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Early weaning in pigeons (*Columba Livia domestica*): effects on squabs performance and reproductive performance of parents

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Abstract

Background Artificial hatching and early artificial feeding of squabs can potentially reduce pigeon rearing costs, shorten breeding cycles, and enhance overall productivity. Two experiments were conducted to evaluate the effect of early weaning on growth performance, feed consumption, parents' reproductive performance, and egg traits.

Methods In Experiment 1, A total of 300 pairs of adult White Mirthys pigeons were randomly divided into three groups: W28, W7, and W0. These groups represent pigeons separated from their squabs at different ages: 28 days, 7 days, and 0 days (at hatch), respectively. Each group consisted of ten replicates, with each replicate comprising ten pairs of pigeons. In experiment 2, a total of 566 White Mirthys pigeon squabs were randomly assigned to three treatment groups: W28, W7, and W0. These groups represent squabs separated from their parents at different ages: 28 days, 7 days, and 0 days (at hatch), respectively.

Results The results indicated that early weaning of squabs significantly decreased body weight, weight gain, feed intake, and feed conversion ratio ($P < 0.05$), while also increasing the mortality rate in the W0 group compared to the W28 and W7 groups. There were no significant differences in body weight, weight gain, or mortality rate between the W28 and W7 groups. Pigeons in the W0 group exhibited significantly lower ($P < 0.001$) egg-laying cycle and reproductive cycle. Still, they produced more eggs laid and weaned squabs than the W28 and W7 groups. Early weaning had no significant impact on hatchability rate ($P = 0.220$), egg weight ($P = 0.580$), egg length ($P = 0.308$), egg width ($P = 0.488$), or egg shape index ($P = 0.167$). However, the eggs from the early weaning group (W0) had a lower shell thickness ($P = 0.002$) compared to the control (W28) and W7 groups.

Conclusions Early weaning at hatching has been found to reduce the growth performance of squabs; however, it significantly enhances the reproductive performance of parent pigeons. This method presents a promising strategy for increasing the reproductive rate of parent pigeons and boosting the annual production of squabs.

Keywords Early weaning, Pigeons, Squab, Hand feeding, Growth performance, Reproductive performance

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Background

Pigeons (*Columba livia*) are recognized as one of the first bird species domesticated by humans, dating back over 3,500 years [1]. Initially, they were used for religious rituals, conveying messages, and later became a food source [2, 3]. Pigeon meat is considered a high-quality food option; it is low in cholesterol, rich in protein, and possesses a distinctive flavor and aroma [4]. In Egypt, pigeon meat is regarded as a delicacy of high value [5]. Pigeon farming for meat has also gained in the United States [6], as well as in Europe and Asia [7, 8]. Additionally, pigeon eggs are a staple food in many cultures. They contain high-quality protein and many essential nutrients [9–11].

Traditional pigeon breeding has evolved into commercial or industrial farms in response to the growing demand for their meat. However, the pigeon meat production sector is distinct from other poultry industries because of its different growth characteristics [12, 13]. Squabs are superaltricial, completely depend on their parents for feeding and care during this early stage of life, until they are weaned [14]. In the traditional breeding method, squabs are usually weaned while remaining in their nests, a process that generally takes about 21 to 28 days after hatching [15–17]. During this period, the parent pigeons care for squabs [14], and they are unable to enter a new egg-laying cycle.

The egg-laying cycle significantly influences the production of pigeons. A breeding pair of pigeons produces about 12 squabs annually through natural weaning, each squab weighs between 450 and 700 g [18]. This production rate is considered low compared to other poultry species. The egg-laying cycle for local Egyptian pigeons is approximately 52.75 days [19]; while for local Indonesian pigeons, it is around 51 days [20]. The silver king pigeon breed has an egg-laying cycle of 39.2 days [17], and local Bangladeshi pigeons have a cycle of 37.17 days [21]. Ahmed [22] reported that the period between hatching and next laying in the White Mirthys breed is 19.50 days.

The traditional breeding system for pigeons is not well-suited for commercial or industrial production, as it limits squab output and hinders the ability to maximize economic returns. To improve production efficiency, it is essential to artificially feed squabs that have been weaned early [23]. Previous studies indicate that early weaning can be used. For instance, Wen et al. [23] reported that domestic pigeon squabs can be weaned as early as the seventh day. Similarly, Abdel-Azim et al. [24] found that pigeon chicks were weaned as early as the third day after hatching and were then hand-fed with crop milk substitutes. For the effect of early weaning of squabs on maternal productivity, if young pigeons are weaned early, the dam can lay eggs 10 to 20 days earlier than usual [24]. This could increase the egg production for each pair of pigeons from 6 pairs to between 10 and 15 pairs per year [25]. While early weaning may negatively affect the body weight and growth rate of squabs [23], it presents a promising strategy to enhance the reproductive rate of parent stock by increasing the annual production of squabs [24]. Currently, squabs are weaned on a large scale in commercial farms immediately after hatching. They are fed a crop milk replacer by hand, which allows their parents to continue laying eggs, thereby increasing the number of eggs and squabs produced. Additionally, to our knowledge, no detailed studies have been previously reported on the effects of weaning at hatching on either the squabs or their parents. Therefore, this study was conducted to evaluate the effects of early weaning of squabs at 0 and 7 days old on growth performance, feed consumption, reproductive performance of the parents, and egg traits.

Materials and methods

The current study was conducted in a commercial pigeon farm, located on the Cairo-Alexandria Desert Road, Alexandria, Egypt.

Experimental design

Two experiments were conducted to evaluate the effects of early weaning on growth performance, feed consumption, reproductive performance of the parents, and egg traits for the White Mirthys pigeon.

In experiment 1, a total of 300 pairs of adult White Mirthys pigeons were randomly divided into three groups: W28, W7, and W0. These groups correspond to the ages at which the pigeons were separated from their squabs: 28 days, 7 days, and 0 days (at hatch), respectively. Each group consisted of ten replicates, with each replicate comprising ten pairs of pigeons.

In experiment 2, a total of 566 White Mirthys pigeon squabs were randomly assigned to the same three treatment groups: W28, W7, and W0, representing separation from their parents at 28 days, 7 days, and 0 days (at hatch), respectively.

Bird housing

Each pair of parent pigeons, consisting of sire and dame, was housed as an individual family in numbered metal cages. Each cage measured 60 cm in width, 60 cm in length, and 50 cm in height, and included two nests. The cages were arranged in an open-house system that maintained hygienic conditions with natural ventilation. To provide adequate light, artificial lighting was used to ensure a total of 17 h of light per day. For artificial incubation in the W0 group, newly hatched squabs are placed in a controlled brooding area set at 35 °C and 60% humidity on the first day after hatching. The temperature is gradually reduced by 1 °C each subsequent day until it reaches 30 °C, which is maintained until the feathers cover the squabs sufficiently. Thereafter, the temperature is further decreased based on feather development until it stabilized at room temperature (approximately 22–24 °C) by the time squabs reached 14–16 days of age.

Experimental diets

The parental pigeons received pellet feed twice daily (17.3% protein and energy content of 12.8 MJ/ kg) and had free access to feed and water. The squabs in the W28 group were fed by the parents from hatching until 28 days old. The squabs in the W7 group were fed by their parents for the first 7 days after hatching and then were hand-fed with mashed feed from days 8 to 28. The squabs in the W0 group were hand-fed with crop milk replacer (40.6% protein and energy content of 14.5 MJ/ kg) for the first 7 days after hatching four times daily and then were hand-fed with mashed feed from days 8 to 28. Crop milk replacer is a commercial powdered product that is mixed with warm water (37 °C) in a ratio of 1:2 and administered using a syringe prepared specifically for feeding young birds. The mash feed is the same as the pelleted feed given to adult pigeons and is prepared by grinding, mixing with warm water (37 °C), and hand feeding to the squabs from 8 to 28 days of age.

Growth performance

Squabs were weighed at days 0 (initial body weight), 7, and 28 (final body weight). Based on these measurements, weight gain during different periods and the feed conversion ratio were calculated with the following formulas:

Weight gain (g) = final body weight – initial body weight.

Feed conversion ratio (FCR) = total feed intake (g) ÷ total weight gain (g).

The mortality rate is the percentage of deaths in squabs, calculated for all treatment groups from hatching until 28 days. The total amount of feed consumed by each pair was calculated in all treatments from hatching to 28 days.

Reproductive performance

The egg laying cycle was calculated as the interval between fertilized egg deposits in consecutive clutches. The reproductive cycle was calculated as the days between two successive weaning. The number of eggs and weaned squabs were calculated for each pair over a period of 160 days. The length and width of each egg were measured, and the egg shape index (%) was calculated by dividing the width by the length and multiplying by 100. Eggs from the W0 group were artificially incubated using a PTO egg hatching machine (Model C2). During the incubation phase, the temperature was consistently maintained at 37.3 °C, and the humidity was kept at 60% according to Vatnick [26]. For the first 15 days, the eggs were turned every two hours. After this period, they were moved to the hatching tray and placed in individual breeding boxes, which are used to ensure that paternity is accurately determined for each squab. The thickness of the eggshell was measured after hatching using a micrometer. Total hatchability percentage is calculated by dividing hatched eggs by incubated eggs.

Statistical analysis

A preliminary analysis was conducted using Jamovi 2.2.5 software (The Jamovi Project, 2022) to obtain least-squares means. The effects of early weaning ages, which included three treatments, were treated as fixed effects according to the model Yij = μ + Tj + eij, where Yij represents the dependent variable for each observation, μ is the overall mean, Tj denotes the effect of treatment j, and eij represents the error term associated with each observation. An analysis of variance (ANOVA) was performed, followed by Tukey's test to determine significant differences among the treatments. The level for statistical significance was set at $p < 0.05$.

Results

Growth performance

The effects of early weaning of squabs at 0 and 7 days of age on body weight, weight gain, mortality rate, feed intake, and feed conversion ratio are presented in Table 1. There was no significant differences ($P = 0.502$) in initial body weight between the groups. However, at both 7 days of age and final body weight, the body weight was lower ($P < 0.001$) in the W0 group compared to the W28 and W7 groups. Weight gain in the W0 group was also significantly lower from 0 to 7 days ($P < 0.001$), from 7 to 28 days ($P < 0.001$), and from 0 to 28 days ($P = 0.005$) when compared to the W28 and W7 groups. The mortality rate for squabs was higher in the W0 group ($P < 0.001$) compared to the W28 and W7 groups. The total feed intake (g/ pair of squabs) was the lowest in the W0 group ($P = 0.034$), followed by the W7 group, and then the W28 group. The W0 group had the best feed conversion ratio ($P = 0.016$), followed by the W7 group and then the W28 group.

Reproductive performance and egg traits

The effects of early weaning of squabs at 0 and 7 days of age on reproductive performance and egg traits are shown in Table 2. Pigeons in the W0 group showed a significantly shorter egg laying and reproductive cycle and significantly higher number of eggs in 160 days/pair ($P < 0.001$) compared to the W28 and W7 groups. There was no significant effects of early weaning on hatchability rate ($P = 0.220$), egg weight ($P = 0.580$), egg length ($P = 0.308$), egg width ($P = 0.488$), or egg shape index ($P = 0.167$). However, eggs from the early weaning group

Table 1 Effect of early weaning on growth performance, feed consumption, mortality rate, and feed conversion ratio

Items	Groups			SEM	*P*-value
	W28	W7	W0		
Initial body weight, g/ squab	17.43	17.61	17.55	0.27	0.502
Body weight at d 7, g/ squab	157 [a]	161 [a]	125 [b]	3.01	< 0 0.001
Final Body weight, g/ squab	458 [a]	465 [a]	367 [b]	8.15	< 0 0.001
Weight gain at 0–7 d of age, g / squab	132 [a]	134 [a]	102 [b]	4.03	< 0 0.001
Weight gain at 7–28 d of age, g / squab	309 [a]	293 [a]	241 [b]	7.33	< 0 0.001
Weight gain at 0–28 d of age, g / squab	442 [a]	446 [a]	349 [b]	21.24	0.005
Mortality rate, %	3.80 [b]	3.28 [b]	26.70 [a]	0.51	< 0 0.001
Total feed intake, g/pair of squabs	3220 [a]	2805 [b]	2033 [c]	41.0	0.034
Feed conversion ratio (g feed/ g gain)	3.66 [a]	3.19 [b]	2.95 [c]	0.21	0.016

W28: weaning group after 28 d of hatching; W7: weaning group after 7 d of hatching; W0: weaning group after 0 d of hatching

[a, b, c] Means within the same row with different superscripts differ significantly ($P < 0.05$)

SEM: standard error of the mean

Table 2 Effect of early weaning on reproductive performance and egg traits

Items	Groups			SEM	*P*-value
	W28	W7	W0		
Egg laying cycle, days	38.1 [a]	37.5 [a]	10.2 [b]	0.54	< 0 0.001
Reproductive cycle, days	38.1[a]	38.3 [a]	11.6 [b]	0.78	< 0 0.001
laying rate in 160 days/ pair	8 [b]	8.59 [b]	16.71 [a]	0.51	< 0 0.001
Hatchability rate, %	94.93	95.01	94.86	0.13	0.220
Number of weaned squabs over 160 days/ pair	7.38 [b]	7.87 [b]	12.44 [a]	0. 25	< 0.001
Egg weight, g	19.93	19.87	20.00	0.18	0.580
Egg length, cm	3.92	3.94	3.91	0.02	0.308
Egg width, cm	2.85	2.94	2.94	0.01	0.488
Egg shape index	73.18	74.30	74.09	0.15	0.167
Shell thickness, mm	0.198[a]	0.195 [a]	0.171[b]	0.01	0.002

W28: weaning group after 28 d of hatching; W7: weaning group after 7 d of hatching; W0: weaning group after 0 d of hatching

[a, b] Means within the same row with different superscripts differ significantly ($P < 0.05$)

SEM: standard error of the mean.

(EW0) had a lower shell thickness ($P = 0.002$) compared to the control (W28) and W7 groups.

Discussion

Growth performance

Pigeons are birds that cannot feed themselves for a certain period after hatching. During this period, they depend entirely on a special type of feed produced by the crop of the parent pigeons, known as crop milk [16, 27, 28]. This crop milk nourishes the squabs until they can eat independently. The crop milk primarily consists of fats and proteins [29, 30]. Additionally, it contains a significant amount of maternal antibodies [13, 31]. Consequently, the growth and development of squabs rely heavily on crop milk [23, 32]. Our results indicate that early weaning from hatch negatively affects growth performance. This finding aligns with observations obtained by Wen et al. [23]. The reduction in body weight and weight gain observed in the W0 group of squabs may be attributed to the differing nutritional values between natural crop milk and commercial crop milk replacers. On the other hand, our study suggests that a slight delay in weaning of squabs to the 7-day-old could help mitigate some of the negative effects associated with early weaning. Previous studies have shown that early weaning adversely affects the length and weight indices of the small intestine, including the duodenum, jejunum, and ileum. This is particularly evident in the ileum, where early weaning leads to a decrease in length [33–35]. This could explain the significant reduction in body weight in birds weaned at hatch. Other studies indicated that providing antioxidants and nutritional supplements can help rabbits and piglets endure a less stressful weaning process by promoting the lengthening of their small intestine [36–38]. If similar approaches are applied to pigeons, it may help minimize the negative effects of early weaning on growth performance in squabs and enhance the reproductive traits of parent birds.

The findings of this study indicate that early weaning at hatch (W0) significantly increases mortality rates among young pigeons. In contrast, early weaning after 7 days (W7) post-hatching shows similar outcomes to natural weaning (W28). While early weaning at hatch is considered a modern approach to enhancing pigeon production, it necessitates further research to ensure proper care and nutrition, thereby reducing mortality rates. The high mortality rates observed in the squabs from the W0 group may be attributed to early weaning. This practice disrupts gut development, influencing the length and weight indices of the ileum [25]. It also adversely affects small intestine health, including enzyme activity, antioxidant status, and inflammatory cytokine levels [25], all of which are crucial for digestion and nutrient absorption. Consequently, these disruptions can lead to increased mortality in the squabs. These findings align with previous studies by Smith et al., [39], Meale et al., [40], Chen et al., [41], Li et al., [42], and Xu et al., [43] which also highlighted the negative effects of early weaning in animals, often resulting in heightened mortality rates.

The results of this study indicate that the birds in the W0 group had a feed intake that was 38.9% lower than that of the W28 group and 27.5% lower than the W7 group. Furthermore, the W0 group exhibited the greatest improvement in feed conversion rate, followed by the W7 group, with the W28 group showing the least improvement.

Reproductive performance and egg traits

To enhance pigeon productivity for commercial purposes, one strategic goal is to reduce the egg-laying and reproductive cycles of parent pigeons. This approach aims to increase the number of eggs available for artificial incubation. Our results indicated that early weaning at hatch (W0) positively affects the egg-laying and reproductive cycles compared to early weaning at 7 days of age (W7) or a control group. The significant decrease in the reproductive cycle due to early weaning at hatch could lead to increased productivity by increasing the number of squabs produced each year per pair of parent pigeons. During the incubation period, parent pigeons care for their eggs and squabs, which prevents them from entering a new egg-laying cycle. It has been suggested that prolactin levels associated with this incubation behaviour may explain the differences in egg laying cycle and reproductive cycle among various groups. Mohamed et al. [44] reported fluctuations in prolactin levels throughout the reproductive cycle, with levels peaking during egg incubation and declining after hatching. Since high prolactin levels are linked to the timing of egg laying, these fluctuations may help explain variations in mating frequency and egg production [45, 46].

Early weaning at hatching increased the number of eggs produced per pair during the experimental period compared to both the 7-day weaning group and the control group. However, early weaning did not affect egg weight, length, width, or shape index. Early weaning resulted in a higher number of mating between dames and sires. This finding aligns with those of Al-Sagheer et al. [47], who reported that mating rates did not influence egg production traits in broiler chickens. Conversely, early weaning at hatching significantly reduced eggshell thickness compared to the other groups. This decrease may be attributed to the higher egg production observed in the W0 group of parent pigeons. This finding aligns with Roberts' [48] observation that several factors, including bird age, breed, production system, and general stress, affect eggshell quality, particularly its strength and thickness.

Conclusion

It can be concluded that Early weaning of squabs at hatching decreased their body weight, growth, and feed intake while increasing squab mortality. The pigeons in the W0 group experienced a shorter egg-laying and breeding cycle, produced more eggs, and successfully weaned more squabs. Early weaning did not have a significant effect on hatching rate, egg weight, egg length, egg width, or egg shape index. However, eggs from the early weaning group did have a lower shell thickness. Overall, while early weaning at hatching was found to reduce the growth performance of the squabs, it significantly improved the reproductive performance of the parent pigeons. This approach presents a promising strategy for increasing the reproductive rate of parent pigeons and enhancing annual egg production. Further studies are needed to decrease squab mortality associated with artificial incubation. This can be achieved by identifying optimal diets enhanced with feed additives and placing the eggs under a less valuable pigeon to take over the incubation and feeding process. Additionally, it is important to evaluate the effect of artificial incubation on the quality of the squabs.

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Author contributions

Conceptualization, O.A.M.; methodology, O.A.M; software, O.A.M, and M.A.E.; validation, O.A.M, I.M.K, and M.A.E; formal analysis, O.A.M.; investigation, O.A.M, I.M.K, and M.A.E; writing—original draft preparation, O.A.M, I.M.K, and M.A.E; writing—review and editing, O.A.M, I.M.K, and M.A.E. All authors have read and agreed to the published version of the manuscript.

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Data availability

Datasets generated and/or analyzed during this study are included in this article version, and if required any further information related to the data involved in the manuscript can be obtained from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
All animal experimental procedures in this experiment received approval from the Animal Care and Use Committee at Alexandria University (Approval no. 0306746). All procedures involving animals in this study were carried out in accordance with the Universal Directive on the Protection of Animals Used for Scientific Purposes, and followed the ARRIVE guidelines for reporting animal research (https://arriveguidelines.org). Informed consent was obtained from the farm owner to use pigeons in this experiment.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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