



## EARLY FEATHERING OBSERVATIONS AND FIRST CLUTCH HATCH RESULTS IN CHICKS OF RED MOSAIC CANARIES: A DESCRIPTIVE STUDY IN 10 PAIRS WITHOUT EXTRA PIGMENT SUPPLEMENTATION

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**Abstract:** The aim of this study was to describe the early feather appearance of chicks obtained from phenotypically red mosaic canaries kept under routine breeder feeding without added canthaxanthin or beta-carotene, and also to summarize first-clutch reproductive data. Ten breeding pairs of red mosaic canaries kept under private breeder conditions were included. The parent birds were purchased after the adult mask and red color pattern had already become visible, and pairing was made around 15 February. During the study, birds received ad libitum a standard ration composed of imported egg soft food and an imported canary seed mixture. No external red pigment source was added in any period. Egg and hatch records from the first clutch were taken from breeder logs and converted into reproductive indicators. During early feathering, all chicks were checked for visible red mask and for any reddish tone in the plumage. From the first clutch of 10 pairs, 37 eggs and 26 hatched chicks were recorded, giving an overall hatchability of 70.3%. Mean egg number and hatched chick number per pair were 3.7 and 2.6, respectively. In none of the 26 chicks, visible red facial mask or general reddish feathering was seen during early feathering. All chicks showed a yellowish-white early feather appearance. These findings suggest that, under routine breeder feeding without added pigment supplementation, the adult-type red mask of red mosaic canaries is not visibly expressed in the early feathering period of first-clutch chicks.

**Keywords:** Canary, Red mosaic, Red factor, Lipochrome, Hatchability, Early feathering

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### 1. Introduction

The biological basis of plumage color in canaries depends on a color system formed by the combined effect of melanin and lipochrome pigments. Perez-Beato (2008) stated that lipochrome pigments arise from the metabolic use of dietary carotenes and xanthophylls. Therefore, color formation depends on intake of these compounds, their conversion to pigments, their deposition in skin and feather precursors, and the genetically determined amount and distribution kept in feather structure.

In red factor canaries, red coloration appears by conversion of yellow dietary carotenoids into red ketocarotenoids. Lopes et al. (2016) showed that at least two genomic regions coming from the red siskin are necessary for red coloration, one including the CYP2J19 region and the other related with the epidermal differentiation complex. For this reason, the red phenotype seen in adult birds has both genetic and metabolic background and cannot be explained only by external appearance. In addition, pigment-related feeding

should be considered in red factor birds. The EFSA Panel on Additives and Products or Substances used in Animal Feed (2014) stated that canthaxanthin has the potential to enhance plumage pigmentation in ornamental birds, and Esatbeyoglu and Rimbach (2017) described canthaxanthin as a red-orange xanthophyll widely used in animal feeding for pigmenting purposes.

Classical literature on canary color genetics also indicates that red phenotype is shaped not only by genotype but also by environmental conditions. Perez-Beato (2008) reported that, under insufficient beta-carotene nutrition, yellow pigment deposition may occur instead of red lipochrome. Thus, phenotype should be evaluated as a combination of genotype and environment.

Developmental stage is also important in mosaic canaries. Perez-Beato (2008) noted that mosaic females in the fledging period often resemble common lipochrome birds, while mosaic males before the first molt may be difficult to distinguish from ordinary lipochrome birds. Distinct markings become more evident only after the first molt. Because of this, the



mosaic red distribution seen in adult breeding birds may not be visible with the same intensity and localization during early feathering in the chicks.

Although the basic ration in canary breeding is generally based on seed mixtures, commercial egg foods are widely used as complementary feeds during reproduction, growth, and molt (Mevliyaoğulları et al., 2021; Demirci and Mevliyaoğulları, 2023; Mevliyaoğulları, 2025). Demirci and Mevliyaoğulları (2023) reported that imported commercial egg foods sold in Türkiye are rich in crude protein and crude fat, whereas imported seed mixtures provide a standard feeding base mainly composed of canary seed, niger seed, canola/rapeseed, oats, flaxseed, and hempseed. In older juvenile canaries, paternal presence and local enhancement have also been shown to increase seed pickup, husking, and ingestion, indicating that feeding-related behavior is influenced not only by feed type but also by social context (Cadiou et al., 1995).

In a study conducted in Yorkshire canaries, no statistically significant difference was found in total egg number between two imported commercial egg foods, but a biologically more favorable tendency was reported for chick number (Mevliyaoğulları, 2025). Also, adult canaries have been reported to consume approximately 3-4 g dry matter or seed kernels daily, and a metabolizable energy requirement around 14.8 kcal (about 62 kJ) has been described for a bird of approximately 22 g body weight (Harper et al., 1998; Harper and Turner, 2000; Mevliyaoğulları et al., 2021).

The aim of this study was to describe together the first-clutch reproductive records and the early feather phenotype of chicks from red mosaic canary pairs kept under routine breeder feeding without external pigment supplementation.

## **2. Materials and Methods**

### **2.1. Study Design and Animal Material**

The study used a series of data obtained from single-center descriptive observations under specific breeder conditions. The data was obtained from Dr. Ercan Mevliyaoğulları's hobby canary breeding facility located in Çukurova district of Adana province. Ten male and 10 female canaries showing phenotypic red mosaic pattern were paired and 10 breeding pairs were formed.

All the chicks whose data was collected were produced by Dr. Ercan Mevliyaoğulları, who is a member of the Seyhan Canary and Songbird Breeders Association (ring no. 070), and breeding was carried out in the same facility. The breeding birds were obtained in October, when adult mask and red color distribution were already established, and pairing was made around 15 February. Each breeding pair was housed in a custom designed breeding cage made of plastic material (50 × 40 × 40 cm), without an internal divider, and equipped with a roll-bottom liner system.

Only first-clutch data were included in analysis. The analytical unit was the pair for reproductive performance

(n = 10) and the chick for early feather phenotype (n = 26).

### **2.2. Feeding Regimen**

During the study, birds were fed ad libitum with a standard breeder ration composed of imported egg-based soft food and an imported canary seed mixture. No canthaxanthin, beta-carotene, or similar commercial red color additive was used at any stage. In this way, study conditions represented routine breeder feeding without external pigment supplementation.

A chemical analysis of the exact ration used in this study was not performed at the same time; however, previous analyses of imported commercial canary egg foods and imported seed mixtures sold in Türkiye describe the nutritional frame of this feeding pattern. According to those reports, imported egg foods contained on average 93.46% dry matter and, on dry matter basis, 18.04% crude protein, 12.23% crude fat, 44.52% starch, 7.89% crude fiber, 4.04% ash, and estimated metabolizable energy of 17.0 kJ/g DM. Imported seed mixtures contained 94.54% dry matter and, on dry matter basis, 20.64% crude protein, 16.89% crude fat, 38.77% starch, 11.61% crude fiber, 4.91% ash, and estimated metabolizable energy of 17.2 kJ/g DM (Demirci and Mevliyaoğulları, 2023). This general frame is also compatible with the ranges reported for imported commercial egg foods used in Yorkshire canaries, namely 18-20% crude protein, 9-12% crude fat, 7-8% crude fiber, and 93-94% dry matter (Mevliyaoğulları, 2025). Earlier canary nutrition studies likewise reported mean seed kernel intake of about 3.5 g/day and mean metabolizable energy intake of about 62 kJ/day in adult birds, supporting the plausibility of this general feeding background (Harper et al., 1998; Harper and Turner, 2000).

The same analysis showed that imported seed mixtures were composed mainly of canary seed (66.92%), niger seed (11.01%), canola/rapeseed (8.91%), oats (5.67%), flaxseed (5.16%), and hempseed (3.70%), while perilla and millet were present at lower levels (Demirci and Mevliyaoğulları, 2023).

### **2.3. Data Recording, Observation Time, and Outcome Measures**

The numbers of eggs and hatched chicks in the first clutch were taken from raw breeder records and converted into processed reproductive indicators. Total egg number, total hatched chick number, overall hatchability, and pair-level descriptive statistics were calculated from these records.

Phenotypic evaluation was done during early feathering after hatching and during the first visible feather development observed approximately in the first half of March. This observation window corresponds to a period of rapid chick development in canaries, since early postnatal growth has been reported to progress quickly during the first two weeks after hatching (Harper and Turner, 2000). The primary phenotypic outcome was presence of a visible red facial mask, and the secondary

outcome was presence of any reddish tone on the face or in the general plumage. Chicks without such coloration were classified as having yellowish-white early feather appearance. Representative photographs were taken during the in-nest and early juvenile stages from chicks of the same breeding year and were kept as visual documentation; these photographs were not included in the statistical analysis.

**2.4. Statistical Analysis**

Egg number, hatched chick number, and pair-level hatchability were summarized as mean ± standard deviation, median, and minimum-maximum. Overall hatchability was calculated by dividing total number of hatched chicks in all pairs by total number of eggs. Phenotypic results were presented as counts and percentages. Exact binomial 95% confidence intervals were calculated for overall hatchability and for the proportions of visible red mask and reddish feathering. Because the design was single arm and descriptive, no hypothesis testing for between group comparison or causal inference was planned. Timeline of the study and observation steps is given in Table 1.

**3. Results**

In the first clutch, the 10 pairs produced 37 eggs in total, and 26 chicks hatched from these eggs. Overall hatchability was 70.3% (26/37; exact 95% CI: 53.0-84.1). At pair level, mean egg number was 3.7±0.5, mean hatched chick number was 2.6±1.3, and mean hatchability was 70.8% ± 33.9%. At least one chick hatched in nine pairs, and complete hatch was observed in four pairs. Processed first clutch performance indicators are shown in Table 2, and distribution summaries are given in Table 3.

Phenotypic evaluation was performed in 26 chicks. During early feathering, visible red mask was recorded in 0/26 chicks (0.0%; exact 95% CI: 0.0-13.2), and any reddish feathering was also recorded in 0/26 chicks (0.0%; exact 95% CI: 0.0-13.2). All chicks showed yellowish-white early feather appearance (26/26; 100.0%; exact 95% CI: 86.8-100.0). Phenotypic outcomes are presented in Table 4, and representative color photographs are presented in Figure 1.

**Table 1.** Timeline of the study and observation steps

Stage	Time	Description
Breeding stock acquisition	October	Purchase of breeding birds with already established adult red mosaic phenotype
Pairing	Around 15 February	Pairing of 10 males and 10 females to form 10 breeding pairs
First clutch	Late February-early March	Laying of first eggs and start of incubation
First hatches	March	Hatching of chicks from the first clutch
Early feathering observation	Around 10-15 March and the following early period	Evaluation of face, head region, and general plumage for red mask or any reddish feathering



**Figure 1.** Representative color photographic records of red mosaic canary chicks from the first clutch. (A-B) Yellowish white plumage during the in nest early feathering period, without visible red mask. (C-D) No clear accumulation of red pigment in the mask region during the early juvenile period.

**Table 2.** Processed indicators for first clutch reproductive performance (n = 10 pairs)

Domain	Indicator	Estimate	95% CI / distribution
Clutch scope	Number of evaluated pairs	10	-
Clutch scope	Total number of eggs	37	-
Clutch scope	Total number of hatched chicks	26	-
Hatching success	Overall hatchability	70.3%	53.0-84.1
Hatching success	Pairs with at least one chick hatched	9/10 (90.0%)	55.5-99.7
Hatching success	Pairs with all eggs hatched	4/10 (40.0%)	12.2-73.8
Pair-level summary	Eggs per pair	3.7 ± 0.5	Median 4 (Q1-Q3: 3.25-4.00)
Pair-level summary	Hatched chicks per pair	2.6 ± 1.3	Median 3 (Q1-Q3: 2.25-3.00)
Pair-level summary	Hatchability per pair	70.8% ± 33.9%	Median 75.0% (Q1-Q3: 56.3%-100.0%)

**Table 3.** Distribution summary of first-clutch reproductive variables (n = 10 pairs)

Variable	Mean ± SD	Median (Q1-Q3)	Min-Max	CV (%)
Eggs per pair	3.7 ± 0.5	4.0 (3.25-4.00)	3-4	13.1
Hatched chicks per pair	2.6 ± 1.3	3.0 (2.25-3.00)	0-4	48.7
Hatchability per pair (%)	70.8 ± 33.9	75.0 (56.3-100.0)	0.0-100.0	47.8

**Table 4.** Early feather phenotypic outcomes in first clutch chicks (n = 26)

Phenotypic outcome	Positive observations / total	Proportion (%)	Exact 95% CI
Visible red mask	0/26	0.0	0.0-13.2
Any reddish feathering	0/26	0.0	0.0-13.2
Yellowish-white early feather appearance	26/26	100.0	86.8-100.0

Note: Proportions are given with exact binomial 95% confidence intervals.

#### 4. Discussion

In this study, 26 chicks were obtained from 37 eggs in the first clutch of 10 red mosaic canary pairs kept on a standard breeder ration without added red pigment supplementation. None of these 26 chicks showed visible red mask or reddish feathering during early feathering. From statistical point of view, this series suggests that the frequency of visible red mask in this early period is, with 95% confidence, below about 13.2%.

Perez-Beato (2008) emphasized that lipochrome pigments in canary plumage arise from metabolic processing of dietary carotenes and xanthophylls, and that red phenotype depends not only on genotype but also on environmental conditions. The same source stated that when birds do not receive enough beta-carotene, yellow pigment deposition may occur instead of red lipochrome. This information makes the absence of red appearance in chick plumage under the pigment-unsupplemented feeding conditions of our study biologically reasonable. However, because our design was not planned to show causality, this finding alone cannot be accepted as definitive proof that lack of pigment supplementation caused the absence of red coloration.

Modern genomic findings show that red coloration is more complex than can be explained only by external appearance. Lopes et al. (2016) reported that at least two genomic regions are necessary for red ketocarotenoid-based coloration in red factor canaries, one including

CYP2J19 and the other containing genes related with the epidermal differentiation complex. Therefore, even if adult parents show a red mosaic phenotype, the same visible pattern does not need to appear immediately during early feathering in the chicks.

The most suitable explanation for our findings seems to be the developmental timing of the mosaic phenotype. According to Perez-Beato (2008), mosaic females in the fledging period often resemble common lipochrome birds, whereas mosaic males before the first molt may be similar to ordinary lipochrome birds, and clear mosaic markings become evident only after that molt. Harper and Turner (2000) also summarized that canary chicks may reach about 90% of their asymptotic body mass by around day 11, emphasizing that the early feathering stage represents a short and dynamic developmental interval rather than the definitive adult phenotype. For this reason, absence of red mask during early feathering is not necessarily inconsistent with the adult distribution of the mosaic phenotype. In the representative images presented in Figure 1, the face and head region also do not show the dense and localized red pigment distribution typical of adults; instead, a pale yellowish-white lipochrome appearance is seen. These visual records agree with previous descriptions indicating that, before the first molt, mosaic phenotype may temporarily resemble ordinary lipochrome birds.

In breeding practice, imported red egg foods and commercial pigment additives may be used in red factor

canaries to induce or strengthen the red color factor. Demirci and Mevliyaogullari (2023) noted that color factors may be introduced into water or diet from 3-6 weeks of age in chicks and from about two weeks before the breeding season in adults until the end of molt, and the same source states that canthaxanthin and beta-carotene are used as color factors in red canaries. Therefore, the fact that no imported red egg food or pigment additive was used in our study is directly important when interpreting the absence of red mask during early feathering, especially in relation to absence of exogenous pigment supply. This practical interpretation agrees with the broader canthaxanthin literature. The EFSA Panel on Additives and Products or Substances used in Animal Feed (2014) concluded that canthaxanthin can enhance plumage pigmentation in ornamental birds and considered 8 mg/kg complete feed safe for breeder hens of ornamental birds, whereas Esatbeyoglu and Rimbach (2017) summarized that canthaxanthin is used in animal feeding mainly as a pigmenting carotenoid. Accordingly, the absence of supplemental pigment in the present study should be seen as an important nutritional context, although genotype and developmental timing still remain the main biological explanations.

In a study comparing two different imported commercial egg foods in Yorkshire canaries, no statistically significant difference was found in total egg number, while a biologically more favorable tendency was reported for chick number (Mevliyaogullari, 2025). This finding suggests that supplementary feed formulations in canaries should be evaluated not only by egg production, but also by more sensitive outcomes such as incubation success and early chick performance. Similarly, a study investigating the timing of artificial insemination in Gloster canaries showed that timing of application during the nest-building phase can significantly affect fertilization success (Özkök, 2022).

Nevertheless, the biological effects of feeds cannot be reduced only to labeled macronutrients. In the physicochemical characterization of an imported extruded pigeon feed, water-holding capacity, particle size distribution, powder flowability, and structural hardness were among the reported technical traits (Mevliyaogullari, 2026). The broader feed processing literature also shows that formulation ingredients and processing type can change product lightness, hardness, porosity, and in vitro digestibility indices (Mevliyaogullari et al., 2023). Therefore, absence of additional physicochemical and process-based characterization of the imported egg food and seed mixture used in the present study should be considered as a limitation when interpreting the results.

Strengths of this study include observation of all 10 pairs under the same husbandry and feeding regimen, completeness of breeder records for the first clutch, and presentation of these records as processed statistical indicators. Limitations include absence of a control

group, lack of sex determination in chicks, lack of objective spectrophotometric color measurements, absence of follow-up until the end of first molt, and lack of genotype confirmation.

Future studies would gain stronger explanatory value by comparing pigment-unsupplemented and controlled pigment-supplemented feeding groups within the same lineage; by following chicks until the end of the first molt with serial photography or quantitative color measurements; by characterizing the imported egg food and seed mixture not only for proximate composition but also for physicochemical traits such as water-holding capacity, particle distribution, color, texture, and, where possible, in vitro digestibility (Mevliyaogullari et al., 2023; Mevliyaogullari, 2026) and by adding genetic confirmation when possible.

## 5. Conclusion

In the first clutch of 10 canary pairs showing red mosaic phenotype, 26 chicks were obtained from 37 eggs, and none of these chicks showed visible red mask or reddish feathering during early feathering under routine feeding without added pigment supplementation. This finding is in agreement with the view that red coloration depends both on dietary carotenoid substrate and on genetic conversion mechanisms, and that the mosaic phenotype may become clearer after the first molt. Also, considering that imported red egg foods and pigment additives can be used in breeding practice to intensify the red factor, this observation obtained under a standard ration without pigment supplementation is noteworthy from an applied point of view.

## Author Contributions

The percentages of the authors' contributions are presented below. All authors reviewed and approved the final version of the manuscript.

	E.M.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C= concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

## Conflict of Interest

The authors declared that there is no conflict of interest.

### Ethical Consideration

This study did not require ethics committee approval, as it was based exclusively on data from routine husbandry practices, breeding monitoring, and existing breeder records of canaries maintained by private breeders. The author declares that all procedures were conducted in accordance with the ethical standards and guidelines of the target journal.

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