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RESEARCH ARTICLE

# Ontogenetic changes in the live weight of Saker falcon (*Falco cherrug*) chicks during the artificial feeding from hatching to transferring

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**Abstract**

The dynamics of changes in the live weight of saker falcon (*Falco cherrug*) chicks in the early postnatal period and the comparison of the growth energy of chicks of different morphometric groups during artificial feeding from hatching to transferring were investigated. The average period of minimum live weight gain in saker falcon chicks was 144–192 hours. The chicks with a smaller initial weight compensated it with higher growth energy on days 6–7 compared to the larger chicks.

**Keywords**

Chick, live weight, postnatal ontogenesis, diet, artificial breeding

## Introduction

The study of the dynamics of changes in morphometric parameters of rare bird species in the early period of ontogenesis kept in captivity for the purpose of subsequent reintroduction is one of the most important problems having both theoretical and practical importance (Armstrong, Seddon 2008; Iankov, Gradinarov 2012; Orta et al. 2020). The development of saker falcon chicks (*Falco cherrug*), which are characterized by intensive postembryonic growth, is insufficiently studied, which is

explained by the absence of methodological guidelines on the cultivation of saker falcon chicks in captivity (Cade et al. 1988; Baumgart 1991; Knaus et al. 2018; Lazarova et al. 2021). Identification of growth and development patterns requires a significant amount of material and ensures improvement of diet composition (Watson, Clarke 2000; Medammal, Azeez 2013). All works devoted to chick growth are based on their weighing measurement of exterior elements (Dzialak et al. 2007; Sielicki, Sielicki 2009; Krist 2011; Dizon et al. 2020). Growth rate criteria are mainly taken as specific growth rate, growth constant, and relative growth values (Lindberg, Sjoberg 2009; Kovács et al. 2014; Ragyov et al. 2009, 2010, 2012). The purpose of our study is to investigate the growth of body weight of saker falcon nestlings and to identify the dynamics of changes in this trait.

## Materials and methods

The dynamics of saker falcon nestling growth from the moment of hatching to achievement of live weight not less than 60 g, which is the minimal morphometric index of the individual development before chick transfer to adoptive parents (Sielicki, Sielicki 2009; Lazarova et al. 2021), was analyzed on the basis of research conducted in the Rare Bird Nursery "Altai-Falcon", Altai State University (Barnaul, Russian Federation, 53°15′40″N, 83°40′10″E) in 2021–2022. The chicks were fed every four hours at 8:00 a.m., then at 12:00 pm 2:00 pm, 4:00 pm, and 8:00 pm. After the chicks were hatched, they were placed in a brooder where constant temperature of 37 °C was maintained throughout the feeding period. The composition of the diet was represented by minced meat from the carcasses of daily chicks, quail meat and chicken. The starting component for the first 24 hours was minced meat, to which gradually, in increasing proportions, minced chicken minced meat and minced meat from whole daily chickens were added. On the last day the falcons were transferred to minced whole-day-old chicks after removal of egg yolk, internal organs, and tubular bones from the carcass. Stuffing was given to the falcons on a plastic spoon in portions of 2–4 g until the chick's goiter was filled and a drowsy state at satiation occurred. From the moment of hatching the chicks were weighed daily on electronic scales RA-213, with a precision of 0.01 g. The hatched chicks were assigned identification numbers corresponding to the numbers on the egg shells that indicated their origin. Weighing was performed every 24 hours before the first morning feeding. The increasing dynamics of chick live weight increase was recorded in the established "Incubation Logbook» form. The results were estimated using the method of parallel groups with body weight of 24.9–35.0 g, 35.1–40.0 g, and 40.1–48.0 g (Tables 1–3). To reveal the peculiarities of changes in body weight, growth rates were calculated by correlating the sizes of these traits in each weight group with their size in the previous age group.

## Result

A characteristic feature of the postnatal development of saker falcon chicks was the presence of stabilization periods on days 3–4 and 6–7 during which the dynamics of changes in the size of the trait was almost constant in each group. The absolute values of the indicators are given in Tables 1–3.

**Table 1.** Changes in live weight of saker falcon chicks (initial body weight 29.4–35.0 g, n = 26)

| Chick number | Chick weight, g<br>Life period, days | | | | | | | | | | Live weight gain, g | Live weight gain fraction, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hatching | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | |
| 1-4-4 | 31.3 | 29.1 | 30.0 | 30.0 | 33.2 | 39.0 | 46.3 | 57.3 | 73.5 | - | 5.55 | 252.6 |
| 2-12-9 | 33.0 | 31.5 | 31.7 | 31.9 | 33.2 | 37.1 | 42.4 | 47.8 | 57.2 | 72.5 | 4.45 | 230.6 |
| 2-4-1 | 34.5 | 33.8 | 34.5 | 50.0 | 60.0 | 56.8 | 70.0 | - | - | - | 6.03 | 207.1 |
| 2-4-2 | 30.0 | 29.0 | 28.2 | 32.8 | 39.6 | 46.0 | 45.1 | 52.1 | 60.7 | - | 3.96 | 209.3 |
| 1-4-3 | 31.9 | 30.8 | 30.2 | 30.1 | 30.0 | 33.1 | 41.0 | 47.2 | 61.2 | - | 3.8 | 198.7 |
| 1-4-6 | 30.5 | 28.0 | 28.5 | 31.7 | 38.0 | 46.7 | 57.2 | 71.6 | - | - | 6.23 | 255.7 |
| 1-14-5 | 33.1 | 29.9 | 34.0 | 34.2 | 39.5 | 47.8 | 60.9 | 74.7 | - | - | 6.4 | 249.8 |
| 2-4-6 | 31.6 | 30.1 | 32.2 | 33.4 | 40.0 | 45.1 | 61.2 | 69.9 | - | - | 5.69 | 232.2 |
| 2-12-10 | 33.1 | 32.5 | 31.4 | 34.8 | 35.3 | 36.4 | 40.6 | 46.6 | 55.9 | 66.6 | 3.79 | 204.9 |
| 2-12-13 | 31.4 | 30.1 | 31.6 | 36.2 | 42.5 | 52.1 | 66.6 | - | - | - | 6.08 | 221.3 |
| 1-4-5 | 32.0 | 31.6 | 31.4 | 36.3 | 36.1 | 37.7 | 44.5 | 60.9 | - | - | 4.18 | 192.7 |
| 1-12-7 | 35.0 | 34.1 | 31.1 | 32.6 | 35.5 | 40.7 | 51.2 | 65.5 | - | - | 4.49 | 192.1 |
| 2-4-5 | 33.3 | 32.1 | 32.0 | 32.4 | 32.8 | 34.1 | 43.0 | 46.9 | 52.9 | 65.8 | 3.74 | 205.0 |
| 2-4-8 | 33.6 | 32.5 | 33.1 | 33.7 | 39.9 | 46.3 | 62.4 | - | - | - | 4.98 | 192.0 |
| 1-14-10 | 30.0 | 28.8 | 30.1 | 31.3 | 33.0 | 36.6 | 49.7 | 61.7 | - | - | 4.7 | 214.2 |
| 1-4-10 | 32.0 | 30.4 | 29.7 | 30.0 | 33.6 | 39.9 | 52.4 | 60.8 | - | - | 4.34 | 200.0 |
| 2-4-9 | 33.4 | 31.1 | 31.9 | 32.7 | 35.9 | 41.0 | 55.1 | 66.2 | - | - | 5.0 | 212.9 |
| 1-4-9 | 30.9 | 29.5 | 29.4 | 30.0 | 35.1 | 39.9 | 51.6 | 70.0 | - | - | 5.79 | 237.3 |
| 1-10-5 | 29.7 | 27.6 | 27.8 | 28.3 | 33.8 | 39.4 | 53.5 | 62.1 | - | - | 4.92 | 225.0 |
| 1-10-4 | 29.6 | 28.2 | 28.0 | 28.2 | 31.8 | 37.2 | 47.1 | 56.6 | 60.8 | - | 4.08 | 215.6 |
| 1-14-10 | 32.5 | 31.6 | 33.8 | 40.4 | 53.6 | 65.9 | - | - | - | - | 6.86 | 208.5 |
| 1-10-8 | 29.6 | 27.5 | 28.4 | 33.2 | 40.4 | 54.1 | 67.6 | - | - | - | 6.68 | 245.8 |
| 1-14-11 | 32.0 | 31.6 | 33.8 | 38.6 | 46.6 | 63.0 | - | - | - | - | 6.28 | 199.4 |
| 1-14-12 | 31.7 | 30.3 | 34.6 | 41.3 | 46.3 | 60.0 | - | - | - | - | 5.94 | 198.0 |
| 1-4-8 | 31.8 | 30.6 | 30.1 | 30.0 | 33.5 | 39.2 | 51.6 | 59.3 | 70.8 | - | 5.03 | 231.4 |
| 1-14-9 | 34.3 | 33.3 | 33.6 | 37.8 | 47.6 | 58.4 | 67.4 | - | - | - | 5.68 | 202.4 |
| Average body weight, g | 31.9 | 30.6 | 31.2 | 38.7 | 38.7 | 45.1 | 53.4 | 41.1 | 61.1 | 68.3 | 5.18 | 216.7 |

We found that the difference in the live weight after hatching was 62.6%, ranged from 29.6 to 47.3 g and depended on the egg weight. According to this trait, chicks can be divided into three groups: 29.4–35.0 g (31.9 g); 40.1–48.0 g (37.4 g); and 40.1–48.0 g (43.8 g). Hence, the average value of the live weight of a chick obtained in captivity by artificial incubation is 37.7 g ($P \leq 0.05$). The period to reach the live weight of 60 g does not exceed 96 hours (4 days) only for 27.3% in the chicks of the third group. However, their average live weight (38.1 g) was only 86.9% of that of the third group (43.8 g), which was only 1.9% higher than in the second group. For 68.2% of the chicks in the first group it takes 120–144 hours (5–6 days). The period of reaching the minimum value of live weight for the chicks to be placed with their parents (5 days–120 hours) was 11.5% in the first group, 26.9% in the second group and 31.8% in the third group. The maximum percentage of chicks for rearing (46.2%) was recorded after 144 hours (6th day) in the middle group with the starting live weight of 37.4 g. The second place is occupied by the third group of the largest chicks, of which the live weight for weaning reached 31.8%. And only 19.2% of the chicks from the first group reach the control indicator after 144 hours. After 168 hours (7 days), 38.5% of chicks with minimum live weight are ready for weaning, in the second group these values do not exceed 11.5 % and in the third group – 4.5 % respectively.

**Table 2.** Changes in live weight of saker falcon chicks (initial body weight 35.1–40.0 g, N = 26)

| Hatching | Chick weight, g<br>Life period, days | | | | | | | | | Live weight gain, g | Live weight gain fraction, % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | |
| 35.9 | 35.0 | 37.6 | 39.4 | 44.0 | 51.3 | 60.0 | - | - | - | 4.18 | 171.4 |
| 36.9 | 35.0 | 40.6 | 47.3 | 53.7 | 65.3 | - | - | - | - | 6.06 | 185.7 |
| 40.0 | 38.8 | 39.5 | 43.8 | 43.8 | 52.8 | 62.8 | - | - | - | 4.0 | 161.8 |
| 38.5 | 37.5 | 38.2 | 39.3 | 43.7 | 52.8 | 61.9 | - | - | - | 4.07 | 165.1 |
| 40.0 | 39.0 | 40.9 | 40.0 | 37.4 | 40.8 | 48.8 | 57.9 | 74.3 | - | 1.5 | 125.1 |
| 37.1 | 36.2 | 36.5 | 36.6 | 38.8 | 47.3 | 56.2 | 66.5 | - | - | 3.33 | 155.2 |
| 37.2 | 36.4 | 37.2 | 44.1 | 52.5 | 59.8 | 73.5 | 79.5 | - | - | 6.18 | 201.9 |
| 36.3 | 35.1 | 36.0 | 36.1 | 36.1 | 37.5 | 44.8 | 52.9 | 67.3 | - | 1.62 | 127.6 |
| 35.3 | 34.6 | 36.2 | 40.0 | 47.0 | 57.4 | 66.6 | - | - | - | 5.22 | 195.3 |
| 37.9 | 36.5 | 42.2 | 48.8 | 55.9 | 65.5 | - | - | - | - | 5.8 | 179.4 |
| 40.0 | 32.3 | 34.5 | 40.0 | 44.2 | 50.6 | 59.5 | 69.0 | - | - | 4.53 | 184.2 |
| 37.6 | 35.4 | 36.9 | 37.0 | 40.0 | 48.6 | 62.9 | - | - | - | 4.58 | 177.7 |
| 36.1 | 35.2 | 35.4 | 35.5 | 39.8 | 44.2 | 43.5 | 50.0 | 61.5 | - | 1.38 | 128.6 |
| 37.4 | 36.3 | 37.5 | 43.5 | 52.5 | 63.8 | - | - | - | - | 5.56 | 176.6 |

| Hatching | Chick weight, g<br>Life period, days | | | | | | | | | Live weight gain, g | Live weight gain fraction, % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | |
| 36.4 | 34.6 | 34.7 | 38.9 | 44.2 | 52.5 | 63.8 | - | - | - | 4.87 | 184.4 |
| 36.8 | 35.0 | 35.2 | 38.7 | 47.4 | 57.9 | 69.1 | - | - | - | 5.68 | 197.4 |
| 36.4 | 35.8 | 38.4 | 43.5 | 52.3 | 61.8 | - | - | - | - | 5.2 | 172.6 |
| 34.0 | 33.1 | 35.1 | 37.4 | 45.1 | 56.5 | 70.8 | - | - | - | 6.28 | 213.9 |
| 36.0 | 33.8 | 33.7 | 34.1 | 34.9 | 38.0 | 43.0 | 49.2 | 57.1 | 73.8 | 4.44 | 127.2 |
| 39.0 | 37.4 | 40.0 | 44.0 | 52.7 | 66.3 | - | - | - | - | 5.78 | 177.3 |
| 40.0 | 38.8 | 41.6 | 49.3 | 58.3 | 70.4 | - | - | - | - | 6.32 | 181.4 |
| 38.9 | 37.7 | 38.3 | 40.0 | 46.8 | 53.2 | 64.7 | - | - | - | 4.57 | 173.5 |
| 37.4 | 36.6 | 37.0 | 38.4 | 43.0 | 54.9 | 70.5 | - | - | - | 5.65 | 192.6 |
| 37.3 | 36.7 | 36.8 | 42.9 | 50.0 | 63.6 | - | - | - | - | 5.38 | 173.3 |
| 38.9 | 37.2 | 39.9 | 42.7 | 48.0 | 62.9 | - | - | - | - | 5.14 | 169.1 |
| 35.7 | 34.1 | 36.5 | 44.3 | 51.4 | 59.3 | 69.4 | - | - | - | 5.88 | 203.5 |
| Average body weight, g | 37.4 | 35.9 | 50.8 | 40.9 | 46.3 | 55.2 | 57.3 | 60.7 | 73.8 | 4.7 | 153.9 |

**Table 3.** Changes in live weight of saker falcon chicks (initial body weight 40.1–48.0 g, n = 22)

| Chick number | Chick weight, g<br>Life period, days | | | | | | | | | | Live weight gain, g | Live weight gain fraction, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hatching | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | |
| 1-1-7 | 41.7 | 40.0 | 40.1 | 40.0 | 42.4 | 49.4 | 59.5 | 71.3 | - | - | 3.25 | 148.8 |
| 2-10-7 | 42.7 | 40.2 | 42.6 | 42.7 | 49.9 | 58.8 | 71.7 | - | - | - | 5.25 | 178.4 |
| 2-3-6 | 41.0 | 39.2 | 39.3 | 39.4 | 42.9 | 52.5 | 67.2 | - | - | - | 4.67 | 171.4 |
| 2-3-7 | 40.7 | 38.5 | 38.1 | 41.2 | 48.0 | 58.5 | 68.0 | - | - | - | 4.92 | 189.9 |
| 2-10-6 | 45.0 | 43.9 | 45.5 | 50.0 | 57.8 | 69.5 | - | - | - | - | 5.12 | 158.3 |
| 1-1-1 | 43.1 | 41.7 | 45.9 | 53.2 | 64.8 | - | - | - | - | - | 5.58 | 155.4 |
| 1-7-1 | 45.2 | 44.5 | 44.3 | 53.9 | 62.8 | - | - | - | - | - | 4.58 | 141.1 |
| 1-1-2 | 46.2 | 45.9 | 46.6 | 54.0 | 62.5 | - | - | - | - | - | 4.5 | 136.1 |
| 1-7-4 | 45.6 | 44.1 | 45.3 | 52.7 | 57.7 | 67.2 | - | - | - | - | 4.62 | 152.4 |
| 2-9-1 | 43.0 | 42.1 | 43.2 | 46.3 | 53.0 | 64.2 | - | - | - | - | 4.42 | 152.5 |
| 1-1-5 | 43.3 | 42.8 | 43.4 | 50.0 | 60.5 | - | - | - | - | - | 4.42 | 141.4 |
| 1-1-6 | 41.5 | 40.4 | 41.0 | 46.4 | 57.9 | 69.0 | - | - | - | - | 7.75 | 215.1 |
| 2-10-1 | 46.7 | 45.2 | 45.6 | 50.0 | 60.0 | - | - | - | - | - | 3.7 | 132.7 |

| Chick number | Chick weight, g | | | | | | | | | | Live weight gain, g | Live weight gain fraction, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Life period, days | | | | | | | | | | | |
| | Hatching | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | |
| 1-7-5 | 43.8 | 42.7 | 43.4 | 47.0 | 57.5 | 64.7 | - | - | - | - | 4.4 | 151.5 |
| 1-12-1 | 43.4 | 39.9 | 41.0 | 46.1 | 45.0 | 53.1 | 64.1 | - | - | - | 4.03 | 153.9 |
| 1-1-4 | 43.9 | 42.5 | 44.5 | 45.9 | 51.2 | 61.4 | 76.0 | - | - | - | 5.58 | 178.8 |
| 2-10-3 | 46.4 | 44.3 | 42.7 | 42.9 | 42.7 | 48.9 | 56.7 | 67.4 | - | - | 3.3 | 152.1 |
| 1-7-3 | 45.1 | 43.4 | 48.9 | 59.1 | 70.8 | - | - | - | - | - | 6.85 | 163.1 |
| 1-6-2 | 41.4 | 39.7 | 40.3 | 41.4 | 46.3 | 55.1 | 67.9 | - | - | - | 4.7 | 171.0 |
| 1-3-2 | 47.3 | 44.1 | 42.0 | 43.5 | 46.9 | 54.2 | 67.8 | - | - | - | 3.95 | 153.7 |
| 2-2-2 | 41.2 | 40.6 | 42.6 | 47.2 | 53.5 | 67.7 | - | - | - | - | 5.42 | 166.7 |
| 1-3-5 | 44.5 | 43.1 | 44.3 | 43.9 | 45.0 | 53.8 | 63.5 | - | - | - | 3.4 | 147.3 |
| Average body weight, g | 43.8 | 42.2 | 43.2 | 47.1 | 53.6 | 55.8 | 66.2 | 59.4 | - | - | 4.74 | 159.6 |

Thus, the maximum period to reach the benchmark for chicks of the third group did not exceed 144 hours (6 days) for 90.1% of the newborns. Only two chicks from this group required 168 hours. 74.2% of the chicks in the first group reached this indicator after 168 hours, the rest 192 hours (19.2%) and 216 hours (11.5% of the chicks), respectively. In the second group, 11.5% and 3.8% of the chicks required 192 and 216 hours, respectively. The value of the average daily gain is the highest in the group of the youngest chicks – 5.18%, which is 4.1% higher than the growth energy of the second group and 5.8% higher than in the third group.

The maximum value of growth energy was recorded in the chick No. 1-14-10 of the first group – 6.86% per day. At a starting mass of 32.5 g on the sixth day, its weight increased by 208.5% to 65.9 g. The growth dynamics was recorded only in one chick from the second group No. 2-3-11 whose weight (40.0 g) reached 70.4 g after 144 hours, which is 26.8% less than the value of No. 1-14-10. Despite the fact that the control weight of 60.0 g in the third group, chick number 1-7-3 reached on the fifth day, the energy of growth of the chick was 0.1% less than the value of the chick from the first group (6.85 and 6.86%, respectively). The gain in live weight does not exceed 163.1%, which is 18.5% and 44.9% less than in the chicks of groups 2 and 1. Therefore, the chicks with a smaller starting weight compensate for it on days 6–7 with more energy for growth compared to the larger chicks. The decrease in live weight of 3.7–4.1% in the first 24 hours after birth with a subsequent remission and an increase in the average value of the analyzed indicator by 101.2–115.2% in 48–36 hours is typical for all morphological groups. In the subsequent period of ontogenesis, the dynamics of live weight gain stabilizes within the range of 109.5-113.3% ±3.8%.

## Conclusion

We revealed stabilization periods in live weight dynamics, caused by the structure of the post-embryonic period. We also noted that the reduction of body weight at the end of the first day of life resulted from egg yolk nutrient reserves ending with subsequent remission and the average daily increasing by 101.2–115.2 %. The average period of minimum live weight gain in saker falcon chicks was 144–192 hours. Chicks with a smaller initial weight compensated it with a higher growth energy on day 6–7 compared to larger chicks.

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