Full Length Research Paper

Analysis of the laying characteristics of Nera black hens in a hot and humid environment

Ogbu, C. C.1*, Ani, A. O.2 and Okpara, M. O.2

1Department of Animal Health and Production, College of Veterinary Medicine, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
2Department of Animal Science, University of Nigeria Nsukka, Enugu State, Nigeria.

Received 21 April, 2014; Accepted 9 January, 2015

The study was conducted to analyze the laying characteristics of Nera black hens in a hot and humid environment and assess the physical characteristics of good, intermediate and poor layers. Seventy-five eight months old Nera black hens of mean body weight 1.35 ± 0.24 kg (range: 1.20 -1.65 kg) in their 12th week of lay and housed individually in battery cages were used for the study. Eggs were collected daily and recorded for each hen. The hens were subsequently divided into three classes based on their laying performance as follows: Good layers, intermediate layers and poor layers and their physical conditions appraised. Results showed that the peak of lay was between 06:00 to 08:00 h and egg production declined gradually throughout late afternoon hours until no egg was laid between 17:00 and 18:00 h. About 88.75 and 11.25% of the eggs were laid in the morning and afternoon hours, respectively. Eggs laid between 6:00 and 7:00 h had the heaviest (P<0.05) mean egg weight (70.10 ± 0.92 g) and the first eggs in a clutch were the heaviest eggs (P>0.05). Hens with the longest clutches and shortest number of pause days produced the greatest number of eggs. Good and intermediate layers had smooth, pinkish and full combs and wattles, moist and enlarged vents and flexible pubic bones with wide space in-between. Poor layers had dry combs and wattles, tight and hard abdomen and narrow space between pubic bones. It was concluded that Nera black hens could lay up to 229.68 eggs/annum and lay most eggs between 06:00 and 08:00 h of the day. Egg collection especially in floor managed flocks should be intensified within this time period to minimize losses from cracks and egg eating by the birds.

Key words: clutch traits, egg production, Nera black, oviposition time, pause days.

INTRODUCTION

Increased table egg production is one of the fastest means of providing quality animal protein at minimum cost in Nigeria (Oluyemi and Roberts, 2000). Today’s commercial layer chicken is well suited for table egg production due to the tremendous genetic improvement in laying performance (Pym, 2010; Ogbu, 2012) as well as in management and husbandry techniques. Egg production of the individual bird is influenced by a number

*Corresponding author. E-mail: coschi07@yahoo.com
Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License
of laying traits such as clutch/sequence number, clutch/sequence length, the rate of lay, oviposition time, oviposition interval, lag time, frequency of pauses (pause number), number of pause days (pause length or size), tendency to go broody, and length of the broody period (Romanove et al., 2002; Eltayeb et al., 2010; Al-Nedawi et al., 2008; Erensayin and Camci, 2003; Gümülka et al., 2010). Longer sequence lengths, fewer pauses, shorter pause lengths, and uniform oviposition time indicate good layer performance (Etches, 1996; Jakowski and Kaufman, 2004; Reddy et al., 2004). Good layers lay sequentially and persistently (Miles and Jacob, 2000; Smith, 2003; Van Der Molen, 2004; Clauer, 2005). The laying status of a hen had been assessed using some physical characteristics such as appearance of the comb and wattles, eyes, beaks, distance between the two pubic bones, and wideness and moistness of the vent (Reddy et al., 2004; Ani and Nnamani, 2011). Apart from the laying traits enumerated above, egg production is also affected by such environmental factors as nutrition, ambient temperature, photoperiod, and relative humidity. These environmental factors change over time hence flocks should be continuously evaluated for performance. Egg production varies within a flock indicating individual bird differences in laying performance. Though overall flock performance may be high, not all hens in the flock lay at the same rate. Furthermore, while some hens may be laying at a very high rate, some others may not be laying at all (Miles and Jacob, 2000; Ani and Nnamani, 2011) or laying at sub economic levels. Knowledge of good laying attributes enables the farmer to identify and cull poor layers from time to time thereby optimizing his profit. Knowledge of the distribution of oviposition during the day is also necessary in recommending frequency of egg collection to minimize cracks and associated vices. When buying birds at point of lay, knowledge of the physical features that indicate well being and laying potentials will enable the farmer make informed choices. Nera black, the subject of the current study was newly introduced in our teaching and research farm. The need therefore arose to study their laying characteristics and performance.

MATERIALS AND METHODS

Location and duration of study

The study was conducted at the Poultry Unit of the Department of Animal Science Teaching and Research Farm, University of Nigeria, Nsukka. Nsukka lies in the derived savannah region, and is located on longitude 6° 25’ N and latitude 7° 24’ E at an altitude of 430 m above sea level (Breinholt et al., 1981). The climatic data obtained from the Energy Centre of the University of Nigeria, Nsukka during the period of the experiment showed that the study area had a natural day-length of 13 to 14 hours, mean maximum daily indoor and outdoor temperatures of 29.2 and 30.5°C, respectively, mean relative humidity of 76.6% and mean monthly rainfall of 781.33 mm (Energy Centre, University of Nigeria, Nsukka, 2011). The study lasted for 10 weeks. During this period, hens were observed daily and egg collection was done hourly between 06:00 and 18:00 h for the first eight weeks.

Experimental birds and management

The experiment was carried out in accordance with the provisions of the Ethical Committee on the use of animals and humans for biomedical research of the University of Nigeria, Nsukka (2006). Seventy-five eight months old Nera black hens in their 12th week of lay were used for the study. The hens were randomly selected from a flock of laying Nera black hens in the farm and weighed 1.35 ± 0.24 kg on the average (range: 1.20 to 1.65 kg). The hens were identified with hen numbers and housed in individual battery cages in an open-sided building with a block wall of 90 cm high and wire netting to the roof which was of asbestos. Hens were fed commercial layers mash containing 16.5% crude protein, 2650 kcal/kg of metabolizable energy, 4% crude fat, 6.5% crude fiber, 3.6% calcium and 0.4% phosphorus at 125 g/bird/day with ad libitum supply of cool and clean water. Routine vaccination and medication of the birds were carried out to maintain optimal health of the flock. To control wetness and odour from the litter, wood shavings were spread under the battery cages to absorb moisture. Litters were removed weekly. No supplemental light was provided during the period of the study. Data collected on each hen were oviposition time, total egg production, clutch/sequence length, total number of pause days, and individual egg weight (g) in relation to egg sequence and oviposition time.

Physical characteristics

After the eight week data collection on egg production traits, the hens were divided into three groups namely good layers (birds that laid 39 eggs and above or ≥69.6%), intermediate layers (28 to 38 eggs or 50.0 to 68.0%) and poor layers (<28 egg or <50.0%) and the physical characteristics associated with laying namely colour and general appearance of comb, wattles, eyes, beaks, cloaca, vent, and space between the pubic bones were assessed in the three groups.

Statistical analysis

Data collected were analyzed and presented using descriptive statistics such as means, standard deviation and frequency distribution. Good, intermediate, and poor layers were compared for laying performance using analysis of variance (ANOVA) for completely randomized design (CRD) using the SPSS Computer Package (SPSS, 2007). Significantly different means were separated using Duncan’s New Multiple Range Test option in SPSS.

RESULTS

The trend in laying (oviposition) with oviposition time in the population of Nera black hens is presented in Figure 1 while Figure 2 presents the distribution of layers according to number of eggs laid. As shown in Figure 1, most eggs (88.7%) were laid in the morning hours (06:00 to 11:59 h), 11.1% of eggs in the afternoon hours (12:00 to 15:59 h), and only 0.2% between 16:00 and 18:00h. Oviposition reached a peak between 07:00 and 07:59h and declined progressively as the day advanced. Figure
2 shows that the highest number of birds (23) laid between 45 and 49 eggs (80.4 to 87.5% lay). These were followed by those that laid 35 - 39 eggs (13 birds, 62.6 - 69.6% lay), 40 to 44 eggs (12 birds, 71.4 to 78.6% lay), and 50 - 54 eggs (11 birds, 89.3 to 96.4% lay). A total of ten birds laid between 0 and 19 eggs (0.0 to 33.9% lay) during the experimental period. Thus 61.3% of the birds produced at between 71.4 and 96.4%, 25.3% of birds between 35.7 and 69.6%, and 13.3% of birds between 0 and 33.9%. Thus the least number (and percentage) of birds laid at the lowest percentages of production. In terms of the economics of laying performance, 59 birds (78.7%) laid above 50% (economic threshold) while 16 birds (21.3%) laid below 50% production level.

The distribution of Nera black layers according to range of clutch number is presented in Figure 3. The number of clutches (egg sequences) in the present study ranged from 0 to 19. Birds with clutches in the range of 5 to 9 were highest in number (33 or 44.0%) followed by those that produced 10 to 14 clutches (25 or 33.3%). Birds of 15 to 19 clutches were least in number (3 or 4.0%).

The distribution of clutch length among 75 Nera Black layers is presented in Figure 4. Clutch length ranged from 2 to 17 eggs. Clutches of 2, 4, 5, 3 and 6 eggs (in decreasing order) were highest in number (cumulative: 42 clutches or 56.0% of all clutches) followed by those of 7, and 8 eggs which were 4 clutches each (cumulative: 8 clutches or 10.7%). Nine (9), 10, 11, 12, 13, 14, and 15 egg clutches were 3, respectively (cumulative: 21 clutches or 28.0%) while 16, and 17 egg clutches were 2, respectively (cumulative: 4 clutches or 5.3%).

The classification of Nera black layers according to
Laying performance (good, intermediate, and poor layers) is presented in Figure 5 while the laying characteristics (egg production, pause days, clutch length, and clutch number) of these groups of layers are presented in Figure 6. As shown in Fig. 5, good layers (birds that laid 39 eggs and above during the experimental period) were 49 (65.3% of experimental birds); intermediate layers (birds that laid between 28 - 38 eggs) were 12 (16.0%), and poor layers (birds that laid less than 28 eggs) were 14 (18.7%). There were significant ($P < 0.05$) differences between layer groups in egg production, total pause days and clutch length but not for clutch number (Figure 6). As expected, good layers laid the highest number of eggs ($46.76 \pm 3.96$) followed by intermediate layers ($34.75 \pm 2.83$), while the least number of eggs was laid by poor layers ($10.93 \pm 9.39$) (Figure 6A).

The variation in egg production within groups was highest ($9.39$ SD) in poor layers compared to good layers ($3.96$ SD) and intermediate layers ($2.83$ SD). Egg production in this group ranged from 0 to 27 eggs in 56 days (8 week) compared to 39 to 54 eggs and 28 to 37 eggs for good and intermediate layers, respectively. Good layers had the least ($P < 0.05$) number of pause days ($9.04 \pm 3.80$ pause days, range: 2 to 17 pause days) followed by intermediate layers ($21.25 \pm 2.83$ pause days, range: 19 - 28 pause days), while poor layers had the highest number of pause days ($45.07 \pm 9.39$ pause days, range: 29 - 56 pause days) (Figure 6B). Clutch length was longest ($P < 0.05$) in good layers ($7.26 \pm 3.53$ days, range: 2.73 - 17.0 days) followed by intermediate layers ($3.99 \pm 1.62$, range: 2.18 - 7.20 days) but shortest in poor layers ($1.45 \pm 0.62$, range: 0.00 - 2.50 days) (Figure 6C).
Clutch number also differed significantly (P < 0.05) among the layer groups with good and intermediate layers having the highest number of clutches (7.72 ± 2.93 and 10.17 ± 4.15 clutches, respectively). Poor layers had the least clutch number of 6.64 ± 5.14 clutches (range: 0 - 14 clutches) (Figure 6D).

There was a gradual reduction in egg weight as oviposition time advanced (Figure 7). Eggs laid between 06:00 and 08:59h had the highest egg weights (70.1 ± 0.92, 69.46 ± 0.71, and 68.51 ± 0.72 g, overall mean = 69.36 ± 0.46 g) and these were significantly (P < 0.05) higher than eggs laid between 09:00 and 11:59h (67.94 ±...
0.64, 66.21 ± 0.55, and 63.79 ± 0.64 g, overall mean = 65.98 ± 0.49 g) which were in turn heavier than those laid between 12:00 and 18:00h (59.79 ± 0.51, 57.39 ± 0.47, 54.97 ± 0.58, and 52.66 ± 0.71 g, overall mean = 56.20 ± 0.55 g). Across the oviposition period from 11:00 to 14:59h, egg weight decreased significantly (P < 0.05) with every two hour increase in oviposition time (namely, 63.79 ± 0.64 vs. 59.79 ± 0.51 g, 59.79 ± 0.51 vs. 57.39 ± 0.47 g, and 57.39 ± 0.47 vs. 52.97 ± 0.58 g, for 11:00 - 11:59 vs. 12:00 - 12:59 h, 12:00 - 12:59 vs. 13:00 – 13:59h, and 13:00 - 13:59 vs 14:00 - 14:59 h, respectively). The mean weight of eggs laid between 14:00 and 14:59, and 15:00 and 18:00 h, were similar (52.97 ± 0.58 g, and 52.66 ± 0.71 g, respectively).

The effects of egg position and clutch size on egg weight of Nera Black layers are presented in Figure 8. Significant (P < 0.05) differences existed between eggs of different positions in egg sequences (Figure 8A) as well as between egg sequences (clutches) (Figure 8B). First-in-sequence eggs (FI) weighed significantly heavier than eggs in the 3rd to 15th position (in 3 to 15 egg clutches) but were similar to those in the 16th and 17th position (for 16 and 17 egg clutches). Second-in-sequence eggs also weighed heavier than 3rd to 11th, and 13th to 15th inception eggs but were similar to those in the 16th and 17th position. Third (3rd) to 15th-in-sequence eggs were similar in weight but significantly (P < 0.05) lower than those of 16th and 17th position. For length of clutches (Figure 8B), 2 and 3-egg clutches had the highest (P < 0.05) egg weights followed by those of 7, 17, 9, 14, and 16 egg clutches which were similar in egg weight. Clutches of least egg weight were those of 12, and 13; 4, and 10; 5, 8, and 15; and 6, and 11 eggs in decreasing order.

Appraisal of the physical characteristics associated with good, intermediate, and poor egg production (appearance
of the comb, wattles, beaks, shank, cloaca, and space between the pubic bones) showed that good and intermediate Nera Black layers displayed the usual physical features associated with high rates of egg production: Bright and attentive facial expression, alertness, bright eyes, pinkish and moist mucous membranes of the eyes, mouth, vent and cloaca, bright red/pink comb that is full (for the age), bleached beak, thin and flexible pubic bones with a wide space in between (could accommodate 2-3 average fingers). Poor layers on the other hand were not as bright and robust as good layers and had a space between pubic bones that could barely accommodate two average fingers. In addition they showed high excitability.

**DISCUSSION**

**Effect of oviposition time on egg production**

The significant variations in oviposition with oviposition time (Figure 1) show that oviposition is not equally or randomly distributed over the diurnal period. Most eggs (88.7%) were laid between 06:00 and 11:59 h indicating that this is the most critical oviposition period in this genotype. Oviposition period of 06:00 to 11:59h was found the most critical for oviposition in layers (Ajao and Ezekwe, 2006; Ani and Nnamani, 2011). Zakaria et al. (2005) reported that a flock of 34 week old broiler breeders laid most of their eggs between 0700 and 1300h when feeding was at 0800h, with the greatest number of eggs for a single hour being between 0900 and 1000h. The same authors reported that oviposition in an older (59 week) broiler breeder flock under the same management schedule was more evenly distributed between 0700 and 1500h. Lillipers and Wilhelmson (1993) however noted that early afternoon was the main egg laying period in a White Leghorn layer flock housed in individual cages. In an earlier study in the same environment as the present study Orji and Nwakalor (1984) reported that Hypaco Goldline and Shaver Brown hens laid 76 and 71% of their eggs before 12:00h, respectively. More recently Ani and Nnamani (2011) studied the physical and laying characteristics of Golden Sex-Linked hens in the same environment and reported that the time period 06:00 to 11:59h was the most critical period for egg laying. In the present study, oviposition peaked between 07:00 and 07:59h but laying was more or less evenly distributed within the first 4h of day light (06:00 – 09:59h). The high frequency of oviposition in early morning hours compared to afternoon hours in the present study could be ascribed to the high rate of egg production in layers compared to broilers. Lewis et al. (2004) reported that in commercial crossbreeds of laying hens, the mean oviposition time was about 1h earlier in comparison with broiler breeder hens. Our results indicate that egg collection by attendants should be intensified within time period 06:00 to 11:59h to minimize losses in eggs and revenue through egg soiling, cracks and egg eating by hens especially in deep litter operations. Furthermore, management lapses that affect oviposition (e.g., inadequate and irregular feeding and watering, and undue disturbances of birds during peak period of lay, etc) should be avoided as these could adversely affect egg laying. Almost all the eggs for a particular day (99.8%) were laid between 06:00 and 15:59h (11 h) which was in agreement with the report by Zakaria et al. (2005) and also of Smith (2001) that chickens do not normally lay eggs in the late afternoon. This suggests that once laying is delayed beyond early afternoon (12:00 - 15:30h), oviposition is differed to the following day. Gumulka et al. (2010) however presented data on individual pattern of successive ovipositions in sequences of broiler breeder hens in which some eggs were laid during darkness. These ovipositions which were of varying percentages were defined as out-of-lay rhythm. The range of oviposition time in the present study suggests that oviposition during the day is mainly regulated by a circadian rhythm, entrained by the daily light-dark cycle related to the open period for preovulatory LH surge (Gumulka et al., 2010; Wolc et al., 2010) and maturation of ovarian follicle (Wolc et al., 2010) although within breed genetic differences may also be important (Wolc et al., 2010). Prolific layers are known to lay early and as clutch length increases, first ovipositions were reported to occur earlier and oviposition interval shortened (Gumulka et al., 2010).

**Total egg production and other egg production parameters**

The observation that 56 birds (78.7% of the total Nera black hens used in the study) produced at between 62.5 and 96.4% (Figure 2) shows that this population accounted for the majority of eggs laid each day and hence the greater proportion of the revenue due to egg production in this flock. Twenty-three percent (21.3%) of the birds (16 hens) produced at/or below economic threshold. Careful selection and elimination of unproductive birds and birds laying at below economic threshold would reduce wastage, and increase revenue for the farmer. The average number of eggs laid by each hen for the period of the experiment (56 days or 8 week) was 38.28 eggs. Total egg production of exotic commercial laying hens in Nigeria has been estimated to about 280 eggs per annum (Oluvemi and Roberts, 2000).

**Clutch number and Length**

The observed frequency of 33 (44%) for 5 to 9 egg clutches and 25 (33.3%) for 10 to 14 egg clutches (Figure 3) indicate that the clutch numbers of a majority (73.3%,
that is, 44% + 33.3%) of the Nera black hens in the current study fall within these ranges. Numerous egg clutches indicate frequent pauses which could mean lesser eggs. On the other hand, scanty clutches could indicate prolonged clutches (long clutch lengths, bigger clutch sizes) and more eggs (Miandmients et al., 1993; Gumulka et al., 2010; Wolc et al., 2010) or prolonged pause days and lesser eggs while a zero clutch means lack of egg production by the hen. Generally, clutch number and clutch length (as well as egg production) are negatively correlated phenotypically and genetically (Erensayin and Camci, 2003; Wolc et al., 2010). Clutch numbers of 5 to 14 appear to be intermediate between 0 and 19 (the extreme clutch numbers in the present study) and were associated with the greater number of birds (58 or 77.3%). However, as described above, clutch number alone may not reveal much concerning the laying performance of a hen.

Clutch length or sequence length (Figure 4) indicates the number of days a hen laid without a break or pause. The longer the clutch length, the fewer would be the clutch number and the higher the egg production of a hen within a given period (Gumulka et al., 2010; Wolc et al., 2010). Hens which had the longest clutch length (17 days) produced the highest number of eggs (54) in the present study which agrees with the reports by Miandmients et al. (1993), and Ani and Nnamani (2011). Ani and Nnamani (2011) reported that hens with the longest clutches produced the largest number of eggs each laying year because they have the fewest number of non-productive days. Short clutch lengths indicate frequent pauses, more number of small sized clutches, and lesser eggs within a given period. The differences recorded in the clutches of the experimental hens might be due to individual bird differences in rate of follicular maturation which could be genetic or environmental in origin (Wolc et al., 2010). Slow follicular maturation (26 - 28 h or more) lead to shorter (2-3 days) sequences or clutches while hens that lay very long sequences typically have maturation rates of 24 h or less (Jakowski and Kaufman, 2004; Ajaero and Ezekwe, 2006).

### Good, intermediate, and poor layers

It was observed that good layers (birds that laid at ~ 70% and above) accounted for 65.3% of the experimental birds while intermediate layers (birds that laid between 50 and 68%) accounted for 16.0% of the flock (Figure 5). These values indicate that birds that were economically viable were 81.7% of the entire flock while birds that laid below 50% constituted 18.7% of the flock. These birds were identified as poor layers and in commercial egg production such hens should be culled as they constitute a drain on the income of the enterprise. The physiological basis for the distinction between good, intermediate and poor layers relate to the rate of egg formation (Gumulka et al., 2010; Wolc et al., 2010) which is related to the rate of ovulation (follicular maturation) (Zakaria et al., 2005, 2009; Wolc et al., 2010) and the time spent in the various sections of the oviduct (Warren and Scott, 1935). The rate of egg production depend largely upon the size of the clutch and this is conditioned by the interval length (oviposition interval or lag period between successive ovipositions) and the length of the pause between clutches. Whereas good layers have long clutches and short interval lengths, poor layers have small clutches and long intervals lengths (Brun et al., 2003). The greater percentage of the variability in interval length between high and low intensity birds has been attributed to differences in the time for egg formation (Brun et al., 2003) and the delay in ovulation (longer pauses between clutches) (Brun et al., 2003). The longer interval and pause lengths of poor layers result from longer period of egg formation in the oviduct and delay in ovulation, respectively. Since birds do not lay at night (Smith, 2001), long interval lengths lead to short clutches due to the termination of clutches on account of photoperiod effect. Gumulka et al. (2010) reported that with increasing sequence length, time intervals (lag periods) between subsequent oviposition within a sequence were shortened. The authors reported mean oviposition lag in hours as highest (4.03 ± 1.26 SD) for 2-egg sequences and tended to decrease with sequence length (3.20 ± 1.11, 2.18 ± 0.57, 1.46 ± 0.59, and 1.06 ± 0.56, for 3, 4, 6, and 9 egg clutches, respectively).

### Egg production, pause days and clutch traits of classes of Nera black layers

The variations in egg production, total pause days, clutch length and clutch number among the performance classes of Nera black layers (Figure 6) were expected. These parameters characterize the egg production performance of individual birds as well as the entire flock. The shortest (9.04 ± 3.80 days, range: 2 - 17 days) and longest (45.07 ± 9.39 days, range: 29 - 56 days) total pause days observed for good and poor layers, respectively reflect the intensity of egg production in the two groups. Jakowski and Kaufman (2004) showed that egg sequences in prolific hens are separated by not more than a day of rest and that total pause days of prolific hens were lower than that of poor layers. In a Japanese quail (Coturnix coturnix japonica) flock of high egg rate, Erensayin and Camci (2003) reported 70.4% one-day pauses, 16.0 and 4.11%, 2- and 3-day pauses, respectively with mean pause length as 1.40 ± 0.04 days. In a study of the effect of pause size and number on egg mass of White Leghorns, Al-Nedawi et al. (2008) found the highest egg mass for the lowest pause size, and pause number, respectively. They reported that differences in egg mass belonged to pause size and pause number and that egg mass decreased as pause...
size and pause number increased. Erensayin and Camci (2003) reported significant negative correlations between hen-day production and number of pauses and pause length in Japanese quail.

Clutch length was longest in good layers compared to intermediate and poor layers (7.26 ± 3.53, range: 2 - 17 vs. 1.45 ± 0.62, range: 0 - 2.5 day or eggs) showing that egg sequences were more in this group. Wolc et al. (2010) reported maximum and average clutch length (mean ± SD) of 49.19, and 9.10 ± 5.07 eggs, respectively in a Rhode Island White flock of hens. In the study by Gumulka et al. (2010), the number of eggs laid in the longest sequences averaged 17.6 ± 2.0 eggs and the highest number of sequences was those of 2 to 9 eggs. Within breed differences in sequence length under the same management practices have since been recognized in laying hens (Johnson and Gous, 2007). Reasons for variability in egg sequence length within a flock range from differences in the length of open period for LH release to the dynamics of ovarian follicle maturation (Gumulka et al., 2010; Wolc et al., 2010). It has also been suggested that in some hens daily photoperiod is not synchronized with the ovulatory cycle (Gumulka et al., 2010) while Johnson and Gous (2007) suggested that this could be as a result of internal ovulation in some layers which is difficult to reveal in commercial production conditions. Generally, rate of egg production (laying intensity) is strongly positively correlated with clutch length or clutch size (Erensayin and Camci, 2003).

Clutch number did not differ significantly between good and poor layer groups. Furthermore, the values for clutch number in the three groups (7.72 ± 2.93, 10.17 ± 4.15, and 6.64 ± 5.14 for good, intermediate, and poor layers, respectively) were closer when compared to those of pause days (9.04 ± 3.60, 21.25 ± 2.83, and 45.07 ± 9.39 days, respectively) and clutch length (7.26 ± 3.53 days, 3.99 ± 1.62, and 1.45 ± 0.62 days, respectively). This could mean that clutch number may not be an independent criterion for comparing laying performances as obtained with pause days and clutch length. It has also been reported (Bednarczyk et al, 2000; Chen and Boichard, 2003b; Rosinski et al., 2006; Wolc et al., 2010) that number of clutches and average clutch length are negatively correlated while egg production and maximal clutch length are positively correlated (Wolc et al., 2010). This indicates that clutch length can be improved (with correlated improvement in egg production) by selecting against clutch number. The greater variation in egg production, within the poor layer group (9.39 SD) compared to other groups resulted from the wide range of performance values (0 - 27 eggs or 0.0 - 48.2%) observed for this group as well as the small number of birds (14 or 18.7%) in the group. Total pause days and clutch number also varied more in the poor layer group on account of the same reasons as well as the extremely low and high values observed for these parameters in this group.

**Effect of oviposition time on egg weight**

Egg weight showed a polynomial distribution with a gradual decrease as oviposition time advanced (Figure 7). Eggs laid between 06:00 and 08:59 were the heaviest followed by eggs laid between 09:00 and 11:59. Eggs laid between 12:00 and 18:00 were therefore the least in weight.

These results agreed with earlier reports (Zakaria et al., 2005; Tumova et al., 2007, 2009; Zakaria et al., 2009; Laughlin, 2011; King'ori, 2012). Zakaria et al. (2005) reported that early laid eggs were significantly heavier than mid-sequence eggs which were in turn heavier than late laid eggs in two broiler breeder layer flocks differing in age. Tumova et al. (2007) reported that eggs laid in the early morning are heavier than those laid late in the day while Laughlin (2011) reported a strong correlation between early and late egg weights among other parameters. Gumulka et al. (2010) reported that weight of eggs laid successively in a sequence decreased. These authors as well as Zakaria et al. (2005) suggested that a greater proportion of the early laid eggs were first-in-sequence eggs.

**Effect of egg position and clutch length on egg weight**

First and second-in-sequence eggs were found to be the heaviest eggs. This is in agreement with earlier reports (Robinson et al., 1991a; Novo et al., 1997; Zakaria et al., 2005; Gumulka et al., 2010). These eggs were heavier than those of 3rd to 15th position in the present study but of the same weight with eggs in the 16th and 17th positions. The reason for this similarity is yet to be understood. Significant differences in egg weight due to egg position in a sequence was not noticed among 3rd to 15th position eggs which were lower than those of 16th and 17th positions. Positional differences in egg weight have been attributed to differences in follicular growth period (Zakaria, 1999a, b; Zakaria et al., 2005, 2009). Zakaria et al. (2009) summarized the result of a number of studies (Zakaria et al., 1983; 1984a, b; Zakaria, 1999a, b) which among other findings indicated that average follicle growth period increased as sequence size decreased, follicular growth period decreased as egg position in a sequence increased from second to sixth, follicular volume tended to be less in terminal follicles in sequences of 2 to 5 eggs, and that the follicular growth period of the first-in-sequence egg was longer than for terminal follicles. From these findings differences in egg weight due to position effect can be attributed to differences in yolk weight and a definite trend would be expected from the 2nd to the 5th egg positions. Also Figure
8A reveals a steep decline in egg weight from the second to the fifth egg, which is in agreement with the foregoing. Beyond this position no definite trend was evident. Thus for sequences of 2 to 5 eggs, the rapid growth phase of terminal follicles was probably shorter while that of the first follicles was probably longer to account for the differences in the egg weight between first and terminal eggs of such sequences. Kingori (2012) reported that longer intervals of egg formation result in an increase in egg weight, albumen weight and a decrease in yolk percentage. Gumulka et al. (2010) reported that egg weight variation with laying order and sequence length is typical of wild and domestic birds. The authors however reported non-significant differences in the weight and percentage of yolks and albumens in eggs in relation to position in egg sequences of broiler breeder hens used in their study. Whereas Tumova and Ebeid (2005) and Tumova et al. (2007) found lower yolk percentages in eggs laid in the afternoon compared to those laid in the morning hours, Tumova et al. (2009) did not show the effect of oviposition time on yolk weight in three genetic groups of laying hens. Clutch size (or length) had significant effect on egg weight (Figure 8B) which could be as a result of the negative phenotypic and genotypic relationship between rate of egg production (laying intensity) and egg weight (Erensayin and Camci, 2003; Zakaria, 2001; Brun et al., 2003; Jonhson and Gous, 2003; Zakaria et al., 2009). In the present study, 2 and 3 egg clusters were the highest in egg weight in agreement with the findings of Gumulka et al. (2010) and Zakaria et al. (2005). The reports by Zakaria et al. (1983; 1984a, b; Zakaria, 1999a, b) indicate that average follicle growth period is negatively correlated with sequence length. Thus longer clutches experience shorter growth periods and hence smaller eggs. The trend of decrease in egg weight with clutch length was specifically observed between 2 to 5 egg clutches with no definite trend for longer clutches.

Lillipers and Wilhelmson (1993) had observed that egg weight decreased significantly with increasing clutch length, but only for sequences with less than 18 eggs. Egg weight variation with laying order and clutch length has evolutionary significance in wild birds (Sanchez-Lafuente, 2004; Gumulka et al., 2010) and could be important in determining fitness (Tinbergen and Both, 1999; Sanchez-Lafuente, 2004; Aslan and Yavuz, 2010). Also in sexually dimorphic species, within sequence variation in egg weight could be important in sex determination (Blanco et al., 2003; Magrath and Brouwer, 2003). These phenomena could be important in the unimproved domestic chicken.

Conclusion

Ovipositions occurred mainly (88.75%) between 6:00-11:00h. Egg collection should be frequent over this period to minimize losses. Clutch number is not a reliable index of laying efficiency compared to clutch length, pause number and pause length. Where individual bird performance cannot be measured (e.g., deep litter operations), farmers should use the physical features of poor layers to identify and cull unproductive hens to minimize losses of revenue and enhance profit.

Conflict of Interest

The authors have not declared any conflict of interest.

REFERENCES


Jonhson SA, Gous RM (2003). An improved mathematical model of the