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THE INFLUENCE OF EMU (*DROMAIUS NOVAEHOLLANDIAE)* EGG STORAGE TIME ON HATCHABILITY AND CHICK SURVIVAL

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ABSTRACT

The study involved 113 emu eggs, laid by 4–yr–old hens kept by a Canadian breeder in Ontario. Those eggs which the shells had been damaged during transport were used for chemical assays to determine dry matter, protein, and fat contents in the yolk. The egg weight and shape index were determined as well.

The eggs were divided into three groups (I, II, III) differing in the time of storage before incubation (7, 14, and 21 days, respectively). The eggs were incubated in an electronically controlled incubator, adapted to the emu egg incubation technology. During incubation, the eggs were candled on day 7, 14, 28, 35, and 49. On the day the eggs were transferred to the hatcher, they were re–weighed to determine weight loss. Hatchability rates with

respect to the number of eggs incubated and fertilised were determined, as were the percentages of dead and unhatched embryos. The emu chick weight was monitored weekly by the sixth week of life; records of mortality and health–related culling were kept until the emu were 3 months old.

The mean weight and egg shape index before incubation did not deviate from the standards for the species and amounted to 625.5 g and 66.07%, respectively. Chemical assays revealed high contents of dry matter, fat, and protein in the yolk: 54.14; 35.84; and 15.54%, respectively. The egg white showed protein content (9.58%) lower than that found in eggs of other birds. Egg weight losses were similar in all the groups and averaged 11.60%. A negative effect of pre–incubation storage time on hatching success was found, as the highest percentages of dead embryos were recorded in Groups II and III, 31.91 and 32.00%, respectively, the percentage in Group I (the shortest storage) being lower by about 10%. The newly hatched chicks' body weight was similar in all the groups and averaged 414 g, i.e., 66.00% of egg weight. The best results of growing the chicks to the third month of life were recorded in Group II with total losses amounting to 11.54%, the losses being by 2.74 and 9.88% higher in Groups I and III, respectively.

Key words: emu, incubation, hatchability, chick survival

INTRODUCTION

Emu breeding has recently become increasingly popular all over the world. The popularity stems from a great potential utility offered by those birds which supply not only eggs, but also a valuable oil, meat, leather, and feathers [2, 22, 30, 34]. One of the factors limiting breeding of those exotic birds is the lack of any standardised egg incubation technique. The available literature contains contradictory recommendations as to the incubation temperature range, relative humidity, and egg positioning in the incubator. Delfel and Rosseland [9] recommended the incubator temperature to be 35.9°C at 33 to 38% relative humidity, while Stewart [33] suggested the temperature range of 36.0–36.7°C at a rather wide relative humidity range (25 to 40%). According to Stephenson [31], when the initial relative humidity is on the order of 20%, the embryo is often malpositioned, while the relative humidity of 40% delays hatching, the hatchlings being overhydrated and unhealthy. Considering those effects, the author mentioned recommends the initial humidity and temperature of 30% and 36.7°C, respectively. Brake and Rosseland [5] allow for a temperature range of 34.9–36.3°C; in their opinion, the actual relative humidity should depend on the duration of egg storage. If the eggs are be stored for a period shorter than 7 days, incubation should proceed at relative humidity of 28–33%; incubation after a 7 day – and longer storage should take place at 33–38% and 38–43% relative humidities, respectively. A wide range of hatching temperatures (35.5–36.7°C) at the initial relative humidity of 24–35% was recommended by Minnar and Minnar [22], 35.8–36.4°C being their optimum temperature range.

Egg positioning in the incubator has given rise to some controversy as well. Nevertheless, incubation of eggs positioned both vertically and horizontally is possible [9]; however, due to difficulties with locating the air cell, it is recommended to position the eggs horizontally, like under natural conditions. The eggs should then be turned by 90° along their long axis at 3–h intervals [5], while Minnar and Minnar [22] recommend less frequent turning (6 times within 24 hours). Torpedo – or football–shaped eggs should be positioned horizontally [5]. If the air cell can be located, the eggs are placed at an angle of 45°, with the air cell facing upwards [22].

The period which eggs are stored before hatching affects greatly the incubation success. A prolonged storage of eggs of the traditional poultry species was found to decrease egg quality, to increase embryo mortality, and to extend incubation time [16, 20, 21]. The available literature contains little information on storage time effects on emu egg hatchability. Christensen [8] recommended storing the eggs at 12.7–18.3°C and 75% relative humidity for not longer than 7 days. Delfel and Rosseland [9] are of the opinion that, for optimal results to

be achieved, the eggs should not be stored for a period exceeding 10 days; the initial storage temperature of 21.1°C should be gradually reduced to 15.5°C at the end of storage. The literature contains a view that the quality of eggs intended for incubation is affected by the hen's age and the egg laying phase. Eggs obtained during initial weeks of that phase from young hens can be stored for a longer time; the shell is then thicker and the egg proteins retain their desirable physical properties for a longer time. Those eggs laid by hens at the final weeks of egg laying phase, due to a thinner shell and a lower quality of structural proteins, are less suitable for prolonged storage [9].

In view of the aforementioned ambiguities and paucity of information, the present work was aimed at determining effects of storage time (7, 14, and 21 days) on the emu hatching success.

MATERIALS AND METHODS

The study involved a total of 113 eggs from 4–year–old emu, kept by a Canadian breeder in Ontario. The eggs, produced by emu pairs the lineage of which could be determined to two generations back, were laid at mid–part of the laying phase. The females had been paired in a 1:1 ratio with their contemporary males.

The eggs were incubated at the Department of Poultry Breeding, Agricultural University in Szczecin. Prior to transfer to the incubator The eggs were weighed; the long and short axes were measured with the callipers to calculate the shape index. The 10 eggs the shells of which had been damaged during transport were used for chemical assays, dry matter, protein, and fat contents being determined in the egg white and yolk.

At the first stage of the study, the emu egg hatchability was determined; depending on the storage period, the eggs were divided into three groups: Group I, II, and III contained eggs stored for 7, 14, and 21 days, respectively.

The eggs were desinfected with formaldehyde immediately before they were placed in the electronically controlled incubator, adapted to the technology of incubating emu eggs imported from Canada. In the incubator, the eggs were placed horizontally on plastic rollers connected to a turning mechanism; the eggs were turned, by 180°, 6 times a day. A constant incubation temperature (36.4°C) was maintained, the relative humidity in the incubator and hatcher being 35 and 45%, respectively. During incubation, the eggs were candled with a Powertec Model RPS 1204 on day 7, 14, 28, 35, and 49. The day the eggs were transferred to the hatcher they were re–weighed to determine the weight loss.

The timing of hatching was monitored; if it exceeded 24 hours, the chicks were assisted in leaving the shells. The newly hatched chicks were weighed to determine the chick per cent contribution to the egg weight. On termination of hatching, the unfertilised eggs and those containing dead and unhatched embryos were opened; hatchability indices were calculated for each egg batch and per cent contribution of dead embryos and unhatched chicks was determined.

Once hatched, the chicks were kept in the hatcher for 24 hours and then transferred to a nursery pen. For the first 3 days after hatch, the chick were kept at 30°C under the "mock hen", the surrounding temperature being 26°C. At the end of the first week, the temperature was decreased to 28 and 24°C, respectively; the temperature was further decreased by 2°C every subsequent week, down to 20–22°C. During the first three days after hatch, the nursery

pen was lit for 24 h; on days 4 and 5, the lighting period was reduced to 18 h, 16–h lighting being kept on day 6 and 7.

Starting in the second week of life, when the outside temperature was at least 15°C and higher, the birds were allowed to use sand– and grass–covered exercise pens, separate for different age groups.

The hatched chicks were fed full pelleted mixed feeds containing 22% protein, 2685 kcal·kg^{-1}, and 4% dietary fibre.

Until the sixth week of life, the chicks were weighed at weekly intervals to determine their growth rate. The following formula was used:

$$g_r = (w_e - w_b)/0.5(w_b + w_e),$$

where:
g_r, growth rate over a given period;
w_b, body weight at the beginning of the period;
w_e, body weight at the end of the period.

The hatched chicks were examined throughout the period of study; deaths and health defects were recorded, the dead birds being autopsied.

The data were processed statistically with the 1–way analysis of variance and Duncan's multiple range tests. Arithmetic means and their standard deviations were calculated for selected characteristics.

RESULTS AND DISCUSSION

The egg weight and shape index values were homogenous in all the groups, no significant differences being detected between them (Table 1). The data, obtained in this study were similar to those reported by Minnar and Minnar [22] on the egg mean weight. On the other hand, in the studies described by Burley and Vadehra [7] ands Romanoff and Romanoff [27], emu eggs were heavier by about 86 g than those in the present study. The high shape index values obtained in all the groups resulted from the elongated shape, typical of the species. As shown by Gonzales *et al.* [12], larger eggs are more ellipsoid (low shape index), while smaller eggs are more spherical, hence the high shape index.

Table 1. Weight and shape index of incubated eggs

Parameter		Group		
		I	II	III
Egg weight [g]	$\bar{x}$	625.50	627.74	629.48
	SD	56.50	62.10	55.04
Shape index [%]	$\bar{x}$	66.37	65.81	66.03
	SD	3.08	3.22	2.81

differences not significant ($p \leq 0.05$)

The egg chemical composition revealed high percentages of dry matter, fat, and protein in the yolk, the respective values being 54.14; 35.84; and 15.54% (Table 2); the values are comparable to the proportions of those components in goose eggs [27]. The egg yolk showed a high content of ash (1.78%), evidencing a considerable concentration of mineral components in the egg. This is important also from the consumer's point of view, as the emu eggs are not only a reproductive material, but may also be used as a standard food product.

Table 2. Chemical composition of egg yolk and white (%)

Egg part	Dry matter		Fat		Protein		Ash	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Yolk	54.14	0.79	35.84	1.34	15.54	0.66	1.78	0.26
White	11.33	0.89	traces	–	9.58	1.56	0.71	0.06

The emu egg white showed much lower protein content [9.58%] than that found in other avian eggs [27]. Angel [1], too, showed the emu egg protein content to be the lowest of all the birds compared.

As the chick quality depends on the egg water loss, the loss was analysed in this study as well. As shown in Table 3, weight losses during 49 days in the incubator were similar in all the groups, no significant differences being found between them. Minnar and Minnar [22] are of the opinion that if the water loss over a 49–d–long incubation is not lower than 10% and not higher than 20%, it can be regarded as appropriate. It seems, however, that the egg weight losses arrived at in this study (about 11.60%) were too low, because some of the chicks showed symptoms of overhydration (swollen occiput). Chick overhydration is a common problem during incubation of ostrich eggs as well, the cause being sought in hatching technology [18, 25]. Poultry chickens with similar symptoms show a 52.90% mortality rate during the first ten days of life and, according to Borzemska [3] should be culled. Due to high costs involved, however, this is not done in ratites, as a considerable proportion of the affected chicks survive and develop.

Table 3. Egg weight losses during incubation (g, %)

Group	Weight before incubation		Weight on day 49 of incubation		Weight loss		
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	%
I	627.21	75.20	554.58	52.36	72.63	8.35	11.58
II	630.35	75.62	556.96	62.35	73.04	12.21	11.59
III	623.82	75.70	550.96	64.00	72.86	10.20	11.68

Differences not significant ($p \leq 0.05$).

Candling was the only procedure used in this study to monitor embryonic development during incubation. In spite of the incubator manufacturer's assurance that the egg interior can be penetrated by the infrared light beam, visibility of the interior was greatly restricted by the thick and dark–coloured shell. Before the eggs were placed in the incubator, candling made it possible to identify the air cell which was small and brighter coloured than the egg content. Identification of fertilised eggs was possible only as from week 3 of incubation. The egg content, below the brighter and enlarged air cell, was dark and opaque, while unfertilised eggs

possessed small air cells and bright–coloured content which moved when the egg was shaken; in some cases, the yolk moved towards the shell. The air cell size increased as the embryo grew; on the day when the eggs were transferred to the hatcher, the air cell of some eggs extended in the egg from one end to the other.

Chick movements could be observed at 5 weeks of incubation. The intensity of movements increased greatly in the sixth week, particularly when the eggs were tapped. During the final three days of incubation, the chicks inside the eggs produced audible squeaks. Candling made it also possible to pinpoint the moment when the air cell was pierced. During the last phase of incubation, the entire egg – filled by the chick – was dark inside and the chick's beak, pressing the membrane underneath the shell, was visible against the lighter–coloured background of the air cell. Most often, the chicks broke the shell near its equator, towards the blunt end of the egg. A small crack or a 3–6 mm diameter hole appeared initially; occasionally, a larger shell fragment would fall off and the beak would be visible in the opening. As the hole in the shell increased, the right leg was observed to participate in breaking the shell. Trying to get out of the shell, the chick stretched its body and kicked with its right leg which pushed against the shell. When the shell was breaking, the chick pushed its upper body through the hole and got out of the shell. It is necessary to carry out detailed observations to arrive at a model of the hatching process, particularly with respect to the timing of air cell and shell puncture, which would restrict human intervention into the process. According to Kinder [14], the period of time between air cell puncture and hatching in the ratites may extend to 3 to 5 days.

In keeping with the initial design of the study, the imported egg hatchability was related to the pre–incubation storage time. It is a common knowledge that the duration of storage preceding incubation, coupled with storage conditions, significantly affects results of incubation. Publications dealing with those relationships in chickens and turkey are very numerous [6, 16, 24, 28]; however, no research–based information of that kind was found on emu.

The lowest percentage of dead embryos in this study (21.95%) and the highest hatchability rate in fertilised eggs (73.68%) were recorded in Group I (eggs stored for 7 days) (Table 4). The embryo mortality in Groups II and III [eggs stored for 21 days] was by about 10% higher than that in Group I. The results obtained are supported by the suggestion presented by Stern [32] that, optimally, the ratite eggs should not be stored before incubation for a period longer than 1 week.

Table 4. Results of incubation and hatching in relation to time of storage

Item		Group		
		I	II	III
Time of storage	[days]	7	8–14	15–21
No. of eggs to be incubated		41	47	25
Fertility	[number]	38	42	22
	[%]	92.68	89.36	88.00
Unfertilised eggs	[number]	3	5	3
	[%]	7.32	10.64	12.00
Dead embryos	[number]	9	15	8
	[%]	21.95	31.91	32.00

Disabled chicks	[number]	1	1	–
	[%]	2.44	2.13	–
No. of healthy chicks		28	26	14
Hatchability of set eggs	[%]	68.29	55.32	56.00
Hatchability of fertilised eggs	[%]	73.68.	61.90	63.64
Incubation time [days]	$\bar{x}$	53.76	54.36	54.72
	SD	2.66	3.31	3.31

Between days 7 and 14 of incubation, the hatchability rate in Group II was decreasing by 1.68% a day. Some authors recorded a decrease as high as 5% after 7 days of egg storage [10, 13]: quoted after Mayes and Takeballi [21].

In this study, the period of incubation extended in proportion to the time of storage, but the differences between groups were not significant (Table 4). According to Mather and Laughlin [20], the embryo growth rate slows down in those eggs stored for a prolonged period of time. However, the ability of avian chicks to synchronise their hatching depends not only on storage time, but also on the hen health [4], atmospheric pressure [36], genetic potential of the flock, feeding, and environmental conditions [4, 19], incubation technology and microclimate [16, 29, 35], and incubation hygiene [11]. For this reason, it is not possible to unequivocally evaluate the assumptions underlying the study described.

The newly hatched chick body weight was similar in all the groups and averaged 414.00 g, without significant between–groups differences (Table 5). The newly hatched chick weight was 65.52–66.65% of the egg weight, the differences between the groups being very small and not significant.

Table 5. Relationship between chick and egg weights

Group	Egg weight [g]		Chick weight [g]		Chick weight as percent of egg weight	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
I	627.21	75.20	418.52	60.26	66.65	3.01
II	630.35	75.62	413.85	61.72	65.55	3.21
III	623.82	75.70	409.64	57.43	65.52	2.47

Differences not significant ($p \leq 0.05$).

The chicks were weighed weekly until week 6, i.e., during the time of the fastest growth rate (Table 6). The lowest body weight increments and the slowest growth rate were recorded during the first week of life, which was caused by the fact that the chicks were relying on nutrients contained in the yolk sac. A similar observation was reported by Nelson [23] in whose study the emu body weight was decreasing by day 5 of life, to show 56.60 g daily weight increments thereafter. In this study, the daily weight increments until week 2 were lower by about 7.73 g than those reported by Nelson [23]. During the last week of weighing, the chicks were 8 times heavier than immediately after hatching, the respective weights being 3492.27 and 990.00 g. However, no statistically significant differences between the groups,

either in the chick body weight or in weight increments in different weeks, could be detected. According to Kinder and Anthony [15], the largest weight increments were shown by emu chicks between week 8 and week 20, the sexual dimorphism being observable in the body weight as late as in week 16, when males attained higher increments than females. In view of the results obtained by Kinder and Anthony [15], it would be desirable to breed males and females separately; the knowledge on age–specific weight standards would allow to control the weights and adjust feed doses accordingly (in this study, the birds were ad lib fed). Such a course of action would bring also health benefits, particularly during the first month of growth, because – as already mentioned – it is at that time that leg malformations appear, the excessive weight increments being one of potential causes.

Table 6. Chick weight and weight increments during growth [g]

Group	Item		Chick weight	Week					
				1	2	3	4	5	6
I	weight	$\bar{x}$	418.52	508.93	847.22	1272.00	1960.44	2580.20	3488.33
		SD	60.26	94.16	157.19	291.10	318.22	410.09	521.92
	increment	$\bar{x}$	–	90.41	338.29	424.78	688.44	619.76	908.13
		SD	–	63.32	73.87	122.43	220.14	169.87	246.60
II	weight	$\bar{x}$	413.85	475.42	817.92	1289.55	1882.59	2502.27	3492.27
		SD	61.72	91.02	178.75	178.54	294.38	309.16	535.56
	increment	$\bar{x}$	–	61.57	342.50	471.63	593.04	619.68	990.00
		SD	–	46.43	103.29	102.54	193.75	162.30	284.75
III	weight	$\bar{x}$	409.64	449.95	795.57	1241.90	1862.18	2442.89	3331.82
		SD	57.43	51.36	117.50	160.15	198.67	308.03	451.03
	increment	$\bar{x}$	–	40.31	345.62	446.33	620.28	580.71	888.93
		SD	–	30.89	78.93	99.26	192.96	244.24	208.33

Differences not significant ($p \leq 0.05$).

The emu chicks of all the groups grew most rapidly until the second week (Fig. 1), the growth rate decreasing gradually within weeks 3 and 5, to pick up again between weeks 5 and 6. The highest growth rate (55.50%) was typical of the 2–wk–old chicks in Group III, the lowest growth rate being recorded in the same group in week 1.

The first three months of life are the most difficult period for emu, therefore monitoring the health of the flock is very important. The best results of breeding at that time were obtained in Group II, the total losses amounting to 11.54%; the total losses in Groups I and III were higher by 2.74 and 9.88%, respectively (Table 7).

Fig. 1. Emu chick growth rate during initial 6 weeks of life growth rate during 6 weeks [%]

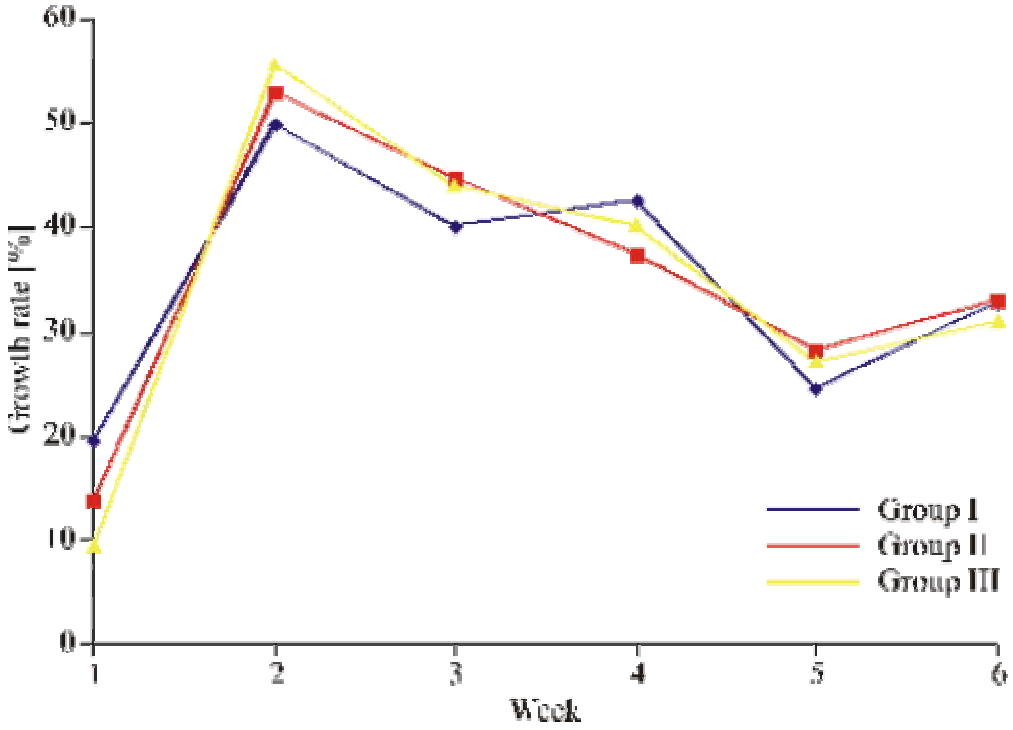

Table 7. Chick mortality and health–related culling during initial 3 months of life

Item		Group		
		I	II	III
No. of hatched chicks		28	26	14
Dead chicks	[number]	2	1	1
	[%]	7.14	3.85	7.14
Health–related culling	[number]	2	2	2
	[%]	7.14	7.69	14.28

The health–related culling was in all the groups caused by limb malformation. The first symptoms of the condition appeared during the first week after hatching, and not later than in week 2. The condition broke out abruptly and progressed; that after a few days the leg was noticeably twisted in the tarsal joint and bent. The chicks affected were observed to limp, lose condition, and prefer to lay down, the contorted leg making it impossible for them to move. To prevent the condition from progressing, vitamins (B, C, and D_3 were administered daily, but the therapy applied did not eliminate the clinical symptoms. Attempts at physical therapy were made as well, by forcing the chicks to move, massaging the legs affected, and binding the legs to position them properly. All those efforts brought no desired effects because the chicks were unable to keep their balance when walking; they were stumbling and falling down, which increased the stress and was dangerous. Although in two cases (Group I) the progress of the condition was arrested, the only humane solution was to sacrifice both chicks, one aged 6 weeks and the other aged 13 months, as the pathological changes rendered them incapable of walking. With the exception of the two cases described, the birds were very healthy during the period between month 3 and the age of sexual maturity; no mortality was recorded and there was no need for health–related culling. According to Kinder and Anthony

[15], leg deformations may affect as many as 30% of the flock. A leg condition with clinical symptoms similar to those described above occurs also in the turkey, the resultant average mortality being much lower – 2.7–3.3% [26]. Similarly to emu, the excessive body weight is regarded as the causative agent.

CONCLUSIONS

1. The emu egg yolk was rich in dry matter, fat and ash: 54.14, 35.84, 1.78%, respectively. The eggs whites were poorer in protein (9.58%) then eggs of other bird species.
2. A negative effect of pre–incubation storage time on hatching success was found, as the highest percentages of dead embryos were recorded in Groups II and III, 31.91 and 32.00%, respectively, the percentage in Group I (the shortest storage) being lower by about 10%.

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