). It has to be noted, they used only the 4th - 20th eggs because the 1st – 3rd eggs are usually low in quality and last-laid eggs are outside of the range occurring in natural positions (CUCCO *et al*., 2017; POTTS, 1986).
With an increase in egg mass, the most notable increase in component mass was that of albumen, constituting approximately 77% of the increase in initial egg mass. Yolk and shell constituted roughly 19% and 4% of the initial egg mass increase, respectively (FINKLER *et al*., 1998). It is accepted that in the domestic hens, the eggs' weight increases by the progress in the production period as a result of a decrease in laying and changes in egg formation rate (OTWINOSKA-MINDUR *et al*., 2016). But, in our investigation, we did not find the same reasons.

In a common precocial species, the Lapwing (*Vanellus vanellus*) egg quality and chick survival rate were studied in southwestern Sweden (BLOMQUIST *et al*., 1997). They found egg size did not affect chick survival independently of parental quality. The correlation between brood survival and egg volume was significant only for first clutches, suggesting that other factors than egg size were important for chick survival in replacement clutches (BLOMQUIST *et al*., 1997). It seems in egg production of grey partridge also shows a similar pattern than lapwing.

Data on the breeding biology of geese support the idea that the brood-reduction hypothesis, which was previously discussed in relation to altricial birds, can be applied to geese and perhaps other precocial species (FRIEDL, 1993).

CONCLUSIONS

We found in a single clutch the deviation between the smallest and the biggest egg fairly high. We noticed as high as 85.5% deviation between the largest and the smallest egg mass.

From altogether 35 evaluated breeding pairs, egg mass tendency of 17 pairs showed a stagnant trend during egg-laying season. At the same time, from the other 18 breeding pairs, two pairs showed an explicit decreasing, other 16 pairs an explicit growing tendency in egg weight after laying order at 5% level ($p<0.05$). This data is a novel approach of egg-laying investigations in a precocial bird species, the grey partridge.

In the next period of our investigations, we plan to examine the composition data of the eggs laid in different periods during the egg production period.

Further investigations required to find other tendencies on egg production of grey partridge, starting from the related literature cited.

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