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The First Survey Of European Serinchick's Growth Under Natural Conditions: Which Organs Get Maturity Before Nest Leaving?.

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ABSTRACT

While *Serinusserinus* is widely common in Morocco, the morphometric data on the growth of its chicks is nonexistent. The present work conducted in AitAyach-Midelt, during the breeding seasons (2015-2016), aims to produce morphometric data related to the growth of the Serin's chicks. A total of 30 chicks and 20 adults were measured with a rate of once every two days (juveniles). The measures were focused on the bill-head length, the elongated wings, the tarsus, the tail, the body, and the body weight. Obtained results show a variable growth depending on the structure. Locomotive organs, including wings, are characterized by rapid growth, to ensure safe and rapid flight. These structures continue to grow even after nest leaving. However, tarsus and head structures seem to be mature at the first flight. Chick's weight showed also a continuous development after the flight. However, the weight gain was significant during the first phase following the hatching. Furthermore, the morphometric comparison of young and adults enabled us to differentiate organs that complete their growth before chicks nest leaving, such as the tarsus and bill (P>0.05). These two structures reach their maturity before flight.

Keywords: *Serinusserinus*, morphometric, growth, flight, Midelt.

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INTRODUCTION

The Serin "*Serinusserinus*" is a Mediterranean finchavifauna [1], whose geographical distribution is widely diversified. In Europe, it is found in France, Spain, northern of Germany and Denmark [2, 3].In Africa, it is revealed in the north and the west of the continent [4].In Morocco, this finch is widespread, from the Mediterranean coast to the first South saharianoasis [5]. It was spotted particularly in Taza National Park [6],in the regions of Marrakech-Haouz and High Atlas[5, 7].

Studies on this specie were mainly concentrated on breeding biology, ecology and diet [8-10]. Except the feeding behavior, no study has been conducted on the Serin chicks [11]. However, the growth and survival of chicks are crucial steps in birds breeding. Juveniles are vulnerable and threatened by various factors, including predation and agricultural activities [12, 13].

In the present work, done in Moroccan ecosystems, particularly in the High Atlas region, we seek in the first hand to provide a basic data on the Serin chick's growth and the development, via morphometric measurements, during their nest's growth phase. In the second hand, we aim to highlight chick's growth rate variation before and after their flight, through a comparison of biometric measurements between chicks just before their flight and those of adults. This will inform us more details about the chick's maturity before leaving the nest and their capabilities to avoid predators.

MATERIAL AND METHODS

Study area

This study was conducted in AitAyach, Midelt region (32 ° 41 'North 4 ° 44' West) (figure1), at the junction of the Middle Atlas mountains chains and the eastern High Atlas. This mountainous region is dominated by agricultural activities including apple and olive plantations.

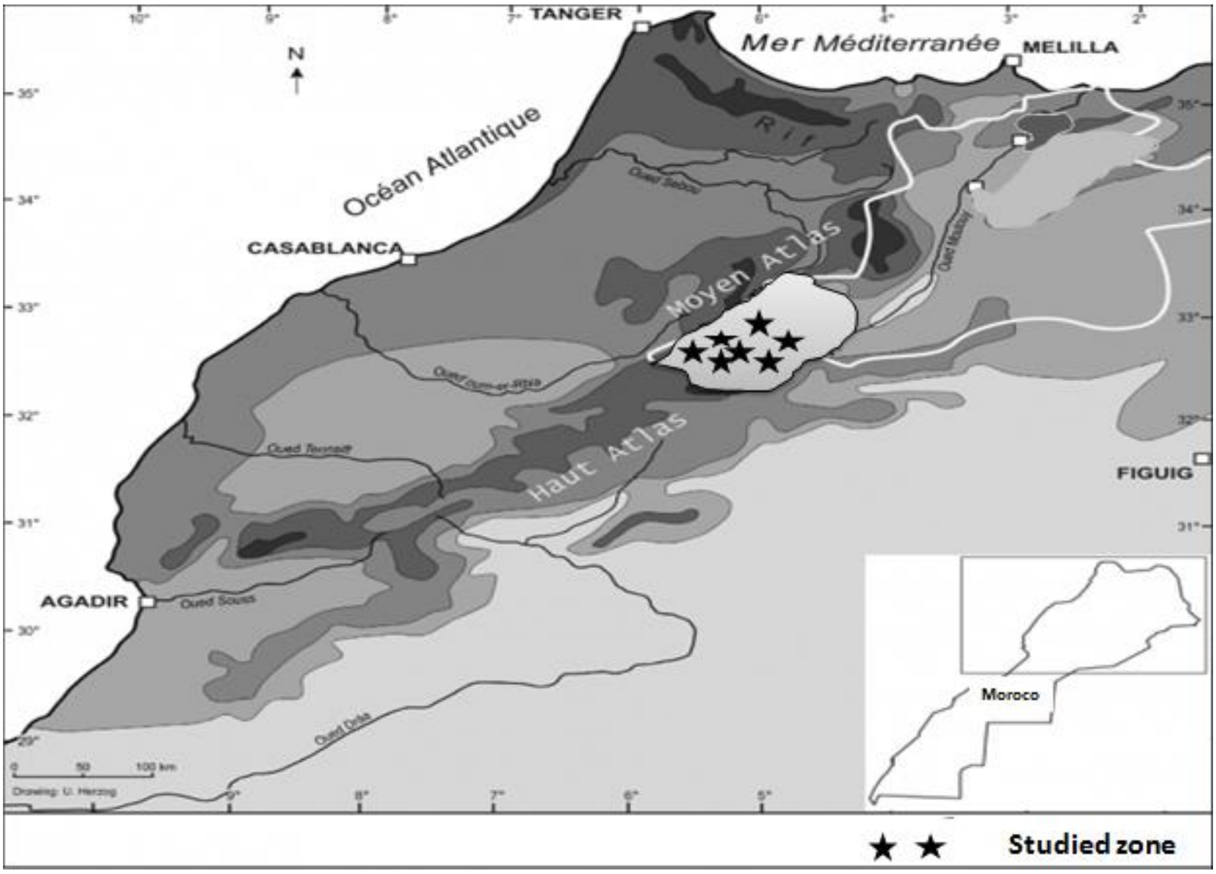

Figure 1: Geographical location of Midelt region (Middle Atlas, Morocco).

Ethical note

This study was performed under the proper legislation of the Moroccan law and was approved by the Ethical Committee of both Moroccan Research Group for bird protection (Birdlife Morocco) and laboratory of Functional Ecology and Environment, Biology department, Faculty of science and technology-Fez. Also, during study, all nest and birds were recorded with minimum disturbance. This is reflected by the survival of all examined birds.

Data collection

Growth assessment was conducted on30*Serinusserinus*chicks (15 nests) and 20 adults, during the period from June to August 2015-2016, under natural conditions, using the method described by[14]and [15].This method consists of estimating the growth rate of nesting chicks by monitoring and comparing the following morphological structures:length of the elongated wing (EW), length from the back of the head to the bill tip (lengthbill+head: BH),bill length (BL),head width (HW), tail length (TL), and tarsus length following the method called the short tarsus (TS) (figure2).

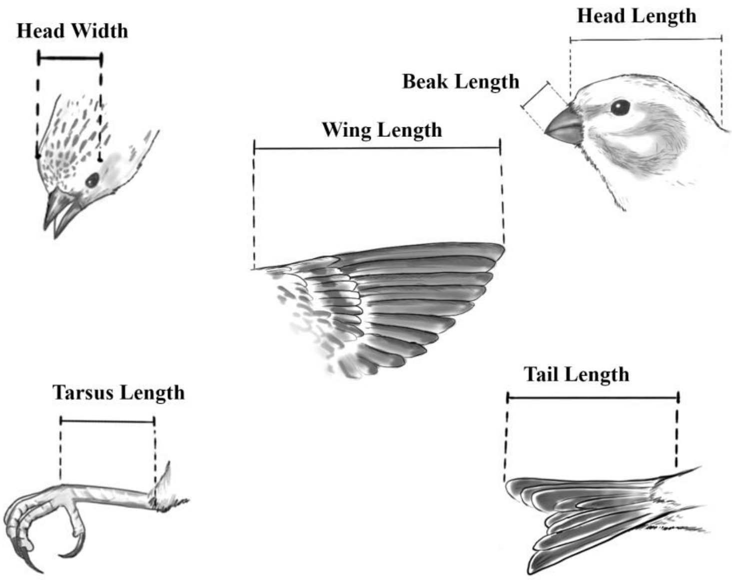

Figure 2: Different studied structures in Serin chicks.

After eggs hatch, measurements were performed every two days(because exhaustive manipulations can significantly increase the stress in chicks),using digital calipers accurate to 0.1 mm. Wing length is measured using a non-digital precision ruler calipered to 0.1 mm. Weight is measured in the morning before feeding, in order to avoid the influence of food on their weight. All measurements were performed on Serin chicks and adults, then a ratio was calculated according to growth phases: young hatched/young before flight (YH/YF),young before flight/Adult (YF/AD).All measurements are performed three times; afterwards, the average is calculated to remove extreme values.

Data analysis

The results were given as mean ± SD. The statistical analysis was performed using the SPSS software (for windows)(version 18.00.IBMCorporation, 2009).Because of normalized data, we used a Pearson correlation to analyze the relation between different organs during their growth and all significant values are at 0.05. Also, to compare the structure's maturity before nest leaving we have used one-way ANOVA test. We used generalized linear model (GLM) to analyse which organs are controlling body length development. On the other hand, all graphs are created by GraphPad Prism 6.01.

RESULTS

Chicks' growth

At hatching, chicks are covered with a fine sparse duvet that is denser on the head and back (figure 3-A). They are born blind with a yellowish bill and separate toes. The plumage emerges on the fourth day. However, the feather sheaths are discernible under the skin on the third day. Flight feathers (primary and secondary) and tail feathers appear first. Then the spinal and ventral feathers appear around the seventh day. Eyes open on the fourth day. After about nine days, the chick's whole body is covered by both fluff and feathers (figure 3-C).The flight is recorded around the thirteenth day after hatching. However, the flight behavior begins to appear from the ninth day, when the chicks attempt to leave their nest.

Figure 3: Pictures showing the different growth stages of the *Serinusserinus* chicks: A) 1 day; B) 5 days and C) 13 days.

Head growth

Measurements of various structures in chick's head (Bill, Bill+Head, Head Width) are shown in figure 4. Graphical representation shows a parallel growth in different organs studied during chick's nesting. The bill+head (B+H) are the structures that are shown to have the fastest growth in the first seven days. After this period, growth stabilizes for four days, and then accelerates again between the 11thand the 13thday (time where chicks fly away). Concerning the bill length (BL) and the head width (HW),we noticed that their growth rate is slower than the bill+head. This low growth occurs in the first seven days and then stabilizes until the 13th day, the time of flight. These two parts of the head seemed to be mature at the time where chicks fly away. In addition, we have noticed a strong correlation between different structures in the chick's head (Table 1).Thus, the Pearson coefficient between head length and head width is0.91 ($P<0.05$), while the correlation between the "Bill+head" and the entire bill is 0.87 ($P<0.05$). Also, the "Bill+head" is high significantly correlated to the head's width (Pearson coefficient r=0.98,$P<0.05$).

Table 1: Pearson correlation among head structures

Parameters	Bill	Bill + Head	Head Width
Bill	1	0.873**	0.912**
Head+Bill	0.873**	1	0.981**
HeadWidth	0.912**	0.981	1

N=30 for each parameters of each period (13 days), Standard error of means **: p<0.01

Table 2: Pearson correlation among locomotive organs

Parameters	Wing	Tarsus	Tail
Wing	1	0.966***	0.935**

Tarsus	0.966**	1	0.832*
Tail	0.935**	0.832*	1

N=30 for each parameters of each period (13 days), Standard error of means *: $p<0.05$, **: $p<0.01$, *** $p<0.001$.

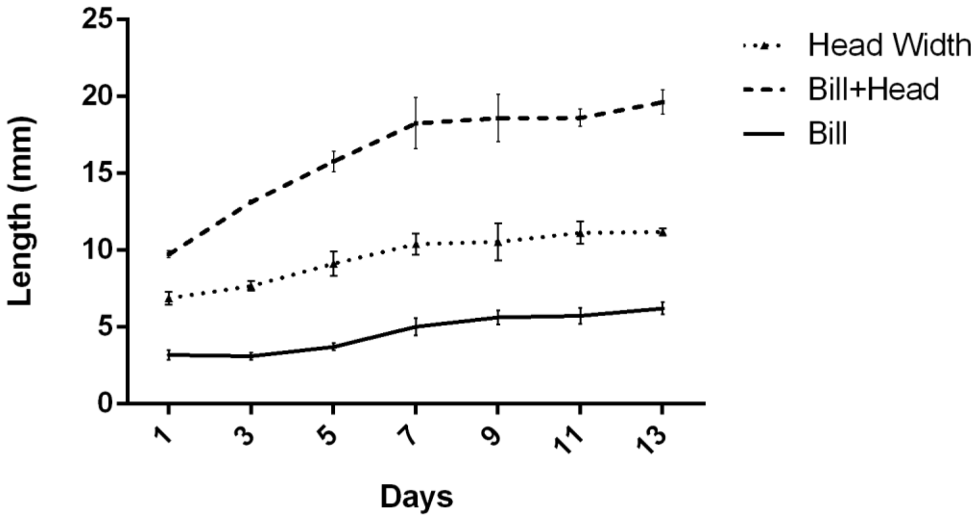

Figure 4: Head structures growth during Serin chicks nesting.

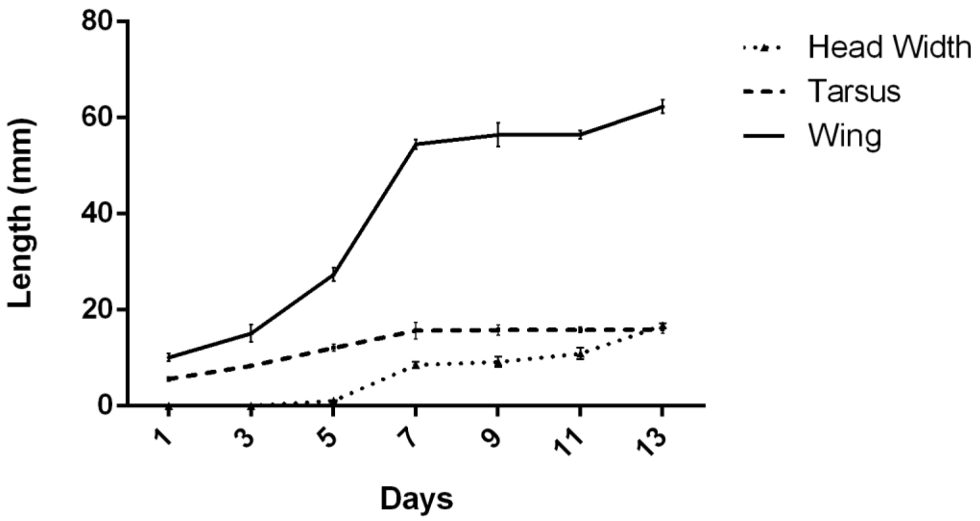

Figure 5: Growth of Serin chick's locomotive organs during nesting phase.

Locomotive structures

In order to determine fly capacities of the Serin chicks at the time of fly away, we followed the growth of their locomotive organs from the hatching to the first flight. Obtained results are shown in fig. 5.Unlike different head structures, the growth rate of locomotive organs differs from one structure to another (figure5).Wings have a very rapid growth from hatching until the seventh day. Their progress stabilizes for a short period before making a sharp increase right before first flight (13th days).On the contrary, the tail and tarsus have a slow growth in comparison with the wings. The tarsus is characterized by slow and constant growth throughout the nesting period. However, tail elongation starts after five days. This development slows down for four days and then peaks in the 11th day before the flight. In addition, different locomotive structures show a significant correlation during nesting (Table 2).A strong correlation in the range of 0.96 to 0.93 (*P<0.05*) is recorded between the wings and tarsus on one hand, and between the wings and tail on the other hand. In the opposite, the correlation recorded between tail and tarsus is not significant (*P>0.05*).

Weight and size evolution

The progression of body weight and total length in Serin chicks is given in the figure6.The weight development in nesting chicks proceeds rapidly from hatching to the first flight (figure6-A).This suggests a continuing evolution of weight even after youth fledging chicks leave their nest. However, the weight gain measured during chick's development (figure7) shows an important progress during the first five days after hatching. Then this weight gain gradually decreases until the chick's flight. In contrast, the body total length increase gradually with time, but two phases of stunting are noted(figure6-B).First period is recorded between the seventh and the ninth day after hatching; the second phase has been observed before the flight between the 11th and 13th day. Moreover, a significant correlation of 0.9 (*P*<0. 05) was highlighted between the two parameters studied.

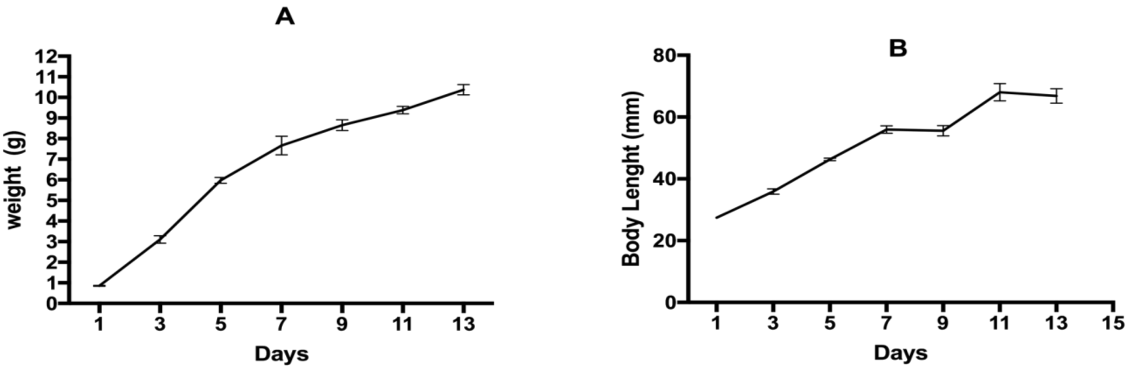

Figure 6: A) Progress of Serin's body weight; B) Progress of chick's length during nesting.

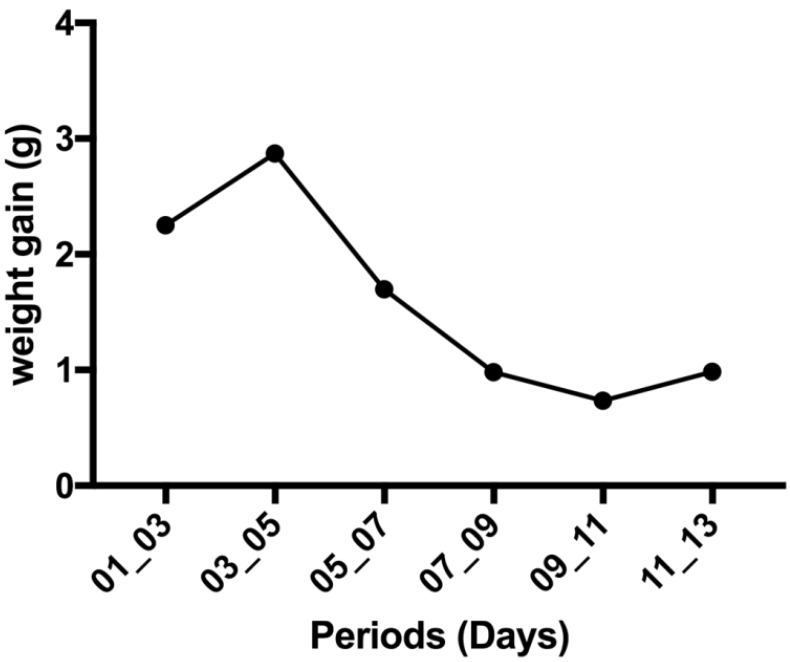

Figure 7: Evolution of weight gain in serin during chick's growth.

Young-adult morphological ratio

Morphological structures, body weight and ratio (YH/YF, YH/AD and YF/AD) data are shown in Table 3.Comparison of these characteristics allowed us to monitor chick's growth before and after nest leaving (table 4). Hence, body size varies according to growth phases. From hatching to their flight, all chicks' structures show a progress with an important growth (YH/YF ratios are small). But after flight, young bird's structures reveal a varied rhythm in their growth (Table 4). Locomotive organs, except the tarsus (ratio YF/AD=0. 98, ANOVA:F=0.2, df=1,*P*=0.65),continue to grow in a similar way as the nesting phase. However, head structures are almost in maturity before nest leaving except the Bill (Table 4).This conclusion is reinforced by the comparison between the measurements taken before the flight and in adult age (ratios YF/AD exceed 0.9in all studied morphological structures).

Table 3: Serin young-Adult's ratio; AD: Adults; YH: Young hatched; YF: Young at the first flight

	Weight (g)	Bill (mm)	Bill+head (mm)	Head width (mm)	Wing (mm)	Tarsus (mm)	Tail (mm)	Body length (mm)
YH (FirstDay)	0.87± 0.02	3.23± 0.03	9.74± 0.13	6.88 ±0	10.08 ±0.16	5.61± 0.22	0±0	27.42± 0.01
YF (13th Day)	10.37±0. 16	5.63± 0.17	19.63± 0.11	11.13± 0.12	62.31 ±0.83	15.69 ±0.09	16.73 ±1.92	67.47± 1.75
Adults (A)	16.71±0. 19	5.93± 0.19	25.52± 1.30	12.11± 0.12	71.07± 10.54	16.01 ±0.12	33.54± 2.12	77.07± 0.90
YH/ YF	0.08	0.57	0.49	0.61	0.16	0.35	0	0.40
YH/ AD	0.05	0.54	0.38	0.56	0.14	0.35	0	0.35
YF/AD	0.62	0.94	0.76	0.91	0.87	0.98	0.49	0.87

Table 4: One-way analysis of variance showing the relative variation in growth of *Serin* chick's structures after nest leaving

Parameters	Adults	Chicks before first flight (13th days)	F	DF	*P*
Weight (g)	16.71±0.19	10.37 ±0.16	605.89	1	<0.001
Bill (mm)	5.93±0.19	5.63±0.17	1.28	1	0.27
Bill+Head (mm)	25.52±1.30	19.63±0.11	19.81	1	<0.001

Head Width (mm)	12.11±0.12	11.13±0.11	35.01	1	<0.001
Wings (mm)	71.07±0.54	62.31±0.83	107.81	1	<0.001
Tarsus (mm)	16.01±0.12	15.69±0.09	0.2	1	0.65
Tail (mm)	33.54±2.12	16.73±0.09	51.11	1	<0.001
Body Length (mm)	77.07±0.90	67.47±1.75	41.81	1	<0.001

Chick's body length and weight continue their growth even after flight (ratio YF/A≤0. 8and P<0.001). However, these growing rates are less important when compared to the nesting growth period.

DISCUSSION

According to the characteristics of Serin chicks, especially the feather's development, their post-embryonic development can be classified altricial, as noted by[16] and [17]. The Serin chicks are nidicolous, with closed eyes and are fed by their parents during their nesting period. On the contrary, there are other chicks that have autonomy and independence just after hatching, as in the case of ducks[18].Concerning chick's early flight attempts, they appear to be due to the physical stress caused by manipulations[19].The reduction of care time and food supply provided by the parents, during the final stage of fledging, can also change the behavior of young chicks in the nest and push them to leave[20, 21, 22].

In head, only "bill+head" showed a great growth. These findings are reported in other bird species [17, 23, 24]. Also,[14]has reported a steady and slow growth in the Kingfisher martin's bill, during the nesting phase. Serin chicks leave their nests with approximately mature bills. This may indicate that a long bill is a vital element for the survival of these juveniles, especially with a fundamental role in their diet[25].

Unlike different head structures, the growth rate of locomotive organs, especially wings was fast. Similar results were obtained in other bird species as ducks and Kingfishers[14, 17, 24].These authors have shown a variable growth in different body parts, depending on the species. In our results, wings undergo a rapid development, during the first days after hatching. This is consistent with the results obtained by [26].This growth acceleration in the wings can be explained by the appearance and development of primary and secondary flight feathers. These take the place of the duvet feathers, characterized by a very limited size and length [27].The need for a fast and secure flight (predator avoidance)also requires a rapid and significant development of bird's wings[14, 28]. But, the delay noticed in the tail growth is due to the tail feathers(flight feathers located on the tail, which play a role as a landing spoiler). These feathers remain hidden under skin for five days after hatching[14, 29].As for the chicks' tarsus, its maturity is not completed until almost the seventh day after hatching. At this age, chicks are also able to move and fix on the tree branches. In addition, except tail and tarsus, different locomotive structures show a significant correlation during nesting (Table 2).These facts indicate a variable correlation between morphological traits in Serin chicks. However, this finding appears to be linked with age. Indeed, [30] showed that among Serin adults, correlations are very low, or even absent among their morphological traits. Furthermore, [30, 31]showed that the correlation between morphological traits of the *Serinus serinus*is very different and variable according to the sex. This may be due to a genetic determinism, as it can be governed by a divergent development of specific organs, under the influence of environmental conditions [32-34].

Weight development in nesting chicks proceeds rapidly from hatching to the first flight as the case of many avian species[13, 14, 27]and other wild animals [35].With the Kingfisher for example, the evolution of body weight in chicks is generally restricted in the end of nesting phase, because of the reduction in nutrients provided by their parents[13, 14, 36].In this work, we showed that the increase in body weight was fast, mainly during the first five days after hatching, followed by a regression in weight gain until the chicks' flight. This can be explained by the insufficient quantity of food provided by parents to chicks, because during their growth, they require more and more quantities of food with age[37-39].As for the evolution of the chicks' body length, it is accompanied by the development of other body parts, including the tail (feathers) (Wald $_{Tail}\chi^2$=0.00,df=1.P<0.001) and the head (neck and bill).These are characterized by a variable growth from one period to another. The positive correlation between the weight and size of chicks shows a similar trend and progress of these two parameters.

Comparison of morphological characteristics between chicks and adult (table 3, 4), chow an important growth, especially during nesting phase. These results agree with those mentioned in other avian species [14, 35]. According to these authors, avian chicks leave their nests with a smaller sizes than adults. In our case, only tarsus and bill are almost in the same size as the adults, even before the first flight. Other locomotive organs continue their growth after chicks leave the nests. This suggests the dependence of young chicks to their parents after nest leaving, because of the locomotive organ's immaturity, in particular wings and tail [27].In the contrary, the bill development can provide food independence for young chicks [27, 40].Though, it is difficult to confirm if the young birds are still fed by their parents in the first few days after leaving or not, as was reported by [14].

Finally**,** with this study, we have recorded a basic data on the growth of Serin's chicks, one of finch species in decline [41],through the biometric monitoring of their organs. This growth is achieved in two phases: at the nest before fledging (for 13 days) and after the flight. The growth of various structures varies according to their importance (in feeding or mobility) and depending on the environmental conditions (food availability and parents cure).The need for a quick and safe flight requires a rapid growth of locomotive organs, especially the wings. The significant growth noted in the tarsus and the bill can be explained by their importance in chick's feeding. In the same way, after the flight, certain organs such as the tail, head and even wings continue their development. Similarly, the chick's weight showed a continuous development before and after the nest leaving.

Through biometric measurements and comparison between juveniles and adult birds, we were able to differentiate organs that complete their growth before chick's emancipation, as tarsus and bill. However, by monitoring the chicks' feeding and locomotive organs after the flight, and by analyzing their relationship to the search for food and their ability to escape predators, we can provide more important data for a sustainable management of this finch in the study area.

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