Chinese Leaf Warbler *Phylloscopus yunnanensis* in South Korea: confirmation of the first adequately-documented national record through analysis of sound recordings

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A Chinese Leaf Warbler *Phylloscopus yunnanensis* was sound-recorded on Baekryeong Island, Incheon, South Korea, on 1 and 2 May 2020. This is the first adequately-documented national record of the species. The calls and song of this species are diagnostic, and identification in the field based on these vocalisations was straightforward and immediate. However, there is a strong prevalence in East Asia to place much higher value on records confirmed by photographs, specimens or in-the-hand measurements than on records documented only with sound-recordings. We therefore analysed the recordings to confirm the bird's identity. While the origins of a preference for visual documentation are understandable, a wider acceptance of the value of sound-recordings in documenting the presence or absence of species will likely prove immensely helpful in improving the understanding of the distribution, abundance and conservation status of many taxa which are morphologically extremely similar.

INTRODUCTION

Across much of South-East and East Asia, a strong dependence on visual identification of bird species remains prevalent, including in the confirmation of national first records. Some recent exceptions can be found in the region, such as the addition of Sakhalin Leaf Warbler *Phylloscopus borealis* to the Singapore list on the basis of vocalisations (Yap *et al*. 2014). In South Korea, 31 papers published in the Journal of the Korean Ornithological Society between 2007 and 2019 (out of a total of 250 listed in the website portal at https://osk.jams.or.kr) deal with national first records, with identification in each case made through specimens, sight records and photographs. None of these papers use vocalisations and sonograms as a basis for identification. To the best of our knowledge, with the exception of taxa elevated to full species based on bioacoustic data, no species has been added to the national list primarily on the basis of vocalisations in China either (P. Holt *in litt*. 2020); in Thailand, no migrant species has been added to the national list on the basis of vocalisations alone (P. Round *in litt*. 2020); and in the Philippines, the national rarities committee usually only considers records supported by photographs (D. Allen *in litt*. 2020). Indeed, a review of notable new records in the Philippines by Jensen *et al*. (2015) that includes 54 national first records of presumed accidental visitors does not include any that were identified primarily on the basis of vocalisations.

Species identification based on bioacoustics has already become primordial in other groups such as bats (Sugai *et al*. 2019) and amphibians (Guerra *et al*. 2018). However, the strong dependence on plumage, photographic evidence and on specimens to identify birds in East Asia suggests a lack of confidence in identification based on descriptions of calls and even of sonograms. This results in obvious limitations in detecting and confirming the presence of some species. Many cryptic, secretive and similar-looking species are best identified through vocalisations (Alström & Ranft 2003); and bioacoustic datasets have been an important tool in the discovery of multiple new species. These include several species of Asian *Phylloscopus* leaf warblers (Rheindt 2006, Martens 2010) whose separation from similar-looking taxa has by now been supported by genetic evidence (e.g. Martens *et al*. 2004, 2008, Martens 2010, Alström *et al*. 2011).

One of these recently-recognised species is the Chinese Leaf Warbler *P. yunnanensis*. First described by La Touche (1922), Alström *et al*. (1992) highlighted the vocal distinctiveness of this taxon when describing it under the junior synonym *P. sichuanensis*. *P. yunnanensis* is now widely accepted as a full species because of its distinctive vocalisations and unique genetic signature (e.g. Martens *et al*. 2004). The species is a long-distance migrant which breeds as far north as northern China and winters south at least to Thailand (BirdLife International 2020), with at least one claimed sight record in South Korea (Moores 2007). The lack of any supporting photographic documentation (and perhaps the lack of sound recordings) of that individual means that *P. yunnanensis* remains excluded from several national checklists and field-guides (e.g. Ornithological Society of Korea 2009, Jung 2014).

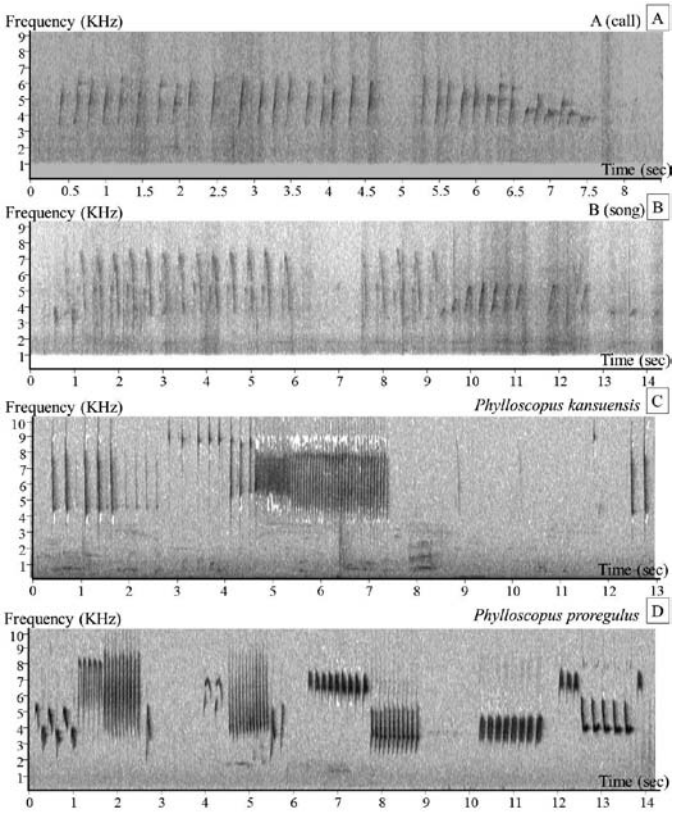
In common with several small leaf warblers, *P. yunnanensis* has a complex head pattern and a pale rump band, shared for example with the extremely similar Gansu Leaf Warbler *P. kansuensis* (Martens *et al*. 2004) and the more widespread but typically more brightly-plumaged Pallas's Leaf Warbler *P. proregulus*. While *P. kansuensis* has yet to be claimed on the Korean Peninsula, *P. proregulus* is a widespread migrant and a locally common summer visitor to mountain forest in the Korean Peninsula from north-eastern South Korea northward (e.g. Choi & Park 2005, Tomek 2002, Moores 2017).

As is typical for many species in the genus *Phylloscopus*, these three species are a challenge to identify on plumage alone, but they have diagnostic vocalisations which are usually easy to identify. *P. yunnanensis* has a very insistent and repetitive song and an explosive, metallic trilling call. *P. proregulus* typically has a short and squeaky call with several harmonics and a complex song comprised of hurried trills and measured phrases, admixed with higher- and lower-pitched notes. Based on recordings and sonograms on the xeno-canto website (www.xeno-canto.org) and on descriptions in Martinez *et al*. (2017), *P. kansuensis* has a complex, somewhat squeaky call with some very high elements, and also a song that starts with several well-spaced, very high notes, like the opening phrases of the song of Siberian Blue Robin *Larvivora cyane*, before falling into a rapid trill.

On 1 May 2020, during a bird survey in the western part of Baekryeong Island (37.966°N 124.620°E), NM heard a prolonged, emphatic, loud and monotonous series of clicking *sree-dee* notes rapidly repeated 50–100 times without a break, somewhat like an extended song of an Eastern Great Tit *Parus minor*. Because of its distinctiveness, he recognised this as the main song-type of the Chinese Leaf Warbler.

This song was mixed at times with an explosive metallic trill and some slightly more hesitant but still very insistent and rapidly-given *hw-eet* notes (recording XC585750; https://www.xeno-canto.org). These latter vocalisations, thought likely to be contact and agitation calls, were earlier described as contact and alarm calls by Alström *et al*. (1992). Considered by some experienced observers

Figure 1. (A) Call and (B) persistent song of *Phylloscopus yunnanensis*, May 2020, Baekryeong Island, South Korea; (C) Sonogram of *Phylloscopus kansuensis* extracted from https://www.xeno-canto.org (XC69081); (D) Sonogram of *Phylloscopus proregulus* (XC378848).



to be remarkably similar to vocalisations given by Gould's Sunbird *Aethopyga gouldiae* (J. Martinez *in litt*. 2020), these calls were in the Korean context more reminiscent of explosive trilling calls given by Manchurian *Horornis canturians borealis* and Japanese Bush Warblers *H. diphone*, although they sounded sharper and when decelerating did not break so obviously into bisyllabic phrases. Both the calls and the repetitive, sewing machine-type persistent song were given (Figure 1), generally, from 1–2 m above ground within dense vegetation at the edge of some deciduous forest mixed with bamboo and a few coniferous trees.

Because the bird was extremely secretive and moved rapidly through dense vegetation, only brief views were had over two hours of a small *Phylloscopus* with a pale grey patch to the rear of the median crown stripe and a whitish rump band. No reasonable photographs could be taken. Instead, several poor-quality recordings of both vocalisation types were made through a Samsung 5.0.1 phone.

Returning to the same area for several hours on 2 and 3 May, the bird was again heard singing and calling insistently, and again proved extremely difficult to see. More recordings were made on 2 May, including recording XC585752 (https://www.xeno-canto.org).

On all three dates, NM played briefly two tracks of *P. yunnanensis* recorded by Frank Lambert, downloaded from the xeno-canto website (recordings XC414466 and XC183043) in order to tempt the bird into view so that images could be secured. Under field conditions, the vocalisations of the bird and the recordings sounded more or less identical. While the recordings provoked an agitated response, with the bird singing persistently and coming much closer, no recognisable images could be taken.

On subsequent dates, no vocalisations were heard and the bird was assumed to have moved on. Here, we conclusively identify the calling individual, and promote the use of non-image media for bird identification.

METHODS

To provide confidence in the bird's identification as *P. yunnanensis*, sonograms were generated for six of the recordings collected in the field using Raven Pro 1.4 (Cornell Lab of Ornithology, New York, USA), with a total recording length of 175 seconds. Prior to data extraction, background noise was filtered out at 2 kHz, and spectrogram configuration was set at a Hann sample window size of 256, 128-sample hop size with 50% frame overlap, and 172-Hz frequency grid spacing with 256-sample DFT size (Figure 1).

Recordings of three morphologically similar species, namely of *P. yunnanensis*, *P. proregulus* and *P. kansuensis,* were also downloaded from the xeno-canto website, a curated database in which species identification is widely considered to be reliable. Six recordings of two main vocalisation types were selected for each of the three species (Table 1). Those vocalisations with sonograms on xeno-canto which looked closest to those of the bird on Baekryeong Island were selected. For each vocalisation type (call and song), three parameters were measured, namely: note duration, peak frequency and 90% bandwidth, defined as the width of the frequency band in which 90% of its power is located (sample sizes in Table 1). We measured these parameters across ten notes per recording, preferably from the same vocalisation bout, but we picked from across multiple bouts if all vocalisation bouts consisted of <10 notes. All notes of a recording were included for measurements if <10 notes were available in total. For the comparison, each vocalisation for all species was compared to homologous vocalisation types, here dichotomised between calls and songs.

For each vocalisation, measurements of each of the three parameters were then compared against corresponding measurements across the three species for both vocalisation types. To statistically differentiate between vocalisations for each call (n = 219) and song (n = 198) between species and to ensure that we captured the general variation, we conducted a principal component analysis (PCA) on each dataset. The PCAs were set such that principal components (PC) were to be extracted if their eigenvalue >1, under varimax rotation and with Kaiser normalisation.

A single PC was extracted for the call dataset, with the value of the resulting PC significantly distributed under a Kolmogorov-Smirnov test with Lilliefors corrections ($D(219) = 0.07$, $p = 0.010$). We relied on a one-way ANOVA with PC as the dependent variable and species as an independent variable to test for variation between clades.

Two PCs were extracted for the song dataset, with the values for the resulting PCs significantly distributed under a Kolmogorov-Smirnov test with Lilliefors corrections (PC1: $D(198) = 0.15$, $p < 0.001$; PC2: $D(198) = 0.10$, $p < 0.001$). We also relied on a one-way ANOVA with PCs as dependent variables and species as an independent variable to test for variation between clades. All analyses were conducted in SPSS v.21 (SPSS, Inc., Chicago, USA).

RESULTS

The PCA on calls resulted in the extraction of a single PC, representative of 53.49% of the variance. The factors loaded into the PC were such as: note length -0.80, 90% bandwidth 0.37 and peak frequency 0.85. The ANOVA on the resulting PC was significant ($\chi^2 = 23.11$, $F_{(215,218)} = 33.42$, $p < 0.001$).

The PCA on songs resulted in the extraction of two PCs, representative of 91.92% of the variance. The factors loaded into the PC1 were such as: note length 0.92, 90% bandwidth 0.91 and peak frequency -0.09. The factors loaded into the PC2 were such as: note length -0.12, 90% bandwidth 0.22 and peak frequency 0.99. The ANOVA on the resulting PCs was significant (PC1: $\chi^2 = 50.17$, $F_{(194,197)} = 209.38$, $p < 0.001$; PC2: $\chi^2 = 10.05$, $F_{(194,197)} = 11.68$, $p < 0.001$).

Table 1. Details of the vocalisation properties used in the analysis. Those listed as *Phylloscopus* sp. were recorded on Baekryeong Island, South Korea, in May 2020; the remainder were downloaded from the website xeno-canto for comparison (www.xeno-canto.org).

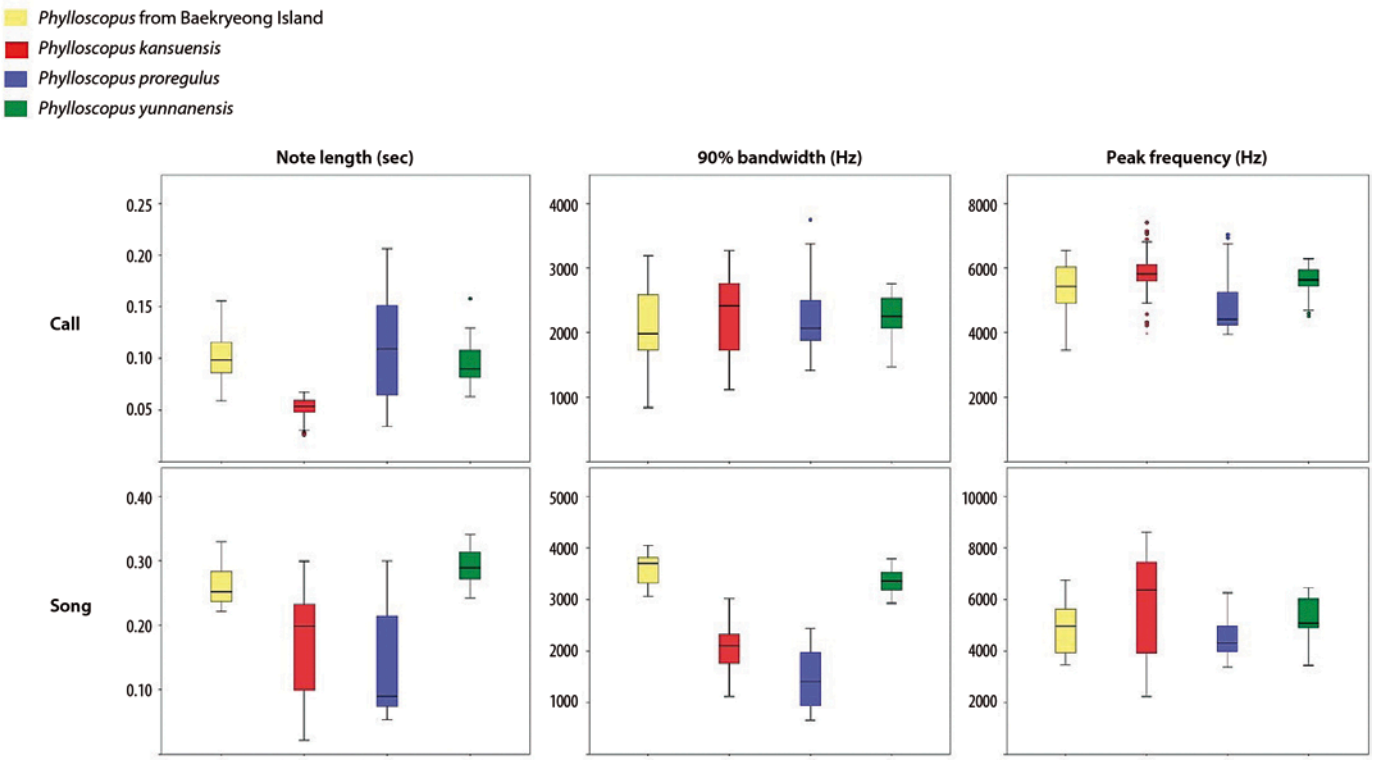
Species	Call ID/catalogue number	Call type	# notes extracted
Phylloscopus sp.	–	Call	10
Phylloscopus sp.	–	Call	7
Phylloscopus sp.	–	Call	10
Phylloscopus sp.	–	Call	8
Phylloscopus sp.	–	Call	10
Phylloscopus sp.	–	Song	10
Phylloscopus sp.	–	Song	10
Phylloscopus sp.	–	Song	5
Phylloscopus sp.	–	Song	10
Phylloscopus yunnanensis	XC487281	Call	10
Phylloscopus yunnanensis	XC414464	Call	10
Phylloscopus yunnanensis	XC414461	Call	10
Phylloscopus yunnanensis	XC161168	Call	10
Phylloscopus yunnanensis	XC69119	Call	10
Phylloscopus yunnanensis	XC332451	Call	10
Phylloscopus yunnanensis	XC113241	Song	10
Phylloscopus yunnanensis	XC266229	Song	9
Phylloscopus yunnanensis	XC419158	Song	8
Phylloscopus yunnanensis	XC491452	Song	10
Phylloscopus yunnanensis	XC491453	Song	10
Phylloscopus yunnanensis	XC491455	Song	10
Phylloscopus proregulus	XC555549	Call	10
Phylloscopus proregulus	XC486666	Call	9
Phylloscopus proregulus	XC378848	Call	7
Phylloscopus proregulus	XC378253	Call	10
Phylloscopus proregulus	XC375245	Call	8
Phylloscopus proregulus	XC266017	Call	10
Phylloscopus proregulus	XC376513	Song	10
Phylloscopus proregulus	XC485952	Song	9
Phylloscopus proregulus	XC485954	Song	10
Phylloscopus proregulus	XC486667	Song	10
Phylloscopus proregulus	XC486666	Song	10
Phylloscopus proregulus	XC486671	Song	10
Phylloscopus kansuensis	XC328532	Call	10
Phylloscopus kansuensis	XC491428	Call	10
Phylloscopus kansuensis	XC491427	Call	10
Phylloscopus kansuensis	XC491426	Call	10
Phylloscopus kansuensis	XC391023	Call	10
Phylloscopus kansuensis	XC69081	Call	10
Phylloscopus kansuensis	XC491433	Song	10
Phylloscopus kansuensis	XC102986	Song	2
Phylloscopus kansuensis	XC328532	Song	10
Phylloscopus kansuensis	XC526633	Song	5
Phylloscopus kansuensis	XC191253	Song	10
Phylloscopus kansuensis	XC391023	Song	10

These analyses highlight the difference in identity between the Baekryeong bird and the other species selected for both call and song, as highlighted by the box-plot drawn for each variable analysed for each species and type of vocalisation (Figure 2). The values for confirmed individuals of *P. yunnanensis* from xeno-canto were closer to the Baekryeong bird (Figure 2) compared to the two other species.

DISCUSSION

In direct visual comparison, the warbler under discussion appeared more or less intermediate between *P. proregulus* and *P. inornatus* in size and structure. Although many leaf warblers can look very dull in spring because of wear, this individual had a remarkably dull plumage, substantially duller than even the most worn and faded-looking *P. inornatus* present on the same dates, making it easy to pick out with the naked eye on the few occasions when it briefly moved out of deep cover or was visible through the canopy. Lacking any amber or clean yellow tones, the bird instead showed pale grey to the rear of the median crown stripe (noted at the time as a 'grey nape patch') and an almost white rump band, and otherwise looked dull greenish-grey above with bland looking tertials, a broad whitish greater covert wingbar and a much-reduced median covert bar. The underparts were pale dirty-white, with brownish-grey smudging on the breast sides and a strong greenish-yellow wash across the

Figure 2. Box plots of parameter comparison for calls and songs of the *Phylloscopus* from Baekryeong Island, South Korea, May 2020, versus *P. yunnanensis, P. proregulus* and *P. kansuensis*.



undertail coverts. Few of these features are discernible even in the best image of the bird that was taken.

Fortunately, like other *Phylloscopus* species (including the morphologically similar Lemon-rumped Warbler *P. chloronotus* and Sichuan Leaf Warbler *P. forresti* as well as the species used in the analysis), the bird on Baekryeong Island had a very distinctive song and call, and sound recordings could easily be made through a smart phone to help confirm the identification.

Simple visual comparison of sonograms of these three species (and of other very similar-looking species, such as *P. forresti*) should be sufficient to confirm the identification of the warbler on Baekryeong as *P. yunnanensis*, even though the recordings were of poor quality. For example, in sonograms, the song of *P. yunnanensis* is shown to be a remarkably invariable series of 'jagged teeth', while the introductory notes of the song of *P. kansuensis* show as multiple high-pitched well-separated notes, followed by a dense trill, with almost no space between individual notes (Figure 1). More formal analysis, as conducted on the vocalisations of the warbler on Baekryeong, has particular value in confirming that these differences are not random. Rather, they can be shown to be statistically significant.

The occurrence of *P. yunnanensis* on Baekryeong Island in early May 2020, following on from the sight record of one individual in October 2004 on Socheong Island (37.773°N 124.745°E), only 25 km to the south, is perhaps not entirely unexpected. The species is a long-distance migrant and breeds in high numbers only ~900 km to the north-west, with an apparently isolated breeding population further east in central Shandong province, China (P. Holt *in litt*. 2020), only 700 km to the west-south-west of Baekryeong Island. In addition, the species has a history of vagrancy. As summarized by P. Holt (*in litt*. 2020), *P. yunnanensis* is a vagrant to Taiwan (April) and China—Jiangxi (May), Shanghai (May, August and September) and Hong Kong (December). Even more remarkably, the species has also been recorded recently as far east as Japan, with one found in song in late June 2016 by Nakano Kouichirou, with sound recordings subsequently identified by Watabe Yoshiki (Yoshiki W. *in litt*. 2020).

The discovery of this individual on Baekryeong Island followed a week or so of south-westerly winds across the Yellow Sea, and also coincided with the arrival of a single singing Yellow-streaked Warbler *P. armandii* in the same part of the island. Based on online range maps, *P. armandii*, which is now recorded more or less annually in South Korea (pers. obs.), has a broadly similar geographical distribution to *P. yunnanensis*, and therefore seems likely to be drifted across the Yellow Sea by similar weather systems. Moreover, Baekryeong Island, like Socheong Island, is a migration hotspot, and more than two dozen species recorded in South Korea fewer than ten times (Moores *et al.* 2018) have been documented on the island. This includes South Korea's first records of Mongolian Lark *Melanocorypha mongolica* on 6 May 2014 and Black Bulbul *Hypsipetes leucocephalus* on 28 May 2019, both of which were photographed (e.g. Moores 2014, 2019).

The high numbers of individual birds, the diversity of species and the distant geographical origin of some of these species provide strong support to the hypothesis that Baekryeong Island, like the near-adjacent Socheong Island, sits on a major migration route across the Yellow Sea, dubbed the 'Northern Crossing' by Moores (2012). Indeed, Baekryeong and Socheong islands lie only 180 km across open sea from the eastern tip of the Shandong Peninsula, making it the shortest direct sea crossing between China and South Korea. In addition, being situated so far west, during northward migration these islands also potentially provide first land fall for migrants moving north-west anywhere off the Chinese coast between southern Shandong province and Jiangsu province.

Since the time of Alström & Ranft (2003), well-curated resources like the xeno-canto website and smart phones with recording capabilities have been developed, suggesting that a much larger proportion of cryptic or secretive species can now be documented and identified with confidence, even when photographic evidence to support identification is insufficient.

In this case, even short poor-quality recordings made through a phone are sufficient to confirm identification of a leaf warbler on Baekryeong Island as South Korea's first adequately-documented Chinese Leaf Warbler.

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