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HATCHERY WASTE AND HATCHABILITY OF TURKEY EGGS

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Key words: turkeys, age, embryo mortality, hatchability.

Abstract

The objective of this study was to determine the type and quantity of hatchery waste and egg hatchability during the first laying season of heavy-type turkey hens.

The hatchability of 4536 eggs as well as the weight, type and quantity of waste material produced during nine control incubation cycles were monitored in turkey hens aged from 33 to 57 weeks, at three-week intervals. The day of embryo death was indicated and the percentage of embryos that died on successive days and during three incubation stages was calculated.

The optimum egg weight was recorded in hens aged up to 45 weeks, and in older hens the average egg weight was higher than 95 g. Infertile eggs accounted for 2.0 to 8.3% hatchery waste. Embryo mortality reached 4.6 to 17.2% before puncture, and 1.4 to 5.8% after puncture. Loss due to the delay in hatching ranged from 0.8 to 6.1% fertile eggs. The highest number of newly hatched birds classified as unsuitable for rearing was noted in hens aged 57 weeks (5.2%), while in the remaining weeks of the laying period the number of such poults was substantially lower. The first and second mortality peak accounted for 13.0–28.0% and 13.0–23.0% of the total loss during incubation, respectively. Another embryo mortality peak (13%) was observed in turkey hens aged 42 weeks. The highest hatchability rate, at 93.1%, was reported in week 42. Over the period of best hatchability, embryo mortality reached 43%:15%:42% at three consecutive incubation stages. It was found, based on the type and quantity of hatchery waste and hatch rates, that turkey hens aged between 36 and 48 weeks were characterized by the highest reproductive efficiency. The results of this study may be used as reference values while estimating the total loss during incubation due to hen age in heavy-type turkeys.

ODPAD INKUBACYJNY I ZDOLNOŚĆ WYLĘGOWA JAJ INDYKÓW

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Słowa kluczowe: indyki, wiek, śmiertelność zarodków, wylęgowość.

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Abstract

Celem pracy była charakterystyka odpadu inkubacyjnego i ocena zdolności wylęgowej jaj indyków typu ciężkiego w pierwszym sezonie nieśnym. Od 33. do 57. tygodnia życia indyków co 3 tygodnie kontrolowano: masę, rodzaj i wielkość odpadu inkubacyjnego i zdolność wylęgową 4536 jaj w 9 kontrolnych lęgach. W odpadzie inkubacyjnym określono dzień śmierci zarodków, a następnie procent zarodków zamarłych w kolejnych dniach i w 3 fazach lęgu.

Do 45. tygodnia życia niosek masa jaj była optymalna, a po tym okresie średnia ich masa przekroczyła 95 g. Odpad inkubacyjny, którym były jaja niezapłodnione, wynosił od 2,0 do 8,3%. Śmiertelność zarodków przed nakluciem osiągała poziom od 4,6 do 17,2%, a po nakluciu od 1,4 do 5,8%. Straty wynikające z opóźnionego wylęgu wynosiły od 0,8 do 6,1% jaj zapłodnionych. Pisklęt nienadających się do chowu w 57. tygodniu życia było 5,2%, a w pozostałych tygodniach znacznie mniej. Wielkość pierwszych szczytów śmiertelności zarodków wynosiła od 13,0 do 28,0%, drugich była mniejsza i wahała się od 13,0 do 23,0%. Dodatkowy szczyt śmiertelności zarodków na poziomie 13% stwierdzono w 42. tygodniu życia indyków. Najwyższą zdolność wylęgową (93,1%) odnotowano w 42. tygodniu życia indyków. W tym okresie śmiertelność zarodków w kolejnych trzech fazach lęgu wynosiła 43% : 15% : 42%.

Rodzaj oraz wielkość odpadu inkubacyjnego i wyniki wylęgu wskazały najlepszy okres do reprodukcji między 36. a 48. tygodniem życia indyków. Uzyskane wyniki mogą być pomocne do oceny strat inkubacyjnych wynikających z wieku indyków typu ciężkiego.

Introduction

Inadequate hen rearing conditions, unsuitable pre-incubation treatment and errors in the incubation procedure contribute to the production of hatchery waste. The quantity of waste material may be genetically conditioned, and it is higher in heavy-type than in light-type turkeys. The above is due to high egg weight and a high water content of eggs (JANKOWSKI 1989, FARUGA et al. 1996).

The number of infertile eggs is low in turkeys, but it may reach 10% at the beginning and towards the end of the laying season. Incubation loss caused by the death of turkey embryos may exceed 20% of eggs (GRIMES et al. 2004). Live, unhatched poults may account for 0.4–3.9% of fertile eggs (ORŁOWSKA, MRÓZ 2006). In stockbreeding practice, dead embryos and unhatched poults are regarded as the same type of waste which can hinder a correct evaluation of the incubation process (LERNER et al. 1993, FARUGA et al. 1996, MRÓZ, PUDYSZAK 1997). Hatched birds classified as unsuitable for rearing account for around 4% of fertile eggs (BORZEMSKA 1978, ORŁOWSKA, MRÓZ 2006).

It has been found that the quantity of one type of hatchery waste determines the quantity of other types of waste. In a study carried out by MRÓZ and FARUGA (2000), the coefficients of correlation between the percentage of infertile eggs, the percentage of early-dead and late-dead embryos were negative and statistically significant (-0.150^{xx} to -0.101^{xx}). They were higher in eggs with morphological defects than in eggs with normal structure. Significant correlation coefficients were observed between the percentage of early-dead and late-dead embryos (-0.198^{xx}

to 0.268[xx]). Embryo mortality between the first and the second incubation stage is characterized by high coefficients of correlation also in laying hens at $r = 0.450^{X}$ (KUURMAN et al. 2002). According to a different study, the total quantity of hatchery waste in broilers is determined by the duration of the second mortality peak (JASSIM et al. 1996).

The number of dead embryos was higher in paternal strains than in maternal strains, by 3.31% at the first incubation stage and by 4.28% at the second and third stage (MRÓZ 1998). Under adequate incubation conditions, embryo mortality rates were similar in the first and third incubation stage, while significantly lower mortality rates were noted at stage two (KOSOWSKA 1989, MRÓZ et al. 2002, 2006).

Hatchery waste is evaluated when hatching results are low, usually at the peak or in the middle of the laying season (MALEC et al. 1996., MRÓZ et al. 2002, 2002a, 2006). An in-depth analysis of hatchery waste at selected times of the laying season of Nicholas turkeys was carried out by GRIMES et al. (2004). The study showed an increase in the quantity of hatchery waste after the 19th week of the laying season. At the first incubation stage of Leghorn hens, KOSOWSKA (1989) determined the highest number of dead embryos in week 2, 3 and 34 of the laying season. As regards embryo mortality rates at the first and third incubation stage, the above author reported similar results in the remaining weeks of the laying season.

Radical irregularities in turkey breeding practice and errors in incubation technique increase the quantity of hatchery waste in the third and fourth week of the incubation period (BAGLEY et al. 1990, FRENCH 1994, MALEC et al. 1996). High egg weight and abnormal egg structure disrupt embryo development also in the period of intensive growth (stage two) and in the perihatching period (stage three) (MRÓZ, PUDYSZAK 1997, APPLEGATE, LILBURN 1999, GRIMES et al. 2004, ORŁOWSKA, MRÓZ 2006, MRÓZ et al. 2007). Embryos that died in eggs with abnormal structure are characterized by developmental dysfunctions, problems with protein utilization, renal hyperemia and a wrong position (FRENCH 1994, MRÓZ 1998, MRÓZ et al. 2002, 2002a, 2007, 2007a).

Optimal egg weight not exceeding 95 g is difficult to achieve in turkey farms after week 20 of the laying season (SIOPES 2007, APPLEGATE, LILBURN 1996, LERNER et al. 1993, FARUGA et al. 1996). For better results, turkey eggs weighing in excess of 100 g are incubated at lower temperatures (FRENCH 1994, 1997).

This study was carried out in response to the absence of documented sources presenting the detailed characteristics of hatchery waste in heavy-type turkeys. The objective of this study was to determine the type and quantity of hatchery waste and egg hatchability during the first laying season of heavy-type turkey hens.

Materials and Methods

The experimental material consisted of eggs of broad-breasted white turkeys. The studied flock comprised 2020 hens and 150 toms kept and fed in line with the recommendations for heavy-type turkeys. The laying season began when turkey hens reached the age of 33 weeks, and it lasted for 24 weeks. Eggs produced by hens aged 33, 36, 39, 42, 45, 48, 51, 54 and 57 weeks were subjected to nine control incubation cycles. Every incubation cycle comprised 504 randomly selected eggs which were weighed before incubation. A batch of 126 eggs was stored over a period of 4, 5, 6 and 7 days for each incubation cycle. Eggs were incubated in a Petersime incubator. Eggs were candled on the 10th day and transferred to hatching trays on the 25th day of incubation.

After candling and incubation, unhatched eggs were cracked and the number of infertile eggs, eggs with embryos that died before and after puncture, eggs with live, unhatched poults and the number of hatched birds classified as unsuitable for rearing was determined. The gathered data were expressed in percentage terms: the number of infertile eggs in relation to set eggs, the number of hatched poults classified as unsuitable for rearing in relation to hatched poults, the quantity of the remaining hatchery waste in relation to the number of fertile eggs. The day of death of embryos and unhatched poults was determined using the key for determining the age of turkey embryos (DZIACZKOWSKA, FARUGA 1983). The distribution patterns of embryo mortality were determined in the hatchery waste of each incubation cycle on consecutive days of the incubation period (days 1–28) and at three successive incubation stages (first incubation stage – up to day 10, second stage – between day 11 and 24, third stage – from day 25 to day 28). The distribution patterns of embryo mortality are presented in chart form. The days on which mortality rates exceeded 10% were identified as mortality peaks, and the days on which mortality rates ranged from 5% to 10% were defined as days with elevated mortality. Hatchability was evaluated based on fertilization rates and hatch rates of fertile eggs.

Experimental data were processed by one-way analysis of variance, and it was verified by Duncan's multiple range test. Egg weight, hatch rates and the percentage of infertile eggs were presented using means ($\overline{x}$) and coefficients of variation (v). A small number of birds not suited for rearing was reported, and they were not subjected to a statistical analysis. The remaining hatchery waste characterized by high variation was analyzed using the Kruskal–Wallis test (BOCHNO et al. 2001).

Results and Discussion

The optimum egg weight was recorded in hens aged up to 45 weeks, and it exceeded 95 g in hens aged 48 weeks and older (Table 1). High egg weight and weight variations in hens aged 57 weeks are indicative of a low biological value of eggs. The problem of high egg weight in turkey hens aged 48 weeks and older has also been noted by other authors (APPLEGATE, LILBURN 1996, FARUGA et al. 1996, GRIMES et al. 2004).

Table 1

Turkey egg weight, g ($\bar{x}$, V%)

Weeks of age	Eggs weight
33	81.9^{a} 6.58
36	89.9^{b} 6.74
39	90.3^{b} 7.14
42	92.3^{b} 6.60
45	94.0^{c} 6.79
48	96.0^{cd} 6.42
51	97.4^{d} 6.80
54	97.9^{d} 6.76
57	101.4^{c} 40.25
33–57	93.5 16.87

Explanation: values in columns followed by abcd differ at $p \leq 0.05$

Eggs were incubated in accordance with the procedure for this bird species. No technological problems were reported. Five types of hatchery waste were identified in control incubation cycles (Table 2). The percentage of infertile eggs was high only in hens aged 33 and 57 weeks, pointing to an impairment in the turkeys' reproductive ability during that period. Low fertilization rates were also reported by GRIMES et al. (2004) at the initial and final stages of the reproductive period, and by LERNER et al. (1993) at the initial stage of the reproductive period. A decrease in fertilization rates in hens older than 45 weeks justifies the need to improve turkey rearing, management and replacement strategies.

Table 2

Hatchery waste characteristics, % (x, V%)

Weeks of age	Fertile eggs n	Infertile eggs (1)	Dead embryos (2)			Unhatched poults (2)	Poults classified as unsuitable for rearing (3)
			unpunctured eggs	punctured eggs	total		
33	472	6.4^{ab} 2.16	17.2	1.5	18.7 16.35	5.8 77.20	–
36	492	2.4^{b} 1.02	9.6	2.4	12.0 40. 12	3.3 58.85	–
39	493	2.2^{b} 0.99	6.3	1.4	7.7 46.76	3.7 28.22	1.4
42	494	2.0^{b} 1.40	4.6	1.4	6.1 41.94	0.8 1.23	0.6
45	486	3.6^{b} 2.00	7.2	1.6	8.8 34.69	2.3 56.58	1.2
48	483	4.0^{ab} 2.91	7.1	2.3	9.5 56.86	3.1 44.52	1.2
51	483	4.0^{ab} 1.90	12.0	2.9	14.9 41.18	4.8 28.09	3.3
54	487	3.2^{b} 1.60	8.4	3.3	11.7 22.88	4.9 34.62	0.7
57	461	8.3^{a} 3.15	9.3	5.8	15.1 26.32	6.1 34.65	5.2
33–57	4355	4.0 2.80	9.1	2.5	11.6 45.56	3.9 62.60	1.5

Explanation: values in columns followed by ab differ at $p \leq 0.05$
(1) – % in relation to set eggs
(2) – % in relation to fertile eggs
(3) – % in relation to hatched poult

Dead embryos had the highest share of hatchery waste, and embryo mortality before puncture was higher than after puncture (Table 2). Embryo mortality rates after puncture increased in hens aged 48 weeks and older when egg weight exceeded the optimal values. According to the results of statistical tests, age did not affect the percentage of dead embryos. The highest percentage of unhatched birds was noted in turkey hens aged 33 weeks, 51 weeks and older. In this study, the number of poults that did not hatch by the time indicated in the given incubation technology significantly contributed to the quantity of hatchery waste. The percentage of that waste increased when the weight of hatching eggs exceeded 95 g. The share of birds classified as unsuitable for rearing was low (Table 2), and the physiological threshold, which according to BORZEMSKA (1978, 2005) should not be higher than 4%, was exceeded only in hens aged 57 weeks. Weeks 36 to 48 should be regarded as the optimal reproduction age for hens because this period was characterized by low embryo mortality, a small number of live, unhatched birds and disabled

poults (Table 2). The lowest incubation loss in the above rearing period was also reported by other authors (GRIMES et al. 2004).

The highest embryo mortality rates were noted at the first incubation stage, lower mortality rates were reported at the third stage, while embryo mortality was the lowest in the intensive growth phase during the second incubation stage (Figure 1). The highest number of embryos died at the first incubation stage in eggs laid by young hens (aged 33 weeks) and at the end of the rearing period (51–54 weeks). The distribution patterns of embryo mortality at the incubation stage marked by the highest hatchability rates (42 weeks) was 43%:15%:42% at three successive incubation stages (Figure 1). In the period most conducive to reproduction, embryo mortality rates reached 42–43% at the first incubation stage, 40–43% at the third stage and 15–17% at the second stage. The results noted in previous studies suggest that the distribution pattern of embryo mortality fluctuates in the laying season, and it is affected by the age of the flock (KOSOWSKA 1989, TAYLOR 1999, MRÓZ et al. 2002, 2002a, 2006, 2007).

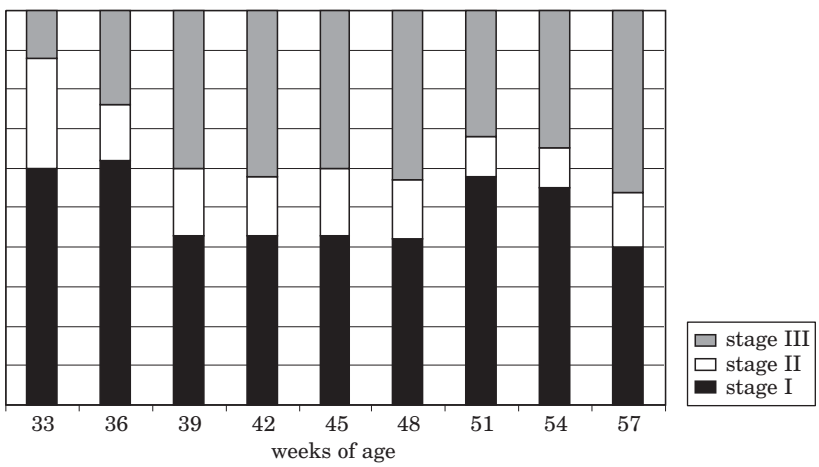

Fig. 1. Distribution patterns of embryo mortality at consecutive incubation stages (%) in relation to all dead embryo

The distribution patterns of embryo mortality on successive incubation days is presented in Figure 2. The first mortality peak was observed up to incubation day 5, and its value ranged from 13% to 28%, subject to hen age. The second, lower mortality peak was noted between incubation day 25 and 27 or on day 28. The mortality peaks reported in this experiment were lower than noted by the authors in their previous studies (MRÓZ et al. 2002). Lower mortality peaks were probably due to advances in incubation technology. An additional mortality peak at 13% dead embryos was reported in hens aged 42 weeks. The laying of eggs without shell pigmentation is intensified in this period, which could explain elevated embryo mortality rates at the second incubation stage (ORŁOWSKA 2007).

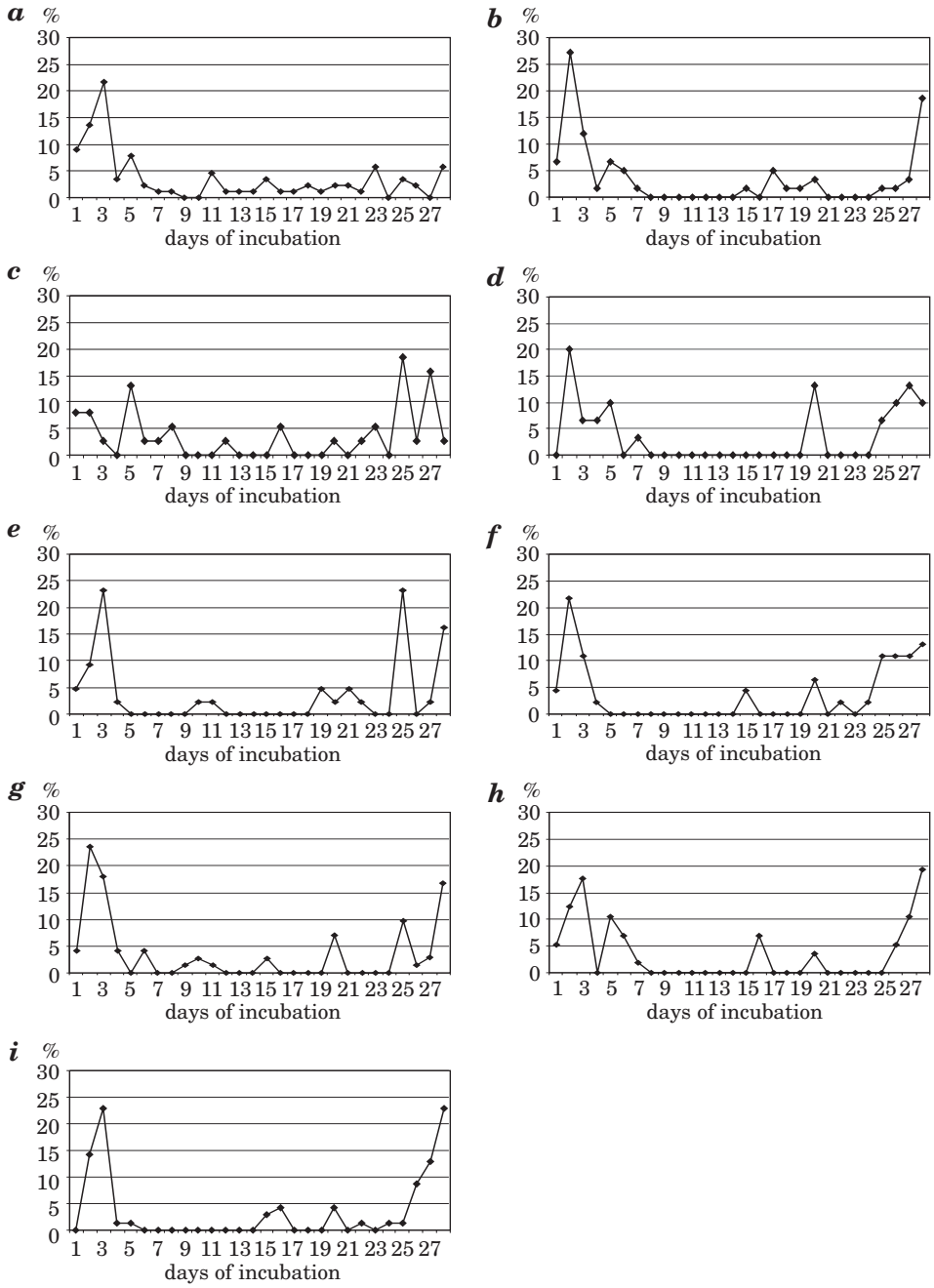

Fig. 2. Distribution patterns of embryo mortality on consecutive incubation days (% in relation to all dead embryos) – weeks of age: a – 33., b – 36., c – 39., d – 42., e – 45., f – 48., g – 51., h – 54., i – 57.

The highest embryo mortality rates were observed during the period of blood island formation, internal and external pipping. An additional mortality peak was noted at the final stage of embryo development on the 20th day of incubation. Low embryo mortality rates persisted for 15 to 21 days during the period of intensive growth (second incubation stage), which is consistent with previous findings (MALEC et al. 1996, MRÓZ 1998, MRÓZ et al. 2002, 2006,2007, GRIMES et al. 2004).

The highest fertilization and hatch rates were reported in hens aged from 36 to 48 weeks (Table 3). The noted values did not differ significantly from the results of a previous study using similar experimental material (ORŁOWSKA, MRÓZ 2006, LERNER et al. 1993). The above authors reported the highest hatch rates in excess of 80% in the second month of the laying season.

Table 3

Selected parameters of egg hatchability,% ($\overline{x}$,V%)

Weeks of age	Number of set eggs n	Fertilization rates	Hatch rates of fertile eggs
33	504	93.7^{ab} 3.85	75.5^{a} 7.40
36	504	97.6^{b} 0.66	84.8^{abc} 7.31
39	504	97.8^{b} 1.02	88.6^{bc} 3.36
42	504	98.0^{b} 0.80	93.1^{c} 2.74
45	504	96.4^{b} 1.58	88.9^{bc} 3.61
48	504	96.0^{ab} 2.95	87.4^{bc} 5.97
51	504	96.0^{ab} 2.02	80.3^{abc} 9.20
54	504	96.8^{b} 2.00	83.4^{abc} 4.83
57	504	91.7^{a} 3.21	78.8^{ab} 7.32
33–57	4536	96.0 2.86	84.5 8.20

Explanation: values in columns followed by abcd differ at $p \leq 0.05$

Conclusions

In this study, hatchery waste consisted of: infertile eggs, eggs with embryos that died before and after puncture, eggs with live, unhatched poults as well as poults classified as unsuitable for rearing which were not determined in young hens.

The type and quantity of hatchery waste and the distribution patterns of embryo mortality at consecutive incubation stages may be used as reference values for estimating the loss during incubation due to hen age in heavy-type turkeys.

The highest hatchability of heavy-type turkeys was noted in hens aged from 36 to 48 weeks.

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