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Short Communication

Yearling Males have Female-Like Body Size in Common Rosefinch

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ABSTRACT

Morphological characters such as wing length and body mass often correlate with life history parameters in avian biology, affect the probability of acquiring a mate, timing of reproduction, success in obtaining extra-pair copulation or survival. We measured biometrics in common rosefinch *Carpodacus erythrinus* among three age groups (Juveniles about 3-month old, yearlings, adults > 2 y) during autumn migration in central China. We found that body measurements changed with age, yearling males have shortest wing length in three groups and similar to adult female, express female-like wing length and plumage coloration. Juveniles have relative longer wing to support their first migration; yearlings have female-like body traits (wing length and plumage coloration) to avoid attacks from adult males in breeding season and increase maneuverability to escape predation risks. Adults have the longest wing, which could support their early arrival at wintering ground in migration. Our studies suggest that body size in juveniles is fully developed and the yearling males display female mimicry in wing length which is an adaptive strategy to sexual selection.

Morphological characters such as wing length and body mass often correlate with life history parameters in avian biology. They can affect the probability of acquiring a mate, timing of reproduction, success in obtaining extra-pair copulation or survival (Martin, 1995; Cucco and Malacarne, 2000; Nowicki and Searcy, 2004; Mitrus *et al*., 2014; Parapura *et al*., 2018). Body measurements in passerine birds change with age, a phenomenon interested which attracted ornithologists and evolutionary biologists for a long time (Stewart, 1963; Alatalo *et al*., 1984; Bryant and Jones, 1995; Hogstad, 1985; Merom *et al*., 1999; Rising and Somers, 1989; Van Balen, 1987). Sexual dimorphism is one of the vital hotspots for life-history. The morphological sexual dimorphism changed with age. Wing length increased with age in many species (Hogstad, 1985; Merom *et al*., 1999), other morphological traits, like body mass, have the similar pattern with wing length (Merom *et al*., 1999). Skeletal traits, such as beak size may increase with age (Gosler, 1987), while tarsus length decreased with age in some species (Smith *et al*., 1986). These age-related morphological differences might be adaptations for age-dependent differences of selective pressures or trade-offs between survival and breeding. In songbirds, yearling males sometimes have female-like morphology, such as duller coloration, and similar body size to female (Li *et al*., 2016).The delayed plumage maturation may increase young male survival rate by decreasing detectability from predators and increase mating success by deceiving competing males (Enoksson, 1988; Martin, 1995; Cucco and Malacarne, 2000; Mitrus *et al*., 2014).

Despite rich literature on delayed plumage maturation, not many studies focused on other body measurements, because this fitness benefit of delayed plumage maturation. In the present study, we recorded the age-related variations of body measurements of common rosefinch *Carpodacus erythrinus,* a widespread songbird distributed in Eurasia and is known for sexual dimorphism. Males with delayed plumage maturation (Björklund, 1990), variability in plumage coloration, yearling having greyish-green heads and chests, with plumage similar to females, whereas the adult males have a carmine color and older males sing longer strophes than younger individuals (Parapura *et al*., 2018). In previous field studies, we have collected data of migration behavior and time of this migratory songbird in spring and autumn. When the solar term of Grain Rain comes, the birds arrived at Liupan Mountain by spring migration lasting for about 45 days, and the adult males come first in flocks. In August, autumn migration begins from Liupan Mountain. The yearlings and adults leave first in small flocks, until the end of August, and then the juveniles of the current year begin leaving. In September, there are no yearlings and adults. All observed individuals were juveniles and the autumn migration lasted until

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the middle of October (authors' unpublished data). To determine whether yearling males have female-like body size in species with delayed plumage maturation, we aimed to explore in this study, the variations of body size with age in common rosefinch and predicted that the yearling males have female-like morphometrics.

Materials and methods

Our study site was located at Shuiluo village (35°12′58″N, 106°01′12″E, 1600 m above sea level) at western of Liupan Mountain, a breeding habitat of common rosefinch of Zhuanglang County, Gansu province, central China.

For morphological traits measurement and sex determination, we captured individuals using mist-nets combined with playback methods, at the breeding grounds from the end of July to early August of the year 2018 and 2019. In this period, the breeding season is nearly over and rosefinches get ready to depart. This assured that captured birds belong to local population. We categorized these captured males into three age groups by plumage coloration and pattern: juveniles, yearlings (second calendar year of life) and adults (older than 2 years). Females were divided as juvenile and adult as the plumage coloration and pattern of females in second year were similar to even elders. We took blood samples from venipuncture of the brachial veins of yearling males with the female-like plumage and used for genetic sexing. We extracted DNA using a TIANamp Gemonic DNA kit (TianGen Biotech, Co., Ltd., Beijing, China). The sexes of the birds were determined using the genetic primer pair sex1/sex2 (Wang *et al*., 2010). We measured 6 morphological parameters: beak length measured from the transition between skull and maxilla and the tip of the beak, beak width measured as the largest latero-lateral width of the mandible, beak height measured between the transition between skull and maxilla and the lowest/most caudo-ventral point of the mandible. Tarsus length, wing length, and tail length were determined with digital calipers (to 0.01 mm) following the methods of Wagner (1999) and body mass with an electrical balance (to 0.01 g) following the methods of Merom *et al*. (1999). We banded each bird with a unique combination of colored leg rings and released them after measurements. We captured and measured 266 individuals (48 juvenile males, 39 juvenile females, 80 adult females, 40 yearling/subadult males, 59 adult males), we believe all captured individuals belong to local breeding population, as our fieldworks were conducted at the end of the breeding season, before migration. All procedures in the field work have been done with the permission of Animal Ethics Committee of the Longdong Unniversity.

For statistical analysis we used generalized linear model to test the variations of body measurements among different age groups of males, it will give a more comprehensive look at the biometric variability observed in this species. Covariance analysis were used to distinguish the suitable linear predictors of body size, one-way ANOVA was used to investigate differences in all body measurements among all age groups, independent sample T-test to compare the differences between any different age males and mature females. All statistical tests were performed with SPSS software package for Windows 22.0, and all probabilities were 2-tailed with a significance level of *alpha* = 0.05.

Results

Table I shows average values of all body measurements of all males classified by age. The data belongs to 147 males (48 juvenile, 40 yearlings and 59 adults) and 119 females (39 juveniles and 80 mature individuals) captured in two years. Because age of females cannot be determined by plumage after second year, we combined them together as mature females.

The results of generalized linear model showed that the wing length, tail length and tarsus length were significantly different in different age groups of male rosefinches (Table II). Covariate analysis showed that beak length and wing length are suitable predictor of body size (body mass) in our bird (beak length: Beta = 0.346, t = 3.851, $P < 0.001$, wing length: Beta = 0.220, t = 2.452, P = 0.016). Based on these results, therefore, we select wing length as the strongest predictor of body size in this work.

Table I.- Morphological measurements (Mean ± SD) of male common rosefinch *Carpodacus erythrinus* of different age groups.

Age	Sample (n)	Beak length (mm)	Beak width (mm)	Beak depth (mm)	Wing length (mm)	Tail length (mm)	Tarsus length (mm)	Body mass (g)
Juvenile males	48	8.33 ± 0.33	8.23 ± 0.33	8.26 ± 0.34	79.54 ± 2.79	60.04 ± 4.68	18.56 ± 0.79	13.92 ± 1.10
Yearling males	40	8.61 ± 0.51	8.10 ± 0.55	8.42 ± 0.31	77.86 ± 2.49	56.98 ± 3.78	18.29 ± 0.90	14.15 ± 1.16
Adult males	59	8.81 ± 0.93	8.17 ± 0.40	8.37 ± 0.40	80.26 ± 3.25	58.05 ± 4.52	18.19 ± 1.00	14.34 ± 0.84
Females	80	8.51 ± 0.24	8.14 ± 0.25	8.32 ± 0.21	77.36 ± 0.36	58.98 ± 1.71	18.31 ± 0.61	14.05 ± 0.56

Table II.- The results of generalized linear model to analyze the biometrics among age groups of male common rosefinch *Carpodacus erythrinus*. The significant parameters marked in bold.

Explanatory variables	Coefficients	Wald Chi-Square	P
Beak length	0.060	0.085	0.770
Beak width	-0.183	0.977	0.323
Beak depth	0.186	0.736	0.391
Wing length	0.129	14.647	**< 0.001**
Tail length	-0.047	7.147	**0.008**
Tarsus length	-0.126	1.865	0.172
Body mass	0.120	2.181	0.140

Independent sample T-test showed that wing length of yearling males is close to those mature females (average value: 77.36 ± 0.36 mm, n = 80; t = -0.555, P = 0.581; Fig. 1), but different from adult and juvenile males (Table I). The results suggest that sub-adult males grew female-like wing length in their first potential breeding season.

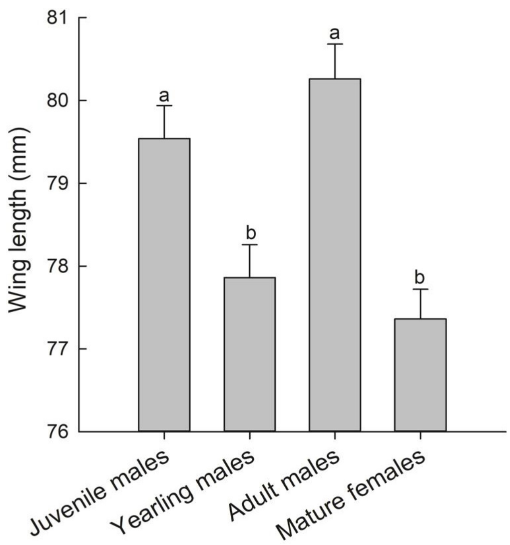

Fig. 1. Comparisons of wing length across different age groups of males and mature females in Common Rosefinch *Carpodacus erythrinus*. The individual effects were removed by covariance analysis with bode mass as covariate. The same letter above the bars showed no significant difference, conversely, differences were significantly.

Discussion

Our results indicated that yearling male of common rosefinch differed from adults not only in plumage coloration and song characteristic (Parapura *et al*., 2018), but also in body size. Although some studies believed full body size is attained before fledging in altricial birds (Merom *et al*., 1999).Several studies have suggested that body measurements grow for a long time and change with age in many songbirds (Alatalo *et al*., 1984; Bryant and Jones, 1995; Hogstad, 1985; Merom *et al*., 1999; Van Balen, 1987; Merom *et al*., 1999). Our results suggest that the beak size is fully-grown in juvenile common rosefinch. The beak morphology and size are closely related with foraging behavior and diet in birds, beak size increased with age in Darwin·s medium ground-finches *Geospiza fortis* (Price and Grant, 1984) and song sparrow *Melospiza melodia* (Smith *et al*., 1986). Individuals with bigger bill could have better foraging ability and therefore have heavier body mass. In autumn migration, yearlings and adults leave breeding ground earlier and hence accumulate fat stores earlier than juveniles (Merom *et al*., 1999). Body mass increased significantly with age in male rosefinches, heavier body mass are also related to foraging experiences in birds (Gosler, 1987; Enoksson, 1988). Age-related increases of body mass with age were also reported in other passerine birds, such as reed warbler *Acrocephalus scirpaceus* and clamorous reed warbler *A. stentoreus* (Merom *et al*., 1999).

Wing length and tail length of juvenile males is relative longer than yearlings, and similar to adults which suggests that wing length is important for first migration of juveniles. Shorter wings may increase maneuverability, while longer wings could fly faster (Alatalo *et al*., 1984; Merom *et al*., 1999). Wing length is the best predictor of body size in our bird, which is consistent with some other passerine birds (Gosler *et al*., 1998; Gardner *et al*., 2009). Wing length and shape in juveniles of migratory passerines may results from a greater importance of predation avoidance, which relates to migration performance in the first year of life (Pérez-Tris and Tellería, 2001). In our birds, juveniles begin autumn migration where they are about three months old. This leads to poorer flight performance. Longer wings could possible compensate for these negative effects. Adult males have longest wing could support they arrived breeding grounds earlier (Stolt and Fransson, 1995), and longer wings is also important for birds departing from breeding grounds. Unlike wings, tails have often been selected for additional functions other than flight, such as balancing aid in other types of locomotion (Leisler and Winkler, 2003).

Yearling male common rosefinch derived shorter wing after their first molt at wintering ground (Björklund, 1990). The wing length is similar to that of females but shorter than the length of the same sex juveniles. Similar to the delayed plumage maturation, this may be an important life history strategy that could help avoid attacks from adult males in the first potential breeding season. Interestingly, adult males sing to attract mates when arrive at breeding sites. Yearling males follow the adult male until the latter paired (personal observations). This is different from reed warbler *Acrocephalus scirpaceus* and clamorous reed warbler *A. stentoreus* (Merom *et al*., 1999), while consistent with the orange-flanked bush-robin *Tarsiger cyanurus*, a passerine bird with delayed plumage maturation. First-year males showed female-like plumage and male-like wing length (Li *et al*., 2016). These results suggest that the female mimicry in body size of sub-adult males in birds showed delayed plumage maturation may be a commonly strategy.

Tarsus length decreased slightly with age but not significant when taking body mass into considerations, this skeletal trait may be related with ontogeny as avian bones coalesced significantly. In song sparrow *Melospiza melodia*, tarsus length was also found decreased with age (Smith *et al*., 1986). Our results suggest that tarsus is probably fully developed before plumage maturation in this species. Another explanation is that tarsus length is decreased with age because of loss of bone materials, or/and shrinkage of the scutes on the anterior of the tarsus (Smith *et al*., 1986).

Studies of avian morphology are often correlated with life history strategy (Merom *et al*., 1999). Our results enhanced our understanding for life history in this species. The full development of body size in juveniles assured their first migration, while yearlings with female-like morphology include both wing length and plumage coloration in first breeding season may reduce repulsion from adult males and get mating chance. This adaptive strategy may evolve under the pressure of sexual selection.

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Statement of conflicts of interest

The authors have declared no conflicts of interest.

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