

Theses of Doctoral (PhD) Dissertation

Evaluation of factors affecting the production parameters and behaviour of some Hungarian ostrich populations

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1. INTRODUCTION

The ostrich was domesticated in South Africa in the 19th century. The advantage of the species is its longevity since it is capable of economical egg production up to 15-20 years of age.

Ostriches were first imported to Hungary in the '90s when the first populations started egg production. Currently, there are two large farms (> 60 adult males and females) and several farms with a few breeding animals in our country. The domestic population covers a few hundred breeding birds.

The transport of breeders and/or eggs requires the existence of a breeding program, including all parts of the breeding. The Department of Animal Husbandry of the University of Debrecen is carrying out a five-year research program on behalf of the Ministry of Agriculture with the aim of the recognition of the Hungarian ostrich and establishing a recognized breeding organization. My doctoral thesis lays the foundations of the breeding program through the assessment of breeding and production parameters of the domestic ostrich population. As a result of the research program, a breeding organization can be created that implements the breeding program, coordinates the breeding and registers the breeders.

My research involved:

- ethological observation in different stages of the production year to examine the daily behaviour and social relationships of the individuals,
- microbiological assessment of environment/condition of breeding animals, eggs and chicks,
- the analysis of the production characteristics (egg and meat production) among domestic husbandry, feeding and management conditions,
- the examination of egg composition in certain months of the production year,
- the detection of the date and causes of embryo mortality,
- the determination of factors that influence the survival of slaughter birds from hatching to slaughter age.

2. MATERIALS AND METHODS

2.1. Description of the ethological observations

A total of 24 behavioural elements were evaluated that occur in ostriches. To facilitate assessment, five behaviour categories (maintenance, active comfort, passive comfort, location-changing, social and/or reproductive) were established.

The scan-type group observations with the 0-1 method (LEHNER, 1992) were carried out on Farm “A” between February and October 2021 (February, March, June, September and October). Altogether 12 individuals from two trios and two harems were included in the analysis, one male and two females per pen, randomly selected. In parallel with the personal observations, a camera recording was also made.

The differences in the frequency of each behaviour depending on the husbandry technology (sex ratio), time of the day, month and sex were determined using the IBM SPSS Statistics 23.0 program with Pearson's Chi² test of independence (P<0.05).

2.2. Microbiological examinations

For the microbiological investigations, samples from Farm „A” and Farm „B” were taken. The birds were not vaccinated or treated with antibiotics at any of the farms.

The following types of samples were used for the analysis (**Table 1**).

Table 1: Name, quantity, origin of the samples and the method of examinations

Sample name	Number and origin of the samples	Sample material	Methods
faeces	20 (A), 33 (B)	mixed samples per pen	surface enrichment with saline solution, salmonella enrichment and bacterium isolation
dead-in-shell eggs	43 (A), 50 (B)	egg content and yolk sac	salmonella enrichment and bacterium isolation
dead chicks	15 (B)	liver and heart blood	
swabs	14 (2x7) (A)	the surface of the eggshell (n=7), storage room and incubator facilities (n=7)	

With the routine laboratory technique generally used in practice, the presence of the following pathogens was confirmed:

Evaluated parasites:

- *Ascaridia spp.*
- *Heterakis spp.*
- *Capillaria spp.*

Evaluated bacteria:

- *Salmonella spp.*
- *Escherichia coli*
- *Bacillus spp.*
- *Klebsiella spp.*
- *Enterococcus faecalis*
- *Streptococcus spp.*
- *Pseudomonas spp.*
- Coliform bacteria
- *Staphylococcus spp.*

The analyzes were carried out by the Animal Diagnostic Institute of the National Food Chain Safety Office in Debrecen, based on MSZ EN ISO and ISO standards.

The number of pathogens identified on the farms and in the samples was obtained by summing them up. The proportion of pathogens was calculated by using the formula " $x\% = (n_x/n_{total}) * 100$ ".

2.3. Examination of egg production and hatchability

The performance of a total of fifteen trios, i.e. thirty females, was evaluated on Farm „B”. Birds between the ages of two and eight years were included in the study. There was no correlation between the time spent in production and the age of birds since the females started laying eggs at different ages.

The analyzed parameters included the beginning and end of the production year (number of days after January 1 of the given calendar year), the length of the production year (days), the number of days between the laying of two eggs, the length and number of long breaks between cycles (more than 6 days). In addition, the number of eggs laid during the production year (pcs), the number and rate of eggs set (%), the hatching time of chicks (days), the hatchability (%) and the number of chicks hatched were also examined.

The production data were collected by the owner of the farm. The statistical evaluations were carried out with Microsoft Office Excel 2016 and IBM SPSS Statistics 23.0 programs. For the comparison of the means, multifactorial analysis of variance was applied, and for the

determination of differences between the effects, Tukey's test was used at a confidence level of 95% ($P < 0.05$).

2.4. Evaluation of the relationship between the production month and egg composition

The examinations were carried out on Farm „A" on eleven randomly selected eggs in the normal weight range (1200-1600 g) in May and July 2021.

Regarding egg composition, the dry matter content (%), crude protein content (%), amino acid composition (m/m%), crude fat content (%), saturated fatty acid content (%), mono-unsaturated fatty acid content (%), poly-unsaturated fatty acid content (%), saturated/unsaturated fatty acid ratio and mineral content (Ca, Mg, P, Zn, Cu, Fe, K, Na, S, Mn; mg/kg) were determined. The analysis of the egg composition was carried out by the University of Debrecen Agricultural Equipment Center based on MSZ ISO and ISO standards. For the measurements, homogenized samples of egg content (albumen and yolk together) were used.

For the statistical evaluation, IBM SPSS Statistics 23.0 program was applied. The effect of the month was examined with a one-factor analysis of variance, and the difference between the months was determined with Tukey's test at a confidence level of 95% ($P \leq 0.05$). Results are presented as means and standard error of the mean.

2.5. The method of the dissection of dead embryos

The eggs removed from the incubator during candling on the 38th day of incubation were collected on Farm „A". The dissection was performed on the day of culling under sterile conditions. After measuring the weight of the eggs, they were opened with a cutting disc at their blunt ends, and the sizes of body parts were taken.

Egg weight (g), eggshell weight (g), the weight of egg contents (g), embryo/fetus weight (g), liver weight (g) and heart weight (g), head width (cm), beak length (cm), the length of the right wing (cm), the length of the right thigh (cm), and the length of the right leg (cm) were measured. When recording the weight and size of body parts and organs, their measurability and importance were the main aspects. In addition to the measurements, findings regarding the appearance of the egg contents, corpses and their organs were also made. A total of 30 eggs were examined, of which the egg and embryo weight and body dimensions were measured on 20 eggs.

The descriptive statistics (mean \pm S.E.) of the recorded weights and measurements were calculated with the IBM SPSS Statistics 23.0 program.

2.6. Survival analysis of ostriches from hatching until 48 weeks of age

The examinations were based on the data of Farm „B". The effects of the following factors were analysed:

- Combination of the year and season of the production year;
- Egg weight (small: <1430 g; medium: 1431-1456 g; large: >1457 g);
- Hatching order in the year (weekly hatchings);
- Egg hatchability (poor: $\leq 50\%$, average: 51–69%, good: $\geq 70\%$), including all analyzed years and groups. Hatchability was calculated by using the following equation:

$$\text{Hatchability (\%)} = \frac{\text{number of chicks hatched}}{\text{number of eggs set}} \times 100$$

The survival analysis was performed with the Survival Kit program and the Weibull model using the following equation (MÉSZÁROS et al., 2013):

$$\lambda(t) = \lambda_0(t) \exp\{ys_i + hew_j + hob_k + h_l\}$$

where $\lambda(t)$ = risk factor (momentary probability of culling per chick, for a given period t ; $\lambda_0(t)$ = initial Weibull risk factor with scale index λ ; ys_i = fixed, time-independent effect of the combination of year and season of egg production; hew_j = fixed, time-independent effect of hatching weight; hob_k = fixed, time-independent effect of hatching order; h_l = fixed, time-independent effect of hatchability.

The effect of factors on the relative risk of total loss was analysed with the Weibull model (MÉSZÁROS et al., 2013). The mathematical calculations related to egg production and hatchability were performed using the functions of the Microsoft Office Excel 2016 program. The production data were provided by the owner of the farm. During the three years, a total of 1606 chicks were evaluated until the age of 48 weeks, as the international literature indicates that the optimal slaughter weight is reached at the earliest age of 48 weeks (12 months) (POLLOK et al., 1997). Those animals that were still growing or alive were censored. The ratio of censored data was 38.36%.

2.7. Examination of the slaughter value and meat quality of ostriches

Slaughter birds aged between 12 and 18 months (n=30, 14 females and 16 males) from Farm „A" took part in the study. The slaughter weight, the carcass weight, the weight, colour and pH of the meat parts were examined in both age groups, while the chemical composition, technological characteristics and sensory properties of the meat parts were examined only in the 18-month-old birds. At the slaughterhouse, a two-decimal accuracy scale was used for

measuring the weight of the feathers, head, neck, feet, and internal organs (heart, lungs, gizzard, and liver). Due to their small scientific value, these parameters are not presented in the results. The weight of the eleven meat parts from the rump and thigh from one side of the carcass was measured in the processing plant with a two-decimal accuracy scale. After weighing, the pH and colour of the five most valuable meat parts (outside strip, oyster, tip, outside leg and medalion) were determined.

Among the technological properties, the dripping, freezing and cooking loss (%), as well as the shear force (N/mm) of meat parts were examined. The drip loss was measured based on the instructions of HONIKEL (1998). The freezing loss was obtained after thawing the samples by calculating the difference between the original weight and the weight after thawing. To determine the cooking loss, meat slices were placed in a plastic bag and cooked for half an hour until a core temperature of 75 °C. The samples were cooled under running water and wiped with a paper towel, and then their weights were measured. After cooking, samples were put in a refrigerator at 4 °C overnight. The determination of shear force on the cooled samples was carried out by the University of Debrecen Agricultural Equipment Center using a Warner-Blatzer Texture Analyzer.

The analysis of meat composition was carried out by the University of Debrecen Agricultural Equipment Center based on MSZ ISO and ISO standards. For the evaluations, the meat parts were cooked at 90 °C until a core temperature of 75 °C (BEJERHOLM and AASLYNG, 2004). The samples were cut into 2 cm x 2 cm x 2 cm cubes, and then their temperature was tempered at 45-55 °C until the evaluation. The organoleptic judgement was carried out by an experienced panel of 21 people. The reviewers scored the samples on a five-point hedonic scale (1-very bad, 5-excellent). The judging criteria included smell, taste, juiciness, tenderness, and texture. The presence of an aftertaste was also determined by the panel members. For the statistical analysis, IBM SPSS Statistics 23.0 and Microsoft Office Excel 2016 programs were used. The mean values were compared with a one-factor analysis of variance, including Tukey's test, at a confidence level of 95% ($P < 0.05$).

3. RESULTS AND DISCUSSION

3.1. The results of the ethological observations

The frequency of the behaviours did not change in the three analyzed times of the day (morning, noon and afternoon) and in the two sexes ($P>0.05$).

Figure 1 represents the frequency of active comfort behaviours by population size.

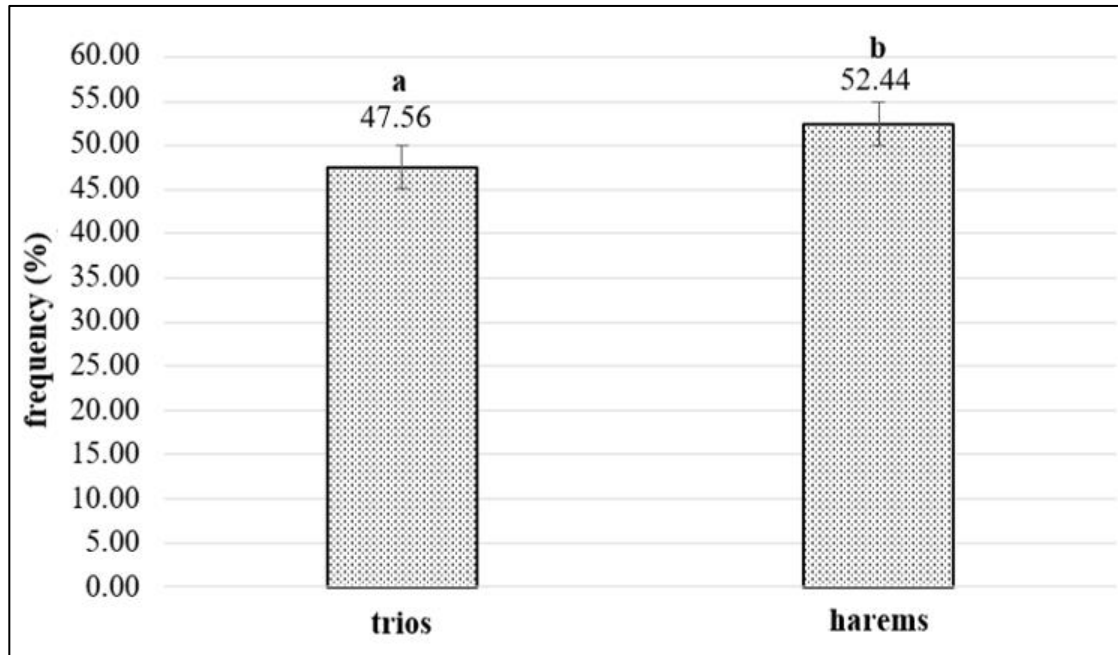


Figure 1: Frequency of active comfort behaviours by population size

^{a,b} letters indicate significant differences ($P<0.05$)

Comparing the husbandry systems, the active comfort behaviours occurred at a higher frequency in harems than in trios during the observation period (**Figure 1**). This means that ostriches kept in harems peck, preen, dust bath, stretch, and scratch more than individuals living in trios. We can find literature on the effect of group size only in wild ostriches.

It is known that in larger groups, the individual vulnerability of birds is lower (BERTRAM, 1980; ELGAR, 1989; FERNÁNDEZ et al., 2003). The number of research related to group size is small, and the existing ones only provide information on the topic of group composition and social relations (QUENETTE, 1990; BLUMSTEIN et al., 1999; BEAUCHAMP, 2003). Birds are assumed to feel safer in larger groups, so the frequency of active comfort behaviours in the group increases. Based on the above findings, it can be stated that, from an animal welfare point of view, harem-like group housing is more appropriate.

3.2. Results of the microbiological evaluations

The results of bacterium isolation with the identified bacteria and the number of positive samples by sample type are presented in **Table 2**.

Table 2: Results of the bacterium isolation attempt with the number of positive samples for each bacterium. *Several samples contained more than one of the tested microbe species

Bacteria	Faecal samples		Eggshell surface swabs	Storage room & incubator swabs	Dead-in-shell eggs		Dead chicks*	Sum
	A (n=20)*	B (n=33)*			A (n=7)	A (n=7)		
Farm (number of samples)								175
<i>Bacillus spp.</i>	9	8	5	4	1	2	-	29
<i>Coliform bacteria</i>	-	-	-	2	14	9	2	27
<i>Enterococcus faecalis</i>	-	-	-	-	1	-	5	6
<i>Escherichia coli</i>	17	32	-	-	8	3	2	72
<i>Klebsiella spp.</i>	-	1	-	-	1	1	-	3
<i>Pseudomonas spp.</i>	-	-	-	-	3	3	1	7
<i>Salmonella spp.</i>	-	-	-	-	-	5	-	5
<i>Staphylococcus spp.</i>	-	-	-	-	-	3	-	3
<i>Streptococcus spp.</i>	-	-	-	-	-	-	-	-
Positive	19	33	5	6	28	26	8	120
Negative	1	-	2	1	22	22	7	55

Considering all the investigated samples (**Table 2**), *Escherichia coli* and *Bacillus spp.* were the two most common bacterial species from the 175 analyzed samples. Some of the bacteria were detected in more than one sample. *Escherichia coli* was predominant in the faeces on both farms. It was also present in dead-in-shell eggs and dead chicks but in much lower proportions. Almost 10% of the faecal samples were contaminated with *Bacillus spp.* Coliform bacteria were the second most frequent bacteria present in dead-in-shell eggs. Coliform bacteria also occurred in small percentages in dead chicks and incubator swab samples. *Bacillus spp.* was detectable in all other samples except for dead chicks, and most of them were present in the faeces. *Salmonella spp.* and *Staphylococcus spp.* were present only in dead-in-shell eggs. *Pseudomonas spp.* and *Enterococcus faecalis* bacteria were found in dead-in-shell eggs and dead chicks. *Klebsiella spp.* occurred both in faeces and dead-in-shell eggs.

According to ASMAA (2016), the environment of ostriches, such as drinking water, feed, soil and faeces, is the largest source of *Escherichia coli* and *Salmonella spp.* infection. JAHAN et al. (2017) isolated *Escherichia coli* and *Salmonella spp.* in 40 and 48%, *Staphylococcus spp.* in 8%, and *Bacillus spp.* in 4% of the faeces of three to seven-month-old ostriches. Omphalitis is one of the main causes of death of newly hatched chicks (IJAZ et al., 1994), and *Escherichia coli* plays a significant role in its appearance (SAIF et al., 2008). In addition, from dead chicks, *Proteus spp.*, *Streptococcus spp.*, *Klebsiella spp.*, *Pseudomonas spp.* (IQBAL et al., 2006), *Staphylococcus spp.* and *Bacillus spp.* species were also isolated (HUSSEIN et al., 2008).

3.3. Egg production and hatchability

Table 3 represents the hatchability parameters.

Table 3: The ratio of eggs set and hatched in the evaluated years related to female age and trios

Evaluated parameters		Number of eggs set per female (pcs)	Ratio of eggs set per female (%)	Hatching time per female (day)	Hatchability per female (%)	The number of chicks hatched per female
Production year	2018	29,21±4,96 ^{ac}	98,41±3,04 ^b	39,55±0,24 ^a	41,14±7,91	12,74±4,11 ^a
	2019	25,08±3,51 ^{ab}	91,75±2,15 ^b	40,66±0,16 ^b	61,43±5,59	16,76±2,90 ^a
	2020	41,65±3,20 ^c	87,33±1,96 ^a	40,85±0,15 ^b	63,49±5,10	27,91±2,65 ^b
	2021	35,28±3,21 ^c	87,19±1,97 ^a	41,23±0,15 ^c	57,86±5,11	20,22±2,65 ^a
Female age (year)	2, 3, 4	24,46±3,80	89,60±2,33	40,67±0,18	52,03±6,06	13,29±3,15
	4, 5, 6	36,89±2,09	94,89±1,29	40,53±0,09	57,20±3,34	21,47±1,74
	7, 8	37,07±6,47	89,01±3,97	40,52±0,30	58,71±10,31	23,45±5,35
Trio with ID numbers	3	32,22±5,18 ^{abcde}	96,75±3,17 ^e	40,56±0,25 ^{bcde}	54,98±8,25 ^{abcd}	18,54±4,29 ^{abcd}
	4	27,72±5,18 ^{abc}	92,46±3,17 ^{bcde}	40,15±0,25 ^{abc}	63,36±8,25 ^{cd}	19,21±4,29 ^{abcde}
	5	37,03±4,79 ^{bcde}	95,85±2,94 ^{de}	40,62±0,25 ^{bcde}	62,35±7,63 ^{bcd}	24,71±3,97 ^{cde}
	6	26,37±6,18 ^{abc}	93,19±3,79 ^{bcde}	41,23±0,29 ^e	53,13±9,85 ^{abcd}	14,07±5,12 ^{abc}
	7	33,39±5,11 ^{abcde}	94,29±3,13 ^{bcde}	40,37±0,25 ^{abc}	72,02±8,14 ^d	24,30±4,23 ^{bcde}
	8	28,53±4,53 ^{abc}	88,84±2,78 ^{abcd}	40,37±0,24 ^{abc}	45,41±7,22 ^{abc}	15,73±3,75 ^{abc}
	9	37,28±4,53 ^{bcde}	91,41±2,78 ^{bcde}	40,71±0,23 ^{bcde}	68,86±7,22 ^d	26,73±3,75 ^{de}
	10	29,22±5,18 ^{abcd}	88,67±3,17 ^{abcd}	40,56±0,25 ^{bcde}	66,85±8,25 ^d	20,21±4,29 ^{abcde}
	13	43,65±4,53 ^e	86,95±2,78 ^{ab}	40,49±0,23 ^{abc}	43,68±7,22 ^{ab}	20,48±3,75 ^{abcde}
	14	27,70±4,32 ^{ab}	87,96±2,65 ^{abc}	40,56±0,21 ^{bcd}	60,17±6,89 ^{bcd}	17,96±3,58 ^{abcd}
	15	37,89±5,18 ^{bcde}	87,40±3,17 ^{abc}	40,66±0,25 ^{bcde}	39,74±8,25 ^a	10,54±4,29 ^a
	18	20,29±6,02 ^a	94,05±3,69 ^{bcde}	39,79±0,34 ^a	35,09±9,59 ^a	12,18±4,99 ^{ab}
	19	27,83±6,23 ^{abcd}	95,96±3,82 ^{cde}	40,83±0,29 ^{bcde}	58,44±9,92 ^{abcd}	15,84±5,16 ^{abcd}
	20	42,01±5,09 ^{de}	91,09±3,12 ^{abcde}	41,06±0,26 ^{de}	65,37±8,11 ^d	29,49±4,22 ^e
21	40,97±4,74 ^{cde}	82,69±2,90 ^a	40,61±0,23 ^{bcde}	50,24±7,55 ^{abcd}	21,11±3,92 ^{abcde}	
Mean	32,81±2,32	91,17±1,42	40,57±0,11	55,98±3,69	19,41±1,92	

Means indicated by ^{a-c} letters within a factor and column significantly differ from each other (P<0,05)

The number of eggs set was twelve more in 2020 and 2021 compared to 2018 and 2019 (**Table 3**). There was no difference by female age. 32 eggs were set per female per production year, on average. Most eggs were set from Trio 13 and the least from Trio 18. On an annual average, 91% of eggs were appropriate for incubation. 9% of the unset group included eggs with cracked, deformed, rough and dirty eggshells, as well as eggs with higher than optimal weight loss (> 10 g), damaged yolk and watery albumen. The hatching time of chicks was two days longer in 2021 than in 2018. The hatching time was 40 days, on average. Chicks of Trio 18 hatched the earliest (on the 39th day of incubation), while the chicks of Trio 6 hatched the latest (on the 41st day of incubation). Hatchability differed only by trios being the lowest in Trio 15 and Trio 18 (39 and 35%) and showed the highest ratio in Trio 9, 10, and 20 with more than 60%. The hatchability was 55.98% on average, having a 37% difference between the extreme values. Most chicks hatched in 2020, and there was no difference by female age. However, differences between trios were significant. In Trio 15 ten, in Trio 20, 29 chicks hatched per female on an annual average resulting in 19 chicks per female per production year altogether.

Literature on the number of set eggs is not available. However, in the ratio of set eggs, KONTECKA et al. (2011) found differences by female age. The ratio of eggs set was 30.9% higher in seven-year-old females compared to five-year-olds. In my case, a small number of five and seven years old females participated in the evaluation, which is unsatisfactory for drawing more precise conclusions. In agreement with my results, according to KONTECKA et al. (2011), there was no difference in the hatching time and hatchability between the five- and seven-year-old females. Ostrich egg hatchability is typically between 37.8 and 53.8% (IPEK and ŞAHAN, 2006; DZOMA és MOTSHHEGWA, 2009; EL-SAFTY, 2011; KOUTINHOIN et al., 2014). RIZZI et al. (2002) in Italy also found great variability between trios in hatchability (between 26.3% and 78.3%) on the same farm. Differences between trios can be explained by genetic and physiological causes, and also males could affect hatchability. In some cases, the production of females was similar, so the microenvironment inside the pen (competition between the individuals) could also cause the alterations.

3.4. The relationship between the month of the production year and egg composition

Figure 2 represents the chemical composition of eggs in the evaluated months.

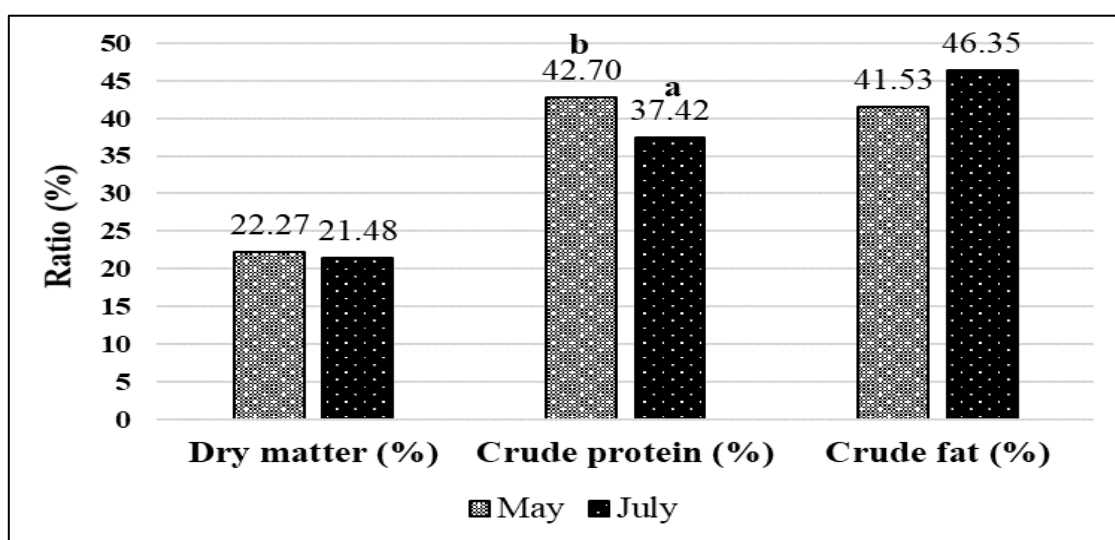


Figure 2: Changes in the chemical composition of ostrich eggs in May and July

^{a,b} letters indicate significant differences ($P < 0.05$); *values are given on a dry matter basis

The average dry matter content of eggs was 21.88% (Figure 2). The crude protein content decreased by 5.28% from May to July and showed 40.06% on average. Egg yolk is rich in fat, so its fat content was 44.46%. Even though there were significant differences between months, alterations in fat content in the examined period were not significant ($p = 0.051$).

SINANOGLOU et al. (2011) found the crude fat content of yolk to be smaller (37.14%) than my findings. EL-SHAWAF et al. (2011) revealed higher crude protein (44.59%) and smaller crude fat content (36.95%). ABU SALEM and ABOU-ARAB (2008) measured the crude protein and crude fat content of ostrich eggs to be 47.09% and 45.10%. In their research, the fat content was higher, and the protein content was much higher compared to the average of my results. Differences could stem from the different feed compositions; however, there was no information available on this parameter. DI MEO et al. (2003) stated that the dry matter content of albumen increases during the production period from 11.1% to 12%. The dry matter content of egg yolk decreased until the end of the production year (from 52.7% to 47.5%), then sharply increased to 51.1%, and by the end of the production year, showed a small decrease to 50.7%. The crude protein (between 47.7 and 48.2%) and crude fat (between 47.7 and 48.2%) content of ostrich eggs differed between small limits during the examined period. The decrease in the fat content could be the effect of the production year, in line with the depletion of female nutritive reserves. It can be assumed that the crude protein, which was necessary for the building processes of their organisms, was in part distracted from egg formation.

3.5. Results of the dissection of dead-in-shell eggs

3.5.1. Pathological condition of fetuses and the extraembryonic membranes

Six of the 30 examined eggs were infertile. Inflammatory exudates and microbial colonies were discovered on the embryos, localized in the chest and abdominal cavity in four cases. In five cases, serous fluid was present in the abdominal cavity. In addition, we found three cases of pleurisy, serous build-up and ascites in the chest cavity. Nine of the fetuses had abnormal liver with several different symptoms, such as spongy texture, distal and centrilobular haemorrhages, greenish bile-like lesions on the left lobe of the liver, enlargement and underdevelopment. In several cases, the yolk was coloured lime, olive and avocado green, unlike the normal bright yellow, and the protein was yellow and had a gelatinous texture. One of the embryos lacked the upper beak and the right eye (**Picture 1**). In most fetuses, 70 to 80% of the albumen and yolk was not absorbed.

Based on the literature data, the examined embryos could have died at different stages of hatching, from the age of four days up to the 37th-38th days immediately preceding the hatching phase. According to BRAND (2012), female age (over 10 years), egg treatment (i.e. transport), and egg storage length (< 1 day, 6 days <) are the most influential factors affecting ostrich embryo mortality. Inappropriate intensity and frequency of egg turning can cause oedema and embryonic death during the hatching phase (BROWN et al., 1996; BRAND, 2012). The presence of bacterial colonies and inflammation indicates disinfection deficiencies. Body abnormalities and the underdevelopment of fetuses and their organs are the signs of pathological and unsatisfactory metabolism. All this could stem from the lack of appropriate feeding and incubation technology (MUSARA et al., 1999; BROWN et al., 1996); however, the exact causes are not known.



Picture 1: Fetus without upper beak and right eye

3.6. The evaluation of effects affecting the survival of ostriches until 48 weeks of age

Figure 3 shows the survival rate and survival probability of ostrich chicks by week.

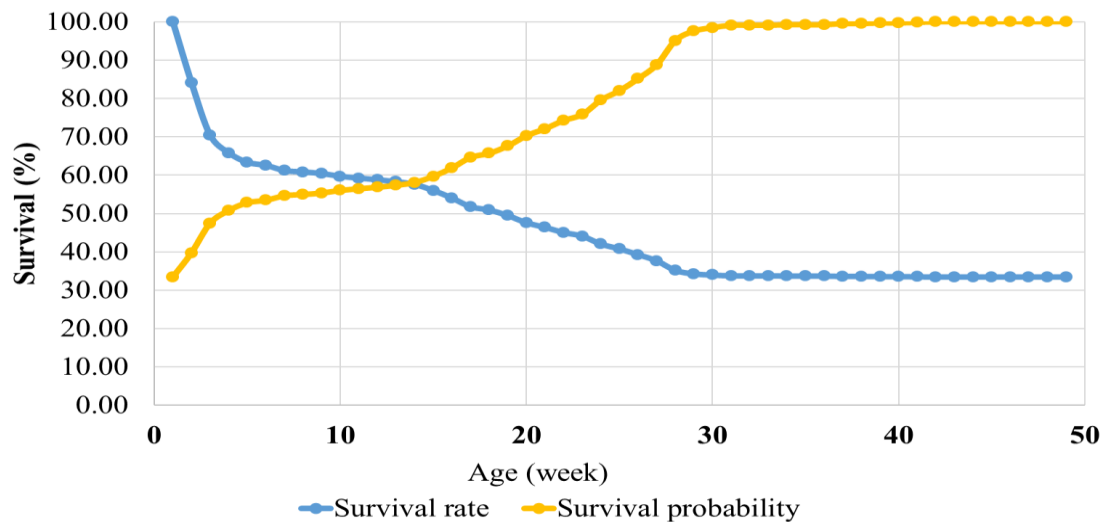


Figure 3: Survival rate and survival probability of ostrich chicks until the age of 48 weeks

The survival rate is the percentage of hatched chicks that survive until a given age, and the survival probability is the probable survival chance of the individual of the given age until the 48th week of life. The survival rate decreased by 39% up to the age of six weeks (Figure 3). From six to 13 weeks of age, a further small decrease (5%) was observed in the proportion of survivors. A linear (23%) decrease was experienced from 13 to 29 weeks of age. From the age of 29 weeks, death was not identified. 33% of chicks hatched survived until the age of 48 weeks. The survival probability of newly hatched chicks was 33%, which increased to 53% at the age of four weeks, so those that lived to the age of four weeks had a 53% chance to survive until the age of 48 weeks. The survival probability increased by 3% from five to ten weeks of age and then increased linearly (by 42%) from the 11th to the 30th week and reached 99%. There was an increase of 1% from 31 to 35 weeks of age and remained unchanged from the 36th week.

CLOETE et al. (2001) reported that the mortality rate of chicks in the first week after hatching was 46.7%, and another 30% died by the 90th day of life. ADEWUMI et al. (2017) stated that the mortality of chicks up to six weeks of age is 53.55%. Compared to the findings of the authors, I observed less mortality in the same period of life. In Australia, 37% of ostriches died by the age of three months and 60.8% by the age of four months. In Israel, this ratio was between 15 and 50% (MORE, 1996). In my case, 49% of the birds died by the age of four months, which can be considered the same ratio as in Israel.

3.7. Slaughter value and meat quality of ostriches

Table 4 represents the chemical composition of meat parts.

Table 4: Chemical composition of valuable meat parts of 18-month-old birds (n=10)

Meat parts/nutrients	Dry matter (w/w%)	Crude protein (w/w%)	Crude fat (w/w%)	Hydroxyproline (w/w%)
Outside strip	26.23±0.13 ^d	20.49±0.08 ^{cd}	4.41±0.12 ^c	0.01±0.001 ^a
Oyster	23.84±0.31 ^a	20.10±0.32 ^{bcd}	2.36±0.07 ^a	0.03±0.001 ^c
Tip	24.35±0.15 ^{ab}	18.40±0.09 ^a	4.50±1.09 ^c	0.08±0.001 ^d
Outside leg	24.51±0.15 ^b	19.49±0.11 ^b	3.64±0.14 ^b	0.01±0.001 ^a
Medallion	25.54±0.13 ^c	20.62±0.16 ^d	3.57±0.11 ^b	0.02±0.001 ^b

^{a-d} letters indicate significant differences (P<0,05)

The dry matter content of the five examined meat parts was between 23.84% and 26.23%, the crude protein content ranged between 2.36 and 4.50%, the crude fat content showed values between 2.36% and 4.50%, and the hydroxyproline content was between 0.01 and 0.08% (**Table 4**). In terms of healthy nutrition, the tip had the highest crude protein content, while the oyster showed the lowest fat content. The outside strip had the highest dry matter content, and the tip showed the highest hydroxyproline content.

The crude protein content of the inside leg of 12-14-month-old ostriches is 21.6%, 20.81% for the tip, and 21.0% for the fan (SALES, 1994). All of the meat parts that the author analyzed had a higher crude protein content. This was probably due to the younger age of the birds. Data on feeding could not be found. The hydroxyproline content determines the tenderness of the meat. The smaller this value is, the tougher the meat is. According to AKRAM et al. (2019), the hydroxyproline content of ostrich meat is 0.09%, being higher than the value I experienced, resulting in lower tenderness. No information was provided on the age and meat parts of the birds. MAJEWSKA et al. (2009) determined the following dry matter, crude protein and crude fat contents. Outside strip: 24.2%, 21.5%, 1.44%; oyster: 23.8%, 20.70%, 1.22%; tip: 23.00%, 20.80%, 0.95%; medallion: 24.10%, 21.30%, 1.34%. Regarding dry matter and crude protein content, the values of the oyster were the closest to my results. Overall, the dry matter and crude fat content of all meat parts that the authors examined were lower, and the crude protein content was higher, so its composition can be considered more valuable from a nutritional point of view.

4. NEW SCIENTIFIC RESULTS

1. The examination of the effect of group size on ostrich behaviour is considered unique on the international and also on the Hungarian levels. It was stated that the active comfort behaviour of birds differs by group size. The ratio of the frequency of active comfort behaviours was 4.88% higher in larger groups (harems) compared to the smaller ones (trios).
2. Extensive microbiological research has been conducted for the first time on the two largest farms in Hungary. 80% of the evaluated samples were contaminated. The *Escherichia coli*, *Bacillus spp.* and *Coliform* bacteria showed the highest prevalence of all. However, the parasites showed a ratio smaller than 10%.
3. The evaluation of egg production showed that there was no correlation between the length and number of long intervals ($P= 0,159$).
4. The effect of production month on the mineral composition of ostrich eggs has been evaluated for the first time. From May to July, the Cu content of the eggshell decreased by 15.36 mg/kg, and the Zn content fell by 7.62 mg/kg. In the examined period, the Na, P, S and Zn content of the albumen and yolk decreased by 1449 mg/kg, 1413 mg/kg, 162 mg/kg, and 14 mg/kg.
5. The combination of hatching year and month, hatching order in the year, and hatchability had significant effects on the relative risk of total loss (death or culling until the age of 48 weeks). The relative risk differed by year and also showed a smaller ratio in spring. The relative risk of total loss increased with the progress of the production year and in the weak-hatchability group. The survival ratio decreased by 39% until the 6th week of age. From the 7th to the 29th week, the relative risk fell by 28%, then remained unchanged. Until the age of 48 weeks, 33% of the initial population stayed alive.
6. According to the judgement of the panel on the five valuable meat parts (outside strip, oyster, tip, outside leg and medalion) from ostriches grown and fattened in Hungary, the outside strip and the tip were the most tender and delicious ones. By the evaluation on a five-point hedonic scale, ostrich meat received average scores (between 2.71 and 3.33).

5. RELEVANT RESULTS FOR THE PRACTICE

1. The behaviour of animals and the frequency of behaviour elements inform us about their well-being. Until nowadays, no study has dealt with the animal welfare point of view of ostrich husbandry, neither in the EU nor in Hungary. My ethological results can provide information on the welfare of domestic ostriches. The harem-like husbandry system was indicated to be more favourable from the animal welfare point of view than the trio. The decrease in the ratio of comfort behaviours during summer highlights that due to the higher temperature typical in this period, the comfort of birds is lower. Based on my findings, the establishment of more shading plants and the installation of steam gates can be suggested.
2. The research pointed out that due to the inappropriate husbandry condition and egg disinfection, there was a transmission of contamination between the samples. Knowing the pathogens, their prevalence and place of occurrence, it is possible to elaborate a vaccination and a specific disinfection protocol.
3. By the examination of dead-in-shell eggs, the date and cause of mortality can be determined based on the pathological changes. By discovering causes of death, husbandry technology can be improved, resulting in more effective breeding and production.
4. By knowing the factors that influence the survival of ostriches, the survival of young birds can be increased by supplementing the chicks with vitamins and probiotics in the fall and winter periods, as well as breeding birds at the end of summer. Also, the stocking capacity and feed requirement of the farms can be planned. The decrease in the survival rate of hatching groups draws attention to increasing the effectiveness of disinfection.

6. REFERENCES

1. ABU SALEM, F. M. – ABOU-ARAB, A. (2008): Chemical, microbiological and sensory evaluation of mayonnaise prepared from ostrich eggs. *Grasas Y Aceites*. 59 (4), 352-360.
2. ADEWUMI, A. – SAMUEL, A. – SAMMAN, A. (2017): Performance Traits and Survival Rate of Ostrich *Struthio Camelus* (linnaeus, 1758) Chicks in Captivity. *Nigerian Journal of Agriculture, Food, and Environment*. 13 (2), 45-49.
3. AKRAM, M. B. – KHAN, M. I. – KHALID, S. – SHOAIIB, M. – HASSAN, S. A. (2019): Quality and Sensory Comparison of Ostrich and Goat Meat. *SSR Institute of International Journal of Life Sciences*. 5, 2168–2175.
4. ASMAA, M. (2016): Prevalence of *Escherichia Coli* and *Salmonella* Species in Ostrich Farms in Egypt. *Journal of Environmental Science, Toxicology and Food Technology*. 10 (4), 6-11.
5. BEAUCHAMP, G. (2003): Group-size effects on vigilance: a search for mechanisms. *Behavioural Processes*. 63, 111-121.
6. BEJERHOLM, C. – AASLYNG, M. (2004): The influence of cooking technique and core temperature on results of a sensory analysis of pork - Depending on the raw meat quality. *Food Quality and Preference*. 15, 19-30.
7. BERTRAM, B. C. R. (1980): Vigilance and group size in ostriches. *Animal Behaviour*. 28 (1), 278-286.
8. BLUMSTEIN, D. T. – EVANS, C. S. – DANIEL, J. C. (1999): An experimental study of behavioural group size effects in tammar wallabies, *Macropus eugenii*. *Animal Behaviour*. 58, 351-360.
9. BRAND, Z. (2012): Studies on embryonic development and hatchability of ostrich eggs. PhD Thesis, University of Stellenbosch. 1-215.
10. BROWN, C. R. – PEINKE, D. – LOVERIDGE, A. (1996): Mortality in near-term ostrich embryos during artificial incubation. *British Poultry Science*. 37, 73-85.
11. CHADFIELD, M. S. – CHRISTENSEN, J. P. – JUHL-HANSEN, J. – CHRISTENSEN, H. – BISGAARD, M. (2005): Characterization of *Enterococcus hirae* Outbreaks in Broiler Flocks Demonstrating Increased Mortality Because of Septicemia and Endocarditis and/or Altered Production Parameters. *Avian Diseases*. 49 (1), 16-23.
12. CLOETE, S. W. P – LAMBRECHTS, H. – PUNT, K. – BRAND, Z. (2001): Factors related to high levels of ostrich chick mortality from hatching to 90 days of age in an intensive rearing system. *South African Veterinary Association*. 72 (4), 197-202.

13. CORTÉS, C. R. – TÉLLEZ ISAÍAS, G. – LÓPEZ CUELLO, C. – VILLASECA-FLORES, J. – ANDERSON, R. C. – ESLAVA CAMPOS, C. (2004): Bacterial isolation rate from fertile eggs, hatching eggs, and neonatal broilers with yolk sac infection. *Revista Latinoamericana De Microbiología*. 46 (1-2), 12-16.
14. DI MEO, C. – STANCO, G. – CUTRIGNELLI, M. I. – CASTALDO, S. – NIZZA, A. (2003): Physical and chemical quality of ostrich eggs during the laying season. *British Poultry Science*. 44 (3), 386-390.
15. DZOMA, M. B. – MOTSHOGWA, K. (2009): A retrospective Study of Egg Production, Fertility and Hatchability of Farmed Ostriches in Botswana Interna. *Journal of Poultry Science*. 8 (7), 660-664.
16. EDERLI, N. B. – DE OLIVEIRA, F. C. R. (2015): Gastrointestinal nematodes in ostriches, *Struthio camelus*, in different regions of the state of Rio de Janeiro, Brazil. *Brazilian Journal of Veterinary Parasitology*. 24 (2), 168-173.
17. ELGAR, M. A (1989): Predator vigilance and group size in mammals and birds. *Biological Reviews*. 64, 13-33.
18. EL-SAFETY, S. A. (2011): Using stepwise regression analysis to determine the factors affecting chick weight at hatch in ostrich (*Struthio camelus*). *Egyptian Poultry Science*. 31, 695-704.
19. ELSAYED, M. N. (2016): Occurrence of some Parasites in farmed ostriches (*Struthio camelus*) in Egypt. *Egyptian Veterinary Medical Society of Parasitology Journal*. 12, 91-100.
20. EL-SAWAH, A. A. – AL HUSSINIEN, M. D. – NASEF, S. A. – EL-NAHASS, EL-S. – NAYEL, A. I. (2016): Characterization of *E. coli* and *Salmonella spp.* isolates associated with omphalitis in baby chicks. *Journal of Veterinary Medical Research*. 23 (1), 61-70.
21. FERNÁNDEZ, G. J. – CAPURRO, A. F. – REBOREDA, J. C. (2003): Effect of group size on individual and collective vigilance in greater rheas. *Ethology*. 109, 413-425.
22. FERTNER, M. – OLSEN, R. – BISGAARD, M. – CHRISTENSEN, H. (2011): Transmission and genetic diversity of *Enterococcus faecalis* among layer chickens during hatch. *Acta Veterinaria Scandinavica*. 53 (56), 1-6.
23. GLATZ, P. C. – MIAO, Z. H. (2008): Husbandry of ratites and potential welfare issues: A review. *Australian Journal of Experimental Agriculture*. 48 (10), 1257–1265.
24. HONIKEL, K. O. (1998): Reference methods for the assessment of physical characteristics of meat. *Meat Science*. 49, 447–457.

25. HUSSEIN, S. A. –, HASSAN, A. H. – SULIMAN, R. R. (2008): Bacteriological and pathological study of yolk sac infection in broiler chicks in Sulaimani district. *Journal of Dohuk University*. 11 (1), 48–56.
26. IJAZ, M. – ARSHAD, M. – ANWAR, M. – HUSSAIN, M. – IQBAL, M. (1994): Studies on the prevalence of bacterial agents isolated from yolk of broiler chicks suffering from omphalitis. *Journal Animal Health and Production*. 14, 51–54.
27. IPEK, A. – ŞAHAN, Ü. (2006): Egg production and incubation results of ostrich farms in the Marmara region of Turkey. *Archiv für Geflügelkunde*. 70 (2), 69-73.
28. IQBAL, M. – SHAH, I. A. – ALI, A. – KHAN, M. A. – JAN, S. (2006): Prevalence and *in vitro* antibiogram of the bacteria associated with omphalitis in chicks. *Pakistan Veterinary Journal*. 26 (2), 94–96.
29. JAHAN, I. – RUMI, N. A. – HOSSAIN, K. M. – RAHMAN, S. M. – FAKHRUZZAMAN, M. – AKTER, S. – MIAHA, G. (2017): Microbial assessment of different samples of ostrich (*Struthio camelus*) and determination of antimicrobial susceptibility profiles of the isolated bacteria. *Asian Journal of Medical and Biological Research*. 3 (4), 437.
30. KONTECKA, H. – WOZNICKA, J. – WITKIEWICZ, K. – NOWACZEWSKI, S. (2011): Laying, egg and hatchability characteristics in ostrich (*Struthio camelus*) at different age. *Folia Biologica*. 59, 163-167.
31. KOUTINHOIN, G. B. – TOUGAN, U. P. – BOKO, C. – BABA, L. – FANOU, L. – CHITOU, I. B. – EVERAERT, N. –THEWIS, A. (2014): Egg physical quality and hatchability in captive African Ostrich (*Struthio camelus camelus*, Linnaeus 1758) reared in Benin: effect of season and relationships. *International Journal of Advanced Research*. 2 (6), 510–516.
32. LEHNER, P. N. (1992): Sampling Methods in Behavior Research. *Poultry Science*. 71 (4), 643-649.
33. MÉSZÁROS, G. – KADLEČÍK, O. – KASARDA, R. – SÖLKNER, J. (2013): Analysis of longevity in the Slovak Pinzgau population -Extension to the animal model. *Czech Journal of Animal Science*. 58, 289–295.
34. METAWEA, Y. F. – EL-SHIBINY, A. A. (2013): Epidemiological Studies on the Bacterial Contamination of an Ostrich Hatchery and the Application of Control Measures. *International Journal of Microbiological Research*. 4 (2), 138-146.
35. MORE, S. J. (1996): The performance of farmed ostrich chicks in eastern Australia. *Preventive Veterinary Medicine*. 29 (2), 91-106.

36. MORISHITA, T. Y (2019): Enterococcosis in Poultry – Poultry. MSD Veterinary Manual. 18 (32), 5.
37. MUSARA, C. – CHIDHUMO, P. – MURONZI, N. (1999): A retrospective analysis of water balance and hatchability in artificially incubated ostrich (*Struthio camelus*) eggs. Zimbabwe Veterinary Journal. 30 (3), 75-84.
38. POLLOK, K. D. – HALE, D. S. – MILLER, R. K. – ANGEL, R. – BLUE-MCLENDON, A. – BALTMANIS, B. – KEETON, J. T. (1997): Ostrich slaughter and by-product yields. American Ostrich. 4, 31-35.
39. RIZZI, R. – ERBA, M. – GIULIANI, M. G. – CEROLINI, S. – CERUTTI, F. (2002): Variability of ostrich egg production on a farm in northern Italy. Journal of Applied Poultry Research. 11, 332–337.
40. QUENETTE, P. Y. (1990): Functions of vigilance in mammals. Acta Oecologica international. Journal of Ecology. 11, 801-818.
41. SAIF, Y. M. – FADLY, A. M. – GLISSON, J. R. – MCDOUGALD, L. R. – NOLAN, L. K. – SWAYNE, D. E. (2008): Diseases of poultry. 12th ed., Blackwell Publishing, London. 703–705.
42. SALES, J. (1994): Identification and improvement of quality characteristics of ostrich meat. PhD. thesis, University of Stellenbosch, South Africa
43. SHARAF, A. (2006): Chemical Characteristics of Ostrich Meat in Comparison with Beef and Chicken Meats. Egyptian Journal of Applied Science. 21, 569–580.
44. SINANOGLU, V. J. – STRATI, I. F. – MINIADIS-MEIMAROGLOU, S. (2011): Lipid, fatty acid and carotenoid content of edible egg yolks from avian species: A comparative study. Food Chemistry. 124 (3), 971-977.
45. YAZEED, H. A. E. – HAIRI, M. E. – SALEH, E. – AFIFI, M. A. – SAMIR, A. – REFAI, M. (2015): Bacterial Causes of Embryonic Death in Ostrich Egg. International Journal of Research Studies in Biosciences. 3 (8), 46-52.

7. LIST OF PUBLICATIONS



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List of publications related to the dissertation

Hungarian scientific articles in Hungarian journals (1)

1. **Brassó, D. L.**, Komlósi, I., Rózsáné Várszegi, Z., Varga, É., Béri, B.: Egy magyar struccállomány tojástermelésének értékelése (előzetes közlemény).
Állatteny. Takarm. 70 (4), 284-297, 2022. ISSN: 0230-1814.

Foreign language scientific articles in Hungarian journals (4)

2. **Brassó, D. L.**, Knop, R., Rózsáné Várszegi, Z., Bársony, P., Komlósi, I., Bacsadi, Á., Bistyák, A.:
Assessment of the microbiological status of two Hungarian ostrich farms.
Acta Vet. Hung. 71, 1-9, 2023. ISSN: 0236-6290.
DOI: <https://doi.org/10.1556/004.2023.00765>
IF: 0.9 (2022)
3. **Brassó, D. L.**, Komlósi, I., Szabó, C., Rózsáné Várszegi, Z.: The environmental effects on the quality parameters and chemical composition of ostrich eggs.
Anim. Welf. Etol. Housing sys. 18 (1), 1-16, 2022. ISSN: 1786-8440.
DOI: <http://dx.doi.org/10.17205/SZIE.AWETH.2022.1.001>
4. **Brassó, D. L.**, Komlósi, I.: Evaluation of egg quality parameters of two Hungarian ostrich populations.
Agrártud. Közl. 1, 51-57, 2021. ISSN: 1587-1282.
DOI: <http://dx.doi.org/10.34101/actaagrar/1/8523>
5. **Brassó, D. L.**, Béri, B., Komlósi, I.: Studies on Ostrich (*Struthio Camelus*) - Review.
Agrártud. Közl. 1, 15-22, 2020. ISSN: 1587-1282.

Foreign language scientific articles in international journals (3)

6. **Brassó, D. L.**, Török, E., Komlósi, I., Posta, J.: Factors Affecting the Survival of Ostrich from Hatching Until the Age of 48 Weeks.
Agriculture-Basel. 12, 1-11, 2022. EISSN: 2077-0472.
DOI: <https://doi.org/10.3390/agriculture12101591>
IF: 3.6





7. **Brassó, D. L.**, Szabó, V., Komlósi, I., Pusztahelyi, T., Rózsáné Várszegi, Z.: Preliminary Study of Slaughter Value and Meat Characteristics of 18 Months Ostrich Reared in Hungary. *Agriculture-Basel*. 11 (9), 1-15, 2021. EISSN: 2077-0472.
DOI: <http://dx.doi.org/10.3390/agriculture11090885>
IF: 3.408
8. **Brassó, D. L.**, Komlósi, I.: Studies on ostrich (*Struthio camelus*) meat - Review. *Revista Ciencias Agropecuarias*. 7 (2), 83-91, 2021. EISSN: 2422-3484.

List of other publications

Hungarian book chapters (2)

9. **Brassó, D. L.**, Béri, B.: A heterózistenyésztés hatása a tejhasznosítású tehének tejtermelésére, termékenységére és egészségi állapotára.
In: InterTalent Unideb 2018. Szerk.: Mándy Zsuzsanna, Mező Lilla Dóra, Mező Ferenc, Debreceni Egyetem, Debrecen, 65-68, 2019. ISBN: 9789634901983
10. **Brassó, D. L.**, Béri, B.: A heterózistenyésztés jelentősége és előnyei tejhasznosítású szarvasmarhaállományoknál.
In: "Termőföldtől az asztalig" : A Tormay Béla Szakkollégium hallgatóinak tudományos eredményei. Szerk.: Illés Árpád, Bodnár Karina Bianka, Debreceni Egyetem Tormay Béla Szakkollégium, Debrecen, 1-6, 2018. ISBN: 9789634900092

Foreign language scientific articles in international journals (1)

11. Sipos, P., Peles, F., **Brassó, D. L.**, Béri, B., Pusztahelyi, T., Pócsi, I., Győri, Z.: Physical and Chemical Methods for Reduction in Aflatoxin Content of Feed and Food. *Toxins*. 13 (3), 1-17, 2021. EISSN: 2072-6651.
DOI: <http://dx.doi.org/10.3390/toxins13030204>
IF: 5.075

Hungarian conference proceedings (1)

12. Béri, B., **Brassó, D. L.**: A procross rotációs keresztezés hatása a tejhasznú tehének tejtermelésére.
In: XXXVII. Óvári Tudományos Napok, 2018. november 9-10. : Fenntartható agrárium és környezet, az Óvári Akadémia 200 éve - múlt, jelen, jövő. Szerk.: Szalka Éva, VEAB Agrártudományi Szakbizottság, Széchenyi István Egyetem Mezőgazdaság- és Élelmiszertudományi Kar, Mosonmagyaróvár, 293-300, 2018. ISBN: 9786155837159





Informational/educational articles (3)

13. Béri, B., **Brassó, D. L.**: A tartás- és fejéstechnológia hatása a nyerstej mikrobiológiai minőségére.
Értékálló aranykorona. 19 (3), 24-25, 2022. ISSN: 1586-9652.
14. Béri, B., **Brassó, D. L.**: A heterózistenyésztés lehetősége és előnyei tejhasznosítású állományoknál.
Partnertájékoztató Hírlevél. 17 (9), 36-40, 2017. ISSN: 2063-3491.
15. Béri, B., **Brassó, D. L.**: Új irányzat a tejhasznosítású fajták tenyésztésében.
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