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MATHEMATICAL APPROACH FOR STUDYING THE INFLUENCE OF THE SHAPE INDEX OF TURKEY EGGS AND THEIR MASS ON SOME INCUBATION INDICATORS

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Abstract

The present study analyses the influence of the egg shape index and its mass on some incubation indicators of three lines of turkeys: Layer Light turkey-LL, Meat Heavy turkey TM and North Caucasian Bronze Turkey (NCB). Graphical images represent the change of the relevant indicators as a result of the change in the egg shape index and egg mass. Mathematical models have been built that link the analyzed features. With the increase in the egg shape index and egg mass in Layer Light turkeys, the fertilized eggs and the hatched turkeys have the same growing trend.

In Meat Heavy turkeys with the increase of the index, relative stability in the studied indicators is observed as well as dynamics concerning the average mass. In NCB-turkeys with the increase in the egg shape index, the number of fertilized eggs and hatched turkeys decreases. With the increase in the average mass, the number of fertilized eggs and hatched turkeys also increases. Upon the increase in the index, relative stability in the surveyed indicators is observed as well as sharp peaks and falls in the average mass.

Keywords: regression model, shape index, mass, turkey eggs.

INTRODUCTION

One of the most important characteristics of breeding eggs is their mass and shape. The values of these indicators play an important role in the development of embryos and the successful hatching. Many authors report that the mass and shape of the eggs have a great impact on the development of the embryos and the hatching of chickens (Sergeeva, 1983; Christensen et al., 2000; Narushin and Romanov, 2002; Ngambi et al., 2013; Yalcin et al., 2013).

In a study of turkey eggs, some authors (Bachev and co-authors, 1970; Sharlanov and co-authors, 1988; French, 1997; Hristakieva and co-authors, 2008) found that the heaviest eggs have low fertility and hatchability, and the most chickens hatch from medium to heavy eggs. Shevchenko and co-authors (1983), found that the highest hatching is characteristic for the heaviest eggs – over 100 g in the first experiment and for the eggs with a mass of 81–85 g in the second experiment. Deeming (1993, 1994) and Button et al. (1994) in ostrich eggs reported the influence of the mass of incubated eggs on hatching qualities.

The egg shape index is defined as the ratio of the width to the length of the egg (Panda, 1996; Gunlu et al., 2003). The significance of this indicator is mostly revealed in determining the direction of rotation during incubation and the movements of the embryo during the utilization of nutrients. According to Tsarenko (1988), the hatchability of eggs with a shape index of 70 to 80 is almost the same. Kosenko and co-workers (1983), Sharlanov and co-workers (1988) consider that the deviation of the shape index below 71 and over 74 results in an increase in the number of cracked and broken eggs.

The objectives in the present work could be classified into the following two directions:

- to analyze the impact of the egg shape index on the following hatching characteristics: number of fertilized eggs, number of hatched turkeys, number of dead embryos 1st review and number of dead embryos 2nd review during incubation;
- to examine the influence of the egg mass on the given indicators for the three lines of turkeys.

MATERIALS AND METHODS

The present study was conducted in the turkey farm at the Agricultural Institute in the town of Stara Zagora in the section “Selection of Population Genetics and Technologies of Birds and Rabbits”. Eggs from three lines of turkeys were used as an experimental material: Layer Light turkey-LL, Meat Heavy turkey-TM and North Caucasian Bronze Turkey – NCB) at 36 weeks of age. They were artificially inseminated, fed and bred using the technology applied on the farm.

In the middle of the productive period (April), from each line of turkeys proportionally eggs were taken from the daily egg yield to experiment. The length and width of the eggs were measured with a caliper with an accuracy of 0.05 mm. The shape index is defined by the formula: I f (%) = d/Dx100. The weight of the eggs was measured with a scale with an accuracy of 0,01 g. Each egg was weighed and measured individually. The eggs were divided according to the value of the calculated shape index into 5 groups: group I – with the index up to 70, group II – with index 70 to 72, group III – 72 to 74, group IV – 74 to 76 and group V – over 76.

The incubation of the eggs was done in "Optima" incubator cabinets, each incubated egg being weighed in advance. At the 1st review (on the 9th day of setting), the non-fertilized eggs were removed. At the second review (on the 15th day from the beginning of incubation) the dead embryos were removed, on the 25th day the eggs were transferred to the hatchery cabinet for hatching in groups. On the 28th day, the live hatched turkeys were counted.

To achieve the objectives set at the beginning of the study, graphs were built, presenting the change in the relevant indicators in a relation both with the egg shape index and egg mass. Mathematical models were made, presenting in analytical terms the above-mentioned relations. The corresponding determination coefficients have been calculated to provide information on the degree of influence of the egg shape index and egg mass on the change in the studied incubation indicators. The mathematical and statistical analysis was done through MS Excel 2010.

RESULTS AND DISCUSSION

The change in the number of fertilized eggs, the number of hatched turkeys, the dead 1st review and the dead 2nd review depending on the egg shape index in Layer Light turkeys is graphically presented in Figure 1. It was found that by increasing the index to 72 all indicators increase, and this is most noticeable in the number of fertilized eggs and the number of hatched turkeys, and less sensible – in the dead 1st review. With the index rising to 74, for all indicators, except for the dead 1st review, there is a decline. It is the strongest in the number of fertilized eggs. When the index is 74 to 76, there is a decline in all indicators, except for the dead embryos 2nd review during incubation, and this drop is very sharp in the number of fertilized eggs and the number of hatched turkeys. Unlike turkey eggs, least chickens are hatched from eggs with prolonged shape, i.e., with shape index below 72 (Beremsky, 1996).

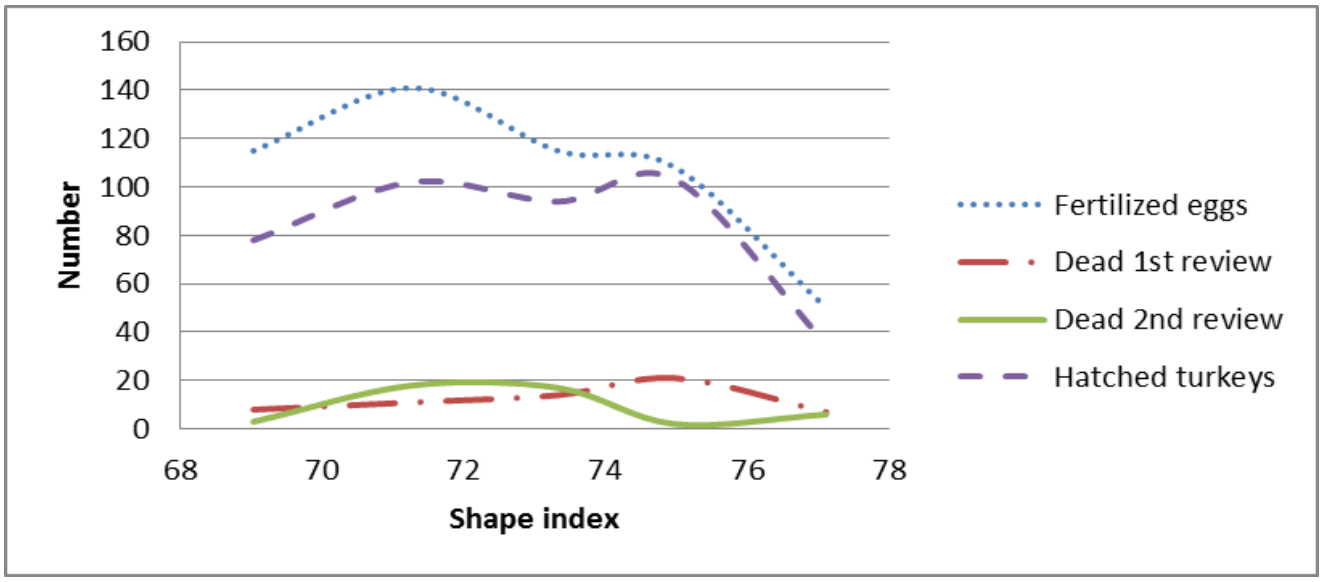

Fig. 1. *Graphical presentation of the change of the tested indicators depending on the egg shape index in Layer Light turkeys*

The influence of the egg mass on the analyzed indicators clearly stands out on the graph in figure 2. With an increase in the mass to 86.2, there is an increase in the number of fertilized eggs and dead 2nd review and the number of hatched turkeys decreases.

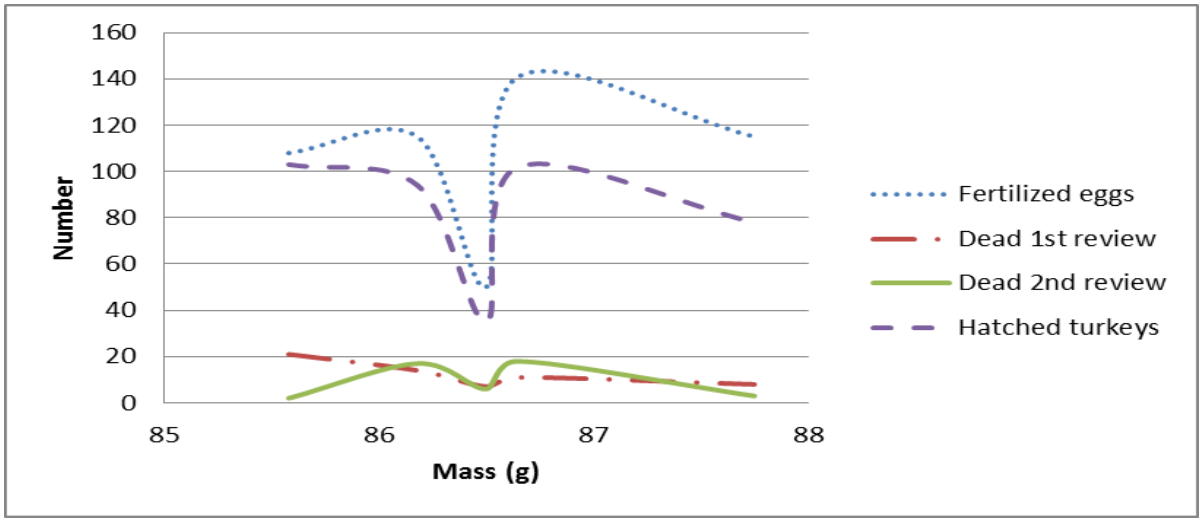

Fig. 2. *Graphic presentation of the change of the studied indicators depending on the egg mass (g) in Layer Light turkeys*

Following is a significant decrease in the number of fertilized eggs and hatched turkeys, which continues to 86.5, after which there is a growth in all indicators, which is the highest for the number of fertilized eggs, followed by the number of hatched turkeys.

After reaching an average mass of 86.8 g, a gradual decline occurs in all indicators. This coincides with the study of the incubation qualities of hen eggs from Abiola et al. (2008), which reported the best hatchability of eggs with medium mass.

The influence of the egg shape index on the studied indicators for Heavy Meat turkeys is presented in Figure 3.

With the index rising to 72, there is a decrease in the number of dead 1st review, and the other indicators show a trend of stability. When the index rises to 74, the decrease in the above indicators is more sensible, and it covers all indicators, except for dead 1st review where there is a slight increase in its values.

The increase in the number of fertilized eggs and the number of hatched turkeys with an index of up to 76 is noticeable, but it is followed by a sharp decrease when the index rises above 76.

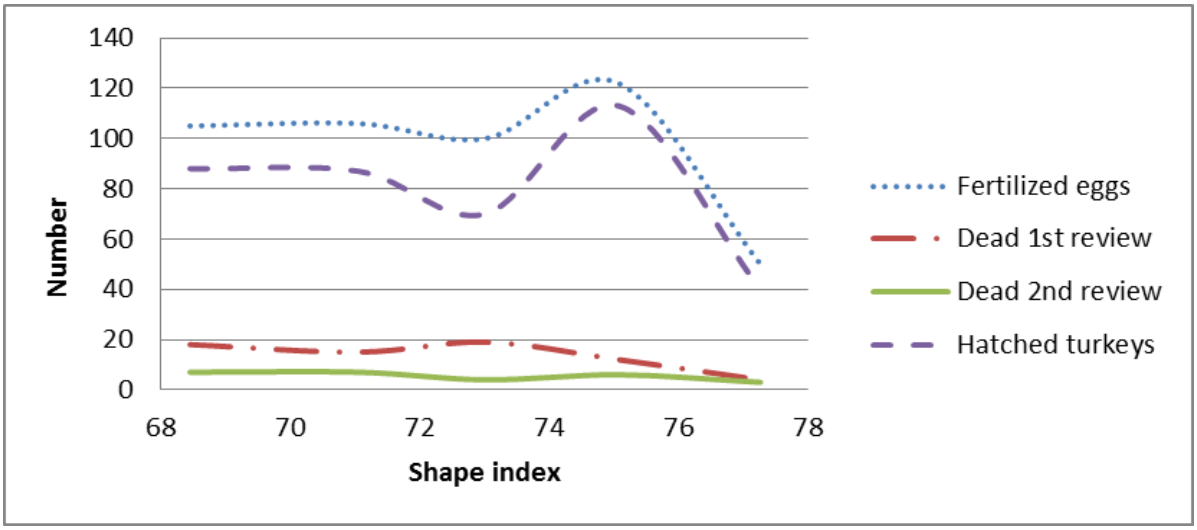

Fig. 3. *Graphic presentation of the change of the studied indicators depending on the egg shape index for Heavy Meat turkeys*

The change in the values of the indicators as a result of an increase in the average egg mass in Heavy Meat turkeys is presented in Figure 4. With an increase in the egg mass to 88, there is a noticeable increase in the number of fertilized eggs and the hatched turkeys.

Following is a significant drop in this number till reaching a mass of 90, followed by a slight increase and stabilization of these indicators. The number of dead 1st and 2nd review show relative stability throughout the whole observation period. The result of the influence of the change of the egg shape index on the studied indicators for NCB-turkeys is presented in Figure 5.

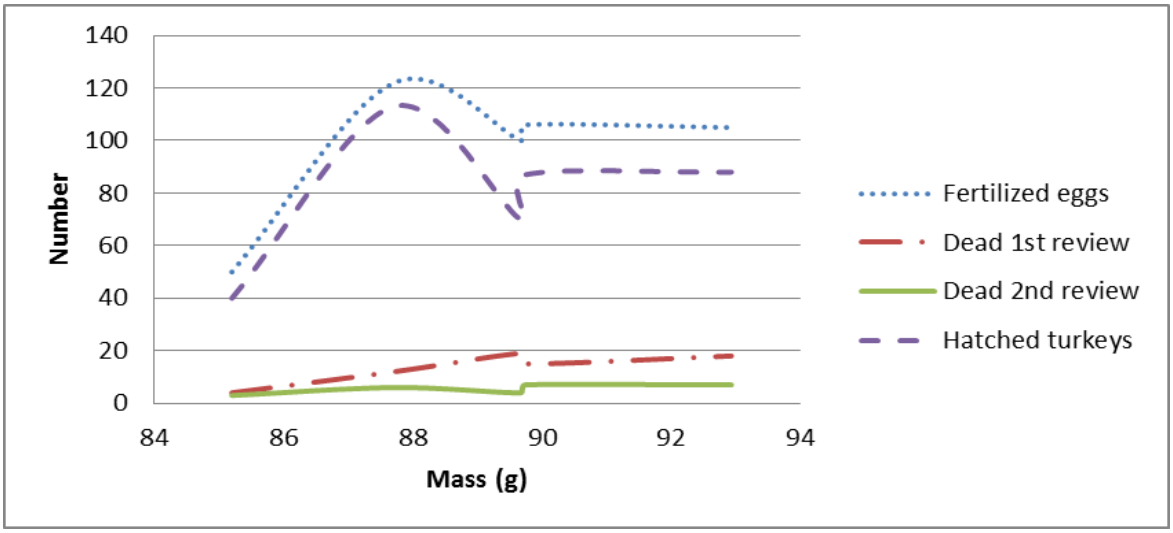

Fig. 4. *Graphic presentation of the change of the studied indicators depending on the egg mass (g) for Heavy Meat turkeys*

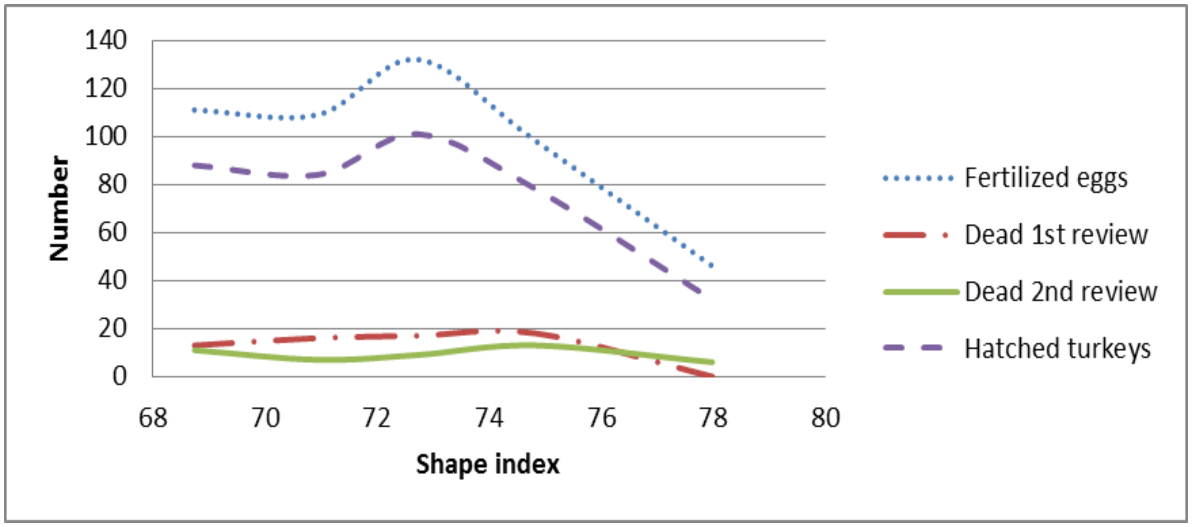

Fig. 5. *Graphical presentation of the change of the studied indicators depending on the egg shape index for NCB-turkeys*

As the index increases, the number of dead 1st review also shows an increase in the respective values, while for the other indicators we find a slight decrease until index 74 is reached. Then we see a trend of increase in all indicators, which is more sensible in some indicators /number of fertilized eggs and some hatched turkeys/, and less sensible in others. The number of fertilized eggs and the number of hatched turkeys reach their peak here, followed by a sharp decrease that continues

with an index greater than 76. The rest also show a decline, but it is much smoother compared to the other indicators. The average egg mass has a strong impact on the indicators in NCB-turkeys, which clearly stands out in the graph in Figure 6. As the mass increases to 84.7 g, there is a decrease in the values of the four indicators, which is most significant in the number of fertilized eggs and the number of hatched turkeys. Following is a period of increase in the number of fertilized eggs and hatched turkeys.

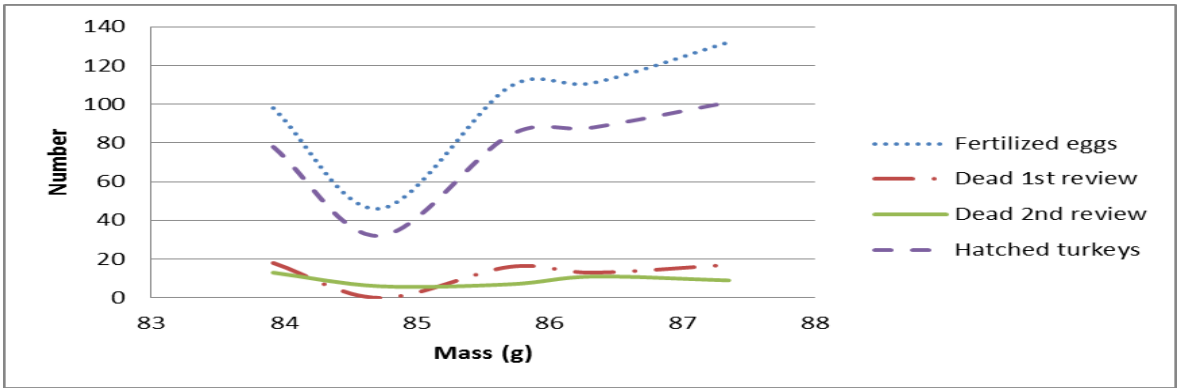

Fig. 6. *Graphical presentation of the change of the studied indicators depending on the egg mass (g) for NCB-turkeys*

This growth continues until the maximum mass of the egg is reached (Bachev and co-authors 1970; Sharlanov and co-authors 1988; French, 1997; Hristakieva and co-authors, 2008). Tables 1-3 show the mathematical models presenting in an analytical form the relations of the indicators: a number of fertilized eggs, hatched eggs, dead 1st review and dead 2nd review for the three breeds of turkeys, with the egg shape index and egg mass. Regression analysis is applied for determining the regression coefficients. It was found that for all three turkey lines, all analyzed relations are modeled by regression polynomial models of the second degree.

From Table 1 it is clear that 96% of the change in the number of fertilized eggs is due to the change in the shape index and only 4% to its mass. For the number of hatched turkeys, the impact of the index and the mass is respectively 87% and 19%. The change in the egg shape index determines the change in the number of dead 1st and 2nd review, respectively in 56% and 43% of the examined cases. The mass influences to 88% and 57%, respectively.

Table 1. Regression models presenting the relations of the studied indicators with the egg shape index and egg mass (g) in Layer Light turkeys

	Indicator	Regression model	Sign. of regression model	Coeff. of determination (%)
Shape index	Number of fertilized eggs	$y = -2{,}6771x^2 + 383{,}08x - 13570$	*	96
	Number of hatched turkeys	$y = -2{,}9294x^2 + 423{,}8x - 15220$	*	87
	Dead 1st review	$y = -0{,}5109x^2 + 75{,}034x - 2738{,}7$	*	56
	Dead 2nd review	$y = -0{,}6218x^2 + 90{,}461x - 3275{,}7$	*	43
Mass	Number of fertilized eggs	$y = 9{,}0469x^2 - 1564{,}2x + 67717$	n.s.	4
	Number of hatched turkeys	$y = 15{,}867x^2 - 2761{,}7x + 120239$	*	19
	Dead 1st review	$y = 4{,}8547x^2 - 847{,}48x + 36993$	*	88
	Dead 2nd review	$y = -9{,}6141x^2 + 1666{,}4x - 72192$	*	57

*the regression model is statistically significant at significance level $p<0.05$
n.s. the regression model isn't statistically significant at significance level $p<0.05$

Table 2. Regression models presenting the relations of the studied indicators with the egg shape index and egg mass (g) in Meat Heavy turkeys

	Indicator	Regression model	Sign. of regression model	Coeff. of determination (%)
Shape index	Number of fertilized eggs	$y = -1,6974\ x^2 + 243,01\ x - 8581,6$	*	62
	Number of hatched turkeys	$y = -1,2102\ x^2 + 173,08\ x - 6095$	*	35
	Dead 1st review	$y = -0,3021\ x^2 + 42,589\ x - 1482,8$	*	87
	Dead 2nd review	$y = -0,0218\ x^2 + 2,7589\ x - 79,789$	*	62
Mass	Number of fertilized eggs	$y = -2,1408\ x^2 + 386,97\ x - 17373$	*	72
	Number of hatched turkeys	$y = -1,673\ x^2 + 302,21\ x - 13555$	*	44
	Dead 1st review	$y = -0,3159\ x^2 + 58,119\ x - 2654,6$	*	94
	Dead 2nd review	$y = -0,0418\ x^2 + 7,9018\ x - 366,49$	*	55

* the regression model is statistically significant at significance level $p<0.05$

In Meat Heavy turkeys, there is a high influence of the egg shape index and egg mass on the number of dead 1st review.

Taking into account the determination coefficient, in NCB-turkeys very high degrees of relations were found between the egg shape index and the number of fertilized eggs, the number of hatched turkeys and the number of dead 1st review. The mass in NCB-turkeys has the greatest impact on the number of fertilized eggs and the number of hatched turkeys.

Table 3. Regression models presenting the relations of the studied indicators with the egg shape index and egg mass (g) in NCB turkeys

	Turkey line name	Regression model	Sign. of regression model	Coeff. of determination (%)
hape index	Number of fertilized eggs	$y = -1,8265\ x^2 + 261,35\ x - 9226,7$	*	92
	Number of hatched turkeys	$y = -1,4581\ x^2 + 208,37\ x - 7348,9$	*	93
	Dead 1st review	$y = -0,5398\ x^2 + 78,021\ x - 2800,5$	*	93
	Dead 2nd review	$y = -0,0781\ x^2 + 11,236\ x - 393,82$	n.s.	17
Mass	Number of fertilized eggs	$y = 7,3281\ x^2 - 1238,8\ x + 52434$	*	55
	Number of hatched turkeys	$y = 5,9456\ x^2 - 1005,8\ x + 42601$	*	49
	Dead 1st review	$y = 2,2109\ x^2 - 377,16\ x + 16095$	*	24
	Dead 2nd review	$y = 1,1079\ x^2 - 190,12\ x + 8163,3$	*	33

*the regression model is statistically significant at significance level $p<0.05$
n.s. the regression model isn't statistically significant at significance level $p<0.05$

CONCLUSIONS

As a result of the analysis of the incubation indicators in the three breeds of turkeys: Layer Light, Meat Heavy and NCB-turkeys, different trends were observed in the change of the respective indicators for the different breeds.

In Layer Light turkeys, it appears that with an increase in the egg shape index and egg mass the direction of the change in the number of fertilized eggs and hatched turkeys coincides.

In Meat Heavy turkeys, the influence of the egg shape index and egg mass on the change in the number of fertilized eggs and hatched turkeys have opposite direction. When with the increasing of the index we see the relative stability of the respective indicators, then we have sharp peaks and drops with the same indicators regarding average mass and vice versa.

In NCB-turkeys it was found that the larger the egg shape index, the more the number of fertilized eggs and the number of hatched turkeys decreases. The trend in increasing the average egg mass is opposite.

The number of dead embryos 1st and 2nd review show relative stability in the studied indicators of eggs in all three turkey lines, and we always have periods of decrease and increase, depending on index and mass values but these changes are smooth and are within small limits.

After applying regression analysis, it was found that in all studied turkey lines, the relations between the egg shape index and egg mass, on the one hand, and the number of fertilized eggs, hatched eggs, dead 1st review and dead 2nd review on the other, are modeled by polynomial regression models of second degree. Very high coefficients of determination were found in large part of the analyzed relations.

REFERENCES

Abiola, S., O. Meshioye, B. Oyerinde, M. Bamgbose, 2008. Effect of size on hatchability of broiler chicks. Arch. Zootec. 57(217):83-86.

Bachev, N., K. Sharlanov, 1970. Study of some morphological qualities of EMPIRE WHITE turkey eggs and their relationship to fertility and hatchability. Journal of Animal Science, 4:77-83.

Beremski, Ch., 1996. Possibilities for more appropriate use of non-standard hatching eggs. Poultry, 3, 9-11.

Button, C., D. Moon, and D. Turner, 1994. Improving the hatchability of ostrich eggs. Aust. Ostrich Assoc. J. 27:18–23.

Christensen, V. L., J. L. Grimes, W. E. Donaldson, S. Lerner, 2000. Correlation of Body Weight with Hatchling Blood Glucose Concentration and Its Relationship to Embryonic Survival. Poultry Science 79:1817–1822.

Deeming, D. C., 1993. The incubation requirements of ostrich (*Struthio camelus*) eggs and embryos. Pages 1–66 in Ostrich Odyssey, Proceedings of the Meeting of the Australian Ostrich Association Inc. (Vic.), No. 217. Post Graduate Committee in Veterinary Science, University of Sydney. Sydney, Australia.

Deeming, D. C., 1994. Hatchability and egg size in ostrich. Ostrich News 8:57–59

French, N., 1997. Modeling Incubation Temperature: The Effects of Incubator Design, Embryonic Development, and Egg Size. *Poultry Science* 76: 124-133

Hristakieva, P., M. Oblakova, M. Lalev, 2008. A study of the interrelation between the weight and the incubation qualities of turkey eggs. Journal of Animal Science. XLV, 4: 85-90

Narushin's, V.G., M.N. Romanov, 2002. Egg physical characteristics and hatchability. Poultry Science Journal. 58:297-303

Ng'ambi, J. W., M. W. Thamaga, D. Norris, M. Mabelebele, O. J. Alabi, 2013. Effects of egg weight on hatchability, chick hatch-weight and subsequent productivity of indigenous Venda chickens in Polokwane, South Africa. S. Afr. J. Anim. Sci. 43:67–69.

Sergeeva, A., 1983. Incubation of eggs from different weight categories. Poultry Breeding 9: 14-15.

Sharlanov, D., N. Bachev, 1988. Influence of the size of turkey eggs on their hatching qualities and the weight gain of turkeys hatched by them. Journal of Animal Science 1: 77-81.

Yalcin, S., G. Izzetoglu, A. Aktas, 2013. Effects of breeder age and egg weight on morphological changes in the small intestine of chicks during the hatch window. Br. Poult. Sci. 54:810–817.