The short-term effects of delayed feeding (DF) for 2 d posthatching were measured in neonate chicks and compared to early feeding (EF). Chicks from 10 independent families were used in this study to determine whether genetic background control of growth may be influenced by EF and DF. Early feeding maintained significant interfamily body weight variations from hatch to 4 d of age, whereas there were no significant differences from 1 d of age when feeding was delayed to 48 h posthatching. These results suggest that posthatching feeding delay may distort genetic selection by masking the expression of genetic potential and disturbing the estimation of chick breeder value. In DF chicks, overall body growth was delayed until the beginning of feeding and body weight at 6 d of age was 25% lower than EF chicks.

(Key words: neonate feeding, genetics, growth, intestine, skeletal muscle)

INTRODUCTION

Broilers now reach slaughter weight physiologically younger and the first week after hatching represents a larger proportion (20%) of the whole life span. Due to improvements in diets and genetic selection, morphologic changes are emphasized between different genetic types (broiler and layer type birds) and between lines selected for different growth rates with the same genetic background (Nitsan et al., 1991b; O’Sullivan et al., 1992; Remignon et al., 1994; Dunnington and Siegel, 1995; Siegel et al., 1997). Body weight is increased two- to threefold during the first week and considerable changes in gut and muscle weight and morphology are observed (Moss, 1968; Murakami et al., 1992; Duclos and Remington, 1996; Jin et al., 1998). Gastrointestinal development plays an essential role in the early stages of chick growth (Nitsan et al., 1991a; Nir et al., 1993; Dibner et al., 1996). In practice, hatching and transportation procedures delay the feeding of chicks by 10 to 60 h (Noy and Sklan, 1999a). Nutrients in the residual yolk not used during fetal life are supposed to supply the lack of food during the fasting period. However, they represent an insufficient contribution to the nutritional requirements for both maintenance and growth in today’s broiler chicks (Bigot et al., 2001). Delayed feeding (DF) in the first few days of life reduces final BW (Noy and Sklan, 1999a), and it probably affects immunological capacities (Dibner et al., 1998). Early posthatching feeding is recommended to reduce the effects, for example, adding food in transportation boxes. On the other hand, it may be possible to develop “new” diets which could partially or totally overcome the consequences of DF. It is thus necessary to understand precisely the consequences of DF on intestine and muscle development. The aim of the experiments was to study the effects of early and 48 h posthatching DF on both body growth and intestine and muscle development during the six first days posthatching of chicks. Because the exact age of chicks is not precisely known in most genetic selection studies, we have examined whether delayed feeding may actually influence interfamily variation in BW.
MATERIALS AND METHODS

Equipment and Hatching Conditions

Two independent rooms were environmentally conditioned in an experimental poultry shed. Temperature in the hatching room was maintained at 32 ± 1 C (room 1); relative humidity was maintained at 75 ± 5% to simulate hatchery conditions. Ten pierced metal boxes containing 30 eggs each were placed in room 1. Twenty-eight floor pens (30 cm × 30 cm) for 10 growing chicks were installed in room 2 (32 ± 1 C). Pen floors were covered with wood shavings and equipped with a feeder and a watering place to provide free access to food and water. Fourteen pens were identified as A pens and fourteen as B pens.

Animals

Fertile pedigree broiler eggs (n = 285) were collected from 10 independent families (1 sire + 4 hens). Eggs were incubated under regular conditions (37.7 C, 45% RH) in an incubator at the Station de Recherches Avicoles (INRA, Tours).

One egg per family was sampled for embryo measurements on d 19 of incubation (n = 10), and on d 20, the remaining 275 eggs were transferred to the boxes in room 1 where hatching was observed by video. The hatching hour was noted, and only chicks hatched from 2000 h (Nov. 23, 2000) to 0800 h (Nov. 24, 2000) were used for experiments (n = 175). Chicks were identified with a leg tag immediately after hatching and weighed. Two chicks descended from the same family and hatched approximately at the same time were assigned to pens A and B, respectively. Pens from each group were progressively filled with 10 chicks before proceeding to the next pen. Thus, 9 A pens and 9 B pens were used for the experiment.

Chicks in A pen (n = 89, early feeding group) were fed ad libitum 6 h after hatching (time required for chicks to dry) with a balanced starter diet containing 2,900 kcal/kg metabolizable energy and 22% crude protein. Chicks in B pen (n = 86, DF group) remained for 2 d, i.e., 54 h (48 + 6 h) after hatching without food before receiving the same diet. Both groups had free access to water from hatching.

Procedure

The 10 eggs sampled for embryo measurements were opened, embryos were removed, weighed, and pectoralis major muscles (left and right) were excised and stored at −80 C. Individual BW, tissue weights, and pen feed consumption were recorded in relation to the hatching time, so that ages at which measurements were taken corresponded to hatching time ± 2 h.

Experiment 1. Growth analysis was performed on 83 chicks (47 EF chicks and 36 DF chicks). They were weighed at hatching and at 1, 2, 3, 4, and 6 d of age.

Experiment 2. Ten chicks were removed at 6 h of age (age 0), and one chick for each family was selected from EF and DF groups at 1, 2, 3, and 4 d of age according to their biological age (n = 80). Chicks were killed by decapitation and yolk sacs and pectoralis major muscles (left and right) were removed and weighed. The first 10 cm of the jejunum were quickly excised, opened to eliminate gut content, washed in saline buffer solution, and briefly dried on absorbent paper then weighed. Tissues were immediately frozen in liquid nitrogen and stored at −80 C.

Analytical Methods

Frozen muscles were ground in liquid nitrogen and homogenated in 2% HClO4 according to the Schmidt-Thannhauser method as modified by Munro and Fleck (1969). Protein content was measured according to Smith et al. (1985) by the colorimetric reaction with bichonichinic acid.2 Total RNA was measured on the basis of the ultraviolet absorbance at 260 nm with a correction for peptide material based on the ultraviolet absorbance at 232 nm. The ribosomal capacity (mg RNA/g protein), i.e., the capacity for protein synthesis, was estimated as the ratio of RNA to protein because most of the RNA present in times is of the ribosomal form (Tesseraud et al., 1996). The DNA level was measured on the basis of the difference between absorbance at 595 nm and absorbance at 700 nm according to the Burton diphenylamine method as modified by Gilles and Myers (1965).

Calculation

Food intake per chick was determined as food intake per pen/number of animals per pen and expressed as grams per day per 100 g BW (relative food intake).

Experiment 1. Individual exponential growth curves were fitted to our data, as in Brody (1945):

\[ BW_h = BW_0 e^{ah} \]

where \( BW_h \) was BW at age h (in h), \( BW_0 \) the estimated BW at hatching, and parameter a the specific growth rate, as \((1/BW_h) \) (dBW/dh) is equal to a. Growth curves were fitted with a nonlinear regression (PROC NLIN, SAS, 1989). Observations were weighted by the inverse of the phenotypic variance of BW at age h in each group (EF or DF), as suggested by Pasternak and Shalev (1994). All available data were used in the EF group. However, as the DF group did not grow until fed, we only included weights recorded after 48 h, i.e., when chicks began to grow. We also applied a translation to their data, thus treating BW at hour in the DF group as a BW at \((h − 48)\) hour in the EF group. For example, if an animal weighed \( x \) g at hatching, \( x \) at 24 h, \( x \) at 48 h, \( x \) at 72 h, \( x \) at 5 at 96 h, and \( x \) at 144 h, these raw data were used to model the growth function if the animal pertained to the EF group. However, if it was in the DF group, a growth function was fitted upon the following data: \( x \) at hatching.
ing, × 4 at 24 h, × 5 at 48 h, and × 6 at 96 h, i.e., weights recorded after 48 h of age and by decreasing the chronological age by 48 h.

Statistical Analysis

Values are given as means with standard errors. In Experiment 1, statistical analysis was performed by ANOVA with repeated measures for BW, relative daily BW gain, and relative daily food intake. The nonparametric Wilcoxon test was used in growth analysis to test the significance of the group effect in BWo and a. Data in Experiment 2 were analyzed using ANOVA, and means were compared by Student-Newman-Keuls test to define the differences between the groups. These analyses were performed using the Stat View Software program (Abacus Concepts, 1996, Inc., Berkeley, CA 94704-1014) and PROCMEANS (SAS, 1989).

RESULTS

Growth

**Experiment 1.** Food deprivation for 2 d posthatching reduced BW of DF chicks by about 7% compared with their hatching weight (not significant), whereas BW increased by 36% in EF chicks during the same period (Figure 1A, P < 0.001). One day of feeding after 2 d of starvation induced rapid and significantly higher BW gain in DF chicks (25.7 ± 0.45 g/d per 100 g BW, Figure 1B) than in EF chicks between 2 and 3 d of age (20.44 ± 0.35 g/d per 100 g BW). At one and two days of age, EF chicks were 15 and 30% heavier than DF chicks, respectively, whereas BW after 2 d of feeding resulted in heavier DF chicks compared to EF chicks (+8 g, P < 0.01). Differences in BW caused by the 2 d posthatching fasting were maintained until 6 d of age and averaged 34.1 g (EF = 133.8 ± 1.9 g, DF = 99.7 ± 1.7 g), i.e., 25% relative value. Delayed feeding decreased feed intake from 3 to 6 d of age compared to EF chicks (P < 0.001, data not shown). When feed intake was expressed in relative to BW (Figure 2), the proportion of feed intake in each group was not changed from 3 to 4 d of age and remained higher in EF than in DF chicks, whereas the proportion of feed intake in DF chicks was increased at 6 d of age and then was greater (P < 0.05).

Growth analysis was performed from hatching to 6 d of age in the EF group and from 2 to 6 d of age in the DF group using exponential growth curves. The BW0 was not different between DF and EF groups (43.9 ± 4.0 and 42.4 ± 3.9, respectively, P = 0.14), which was consistent with the fact that DF chicks weighed as much at 2 d of age as EF chicks at hatching. In contrast, the specific growth rate (parameter a) was higher in the DF than in the EF group (8.9 × 10⁻³ ± 0.8 × 10⁻³ and 8.0 × 10⁻³ ± 0.6 × 10⁻³, respectively, P < 0.001).

**Experiment 2.** Individual BW and relative daily BW gain measured from hatching to 4 d of age in chicks used for tissue sampling were similar to those measured in Experiment 1 (Figures 1C and 1D). Briefly, EF chicks were heavier than DF chicks until 4 d of age and differences in BW averaged 23 g. The DF chicks lost approximately 5% of their hatching weight during the 2 d posthatch of feed deprivation. Relative daily BW gain increased after they received feed and reached similar values as those measured in EF chicks at 4 d of age.

The effect of family on BW were analyzed using all EF and DF chicks for experiments 1 and 2. The BW means per family are presented in Table 1. Family-related differences in BW within the EF group remained significant from birth to 4 d of age. One day of feed deprivation maintained these differences in the DF group, but they were less marked than in the EF group at the same age (P = 0.05 in DF group vs. P = 0.0013 in EF group). Before the beginning of the feeding period, BW was not different between DF families (P = 0.0819 at 2 d of age). In this group, feed availability did not reestablish family-related differences in BW, and no significant interfamily variation of BW was observed from 2 to 4 d of age in the DF group.

Organ and Tissue Development

(Experiment 2)

**Yolk Sac Resorption.** Yolk sac resorption was similar in EF and DF chicks during the first 3 d posthatching (Figure 3). However, at 4 d of age yolk sac weight was slightly higher in EF chicks than in DF chicks (EF = 1.13 ± 0.13 g, DF = 0.75 ± 0.07 g, P = 0.021).

**Intestinal Growth.** Only changes in a 10-cm segment of jejunum were studied to evaluate variations in intestine growth. Significant increases in weight of intestinal fragments were measured in both groups, from 1 d of age (Figure 4A) but weights of intestinal fragments were higher in EF chicks than in DF chicks at least 4 d of age (P < 0.001). At 2 and 3 d of age, EF increased the weight of the intestinal fragment by about 30 and 40% in EF chicks compared to DF chicks and the difference was maintained at 4 d of age (EF = 0.978 ± 0.02 g, DF = 0.592 ± 0.03 g). From hatching to 4 d of age, weights of intestinal fragments were increased by about 3.5-fold in EF chicks and only by about twofold in DF chicks. However, when weights of intestinal fragments were compared after 2 d of feeding (4-d-old DF chicks vs. 2-d-old EF chicks), weights were higher (P < 0.01) in DF chicks than in EF chicks, and the relative weights of intestinal fragments were similar in EF and DF chicks (EF = 0.830 ± 0.41, DF = 0.863 ± 0.035, P = 0.50).

**Pectoralis Major Muscle Growth.** Pectoralis major muscle weight was increased from 1 d of age in EF chicks, whereas it increased only from 2 d of age in DF chicks, corresponding to the beginning of feeding (Figure 4B). Muscle weight remained higher (P < 0.001) in EF than in DF chicks at 2 and 3 d of age, respectively. Mean weight difference between the two groups at 4 d of age reached 1.4 g, 51% in relative value. As observed for the intestine, muscle weight was higher in DF chicks after 2 d of feeding compared with EF chicks (DF = 1.332 ± 0.09 g, EF = 1.008 ± 0.05 g, P < 0.01). After
4 d of life, pectoralis major muscle weight was increased by about 2.5- and 5-fold in DF and EF chicks, respectively.

**Capacity of Protein Synthesis in Pectoralis Major Muscle.** From d 19 of incubation to hatching, ribosomal capacity (Cs) and RNA levels were decreased by 40% and 20%, respectively, whereas protein level per gram of muscle was increased by about 35% (Table 2). The RNA concentration measured in EF chick muscle regularly in-
EF group and chicks increased by about 1.5-fold from birth to 3 d of age and reached 37% in 4-d-old chicks. Ribosomal capacity in EF protein in pectoralis major muscle increased from the first ing, protein concentrations in milligram per gram of pec-

Values measured in EF chicks. During the 4 d posthatching fasting. The RNA concentration in the DF group was increased only from 2 d of age in EF vs. 4 d of age in DF. We compared RNA concentrations in EF and DS were increased significantly between groups at 3 and 4 d of age. Early feeding was observed significantly increased DNA concentrations from hatchling to 3 d of age, whereas values were only slightly increased in the DF group. Ribosomal capacity in EF, then values were similar to those measured in the DF group at 1 and 2 d of age (p < 0.001), and no difference was observed between groups at 4 d of age. Early feeding values remained by about 1.5-fold from birth to 3 d of age in the EF group. Ribosomal capacity in EF muscle only increased during the 24 h of feeding. The increase occurred within 24 h of feeding in EF chicks, whereas the increase was delayed in DF chicks to the third day of age. Total protein was also significantly higher in EF than in DF chicks from 2 d of age. Values increased by about 60% by 24 h and then remained unchanged until 4 d of age, whereas it was not changed in DF chicks during the 2-d posthatching fasting. The RNA concentrations increased from 3 d of age in EF vs. 4 d of age in DF chicks. During the 4 d posthatching fasting. The RNA concentrations increased from 3 of age in EF vs. 4 d of age in DF chicks.

Figure 2. Relative daily food intake in early feeding (EF) and 48-h delayed feeding (DF) chicks. Per day weight in EF and DF chicks from 2 d of age. Values are means ± SEM. They were analyzed using two-way ANOVA. *p < 0.05, **p < 0.01, ***p < 0.001.

TABLE 1. Effects of family and early or 48-h delayed feeding on body weight in chicks from hatching to 4 d of age1,2

<table>
<thead>
<tr>
<th>Age (d)</th>
<th>Group3</th>
<th>Family 1</th>
<th>Family 2</th>
<th>Family 3</th>
<th>Family 4</th>
<th>Family 5</th>
<th>Family 6</th>
<th>Family 7</th>
<th>Family 8</th>
<th>Family 9</th>
<th>Family 10</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>n = 169</td>
<td>451 ± 1.9</td>
<td>437 ± 0.5</td>
<td>446 ± 1.1</td>
<td>461 ± 1.0</td>
<td>43.5 ± 0.7</td>
<td>44.5 ± 0.9</td>
<td>48.0 ± 0.8</td>
<td>41.9 ± 0.9</td>
<td>47.7 ± 0.7</td>
<td>42.8 ± 0.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>1</td>
<td>EF (n = 84)</td>
<td>510 ± 2.4</td>
<td>471 ± 1.1</td>
<td>512 ± 1.4</td>
<td>494 ± 2.0</td>
<td>47.9 ± 1.2</td>
<td>52.2 ± 1.1</td>
<td>53.1 ± 1.3</td>
<td>47.2 ± 1.7</td>
<td>53.0 ± 1.2</td>
<td>47.8 ± 1.4</td>
<td>0.0003</td>
</tr>
<tr>
<td>2</td>
<td>EF (n = 75)</td>
<td>426 ± 2.9</td>
<td>439 ± 0.7</td>
<td>419 ± 1.5</td>
<td>454 ± 0.8</td>
<td>41.5 ± 0.6</td>
<td>44.7 ± 1.3</td>
<td>40.9 ± 0.7</td>
<td>43.6 ± 0.6</td>
<td>40.2 ± 0.6</td>
<td>0.0500</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>EF (n = 66)</td>
<td>382 ± 0.5</td>
<td>443 ± 1.5</td>
<td>409 ± 1.7</td>
<td>454 ± 2.5</td>
<td>44.7 ± 1.8</td>
<td>44.8 ± 1.8</td>
<td>41.3 ± 1.3</td>
<td>40.8 ± 1.1</td>
<td>42.6 ± 0.9</td>
<td>38.9 ± 0.9</td>
<td>0.0193</td>
</tr>
<tr>
<td>4</td>
<td>EF (n = 75)</td>
<td>781 ± 2.2</td>
<td>695 ± 2.1</td>
<td>768 ± 1.9</td>
<td>730 ± 1.9</td>
<td>76.2 ± 2.8</td>
<td>78.3 ± 1.3</td>
<td>78.0 ± 2.8</td>
<td>71.2 ± 3.4</td>
<td>80.5 ± 1.8</td>
<td>75.8 ± 2.4</td>
<td>0.0015</td>
</tr>
<tr>
<td></td>
<td>EF (n = 66)</td>
<td>508 ± 0.1</td>
<td>574 ± 1.0</td>
<td>553 ± 2.9</td>
<td>590 ± 2.2</td>
<td>60.9 ± 2.0</td>
<td>57.1 ± 3.3</td>
<td>53.7 ± 0.5</td>
<td>54.6 ± 1.3</td>
<td>58.3 ± 0.9</td>
<td>53.0 ± 0.6</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>EF (n = 53)</td>
<td>497 ± 4.2</td>
<td>874 ± 2.9</td>
<td>979 ± 2.0</td>
<td>887 ± 2.0</td>
<td>92.9 ± 2.8</td>
<td>96.2 ± 0.2</td>
<td>94.6 ± 3.5</td>
<td>86.8 ± 4.1</td>
<td>100.6 ± 3.2</td>
<td>93.4 ± 3.8</td>
<td>0.0003</td>
</tr>
<tr>
<td></td>
<td>EF (n = 66)</td>
<td>61.0</td>
<td>69.4 ± 1.6</td>
<td>67.3 ± 3.6</td>
<td>682 ± 1.9</td>
<td>74.1 ± 5.4</td>
<td>68.7</td>
<td>64.6</td>
<td>67.6 ± 1.7</td>
<td>69.5 ± 1.1</td>
<td>64.0 ± 1.3</td>
<td>0.1383</td>
</tr>
</tbody>
</table>

1Data are expressed as means ± SEM. They were analyzed using two-way ANOVA.
2Lack of SEM indicates n = 1 in the corresponding family.
3EF = early feeding; DF = 48-h delayed feeding.
which might have reduced the genetic element in the control of food intake (Barbato, 1994). However, the reduction of interfamily variation in BW that we observed in DF chicks from the first day of life suggests that starvation per se reduces the expression of genetic variability during early growth. Genetic control of growth might have been minimized in DF chicks during early starvation because genetic selection on growth primarily stimulates feed intake, which cannot be expressed in starved chicks (Barbato, 1994). Homogeneity in interfamily BW depends on posthatching starvation. This may mask the expression of genetic potential and interfere in genetic selection in which neither the exact age of chicks nor the duration of DF are known. Our results suggest that the length of time of feed deprivation should be used in genetic selection for growth.

Higher initial growth rate in DF chicks, induced by feed intake after 2 d of starvation remained insufficient to correct the consequences of DF on BW at 6 d of age and probably in the longer term (Noy and Sklan, 1999a). Because the relative BW gain only reached similar levels after 4 d of age in both EF and DF chicks, the growth mechanism released at the end of the posthatching fast was probably not compensatory growth. Furthermore, part of the BW variation in DF chicks immediately after feeding was not actual BW but rather larger amounts of food stored in the crop than in EF chicks due to hunger developed during fasting. Our results support the hypothesis that maximal growth rate might be attained during the neonate period when chicks are fed (Murakami et al., 1992); thus, DF chicks could not achieve a faster growth rate than EF chicks. This result confirmed that initiation of BW growth in neonate chicks is directly linked to food availability.

Posthatching starvation delayed pectoral muscle weight gain and the weight increase occurred only after chicks had access to feed. In contrast, the weight of intestinal fragments increased in DF chicks during the fasting period but remained lower than in EF chicks even after refeeding. Intestinal growth during the posthatching fast-

**FIGURE 3.** Yolk sac resorption in early feeding (EF) and 48-h delayed feeding (DF) chicks. Values are means ± SEM, n = 10. Lack of error bars indicates SEM smaller than the symbol. *P < 0.05.

### DISCUSSION

Does DF reduce BW, intestinal and muscle development, and interfamily differences in 6-d-old broiler chicks? Variation in hatching BW was observed in chicks originating from ten different families. Delayed feed intake decreased weight variation, whereas EF chick weights remained significantly different between families up to the last measurement at 4 d of age. Interfamily variation in BW between the groups were mainly due to genetic origin because, first, the age of the hens was the same in the 10 families used in the experiments, and second, egg weights only slightly influence chick weight gain during posthatching growth (Shanwany, 1987; Pinchasov, 1991). Food availability from hatching in EF chicks led them to express “feeding capability” according to their age and need for growth, which maintained interfamily BW variation in this group. In contrast, the feeding behavior after posthatching fasting induced hyperphagia, which might have reduced the genetic element in the control of food intake (Barbato, 1994). However, the reduction of interfamily variation in BW that we observed in DF chicks from the first day of life suggests that starvation per se reduces the expression of genetic variability during early growth. Genetic control of growth might have been minimized in DF chicks during early starvation because genetic selection on growth primarily stimulates feed intake, which cannot be expressed in starved chicks (Barbato, 1994). Homogeneity in interfamily BW depends on posthatching starvation. This may mask the expression of genetic potential and interfere in genetic selection in which neither the exact age of chicks nor the duration of DF are known. Our results suggest that the length of time of feed deprivation should be used in genetic selection for growth.

Higher initial growth rate in DF chicks, induced by feed intake after 2 d of starvation remained insufficient to correct the consequences of DF on BW at 6 d of age and probably in the longer term (Noy and Sklan, 1999a). Because the relative BW gain only reached similar levels after 4 d of age in both EF and DF chicks, the growth mechanism released at the end of the posthatching fast was probably not compensatory growth. Furthermore, part of the BW variation in DF chicks immediately after feeding was not actual BW but rather larger amounts of food stored in the crop than in EF chicks due to hunger developed during fasting. Our results support the hypothesis that maximal growth rate might be attained during the neonate period when chicks are fed (Murakami et al., 1992); thus, DF chicks could not achieve a faster growth rate than EF chicks. This result confirmed that initiation of BW growth in neonate chicks is directly linked to food availability.

### TABLE 2. Muscle characteristics in 19 d embryos and in chicks submitted to early or 48-h delayed feeding from hatching to 4 d of age\(^1\)

<table>
<thead>
<tr>
<th>Age (d)</th>
<th>Group</th>
<th>RNA (mg/g of muscle)</th>
<th>Protein (mg/g of muscle)</th>
<th>Total protein (mg)</th>
<th>Cs(^2) (mg/g protein)</th>
<th>DNA (mg/g of muscle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td></td>
<td>3.13 ± 0.21</td>
<td>65.6 ± 4.8</td>
<td>32.5 ± 1.8</td>
<td>47.8 ± 0.45</td>
<td>ND</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>2.55 ± 0.18</td>
<td>88.3 ± 4.7</td>
<td>48.1 ± 4.7</td>
<td>28.76 ± 0.57</td>
<td>0.09 ± 0.04</td>
</tr>
<tr>
<td>1</td>
<td>EF</td>
<td>2.59 ± 0.09**</td>
<td>84.3 ± 3.3</td>
<td>55.8 ± 3.3</td>
<td>30.78 ± 0.54***</td>
<td>0.29 ± 0.10</td>
</tr>
<tr>
<td></td>
<td>DF</td>
<td>2.01 ± 0.14</td>
<td>74.4 ± 4.3</td>
<td>45.4 ± 3.5</td>
<td>26.96 ± 0.50</td>
<td>0.30 ± 0.09</td>
</tr>
<tr>
<td>2</td>
<td>EF</td>
<td>3.00 ± 0.34</td>
<td>86.6 ± 4.5</td>
<td>82.8 ± 5.8**</td>
<td>35.14 ± 0.57***</td>
<td>0.50 ± 0.15</td>
</tr>
<tr>
<td></td>
<td>DF</td>
<td>2.20 ± 0.25</td>
<td>86.7 ± 8.6</td>
<td>52.9 ± 6.8</td>
<td>24.95 ± 2.31</td>
<td>0.34 ± 0.18</td>
</tr>
<tr>
<td>3</td>
<td>EF</td>
<td>4.02 ± 0.08</td>
<td>92.8 ± 1.4</td>
<td>169.7 ± 9.5***</td>
<td>42.78 ± 4.13</td>
<td>0.77 ± 0.21*</td>
</tr>
<tr>
<td></td>
<td>DF</td>
<td>3.62 ± 0.47</td>
<td>85.5 ± 3.5</td>
<td>73.4 ± 5.9</td>
<td>41.61 ± 0.66</td>
<td>0.21 ± 0.06</td>
</tr>
<tr>
<td>4</td>
<td>EF</td>
<td>4.66 ± 0.10***</td>
<td>106.8 ± 4.0***</td>
<td>303.0 ± 22.6***</td>
<td>43.53 ± 1.45</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>DF</td>
<td>3.65 ± 0.23</td>
<td>85.6 ± 3.1</td>
<td>113.8 ± 11.9</td>
<td>42.43 ± 0.97</td>
<td>ND</td>
</tr>
</tbody>
</table>

\(^1\)Data are expressed as means ± SEM, 7 < n < 10. Statistical analysis compared values in the EF group to those in the DF group; **P < 0.01, ***P < 0.001.

\(^2\)Cs = capacity for protein synthesis.

\(^3\)EF = early feeding; DF = 48-h delayed feeding.
ing period agreed with previous studies (Noy and Sklan, 1999b) and showed that this process might be preferential in early development in chicks compared to muscle growth. It is noteworthy that our results only concerned a fragment of jejunum and could not be extended to the entire intestine tract. Previous studies showed that yolk sac resorption through the intestine could be increased by greater intestinal development when chicks have access to feed in the initial posthatching period, mainly because of increased antiperistaltic activity of the intestine (Bierer and Eleazer, 1965; Noy et al., 1996). Interestingly, no difference in yolk sac resorption between EF and DF chicks was observed in our study, despite differences in intestinal fragment growth between the two groups. However, variations in the amounts of yolk utilized between the studies might be explained by fast duration, water availability, or both e.g., in the experiment of Noy et al. (1996) drinking and feeding were delayed by 96 h. Rather than actually compensating for the lack of food, nutrient contents in the yolk sac might play a complementary role with nutrients provided by feeding to enhance initial posthatch growth, particularly in intestine development which was similar in fast-growing and slow-growing lines (Turro et al., 1994).

Fast-growing lines (broiler-type) mainly differ from slow-growing lines (layer-type, Bantam, or White Plymouth Rocks) of chickens by faster growth rate and earlier initiation of growth during the neonatal period (Barbato, 1992; Nir et al., 1993; Turro et al., 1994; Mitchell and Burke, 1995; Siegel et al., 1997). In the present study, analysis of initial posthatching muscle growth showed that the Cs, i.e., the potential for protein synthesis, was dependent on both feed availability and age. To our knowledge, no previous publication has reported Cs profile in neonate chick muscle. The Cs values in neonate chicks were higher than those measured in older chicks (Tesseraud et al., 1996). In EF chicks, Cs increased during the 3 d posthatching (due a greater increase in RNA than protein levels) concomitantly with increase in DNA level, which suggested satellite cell proliferation as previously described by Halevy et al. (2000). In contrast, RNA level and consequently Cs were only increased after feeding in DF chicks and DNA level remained lower than in EF chicks during the 4 d posthatching. Differences in muscle weight between EF and DF chicks might therefore be related to the lower potential for protein synthesis during posthatching deprivation, illustrated by RNA level. Feed availability increased the potential for protein synthesis by activating the transcriptional phase in DF chicks, but protein levels remained lower than those measured in EF chicks. Intensive posthatching muscle growth is characterized by an increase in muscle fiber size and by a great increase in the number of nuclei per fiber following proliferation and fusion of the satellite cells (Duclos and Remignon, 1996). Delayed feeding in the present experiment might have reduced the proliferation of satellite cells which is critical at 2 to 3 d of age (Halevy et al., 2000).

In conclusion, by comparing the effects of 2 d of fasting posthatching to immediate posthatching feeding, we showed that posthatching starvation reduced interfamily variation in BW that is expressed in chicks given immediate access to feed which may mask the expression of the genetic potential and distort the estimation of chicks’ breeder value. Consequently, genetic selection may be disturbed. Feed availability was essential to enhance body and muscle weight gain in neonate chicks compared to the intestine whose weight slightly increased from hatching when starved chicks had access to water. However, no compensatory growth was observed during the first 6 d of life to compensate for the retardation in body, intestine, and muscle weight gains caused by the fasting period. Differences in muscle weight between the EF and DF groups were mainly caused by a low potential for protein synthesis in DF chicks during the fasting period. Our study confirms that DF in fast-growing broiler chicks induces retardation of development, which may not be offset by regular diet and hatchery practices.

ACKNOWLEDGMENTS

The authors thank Yves Jego (Hubbard-ISA, France) for providing fertile pedigree eggs, Bernard Guillerm for
animal care and Claude Bouchot for technical assistance (INRA, 37380 Nouzilly, France).

REFERENCES


