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# Short Communications

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## Sexual size dimorphism and assortative mating in the Plain Laughingthrush (*Garrulax davidi concolor*)

Pengfei Liu<sup>1,2</sup> and Yuehua Sun<sup>1\*</sup>

**ABSTRACT**—In the breeding seasons of 2014 and 2015, we determined sexual size dimorphism and mating pattern in a breeding population of the Plain Laughingthrush (*Garrulax davidi concolor*) at Lianhuashan Nature Reserve in Gansu, China. We found that males were significantly larger and heavier than females, with a 104.8 body mass dimorphism index. Positive assortative mating based on culmen length was found across breeding pairs. Male-biased territory defense and mate-guarding suggest that sexual selection may be responsible for sexual size dimorphism in this bird. We also found significant positive correlations of body mass and body temperature between breeding pairs. We propose that this type of positive assortative mating could be a consequence of synchronous breeding by pairs in a similar physiological state. *Received 16 March 2016. Accepted 23 June 2017.*

**Key words:** assortative mating, Plain Laughingthrush, sexual size dimorphism.

### **Dimorfismo sexual de tamaño y emparejamiento selectivo en *Garrulax davidi concolor***

**RESUMEN** (Spanish)—En las temporadas de anidación de 2014 y 2015, determinamos el dimorfismo sexual de tamaño y el patrón de emparejamiento en una población reproductiva de *Garrulax davidi concolor* en la reserva natural Lianhuashan en Gansu, China. Encontramos que los machos son significativamente más grandes y más pesados que las hembras, con un índice de dimorfismo de masa corporal de 104.8. El emparejamiento selectivo positivo se encontró en parejas reproductivas basado en la longitud del culmen. La defensa del territorio y la vigilancia de la pareja tiene un sesgo hacia los machos, lo que sugiere que la selección sexual podría ser responsable del dimorfismo sexual de tamaño en esta ave. También encontramos correlaciones positivas significativas de masa y temperatura corporal entre parejas reproductivas. Proponemos que este tipo de emparejamiento selectivo podría ser consecuencia de anidación sincrónica por parejas en un estado fisiológico similar.

**Palabras clave:** Emparejamiento selectivo, dimorfismo sexual de tamaño, *Garrulax davidi concolor*.

Sexual size dimorphism (SSD) is a common pattern across the animal kingdom, believed to result from sexual and natural selection (Darwin 1871, Andersson 1994, Haggerty 2006, Friedman and Remeš 2015). The resource-partitioning hypothesis proposes that sex-related differences in foraging behavior contribute to the evolution and maintenance of SSD (Selander 1966, Shine 1989, Andersson 1994, Temeles et al. 2000, Blondel et al. 2002). The sexual selection hypothesis argues that larger size usually evolves in males because of the advantages it confers in male–male competition for access to breeding territories or mates (Andersson 1994, Haggerty 2006). In practice, determining which of the proposed mechanisms accounts for SSD is difficult, but the study of mating patterns may provide relevant evidence (Haggerty 2006).

Assortative mating is a nonrandom mating pattern that might indicate the occurrence of mate choice. A breeding individual prefers to mate with a partner who has similar phenotypes or genotypes (Haggerty 2006, Jiang et al. 2013), so similar individuals mate more frequently with each other (Bateson 1983, Burley 1983). This mating pattern maintains premating reproductive isolation and assumes an important role in speciation and sexual selection (Galipaud et al. 2013, Jiang et al. 2013).

Assortative mating in birds may arise through mutual mate choice (Andersson 1994, Riebel et al. 2010). Most evidence for assortative mating comes from studies on morphological traits, especially on body size (Jones et al. 2012), age, or body condition (Jouventin et al. 1999, Wagner 1999, Tryjanowski and Šimek 2005, Haggerty 2006, Riebel et al. 2010), but it has also been linked to behavioral and physiological traits (Steinmeyer et al. 2013).

Body temperature ( $T_b$ ), the balance between heat production and dissipation, determines the rate of energy supply as well as almost all biological other rates (Gillooly et al. 2001, 2002;

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Brown et al. 2004). Metabolic rate is the rate of energy uptake, transformation, and allocation, and it determines the rates of almost all biological activities, including growth, survival, and reproduction (Brown et al. 2004, Clarke 2006). Although the metabolic rate of an organism is determined by its body size and temperature, ultimately other rates of biological processes are similarly related to body size and temperature, such as growth and reproduction (Brown et al. 2004, Clarke 2006, Brown and Sibly 2012, McNab 2012, Glazier 2015).

The Plain Laughingthrush (*Garrulax davidi concolor*), a temperate zone Chinese endemic, is the most northerly occurring member of its genus. It is socially monogamous and occurs in shrubs and open woodlands. Here we assessed sexual size dimorphism in several morphometric characteristics in adult Plain Laughingthrush during the breeding season to determine (1) if sexual size dimorphism exists in this species and (2) if assortative mating is present based on body size or/and body condition. The Plain Laughingthrush has a long and curved beak suitable for digging in earth and litter; they feed on food underground in most instances, their diet consisting mainly of insects and larva (Lei and Lu 2006). In Lianhuashan National Natural Reserve, Gansu province, central China, the species is resident and breeds from the end of March to early August. Breeding pairs strongly displayed in male-dominated joint territory defense and mutual mate-guarding. We predicted male-biased SSD in this bird and hypothesized we would find an assortative mating pattern based on body size across breeding pairs. Because it is the only laughingthrush species living in the temperate zone and breeding in early spring, we also hypothesized that  $T_b$  would play an important role in mate choice.

## Methods

We studied the Plain Laughingthrush at the Lianhuashan National Natural Reserve in Gansu Province, central China (see Sun et al. 2003 for a detailed description of the study area).

We conducted our investigation in the study area during 2 consecutive breeding seasons (2014 and 2015) within an area of ~80 ha. We captured 47 males, 39 females, and 27 mated pairs by mist

netting. The paired males and females were captured at the same time on the same day, and all animals were captured in the early breeding season. Captures were restricted to the morning (0700–1100 h) to avoid results biased by circadian rhythm. Following the methods of Haggerty (2006), we measured 6 morphological parameters (culmen length, beak thickness, tarsus length, body length, tail length, and wing length) with digital calipers (to 0.01 mm) and weighed body mass using an electrical balance (to 0.01 g). Adopting the method of Xia et al. (2013), we measured the body temperature of the birds ( $T_b$ ) with a digital thermometer (Beijing Normal University Instruments Co.). All measures were performed by the same person to avoid any bias.

Sex was provisionally determined through the presence or absence of a cloacal protuberance and brood patch. Each bird was banded with a unique combination of colored rings and a numbered metal ring and then released immediately. We further confirmed the sex of the banded birds through subsequent observations of courtship, singing, and copulatory behavior. All handling procedures were approved by the Institutional Animal Care and Use Committee of the Institute of Zoology, Chinese Academy of Sciences.

## Statistical analysis

We used  $t$ -tests to investigate sex differences in all body and temperature measurements. We also calculated an index of dimorphism using the formula: dimorphism index = female mean/male mean  $\times$  100 (Wagner 1999) and a coefficient of variation as: CV = SD/Mean  $\times$  100 (Fletcher and Hamer 2003) for each sex and all variables to indicate the variability of each measurement (Sokal and Rohlf 1995). Pearson's correlation was adopted to evaluate the relationship between body mass and  $T_b$  in males and females separately, as well as to examine the correlation within mated pairs of all body measurements and  $T_b$ . To test the influence of the capture time (date) and body mass on  $T_b$ , one-way ANOVA was performed. All statistical tests were performed with SPSS software package for Windows 16.0 (SPSS Inc. 2007), and all probabilities were 2-tailed with a significance level of  $P = 0.05$ .

**Table 1.** Body measurements, dimorphism indices, and coefficient of variation of Lianhuashan Plain Laughingthrushes. All measurements differed significantly between sexes (for all male measurement,  $n = 47$ ; for female,  $n = 39$ ; all  $P < 0.05$ ).

Body measurement	Sex	Mean (SD)	Range	Dimorphism index	CV
Culmen length (mm)	Male	23.47 (0.79)	21.39–25.90	94.7	3.4
	Female	22.12 (0.78)	19.40–22.89		3.5
Beak thickness (mm)	Male	7.91 (0.48)	7.28–9.16	97.7	6.1
	Female	7.27 (0.42)	5.54–7.64		5.8
Tarsus length (mm)	Male	29.80 (1.24)	27.24–33.25	94.7	4.2
	Female	28.80 (1.04)	26.80–31.33		3.6
Wing length (mm)	Male	87.21 (4.33)	80.69–91.81	97.1	5.0
	Female	84.70 (3.58)	81.23–86.55		4.2
Body length (mm)	Male	116.23 (2.40)	109.75–126.90	96.1	2.1
	Female	111.65 (1.45)	105.13–118.57		1.3
Tail length (mm)	Male	118.65 (5.03)	108.69–128.89	96.7	4.2
	Female	114.69 (4.78)	104.17–122.53		4.2
Body mass (g)	Male	57.90 (3.18)	52.53–67.86	95.4	5.5
	Female	55.25 (3.67)	49.26–61.37		6.6

## Results

The dimorphism indices of culmen length, beak thickness, tarsus length, wing length, body length, tail length, body mass showed that males were significantly heavier (4.6%,  $t = 3.317$ ,  $df = 84$ ,  $P < 0.001$ ) and larger than females (2.9–8.1% depending on body measurement; all  $P < 0.001$ ; Table 1). The most dimorphic measurement was beak thickness (97.7; Table 1). We found no significant difference in  $T_b$  (SE) between sexes: males 41.98 (1.0) °C, females 41.82 (1.0) °C;  $t = 0.653$ ,  $df = 80$ ,  $P = 0.516$ . Results of one-way ANOVA indicated that capture time had no influence on  $T_b$  ( $F = 1.617$ ,  $df = 71$ ,  $P = 0.096$ ), and body mass had no significant influence on  $T_b$  ( $F = 1.181$ ,  $df = 71$ ,  $P = 0.639$ ). Positive assortative mating within breeding pairs was

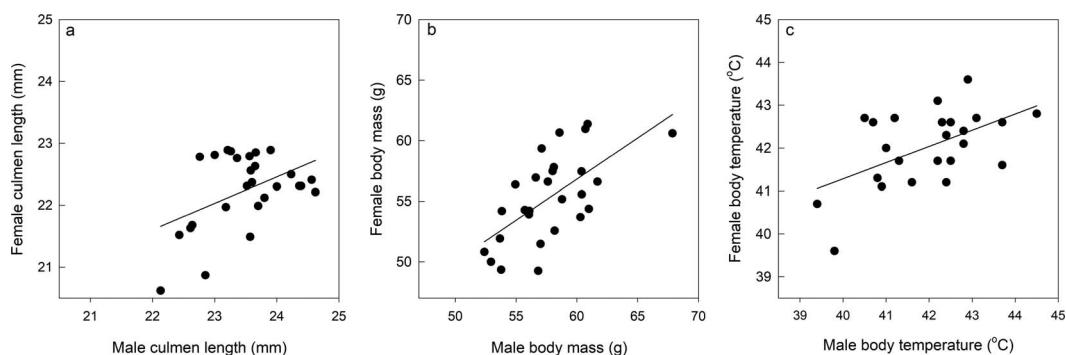
detected in culmen length, body mass, and  $T_b$  (Table 2, Fig. 1).

## Discussion

We found that the Plain Laughingthrush exhibits slight male-biased SSD (2.9–8.1% depending on body measurement), a pattern shared with many other songbirds, for example Carolina Wren (*Thryothorus ludovicianus*; Haggerty 2006), Spot-breasted Wren (*T. maculipectus*; Winker et al. 1996), Rufous-and-white Wren (*T. rufalbus*; Mennill and Vehrencamp 2005), Japanese Bush Warbler (*Cettia diphone*; Chiba et al. 2014), and Tree Swallow (*Tachycineta bicolor*; Hogle and Burness 2014). SSD is variously considered to be either the outcome of natural selection for minimizing intersexual competition for limited food resources or linked to other life history traits (Friedman and Remeš 2015). SSD resulted from males and females foraging for food items of different sizes, reducing intersexual competition (Shine 1989, Friedman and Remeš 2015). In the Plain Laughingthrush, breeding pairs jointly and energetically defend their territories and engage in mutual mate-guarding. The pair bond is maintained even outside breeding season, and the mated pairs often forage close together and on the same substrates. Males do not seem to dominate females in access for food (PL, pers. obs.), and therefore no evidence currently exists to support the resource-partitioning hypothesis (Shine 1989, Temeles et al.

**Table 2.** Pearson's correlations of body measurements between mated pairs in the Plain Laughingthrush. Significant correlations ( $P < 0.05$ ) are indicated in bold.

Variables	$r$	$n$	$P$
Culmen length	0.459	27	<b>0.016</b>
Beak thickness	0.26	27	0.20
Tarsus length	0.18	27	0.37
Wing length	0.31	27	0.12
Body length	0.32	27	0.11
Tail length	0.14	27	0.49
Body mass	0.64	27	<b>&lt;0.001</b>
Body temperature	0.54	24	<b>0.007</b>



**Figure 1.** (a) Culmen length, (b) body mass, and (c) body temperature of females plotted against that of males in mated pairs Plain Laughingthrush. The solid line shows the significant positive correlation resulting from a Pearson's correlation test: (a)  $n = 27$ ,  $r = 0.459$ ,  $P = 0.016$ ; (b)  $n = 27$ ,  $r = 0.64$ ,  $P < 0.001$ ; (c)  $n = 24$ ,  $r = 0.54$ ,  $P = 0.007$ , indicating positive assortative mating.

2000) as an explanation for the occurrence SSD in this species.

Sexual selection theory proposes that intra-sexual contests offer the larger individual a selective advantage to get mates and defend breeding territory (Andersson 1994, Haggerty 2006). In the breeding season, mated pairs displayed strong behavior of male-dominated joint territory defense and mutual mate-guarding, indicating that sexual selection may be driving the evolution of male-biased SSD in this bird.

The mated pairs assortatively paired by culmen length, body mass, and  $T_b$ . The Plain Laughingthrush forages for food underground in most instances, and therefore culmen length may be an important indicator of foraging ability in this bird. Assortative mating based on bill size has been reported in Razorbills (*Alca torda*; Wagner 1999) and by body size in other passerine birds, such as wing length in Carolina Wrens (Haggerty 2006). Mated pairs positively assortative paired by body mass, similar to the Red-backed Shrike (*Lanius collurio*; Tryjanowski and Simek 2005). Body mass was the major determinant of metabolic rate (Mueller 1986; McNab 2008, 2009; Glazier 2015); metabolic rate (and ultimately other biological process rates) of an organism is determined by its body size and temperature (Brown et al. 2004, Clarke 2006, Brown and Sibly 2012, McNab 2012, Glazier 2015).

If culmen length in the Plain Laughingthrush is the indicator of foraging ability, then better foragers would have relatively heavier body mass

and higher  $T_b$ . These birds could therefore have a superior metabolic rate that allows them to commence breeding before birds in worse condition. In passerine birds, because of biparental care and long-term pairbonding, individuals choose a breeding partner based on their own physical quality, so mutual mate choice leads to assortative mating (Riebel et al. 2010). The Plain Laughingthrush breeds from late March to early August in the study area, and one pair produces one clutch per year unless the first attempt fails.

Bill size has been reported to be age-related (Coulson et al. 1981), and body mass is also commonly associated with age. Older birds are generally in better condition, and assortative mating by age is a common occurrence (Reid 1988, Jouventin et al. 1999). Whether the culmen length is really the predictor of foraging ability or is age-related in this laughingthrush is unknown, as is whether higher body mass and  $T_b$  are age-related and reflect high quality (Riebel et al. 2010), and even influence mate choice. More field work is needed to determine whether the assortative mating pattern we found in the Plain Laughingthrush is body state-dependent.

In summary, male-biased SSD was confirmed in Plain Laughingthrush. The breeding pairs mated assortatively by culmen length, body mass, and body temperature. The mechanisms of SSD and positive assortative mating are complicated, and more detailed field and experimental studies are needed to determine if this SSD and mating patterns are related to breeding timing and age.

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## The first case of successful polyterritorial polygyny in the European Blackbird *Turdus merula*

Dariusz Wysocki<sup>1\*</sup> and Łukasz Jankowiak<sup>1</sup>

**ABSTRACT**—This paper describes the first case of successful polyterritorial polygyny in the European Blackbird *Turdus merula*. It was detected in an intensively studied color-banded population of European Blackbirds in Szczecin (northwestern Poland). *Received 13 November 2016. Accepted 18 June 2017.*

**Key words:** European Blackbird, mating strategies, mating system, *Turdus merula*.

### Primer caso exitoso de poliginia politerritorial en el Mirlo Común *Turdus merula*

**RESUMEN** (Spanish)—Este artículo describe el primer caso de poliginia politerritorial exitosa en el Mirlo Común *Turdus merula*. Esta fue detectada en una población muy estudiada de Mirlo Común de Szczecin (noroeste de Polonia) en que los ejemplares son marcados con anillas de colores.

**Palabras clave:** estrategias de apareamiento, Mirlo Común, sistemas de apareamiento, *Turdus merula*.

The European Blackbird (*Turdus merula*) is one of the best-known birds of Europe, and its mating system has been extensively described (Snow 1958, Glutz von Blotzheim et al. 1982, Stefan 1985, Cramp and Simmons 1988, Wysocki 2004a). However, the majority of studies where

individuals were color banded were conducted in Western Europe (Snow 1958, Desrochers and Magrath 1996, Creighton 2000, Streif and Rasa 2001). We studied an urban European Blackbird population in central Europe, where climatic conditions and various other ecological and behavioral features differ from previous studies (Wysocki and Hałupka 2004).

To date, no successful polyterritorial bigyny, known in numerous European and North American passerines (Lundberg and Alatalo 1992; for review see Møller 1986, Ford 1996), has been described in the European Blackbird. The first deliberate attempt by one male to occupy 2 territories and mate with 2 females was recorded at the beginning of the 2003 breeding season (Wysocki 2004a). This male, however, subsequently abandoned his second mate (and territory) when the first female started to build the nest (during nest building, mate guarding is at its most intense; the male usually follows his female at all times, chasing all other males out of his territory; Snow 1958; DW pers. obs.).

We describe the first case of successful polyterritorial polygyny in the European Blackbird (1 male has 2 separate territories at the same time with 2 different active nests) in Szczecin (northwestern Poland). Compared to other European Blackbird populations, our study population is characterized by a much lower density (1.0–2.5

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