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Research Article
Effect of Early Post-Hatch Feeding on Yolk Sac Disappearance, Feed Intake and Weight of Newly Hatched Mule Ducklings in a Tropical Environment

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Abstract

Background and Objective: Prolonged periods without access to feed can negatively impact production and the utilization rate of the absorbed yolk sac in poultry. This study investigated the effect of early post-hatch feeding on yolk sac disappearance, feed intake and live weight change of newly-hatched mule ducklings. **Materials and Methods:** A total of 120 mule ducklings were collected and randomly divided into four treatment groups (T) with 30 ducklings per treatment and varying times for post-hatch feeding: T1 (3 h), T2 (24 h), T3 (36 h) and T4 (48 h). Data were collected for 5 days. On day 6, 6 ducklings per treatment were randomly selected, weighed, euthanized and the residual yolk sac was excised and weighed. The rate of residual yolk sac disappearance was then calculated. **Results:** The overall feeding time did not influence the weight of the residual yolk sac ($p>0.05$) over the five day period. However, on Days 2 and 4 the feeding times did significantly affect the yolk sac as a percentage of body weight ($p = 0.01$, $p = 0.00$; respectively). On Days 2 and 5, ducklings given early post-hatch feeding showed a significant change in total body weight relative to control ducklings ($p = 0.006$ and $p = 0.013$, respectively). On Days 1 and 2, all treatments affected feed intake ($p = 0.000$). The yolk sac completely disappeared within 4.46 days of hatching. **Conclusion:** The residual yolk sac weight in mule ducklings decreased with age and independently of post-hatch feeding time. Early post-hatch feeding time (between 3 and 24 h post-hatch) was associated with the highest increase in body weight, suggesting that this feeding practice could enhance productivity in these ducks.

Key words: Feed intake, live weight, mule ducklings, post hatch, yolk sac

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Worldwide population growth has led to increased demand for both grain and meat. In the Caribbean region, including Trinidad and Tobago, the poultry industry plays a crucial role in providing sources of dietary protein[1]. As one sector of this industry, ducks used for meat are now a viable protein source that ensures national food security. In particular, the mule duck has become the most popular breed used by the duck industry in the Caribbean for meat production[2]. Mule ducks have a rapid growth rate, good breast muscle yield, a lean carcass and a lack of sexual dimorphism[2]. In the first 24-72 h post-hatch, mule ducklings rely solely on the residual yolk sac for nutrients[3]. Under normal hatchery and farm conditions, feed is typically not offered to mule ducklings until approximately 32-48 h post-hatch. This delay can result in decreased body weight and malnutrition if the yolk has insufficient nutrient content[3,4]. Further delays in feed access can negatively impact the overall development and performance and produce a lower final body weight[5].

The practice of early post-hatch feeding of broiler chicks, turkey poults and goslings increases the rate of yolk sac reabsorption and utilization by enhancing intestinal villi growth to optimize the absorptive capacity of the gastrointestinal tract at an earlier age, which in turn promotes increases in body weight of the birds up to market age[6-8]. There is limited information about whether post-hatch feeding would provide similar benefits in mule ducks. In this study, we therefore investigated the effect of early post-hatch feeding times on yolk sac disappearance, feed intake and live-weight change of newly-hatched mule ducklings.

MATERIALS AND METHODS

Location and climate: Trinidad is located within the humid tropics at 10 1/2°North latitude and 6 ½° West longitude. Daily temperatures range between 24.1-36.15°C and the average humidity is 80.21%. There are two seasons: a dry season from January to May and a rainy season from June to December. This study was conducted during the rainy season at The University of the West Indies' Field Station (UFS) located in Valsayn (10°38'15"North 61°25'39"West), a town in northern Trinidad.

Experimental design and bird management: A total of 120 newly hatched mule ducklings obtained from a local hatchery were raised in an open-sided, naturally-ventilated house, in 121.9×61cm cages. They were assigned in a completely randomized design to four post-hatch feeding treatments (T) with feeding at different times after hatching: T1 (3 h), T2 (24 h), T3 (36 h) and T4 (48 h). Each treatment was replicated 6 times with 5 birds/replicate for a total of 30 birds per treatment. T1 received both water and feed 3 h post-hatch, while the other treatments received only water until they were fed at 24, 36 and 48 h, respectively. Feed was offered according to National Research Council standards (NRC)[9] and refusal was measured daily in order to determine feed intake; water was provided *ad libitum*. No vaccination was conducted in keeping with local production practices. The experimental period was five days.

Diet: The ingredients and nutrient composition of the feed used in the experiment are shown in Table 1.

Yolk sac retrieval: On each day, six ducklings per treatment were randomly selected, individually weighed on an electric scale (OHAUS IR SENSOR) and euthanized in a humane manner according to APA 2000 Ethics code. The residual yolk sac was then excised and weighed (Plate 1).

Statistical analysis and calculations: The collected data were analyzed by one way analysis of variance (ANOVA) using Minitab software (2017)[10]. Significance was defined based on the 95% confidence level. Feed intake (FI) was calculated as:

Table 1: Composition of feed used in the study

Ingredients	Starter (g kg^{-1} DM)
Soybean meal (470 g CP kg^{1} DM)	415.2.00
Ground corn	356.4.00
Rice bran	80.0.00
Broken rice	60.6.00
Bran shorts	30.0.00
Soybean oil	15.0.00
Dicalcium phosphate	13.5.00
Limestone	12.8.00
Broiler premix-9943	7.5.00
NaCl (salt)	4.6.00
Bentonite	3.0.00
Luprosil salt	0.9.00
Methionine (dl)	0.4.00
Calculated chemical composition (g kg^{-1} DM)	
Dry matter	889.000
ME (kcal g^{-1} DM)	2.850
Crude protein*	224.000
Neutral detergent fiber	164.000
Ca	10.500
Available P	4.600
Ca: Available P	2.300
Lysine	15.000
Methionine	4.660
Methionine+cysteine	9.160
Tryptophan	3.550
ME/P	12.700
Feed pellet quality factor (FPQF)	3.700
Pellet durability index (PDI)	N/A

Plate 1: Representative image showing attachment point of yolk sac excised in this study

$$FI = \frac{\text{Feed given-feed refused}}{\text{No. of ducklings}}$$

The number of birds decreased daily as birds were slaughtered for data collection.

Accumulated feed intake was calculated for four days of the total five day experimental period. Regression analysis was conducted using the Maximum Likelihood Estimation Technique (MLET). During the experimental period, data were corrected for heteroskedasticity and auto correlation using Newey-West standard errors (HAC) estimators. Data were estimated using the econometric software Gnu Regression, Econometric and Time Series[11]. Akaike Information Criterion was used for Model selection. Maple software (Maple Soft version 15, 2015)[12] was used to generate graphs displaying yolk sac weights expressed as a percentage of total body weight as a function of age in days (Fig. 1).

The following model was used:

$$y = \beta_0+\beta_1x+\beta_2x^2+\beta_3x^3$$

where, y represents the yolk sac as a percentage of body weight, β_0 represents the estimated value of the constant term, β_i represents the estimated value of the various age terms, x represents the age of the birds in days

The following formula was obtained and used to calculate the total rate of yolk sac reabsorption from the graph generated (Fig. 1).

$y = 30.53-13.89Age+1.57\ Age^2$
p-value (0.000) (0.000) (0.000)
$R^2 = 0.626$ Adjusted $R^2 = 0.620$
dy/d Age = -13.89+3.14 Age

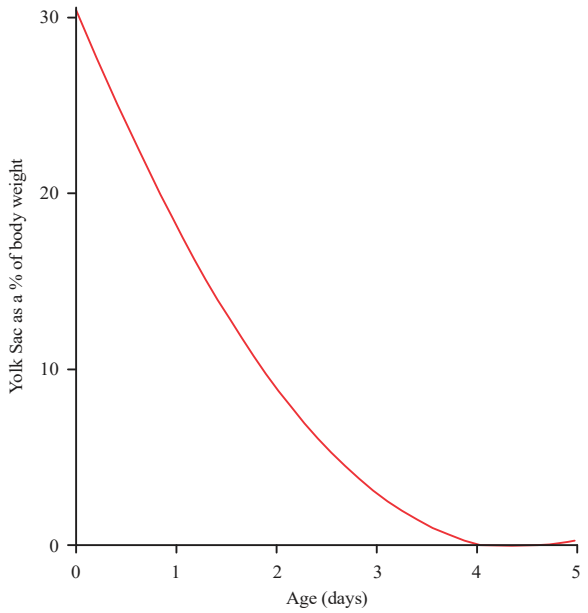

Fig. 1: Disappearance of yolk sac over the first five days post-hatch based on yolk sac weight per 100 g body weight (percentage of body weight)

T1dy/d Age = -13.89+3.14 (1) = -10.75
T2dy/d Age = -13.89+3.14 (2) = -13.89+6.28 = -7.61
T3dy/d Age = -13.89+3.14 (3) =-13.89+9.42 = -4.47
T4dy/d Age = -13.89+3.14 (4) = -13.89+12.56 = -0.33

Therefore: The theoretical Disappearance of yolk sac was:

dy/d Age = -13.89+3.14 Age = 0

Solving the above equation resulted in:

3.14 Age = 13.89
Age = 13.89/3.14 = 4.42 days

RESULTS

Yolk sac disappearance: The effects of the four different treatments on the weight (g) of the residual yolk sac of mule ducklings were observed over a five day experimental period (Table 2). Overall, the residual yolk sac weight was not affected by post-hatch feeding times ($p>0.05$).

The four post-hatch treatments were also evaluated in terms of yolk sac weight per 100 g body weight (Table 3). In contrast to that seen for the overall yolk sac weight, on Days 2 ($p = 0.014$) and 4 ($p = 0.007$) the post-hatch treatments did significantly influence the rate of yolk sac disappearance.

Table 2: Residual yolk sac weight for mule ducklings given different post-hatch treatments

	Post-hatch treatment					
Age (days)	1(3 h)	2 (24 h)	3 (36 h)	4 (48 h)	±SEM	p-value
1	9.25	19.830	8.75	11.08	1.51	0.333
2	6.16	6.917	6.50	5.58	0.60	0.641
3	1.34	1.160	0.83	1.33	0.49	0.873
4	0.58	1.160	0.25	0.33	0.30	0.304
5	0.50	0.160	0.08	0.00	0.35	0.356

Table 3: Residual yolk weight per 100 g body weight

	Post-hatch treatment					
Age (days)	1 (3 h)	2 (24 h)	3 (36 h)	4 (48 h)	±SEM	p-value
1	17.76^{a}	19.67^{a}	15.39^{a}	21.06^{a}	1.035	0.314
2	8.35^{b}	9.75^{ab}	10.32^{a}	10.36^{a}	0.460	0.014
3	2.05^{a}	1.94^{a}	1.41^{a}	2.26^{a}	0.620	0.893
4	0.80^{a}	0.79^{ab}	0.33^{b}	0.48^{b}	0.370	0.007
5	0.63^{a}	0.19^{a}	0.09^{a}	0.00^{a}	0.390	0.544

Rows with different superscript letters indicate significant differences between means of treatments (p<0.05)

Table 4: Daily feed intake of Mule ducklings with different post-hatch feeding times over a five day period

	Post-hatch treatment					
Age (days)	1 (3 h)	2 (24 h)	3 (36 h)	4 (48 h)	±SEM	p-value
1	32.29^{a}	0.00^{b}	0.00^{b}	0.00^{b}	0.69	0.000
2	41.77^{a}	32.72^{b}	31.46^{b}	0.00^{c}	0.98	0.000
3	55.50^{a}	54.75^{a}	54.66^{a}	57.00^{a}	0.80	0.589
4	108.00^{a}	110.83^{a}	110.67^{a}	110.67^{a}	1.22	0.895
Acc. FI (g)	237.56^{a}	198.30^{b}	196.80^{b}	166.50^{c}	0.59	0.000

Rows with different superscript letters indicate differences between means of treatments (p<0.05), FI: Feed intake

Table 5:Total body weight of Mule ducklings with different post-hatch feeding times

	Post-hatch treatment					
Age (days)	1 (3 h)	2 (24 h)	3 (36 h)	4 (48 h)	±SEM	p-value
1	51.80^{a}	51.16^{a}	51.91^{a}	48.41^{a}	0.98	0.563
2	60.00^{a}	51.66^{ab}	49.16^{b}	48.83^{b}	1.03	0.006
3	64.58^{a}	60.66^{a}	58.83^{a}	55.41^{a}	1.11	0.108
4	70.25^{a}	66.58^{a}	74.25^{a}	68.16^{a}	1.15	0.492
5	82.75^{a}	80.33^{ab}	76.16^{b}	69.75^{b}	1.13	0.013

Rows with different superscript letters indicate differences between means of treatments (p<0.05)

Furthermore, across the 5 day period the yolk sac/100g body weight value continued to decrease relative to daily overall treatments.

Yolk sac weight per 100 g body weight was also plotted as a function of age (see Materials and Methods) to determine the theoretical time needed for total disappearance of the yolk sac across all treatments. From this graph, the calculated time to disappearance was 4.46 days.

Feed Intake: The effect of the treatments on daily feed intake (FI) of Mule ducklings was next examined (Table 4). For Days 1 and 2, daily feed intake showed significant differences among the treatments ($p = 0.000$). Overall, the accumulated feed intake also differed among the treatments ($p = 0.000$). Ducklings fed at 3 h post-hatch showed the highest accumulated feed intake.

Effect on body weight: Post-hatch feeding treatment did not affect the body weight on Days 1, 3 and 4 of the five day experimental period (Table 5). However, for Days 2 ($p = 0.006$) and 5 ($p = 0.013$), there were significant differences among treatments. Furthermore, at the end of the experimental period, ducklings fed at 3 h post-hatch were significantly heavier than those fed at 36 and 48 h and slightly heavier than those given feed 24 h post-hatch.

DISCUSSION

Yolk sac disappearance: Results of the present study showed that, regardless of the time feed was offered, in mule ducks the yolk sac weight continued to decrease, which is in contrast to results from previous studies[13]. In terms of absolute weight, decreases in yolk sac weight were not observed across the

5 days experimental period (Table 2) and this result is consistent with findings of Yang[14] for goslings and Moran and Reinhart[15] for broiler chicks. Previous studies showed that at 4 days post-hatch the yolk sac weighed approximately 0.4 g for chicks fed at 24 h, while those fed at 48 h had yolk sac weights of 1.5 g[16-18]. In this study, duckling yolk sac weights were lower at 0.50, 0.16, 0.08 and 0.00 g for post-hatch feedings at 3, 24, 36 and 48 h, respectively.

Bhanja[13] reported that broiler chicks fed immediately post-hatch consumed approximately 3 g of yolk sac weight during the first 24 h and another 1.50 g on the second day post- hatch. In this study, T1 ducklings utilized 3.09 g within the first 24 h and another 2.82 g during the second day post-hatch. Meanwhile, the T4 group, which had the longest interval between hatching and feeding, utilized 5.5 and 4.25 g of yolk sac on the first and second post-hatch day, respectively. This decrease in residual yolk sac weight resulted from the utilization of yolk sac nutrient[15-19]. On Days 2 and 4, there were significant differences in the yolk sac as a percentage of total body weight (yolk sac weight/100 g body weight) (Table 3). The differences among the treatments may be due to the utilization of the yolk sac content and body reserves for the ducklings that is needed for growth in the absence of feed. However, values for yolk sac weight as a percentage of body weight were within the 15-25 g/100 g range as reported by Noy and Sklan[6] for broiler chicks.

The time for total disappearance of the yolk sac was calculated to be 4.46 days (Fig. 1), which is consistent with that obtained by Noy and Sklan[20] and slightly longer than that reported by Romanoff[21] for broiler chicks, which showed total yolk sac disappearance by 4 days post-hatch.

Feed intake: On Days 1 and 2 there were significant differences among all treatments for daily feed intake that could be associated with the different post-hatch feeding times (Table 4). For example, ducks in T3 and T4 groups received no feed for the first 36 and 48 h of the 112 h experimental period. However, on Days 3 ($p = 0.589$) and 4 ($p = 0.895$) post-hatch treatments did affect duckling feed intake. This result contradict with a previous study conducted by Ganjali[22] who reported that daily feed intake of broiler chicks fed at 6 h post-hatch was superior ($p<0.05$) to those fed at 12 and 18 h.

The accumulated feed intake data in this study (Table 4) showed significant decreases for T1-T4 and could explain the higher body weight observed for T1 compared to the other treatments (Table 5).

Effect on body weight: Within the first 24 h an approximate loss of 0.01, 2.75 and 0.42 g of body weight occurred for ducklings in T2, T3 and T4, respectively, which was lower than that seen in earlier studies for broiler chicks (Table 5)[20,23-25]. This body weight loss likely represents utilization of the yolk sac content as well as a reduction in tissue and organ weight[26]. On Days 2 ($p = 0.006$) and 5 ($p = 0.013$), comparisons among T1-T4 revealed that ducklings in T1 had significantly higher body weights than the other groups, which is similar to results obtained by Yang[14] and Zarghi[27] for goslings and Japanese quails, respectively and could be attributed to the earlier feeding. This result strongly supports that there is a direct correlation between the timing of feed and feed intake of ducks on gastrointestinal tract growth[3]and also corroborates findings by Fairchild[28] that birds with early access to nutrients were 8-10% heavier than those fed 48 h post-hatch.

CONCLUSION

The weight of the residual yolk sac of mule ducklings in this study decreased with age (days) independently of post-hatch feeding time and the time needed for disappearance of the yolk sac was 4.46 days. Further, early feed access (3 h post-hatch, T1) was associated with the best growth rate of mule ducklings. Taken together, the findings indicate that in tropical humid climate mule ducklings should be fed between 3-24 h post-hatch.

SIGNIFICANCE STATEMENT

This study will help guide both mule duck farmers and hatchery operations to select optimal post-hatch feeding times to maximize growth and productivity of mule ducks.

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