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Difference in morphology between two closely related Bush Warblers, *Cettia diphone* and *C. seebohmi*, in Japan and the Philippines

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日本とフィリピンの近縁なウグイス2種の形態的差異

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Abstract: Body size measurements of the Luzon Bush Warbler, *Cettia seebohmi*, were described, and compared with those of a subspecies of the Japanese Bush Warbler, *C. diphone cantans*. Male Luzon Bush Warblers were prone to be smaller than male Japanese Bush Warblers, while a female in the Philippines was similar to or a little larger than the females in Japan. The level of sexual size dimorphism was lower in the Philippines, suggesting the weaker sexual selection in the population. Luzon Bush Warblers had the longest primary feather at more proximal position of their wings, and shorter wing-tips, in comparison with Japanese Bush Warblers, meaning that they had rounded wings. This may be related to the nonmigratory habit and their habitat with dense foliage of the Luzon Bush Warbler.

Introduction

External characters in morphology are not only the basic information on taxonomy between closely related taxa, but also important to understand ecological and social conditions of species, because natural selection has shaped the adaptive morphology of each species. In birds, the shape of bills is consistent with the food habit and the foraging behavior (e.g. Grant 1986, Yamagishi & Eguchi 1996), and the wing shape is affected by the migratory habit (e.g. Nishiumi *et al.* 2000, Pérez-Tris & Tellería 2001). The extent of sexual dimorphism is attributed to social mating system (Owens & Hartley 1998, Dunn *et al.* 2001), which is associated with the strength of sexual selection. Thus, the comparison on morphology between closely related species is useful to understand the differences in ecology of the species.

The Luzon Bush Warbler, *Cettia seebohmi*, an endemic resident of northwestern Luzon, the Philippines (Grant 1894, Dickinson *et al.* 1991, Kennedy *et al.* 2000), is the most closely related to the Japanese Bush Warbler, *C. diphone*, that breeds in eastern China, southern Ussuriland, Korea, and Japan (Ornithological Society of Japan 2000), though some taxono-

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mists classify them as the same species and call the Luzon Bush Warbler *C. d. seebohmi* (Delacour 1942, Baker 1997). Biological information of the Luzon Bush Warbler is limited and the body measurements have not been reported in details, though it is known that the Luzon Bush Warbler has a redder crown, a prominent supercilium, and a greyer underpart (Delacour 1942, Kennedy *et al.* 2000). Breeding ecology of this species is unknown, either, since nests or eggs have not been recorded (see Kennedy *et al.* 2000).

In this paper, we describe the body size measurements of the Luzon Bush Warbler, and compare them with those of a subspecies of the Japanese Bush Warbler, *C. d. cantans*. Further, we discuss possible ecological factors of the Luzon Bush Warbler, which have been influencing their morphology.

Methods

The study area in the Philippines was an open forest at Ambangeg (16°31′N, 120° 50′E; 1355 m elev.) in the Cordillera Mountains of northwestern Luzon. The forest consisted mainly of pine trees, *Pinus* sp., with dense bush and thicket, in which Luzon Bush Warblers were singing (Fig. 1). The field work in Japan was conducted in two study areas. Both were deciduous secondary forests in Saitama, central Honshu, one at Furusato (36°06′N, 139°18′E; 70 m elev.) and the other at Shogunsawa (36°01′N, 139°20′E; 50 m elev.; Fig. 2). Both sites included patches of previously cultivated but presently abandoned lands dominated by dwarf bamboos.

Fig. 1. Study area in the Philippines.

We captured Bush Warblers using mist nets, and measured the lengths of the wing (natural wing length), wing-tip (the length from the longest primary feather to the longest secondary feather, Fig. 3), tail, exposed culmen and tarsus, to the nearest 0.01 mm with a digital calliper, except for the wing and tail lengths of Luzon Bush Warblers to the nearest 0.1 mm with a metal ruler. We recorded position of the longest primary feather, P1 being the

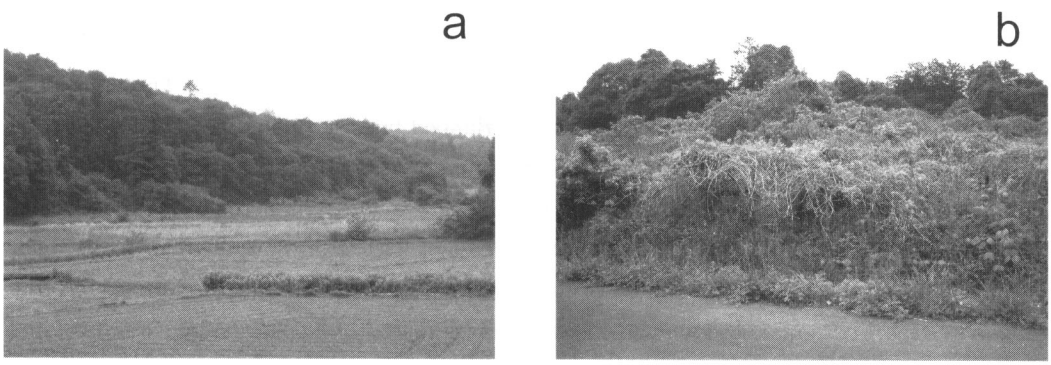

Fig. 2. Study area in Japan (Shogunsawa).

most proximal and P10 the most distal. We also measured body mass to the nearest 0.1 g with a digital balance. The measurements were made by S. H., except for one Luzon Bush Warbler by I. N. All captured birds were released soon after the measurements and DNA-sampling (the results of DNA analyses will be reported elsewhere).

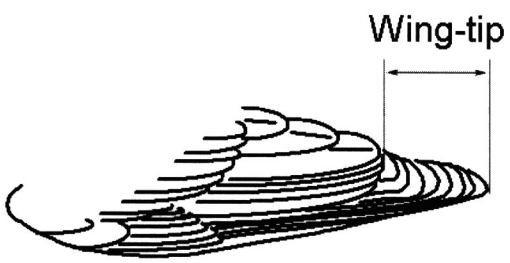

Fig. 3. Measurement of wing-tip.

Sex of Japanese Bush Warblers was identified by the already-known criteria of body measurements (Yamashina 1941, Hamao 1992). Since there is no morphological criterion on sexing of the Luzon Bush Warbler, we sexed them using brood patches (incubation patches; Svensson 1992) and territorial behaviors. We considered individuals that were singing, aggressively responded to the song playbacks, and did not have brood patch to be males, and individuals that were not singing, did not show aggressive response, and had brood patches to be females. Data were obtained from 16 males and 13 females of the Japanese Bush Warbler during the breeding seasons (April - July) in 2002-2004, and from two male and one female of the Luzon Bush Warbler on 26-27 April, 2005.

Results

1. Body size measurements

In the Japanese Bush Warbler, males were larger than females. The ranges of lengths of the wing, tail and tarsus were not overlapped between the sexes (Table 1). Males of the Luzon Bush Warbler were prone to be smaller than those of the Japanese Bush Warbler. Their body mass and natural wing length were under the ranges of Japanese males (Table 1). On the other hand, the body size of a female of the Luzon Bush Warbler was similar to that of Japanese females. Its lengths of the wing, tail, culmen and tarsus were within the ranges of Japanese females. However, the body mass of the Philippine female was over the range of Japanese females (Table 1).

Table 1. Body size measurements of *Cettia diphone* and *C. seebohmi*.

	Natural wing*	Tail*	Exposed culmen*	Tarsus*	Body mass (g)
C. diphone					
Males					
mean ± SD	63.33 ± 1.18	67.98 ± 1.91	11.56 ± 0.39	24.95 ± 0.56	20.17 ± 0.98
Range	59.69 - 65.35	65.39 - 71.80	10.87 - 12.39	23.68 - 25.91	18.00 - 22.00
n	16	14	16	16	16
Females					
mean ± SD	52.65 ± 1.07	55.74 ± 1.72	10.75 ± 0.38	22.03 ± 0.42	10.59 ± 0.81
Range	50.29 - 54.38	51.88 - 57.74	10.15 - 11.33	21.45 - 22.80	9.80 - 12.60
n	13	13	13	13	13
Male / female	1.20	1.22	1.08	1.13	1.90
C. seebohmi					
Male #1	56.3	66.7	10.87	25.00	15.2
Male #2	54.7	63.2	11.79	23.39	14.4
Female #3	51.5	53.0	11.10	21.93	13.4
Male / female	1.08	1.23	1.02	1.10	1.10

*lenght (mm).

The degree of sexual size dimorphism was larger in Japan than in the Philippines. The ratio in body mass of males to females was 1.90 (i.e. males were 1.90 times heavier than females) in Japan, whereas the ratio was 1.10 in the Philippines. The other body size ratios of males to females in Japan were larger than those in the Philippines, except for the tail length (Table 1).

The upper part of the Luzon Bush Warbler was reddish brown, while that of the Japanese Bush Warbler was olive brown. Its underpart and supercilium were greyer than the Japanese ones (Appendix 1a-c, 2a-b). However, we have no quantitative datum in the color morphs.

2. Wing shape

The longest primary feather of Japanese Bush Warblers was P6, with an exception of P5 for one male, whereas that of three Luzon Bush Warblers was P6, P5, and both P5 and P4 (P5 and P4 of a male were the same length; Table 2). Wing-tip of Luzon Bush Warblers was much shorter than that of Japanese Bush Warblers. The lengths of wing-tip of Japanese males and females were 11.43 (range: 9.59 - 13.51) and 8.60 (range: 7.05 - 10.39) mm, respectively (Fig. 4), whereas those in the Philippines were 4.72 and 5.42 mm in males, and 5.56 mm in a female. In Luzon Bush Warblers, outer primary feathers were relatively short, and wing-tips were also short, which means they had rounded wings (see also Appendix 1d, 2c-d).

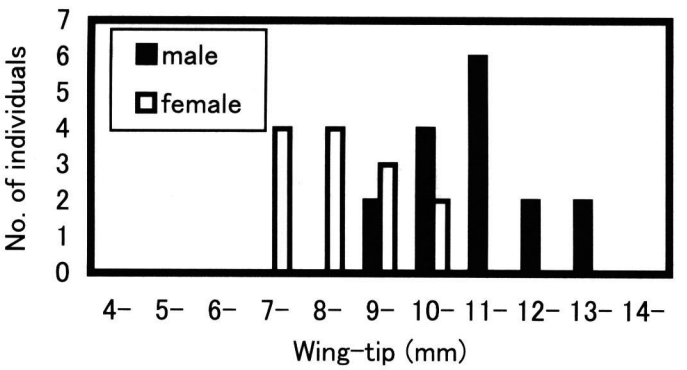

Fig. 4. Distribution of wing-tip length of the Japanese Bush Warbler.

Table 2. The longest primary flight feathers of *Cettia diphone and C. seebohmi.* Numbers of individuals are shown.

	C. diphone		*C. seebohimi.*	
	Male	Female	Male	Female
P6	15	13	1	0
P5	1	0	0	1
P5=P4*	0	0	1	0

*Both feathers had the same length.

Discussion

1. Sexual dimorphism

The Japanese Bush Warbler showed extreme sexual size dimorphism without overlap in body size measurements between the sexes (Table 1). This is consistent with the previous report of another population (Hamao 1992). This sexual size dimorphism would be

formed by strong sexual selection. Recent studies revealed that sexual size dimorphism is associated with the social mating system (i.e. the extent of polygamy; Owens *et al.* 1998, Dunn *et al.* 2001). The Japanese Bush Warbler has a polygynous mating system. Only a part of males, which should be highly competitive males in male-male competition, hold territories, and the successful males acquire six or more females (Hamao 1992). Reproductive success must highly vary among males. Thus it is possible that males are exposed to strong sexual selection pressure in this species.

In the Luzon Bush Warbler, body size measurements of males were larger than those of a female (Table 1), indicating that there is also sexual size dimorphism. However, the level of the dimorphism was lower than that in Japan (Table 1). This suggests weaker sexual selection in the Philippine population. Since density of territories is lower in the Philippines than in Japan (Hamao *et al.* in press), competition among males may be weaker. We speculate that the mating system of the Luzon Bush Warbler is monogamy or polygyny that is not highly developed. Further investigation of territoriality and breeding ecology in this species is required.

2. Wing shape

Luzon Bush Warblers had the longest primary feather at more proximal position of their wings, and had shorter wing-tips, in comparison with Japanese Bush Warblers. This means that the Luzon Bush Warbler has rounded wings, whereas the Japanese Bush Warbler has relatively pointed wings. Long and pointed wings are thought to be advantageous to long-distance flight, such as migration (e.g. Lockwood *et al.* 1998). Both broad interspecific comparison and intraspecific comparison between migratory and nonmigratory populations showed the relationship between the wing shape and migration (reviewed by Mulvihill & Chandler 1990, Dawson 2005). For example, the Oriental Great Reed Warbler, *Acrocephalus arundinaceus orientalis*, that breeds in Japan has longer wings than the Warbler that breeds in Korea and probably winters in Thailand, which may be caused by the long migration over

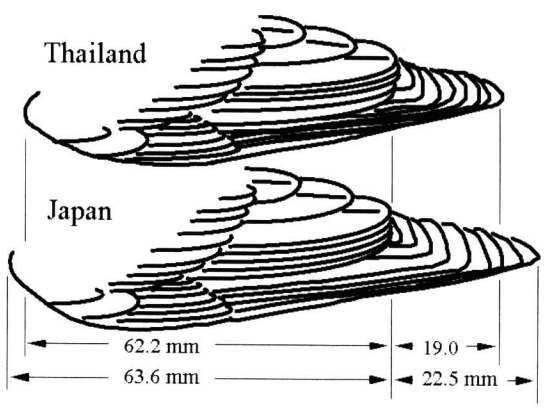

Fig. 5. Wing measurements of Thai and Japanese populations of the Oriental Great Reed Warbler (from Nishiumi *et al.* 2000).

the sea by the Japanese population (Fig. 5; Nishiumi 1998, 2002, Nishiumi *et al.* 2000). The Japanese Bush Warbler performs local migration in Japan (Nakamura & Nakamura 1995, Hamao 1997), whereas the Luzon Bush Warbler is sedentary (Kennedy *et al.* 2000). The pointed wings of the Japanese Bush Warbler may be adapted to migration.

On the other hand, rounded wings are thought to improve manoeuvrability. Birds with rounded wings can take off from the ground at a steeper angle (Swaddle & Lockwood 2003) and higher speed (reviewed by Pérez-Tris & Tellería 2001), which may reduce the risk of being captured by predators (Pérez-Tris & Tellería 2001). Both Luzon and Japanese Bush Warblers inhabit dense thickets. Indeed, the habitat of Luzon Bush Warblers was very dense understory, and warblers were very difficult to see. High manoeuvrability may help their foraging and to escape from predators in the vegetation. Therefore, the rounded wings of the Luzon Bush Warbler are likely suitable to their habitat as well as their sedentary habit.

Acknowledgements

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摘　要

日本のウグイス(*Cettia diphone cantans*)とフィリピンのウグイス(*C. seebohmi*)について、体サイズ測定値と翼の形を比較した。日本のウグイスでは雄が雌よりも明らかに大きく、雌雄のサイズ分布が重複しなかった。フィリピンの雄は日本の雄よりも小さく、雌は日本の雌と同じかやや大きかった(Table 1)。このことは、性的なサイズ二型が日本で顕著であることを示している。日本のウグイスは発達した一夫多妻の婚姻システムをもつが、フィリピンのウグイスは一夫一妻か、あまり発達していない一夫多妻の可能性が考えられる。翼の形では、フィリピンのウグイスは最も長い初列風切羽が翼の内側（体に近い側）にあり、翼差（最も長い初列風切と次列風切の長さの差；Fig. 3）も小さく、日本のウグイスに比べて丸みのある翼をもっていた(Table 2)。丸みのある翼は渡りなどの長距離飛行には適さないが、素早く急角度で飛び立つことを可能にすると言われている。季節的な移動を行う日本のウグイスがとがった形の翼をもつのに対し、フィリピンのウグイスが丸い翼をもつのは、渡りをせず、よく茂ったやぶに棲むことに適応したものと考えられる。この研究は、国立科学博物館の「西太平洋の島弧の自然史科学的総合研究」の一環として行われたものである。

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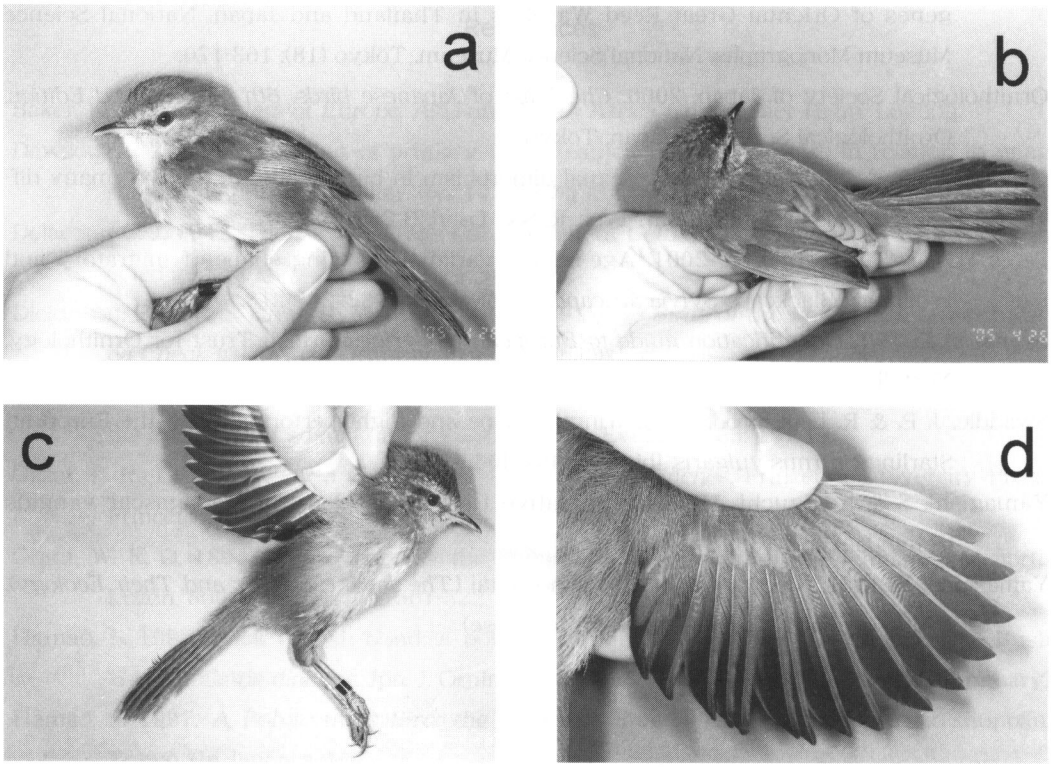
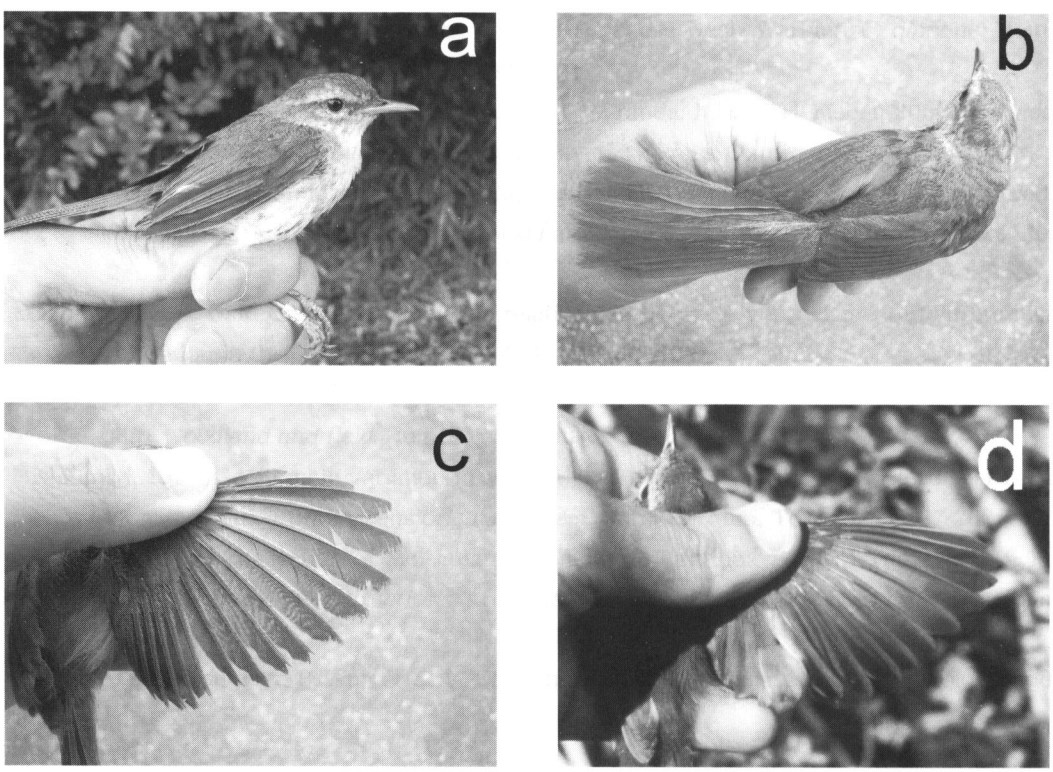


Appendix 1. A Luzon Bush Warbler. All photographs (a-d) are the same individual.



Appendix 2. Japanese Bush Warblers. All individuals belongs to the same subspecies, *C. diphone cantans*, but different localities: Furusato (a study area of the present study: a), Minami-daito Is. (b-c: the same individual) and Niigata (d).