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Original article

Removal of residual yolk at hatch influences food choice and feeding activity in lines of chickens selected for high or low juvenile body weight

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Summary — The effect of residual yolk removal at hatch on growth and feeding behavior was assessed in lines of chickens divergently selected for low (LW) or high (HW) 56-day body weight. At hatch chicks were assigned to 1 treatment: removal of the residual yolk (R) or no surgery (I). Twenty-four chicks per line (12 I and 12 R) were assigned to an all-mash regimen (M) and 48 per line (24 I and 24 R) to a choice (C) between mash and dietary residual yolk. HW were heavier than LW chicks regardless of treatment. On day 5 and thereafter, chicks given a choice were heavier than those eating mash. HW chicks ate more than LW ones. The percentage of yolk eaten increased during the 2–3 d after hatch, remained constant for 2 d, then decreased. Results are discussed in term of yolk need and development of the gastrointestinal tract in the divergent lines.

genetic line / vitellus / deutectomy / feeding behavior / activity / growth

Résumé — Le retrait du résidu vitellin à l'éclosion influence les choix et le comportement alimentaire chez des lignées de poulets sélectionnées pour un poids corporel juvénile fort ou faible. *L'effet de la deutectomie à l'éclosion sur la croissance et le comportement alimentaire a été testé sur des lignées de poulets sélectionnées pour un poids corporel fort (HW) ou faible (LW) à 56 j. À l'éclosion, les poussins sont vitellectomisés (R) ou non traités (I). Vingt-quatre poussins par lignée (12I et 12R) reçoivent un aliment farine (M) et 48 par lignée (24I) et 24R) ont le choix entre l'aliment farine et du résidu vitellin. Les poussins HW sont plus lourds que les LW, quel que soit le traitement. À partir du 5^e^ j, les poussins en choix sont plus lourds que ceux qui ne consomment que de la farine. Les HW consomment plus que les LW. Le pourcentage de résidu vitellin consommé augmente pendant les 2 à 3 j qui suivent l'éclosion, reste constant pendant 2 j puis diminue. Les résultats sont discutés en termes de besoin en vitellus et développement du tractus gastro-intestinal chez ces lignées divergentes.*

lignée / vitellus / deutectomie / comportement alimentaire / activité / croissance

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INTRODUCTION

Free choice feeding tests are commonly used to ascertain how birds select and balance their diet. Several studies have shown that domestic chickens can self-select an adequate ratio of protein and energy (*eg*, Kaufman *et al*, 1978; Brody *et al*, 1983; Sinurat and Balnave, 1986; Rose and Kyriakis, 1991). The ratios, however, may be stock-specific. When chicks from lines of White Plymouth Rocks selected for high or low body weight at 56 days of age (Dunnington and Siegel, 1985) were subjected to free choice feeding, high-line chickens chose diets higher in protein and lower in energy, while low-line chickens preferred lower protein and higher energy diets (Huey *et al*, 1982). Similarly, a genetically fat line of chickens preferred a lower protein diet than one selected for lean (Leclercq and Guy, 1991).

Residual yolk may serve as a source of nutrients during the first few days after hatch (Murakami *et al*, 1988; Nir *et al*, 1988; Nitsan et al, 1991), a period when the young chick shifts from endogenous to exogenous nutrition. Murakami *et al* (1992) showed that removal of residual yolk at hatch delayed growth by 2 d. Residual yolk did not influence the rate of nutrient utilization or *vice versa*, and they suggested that yolk may be transported *via* circulation rather than through the yolk stalk which is consistent with empirical data obtained by Nitsan *et al* (personal communication).

Lines of chickens selected for high or low juvenile body weight (Dunnington and Siegel, 1985) differed in feeding behavior and food intake (Barbato *et al*, 1980; Dunnington *et al*, 1987; Boa Amponsen *et al*, 1991; O'Sullivan *et al*, 1992a; Noble *et al*, 1993). These lines did not react in the same way to removal of the yolk sac at hatch (Turro *et al*, 1994), suggesting a need for further study of utility of residual yolk and interactions between digestive tract development and yolk resorption. Chamblee *et al* (1992) fed diets with different levels of fat to broiler chicks whose yolk sacs were removed. They reported that dietary fat has its greatest effect on growth 10 d after hatch and that initiation of growth may be more heavily dependent upon other nutrients. The experiment reported in this paper investigated the effect of removal of residual yolk at hatch on growth and feeding behavior of chicks from lines divergently selected for 56-day body weight when presented with a feeding choice between a complete starter diet and dried residual yolk.

MATERIALS AND METHODS

Stocks, husbandry procedures and experimental procedures

The chicks used in this experiment were White Plymouth Rocks chicks from the 36th generation of lines selected for a high (HW) or low (LW) body weight at 56 d of age (Dunnington and Siegel, 1985). Chicks from each line were removed from the hatcher, wingbanded, and weighed to the nearest 0.1 g. Seventy-two chicks were then randomly assigned for either removal of the yolk sac (R) or to remain intact (I). Body weights of R chicks were also obtained to the nearest 0.1 g after removal of the yolk sac. The procedure for removal of the yolk sac has been described previously (Turro *et al*, 1994). Briefly, each chick was anesthetized and a small incision made posterior to the umbilicus. The yolk sac was removed from the abdominal cavity and the yolk stalk was tied and severed from the yolk sac. Recovery was made within 30 min and mortality nil. Within 4 h of the beginning of surgery all chicks had been randomly assigned and placed in 36 wire-floor pens in an electrically heated battery with 4 chicks per pen. Within each line chicks were randomly assigned to an all-mash (M) diet (3 146 kcal/kg ME, 24% protein) or a choice (C) between mash and residual yolk (4 953 kcal/kg, 51% protein). Twenty-four chicks per line (12 I and 12 R) were assigned to the M regimen and 48 per line (24 I and 24 R) were assigned to the C regimen.

Lines (HW, LW) and treatments (IM, IC, RM, RC) were not intermingled in the same pens.

Food and water were always available and lighting was continuous. Chicks and feeders were individually weighed to the nearest gram each day with total intake of metabolizable energy and of protein calculated for each group. The number of chicks eating, drinking, standing, or resting was recorded for each pen at 07.00, 07.30, 09.00, 09.30, 13.00, 13.30, 17.00 and 17.30 h as described by Turro *et al* (1994). With choice feeding, the type of feed being eaten was recorded.

At 7 d of age, 2 chicks from each pen were randomly selected and blood was obtained for determination of plasma glucose and lipid. Glucose was measured by the oxidase method (Hestin-Lerner and Ben Yonah, 1963) and total lipids were measured according to the method of Zoellner and Kirsch (1962). Residual yolk, heart, liver, pancreas and small intestine were removed from these chickens and weighed to the nearest 0.01 g. The chyme (contents of the small intestine) was removed and the weight determined as the difference between the full and empty small intestine. Total fat was extracted by chloroform methanol (2:1) from liver and from residual yolk by the method of Folch *et al* (1957). Liver, yolk, and blood protein were measured by Biuret reactions using Sigma Diagnostics Total Protein Reagent Procedure No 541 (Sigma Diagnostics, Saint Louis, MO 63178).

Statistical analysis

Prior to analyses, body and absolute organ weights were transformed into common logarithms and ratios to arcsine square roots. Behavioral data were averaged for the two 30-min periods at each time and transformed to the arcsine square root of the ratio of chicks exhibiting each behavior.

Analyses of variance were conducted separately for each day for behaviors, feed intake, and body weight. Line, treatment, and time of day were main effects for behavioral data, and line and treatment were main effects for food intake and body weights. Organs, blood lipids, glucose, and protein data were analyzed with line and treatment as main effects. When interactions were significant, comparisons of multiple means were made by Duncan's multiple range test within each main effect.

RESULTS

Growth and food intake

Growth

Interactions of line by treatment were significant for body weight at 2 and 3 d, but not at 1, 4, 5, 6 and 7 d after hatch. HW chicks were heavier than LW chicks regardless of treatment (fig 1), while differences among treatments within lines differed on days 2 and 3. The IC and IM chicks were heavier than RC and RM chicks in line HW, while in line LW, IM and RC chicks did not differ, causing the interaction. In both lines and in each treatment, there was a trend for chicks given a choice of mash or yolk to be heavier than those eating mash only with the cumulative effect being that the difference were significant on d 5 and thereafter.

Weight gains from hatch to 4 and 7 d after hatch were less for LW than HW chicks (table I) with the line-by-treatment interaction significant for both time periods. In the LW

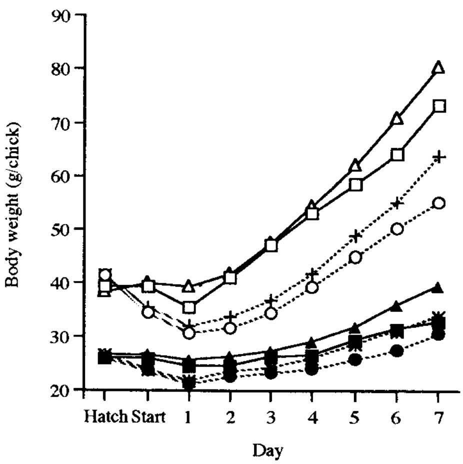

Fig 1. Body weight of chicks (g/chick) by line (LW or HW), with or without removal of the yolk sac (R, I), eating mash or mash and yolk (M, C). —■— LW I M; —▲— LW I C; —□— HW I M; —△— HW I C; ---●--- LW R M; ---✳--- LW R C; ---O--- HW R M; ---+--- HW R C.

Table I. Body weight gains (g/chick) of chicks by line and treatment at 4 and 7 d after hatch.

Treatment	*Gain 0–4*		*Gain 0–7*	
	HW	*LW*	*HW*	*LW*
Intact choice	14.5^{a}	2.6^{a}	40.3^{a}	12.7^{a}
Intact mash	13.9^{a}	0.9^{a}	34.0^{ab}	7.2^{b}
Yolk removed choice	6.2^{b}	1.5^{a}	28.7^{bc}	9.9^{b}
Yolk removed mash	4.4^{b}	0.6^{a}	19.8^{c}	7.0^{b}

Means in a column with the same superscript were not significantly different. Differences between lines are always significant ($P < 0.01$).

line, body weight gains were similar among treatments to 4 d, while in line HW, the IC and IM chicks gained more weight than RC and RM chicks (14.2 *vs* 5.3%). By 7 d, the gain of IC chicks from line LW was greater than that for the 3 other groups (12.7 *vs* 8.0%), while for HW chicks the gain was greater for IC than for RC and RM which did not differ.

Food intake

There was no line-by-treatment interaction for food intake on any day for chicks provided with choice feeding. HW chicks consistently ate more than LW chicks with differences being significant on days 2, 3, 5, 6 and 7 (fig 2a). There were no differences between I and R chicks for feed intake (fig 2b). For groups eating only mash, commencing on day 2, the consumption of I chicks from line HW was consistently greater than that for all other groups with differences significant on days 4, 5 and 6 (fig 3a).

There were no line-by-treatment interactions for percentage yolk consumed in choice feeding on any day. The percentage yolk consumed was low on day 1, it increased during the first 2 to 3 d after hatch, remained relatively constant for about 2 d, and then decreased (fig 3b).

Nutrient intake

Due to the differences existing in nutritive values between mash and residual yolk, the total protein intake and energy intake of chicks for each treatment were calculated from hatch to 7 d of age (tables II and III). The following comments are based on calculated values using 3.146 cal and 0.24 g protein for 1 g mash and 4.953 cal and 0.51 g protein for 1 g yolk.

Metabolisable energy and protein intake

HW chicks consumed more ME and protein than LW (tables II and III). Treatment tended to affect the ME and protein intake (P = 0.08). P values for line-by-treatment and line-by-regimen ranged from 0.10 to 0.16. They reflected that vitellectomy reduces the energy and protein intake of HW but not LW chicks with choice.

Regimen (M, C) did not have a significant effect on protein and energy intake, but tended to modify the responses of the 2 lines. HW chicks tended to increase protein and energy intake from a mash diet to a choice of mash and yolk. In the same situation, LW chickens tended to decrease their energy intake and to maintain protein consumption.

Behavior

Analyses of variance were conducted for behaviors separately for each day. Only 7 of 140 first- and second-order interactions were significant. There was no consistent pattern and we attribute them to chance. For eating, there were no treatment effects, however time of day effects were significant on days 3 and 6. On day 3 the percentage of chicks eating mash at 17.00 h (6.2%) was greater than at other times (0.5%). On day 6 the percentages were 2.1, 7.8, 1.6 and 8.7% for 07.00, 09.00, 13.00 and 17.00 h, respectively, with 7.8 and 8.7% different from the 2.1 and 1.6%. On day 6 the per-

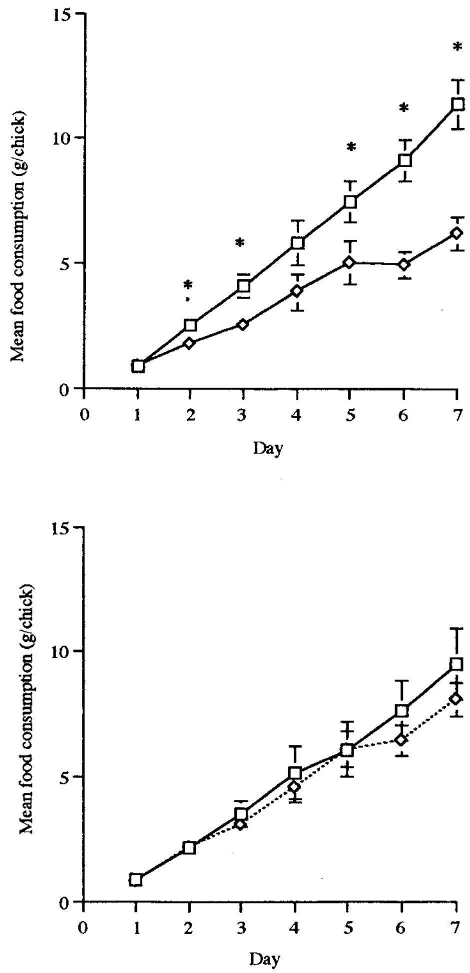

Fig 2. Total food intake (choice group) by line (top) or treatment (bottom) during the first week of life. * $P < 0.05$. Top:□ HW; ◊ LW; bottom: □ intact; ◊ removed.

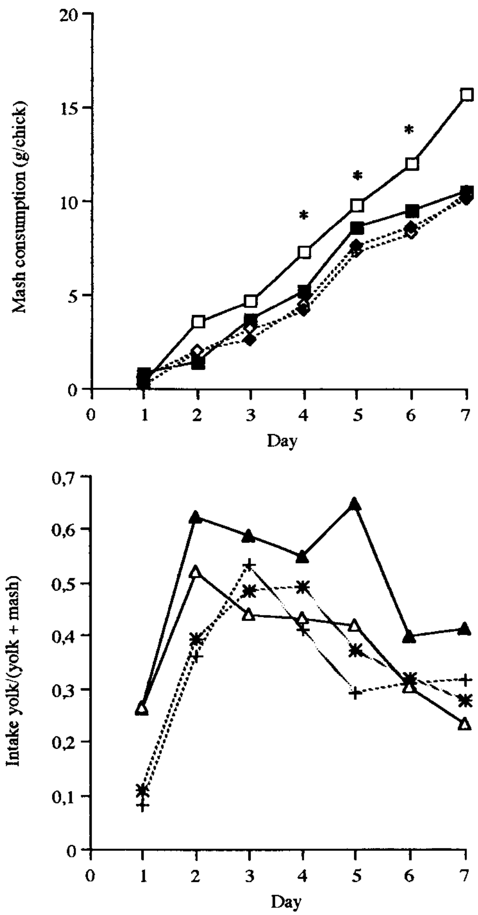

Fig 3. Mean mash consumption during the first week of life of the control chicks (* $P < 0.05$) (top) and ratio of yolk eaten in the choice group (bottom). Top: —□— HWI; ---◊--- HWR; —■— LWI; ---◆--- LWR; bottom: —Δ— HW I C; ---+--- HW R C; —▲— LW I C; ---*--- LW R C.

Table II. Calculated energy (cal/chick) and protein intake (g/chick) and food intake (g/chick) (means ± SEM) from hatch to 7 d of age.

Treatment	*Metabolisable energy*		*Crude protein*		*Food intake*		
	Mash	*Choice*	*Mash*	*Choice*	*Mash*	*Choice*	
						Mash	*Yolk*
HW							
Intact	167.0	171.5	12.7	14.9	53.1	32.7	13.9
	± 6.0	± 24.7	± 0.5	± 2.1	± 1.9	± 5.7	± 1.6
Yolk removed	111.5	135.6	8.5	11.9	35.4	24.4	11.9
	± 18.8	± 8.4	± 1.4	± 0.6	± 6.0	± 3.1	± 0.7
LW							
Intact	124.0	90.8	9.5	8.2	39.4	14.0	9.4
	± 12.1	± 17.2	± 0.9	± 1.4	± 3.8	± 4.9	± 0.5
Yolk removed	112.5	99.7	8.6	8.7	35.7	18.8	8.2
	± 13.8	± 11.1	± 1.1	± 0.9	± 4.4	± 3.8	± 0.9

Table III. Anova of the results presented in table II.

	Anova: main effects and interactions	
	Metabolisable energy	*Crude protein*
Line	$P < 0.01$	$P < 0.01$
Treatment	$P = 0.08$	$P = 0.08$
Regimen	$P = 0.74$	$P = 0.30$
Line x treatment	$P = 0.10$	$P = 0.11$
Line x regimen	$P = 0.16$	$P = 0.11$
Treatment x regimen	$P = 0.44$	$P = 0.53$
Line x treatment x regimen	$P = 0.99$	$P = 0.97$

centage of HW chicks eating mash was greater than that for LW chicks (7.0 *vs* 3.0%) with the percentage similar for those eating yolk (1.3 *vs* 1.7%).

During the total time of the experiment, HW chicks consistently spent more time eating mash (3.5%) than LW chicks (2.8%). Within days, however, the difference was significant only on day 6 (fig 4a). Overall the percentage of I chicks eating mash (2.5%) was less than for R chicks (3.8%) while values for I and R chicks were similar for yolk (1.9 and 2.0%) (fig 4b).

On days 2 and 6, I chicks rested less than R chicks. Percentages on day 2 were 78% for I and 84% for R chicks. For Day 6 the same percentages were 66 and 76% which mirror values for standing (fig 5b). Similarly, between-line comparisons for standing and resting over all observations during the 7 d of the experiment showed that HW chicks spent more time standing (15%) than LW (13%) and less time resting (77 *vs* 81%) (fig 5a).

Organ size

At 7 d of age there were significant line-by-treatment interactions for body, heart, liver, chyme and small intestine (full and empty) weights, but not weights of pancreas or yolk sac. When these traits were expressed per 100 g body weight the interactions were significant only for small intestine full and chyme. This interaction resulted from a dif-

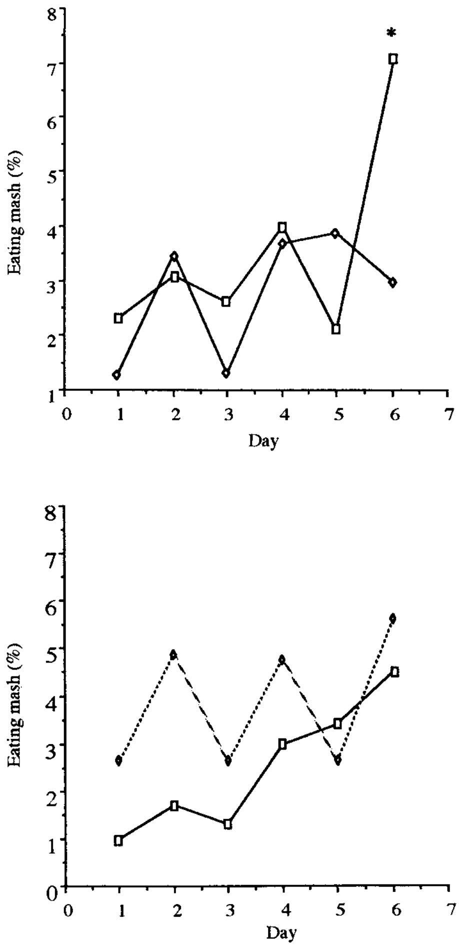

Fig 4. Percentage of time spent eating mash (choice group) by line (top) and by treatment (bottom) during the first week of life. * $P < 0.05$. Top: □ HW; ◊ LW; bottom: □ intact; ◊ removed.

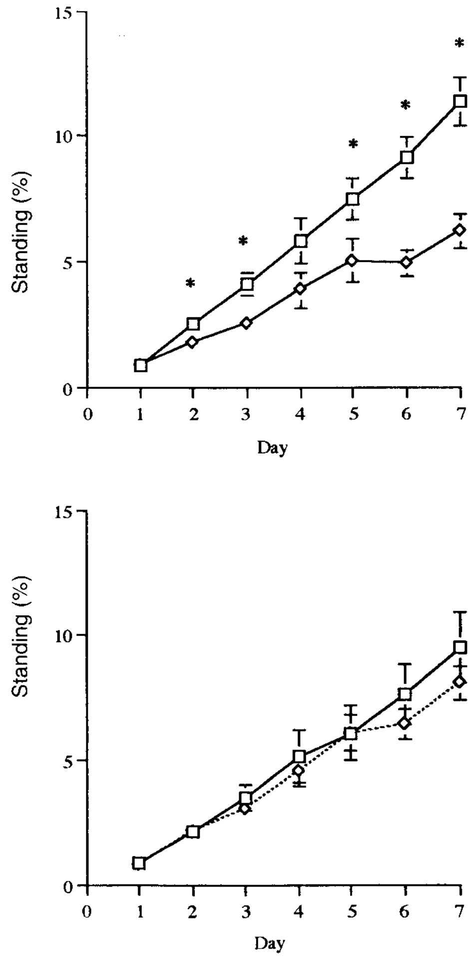

Fig 5. Percentage of time spent standing by line (top) and by treatment (bottom) during the first week of life. * $P < 0.05$. Top: □ HW; ◊ LW; bottom: □ intact; ◊ removed.

ference between lines for RM while RC, IC and IM groups were similar for both lines (table IV). There were no differences between lines or among treatments for heart or liver weights, nor between lines for yolk sac weight. Moreover, IM and IC groups had similar yolk-sac weights. HW chicks had heavier pancreases and small intestines and longer shanks than LW chicks. Liver and pancreas weights were similar for treatment groups. For I chicks and for R chicks the small intestine was larger for M than C chicks. RM chicks had longer shanks than IC and IM chicks.

Table IV. Average weight of organs (g/100 g body weight) and plasma and liver contents at 1 week of age.

	Line		*Treatment and regimen*				*Anova: main effect and interactions*		
	HW (n = 72)	*LW* (n = 72)	*Intact choice* (n = 24)	*Intact mash* (n = 12)	*Yolk removed choice* (n = 24)	*Yolk removed mash* (n = 12)	*Line*	*Treatment and regimen*	*Line x treatment and regimen*
Body weight (g)	67.35	35.47	57.96^{a}	57.07^{a}	49.70^{b}	44.40^{b}	**	**	**
Heart	0.80	0.75	0.73^{a}	0.77^{a}	0.82^{a}	0.76^{b}	NS	NS	NS
Yolk	0.30	0.32	0.65^{a}	0.57^{a}			NS	NS	NS
Liver	3.74	3.58	3.77^{a}	3.66^{a}	3.64^{b}	3.54^{c}	NS	NS	NS
Pancreas	0.59	0.53	0.54	0.53	0.58	0.59	*	NS	NS
SI full	9.16	6.38	7.00^{b}	8.84^{a}	7.49^{b}	8.95^{a}	**	**	*
SI empty	5.80	3.84	4.43^{c}	5.19^{ab}	4.76^{bc}	5.61^{a}	**	**	NS
Chyme	3.36	2.54	2.60^{c}	3.65^{a}	2.72^{bc}	3.34^{ab}	**	*	*
Shank length (cm/100 g body weight)	3.91	6.19	4.74^{b}	4.71^{b}	5.12^{ab}	5.29^{a}	**	*	NS
Plasma lipids (mg/100 ml)	6.33	6.97	7.02	7.00	6.34	6.09	NS	NS	NS
Liver lipids (g/100 g)	7.52	8.25	8.52	8.14	7.40	7.33	NS	NS	NS
Yolk lipids (mg/100 ml)	12.23	14.80	10.32^{a}	17.96^{b}			**	**	*
Plasma glucose (mg/100 ml)	266	206	230^{b}	296^{a}	206^{b}	243^{b}	**	*	NS
Liver protein (g/100 g)	25.78	24.87	26.62	24.52	25.57	24.24	NS	NS	NS
Yolk protein (g/100 g)	33.66	33.34	31.88	36.28			NS	NS	NS

SI: small intestine; means in a row with the same superscript were not significantly different; * $P < 0.05$; ** $P < 0.01$; NS: non-significant.

Protein, lipids and glucose in plasma, liver and yolk

Plasma glucose concentration was higher for HW than LW chicks and for IM chicks than for those in the other groups. Levels of lipids in the plasma and in the liver and protein in liver and in yolk were not affected consistently by line or treatment (table IV). Line LW chicks eating mash had higher levels of yolk lipids than those given a choice of mash and yolk. For the group eating mash only, the level was also higher in LW than HW chicks.

DISCUSSION

The results obtained in this experiment confirm observations (Nitsan *et al,* personal communication; Turro *et al,* 1994) that lines HW and LW differed in their responses to removal of the yolk sac at hatch and that the first 3 d after hatch were critical to the chick's development. Growth and feeding behavior varied between treatments and lines. Both yolk-intact and yolk-removed HW chicks ate more food and were heavier than their LW counterparts. This pattern has been observed several times with intact chicks from these lines and can be explained by the selection for body weight which is associated with appetite (Siegel and Wisman, 1966; McCarthy and Siegel, 1983). Moreover, the 2 lines have different ingestion capacities, with the digestive system being more developed during the early post-hatch periods in HW than LW chicks (O'Sullivan *et al,* 1992b) as confirmed by the larger pancreas and intestine of the HW *vs* LW observed in the present study.

Feeding motivation is quite different in the 2 lines (*eg,* Barbato *et al,* 1980; Boa-Amponsen *et al,* 1991; O'Sullivan *et al,* 1992b; Noble *et al,* 1993). Generally, HW chickens were hyperphagic while LW ones were hypophagic with some individuals being anorexic (Burkhart *et al,* 1983; Zelenka *et al,* 1988). Such behavior has even been observed at hatch (O'Sullivan *et al,* 1992a). In the present experiment, in addition to line differences, I chicks consumed more food and gained more weight than those with yolk removed, an observation consistent with those reported for broiler chicks by Murakami *et al* (1992) and Chamblee *et al* (1992).

Nitsan *et al* (1991) suggested that nutrients from the yolk are used in development of the gastrointestinal tract (GIT) of the embryo. It may be hypothesized from our results that this role might continue during the first days after hatch. In contrast to intact chicks, those from which the yolk sac has been removed do not have this high source of nutrients available in order to develop the GIT for a more efficient utilization of exogenous food. This may contribute to retarded growth in those chicks.

Relative to body weight, the GIT was heavier in mash-fed chicks than in those given a choice of yolk and mash. Intact chicks eating only mash ingested greater amounts of food than the other groups, even more than those given a choice between yolk and mash. However, chicks with choice had a very high source of energy and protein from the yolk, so they could reduce the amount of dry matter eaten to balance their diet.

The responses of the chicks in terms of metabolisable energy and protein intake were different from that of total intake and tended to vary according to line and treatment. Because LW chicks consumed a higher percentage of yolk and had lower eating motivation and a smaller GIT than HW chicks, they might have been limited in the amount of food they ate. It may be assumed that they preferred a higher energy food, such as yolk, and ingested less of the low density diet. Huey *et al* (1982) observed that HW chickens preferred diets containing relatively higher protein and lower energy, while LW ones preferred relatively lower protein and higher energy diets. Thus, the preference for yolk may be linked to an avoidance by LW chicks for carbohydrate contained in the mash diet because their GIT would be inefficient in digesting it during the first few days after hatch.

In intact chickens, Calabotta *et al* (1983, 1985) found higher levels of plasma lipid and greater lipolytic capacities with mash feeding in LW than in HW chicks. In our experiment, LW chicks also tended to have higher levels of plasma lipid than HW chicks. This difference did not, however, mean that the residual yolk which contained about 35% fat was digested efficiently by LW chicks.

The responses of chicks to choice feeding are influenced by genetic stock, feeding treatment, and age. By the third day after hatch considerable changes had occurred in the young chick. Nutrients from the residual yolk were essentially utilized (Nitsan *et al,* 1991; Nir and Levanon, 1993) and the chick had changed from primarily a lipid-based to a carbohydrate-based metabolism with external food sources (Duke, 1984). This change might explain the pattern of reduced yolk intake 5 d after hatch. The shift from an endogenous to an exogenous feed source was apparently delayed in R chicks. This delay may be because removal of the yolk sac resulted in a delay in the general development of the chick, particularly in the capacity of using exogenous yolk and in functionality of the GIT. Such a delay in development is consistent with the observation of Murakami *et al* (1992) that removal of residual yolk at hatch resulted in a 2-d delay in growth. In the same way, intact HW chicks increased in growth on day 2 while in R chicks this increase occurred on day 3. Finally, while intact chicks eating mash and those eating mash and yolk had similar growth curves, the exogenous yolk allowed an increase in growth. HW chicks in which the yolk sac was removed did not compensate for the lack of the yolk sac by overconsumption of energy or protein.

In the LW line, I chicks ate less than R ones but the percentage of yolk in the diet was higher. R chicks with choice tended to consume more protein than intact ones. Overconsumption of protein could explain the ability of the LW-R chicks to maintain the same growth rate as that of I chicks eating only mash. Compared to chicks fed only mash, choice feeding of yolk and mash improved the growth of I and R chicks from both lines. Choice feeding, however, only partially compensated for yolk sac removal in R chicks. Differences between lines may have been due to differences in metabolic and/or digestive utilization of the nutrients from the yolk (endogenous and exogenous). Moreover, because the GIT was more developed in I than R chicks from line HW, it may be hypothesized that those chicks were able to utilize endogenous yolk more efficiently than the exogenous yolk to develop their GIT. There may be difficulties in digesting the yolk, which is very high in lipids. It may be possible that endogenous yolk was not digested in the intestine through the yolk stalk but was transported directly to the circulation (Nitsan *et al,* personal communication).

Development of the GIT was similar in I and R chicks from line LW suggesting that they responded similarly to endogenous and exogenous yolk. Chicks from this line had higher levels of lipids (liver, plasma) than those from the HW line which is consistent with results of Calabotta *et al* (1985), who observed more extensive lipolysis and lipogenesis in LW than HW chicks. Conversely, HW chicks had higher levels of glucose in plasma, so they may have digested carbohydrates more efficiently than the LW chicks during the first few days after hatch. Because LW chicks consumed greater amounts of yolk than the HW chicks, and HW chicks consumed more mash than LW ones, perhaps HW chicks had greater capabilities to digest the carbohydrate part of the diet while LW chicks were more efficient in digestion of lipid. Moreover, LW line chicks presented with a choice reduced their energy intake and maintained protein consumption, as compared with control chicks eating only mash. Those chicks ate less but gained more weight to 4 and 7 d of age than controls. Therefore LW chicks were not as efficient as HW chicks in the digestion of the carbohydrate part of the mash while protein may be well digested in both lines. These results may explain why 'exogenous' yolk improved growth even in the HW line chicks. This experiment suggests that yolk residue has a determining role in the initiation of growth (during the first week after hatch) which cannot be compensated by feeding exogenous yolk nutrients in fast growing animals. Nutrition of the very young chick requires further research in relation to the early development of their GIT.

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