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## Short Communication

# Morphological Traits and Body Condition Determine Assortative Mating in Grey-capped Greenfinch

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**PL designed the research. FS and PL conducted the field works, analysed the data and wrote the draft.**

**Key words**
***Chloris sinica*, Sexual size dimorphism, Assortative mating, Mate choice, Body condition**

## ABSTRACT

We investigated morphological differences between sexes, and mating patterns respect to their body size and condition in a wild population of the grey-capped greenfinch *Chloris sinica*. The results showed that male birds with significant longer bill and wing than female; breeding pairs assortative mated positively by culmen height, wing length, body mass and body condition. We argued that the body condition of greenfinches may be important in mutual mate choice. Male air courtship and incubation feeding behaviour provide evidence that female mate choice may be responsible for sexual dimorphism of bill size and wing length. Mutual mate choice and life histories may be responsible for non-randomly mating pattern by body condition, high quality individual prefer to mate with each other.

Sexual size dimorphism (SSD) is widespread in animal kingdom. Several hypotheses include sex and environment related effects have been proposed to explain SSD in birds (Shine, 1989; Andersson, 1994). Specifically, the resource partitioning hypothesis suggests that the sex-related differences in foraging behaviour contribute to the evolution and maintenance of SSD, for example the Galliformes birds and great bustard *Otis tarda* (Andersson, 1994; Blondel *et al*., 2002; Blanckenhorn, 2005; Haggerty, 2006). The sexual selection hypothesis instead argued that male size could evolve towards larger because of its advantages to attract potential mates or defend territories, such as the species with sexual dichromatism and polygamy (Andersson, 1994; Haggerty, 2006). In practice, it is difficult to determine which of the proposed mechanisms accounts for SSD intuitively.

Assortative mating by body size is one of the most commonly observed mating patterns in animals (Crespi, 1989; Jiang *et al*., 2013). It describes the propensity of phenotypically similar individuals prefer to mate with each other (MacDougall and Montgomerie, 2003Jiang *et al*., 2013). In biparental care species, assortative mating arises from mutual mate choice on the same trait or by the behavior of only one sex, or possible inbreeding. Assortative mating promotes divergent evolution of selected traits such as body size and conditon (Hooper and Miller, 2008; Jones *et al*., 2012).

Grey-capped greenfinch *Chloris sinica* is one of these biparental care species, which shows sexual dimorphism in plumage. Early in breeding season, male greenfinches showed a slow, stiff-winged butterfly-like displaying flight to attract potential females (Clement, 2020), and males compete, aggressive each other on the tree for access to food, potential mates and other resources, once paired, male and female nesting together, the incubation undertake by only female and feed by her partner. Many ecological studies have been conducted on the grey-capped greenfinch, such as population size, habitat selection (Nakamura, 1969), breeding biology (Haneda and Nakamura, 1970), molting and flocking behavior (Nakamura, 1979) ecological adaptation (Nakamura, 1997), feeding assemblages (Suzuki and Kobayashi, 1990) and molecular phylogeny (Saitoh *et al*., 2020), while the study on the body size and mating pattern of this widespread small seed eating passerine bird is rare.

We measured morphological traits in adult greenfinches in early breeding seasons and tested mating pattern and body size dimorphism. As the male and female always foraging together in the breeding season, and flocks in the winter, we hypothesized there is no significant difference between male and female in morphological measurements because the partitioning of the dietary niche is absent in this species. In this species, females would prefer more agile males in aerial display, and males with smaller sizes (with longer wings) could perform better (the aerial display hypothesis; Blomqvist *et al*., 1997; Blanckenhorn, 2005), breeding season of the species comes earlier spring, and no molt in this period were

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observed, based on these life history traits, we predicted the breeding pairs are assortative mated by wing length and body condition.

## *Materials and methods*

Grey-capped greenfinch is a socially monogamous seed eater, widely distributed in East Asia, occurs in city gardens, village surroundings and open woodlands. At our study area, the species is resident, males started to display in early March. Once formed a pair bond, both males and females construct nests. Only the females incubate and are fed by males, the incubation period is about 13 days. Both parents cooperatively provision food to nestlings for 13-15 days, but males undertake the majority of post-fledged provisioning. The earliest fledged chicks are seen in middle April (e.g. April 17, 2018; April 14, 2019; unpublished data). They form flocks during non-breeding season, while for unpaired males, the flock did not dismiss until early June (Clement, 2020).

In 2018 and 2019, we captured birds with mist-nets from March to early May on the campus of Longdong University (35°43′47″N, 107°41′04″E, 1367.3 m above sea level), Qingyang city, Gansu province, China. We located and monitored most of the nests during nest-building and incubation periods. To minimize disturbance caused brood abandonment, we only captured paired birds when incubation. We determined the sex of captured individuals according to the plumage coloration, and a same person (PL) measured morphological traits (culmen length: The linear length from anterior of nostril to the tip of culmen, culmen width: the width of bill base, culmen height: the depth of bill base, tarsus length: the linear length from intertarsal joint to the inferior of first palta of the tarsi, wing length: the chord length from digital joint to the tip of the longest primary feather, and tail length: the linear from tail base to the tip of the longest tail feather) with digital calipers (0.01 mm), methods consistent with which were used in studies on this species (Saitoh *et al*., 2020), and weighed body mass using an electrical balance (0.01 g). We also banded each bird with a combination of colored leg rings, determined and recorded the pairing relationships through incubation feeding behaviours. We totally captured and measured 48 males and 27 females, including 22 pairs in this work, and body condition of each individual were included in analyze. Body condition is a commonly used parameter in passerine studies, calculated as body mass/tarsus length (MacDougall and Montgomerie, 2003).

We used t-tests to investigate differences between sexes in all body measurements. We used Pearson's correlation to detect morphometrics associations between the mated pairs and tested assortative mating. All statistical tests were performed with SPSS software package for Windows 16.0 (SPSS Inc., 2007). Results were given as Mean ± SD, and all probabilities were 2-tailed with a significance level of *alpha* = 0.05.

## *Results and discussion*

Only culmen length and wing length showed significant differences between sexes (Table I). This species showed positive assortative mating patterns by body mass (Fig. 1), wing length (Fig. 1), culmen height (Fig. 1), and body condition (Fig. 2), but not in culmen length, culmen width, tarsus length and tail length.

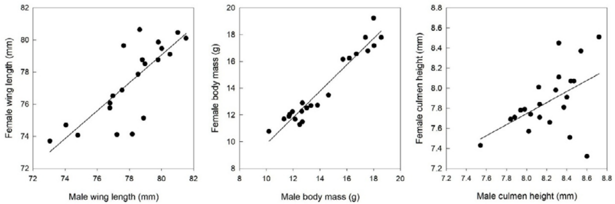

Fig. 1. Assortative mating by wing length, body mass and culmen height across breeding pairs of the Grey-capped Greenfinch *Chloris sinica* from a breeding population at the campus of Longdong University, eastern Gansu, central China.

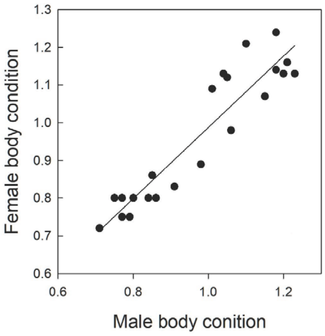

Fig. 2. Assortative mating by body condition across breeding pairs of Grey-capped Greenfinch *Chloris sinica* from a breeding population at the campus of Longdong University, eastern Gansu, central China.

We found that males were moderate larger than females, male greenfinches with longer wing than female, slight SSD were detected in our population, similar to American goldfinch *Carduelis tristis*, however, in other traits, the two species exhibit distinctly difference, the causes of this different in these two species is ambiguous, as they have very similar life history and breeding system (MacDougall and Montgomerie, 2003). The blue-black Grassquit *Volatinia jacarina* is a seed-eater, migratory species of which males perform an aerial display. Grassquits and grey-capped Greenfinches have similar patterns of sexual size dimorphism and life-history except

**Table I. Morphometric differences between male and female grey-capped greenfinch *Chloris sinica* in a breeding population at the campus of Longdong University, eastern Gansu, central China. Measurements that differed significantly between sexes is shown in bold ($P < 0.05$).**

| Morphometrics | Sex | Mean ± SD (Range) | t | P |
|---|---|---|---|---|
| Culmen length (mm) | Male (n=48) | 9.16±0.44 (8.11-10.08) | 2.226 | **0.03** |
| | Female (n=27) | 8.88±0.50 (8.01-9.75) | | |
| Culmen width (mm) | Male (n=48) | 7.27±0.67 (5.79-8.51) | 0.191 | 0.191 |
| | Female (n=27) | 7.44±0.44 (6.79-8.19) | | |
| Culmen height (mm) | Male (n=48) | 8.22±0.46 (6.17-9.05) | -0.971 | 0.335 |
| | Female (n=27) | 8.05±0.34 (7.57-8.87) | | |
| Wing length (mm) | Male (n=48) | 78.69±2.23 (74.05-82.44) | 3.054 | **0.003** |
| | Female (n=27) | 76.72±2.63 (71.15-80.47) | | |
| Tail length (mm) | Male (n=48) | 48.06±3.30 (40.41-53.56) | -1.291 | 0.201 |
| | Female (n=27) | 49.24±3.37 (42.81-56.36) | | |
| Tarsus length (mm) | Male (n=48) | 15.11±0.95 (13.06-17.10) | 0.106 | 0.916 |
| | Female (n=27) | 15.08±0.88 (12.42-16.11) | | |
| Body mass (g) | Male (n=48) | 14.84±3.11 (10.19-19.53) | 0.954 | 0.344 |
| | Female (n=27) | 14.03±2.96 (10.77-19.24) | | |

the male greenfinches feeding the incubating female (Carvalho *et al*., 2007). In greenfinches, males not only provide foods to incubating females and their nestlings, but also nest defense and majority of post-fledging provisioning, during mate choice, females may prefer to mate with males with larger bill size, as greenfinch is a seed-eater, bill size may predict the foraging ability of males (Grant and Grant, 2006). As an aerial display songbird, paired males has longer wings but with nearly mass to female. Our foundings in this work is different from previously reported results in other two passerine birds, Elliot's Laughingthrush *Trochalopteron elliotii* (Liu and Sun, 2016) and Plain Laughingthrush *Garrulax davidi concolor* (Liu and Sun, 2018), in which two species, males were larger than females in all determined body measurements, and both male's display occurred on the ground, which is inclined to favor to larger body size of males.

In our study, culmen height, wing length, body mass and body condition were significantly correlated within pairs, indicating positive assortative mating. This non-random mating pattern were reported in many other birds (Sandercock, 1998; Delestrade, 2001; Tryjanowski and Šimek, 2005; Haggerty, 2006). American goldenfinch, also a cardueline finches, positively assortative mated by carotenoid-based plumage color (MacDougall and Montgomerie, 2003), in which males experience prealternate spring moult before breeding season (Middleton, 1993), this is distinctly different from Greenfinches, whose males experienced autumn moulting and yellow plumage getting brilliant at least 2 weeks before spring, while females remain duller until breeding season comes, the mutual mate choice in this species may depend on the body condition rather than plumage coloration. In general, plumage coloration is good indicator of body condition (good health). So the relationship between body condition and plumage coloration is inseparable, this need figure out in our future works. We argued that the mate choice and evolution of sexual selected traits exhibited different patterns in different species with different life histories. Body mass is still a key physiological trait of adaptation, mated assortatively by body mass ensured synchronous physiological pace of the pairs, and favorable to breeding success (Mueller, 1986; Moreno, 1989; Haggerty, 2006). Fat reserves can be very important during incubation, because many bird species must endure starvation, and the physiological costs of incubation can be very high (Hipkiss, 2002; Halley *et al*., 2015). Individuals that have a higher body mass also may have more fat reserves, and could therefore spend more time in incubation (Halley *et al*., 2015), especially in this only-female incubation species. In the course of mate choice in Greenfinches, males may prefer to mate with females with heavier body mass, this will reduce his energy cost in foraging and back to incubation feeding, and also brood predation risk. However, females prefer to mate with males with higher foraging ability, this could ensure her food supply during incubation. If assortative mating in body mass and body condition is the result of mutual mate choice, males should prefer to mate with heavier females and females should prefer to mate with heavier males. A migratory species in which high quality individuals (of both sexes) arrive earlier to the breeding grounds, high quality females will mate with high quality males even if they mate randomly, because only high quality individuals of both sexes will be present in the breeding grounds early in the season. They would show assortative mating for any trait related to quality even without any mate choice involved. The same might apply to non-migratory species if high quality individuals (of both sexes) begin to breed earlier. Therefore, sexual selection rather than resource partitioning may drive the sexual morphological difference and mate choice promote assortative mating by body condition in this passerine bird.

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*Statement of conflict of interest*

The authors have declared no conflict of interest.

*References*

Andersson, M., 1994. *Sexual selection*. Princeton University Press. Princeton.

Blanckenhorn, W., 2005. Behavioral causes and consequences of sexual size dimorphism. *Ethol,* **111**: 977–1016. https://doi.org/10.1111/j.1439-0310.2005.01147.x

Blomqvist, D., Johansson, O., Unger, U., Larsson, M. and Flodin, L., 1997. *Anim. Behav.,* **54**: 1291-1299. https://doi.org/10.1006/anbe.1997.0532

Blondel, P., Perret, M. and Anstett, C., 2002. *J Evol. Biol.,* **15**: 440–450. https://doi.org/10.1046/j.1420-9101.2002.00397.x

Carvalho, C., Macedo, R. and Graves, J., 2007. *Braz. J. Biol.,* **67**: 275–281. https://doi.org/10.1590/S1519-69842007000200012

Chiba, A., Uchida, H. and Imanishi, S., 2014. *Zool. Sci.,* **31**: 741–747. https://doi.org/10.2108/zs140087

Clement, P., 2020. *Oriental greenfinch (*Chloris sinica*), version 1.0*. In: *Birds of the world* (J. del Hoyo, A. Elliott, J. Sargatal, D. A. Christie and E. de Juana Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.origre.01

Crespi, B., 1989. *Anim. Behav.,* **38**: 980–1000. https://doi.org/10.1016/S0003-3472(89)80138-1

Darwin, C., 1871. *The descent of man and selection in relation to sex*. John Murray, London. https://doi.org/10.5962/bhl.title.24784

Delestrade, A., 2001. *Auk*, **118**: 553–556. https://doi.org/10.1093/auk/118.2.553

Fletcher, K., Hamer, K., 2003. *Bird Study,* **50**: 78–83. https://doi.org/10.1080/00063650309461294

Friedman, N. and Remeš, V., 2015. *Ecography,* **38**: 1–9.

Grant, P.R. and Grant, B.R., 2006. *Science,* **313**: 224–226. https://doi.org/10.1126/science.1128374

Haggerty, T., 2006. *J. Field Ornithol*., **77**: 259–265. https://doi.org/10.1111/j.1557-9263.2006.00051.x

Halley, M., Holmes, A. and Robinson, W., 2015. *J. Field Ornithol.,* **86**: 153–162. https://doi.org/10.1111/jofo.12098

Haneda, K. and Nakamura, H., 1970. *Tori,* **20**: 41–59 (in Japanese). https://doi.org/10.3838/jjo1915.20.41

Hipkiss, T., 2002. *J. Zool.,* **251**: 287– 285. https://doi.org/10.1001/jama.287.3.285

Hogle, N. and Burness, G., 2014. *J. Ornithol.,* **155**: 91–100. https://doi.org/10.1007/s10336-013-0991-y

Hooper, P. and Miller, G., 2008. *Adapt. Behav.,* **16**: 53–70. https://doi.org/10.1177/1059712307087283

Jiang, Y., Daniel, I. and Bolnick, M., 2013. *Am. Nat.,* **181**: 125–138. https://doi.org/10.1086/670160

Jones, T., Arnqvist, G., McNamara, K. and Elgar, M., 2012. *Behav. Ecol. Sociobiol.,* **66**: 995–1003. https://doi.org/10.1007/s00265-012-1347-y

Liu, P. and Sun, Y., 2016. *Ardea,* **104**: 177–182. https://doi.org/10.5253/arde.v104i2.a2

Liu, P. and Sun, Y., 2018. *Wilson J. Ornithol.,* **130**: 510-515. https://doi.org/10.1676/16-031.1

MacDougall, A. and Montgomerier, R., 2003. *Naturwissenschaften,* **90**: 464–467. https://doi.org/10.1007/s00114-003-0459-7

Middleton, A., 1993. *American goldfinch (Carduelis tristis).* In: (eds. A. Poole and R. Gill). The birds of North America, vol 80. Academy of Natural Sciences, Philadelphia. https://doi.org/10.2173/bna.080

Moreno, J., 1989. *Biol. J. Linn. Soc.,* **37**: 297–310. https://doi.org/10.1111/j.1095-8312.1989.tb01907.x

Mueller, H., 1986. *Wilson Bull.,* **98**: 387–406. https://doi.org/10.1177/089033448600100422

Nakamura, H., 1969. *J. Yamashina Inst. Ornithol.,* **5**: 623–639. (in Japanese).

Nakamura, H., 1979. *Tori,* **28**: 1–27 (in Japanese). https://doi.org/10.3838/jjo1915.28.1

Nakamura, H., 1991. *J. Yamashina Inst. Ornithol.,* **22**: 9–55 (in Japanese).

Nakamura, H., 1997. *Jap. J. Ornithol.,* **46**: 95–110. https://doi.org/10.3838/jjo.46.95

Saitoh, T., Kawakami, K., Red·kin, Y., Nishiumi, I., Kim, C. and Kryukov, A., 2020. *Zool. Sci.,* **37**: 280–294. https://doi.org/10.2108/zs190111

Sandercock, B., 1998. *Auk,* **115**: 786–791. https://doi.org/10.2307/4089430

Shine, R., 1989. *Quart. Rev. Biol.,* **64**: 419–461. https://doi.org/10.1086/416458

Suzuki, T. and Kobayashi, K., 1990. *Jap. J. Ornithol.,* **39**: 66–68 (in Japanese). https://doi.org/10.3838/jjo.39.66

Tryjanowski, P. and Šimek, J., 2005. *J. Ethol.,* **23**: 161–165. https://doi.org/10.1007/s10164-004-0142-2