REVIEW

TIME OF OVIPOSITION AND EGG COMPOSITION: A REVIEW*

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Time of oviposition depends on several factors, which include changes in lighting regime. Hens lay their eggs generally 6 hours after switching on the light. The earlier turn on, causes laying of majority of eggs in the early morning. Oviposition time affects characteristics of egg quality, especially weight of egg and shell quality. Eggs laid in the morning are heavier. However, eggs laid in the afternoon have better quality of eggshell. Time of oviposition and egg weight depends on genotype of hens as well. Brown eggs tend to be laid in the morning and they are heavier than white and tinted eggs, that are lighter and tend to be laid in the afternoon. Albumen weight and Haugh units decline, but yolk weight increased with oviposition time. Also housing system influences oviposition time. Genotype, housing system and oviposition time significantly affect egg weight and Haugh units, the characteristic of internal egg quality. An understanding of range of factors that affect egg quality is necessary for the production of egg of high quality. Egg quality vary according to interactions between all mentioned factors.

oviposition time; lighting regimes; egg weight; egg quality; genotype of laying hens, housing system

Introduction

Time of oviposition and egg quality have been studying for a long time. A lot of scientists are engaged in researches of relationships regard to oviposition. There are many factors which affect mean time of oviposition. Detection of the best collection time and the best egg quality should be economic advantage not only for poultry farms but also for consumers. Patterson (1997) showed that the best management practices for egg collection might include continuous egg gathering to reduce the number of eggs on the belts at any time and better distribute the peak egg volume through the washing, grading and packing equipment. Quality of shell and internal quality of egg depends on numerous factors which combine to influence the final product. Difference in egg quality are dependent on genotype and age of laying hens as well. At the end of laying period eggs are heavier, contain a higher proportion of yolk and therefore more lipid, have a poorer and more variable eggshell.

There are important changes in housing system for laying hens. In the European Union battery cages will be prohibited from 2012 and therefore, many authors are concerned with alternative systems for layers, their advantages and disadvantages. There are a lot of stand-points about welfare and egg quality, e.g. Savory (2004) stated that from the welfare viewpoint cage systems were burdened with a lack of space for laying hens, however conversely they ensured the better health status of layers.

The main purpose of this paper is to evaluate factors which influence time of ovipositon and also factors which are affected by oviposition time, primarily relation to egg quality.

Factors which affect oviposition time

It is well known that oviposition time is influenced by several factors. One of the most important factor is lighting regime. The distribution of oviposition times in laying hen is restricted to an 8 h period of the day (Lillpers, 1991; Etches, 1995), eggs being normally laid between 7:30–8:00 and 15:30–16:00 h under standard lighting conditions (14L:10D; Campo et al., 2007). Bhatti (1987) reported, that oviposition occurs at all times of the day when hens are held in constant light or constant darkness. Etches et al. (1984) detected laying of the first eggs during first hours of ilumination, when the photoschedule was 14L:10D. Under lighting range 14L:10D to 17L:7D hens usually lay their eggs in the early morning hours of the photophase. It is also known, that under many photoschedules hens lay eggs in the dark. Etches (1990) shows, that hens in 14L:7D lay many eggs immediately after dusk and hens in 14L:14D lay all of their eggs in darkness. Lewis et al. (2001) investigated supplemen-

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tary dim light before and after a normal 8-h photoperiod and 16-h photoperiod. Oviposition time was similar for 8-h photoperiod hen and for dim light after 8-h photoperiod, but oviposition was delayed by 3-h for 16-h birds.

The egg yield is influenced by switching on the light. According to Washburn and Potts (1975) the highest percentage of eggs is produced between 10:00 and 12:00 h and Halaj (1974) between 10:00 and 14:00 h. The trial with different turn on the light was realized by Tůmová and Ebeid (2005). They found out that switching light at 3 a.m. (cage system) causes laying majority of eggs at 6 a.m. and then proportionaly oviposition of eggs declines during the day. On the other hand, switching at 6 a.m. (litter system) brought along the same proportionality of eggs all the day. These results showed that proportionality of laid eggs during the day was dependent on turn on the light. It seems that housing system influences time of oviposition as well. Another study of Tůmová et al. (2009) found out that litter system postponed ovipostition time to midmorning (10:00), in comparison with cage system (the highest proportion of eggs laid in 6:00) with the same light regime. Reproductive senescence in hens manifests as an increase in the intra-sequence ovulation and oviposition intervals with time, as well as an increase in the number of pause day. Emmans and Fisher (1986) suggested that the hen's internal cycle length increased with time from the first egg, resulting in a decline in the rates of ovulation and oviposition with age. The decline in the ovulation rate with advancing age, characterised by shorter sequences, may be due to a change in the circadian rhythm, in the process of follicle maturation, or both. Not only are the amplitudes of circadian rhythms lessen with age, but there are also age-related changes in the responses of certain circadian systems to light. The shorter sequences commonly produced by older hens (Johnston, Gous, 2003). Delay of oviposition can cause environmental stressors (more in alternative housing systems), relocation, exposure to unfamiliar conspecifics and removal of nest sited by reason of releasing adrenalin (Haughes et al., 1986). Mills et al. (1991) demonstrated that disturbances of hens increased oviposition intervals.

Genotype and oviposition time

A lot of studies evaluate relationship between oviposition time and genotype of laying hens, because not all breeds of hens lay their eggs at the same time for a given day-length. Lewis et al. (1995) compared brown and white egg-laying hybrids. Mean oviposition time for the brown hybrid was 1.2 to 1.4 h earlier than that for the white hybrid. Autor suggested that it is due to a genetic difference for the luteinising hormone release. Similar results attained Campo et al. (2007) who compared white, tinted and brown egg laying hens. They concluded that white and tinted eggs tend to be laid in the afternoon and brown eggs tend to be laid in the morning. Yoo et al. (1988) reported that the highest producing hens often lay their eggs earlier in the light than the less productive hens. Garces and Casey (2003) studied the effect of oviposition time on dwarf and naked neck layers. The main results showed that dwarf gene increased oviposition intervals and time of oviposition, reduced the sequence lenght and rate of lay. There was no significant effect of naked neck on oviposition traits. Differences in oviposition time between genotypes may be also explained by laying rate. Yoo et al. (1984) showed slower rate of follicular recruitment in birds with lower rate. The positive correlation between oviposition interval and time of oviposition suggested that hens with short intervals laid their eggs earlier in the day than hens with longer intervals (Garces, Casey, 2003). Authors found a significant negative correlation between oviposition interval and egg weight in naked neck normal size hens. Horst and Rauen (1986) detected association between naked neck gene and increasing laying rate, egg size and egg mass in hot environments.

Genotype of hens affects rate of lay during the day. In trial that has been carried out by Tůmová et al. (2007) the effect of three strains of Dominant genotype on oviposition time was evaluated. Blue strain, Plymouth Rock and also their F1 cross laid most of eggs in the morning (6:00 and 10:00 h). The highest number of eggs was collected in the Plymouth Rock strain at 6:00 h (53.2%) and the lowest in the Blue strain at 14:00 h (11.1%). Tůmová et al. (2009) compared three genotypes ISA Brown, Hisex Brown, Moravia BSL housed in conventional cages and on litter system. Results shows interaction of genotype and housing system of hens. ISA Brown produced the highest number of eggs and laid eggs mainly early in the morning (6:00 – 62.8%). Hisex Brown laid majority of eggs before 10:00 (42.0%) and Moravia with the lowest egg production produced the majority of eggs between 10:00 and 14:00. The time of oviposition and rate of lay in relation to age of hens in two commercial flocks of White Leghorn hybrids observed Patterson (1997). The author compared DEKALB Delta and Hy-line W-36 hens at 33 and 76 weeks of age. Both genotypes laid approximately 25, 50 and 75% of their daily eggs by 7:00, 8:00 and 10:00 h at 33 weeks of age. At 76 weeks of age the same daily percentages were laid approximately 1 hour later for W-36 hens and 0.5 hour later for Delta hens. The author indicated that the W-36 hens produced the greatest hourly number of eggs at 9:00 h (23.0 and 30.5% of the daily total at 33 and 76 weeks of age), which corresponded to 14 hours after the beginning of the dark cycle for both ages. The author also detected that young flocks (33 weeks old) laid 50% eggs daily within 13 hours after the beginning of the dark cycle, while in older flocks (76 weeks old) oviposition was delayed another 30 to 60 min.

Traits which are affected by time of oviposition

Literature shows that time of oviposition affects quality of egg. Egg weight is one of the most important characteristics of egg quality. Many studies have indicated that eggs laid early morning are heavier than those laid during day (Washburn, Potts, 1975; Halaj, Szoby, 1977; Choi et al., 1981; Arafa et al., 1982; Lee, Choi, 1985; Harms, 1991; Yannakopoulos et al., 1994; Novo et al., 1997; Patterson, 1997; Pavlovski et al., 2000; Aksoy et al., 2001; Tůmová, Ebeid, 2005; Tůmová et al., 2007; Tůmová, Ledvinka, 2009; Tůmová et al., 2009). Yannakopoulos et al. (1994), Pavlovski et al. (2000), Tůmová et al. (2007) recorded the heaviest eggs at 6:00. Harms (1991) detected that egg weight from commercial laying hens declined steadily between 7:45 and 15:45, but then the egg weight increased. Similar findings recorded Patterson (1997), namely heavier eggs were laid in the morning and egg weights declining 2–9 g/egg/day between 5:00–18:00 h. Aksoy et al. (2001) noticed, as well as other scientists, heavier eggs in the morning (9:00 h) and the lightest eggs in the afternoon (15:00 h). On the contrary Tůmová et al. (2008) observed heavier eggs at 10 and 14 h in comparison with eggs laid at 6 h.

Differences in weight of eggs laid during the day also depend on position of eggs in sequence. Choi et al. (1981) and Miyoshi et al. (1997) showed that the average weight of eggs laid in the morning were heavier than those laid in the afternoon, because most of the first eggs in clutches were laid in the morning. Lillpers and Wilhelmson (1993) reported that egg weight decreased significantly as the serial number within a clutch increased, but there were no significant changes in egg weight for clutch size of more than 18 eggs. Miyoshi et al. (1997) detected a large difference in egg weight between the first egg and subsequent eggs (3–4 g or about 6%). The changes in the egg weight within a clutch may be explained by the physiological condition of the hens. At the beginning of laying cycle, hens may resume its physiological state and have ability to produce a heavier eggs (Choi et al., 1981).

Egg weight generally increases with age of hens (Campo et al., 2000; Silversides, Scott, 2001; van den Brand et al., 2004; Tůmová, Ledvinka, 2009). As an example the trial of Wezyk et al. (2006) can be used, in which egg weight increased in lines of Astra H (black-feather Polish laying hens) and Astra S (brown-feather Polish laying hens). At 20 weeks of age egg weight was approximately 45 g and at the end of the experiment (63 weeks) 65–66 g, with no clear differences between Astra H and Astra S. Also Odabasi et al. (2007) stated increasing in egg weight with age, at 25 weeks of age the mean egg weight was 58.83 g in commercial-type Hy-line brown hens and after 10 months was the weight 66.64 g. Patterson (1997) found out essentially similar increasing of egg weight with age in two commercial flocks of white leghorn hybrids. Al-Rawi and Abou-Ashour (1984) recorded maximum egg weight at the end of laying period, when fewer eggs were laid.

Egg weight is a direct proportion of albumen, yolk and shell. Egg weight may be predicted as a unit or as the sum of the weights of its three components (Johnston, Gous, 2007). Growing egg weight increased albumen weight percentage, while yolk weight percentage decreased (Shi et al., 2009). Conversely, Yannakopoulos et al. (1994) and Johnston and Gous (2007) recorded that increasing of egg weight is accompanied with a significant increasing of percentage content of egg yolk relative to albumen. Decreasing of egg albumen is caused in the process of aging, because water is displaced from the albumen to the yolk. Tůmová and Ledvinka (2009) detected that yolk weight was more related to hen age than albumen weight. Yolk weight increased about 40% from the beginning of the laying period, whereas albumen weight increased only about 11%. Similarly, Yannakopoulos et al. (1994) acknowledge that egg laid at 10 months of age had about 12.3% more yolk and 4.5% less albumen than eggs laid at 7 months. Increasing of yolk weight and decreasing of albumen is resulting in an increase in yolk:albumen ratio (Silversides, Scott, 2001; van den Brand et al., 2004). On the contrary the relative changes in egg component traits (yolk weight and shell weight) do not follow the pattern of changes in egg weight. The changes in albumen weights reflect the dependent change of egg weights by albumen weights (Miyoshi et al., 1997). Rous (1972) presented, that high positive corelation exists between total egg weight and weight of components of the egg. But some components increase more quickly or more slowly than the total egg weight.

Internal quality characteristics of egg depend on time of oviposition. The effect of oviposition time on albumen weight when egg weight remained constant revealed Yannakopoulos et al. (1994). Afternoon eggs had significantly more albumen than morning eggs. This could be due to the fact that an afternoon eggs absorb more albumen during formation, which in turn does not contribute to an increase of its weight. Results of Tůmová et al. (2008) showed that albumen quality was lower in eggs laid in the morning (6:00 h) and then increased (10:00 and 14:00 h). Tůmová et al. (2007) found out that the highest percentage of albumen was in eggs laid at 10:00 h for Blue strain and Plymuth Rock, but in their F1 cross percentage of albumen was the highest in eggs laid at 14:00 h. Contrary percentage of yolk was the highest in eggs laid in the morning (6:00 h), except F1 cross in which the highest values were detected at 10:00 h. No significant effect of oviposition time on yolk weight was recorded by Yannakopoulos et al. (1994). The authors recorded also higher content of water in albumen or yolk in afternoon eggs than in morning eggs and concluded that the water content in yolk or albumen is predicted accurately by egg weight alone. The excess water in the yolk causes the vitelline membrane to stretch and lose elasticity (Kirunda, McKee, 2000). Yolk:albumen ratio and collection time is contrary at the beginning and at the end of the laying cycle. According to Tůmová and Ledvinka (2009) it is connected with smaller deviations in yolk weight in the second half of lay then at the beginning.

The main characteristics of internal quality of egg, Haugh units, depend on time of oviposition. In eggs laid in the afternoon were by 2.86 units higher (Tůmová et al., 2008). The same trend demonstrated Tůmová and

Ebeid (2005) with difference 2.14 units between collection time at 6:00 and 14:00 h. However, Tůmová et al. (2007; 2009) noted lower values of Haugh units in eggs laid in the afternoon in different genotypes. This is consistent with Pavlovski et al. (2000) who documented that eggs laid in the afternoon showed a lower Haugh units.

At the beginning of laying cycle young hens produce smaller eggs with strong eggshells and albumen that stands high. As the hen ages, egg weight increases, the shell thins and the albumen begins to weaken and run (Scott Beyer, 2005). In greater eggs is more yolk and albumen than in small eggs, but percentage of yolk and albumen in egg not have to be the same (Rous, 1972). Effect of hen's age on egg quality detected Bozkurt and Tekerli (2009) as well. They found out that egg weight, albumen height, albumen index, yolk height, yolk index and Haugh units were higher in eggs from young hens. Petek et al. (2009) ascertained positive effect of hen's age only on Haugh units, and negative effect on yolk colour and albumen pH. Increasing of Haugh units with age of hens reported also Zita et al. (2009). Decreasing of albumen height with age of hens revealed van den Brand et al. (2004).

The eggshell quality, another important characteristic of quality of the whole egg, depends on time of oviposition. The most of studies indicated that eggshell characteristics are better in the afternoon eggs (Yannakopoulos et al., 1994; Novo et al., 1997; Pavlovski et al., 2000; Tůmová, Ebeid, 2005; Tůmová et al., 2007; 2009). Yannakopoulos et al. (1994) assumed that higher shell quality is due to thicker shell and lower deformation values in the afternoon eggs. Shell percentage was somewhat higher in afternoon eggs (10.33 and 10.31%, 14 and 10 h respectively), whereas in the morning eggs (6 h) shell percentage decreased (10.03%; Tůmová, Ebeid, 2005). The same results noticed Tůmová et al. (2007) in trial with three strains of Dominant genotype. In all of these genotypes time of oviposition had the significant effect on determining eggshell quality. All eggshell quality characteristics, eggshell weight, shell percentage, eggshell strength and eggshell thickness were significantly better in afternoon eggs (14 h). Harms (1991) recorded significantly greater shell weight of eggs laid before 7:45 than for eggs laid between 7:45 and 11:45. Then shell weight significantly increased until 12:45 and remained greater through the rest of the day with exception of eggs laid between 14:45 and 16:45 h. In contrary, Tůmová et al. (2009) described declining trend in shell weight with collection time. As regards shell thickness, Tůmová et al. (2008) revealed significantly higher thickness in the morning collection time (6:00 h), without any effect on another shell quality. However, Harms (1991) or Tůmová and Ledvinka (2009) stated, that eggshell weight declined with collection time parallel to egg weight.

Bozkurt and Tekerli (2009) found out decreasing of shell thickness and increasing shell weight with advancing hen's age, which was also confirmed by Campo et al. (2000). Eggshell percentage decreased with layer age in trial of van den Brand et al. (2004), however Zita et al. (2009) determinated that eggshell strength improved from onset of lay till the end of the first phase and afterwards declined. Pavlík et al. (2009) detected decreasing eggshell breaking strength with age of birds. This is similar to Roland et al. (1975) who concluded that the decline of eggshell quality with age of hens caused a constant amount of eggshell calcium deposition occurred as the hen aged. Changes in colour of brown eggshell with hen age studied Odabasi et al. (2007). When the colour components were corrected by egg weight for the change in egg size as hen aged, the colour components were found to be practically stable in time. The larger eggshell surface area, due to the increase in egg weight, resulted in lighter coloured eggs. Changing of colour of shell also stated van den Brand et al. (2004), but with no clear pattern.

Quality of eggshell is influenced by position of egg in sequence (Hashiguchi, 1996; Miyoshi et al., 1997). Hashiguchi (1996) did not observe differences in strength of shells between the first and the second egg in 2-egg sequences, but higher strength was recorded in the first and the last egg of 3-egg sequences compared to that of the second egg. The same condition occurred in 4-egg sequences. The author established that the strength of shells of the first and the last egg appeared to be higher than that of the intervening eggs in sequences of 3 eggs or more. The position of eggs in sequences affects their eggshell weight. Miyoshi et al. (1997) found out higher shell weight for the first and terminal eggs in the clutches. The other characteristics of the shell were similar to the changes in eggshell weight. The largest values of shell strength were mostly observed in the terminal eggs. The terminal eggs had also a thicker eggshell than the other egg in the same clutch. Roland et al. (1973) pointed out that the improvement in shell quality of eggs laid in the afternoon was because in photoperiod makes it possible for hens to consume calcium for a greater percentage of time during the process of shell formation. During the dark, much of calcium for shell formation must be provided from the skeleton. Roland (1981) detected that much of difference in the interval between ovipositions of morning and evening eggs is not due to the time eggs spends in the oviduct, but is instead due to delay inovulation.

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Doba snesení vejce a jeho složení: přehled literatury.

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Doba snesení vejce závisí na několika faktorech, mezi které patří změny světelného režimu. Slepice snášejí vejce většinou 6 hodin po rozsvícení. Dřívější rozsvícení světla způsobí snesení většiny vajec brzy ráno. Doba snesení ovlivňuje ukazatele kvality vajec, zejména jejich hmotnost a kvalitu skořápky. Vejce snesená ráno jsou těžší. Nicméně vejce snesená odpoledne mají kvalitnější skořápku. Doba snesení vejce a hmotnost vejce závisí také na genotypu nosnic. Vejce s hnědou skořápkou bývají snesena ráno a jsou těžší než vejce s bílou a skvrnitou skořápkou, která jsou lehčí a snášená odpoledne. Hmotnost bílku a Haughovy jednotky klesaly, ale hmotnost žloutku se s dobou snesení vejce zvyšovala. Také systém ustájení ovlivňuje dobu snesení. Genotyp, systém ustájení a doba snesení vejce signifikantně ovlivňují hmotnost vejce a Haughovy jednotky, ukazatele vnitřní kvality vejce. Znalost faktorů, které ovlivňují kvalitu vajec, je důležitá pro produkci vysoce kvalitních vajec. Kvalita vajec se liší v závislosti na interakcích mezi všemi uvedenými faktory.

doba snesení vejce; světelné režimy; hmotnost vejce; kvalita vajec; genotyp nosnic; systém ustájení

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