Effect of housing system on reproductive results in ring-necked pheasants (*Phasianus colchicus* L.)

H. Kontecka, S. Nowaczewski, S. Krystianiak, M. Szychowiak, K. Kupś

Department of Poultry Science, Faculty of Animal Breeding and Biology, Poznań University of Life Sciences, Poznań, Poland

ABSTRACT: A comparative analysis of reproduction parameters and hatchability results of pheasants raised under two different housing systems (cages and aviaries) was performed. In the first system the pheasants were housed in 420 cages, 3780 from the total were females. In the second housing system, 3200 pheasant hens were placed in eight aviaries, where 50 cocks and 400 hens were kept in each. The following parameters were calculated: laying rate, the percentage of hatching, small and cracked eggs, hatchability from set and fertilized eggs, dead embryos up to day 8 of incubation and, finally, dead embryos after day 8 of incubation as well as unhatched, crippled, and weak chicks. The laying rate for the whole period of reproduction in pheasants kept in cages was significantly higher in comparison with aviaries (59.6 vs 27.2%). A higher ($P \leq 0.05$) percentage of small and damaged eggs ($\bar{x}$ = 13.6) was recorded in aviaries. The percentage of dead embryos for eggs derived from aviaries, up to day 8 of incubation, was also significantly higher ($\bar{x}$ = 4.7%). There were no significant differences between the housing systems with respect to the remaining features. The results of the investigation made it possible to conclude that pheasants kept in cages were characterized by a higher laying performance with fewer eggs unsuitable for incubation. A lower mortality of embryos during the incubation process was found in eggs derived from pheasants reared in cages. Although there were no significant differences between the analyzed housing systems in terms of hatchability, a higher laying rate for pheasants kept in cages implies that more chicks could be obtained from every female.

Keywords: gamebird; keeping; performance; reproduction

INTRODUCTION

Pheasant is a species of considerable importance in hunting. In Poland, like in the rest of the world, there are breeding centres and private game farms involved in the reproduction and raising of these birds. The profitability of pheasants breeding is influenced by many factors, including the number of hatching eggs and the number of healthy chicks obtained from one hen which is, in turn, dependent on the genotype, age, nutrition, and environmental conditions (Kuzniacka et al. 2005; Nowaczewski and Kontecka 2005; Ksiazkiewicz et al. 2006; Krystianiak et al. 2007, Esen et al. 2010). Eggshell colour was also found to have different effects on pheasant hatchability (Mroz and Pudyszak 2000; Krystianiak et al. 2005; Kozuszek et al. 2009). As demonstrated by various research results, egg fertilization and hatchability rates in pheasants tend to vary and often remain unsatisfactory (Demirel and Kirikci 2009; Kozuszek et al. 2009; Esen et al. 2010). Therefore, scientists and breeders keep looking for ways of improving reproduction parameters of these birds.

Ring-necked pheasants are usually bred under farm conditions in aviaries. However, it seems that cages used for pheasant reproduction could provide an alternative to the aviary housing system, not only because of higher production results (egg laying, egg fertilization) but, equally importantly, also due to reduced microbial contamination of eggs (Guidobono Cavalchini et al. 2005; Nowaczewski et al. 2013) which, ultimately, will find its expression in a significant improvement of hatchability results. In view of the fact that other investigations proved that housing systems can influence physical, morphological, and chemical traits of eggs (Matt et al. 2009; Lewko and Gornowicz 2011), it could also mean that those housing systems are important for the reproductive performance in an indirect manner. For example, by comparing two very different housing systems of laying hens (cage and organic), Kucukyilmaz et al. (2012) observed a significant impact of these systems on egg weight and deformation as well as on feed intake and feed conversion ratio (FCR). On the other hand, the effect of the applied housing system on hatchability results in Japanese quail were analyzed by Roshdy et al. (2010). Among other things, these authors found that lower, earlier mortality of embryos occurred during incubation of eggs obtained from birds kept on litter during the reproductive period. Worse results were observed in cages.

Bearing in mind the above remarks and the fact that cage housing systems used in pheasants can contribute to increased economic benefits associated with the reproduction of these birds, the investigations undertaken aimed at providing a comparative analysis of two housing systems, in terms of reproduction parameters and hatchability results in pheasants.

MATERIAL AND METHODS

The experimental material used consisted of pheasants in their first reproductive season, kept on a commercial farm in two different housing systems – cages and aviaries. In the first system, birds were kept outdoors, in cages of the following size: 1.5 m length × 1.5 m width × 0.5 m height. Behind each cage, there was a trough, an extension of wired floor, where laid eggs could roll. Each cage had an area of 2.25 m^2 and was equipped with two nipple drinkers together with an automatic feeder (40 cm long, i.e. 4.0 cm of feeder edge per bird). A natural mating system (harem) was also used in each cage consisting of one male and nine females. Stock density per unit area was 4.4 birds/m^2. From the 420 analyzed cages, the total of 3780 pheasants were female. In the case of the second housing system (aviaries), 3200 pheasant hens were placed in eight aviaries. In each aviary of 900 m^2 area, 50 cocks and 400 hens were kept. Sex ratio and stock density was 1 male : 8 females and 0.5 birds/m^2, respectively. The fenced aviaries were planted with a mixture of colza, sunflower, and Jerusalem artichoke. In all of them, there were 18 semi-automatic feeders (5.3 cm of feeder edge per bird) and 2 round drinkers (0.5 cm of drinker edge per bird).

In both housing systems, a lighting program was used providing 16–17 h of light daily during the months of reproduction. All pheasants were fed *ad libitum* with the same complete diets (Table 1).

The laying period lasted from March 8^{th} till July 8^{th} (18 weeks). Egg collection from pheasants kept in cages and aviaries was made manually twice a day at 7:00 and at 15:00 h. After each collection, the total number of eggs obtained from pheasants kept in each housing system was recorded. Eggs that were too small or damaged were rejected.

The collected eggs were disinfected with an air ionizer (Dezoster; HIVUS s.r.o., Žilina, Slovakia). Then, the hatching eggs were stored for eight days on setting trays at the temperature of 10–12°C with relative air humidity of 65–70%. Next, they were placed in the incubator every 8 days. In the setting (23 days) compartment, the temperature and relative air humidity were kept at 37.7°C and 52% whereas in the hatching compartment (last 2 days), the above-mentioned parameters were 37.6°C and 60–80%, respectively.

On day 8 of incubation, the eggs were candled to eliminate unfertilized eggs and dead embryos. After incubation, the number of unhatched, crippled, and weak chicks was recorded. In total, 12 hatchings were conducted in which 183 199 and 49 914 eggs came from cages and aviaries, respectively.

Table 1. Ingredients and chemical composition of diet

Ingredients (%)	
Maize	45.0
Wheat	10.0
Rapeseed meal	5.0
Sunflower meal	5.0
Soybean meal	19.5
Animal fat	4.5
Limestone	7.0
Concentrate (with Premix)	4.0
Analyses per 1 kg diet	
Metabolizable energy (MJ)	11.7
Crude protein (%)	18.0
Crude fibre (%)	5.0
Ca (%)	3.05
P (%)	0.42
Na (%)	0.14
NaCl (%)	0.45
Lysine (%)	0.93
Methionine (%)	0.42

On the basis of the collected data, the following parameters were calculated (%): laying rate; hatching, small and cracked eggs; hatchability from set and fertilized eggs; dead embryos up to day 8 of incubation; unhatched, crippled, and weak chicks as well as dead embryos after day 8 of incubation.

Statistical calculations were conducted with the assistance of the SAS (Statistical Analysis System, Version 9.2, 2011). Mean values ($\overline{x}$) as well as the standard error of means (SEM) were calculated for all traits. In order to verify the significance of differences between the systems with respect to the analyzed features, the Student's *t*-test was used.

Changes in trait values (dead embryos, unhatched, crippled, and weak chicks as well as hatchability results) in relation to the age of pheasants were presented in the form of regression equations and were used to plot trait linear trend-cycle according to the formula given by Zajac (1988):

$$y_t = a \pm b_t$$

where:

a = trait value at zero period

b = directional factor expressing the increasing or decreasing the value of the trait

t = time expressed for consecutive weeks/hatchings

RESULTS

Egg laying for both of the pheasant flocks began during the first decade of March and ended on July 8th. For a period of 18 weeks, egg production of pheasants reared in cages was higher than of those reared in aviaries (Figure 1). The peak of the laying period in both housing systems was reached during week 7 of reproduction but for pheasants kept in aviaries the peak was shorter and lasted for about one week. Significant differences were also observed in the number of eggs laid during that period. The rate of laying eggs in pheasants reared in cages, at their production peak, was about 85%, while for those in aviaries, the value of this trait did not exceed 60%. After 13 weeks of reproduction, a very low laying rate was observed in aviaries (below 15%). On the other hand, pheasants in cages were characterized by more than 70% egg production in week 14 of laying. In this housing system, the value of this trait fell below 10% only at the end of week 16.

As shown in Table 2, for the whole reproductive period of pheasants kept in cages, the average laying rate was significantly higher (by about 32 percentage units) than for those kept in aviaries. Even though pheasants in cages were characterized by a higher number of hatching eggs (by about 3.7 percentage units), this difference was not confirmed statistically. A significantly higher percentage of small and cracked eggs was recorded for aviaries.

The percentage of dead embryos, up to day 8 of incubation (Table 2), was significantly higher (by more than 2.0 percentage units) in eggs from aviaries. Figure 2 shows the change in the value of this trait during the reproductive season. In both housing systems, the statistically significant

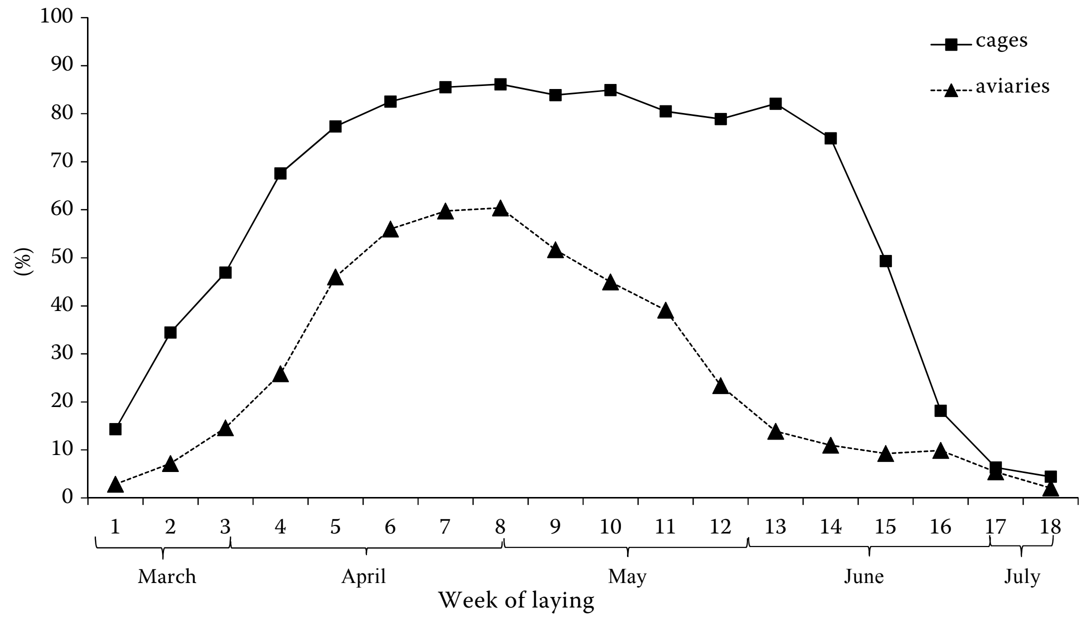

Figure 1. Lying rate of pheasants kept in different housing systems

Table 2. Performance and hatchability results (%) of pheasants kept in different housing systems

Trait	Housing system			
	cage		aviary	
	mean	SEM	mean	SEM
Laying rate	59.59*	2.59	27.23*	1.88
Hatching eggs	90.08	1.36	86.43	1.19
Small eggs	5.49*	0.43	6.50*	0.54
Cracked eggs	4.43*	0.24	7.07*	0.24
Dead embryos until day 8 of incubation	2.67*	0.31	4.74*	0.55
Dead embryos after day 8 of incubation, unhatched and crippled chicks	18.18	0.73	18.44	1.24
Hatchability from set eggs	61.74	3.79	63.02	1.69
Hatchability from fertilized eggs	79.06	0.87	76.98	1.45

SEM = standard error of the means
*mean values in rows differ significantly ($P \leq 0.05$)

trend-cycle was positive and the only difference became apparent in a higher directional factor in the cage system. With regard to eggs of this system, the highest number of dead embryos, up to day 8 of incubation, was obtained on the 5th hatching taking place in mid-May ($\bar{x}$ = 4.6%). For aviaries, the highest value of this trait was found to occur between the 8th and 10th hatching ($\bar{x}$ = 7.3%).

The percentage of dead embryos, coupled with the number of unhatched and crippled chicks after day 8 of incubation, was similar in both groups of pheasants and its value did not differ significantly (Table 2). The research did not prove that the value of the feature mentioned increased significantly in both housing systems with the 12 subsequent hatchings (pheasants' age) even if the values of the directional factors were positive (Figure 3).

Although pheasants kept in aviaries were characterized by higher hatchability from set eggs (by 1.3 percentage units on average), this difference remained unconfirmed statistically (Table 2). During the reproductive period (Figure 4), the values of this trait for pheasants reared in aviaries ranged 50.7–70.8% and were not as diverse as in the case of eggs obtained from cages (36.2–74.6%). It was also found that hatchability from set eggs

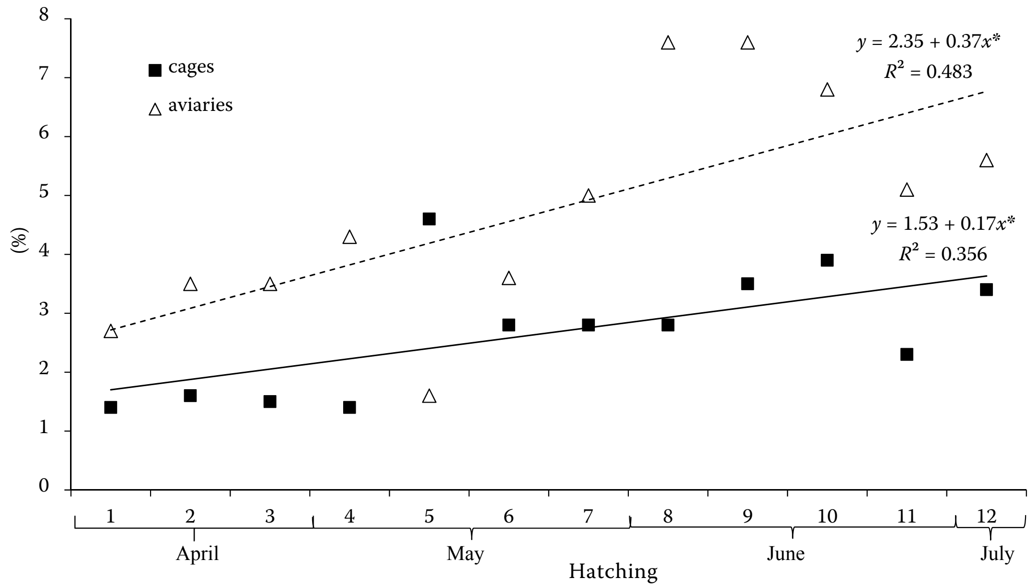

Figure 2. Trend-cycle of dead embryos up to day 8 of incubation in pheasants in following hatchings
*statistically significant trend-cycle

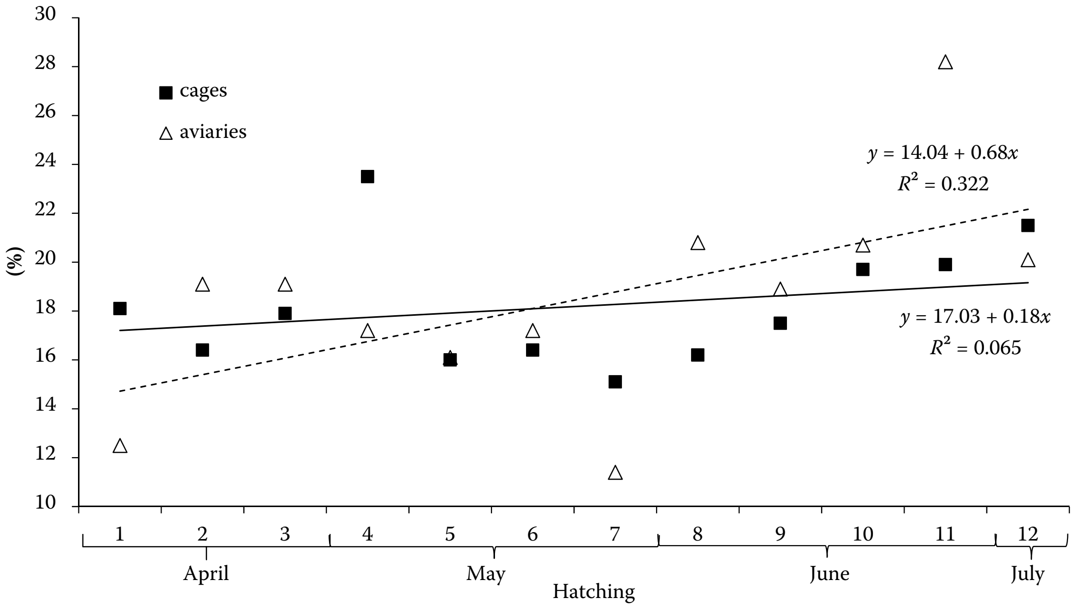

Figure 3. Trend-cycle of dead embryos after day 8 of incubation, unhatched, crippled, and weak chicks in pheasants in following hatchings

decreased in successive hatchings for both housing systems (negative directional factor of the trend-cycles). It should be emphasized that for pheasants reared in cages, mean values of this trait were higher from the 2nd to the 9th hatching (April–June). The research demonstrated (Table 2) that the average hatchability from fertilized eggs laid by females kept in cages was better in comparison with those kept in aviaries (by more than 2.0 percentage units), and the difference remained statistically non-significant as well. As with the previous analyzed feature, hatchability from fertilized eggs was characterized by a negative trend-cycle. In the case of the aviary housing system, it was statistically significant (Figure 5).

Table 3 summarizes the reproduction results of both pheasant stocks. It is noteworthy that the total number of chicks obtained per female kept in cages was shown to be twice as high as with the aviary system.

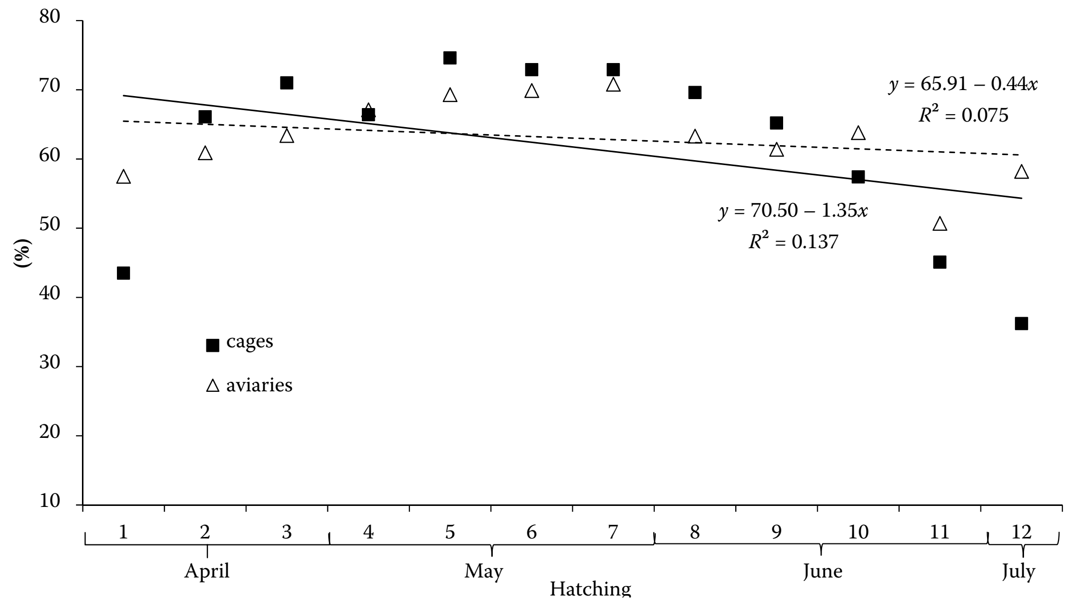

Figure 4. Trend-cycle of hatchability from set eggs in pheasants in following hatchings

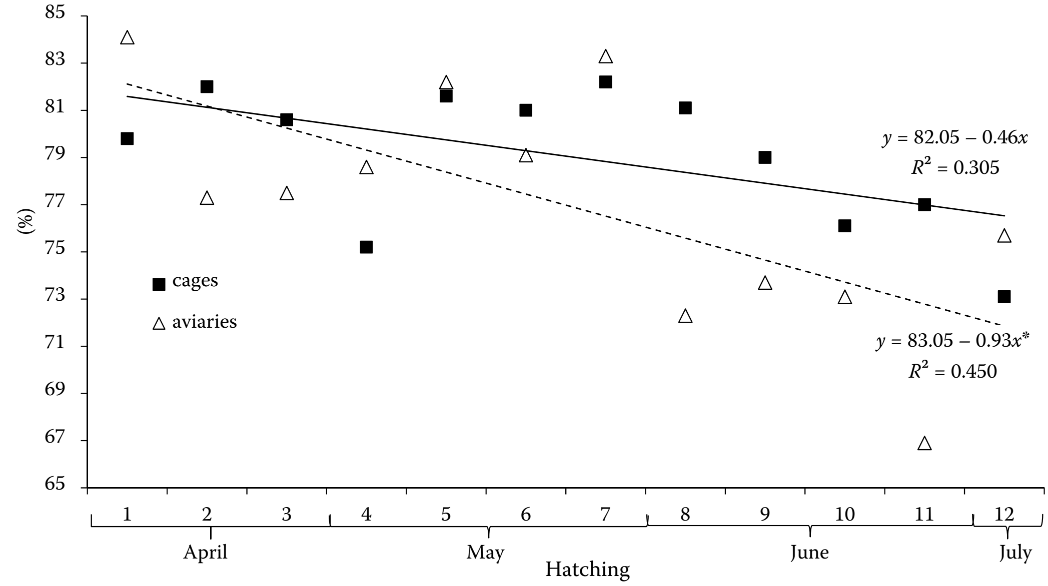

Figure 5. Trend-cycle of hatchability from fertilized eggs in pheasants in following hatchings

*statistically significant trend-cycle

DISCUSSION

Egg production in pheasants kept in cages was definitely higher. It is difficult to determine which factors exerted a key influence. It is possible that pheasants kept in aviaries had more possibilities for various activities and, consequently, birds reared in this system had to use up more energy from feed for living/moving than for production. Another hypothesis may be to lay eggs in aviaries (environment very close to natural) in a broodable number, despite the gradual, daily pick-up. This is evidenced, among others, by Krystianiak et al. (2007). The authors observed that pheasant hens in aviaries had average number of eggs in one clutch between 3 and 13.5.

In the period lasting roughly from week 5 to the end of week 11, the value of this feature was at its highest level (80–86%). Kuzniacka et al. (2005) also reported a high laying rate of pheasants at the peak of production. The fact that the reproductive performance of this species can vary was confirmed by Krystianiak et al. (2007). The authors found that the highest egg laying value was obtained between weeks 3–9 of egg production and in this period, this value fluctuated around 70%. On the other hand, Suchy et al. (2008) reported much worse egg production results in pheasants. The average laying rate was only 44.3% during the 14 weeks of reproduction. The highest value of the feature was found to occur between weeks 2 and 8 (50–55%) by the above-mentioned authors. Such low results are difficult to explain because in their experiment, a similar stock density and nutrition (nutrient content) was exploited as in this study. Lack of light stimulation could play an important role in this regard. Unfortunately, the authors failed to mention the employed lighting program. In fact, in later studies carried out by Ozbey et al. (2011), a low laying rate ($\bar{x}$ = 45.9%) for pheasants kept in cages was obtained when artificial light stimulation was not used. On the other hand, Kirikci et al. (2003), by comparing the egg production in pheasants kept in both cages and aviaries, observed a lower laying rate in the latter housing system (19.4%). In the study, the average value of this trait in pheasants kept in aviaries was low (about 27.2%) but different results were obtained by Nowaczewski and Kontecka (2005). During 11 weeks of the experiment (April–June),

Table 3. Reproduction results of pheasants kept in different housing systems

Summary	Cage	Aviary
Initial number of hens	3 780	3 200
Hatching eggs (*n*)	183 199	49 914
Helthy chicks (*n*)	113 107	31 455
Eggs per hen (*n*)	48.5	15.6
Chicks per hen (*n*)	29.9	9.8

they recorded a higher egg production ($\bar{x}$ = 80%) in pheasants reared in aviaries but in this case, birds were kept in small aviaries where a harem mating system was used (1 male to 8 females). Therefore, it seems that even within the aviary housing system, the size of the bird flock and the space they use can be important for egg production results.

The effect of the housing system on the laying rate was also shown in other poultry species. Kucukyilmaz et al. (2012) analyzed two hybrids of laying hens (white and brown) in different housing systems (organic and cage). The white birds kept in cages were characterized by a higher value of the feature. In another experiment, as in this study, a better egg production was found in caged hens than in free range hens (Hughes and Dun after Ledvinka et al. 2012).

More pheasant eggs with abnormal weight (too small) and damaged shells were found in aviaries ($\bar{x}$ =13.6%). This seems obvious because in cages, eggs rolled down slowly along the above-mentioned trough and, therefore, birds lost contact with them quite quickly. Similar results in this species were obtained by Kirikci et al. (2003). They observed a lower number of damaged eggs (by about 7.7 percentage units) in the cage housing system. Probably, the eggs laid in aviaries kept on the ground were still vulnerable to various kinds of damage. Different results were obtained in laying hens (De Reu et al. 2009; Kucukyilmaz et al. 2012).

As far as embryo mortality during incubation is concerned, statistically significant differences between the housing systems were observed only up to day 8 of incubation. A higher value of the trait was found in eggs laid by birds reared in aviaries. Deeming et al. (2011) reported approximately 5% mortality in pheasant embryos for eggs laid in aviaries, up to day 4 of incubation. On the other hand, in eggs obtained from the aviary housing system, Ipek et al. (2006) analyzed a number of dead pheasant embryos throughout the whole period of incubation in great detail. Contrary to the study, the authors noted a higher mortality in embryos till day 8 of incubation (7–8%). With the passage of the reproductive season, the value of this trait increased in the research. A similar relationship was observed in pheasants by Kuzniacka et al. (2005). In the literature, there are no publications about embryo mortality in eggs derived from pheasant hens kept in cages. In the study, the significantly lower value of this feature (up to day 8 of embryogenesis) in eggs laid by females reared in cages can be associated with a lower microbial contamination of these eggs. In fact, the results of the experiment conducted by De Reu et al. (2005) confirm this statement. They reported a lower egg contamination (aerobic bacteria) of laying hens when birds were kept in cages instead of aviaries. Nowaczewski et al. (2013) also conducted microbiological experiments on pheasants. The authors clearly showed that lower numbers of bacteria and fungi were present in eggs derived from cages than from aviaries.

Although, there were no differences between the housing systems in terms of hatchability, slightly higher results were obtained in cages as far as fertilized eggs are concerned. Moreover, with the passage of the period of reproduction, a significant decline in the value of this feature was observed only in females kept in aviaries. Deeming et al. (2011) analyzed the results of pheasant hatchability for set eggs laid during 10 weeks of reproduction. They reported a higher value for the parameter (69–70%) in comparison with the result obtained in the study for both housing systems. The authors also observed a rapid decline of this feature after week 6 of laying. In the research, it occurred just after weeks 7 or 8 (May/June). On the other hand, Ozbey et al. (2011) conducted an experiment on pheasants kept in cages and observed a slightly lower hatchability value from fertilized eggs ($\bar{x}$ = 72.2%) as compared to the results presented in the current study for the same housing system. Kirikci et al. (2003) demonstrated that pheasant hatchability of fertilized eggs was worse in aviaries than in cages but, in this case, in contrast to the results of this research, the difference was really high (12.9 percentage units).

CONCLUSION

The results of the investigation indicate that pheasants kept in cages could be characterized by a higher laying performance and also by fewer eggs unsuitable for incubation. Although, there were no significant differences between the housing systems in terms of hatchability, a higher laying rate of pheasants kept in cages could result in more chicks to be obtained from every female.

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Corresponding Author

Sebastian Nowaczewski, Ph.D., Poznań University of Life Sciences, Faculty of Animal Breeding and Biology, Department of Poultry Science, 45 Witosa Street, 61-693 Poznań, Poland
Phone: +48 618 466 224, e-mail: sebnow@up.poznan.pl