

Study of Oviposition Pattern and Clutch Traits in a White Leghorn (WL) Layer Population

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Abstract: Various layer traits were recorded on 1082 pullets at 29th generation of selection to evaluate the variability for egg production. Oviposition time of each egg was recorded at hourly and half an hour intervals under 16L: 8D cycle, up to 40 weeks of age and for 15 days period respectively, to study the distribution pattern of oviposition time. Early (06-11h) and late (11-17 h) pattern of oviposition, with 90 % of ovipositions occurring before 13 h of the day was observed. Mean oviposition time (MOT) and mean oviposition interval (MOI) of the flock were 10.99 h and 24.34 h at hourly intervals, whereas, 10.70 h and 24.43 h at half an hour intervals of recording, respectively. Mean values of clutch length, clutch number, maximum clutch length, total pause days and interval between clutches were found to be 11.10 days, 12.69, 38.15 days, 23.67 days and 2.20 days respectively. Recorded data revealed variable degree of skewness and kurtosis for different traits. Clutch traits revealed more variation than MOT and MOI. The distribution of MOT and MOI showed narrow range and low percentage coefficient of variation than other traits.

Key words: Clutch traits, Oviposition time, Layer

I. Introduction

Present day WL layers are the results of long generations of selective breeding for traits governed by many genes. Many layer stocks exhibit a plateau situation with regard to rate of egg production (Siegel *et al.* 2006) due to exhaustion of additive genetic variance in selection criterion (Carlborg *et al.* 2006). Further gain in egg production is unwarranted because of losing genetic variation of the traditional selection traits and limitation of one egg per day (Luc *et al.* 1996). Study of oviposition pattern and clutch traits, that represents the laying characteristics of a pullet might help to unravel the extent of variation with in a flock for egg production improvement.

Egg laying is a complex process in which oviposition time, oviposition interval and clutch lengths are inter-related to each other in an intricate ways. In a 24 h light-dark cycle, egg laying from high yielding strains seldom occur in dark (Patterson 1997). Most of the oviposition occur in very limited part of the day (Lillpers 1991), about 5-6 h after light on (Zakaria *et al.* 2005), leading to mean oviposition time 13 to 14 h after onset of darkness (Lillpers 1991, Patterson 1997). Lighting schedule (Lewis *et al.* 2005), feeding time (Backhouse and Gouse, 2005) and management stress affects oviposition time, apart from the age and genetic background of the flock. The precise relationship between egg production, oviposition time, oviposition interval and clutch traits can only be understood by accurate recording of oviposition in limited part of the day (range is 05 AM to 07 PM) over longer period of production (Patterson 1997). The 24 h barrier of light-dark cycle is the main reason for mean oviposition interval ranging between 24 to 26 h (Sheldon *et al.* 1984). The clutch length reflects the egg production capacity of a hen and shows greater variation in distribution, because of internal ovulation, shell-less eggs and soft shelled eggs that disrupts or alter the sequence length (Johnston and Gous, 2007). In actual experimental conditions, more variation in sequence characteristics among individuals in a flock have been reported than the expected one ((Johnston and Gous, 2007).

Few attempts have been made to record the oviposition time (Patterson 1997, Zakaria *et al.* 2005), oviposition interval (Lillpers and Wilhelmson, 1993, Figueiredo *et al.* 2000) and clutch traits (Chen-Tixier Biochard, 2003, Johnston and Gous, 2007) for estimation of genetic variance (Lillpers and Wilhelmson, 1993, Chen-Tixier Biochard, 2003) and their possible use as alternate selection criterion for improvement in egg production (Noda *et al.* 2002 and Chen-Tixier Biochard, 2003).

In view of the above, the present investigation was designed to record various layer traits including oviposition time, oviposition interval and clutch traits in long term selected WL population with the purpose to utilize the observed variations further in combined family index selection study.

II. Materials And Methods

Experimental stock and history

The IWH strain of WL hens was used for present investigation. This strain has been maintained as a closed flock at experimental layer farm of CARI, Izatnagar, U.P, India since 1972. The experimental strain has undergone intense selection for part period (40 weeks of age) egg production for 22 generation and then 64 week of age egg production till the present 29th generation. The method of selection was combined family index as per Osborne (1957 a, b). The selected pullets were assigned at random to the selected males with only restriction that no half-sib or full-sib matings were permitted. The strain was reported to have improved by about 72 % for part period egg number till 22nd generation over the base population with average response of 0.99 to 1.25 eggs per generation (Anonymous et al. 2007). The egg weight and age at sexual maturity have declined over the base population by 0.68 gm and 1.04 days per generation along with decline in 40 week body weight (Anonymous et al. 2007). Anonymous et al. (2007) reported that, by observing the very low heritability estimates in principle trait (egg number 40, 64), it seems that long period of selection for egg number might have exhausted the additive genetic variance for egg production and thus there is need to explore the new genetic variability in the existing flock.

Management practices

The chicks were obtained from hatchery on zero day, pedigreed by sire and dam, placed on floor pens under hover type brooders and were reared there until about 08 weeks of age. All chicks were vaccinated against Ranikhet disease, Merek's disease, Fowl pox, Infectious bursal disease and Egg drop syndrome-76 and viral infections as per routine vaccination schedule. Starter ration was fed from hatching to 8th week, grower ration from 9th to 16th week and layer ration thereafter. Feed and water were given ad libitum. Sexing was done at 8th week and thereafter both the sexes were kept separately in growing pens. At 16th week of age, all the pullets were transferred to the individual laying cages, arranged in a three-tier system under open sided layer house. Lighting schedule in grower house was set to 14 hour light and 10 hour dark cycle (photoperiod; 06.00 to 20.00 h). At the beginning of 14 week, the length of photoperiod was successively increased and from 16 week of age a 16 L: 8 D light programme was applied, with lights on between 06.00 and 22.00 h. Light intensity at the height of bird's eye was about 30 lux. The management conditions were kept identical as far as possible for all the hatches. The study started when the hens began laying and continued until they reached the age of 40 weeks.

Sample size and recording of traits

Phenotypic performance of 1216 WL pullets were recorded for various layer traits. Body weight was recorded at the age of 16 week (BW16) and at 40 week (BW40) to the nearest of 10 gm accuracy. Average weight of 05 eggs laid by each pullet at 28 week of age (EW28) and at 40 week (EW40) were recorded to the nearest of 0.1 gm accuracy. The age at sexual maturity (ASM) was calculated for each pullet as the difference between the date of hatch and the date of her first egg laid.

Egg number of each pullet was recorded daily by observing the presence of an egg in individual laying cages at hourly intervals at specific period of the day. EN-1: Number of eggs laid in 24 h period. EN-2: Number of eggs laid in 06 h - 11 h (06 AM-11 PM) period. EN-3: Number of eggs laid in 06 h - 12 h (06 AM-12 PM) period. EN-4: number of eggs laid in 11h - 13h (11 AM- 01 PM) period. EN-5: number of eggs in 11 h - 17h (11 AM- 05 PM) period. EN-1 to EN-5 were recorded up to the age of 40 weeks all pullets. The oviposition time for every egg laid in the 06h - 17 h (06 AM-05 PM) period was noted in the data sheet by examining the laying cages of individual hens in each hourly intervals.

Eggs observed before 6 h (06 AM) or after 17 h (05 PM) were treated as the eggs of previous day or this day respectively. For all pullets, these eggs were marked as laid on 6h and 17 h respectively. Examination of cages was carried out twice in each hourly interval with cross checking from front to back of each cage to ensure that no egg was left unseen. At the age of 26 - 28 week, for a 15 day period, recording of egg laying was done in 30 minute intervals (half an hour) from 6 h - 17 h to further ascertain the nearest correct time of oviposition at peak production period.

Mean oviposition time (MOT) for each pullet was calculated by taking the simple arithmetic mean of oviposition time till 40 week of age (MOT 40) and for 15 days period (MOT 15). Oviposition interval is the time taken by a pullet to lay an egg in a sequence (Clutch). Oviposition interval (in hours) for each egg laid by individual pullet was calculated by subtracting the oviposition time of an egg from her subsequent egg within a sequence. A factor of 24 h was added in every calculation to arrive at the time taken by pullet to lay an egg. Because of preceding pause day, the oviposition interval for one egg sequences and for first egg in a sequence was incalculable. The mean oviposition interval was calculated till 40 week of age (MOI 40) and for 15 days period (MOI 15) by simple arithmetic mean of oviposition intervals. Clutch length and numbers were determined as per Blake and Ringer (1987). Clutch length is the number of eggs laid on consecutive days, without a pause. One egg sequences were also counted as a clutch. Average clutch length (ACL) for individual pullet was calculated by dividing the total number of eggs laid with the total number of clutches till 40 week of

age. Total clutch number (TCN) for each pullet was calculated from the data sheet by summing the clutches up to 40 week of age. The longest number of consecutive days in which there were ovipositions from onset of lay to 40 week of age was counted to get the maximum clutch length (MCL) or prime sequence length as described by Pavlidis *et al.* (2002). Total pause days (TPD) are the number of days when no oviposition was observed in the record of the pullet till 40 week of age. Average interval between clutches (AIC) was calculated by dividing the TPD with TCN. Soft shelled, broken, extremely small and one out of two eggs in a day was not considered for calculation.

Statistical analysis of data

As the chicks were obtained in more than one hatch, the data was corrected for significant hatch effects using mixed model least squares and maximum likelihood (LSMLMW) as per Harvey (1990). Only the hatch corrected data was utilized in further analysis. Mean, standard deviation (SD), standard error (SE) and coefficient of variation (CV) was calculated by LSMLMW, model IV (Harvey, 1990). Data was checked for skewness, kurtosis, median and range by using Microsoft statistical package (Microsoft office Excel, 2007). Though, varying degree of departure from normality was evident in traits, no transformations were applied. Frequency distributions were calculated for egg number, oviposition time and clutch lengths to study the distribution pattern of pullets in respective traits using Microsoft office excel 2007.

III. Results

Initial data contained observation on phenotypic performance of 1216 pullets, which was finally adjusted to 1082 pullets belonging to 50 sire and 283 dam families. The data was adjusted for missing sire, dam, individual performance records and pullets laid less than 20 eggs or died before 40 weeks of age, by deleting from the initial record. The mean sum of squares from analysis of variance to test the hatch effects revealed significant difference between hatches for most of the traits. The least squares hatch corrected mean, SD, SE and CV for various traits have been presented in table 1. The mean of EN-2 was found to be 67% of EN-1, which indicates that majority of eggs, was laid in early part of the day. SD and CV was more in EN-2 than EN-1. The mean value for MOT 40 and MOI 40 were 10.99 h and 24.34 h respectively. In spite of shorter recording period, 15 days MOT and MOI showed more variation in terms of SD and CV than MOT 40 and MOI 40. The reason may be more precise recording of oviposition time in half an hour intervals than one hour interval. In comparison to other traits, low values of SD and CV were observed in MOI which was expected because of the existence of 24 h barrier of light dark cycles (Yoo *et al.* 1986). The effect of selection over longer generations may have brought down the time to form an egg to around 24 hours. CV in all clutch traits was found to be more than the conventional as well as oviposition time traits.

The descriptive statistics of population mean for various traits have been shown in table 2 which indicates that ASM, EN-1, MOI, TCN, MCL, TPD and AIC have shown skewness and kurtosis of reasonable degree.

Large variation in range was observed for clutch traits. Highest range was observed for TPD and MCL. Frequency distributions of traits have been shown in fig 1 to 9. These figures show that within respective class intervals, pullets were not distributed uniformly. The distribution of EN-1 was more towards positive tail, indicating skewness of the population. More than 40% of the pullets were laying 120 to 135 eggs in EN-1. However, the distribution pattern of EN-2 was nearly normal, whereas, EN-3, EN-4 and EN-5 showed different patterns. From figure 2 to 5, it can be observed that the distribution pattern of egg production is quite different for early (EN-2 and EN-3) and late period of the day (EN-4 and EN5). Majority of the birds (25%) laying in the afternoon laid between 30 and 45 eggs, whereas, the majority (30%) laying in the morning laid between 75 and 90 eggs. Therefore, a positive skewness would be expected for a frequency distribution of the morning layers, given that these are mainly the better layers, and vice versa with the afternoon distribution. In early period, higher percentage of pullets were laying higher number of eggs, where as lower percentage of pullets were laying lesser number of eggs in later part of the day. The distribution pattern of EN-1 with respect to oviposition time was found to be nearly symmetrical (fig. 6) in 6 h -17 h of the day. From table 3, it is evident that 90% of ovipositions were completed before 13 h of the day. Mean oviposition time showed narrow range of distribution for both period of observation (fig. 6), however, comparatively more spread in distribution was observed for MOT 15 than MOT 40. Likewise MOI 40 and MOI 15 revealed very narrow range of distribution which led to peakedness of the distribution (fig.7). Distribution of flock for ACL and MCN was wider; however, deviation from normality was quite evident (fig. 8 and 9).

IV. Discussion

Present study was planned to record the distribution pattern of different egg production traits, especially oviposition time, oviposition interval and clutch traits with the possibility to use them as selection criterion in further studies. To achieve this objective, various traits were recorded at 29th generation of selection

in a layer flock and distribution pattern was analyzed through population means, descriptive statistics and frequency distributions.

The mean values for BW 16, BW40, EW 28 and EW 40 were comparable to the reports of Chatterjee *et al.* (2008) but higher than Bais *et al.* (2007). Mean of ASM was comparable to the findings of Bais *et al.* (2007) but lower than Chatterjee *et al.* (2008). Differences in mean value from the reported literature might be attributed to the differences in number of generations of selection, selection criterion and genetic architecture of the populations.

The mean values for EN-1 was higher than the findings of Devi *et al.* (2005), Baise *et al.* (2007) and Chatterjee *et al.* (2008) which might be due to differences in generations at which means were reported and differences in population. The SD for ASM, EW and EN-1 were in accordance with the results of Lillpers and Wilhelmson (1993). EN-2 and EN-5 were comparable with the findings of Noda *et al.* (2002), whereas; EN-3 and EN-4 were not comparable because of unavailability of reports.

The oviposition of eggs in different time intervals of the day was studied with the assumption that early laying birds are good layers (Lillpers, 1991). The mean oviposition time was found to be about 05 h after the onset of light period and about 13 h from onset of darkness. The results are in agreement with the reports of Yoo *et al.* (1986) and Noddegaard (1998). However, it varied from the findings of Lillpers (1991) which might be due to the difference in duration of light-dark cycles and difference in onset of darkness.

The extent of variability (CV) was found to be least in ovulation interval (MOI 40 and MOI 15) whereas, more in various clutch traits (ACL, TCN, MCL, TPD and AIC). The cause of low variability in ovulation interval may be the long generations of selection and 24 h barrier of light- dark cycles (Yoo *et al.* 1986). In addition, method of recording the ovulation interval in hourly intervals tends to reduce the spread of distribution. The spread of oviposition time and oviposition interval was more evident in half an hour than one hour intervals of recording. Mean and SD for oviposition intervals of this study were comparable to the findings of Sheldon *et al.* (1984) and Chen and Tixier-Biochard (2003 b).

The mean values for various clutch traits were in agreement with the observation of Johnston and Gous (2007). Similar results have been reported by Johnston and Gous (2007) for TCN, Bednarczyk *et al.* (2000) for ACL and Mc Clung *et al.* (1976) for AIC. However, Johnston and Gous (2007) have reported higher mean for MCL than the present study. The reason for difference in mean from the reported literature may be due to the method of measurement of different clutch traits, selection history and genetic architecture of the population. Internal ovulation, shell less eggs, soft shelled eggs, broken eggs and abnormally small eggs, if not counted in calculation of clutch length, then the ACL and MCL would decrease, whereas, TCN would increase.

It is normally assumed that in a large population, egg production traits follow normal distribution but often in long term selected population, traits deviate from normality as has been observed in figure 1 to 9. Traits like clutch and oviposition interval often tends to deviate from normality (Lillpers and Wilhelmson, 1993 and Chen and Tixier-Biochard, 2003 b). Continued selection for egg number over many generations makes the population skewed and kurtotic, if extremes of high and low values are not excluded from the data before computation of mean. Skewness is a measure of symmetry, or more precisely the lack of symmetry. A data set is symmetric if it looks same at the left and right corner of distribution graph. Kurtosis is a measure of whether the data are peaked or flat relative to the normal distribution. Data sets with low kurtosis tend to have a flat top near the mean rather than a sharp peak. It is evident from table 2 that ASM, EN-1, MOI, TCN, MCL, TPD and AIC have shown skewness and kurtosis of reasonable degree. Literature also confirms the presence of skewness in these traits (Yoo *et al.* 1986, Lillpers, 1991, Luc *et al.* 1996, Chen and Tixier-Biochard, 2003 b), though of smaller magnitude than the present findings. Data were not transformed to follow normal distribution, as the purpose was to estimate the variability in traits within the existing population structure. Large variation in range of clutch traits was observed, which has also been reported by Johnson (2000) and Johnston and Gous (2007) in actual experimental populations.

The distribution patterns of different traits have been further shown in figure 1 to 9, which repeats the deviation from normality. The pattern of distribution observed for EN-2 was similar to the findings of Noda *et al.* (2002). Similarly, the pattern observed for MOT, MOI and clutch traits were following the same trend as has been reported by Yoo *et al.* (1986) and Chen and Tixier-Biochard, (2003 b).

From present study, it becomes evident that EN-2 (early egg production) is having comparatively more variability than the traditional selection trait EN-1 and this trait may be utilized as principle trait either alone or in combination with other traits to improve the egg production further as has been demonstrated by Noda *et al.* (2002) through selection study. Similarly, oviposition time and average clutch length may become the potential trait to increase the egg production further due to greater variability than the traditional selection traits (Wolc *et al.* 2010). Further study on these traits in a large population is required with automated facility of recording oviposition time to validate these findings. Additional study on time dependent variations in layer traits would be useful in understanding the pattern of egg laying in a flock.

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Table1. Least squares means of hatch corrected data for various Layer traits

| Sl. No. | Traits | Unit | Mean | S.D. | S.E. | % C.V. |
|---------|--------|--------|---------|--------|------|--------|
| 1 | BW 16 | gm | 863.49 | 97.70 | 2.97 | 11.31 |
| 2 | BW 40 | gm | 1436.24 | 154.91 | 4.71 | 10.79 |
| 3 | EW 28 | gm | 45.91 | 2.81 | 0.09 | 6.11 |
| 4 | EW 40 | gm | 53.10 | 2.62 | 0.08 | 4.94 |
| 5 | ASM | Days | 140.35 | 10.97 | 0.33 | 7.82 |
| 6 | EN-1 | Eggs | 116.98 | 23.90 | 0.73 | 20.43 |
| 7 | EN-2 | Eggs | 78.29 | 27.48 | 0.84 | 35.10 |
| 8 | EN-3 | Eggs | 95.01 | 25.93 | 0.79 | 27.29 |
| 9 | EN-4 | Eggs | 26.51 | 15.05 | 0.46 | 56.76 |
| 10 | EN-5 | Eggs | 37.71 | 20.46 | 0.62 | 54.27 |
| 11 | MOT 40 | h | 10.99 | 0.76 | 0.02 | 6.89 |
| 12 | MOT 15 | h | 10.70 | 1.23 | 0.04 | 11.53 |
| 13 | MOI 40 | h | 24.34 | 0.34 | 0.01 | 1.39 |
| 14 | MOI 15 | h | 24.43 | 0.60 | 0.02 | 2.46 |
| 15 | ACL | Days | 11.10 | 6.57 | 0.20 | 59.20 |
| 16 | TCN | Clutch | 12.69 | 5.15 | 0.16 | 40.57 |
| 17 | MCL | Days | 38.15 | 21.66 | 0.66 | 56.76 |
| 18 | TPD | Days | 23.67 | 22.16 | 0.67 | 93.60 |
| 19 | AIC | Days | 2.20 | 3.63 | 0.11 | 164.76 |

Table 2. Descriptive Statistics of Population Means

| Sl. No. | Traits | Skewness | Kurtosis | Median | Maximum | Minimum |
|---------|--------|----------|----------|---------|---------|---------|
| 1 | BW 16 | -0.03 | 0.17 | 850.00 | 1200.00 | 500.00 |
| 2 | BW 40 | 0.25 | 0.95 | 1438.50 | 2000.00 | 800.00 |
| 3 | EW 28 | 0.01 | 0.41 | 46.03 | 56.47 | 35.90 |
| 4 | EW 40 | 0.02 | 0.07 | 53.03 | 63.00 | 42.00 |
| 5 | ASM | 0.75 | 1.16 | 140.00 | 185.00 | 114.00 |
| 6 | EN-1 | -2.05 | 4.44 | 123.00 | 153.00 | 20.00 |
| 7 | EN-2 | -0.17 | -0.45 | 78.00 | 148.00 | 6.00 |
| 8 | EN-3 | -0.87 | 0.67 | 99.00 | 148.00 | 9.00 |
| 9 | EN-4 | 0.50 | -0.05 | 26.00 | 79.00 | 1.00 |
| 10 | EN-5 | 0.37 | -0.26 | 37.00 | 109.00 | 1.00 |
| 11 | MOT 40 | -0.22 | 0.21 | 11.05 | 13.73 | 8.39 |
| 12 | MOT 15 | -0.07 | -0.12 | 10.71 | 15.46 | 7.13 |
| 13 | MOI 40 | 3.27 | 16.69 | 24.18 | 30.00 | 23.64 |
| 14 | MOI 15 | 2.59 | 10.29 | 24.24 | 26.71 | 23.75 |
| 15 | ACL | 0.78 | 0.77 | 12.00 | 36.00 | 2.00 |
| 16 | TCN | 2.81 | 14.50 | 9.84 | 66.00 | 1.54 |
| 17 | MCL | 1.22 | 1.77 | 33.00 | 131.00 | 5.00 |
| 18 | TPD | 2.66 | 7.29 | 17.00 | 130.00 | 1.00 |
| 19 | AIC | 7.09 | 72.69 | 1.24 | 58.00 | 0.45 |

Table 3. Distribution of egg production (%) with respect to oviposition time

| Oviposition Time (h) | Percentage production | Cummulative percentage production |
|----------------------|-----------------------|-----------------------------------|
| 06.00 | 0.73 | 0.73 |
| 07.00 | 1.78 | 2.51 |
| 08.00 | 3.88 | 6.39 |
| 09.00 | 14.31 | 20.70 |
| 10.00 | 24.53 | 45.24 |
| 11.00 | 21.92 | 67.16 |
| 12.00 | 14.54 | 81.70 |
| 13.00 | 8.52 | 90.23 |
| 15.00 | 7.75 | 97.99 |
| 17.00 | 2.00 | 99.99 |

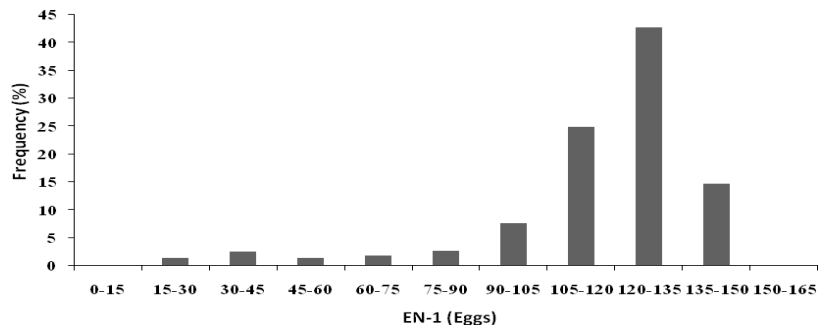


Figure 1. Frequency distribution of EN-1

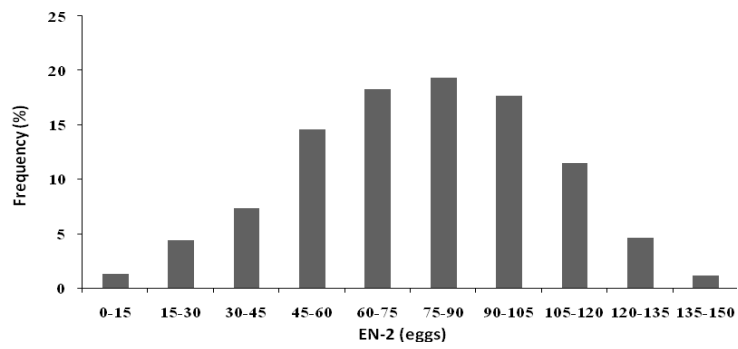


Figure 2. Frequency distribution of EN-2

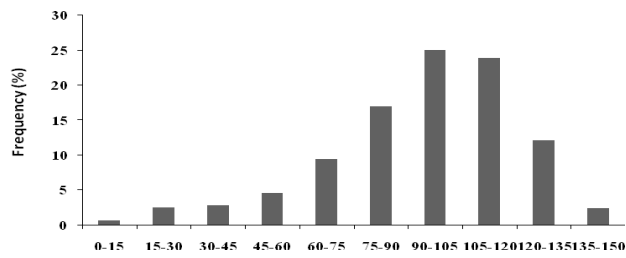


Figure 3. Frequency distribution of EN-3

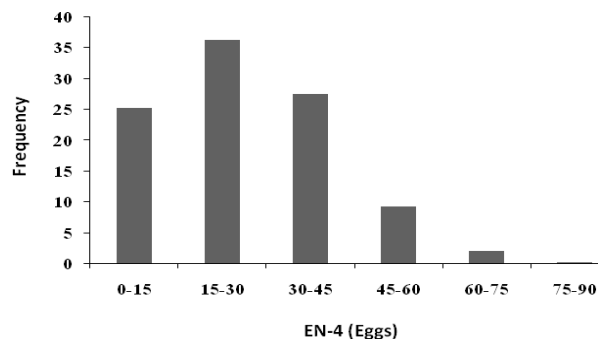


Figure 4. Frequency distribution of EN-4

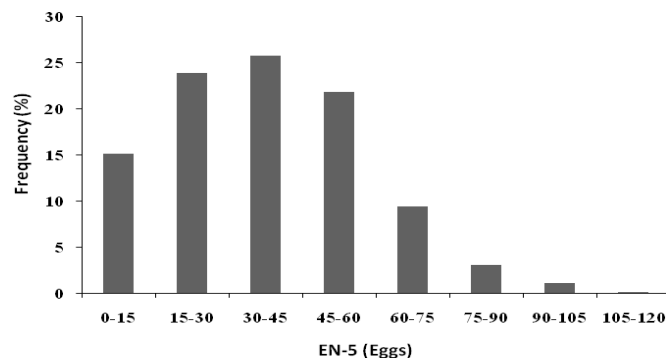


Figure 5. Frequency distribution of EN-5

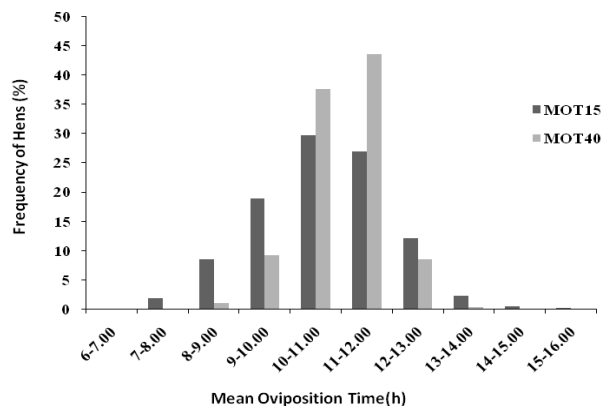


Figure 6. Frequency distribution of Mean oviposition time (MOT)

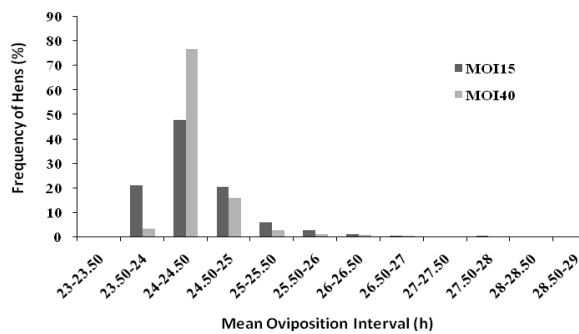


Figure 7. Frequency distribution of Mean oviposition interval (MOI)

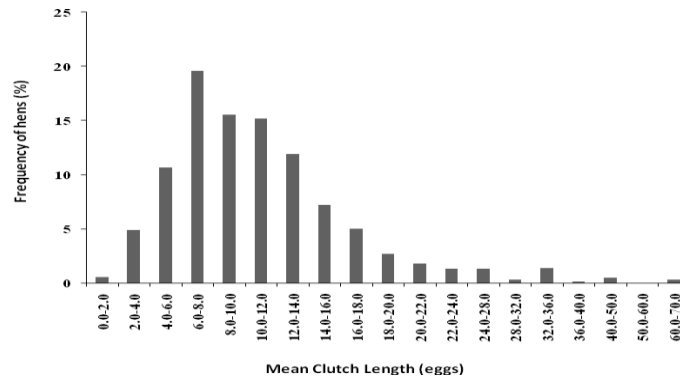


Figure 8. Frequency distribution of Clutch length (MCL)

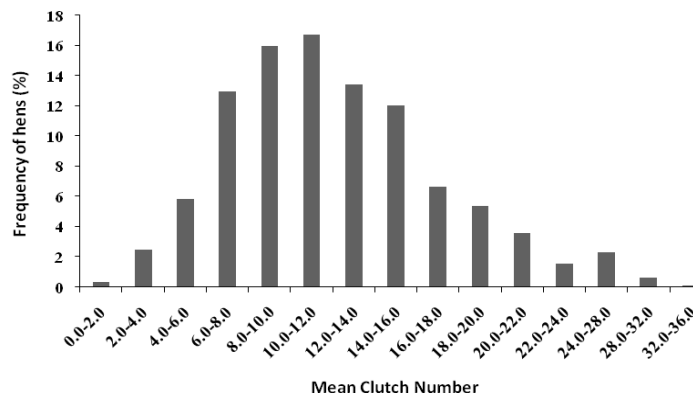


Figure 9. Frequency distribution of Average Clutch number (ACL)