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Use of mathematical modeling to evaluate production performance of some commercial layer strains under Khartoum State conditions (Sudan)

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Data from four commercial poultry farms was used to evaluate egg production of the layer hybrid strains Hyline W98 and Lohmman LSL under Khartoum state (Sudan) conditions in an open housing system. Production records of three flocks from each of the four farms were collected during the period 2005-2007. Two of these farms reared Lohmman LSL, while the other two farms reared Hyline W98 hybrid strains. Data on age at first lay, at 50% and at peak production, percentage at peak, mortality rate, feed intake, production period, egg weight and weekly egg mass were statistically analyzed using t-test and analysis of covariance. The egg production for each flock was regressed on time according to Wood's equation. No significant differences were observed between the two hybrid strains and their standard values in most of the production traits. The mortality rate of each layer strain was significantly higher than that of its standard manual. Hyline W98 feed consumption was significantly lower than that of Lohmman LSL. No significant differences between the two hybrid strains and their corresponding standard values in the production curve parameters. The study concluded that the two hybrid strains showed similar performance that was not different from their standard manuals indicating their good adaptability to the tropical environments. The formula of Wood's could precisely fit the data of egg production, and it can be used for prediction and evaluation of the total production depending on a part of production records.

Key words: Egg production curve, layers performance in tropics

Lohmman LSL is a German hybrid strain introduced to Sudan a long period ago. It is characterized by high productivity, good egg quality, white shell color and good one day old chick, but it has lower ability to tolerate high temperature and harsh environmental conditions compared to other hybrid strains. Hyline W98 and Hyline W36 are American hybrid strains introduced to Sudan recently. They are characterized by high productivity, high tolerance to harsh environmental conditions, they are smaller in body and egg size than Lohmman LSL. No intensive experimental work was reported on Hyline W98 hybrid strain under Sudan conditions.

The nature of any production process can be illustrated by a typical curve, the main features of which are increasing rate of yield in early production followed by a peak yield and thereafter steadily declining rate of yield for the remainder of the production period (Wood 1967 and Grossman *et al.* 2000). Described egg production trend in the tropics, Van Eekeren *et al.* (2004) stated that the production of a poultry stock rose quickly to a peak that maintained for some time and then decreased slowly. Fairfull and Growe (1990) reported that mathematical models can be used to forecast income and flock performance to evaluate theoretical expectations or to predict whole record performance based on part record egg production. Wolc *et al*. (2004) examined the goodness of fit of eight models describing production curves. They reported that Wood's model was one of the most adequate prediction of total production based on part record. They added that this model represented an additional phase called persistency which defined as the number of weeks during which peak production was maintained. This model was proposed by Wood (1967) for the milk yield curve. He subsequently demonstrated the parameters of the model those could be usefully related to the biological processes involved in milk production in order to

establish a biological foundation for the lactation curve.

The present study aimed to investigate the Hyline W98 and Lohmman LSL hybrid strains laying performance and some egg quality parameters under Khartoum conditions in comparison to the recommended standard values of both hybrid strains. The study also aimed to investigate the possibility of using a mathematical model to evaluate the production performance of the two hybrid strains of egg-type chicken under Sudan conditions.

MATERIALS AND METHODS

Data in the present study were collected during the period 2005-2007 from Gabis Company, Judiciary, Juba University and Matthew Company poultry farms to evaluate egg production performance of commercial layer hybrid strains under Khartoum State (Sudan) conditions in an open system of housing. Records of three flocks from each farm were used.

The laying performance traits data of Lohmman LSL hybrid strain were taken from the records of Gabis Company Poultry Farm (Khartoum) and Judiciary Poultry Farm (Khartoum North). Whereas, those of Hyline W98 hybrid strain were taken from the records of Juba University Poultry Farm (Khartoum North) and Matthew Company Poultry Farm (Umdurman). The values of the same traits were also extracted from the Hyline W98 Commercial Management Guide (2006) and Husbandry Manual of Lohmman LSL (2007).

The weekly hen day production percentage was regressed against the corresponding age (weeks) according to Wood (1967) equation: $y=ax^{b} \exp^{-cx}$, where, y was the hen day egg production/week, x was the age in weeks and *a, b, c* were constants describing the initial production, rate of increase to the peak and rate of decrease from the peak, respectively. From this equation, parameters as week of peak hen day production, peak hen day production and persistency of peak were calculated according to Wood (1967) and Cobby and Le Du (1978).

To assess the significance of differences between each hybrid strain and its standard measures, t-test for a single sample was used. The significance of differences between the two hybrid strains was examined using analysis of covariance taking the farm as a covariate (Gomez and Gomez, 1984).

RESULTS

The results of the studied production parameters of Hyline W98 and Lohmman LSL hybrid layer strains reared under Khartoum State (Sudan) conditions compared to their standard values are presented in Tables (1). The result showed that there were no significant differences ($P>0.05$) between the values obtained for the two layer strains and their corresponding standard values in age at first egg lay, age at 50% hen day production, age at peak hen day production, total feed intake until first lay, daily feed intake to end of production, production period, average egg weight at week 27, feed conversion ratio, egg mass at the week of peak and mortality rate up to the first lay. A significantly ($P<0.05$) higher mortality rate up to the end of production was found for the birds kept under Khartoum conditions when compared to their standard manuals.

Table (1) also illustrates the comparison of the laying performance parameters of the two hybrid strains under Khartoum state conditions. The results showed that there were no significant differences between the two hybrid strain for all parameters except the total feed intake until lay and daily feed intake up to end of production. Hyline W98 birds showed significantly ($P<0.05$) lower values than Lohmman LSL in both parameters.

The results of production curve parameters (Table 2) showed that the two hybrid strains were not different significantly from their manuals standard values in initial hen day production, rate of increase to the peak, rate of decrease from the peak, week of the peak, predicted peak and persistency of the peak production. The results also showed that there were no significant differences between the two hybrid layer strains for the components of the production curve.

All of the regressions of the average weekly production hen day percentage of each hybrid strain were significant and precisely explained the relation between hen day production percentage and age as shown by the high coefficients of determinations (r^2). The obtained equations were: $y = 40.48 \times^{0.442} e^{-0.023x}$ ($r^2 = 0.87$) for the standard manual of Lohmman; $y = 34.16 \times^{0.466} e^{-0.026x}$ ($r^2 = 0.86$) for the Lohmman hybrid strain; $y = 30.88 \times^{0.545} e^{-0.026x}$ ($r^2 = 0.67$) for the standard manual of Hyline W98 and $y = 30.45 \times^{0.491} e^{-0.025x}$ ($r^2 = 0.65$) for the Hyline W98 hybrid strain.

Table1: Laying performance parameters of Hyline W98 and Lohmman LSL layers under Khartoum state conditions and their standard manuals values

Trait	Hyline	Hyline S.M.	SE1	LS1	Lohmman	Lohmman S.M.	SE2	LS2	SE3	LS3
No. of flocks	6				6	-	-	-	-	-
Age at first lay, days	118.0	119.0	1.00	Ns	120.5	126.0	3.50	Ns	3.63	Ns
Age at 50% hen day, days	153.0	138.0	8.00	Ns	140.5	147.0	1.50	Ns	8.14	Ns
Age at peak of production, days	206.0	196.0	21.0 0	Ns	189.5	210.0	2.50	Ns	21.04	Ns
Peak hen day %	86.3	93.5	5.90	Ns	84.3	94.0	2.90	Ns	6.57	Ns
Mortality rate until first lay	3.0	2.0	0.06	Ns	3.4	2.5	1.80	Ns	1.80	Ns
Mortality rate up to end of production	15.9	7.0	14.4 0	*	11.1	5.0	3.75	*	4.88	Ns
Total feed intake until first lay, kg/ bird	4.9	5.5	0.07	Ns	7.2	7.2	0.40	Ns	0.41	*
Daily feed intake up to end of production, g/bird/day	88.8	98.0	3.80	Ns	105.5	110.0	0.50	Ns	2.82	*
Production period, day	413.0	420.0	9.00	Ns	410.0	420.0	28.0	Ns	26.40	Ns
Egg weight at week 27, gm	50.7	57.8	2.70	Ns	56.7	59.6	1.35	Ns	3.20	Ns
F.C.R., kg feed/kg eggs	1.8	1.8	1.00	Ns	2.2	2.0	0.04	Ns	0.02	Ns
Weekly egg mass (at week 27), kg Eggs/bird	0.31	0.37	0.03 8	Ns	0.33	0.39	0.004	Ns	0.037	Ns

In this table and the following:
SE1 = Standard error of Hyline W98 strain and its manual means; SE2 = Standard error of Lohmman LSL W98 strain and its manual means; SE3 = Standard error of Hyline W98 and Lohmman LSL W98 strains means.
LS1 = Level of significance for the difference between Hyline W98 strain and its manual; LS2 = Level of significance for the difference between Lohmman LSL strain and its manual; LS3 = Level of significance for the difference between Hyline W98 and Lohmman LSL strains.
Ns = Not significant (P>0.05); * = significant (P<0.05)

Table 2: Production curve parameters of Hyline W98 and Lohmman LSL layers hybrid strain under Sudan conditions "Khartoum state" and their standard values

Trait	Hyline	Hyline S.M.	SE1	LS1	Lohmman	Lohmman S.M.	SE2	LS2	SE3	LS3
No. of flocks	6				6	-	-	-	-	-
a	30.5	30.9	9.38	Ns	34.1	40.5	4.39	Ns	4.36	Ns
b	0.49	0.55	0.02	Ns	0.47	0.44	0.12	Ns	0.36	Ns
c	0.025	0.026	0.02	Ns	0.69	0.023	0.04	Ns	0.043	Ns
Week of the peak	27.9	20.6	4.77	Ns	17.8	19.5	1.05	Ns	7.81	Ns
Peak H.D.%*	82.4	93.1	4.80	Ns	81.9	96.6	3.51	Ns	5.95	Ns
Persistency of peak of production	5.8	5.6	0.87	Ns	5.3	5.4	0.67	Ns	0.87	Ns

a = Initial egg production
b = Rate of increase to the peak
c = Rate of decrease from the peak

The week of the peak = $\frac{b}{c}$

* The predicted peak percentage
Persistency of peak production (weeks) = -(b+1)Ln*c*

DISCUSSION

The two layer strains (Hyline W98 and Lohmman LSL) started laying eggs at the same (P>0.05) age stated in their manuals. The age at first lay observed for the two strains is (16.86 and 18 weeks for Hyline W98 and Lohmman LSL, respectively) consistent with those reported by Van Eekeren *et al.* (2004). They noted that in tropical countries where the poultry industry is well-developed, the hens start laying when they are about 20 weeks of age.

However Lohmman LSL reached 50% hen day egg production at age similar to that stated in its manual, Hyline W98 reached this percentage at an older age than its standard value, but the difference was not significant. This might be due to the effect of heat stress in an open house (North 1984; Etches 1996).

Although, the egg production percentage at peak production for both hybrid strains was lower than the standard values (-7% for Hyline and -10% for Lohmman) the differences were not significant. These low production percentages might be due to the stress of the environmental conditions of the open house in which the hybrid strains were raised (Emery *et al*., 1984). They reported that laying performance parameters and egg quality were affected by the housing conditions, particularly the ambient temperature. The effect of the environmental conditions of the open house was also reflected on the feed intake of both hybrid strains which was lower than that of

their corresponding standard values. Consistently, the production period and egg weight of the hybrid strains were lower than those of their corresponding standard values but the differences were not significant (P>0.05). This might be due to the small number of samples (flocks) available. Mortality rate up to the end of the production cycle was higher for both hybrid strains than their corresponding standard values. This might be due to the lower biosecurity measures and poor hygienic conditions. It is well known that the flocks maintained at optimal stocking density under good hygienic conditions perform better than those kept under poor hygienic condition (Etches 1996).

When comparing the performance traits of the two layers strains with each others, the Lohmman LSL was observed to consume significantly (P<0.05) higher amount of feed than Hyline W98. Whereas, egg weight tended to be better for Lohmman LSL (56.7g) than Hyline W98 (50.7g). This might be associated with the strain genetic differences. The production model described by Wood (1967) has high goodness of fit (r^2 ranged between 0.65 and 0.87) with higher precision for Lohmman LSL strains. There were no significant differences in initial egg production (a), rate of increase to the peak (b), rate of decrease from the peak (c), the week of the peak, the predicted peak and the persistency of peak production between the hybrid strains and their manual values. Also there was no significant difference in the above mentioned parameters between the two hybrid strains. The similarity in the values of b and c constants indicated the similarity in the shape of the production curve and the persistency of production (Tekerli *et al.*, 2000).

The study concluded that Hyline W98 and Lohmman LSL hybrid strains have an acceptable production performance when reared in an open sided deep litter house under Khartoum conditions compared to their standard manuals. Also it is note worthy that Wood (1967) equation can be used with satisfactory precision to predict the laying performance for whole production period based on part records of the production cycle.

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