EDUCATION AND PRODUCTION

Use of Hatch Date for Broiler Breeder Production Planning

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ABSTRACT Data on 109 batches of broiler breeders belonging to six strains and bred in conventional sheds were analyzed to determine the possible influence of natural day length cycle phase on age at start of laying, at sexual maturity, and at peak egg production. The dependence of these variables on date of hatching was characterized by polynomial regression analysis. The resulting equations constitute simple, novel empirical models that are in keeping with current theory on the effects of photoperiod on sexual maturation, and should facilitate production planning in broiler breeder farms.

(*Key words*: broiler breeder, production, start of laying, sexual maturity, peak egg production)

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INTRODUCTION

Broiler breeders are managed in batches of thousands of birds hatched on the same day. A batch is conventionally deemed to have begun laying when 5% of the birds are laying, and to have reached sexual maturity when 50% of the birds are laying (Christmas *et al*., 1979; Wilson *et al*., 1983; Charles and Tucker, 1993). The factors determining the time taken to mature are only partially understood. A *sine qua non* for laying to begin is a certain minimum weight (Dunn and Sharp, 1992), although no clear relationship with feed composition has been established (Summers and Lesson, 1983). In addition, photoperiod has a decisive influence (Sauveur, 1992; Ernst and Millam, 1987). Rose (1997) states that age at sexual maturity is given by the cubic expression:

$$\text{Age at sexual maturity} = \text{General average for strain} - 1.61\ P + 0.00006\ P^2 + 0.001918\ P^3 \quad [1]$$

where P = photoperiod used; that maturation time is reduced if photoperiod increases during rearing; and that this reduction is more marked, the closer the birds are to maturity when the increase occurs. Egg production exhibits an annual cycle that leads the cycle of natural day length (Sharp *et al*., 1992; Sharp, 1993).

For birds bred in conventional houses under a mixture of artificial and natural light, Equation 1 is no longer valid. Under these conditions, batch maturation time exhibits considerable variability that is not explained by differences in artificial photoperiod. Hypothesizing that this variability must be due to the seasonal variation in the natural component of their lighting, and with a view to aiding the improvement of production, in this work we obtained empirical equations for the influence of date of hatch on the age at onset of laying, age at attainment of sexual maturity, and age at peak egg production of broiler breeder batches bred in conventional houses. The results are discussed with reference to theories of the effects of photoperiod on sexual maturation.

MATERIALS AND METHODS

We studied 109 batches of broiler breeders raised from 1 d of age in conventional houses in Ourense, northwestern Spain (41°52′-42°37′ N, 3°10′-4°35′ W). The batches were hatched between January and December (Table 1), and belonged to six strains: Arbor Acres (41 batches), Ross (20), Peterson (18), Hubbard (11), Studler (10), and Cobb (9); the total number of birds was 475,116 (52,758 males and 422,358 females). Artificial lighting was as usual for the interior of conventional houses (Laughlin, 1994). At 20 wk of age, all batches were transferred to laying houses and the birds were provided 14 h of light or natural day length, whichever was greater, with 0.5-h increases every week until a maximum of 17 h of light was reached. This day length was maintained during the entire production period. For each batch, we recorded date of hatching (x) and, from 20 wk of age, daily laying data and mortality of males and females. These data were used to determine onset of laying, attainment of sexual maturity, and peak egg production for each batch. The possible influence of strain was investigated by one-way analysis of variance, after which the data were subjected to polynomial regression analyses with (x) as independent variable; the statistical analyses were performed using StatView 4.0 for Macintosh and Statgraphics 5.0 for PC.

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TABLE 1. Dates of hatching of the broiler breeder batches studied. When more than one batch was hatched on the same day, the number of batches hatched is shown in parentheses

Month	Day
January	4, 8, 9, 13, 20
February	3, 12, 16, 23, 26
March	2, 5, 6, 15 (2), 17 (3), 25 (2), 26
April	1, 6, 14, 16 (3), 19, 21 (3), 25, 26, 28
May	2 (2), 10, 13, 15 (3), 21, 27
June	3 (3), 5 (2), 7 (3), 17 (4), 19 (2), 24 (4), 29 (3)
July	1, 9 (4), 10, 11 (3), 21
August	8, 9, 11, 21, 26, 27, 28
September	3, 8, 15, 24, 25, 26 (2), 29 (2)
October	2, 10, 11, 19, 22, 30
November	10, 19 (2), 20, 24, 27, 29
December	3, 4 (2), 6, 11, 16

TABLE 2. Means and ranges of the ages of broiler breeder batches reared in conventional houses at onset of lay, sexual maturity, and peak egg production

	Onset of lay		Sexual maturity		Peak egg production	
Strain	Mean	Range	Mean	Range	Mean	Range
	(wk)					
Peterson	25.89	23 to 29	29.17	26 to 32	33.06	30 to 36
Studler	26.80	22 to 29	30.00	25 to 32	33.80	29 to 37
Hubbard	26.45	24 to 28	29.55	27 to 32	34.18	31 to 38
Ross	26.25	23 to 29	29.05	26 to 32	33.45	30 to 38
Arbor Acres	26.41	24 to 29	29.54	26 to 32	33.78	29 to 37
Cobb	25.89	23 to 29	28.78	26 to 33	33.00	29 to 37
Total	26.29	22 to 29	29.37	25 to 33	33.58	29 to 38

TABLE 3. Results of one-way analysis of variance to evaluate the influence of strain on the ages of broiler breeder batches reared in conventional houses at onset of lay, sexual maturity, and peak egg production

		Onset of lay		Sexual maturity		Peak egg production	
	df	Sum of squares	Mean squares	Sum of squares	Mean squares	Sum of squares	Mean squares
Strain	5	7.91	1.58	11.39	2.28	14.43	2.89
Residual	103	332.70	3.23	439.93	4.27	592.16	5.75
TOTAL	108	340.61		451.32		606.59	
		F test	*P* =	*F* test	*P* =	*F* test	*P* =
		0.49	0.78	0.53	0.75	0.50	0.77

TABLE 4. Results of fitting cubic equations to the observed data for the influence of date of hatch on the ages of broiler breeder batches reared in conventional houses at onset of lay, sexual maturity, and peak productivity

		Onset of lay		Sexual maturity		Peak egg production	
Polynomial regression							
R		0.886		0.875		0.856	
R^2		0.786		0.765		0.732	
Adjusted R^2		0.780		0.759		0.725	
RMS Residual		0.834		1.004		1.243	
Beta coefficient table							
Intercept		24.190		27.865		32.266	
X		0.0924		0.0913		0.0982	
X^2		–0.001		–0.001		–0.001	
X^3		0.000001		0.000001		0.000001	
		ANOVA					
	df	Sum of squares	Mean squares	Sum of squares	Mean squares	Sum of squares	Mean squares
Model	3	267.63	89.21	345.47	115.16	444.23	148.08
Residual	105	72.98	0.70	105.86	1.01	162.36	1.55
TOTAL	108	340.61		451.32		606.59	
		F test	*P* =	*F* test	*P* =	*F* test	*P* =
		128.35	0.0001	114.22	0.0001	95.76	0.0001

RESULTS AND DISCUSSION

Onset of laying ranged from 22 to 29 wk, sexual maturity from 25 to 33 wk, and peak egg production from 29 to 38 wk, with means of 26.29, 29.37, and 33.58 wk, respectively (Table 2). There was no significant dependence of any of the three variables on strain (Table 3). The data were then satisfactorily fitted by the following cubic equations (Table 4):

Onset of laying =
$24.19 + 0.092x - 0.001x^2 + 1.056 \times 10^{-6}x^3$
Sexual maturity =
$27.865 + 0.091x - 0.001x^2 + 1.132 \times 10^{-6}x^3$
Peak egg production =
$32.266 + 0.098x - 0.001x^2 + 1.275 \times 10^{-6}x^3$

where onset of laying, sexual maturity, and peak egg production were measured in weeks and x in days from January 1 (x = 1) to December 31 (x = 365). The corresponding curves run almost parallel (Figures 1 to 3).

The batches taking longest to develop were those hatched in late March or early April, which began to lay only after 28 wk (in mid-October), attained sexual maturity at 31 wk of age (in November), and reached peak egg production at 36 wk of age (in the second fortnight in December). These batches were hatched during the weeks of rapidly increasing natural day length and reached 20 wk of age in the second fortnight in August, when day length was declining; their retarded attainment of sexual maturity preceded the winter solstice.

Retardation declined with increasing x until batches hatched in late June or early July had onset of lay, sexual maturity, and peak egg production values near the means for the study. The birds began to lay in late December or early January, attained sexual maturity at the end of January, and reached peak egg production at the end of February. Hatched immediately after the summer solstice, these batches reached 20 wk of age in the second fortnight in November; thus, all their preadult growth took place during the period of continuously decreasing natural day length, and their productive life began when the photoperiod of the natural component of their lighting began to increase again.

Batches hatched at later times during summer and autumn were increasingly sexually precocious, until those hatched in late October or early November began to lay after only 23.5 wk (in the second fortnight in April) and attained sexual maturity and peak egg production in May after 26.5 and 30.2 wk, respectively. These batches were hatched during the weeks of rapidly decreasing natural daylength and reached 20 wk of age in the second fortnight in March; their precocious

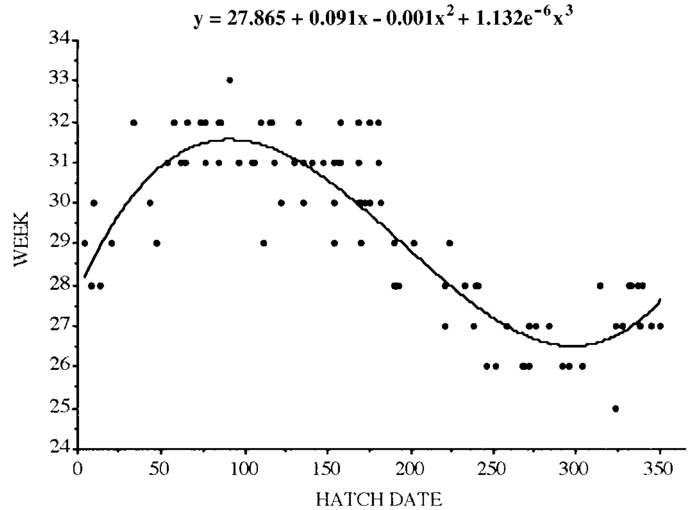

FIGURE 2. Age of broiler breeder batches bred in conventional houses at sexual maturity, plotted against date of hatching in days.

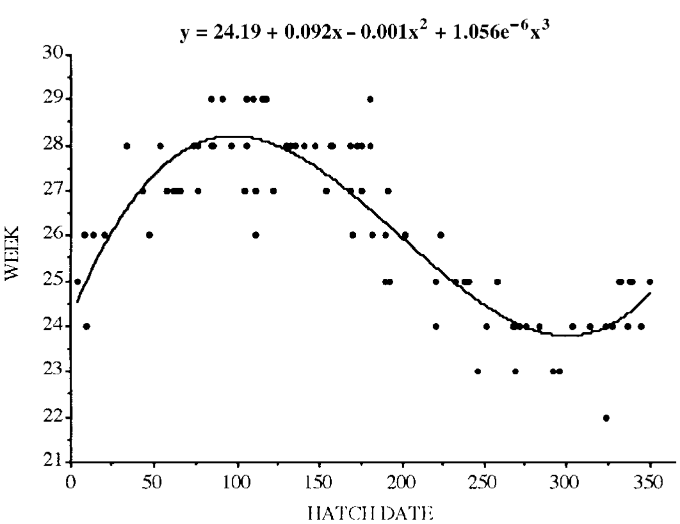

FIGURE 1. Age of broiler breeder batches bred in conventional houses at onset of laying, plotted against date of hatching in days.

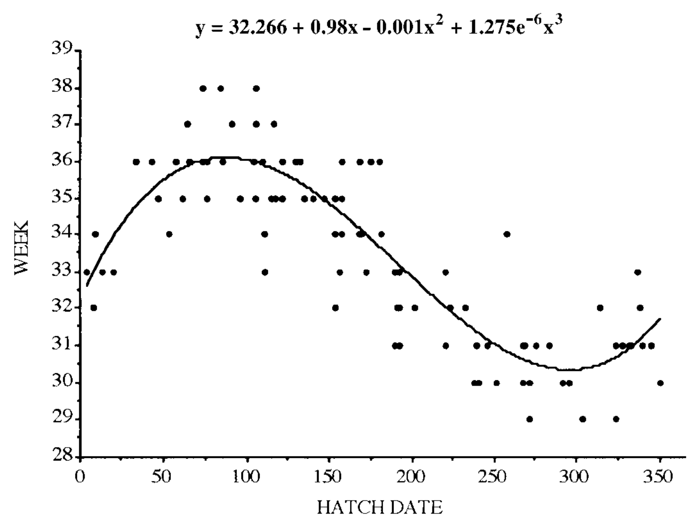

FIGURE 3. Age of broiler breeder batches bred in conventional houses at peak egg production, plotted against date of hatching in days.

attainment of sexual maturity was due to increasing external photoperiod preceding the summer solstice.

In batches hatched after mid-November, precocity declined progressively until those hatched in late January or early February had onset of lay, sexual maturity, and peak egg production values near the means for the study. These birds began to lay in early or mid-August, attained sexual maturity at the end of August, and reached peak egg production at the end of September. Hatched not long after the winter solstice, the preadult growth of these latter batches virtually all took place during the period of continuously increasing natural day length.

The above results, showing that the batches developing slowest and fastest reach sexual maturity shortly before the winter and summer solstices, respectively, appear to be in keeping with previous reports that the annual cycle of egg production leads the cycle of natural day length (Sharp *et al.*, 1992; Sharp, 1993). The results contradict models in which maturation is necessarily accelerated by increasing daylength and slowed by decreasing day length, according to which the fastest- and slowest-developing batches should be those hatched at or shortly after the winter and summer solstices, respectively. In the present study, batches hatched at these times were neither the most retarded nor the most precocious. The absence of marked precocity in batches hatched at the beginning of the year may be attributed to the onset of photorefractoriness induced by prolonged exposure to long days (Sharp, 1993), and the mechanisms of photorefractoriness can likewise explain the absence of marked retardation in batches hatched at or shortly after the summer solstice.

For broiler breeders bred in conventional houses with artificial in-house lighting in the same latitudes as Ourense, equations allow age at the onset of laying, at sexual maturity, and at peak egg production to be predicted from the date the batch hatched. These equations are in keeping with current theory on the influence of photoperiod on sexual maturation, and should aid production planning and the optimal use of labor and facilities on commercial poultry farms.

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