FORKTAIL

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Cover picture: Cambodian Tailorbird *Orthotomus chaktomuk*, Highway 61, near Prek Kdam, Kandal province, Cambodia, 21 November 2012 by James A. Eaton

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CONTENTS

Short Notes

FORKTAIL 29 (2013): 1–14

A new species of lowland tailorbird (Passeriformes: Cisticolidae: *Orthotomus*) from the Mekong floodplain of Cambodia

S. P. MAHOOD, A. J. I. JOHN, J. C. EAMES, C. H. OLIVEROS, R. G. MOYLE, HONG CHAMNAN, C. M. POOLE, H. NIELSEN & F. H. SHELDON

Based on distinctive morphological and vocal characters we describe a new species of lowland tailorbird *Orthotomus* from dense humid lowland scrub in the floodplain of the Mekong, Tonle Sap and Bassac rivers of Cambodia. Genetic data place it in the *O. atrogularis–O. ruficeps–O. sepium* clade. All data suggest that the new species is most closely related to *O. atrogularis*, from which genetic differences are apparently of a level usually associated with subspecies. However the two taxa behave as biological species, existing locally in sympatry and even exceptionally in syntopy, without apparent hybridisation. The species is known so far from a small area within which its habitat is declining in area and quality. However, although birds are found in a number of small habitat fragments (including within the city limits of Phnom Penh), most individuals probably occupy one large contiguous area of habitat in the Tonle Sap floodplain. We therefore recommend it is classified as Near Threatened on the IUCN Red List. The new species is abundant in suitable habitat within its small range. Further work is required to understand more clearly the distribution and ecology of this species and in particular its evolutionary relationship with *O. atrogularis*.

INTRODUCTION

After a hiatus of over half a century owing to the intense human conflicts in the area, the last two decades have witnessed the discovery of a flush of novel bird taxa in Indochina. These recent discoveries have been facilitated by better sampling of remote micro-habitats and to a much lesser degree the greater use of non-morphological characters in delimiting species. Most of these discoveries concerned babblers (Timaliidae) from isolated montane areas in Vietnam (Eames *et al.* 1994, Eames *et al.* 1999a,b, Eames & Eames 2001, Eames 2002). A smaller wave of discoveries involving a diverse range of taxa took place in forested limestone karst in Lao PDR, Vietnam and adjacent areas of China (Zhou Fang & Jiang Aiwu 2008, Woxvold *et al.* 2009, Alström *et al.* 2010). Only one new species, Mekong Wagtail *Motacilla samveasnae*, was named from Cambodian specimens, but it also occurs in Lao PDR, Thailand and Vietnam in 'channel mosaic' habitat on the Mekong and its major tributaries (Duckworth *et al.* 2001, Le Trong Trai & Craik 2008). Here we describe a new species of lowland tailorbird *Orthotomus*, confined to low elevation humid evergreen scrub in the floodplain of the Mekong and associated large rivers, in Cambodia.

THE NEW TAILORBIRD

During routine sampling of birds for avian influenza in 2009, four individual tailorbirds *Orthotomus* sp. were mist-netted and photographed in the hand: one on 28 and another on 29 January 2009 in a patch of scrub near a pond at Kraing Check, Kandal province (11°41′53.36″N 104°46′38.93″E) (J. Reside per F. Goes *in litt.* 2012), one on 24 February 2009 and another on 12 March 2009 near to Phnom Tamao Zoo, Takeo province (11°17′56″N 104°50′22″E), in 3–5 m high scrub near rice fields (HN, A. Yang

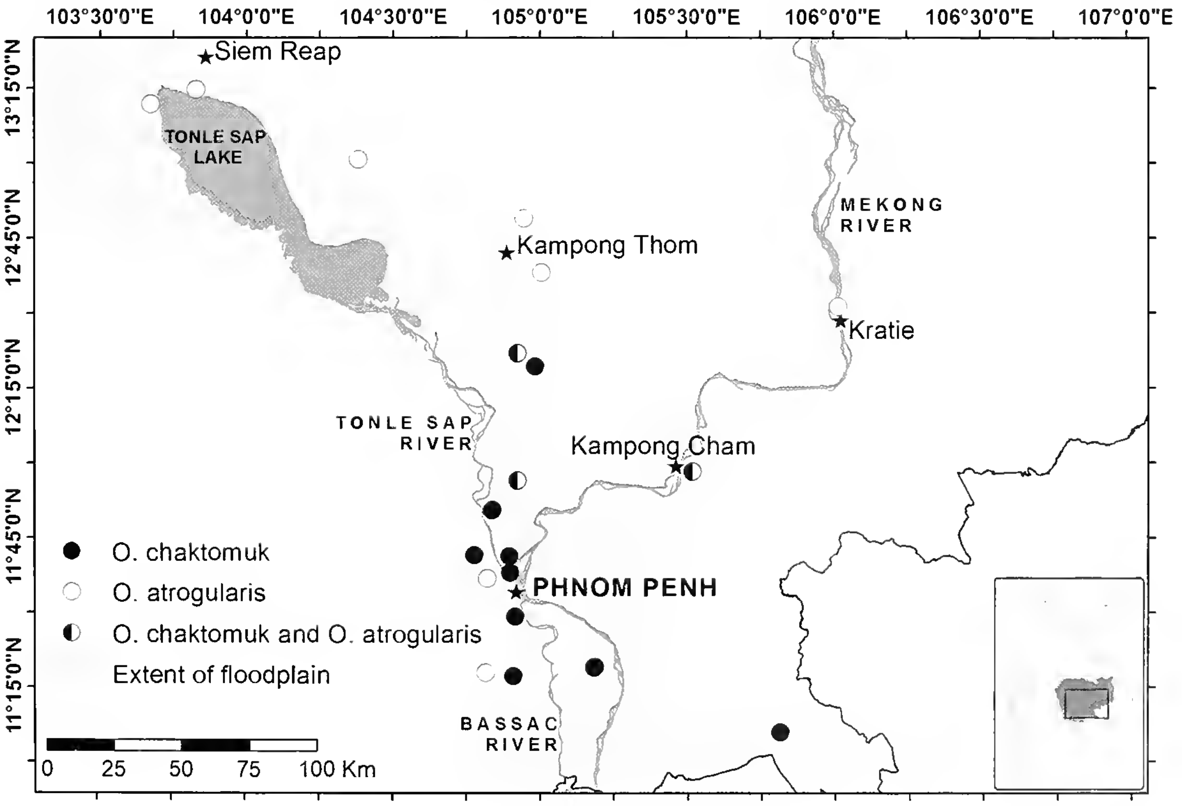

Figure 1. Distribution of records of *Orthotomus chaktomuk* and *O. atrogularis* within and close to the floodplain of the Mekong, Tonle Sap and Bassac rivers.

and P. Joyner *in litt.* 2012). Based on photographs and inferences drawn from incorrect location data (which misleadingly indicated that the birds had been caught close to the coast) these individuals were incorrectly identified as Ashy Tailorbird *O. ruficeps*; the possibility of their representing aberrant Dark-necked Tailorbird *O. atrogularis* was considered and rejected based on general plumage similarity to *O. ruficeps* (F. Goes verbally 2012).

On 29 January 2012, HN found a similar bird at Prek Ksach, in a partially flooded construction site c.15 km from Phnom Penh (11°41′37.14″N 104°53′43.79″E) and, owing to similarity to the 2009 birds, assigned it to *O. ruficeps*. In early June 2012, photographs by AJIJ of an *Orthotomus* sp. from this site raised the interest of SPM. Subsequent field observations by SPM, AJIJ and T. D. Evans and discussion with J. W. Duckworth, P. D. Round, CMP and C. Robson indicated to SPM that these birds might not be *O. ruficeps*, but could perhaps represent an undescribed taxon. On 23 June 2012, SPM, HN and AJIJ searched for additional individuals at Prek Ksach and located five single males and two pairs. Between 23 June 2012 and 20 April 2013, intensive searches revealed at least 100 individuals at nine additional locations (Figure 1, Table SOM 1 [supplementary online material—see page 14]). Seven morphologically typical *O. atrogularis* comprising six males and one female were seen at five floodplain locations at or within 10 km of locations where birds of the new taxon were found (Figure 1, Table SOM 1).

From photographs SPM re-identified all of the individuals mist-netted in 2009 as conforming to the new taxon, thus temporarily removing *O. ruficeps* from the list of birds recorded in Cambodia. Typical *O. ruficeps* has since been recorded in mangrove forest in coastal Cambodia close to the border with Vietnam (Mahood & Martin 2013).

In August 2012 two adult males, one immature male and two immature females (aged by plumage, sexed internally) were collected for formal description (below). SPM was later able to compare these specimens directly with the *Orthotomus* material held at the Natural History Museum, Tring, UK (NHMUK) including a syntype (NHMUK 1886.10.1.1830) of *O. atrogularis nitidus* (the subspecies in Cambodia) and the holotype of Olive-backed Tailorbird *O. sepium* (NHMUK1880.1.1.4473), and also examined specimens at Naturalis Biodiversity Centre, Leiden, Netherlands (RMNH) including the holotype of *O. ruficeps cineraceus* (RMNH 137559). (The disjunct population of *O. ruficeps* in coastal southern Vietnam and Cambodia has not been assigned to a subspecies; however, *O. r. cineraceus* is the subspecies recorded in mainland Asia: Madge 2006). All other *Orthotomus* taxa differed so extensively from the new form that detailed comparison would be superfluous. A detailed list of all specimens examined is provided in Table SOM 2.

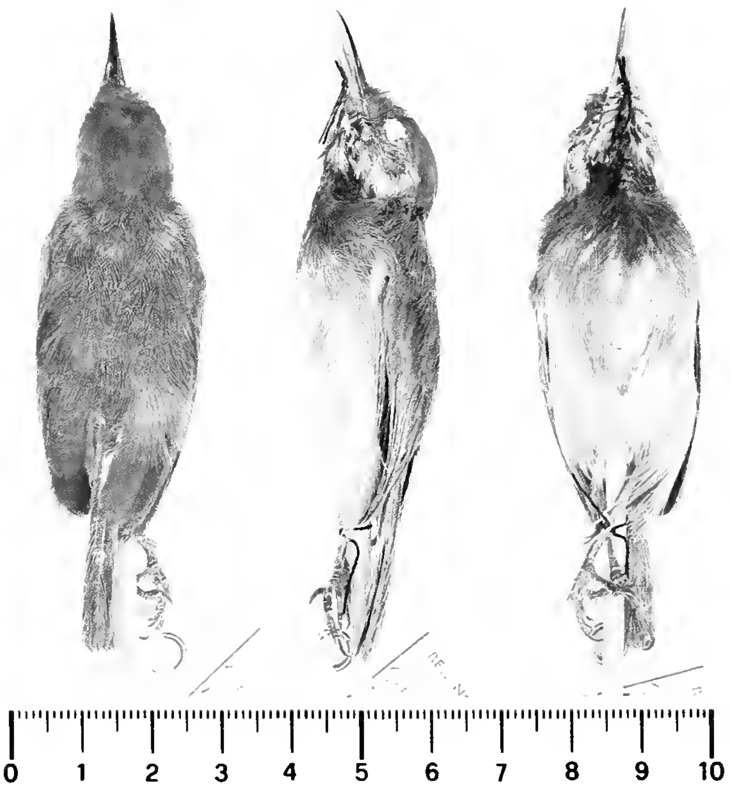

Plate 1. Dorsal, ventral and lateral views of the holotype of *O. chaktomuk*.

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The new taxon shows significant morphological differences from its close relatives and is sympatric with two lowland tailorbird species, *O. atrogularis* and Common Tailorbird *O. sutorius*, without signs of intergradation. We therefore consider that it represents a new species, which we name:

Orthotomus chaktomuk, sp. nov.
Cambodian Tailorbird

http://zoobank.org/urn:lsid:zoobank.org:act:23E9A09C-AD9C-4346-A594-F187DAFB6013

Holotype and paratypes

Study skins deposited in NHMUK (Table 1, Plate 1, Plate 2a–c) were collected by JCE and SPM at Bateay District, Kompong Cham

Table 1. Mensural and other relevant data of holotype and paratypes (in mm, except mass in g).

	Sex	Age	Culmen	Tarsus	Wing	Tail	Mass	Testes length	State of wing moult	Collection date
Holotype NHMUK reg. no. 2012.9.1 LSUMNS tissue accession no. B77286	M	ad	13	19	47	42	8	4.5, 2	P1–5 (R), P2–6 (L), tertials, greater and median coverts	8 August 2012
Paratype NHMUK reg. no. 2012.9.2 LSUMNS tissue accession no. B77287	M	ad	14	19.5	46	41	7	5, 3.5	P1–6 (R), P1–6 (L), tertials, greater and median coverts	9 August 2012
Paratype NHMUK reg. no. 2012.9.3 LSUMNS tissue accession no. B77288	M	1yr	14.5	19	45	36	8	4, 0.5	P1–6 (R), P1–6 (L), tertials, greater and median coverts	9 August 2012
Paratype NHMUK reg. no. 2012.9.4 LSUMNS tissue accession no. B77289	F	1yr	13	18	41	35.5	6.5	n/a	P2–3 (R), P2–3 (L), tertials and median coverts	9 August 2012
Paratype NHMUK reg. no. 2012.9.5 LSUMNS tissue accession no. B77290	F	1yr	12	17	42	35.5	6	n/a	P1–3 (R), P1–3 (L), tertials, greater and median coverts	8 August 2012

M, Male; F, Female; ad, adult; 1yr, first calendar year. State of wing moult lists feather tracts recently replaced; P, primaries; R, right wing; L, left wing.

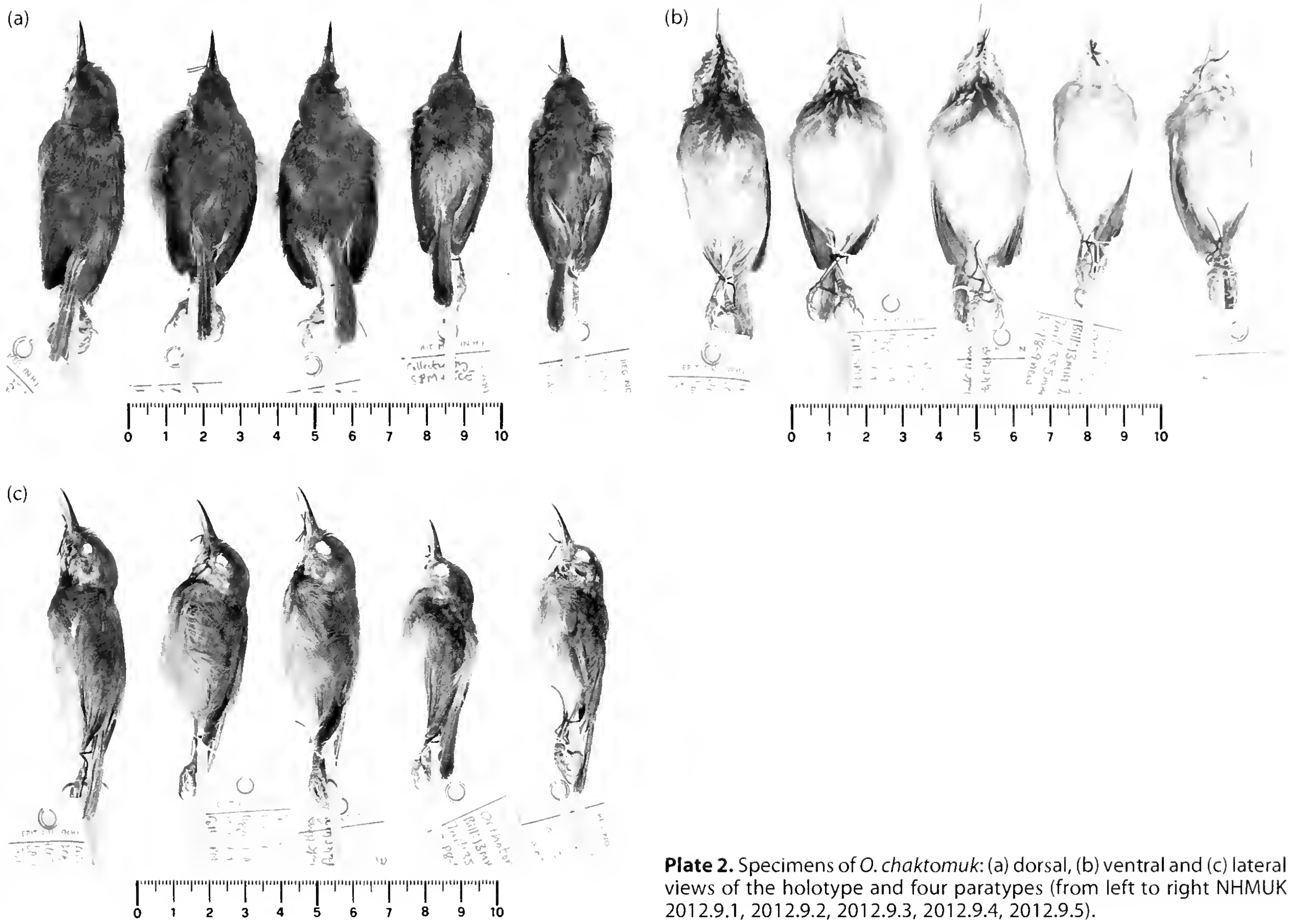

Plate 2. Specimens of *O. chaktomuk*: (a) dorsal, (b) ventral and (c) lateral views of the holotype and four paratypes (from left to right NHMUK 2012.9.1, 2012.9.2, 2012.9.3, 2012.9.4, 2012.9.5).

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province, Cambodia (11°56′53.94″N 104°56′50.94″E), c.43 km north of Phnom Penh at c.15 m elevation on 8 and 9 August 2012, and prepared by JCE. Tissue samples from the same individuals were deposited in Louisiana State University Museum of Natural Science, Baton Rouge, Louisiana, USA (Table 1). Holotype (NHMUK 2012.9.1): adult male; in active wing moult; one large testis (left testis 4.5 mm length, right testis 2 mm length). Paratypes aged by plumage: one adult male (NHMUK 2012.9.2); one immature male (NHMUK 2012.9.3) with unmoulted rectrices olive-green fringed; one immature female (NHMUK 2012.9.4) with some retained greater coverts fringed olive-green indicating immaturity, all other rectrices as adult; and one immature female (NHMUK 2012.9.5) with unmoulted rectrices as immature male.

Diagnosis of species

Head: in male entirely rich cinnamon-rufous crown and contrasting white cheeks, very similar to *O. atrogularis*, differing from *O. ruficeps* and *O. sepium* in cheek colour (Table 2, Plate 3a–c). Rufous of crown less extensive in female. ***Upperparts and wings***: mid-grey in adult, superficially similar to those of *O. sepium* but lacking olive tones, strikingly different from *O. atrogularis* which is yellowish-green (Table 2, Plate 3a, c); tail with dark grey subterminal band and whitish tips when fresh. ***Underparts***: pale

Table 2. Qualitative summary of plumage of *Orthotomus chaktomuk* and closely related species (all adult male).

Species	Crown	Cheeks	Malar stripe	Mantle and rump	Wing	Chin	Throat	Breast	Belly	Vent	Thighs	Tail
O. chaktomuk	Rich cinnamon-rufous	Whitish	White, black speckled	Mid-grey	Mid-grey	Dark-grey with white speckling	Dark-grey with white speckling	Mid-grey with white speckling	Light-grey, darker on flanks	Greyish-white	Whitish-cinnamon	Mid-grey with blackish sub-terminal band and whitish tips
O. a. nitidus	Dull brick-red	Whitish	White, black speckled	Bright yellow-olive	Bright yellow-olive	Black with white speckling	Black with white speckling	Whitish, black streaking on upper-breast	White with greenish-yellow flanks	Bright sulphur yellow	Bright yellowish-orange	Bright yellowish-green
O. r. cineraceus	Bright orange-rufous	Orange-rufous	Orange-rufous	Dark brownish-grey	Dull olive-brown	Bright orange	Mid-grey	Pale-grey	Whitish-grey	White	Bright orange-rufous	Dull olive-brown, whitish terminal tips
O. s. sepium	Fore-crown rufous, central mid- and hind- crown olive-rufous	Cinnamon-rufous	Cinnamon-rufous	Brownish-olive	Dull brown with dull olive fringing	Pale orange-rufous	Dark olive-grey	Greyish-olive	Pale greyish-olive	Whitish-grey	Pale cinnamon-rufous	Pale olive-brown with whitish terminal tips

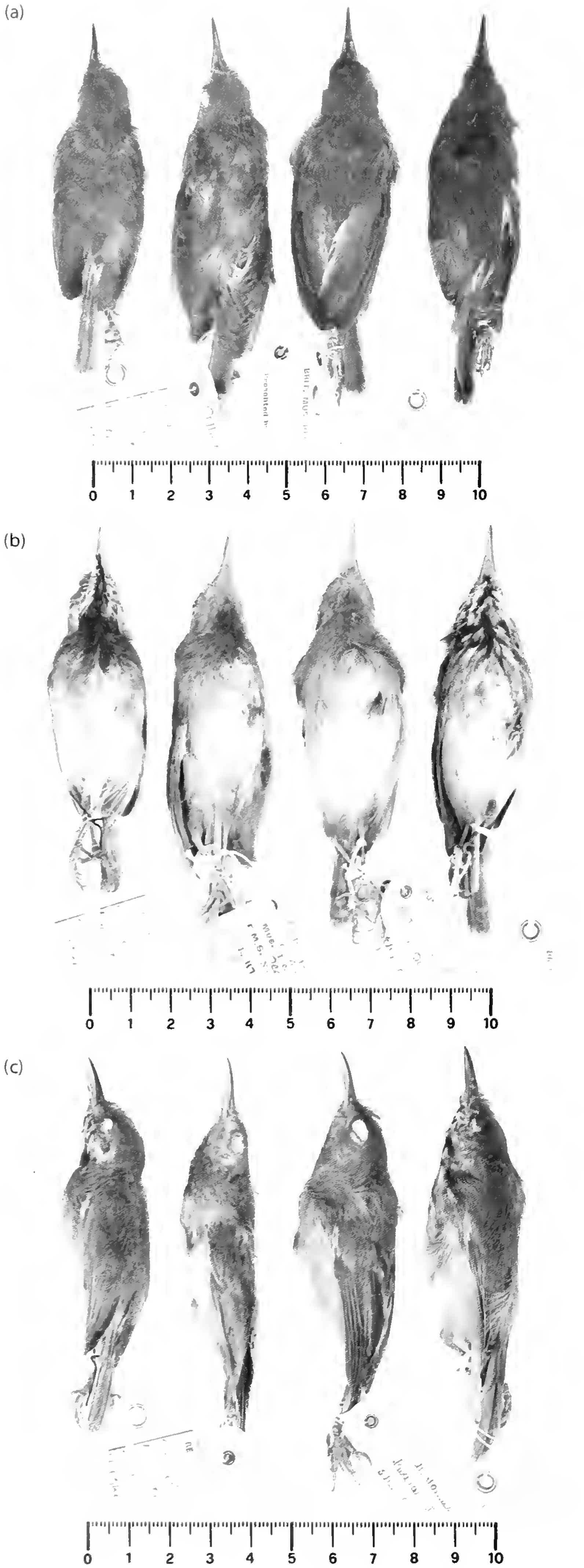

Plate 3. Specimens of the halotype of *Orthotomus chaktomuk* and closely related species (all males): (a) dorsal, (b) ventral and (c) lateral views (from left to right of *O. chaktomuk, O. sepium sepium, O. ruficeps cineraceus* and *O. atrogularis nitidus*).

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grey ground colour with profuse blackish throat-streaking in males (largely absent in females) with white drop-shaped marks, extensive mid-grey on flanks, and white vent; underparts of both sexes superficially similar to those of respective sexes of *O. atrogularis* owing to throat-streaking, but greyer on flanks and vent white, *O. ruficeps* and *O. sepium* lacking throat-streaking in both sexes (Table 2, Plate 3b, c); further distinguished from other members of the genus by whitish-cinnamon thighs. ***Vocalisations***: loud, lengthy, complex and highly varied. Very similar to *O. atrogularis*. Compared to *O. atrogularis*, phrases are given at a quicker pace and the gaps between phrases are shorter. Subjectively, these characteristics mean that the vocalisations of *O. chaktomuk* sound faster and more complicated than those of *O. atrogularis*.

Sexing and ageing

Based on field observations (Plate 4a–k, Media Files SOM 1–3) and specimens (Plate 2a–c), female *O. chaktomuk* can be distinguished from males by paler cinnamon-rufous on crown, which is restricted to forecrown and sides of mid-crown (in lateral view this appears as a short cinnamon-rufous supercilium), paler grey upperparts and wings and whitish underparts with usually faint dark streaking. The latter is usually evident only at the edges of the throat/upper breast, although some (possibly older birds) show stronger and more extensive streaking on throat and breast. Even in these extreme individuals, the degree of female streaking does not approach that in males (Plate 4a–g). All three immature paratypes show shorter tails than adults (Table 1). Immature birds possess bright yellowish-olive fringing to the wing-feathers (Plate 4h), which are moulted during August and replaced with grey adult-type feathers (Plate 4i–j). Immatures are browner (slightly olive) above and paler below, with reduced streaking (Plate 4h–j). Wing-feathers of subadults appear as in adults, except sometimes they retain yellowish-olive-fringed greater coverts (Plate 4k). Overall, subadults resemble adults, but are paler and less heavily marked below. In adults, there is individual variation in colour tone of grey feathering above and below, and intensity of throat-streaking (e.g. Media Files SOM 1–3). It is unknown if this is age-related.

Description of species

The detailed description below was completed in the NHMUK based primarily on the prepared specimens (Plates 1–2), supplemented by information from individuals observed and photographed in the field (Plate 4). It refers to the holotype unless otherwise stated. Although moult of body feathers was almost complete when specimens were collected, all adult specimens retained a few head, throat or breast feathers in pin. The holotype and paratypes were in wing moult. Moult of wing feathers is complete by late August and followed immediately by moult and replacement of tail feathers, which were very worn in all specimens. Subjective colour assessments of plumage are, where possible, followed by a formal colour classification taken from Smithe (1975).

Head and face

Crown from forehead to nape, lores, and feathers on orbital ring and just behind eye rich cinnamon-rufous (136 Raw Sienna) (slightly richer-coloured in the adult male paratype); hindcrown slightly darker and more brownish (23 Raw Umber). Crown feathers in moult with newer feathers slightly richer rufous. On the immature female paratypes the crown is less richly coloured than that of the holotype (240 Kingfisher Rufous) and the cinnamon-rufous lores and feathering on the orbital ring and immediately behind the eye are replaced by rufous-buff (118 Warm Buff). The rufous crown feathering extends from the bill only as far back as the anterior of the mid-crown where dark-grey feathers predominate, imparting an overall greyish-brown colour (129 Dark Brownish Olive) to the hindcrown.

PHOTOGRAPHS BY J. EATON (a,b,f), J. C. EAMES (c,d,j,k), A. J. I. JOHN (e,g,h,i)

Plate 4. *Orthotomus chaktomuk* (a–b) adult males in fresh plumage, 21 November 2012; (c–d) adult male in active moult (holotype), 8 August 2012 (NHMUK 2012.9.1); (e) adult male in worn plumage, 29 July 2012; (f) adult female in fresh plumage, 21 November 2012; (g) adult female in worn plumage, 29 July 2012; (h) immature male pre-moult, 16 July 2012; (i) immature male in active moult, 29 July 2012; (j) immature female in active moult, 8 August 2012 (NHMUK 2012.9.5); (k) sub-adult female in active moult, 9 August 2012 (NHMUK 2012.9.4;).

Five blackish rictal bristles per side, anterior two c.3 mm, twice the length of posterior three. Ear-coverts, cheeks and moustachial stripe almost white contrasting strongly with crown and underparts; however, feathers have buff (124 Buff) tips imparting an off-white wash. Feathers of submoustachial stripe and malar stripe white with very dark grey (82 Blackish Neutral Gray) bases and sometimes tips and fringes; white predominates, giving an impression of white speckling on a blackish base and contrasting strongly with the whitish cheeks. The malar stripe on the immature paratypes is quite different to that of the adult male specimens. It is made up of white feathers with pale grey central portions (85 Light Neutral Gray) and therefore contrasts little with the cheeks.

Upperparts

Boundary between hindcrown and upper neck abrupt. Upper neck, mantle and rump concolorous mid-grey (84 Medium Neutral Gray), slightly blue-toned approaching 78 Plumbeous (all feathers fresh and body moult apparently completed). Feathers on mantle and particularly rump relatively long and filamentous.

Wings

Wings of all prepared specimens in active moult (Table 1). On all specimens, fresh adult feathers are slightly darker grey (83 Dark Neutral Gray) than mantle, tinged very slightly brownish with mid-grey (84 Medium Neutral Gray) fringing (slightly broader on outer webs). Fresh primaries with off-white inner webs; worn adult rectrices buffy-brown (239 Ground Cinnamon) lacking fringing or pale webs. Underside of remiges dull silver-grey (84 Medium Neutral Gray). Underwing-coverts paler grey (85 Light Neutral Gray). Alula and axillaries contrasting white. Unmoulted rectrices of the immature male paratype and immature female paratypes differ strikingly from those of adult male specimens in being fringed bright olive-green (50 Yellowish Olive-Green).

Tail

Slightly rounded, outermost pair of rectrices 7 mm shorter than central pair. Tail of holotype very worn, buffy-brown (239 Ground Cinnamon), dorsal side slightly darker than ventral but heavily worn. Whitish-buff terminal tips just visible on all but central rectrices. Tail of immature female paratype (NHMUK 2012.9.4) less worn than that of the holotype (and other paratypes) and is dark greyish-brown (21 Fuscous) with broader whitish tips than those shown by other specimens. Field observations indicate that fresh tail feathers are mid-grey (similar in colouration to fresh wing feathers and therefore probably 83 Dark Neutral Gray or 84 Medium Neutral Gray) with a blackish-grey subterminal band (c.1 cm wide) and whitish tips.

Underparts

The holotype shows white chin feathers with very dark grey (82 Blackish Neutral Gray) bases, tips and fringes, therefore darker overall than feathers on malar stripe, the latter overhanging those on throat. In the holotype, feathers of throat in an advanced stage of moult, some feathers in pin visible. Throat similar in colouration to chin although with much less white; feathers almost entirely solid dark grey (82 Blackish Neutral Gray) gradually becoming darker towards the breast (83 Dark Neutral Gray) with some white tips throughout. On the breast some dark grey feathers (83 Dark Neutral Gray) possess contrasting white rachis and base of barbs on distal two-thirds of feather, creating a pattern of whitish drops on a mid-grey background. On the edges of the breast, solid mid-grey (84 Medium Neutral Gray) feathers predominate. On the adult male paratype (NHMUK 2012.9.2), the whitish drop-shaped marks on the breast are better developed than on the holotype and extend onto the throat, perhaps because the darker fringes are more worn. Field observations indicate that there is variation in the extent and intensity of dark throat-streaking in males (Media files SOM 1–2). The boundary between breast and belly is gradual; feathers tend towards lighter grey on belly (86 Pale Neutral Grey) and flanks (85 Light Neutral Gray). Flank feathers are relatively long. Vent greyish-white (paler than 86 Pale Neutral Gray). Thighs whitish-cinnamon (6 Salmon).

The underparts of the immature male paratype (NHMUK 2012.9.3) differ from those of the adult male holotype in being paler with reduced dark grey on the throat and upper breast. There is an almost complete lack of dark tones on the throat, and the very dark grey (82 Blackish Neutral Gray) area on the throat is much smaller and barely extends onto the breast. On the throat and breast, feathers with white shafts and distal portions are more abundant than on the holotype, giving the throat a more speckled appearance. On the breast, solid white and pale grey feathers predominate such that the overall colour is whitish-grey (86 Pale Neutral Gray) rapidly grading to off-white on the belly. Flank feathers of the immature male are slightly whiter than those of the holotype. The underparts of the immature female paratypes are even paler than those of the immature male and almost completely lack dark tones. In those two specimens the chin and throat are white. Although there is a small area of mid-grey (84 Medium Neutral Gray) on the sides of the upper breast and the flank feathers are pale grey (86 Pale Neutral Gray or 85 Light Neutral Gray), the underparts are otherwise off-white.

Bare parts

Upper mandible dark horn, lower mandible pink horn, paler and pinker at base (more extensively pink on adult male paratype). Bill slender. Culmen decurved close to tip, not strongly carinated, tip very slightly hooked. Gonys convex. Tarsus and toes pinkish (slightly darker in adult male paratype, paler in immature male paratype); soles of the feet pale pink. Claws pale brownish pink, becoming paler towards tips. On female paratypes tarsi, feet, soles and lower mandibles are paler than those of the holotype. Iris orange-brown. Inside of mouth pale pink.

Description of vocalisations

For clarity we use the following terminology to describe vocalisations: note – a single song element; strophe – a continuous flow of notes, separated from other strophes by silent pauses; phrase – one or more strophes given in quick succession; and song – one or more phrases given in quick succession; strophe pace – number of notes per strophe/strophe length; phrase pace (for phrases with more than one strophe) – phrase duration/strophes per phrase. Note that recordings varied in length and quality, so only those with good quality strophes were analysed.

Male *O. chaktomuk* songs are lengthy, often lasting more than one minute (Figure S1o–s, S1u, Media Files SOM 1–6). They consist of multiple phrases repeated at intervals of 0.42–4.30 seconds, typically much shorter than the maximum interval (mean: 1.7 seconds). Phrases are made up of 2–5 strophes, which are given at 0.12–0.95 second intervals. Males occasionally switch to a different strophe type mid-way through a song, although not within the same phrase. Strophes are also sometimes given singly. Strophes are trilled, consist of 3–18 notes and typically last 0.17–0.49 seconds (Table 3). Twelve distinct male strophe types are known, ranging from up, down or 'overslurred' (the latter referring to sequences of notes that rise and then fall) trills (often with a louder initial or terminal note) to a mix of trilled notes and upslurs, downslurs or 'overslurs' (Table 3, Figure S1a–l, Media Files SOM 1–6). Within strophe type, number of notes varies slightly (Table 4).

Female *O. chaktomuk* vocalisations are typically emitted whilst the male is vocalising, but are sometimes given between male vocalisations (Figure S1o–s, S1u, Media File S1–6). Females give a stereotyped trill at a higher frequency than male vocalisations

Table 3. Transliterations and univariate summary statistics of measurements of strophe characteristics of *Orthotomus chaktomuk*.

Figure no.	No. notes	Length (s)	Notes per second	Max freq. (Hz)	Min freq. (Hz)	Bandwidth (Hz)	Transliteration
Male							
S1a	5–6 (5.5, 0.7, 2)	0.35–0.42 (0.39, 0.05, 2)	0.35–0.42 (0.07, 0, 2)	4,616–5,026 (4,821, 290, 2)	2,291–2,394 (2,343, 73, 2)	2,325–2,632 (2,479, 217, 2)	*pi'pi'PI'PIH*
S1b	9–12 (10.6, 1.0, 25)	0.30–0.41 (0.36, 0.03, 25)	0.03–0.04 (0.03, 0, 25)	3,780–4,657 (4,248, 293, 25)	1,485–1,957 (1,766, 136, 25)	1,991–3,037 (2,481, 334, 25)	*chu'u'u'u'U'U'URH*
S1c	7–8 (7.9, 0.2, 18)	0.31–0.38 (0.37, 0.02, 18)	0.04–0.05 (0.05, 0, 18)	3,864–4,308 (4,101, 143, 18)	1,402–1,778 (1,656, 106, 18)	2,154–2,906 (2,444, 201, 18)	*pu'ru'ru'RU'RU'RU'RU*
S1d	12–14 (13.3, 0.8, 15)	0.38–0.47 (0.43, 0.03, 15)	0.03–0.03 (0.03, 0, 15)	3,658–4,206 (3,946, 156, 15)	1,504–2,667 (1,901, 316, 15)	1,368–2,668 (2,045, 294, 15)	*TR'R'R'R'R'R'R'R'R'R'R*
S1e	10–18 (14.3, 2.7, 6)	0.28–0.40 (0.32, 0.04, 6)	0.02–0.03 (0.02, 0, 6)	4,306–4,545 (4,393, 102, 6)	1,547–1,886 (1,700, 117, 6)	2,602–2,998 (2,694, 154, 6)	*EEEEE\EEU*
S1f	9–12 (10.6, 0.9, 8)	0.27–0.35 (0.31, 0.03, 8)	0.03–0.03 (0.03, 0, 8)	4,836–5,609 (5,271, 112, 8)	1,499–1,838 (1,705, 112, 8)	3,192–4,110 (3,566, 297, 8)	*Pleee/RRIEt*
S1g	10–16	0.33–0.49 (12.1, 1.7, 54)	0.03–0.04 (0.39, 0.03, 54)	2,839–4,286 (0.03, 0, 54)	1,282–1,890 (3,779, 394, 54)	1,183–3,004 (1,608, 119, 54)	*PTeur'R'R'R'R'R'R'* (2,171, 395, 54)
S1h	10–13 (11.1, 0.9, 7)	0.23–0.29 (0.26, 0.02, 7)	0.02–0.02 (0.02, 0, 7)	4,387–4,758 (4,474, 133, 7)	1,653–2,126 (1,866, 196, 7)	2,261–2,902 (2,608, 258, 7)	*CHEEE\UP*
S1i	13–15 (14.0, 0.9, 8)	0.29–0.36 (0.32, 0.03, 8)	0.02–0.02 (0.02, 0, 8)	5,669–6,311 (6,011, 201, 8)	1,451–1,991 (1,687, 178, 8)	3,880–4,725 (4,324, 337, 8)	*ree/Y\uET!*
S1j	3–4 (3.5, 0.5, 33)	0.17–0.24 (0.21, 0.02, 33)	0.05–0.06 (0.06, 0, 33)	3,830–4,821 (4,455, 239, 33)	1,128–2,120 (1,610, 259, 33)	2,394–3,522 (2,844, 252, 33)	*P'P'Biu*
S1k	3–3 (3.0, 0, 5)	0.22–0.23 (0.23, 0.01, 5)	0.07–0.08 (0.08, 0, 5)	4,616–5,026 (4,828, 153, 5)	1,881–2,017 (1,963, 52, 5)	2,633–3,043 (2,865, 152, 5)	*pi'pi'PUi*
S1l	3–4 (3.1, 0.3, 18)	0.19–0.27 (0.20, 0.02, 18)	0.06–0.07 (0.07, 0, 18)	3,680–4,240 (4,097, 135, 18)	1,573–1,949 (1,742, 115, 18)	1,731–2,633 (2,355, 196, 18)	*BI'BI'BBit*
Female							
S1m	5–16	0.24–0.84 (9.4, 3.4, 25)	0.05–0.05 (0.48, 0.18, 25)	4,725–5,805 (0.05, 0, 25)	2,086–3,544 (5,038, 260, 25)	1,485–3,213 (2,673, 398, 25)	*TCRI'I'I'I'I'I'I'I'I'I* (2,365, 421, 25)
S1n	1–1 (1, 0, 17)	0.07–0.23 (0.15, 0.07 17)	0.07–0.23 (0.15, 0.07 17)	4,484–6,243 (5,176, 409, 17)	2,460–4,252 (3,189, 376, 17)	1,553–2,354 (1,987, 280, 17)	*tew*

Analyses based on 12 recordings of male vocalisations from six pairs of *Orthotomus choktomuk* in Kandal province, Cambodia, obtained as follows: (1) four pairs from c.40 km south-east of Phnom Penh (at or very close to 11°19'45.77"N 105°11'48.41"E); (2) one pair from c.15 km north of Phnom Penh (11°41'37.14"N 104°53'43.79"E); and (3) one pair from c.30 km north of Phnom Penh (11°50'18.24"N 104°49'26.55"E). Measurements taken in Raven Pro 1.4 (Raven 2012). Values given are: minimum–maximum (mean; sd; sample size). In vocal transcriptions, notation follows Rasmussen & Anderton (2005).

(typically 5–16 notes lasting 0.24–0.84 seconds; Table 3, Figure S1m, Media File S1–6). Females, and exceptionally males, sometimes produce a nasal squeak consisting of a single note with harmonics (Figure S1n, Media File S6). This vocalisation is usually given singly (Figure S1p), but occasionally more than one is repeated in quick succession; when many squeaks are given in sequence the first is usually longer than others (Figure S1t, Media File S6).

Etymology

The specific epithet '*chaktomuk*' is a Khmer word meaning 'four faces'. It is used in reference to the low-lying area at which the Tonle Sap, Bassac and Mekong rivers come together to form an 'X' centred on Phnom Penh, itself historically known as 'Krong Chaktomuk' (literally 'City of Four Faces'). Based on current knowledge, the global distribution of the new species is restricted to scrub within the dynamic floodplain created by the confluence of these waters. We use *chaktomuk* as a noun in apposition to the genus name, and it is thus invariable.

Nomenclatural acts

The electronic edition of this article conforms to the requirements of the amended International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature 2012), and hence the new name contained herein is available under that Code from the electronic edition of this article. This published work and the nomenclatural act it contains have been registered in ZooBank, the online registration system for the International Commission of Zoological Nomenclature. The ZooBank Life Science Identifiers (LSIDs) can be resolved and the associated information viewed through any standard web browser by appending the LSID to the prefix "http://zoobank.org/". The LSID for this publication is: urn:lsid:zoobank.org:pub:F1778491-B6EE-4225-95B2-2843B32CBA08. The electronic edition of this work was published in a journal with an ISSN, and has been archived and is available from the digital repository *BioTaxa* (http://biotaxa.org).

ECOLOGY AND BEHAVIOUR

Habitat

All observations of *O. chaktomuk* were made on level ground in very dense humid evergreen scrub (multi-stemmed woody plants, 2–6 m tall), sometimes admixed with long grasses or trees (Plate 5), at elevations of 3–25 m above sea level. Trees occur exceptionally; where present they are typically scarce, the scrub forming a dense layer with occasional tree canopies emerging from

S. MAHOOD

Plate 5. Habitat at the type locality of *Orthotomus chaktomuk*.

it. *Orthotomus chaktomuk* has not been seen in forest (defined as a habitat where trees predominate) and is therefore assumed to be absent from it. At all locations where birds have been found, the scrub is located within a floodplain and experiences seasonal or permanent (artificial) flooding. The presence of seasonally flooded scrub in any location is probably typically transitory, since in the absence of disturbance by people, large ungulates or hydrological processes it would presumably revert to seasonally flooded forest.

Orthotomus atrogularis is sometimes found in seasonally flooded scrub occupied by *O. chaktomuk* (Figure 1, Table SOM 1). Where the two species are syntopic, *O. atrogularis* is much the rarer. Typically *O. atrogularis* is found in the edge and canopy of taller forest habitats, showing a preference for disturbed and secondary forest because these offer an abundance of vines (Madge 2006, Wells 2007). In some parts of the Tonle Sap floodplain where *O. chaktomuk* is absent, *O. atrogularis* is common in seasonally flooded forest and scrub, presumably because this habitat also offers an abundance of edge surfaces. At the other end of the habitat continuum, *O. sutorius* replaces *O. chaktomuk* in open scrub and gardens, although at some locations the two species are syntopic, even vocalising from the same individual plants (SPM pers. obs.). *Orthotomus chaktomuk* possibly occupies a habitat intermediate between those of *O. atrogularis* and *O. sutorius*. However, as in other geographic areas where more than one lowland tailorbird species is present, habitat niches are difficult to define and distinguish. Ecological interactions and habitat associations of *O. chaktomuk* and other lowland tailorbirds are worthy of further research.

Birds sharing the habitat of *O. chaktomuk* include widespread species often associated with gardens, e.g. Yellow-vented Bulbul *Pycnonotus goiavier*, Pied Fantail *Rhipidura javanica*, Oriental Magpie Robin *Copsychus saularis*, sometimes *O. sutorius*, and species usually associated with dense lowland humid evergreen scrub, including Striped Tit Babbler *Macronous gularis*, Yellow-bellied Prinia *Prinia flaviventris*, Plain Prinia *Prinia inornata*, Olive-backed Sunbird *Cinnyris jugularis* and *O. atrogularis*. From October to April, Palearctic migrants (e.g. Dusky Warbler *Phylloscopus fuscatus* and Siberian Rubythroat *Luscinia calliope*) are abundant in this habitat. In locations where it occurs, *O. chaktomuk* often appears to be one of the most abundant bird species.

Behaviour

Owing to the structural characteristics of its habitat, *O. chaktomuk* is rarely seen without the aid of playback of vocalisations, and thus data on 'normal' behaviour are few. Almost all encounters have been with what appear to be adult male–female pairs, or adult male–female pairs with one subadult. Prior to moult, immature birds were seen singly, in male–female pairs of exclusively immature birds or in male–female pairs consisting of one immature and one adult bird.

Birds usually stay within dense vegetation, where they glean and sally-glean from live and dead leaves of multi-stemmed bushes and occasionally vines, from ground-level to canopy. *Orthotomus chaktomuk* has not been observed foraging in trees. When vegetation is flooded, birds typically forage below the crown of the bush, on hanging branches just above the water. One individual that was lured out of dense scrub with the aid of playback foraged on long grass-stems, gleaning leaves of a vine that was growing amongst the grass. Individuals have been observed taking the following prey (once each): a small fly Diptera, a small spider Araneae, a small caterpillar Lepidoptera and a small katydid Tettigoniidae; all were consumed immediately.

In response to playback, birds that have approached the observer have been seen to sing, usually in a duet, while perched (usually on or near the top of vegetation, including trees; Media Files SOM 1–3) and occasionally in song flight. Singing is sometimes accompanied by rapid downwards tail-wagging. Sometimes, while singing in duet, perched birds droop and shiver their wings. Immature males gave a simpler, less developed song than adults.

During March and April only males responded strongly to playback of vocalisations; females typically did not respond, or did so only briefly. Because this was in stark contrast to behaviour at other times of year it is thought to indicate that females were on the nest. Although there are no data on the timing of breeding of lowland tailorbirds in Cambodia, in Thailand *O. atrogularis* pairs with dependent young have been recorded from July to early September (Round 2008). The nest and eggs of *O. chaktomuk* remain to be described.

Distribution

The distribution of *O. chaktomuk* is incompletely known. It is apparently constrained by the distribution of seasonally flooded dense scrub within the floodplain of the Tonle Sap, Mekong and Bassac rivers in Cambodia (Figure 1). However, based on current data it is absent from part of this floodplain. Searches at various locations in apparently suitable habitat in the Tonle Sap floodplain have thus far only found the species in the south-east (see Table SOM 1 for a list of all locations in the floodplain of the Mekong, Tonle Sap and Bassac rivers where searches for *O. chaktomuk* have been conducted). In the north of the Tonle Sap floodplain (where we have searched for and not found *O. chaktomuk*), *O. atrogularis* is abundant in habitat that is superficially structurally similar to habitat in the south-east, and it is unclear how far north and west along the lakeshore the distribution of *O. chaktomuk* extends. There is no biogeographic reason why *O. chaktomuk* should be absent from parts of the Tonle Sap floodplain, and the causes of its absence are unknown; *O. atrogularis* is scarce or absent at sites where *O. chaktomuk* was recorded (Table SOM 1).

Orthotomus chaktomuk was not found in seemingly appropriate small seasonally flooded scrub patches at the northern limit of the Mekong floodplain (12°36′27.52″N 106° 01′36.06″E) in Kratie province (Table SOM 1, J. A. Eaton verbally 2012). Satellite data indicate that there is little, if any, suitable habitat for *O. chaktomuk* in the Mekong floodplain in Vietnam and it is currently unrecorded there (although no specific searches have been conducted). As might be expected, we have located only *O. atrogularis* in scrub habitats outside of the Mekong, Tonle Sap and Bassac floodplain (where these records were within 10 km of superficially suitable habitat for *O. chaktomuk* they are mapped on Figure 1). Based on current knowledge of its range, the distribution of *O. chaktomuk* covers less than c.10,000 km^2 (Figure 1); it therefore can be considered a restricted-range species (*sensu* Stattersfield *et al.* 1998).

Conservation

Orthotomus chaktomuk is restricted in distribution. Suitable habitat is patchy outside of the Tonle Sap floodplain and in the latter its distribution is poorly understood. Trends in loss, degradation and fragmentation of floodplain scrub are poorly documented and subject to considerable local variation (e.g. Packman *et al.* 2013). However, most floodplain scrub in Cambodia occupies land suitable for rice cultivation and could be further threatened by changes in ongoing burning, fuel-wood collection, cattle grazing (all of which potentially have a dual role because they also serve to slow succession) and the spread of the invasive plant *Mimosa pigra*. Ironically, *O. chaktomuk* might now be dependent on human activity to keep suitable scrubby habitat from becoming forest, since other anthropogenic impacts—eradication of wild ungulates, replacement of domestic animals by machines, water flow/level control, and changes in agricultural practices such as fallows and cyclical abandonment—have greatly curtailed processes that maintained the scrub. The species occurs in one protected area, Baray Bengal Florican Conservation Area, although at that site habitat is managed to maximise the area of grassland. It has already been lost from one site (Kraing Check) where birds were netted in 2009: visits in late 2012 found no birds and all suitable habitat had been converted to aquaculture ponds.

We believe that *O. chaktomuk* should be classified as Near Threatened on the IUCN Red List because it approaches the thresholds for Vulnerable under criteria B1a+bi,ii,iii,iv (IUCN 2001). Its Extent of Occurrence is 9,385 km^2 and thus below the threshold for Vulnerable (<20,000 km^2; criterion B1). Although most locations where it occurs are small and isolated it has been found in the Tonle Sap floodplain where there is a large area of apparently suitable habitat (although it apparently does not occupy all of it). Because of this, its habitat cannot be considered severely fragmented (subcriterion a). Nonetheless it is inferred to be undergoing a continuing decline (subcriterion b) in (i) extent of occurrence, (ii) area of occupancy, (iii) area, extent and/or quality of habitat, and (iv) number of locations or subpopulations. Its Area of Occupancy has not yet been evaluated owing to uncertainty regarding both the distribution of suitable habitat and its distribution within apparently suitable habitat. Notwithstanding this assessment, if the species is found to be more widely distributed in the Tonle Sap floodplain, then it would warrant downlisting to Least Concern.

Ongoing habitat loss is likely to be exacerbated by the impacts of hydropower development on the Mekong and its tributaries. Models of the effects of hydropower dams predict changes in the duration and size of the annual flood-pulse that will lead to a reduction in the extent of seasonally flooded habitats (Arias *et al.* 2012). Dam construction will also reduce fish populations (the primary protein source in rural Cambodia), cause changes in flood regime and lead to water shortages in the floodplain (Orr *et al.* 2012). These changes will probably lead to additional loss of floodplain scrub owing to expansion of agricultural land for rice production, fish ponds and grazing land for cattle. Construction has started on one mainstream lower Mekong dam (Xayaburi, in northern Lao PDR) and numerous tributary dams and 'pre-construction' works are thought to have begun on another (Don Sahong) in the far south of Lao PDR (International Rivers 2012); nine more mainstream dams are planned (Mekong River Commission 2011).

TAXONOMIC CONSIDERATIONS

Higher-level systematics

Assignment of the new species to the genus *Orthotomus* is straightforward based on its overall structure, plumage and habits, which typify this genus. Genetic analysis provide additional support for this arrangement, as DNA sequence comparisons (detailed below) included specimens of the type species for the genus: *O. sepium* Horsfield, 1821. *Orthotomus* was previously placed in an expanded Sylviidae (Sibley & Ahlquist 1990) until that family was shown to be paraphyletic and the genus was transferred to the Cisticolidae, along with the cisticolas (*Cisticola*), prinias (*Prinia*) and a number of other genera (Alström *et al.* 2006). Within the Cisticolidae, *Orthotomus* occupies a clade with the genera *Heliolais*, *Prinia* and *Urorhipis* (Olsson *et al.* 2013). *Orthotomus* remained intact until molecular evidence led to the removal of four superficially similar species: the two African tailorbird species were transferred to the resurrected genus *Scepomycter* (Nguembock *et al.* 2007) and the Asian mountain tailorbirds, Mountain Tailorbird *Phyllergates cucullatus* and Rufous-headed Tailorbird *P. heterolaemus*, were shown to be not particularly closely related to 'lowland tailorbirds'—the most appropriate English group name for the remaining *Orthotomus* species (Alström *et al.* 2006, 2011). The *Orthotomus* comparisons by Sheldon *et al.* (2012), based on one mitochondrial and two nuclear DNA markers, suggested that *O. sutorius* is sister to the rest of the lowland tailorbirds, which comprise four relatively divergent clades: (1) Rufous-fronted Tailorbird *O. frontalis*, (2) Rufous-tailed Tailorbird *O. sericeus*, (3) *O. atrogularis*–*O. ruficeps*–*O. sepium*, and (4) the rest of the Philippine endemics.

Taxonomic implications from morphology

Lowland tailorbirds appear to be relatively conservative in the evolution of distinctive plumage. For example *O. atrogularis*, the widespread *O. sutorius* and the Philippine endemics Philippine Tailorbird *O. castaneiceps*, *O. frontalis* and Grey-backed Tailorbird *O. derbianus* share the same basic plumage pattern and colouration, but are not particularly closely related (Sheldon *et al.* 2012). Owing to this morphological congruence, various Philippine taxa were long considered part of *O. atrogularis* (Delacour & Mayr 1946). These were later split from that species and grouped under *O. castaneiceps* and *O. derbianus* (Dickinson *et al.* 1991, Kennedy *et al.* 2000). Collar (2011) considered that morphological data alone were insufficient to afford *O. casteneiceps chloronotus* species status to resolve the geographically vexing situation created by the specific recognition of *O. derbianus*. Equally, treatment of *O. frontalis* as a species (proposed by Madge 2006) was deemed untenable using morphological information alone (Collar 2011).

The plumage of *O. chaktomuk* is typical of the *O. atrogularis*–*O. ruficeps*–*O. sepium* clade. Within this grouping, all species are characterised by a rufous crown; white or rufous cheeks; grey, olive-grey or bright olive-green upperparts; and grey or whitish-grey underparts with or without heavy blackish throat-streaking (Table 2, Plate 3). Superficially, the head and underparts pattern and colouration of *O. chaktomuk* are similar to *O. atrogularis*, while colouration of the upperparts is more similar to *O. ruficeps*. However, *O. chaktomuk* shows a suite of plumage features that in combination are unique, and there are various additional subtle plumage differences between it and closely related species (Table 2, Plates 3, 4). Immatures of all species within the clade possess yellow-olive fringing on the wing-feathers; adult *O. atrogularis* exhibit the same colouration on the wings, tail and much of the upperparts. Examination of specimens suggests that this colouration is not as vivid in immature *O. ruficeps* and *O. sepium* as in *O. atrogularis* and *O. chaktomuk*.

In common with other lowland tailorbird species, those in the *O. atrogularis*–*O. ruficeps*–*O. sepium* clade show relatively minor geographic variation in morphology. All three species within the clade are polytypic. Although a detailed examination of morphological variation within these species was not completed, examples (including some type material) of multiple subspecies were examined (Table S2). Within each species, all examined specimens were superficially very similar. Morphological variation within *O. atrogularis* is most marked along the Sabah–Sarawak border area, in common with other species that share a similar distribution (e.g.

White-rumped Shama *Copsychus malabaricus*). The most morphologically divergent taxon within *O. ruficeps*, *O. r. cagayanensis* of Cagayan Sula, Philippines, which is apparently extensively brown or rufous-washed above with pale eyes (Madge 2006), was not examined. Within this context of limited geographic variation within species, any suggestion that *O. chaktomuk* should be considered a highly distinctive localised subspecies of *O. atrogularis* is untenable. Equally, there is no evidence that any lowland tailorbird species possesses regularly occurring colour morphs.

Biometrics of *O. chaktomuk* are similar to other species within the *O. atrogularis–O. ruficeps–O. sepium* clade (Table SOM 3). Using bill length/wing length as a proxy for size, there is an indication that *O. chaktomuk* is smaller than closely related species (Figure 2). This could not be confirmed statistically, because the sample size of *O. chaktomuk* is too small (Table SOM 3). In the field, *O. chaktomuk* appeared to have a shorter tail than local *O. atrogularis*. However, this could not be confirmed from the specimens collected of *O. chaktomuk*, because their tails are very worn.

The description of a new species provides an opportunity to test the quantitative criteria for species delineation proposed by Tobias *et al.* (2010). These criteria use a scoring system for morphological, vocal and ecological features to assess taxonomic rank. Even when applied only to morphological features, *O. chaktomuk* exceeds the threshold score (7) for species status when compared with *O. atrogularis*, *O. ruficeps* and *O. sepium*. It scores 8 against *O. ruficeps*: cheeks white rather than orange-rufous (3), throat and breast very dark grey with white speckling rather than unmarked pale grey (3), thighs whitish-cinnamon rather than orange-rufous (2). Its scores against *O. sepium* are similar. It scores 8 against *O. atrogularis*: upperparts mid-grey rather than bright yellowish-olive (3), vent white rather than yellow (3), thighs whitish-cinnamon rather than yellowish-orange (2).

Taxonomic implications from vocalisations

Vocal data reaffirm the close relationship between *O. chaktomuk* and *O. ruficeps*, *O. sepium* and *O. atrogularis*, in particular the last. *Orthotomus* vocalisations are difficult to define. Males and females often duet, or if three birds are present, all will vocalise simultaneously. Vocalisations of *O. chaktomuk* are typically lengthy, and those of males are extremely varied (Media File SOM 4–6). We do not think that we have documented the full vocal range of the species. In addition, comparisons with closely related species were hampered because it is doubtful that the full vocal repertoire of such species has been documented.

The vocalisations of species in the *O. chaktomuk–O. atrogularis–O. ruficeps–O. sepium* clade fall into two distinct types. Those of *O. ruficeps* and *O. sepium* are largely short, pure-tone whistles, while those of *O. chaktomuk* and *O. atrogularis* are restricted to short trills. To quantify the distinctiveness in songs of *O. chaktomuk* in relation to other species within the clade, we conducted a discriminant analysis (DA) on male vocalisations using XLStat (Addinsoft 2013). We randomly selected one song (defined as above) from each individual of *O. chaktomuk* from which we had obtained recordings (total five individuals) and randomly selected a similar number of songs from five individuals each of *O. a. nitidus* (the geographically closest subspecies of *O. atrogularis*), *O. ruficeps* and *O. sepium*. These included three recordings of *O. atrogularis* from Cambodia (including one from the floodplain of the Tonle Sap) and one recording from Vietnam made within 100 km of the border with Cambodia. (For a full list of recordings used in analyses see Table SOM 4.) Recordings were downloaded from www.xeno-canto.org and http://avocet.zoology.msu.edu/. From each recording we calculated mean values of the following variables: notes/strophe, length (in seconds) of longest note (one per strophe), strophe length (seconds), maximum and minimum fundamental frequencies (one each per strophe), number of strophes per phrase, length of interval between phrases (in seconds) and, for phrases with more than one strophe, interval between strophes and length of phrase (in seconds); we also calculated bandwidth (maximum minus minimum fundamental frequency within a given strophe), strophe pace (number of notes per strophe/strophe length) and, for phrases with more than one strophe, phrase pace (phrase length/strophes per phrase).

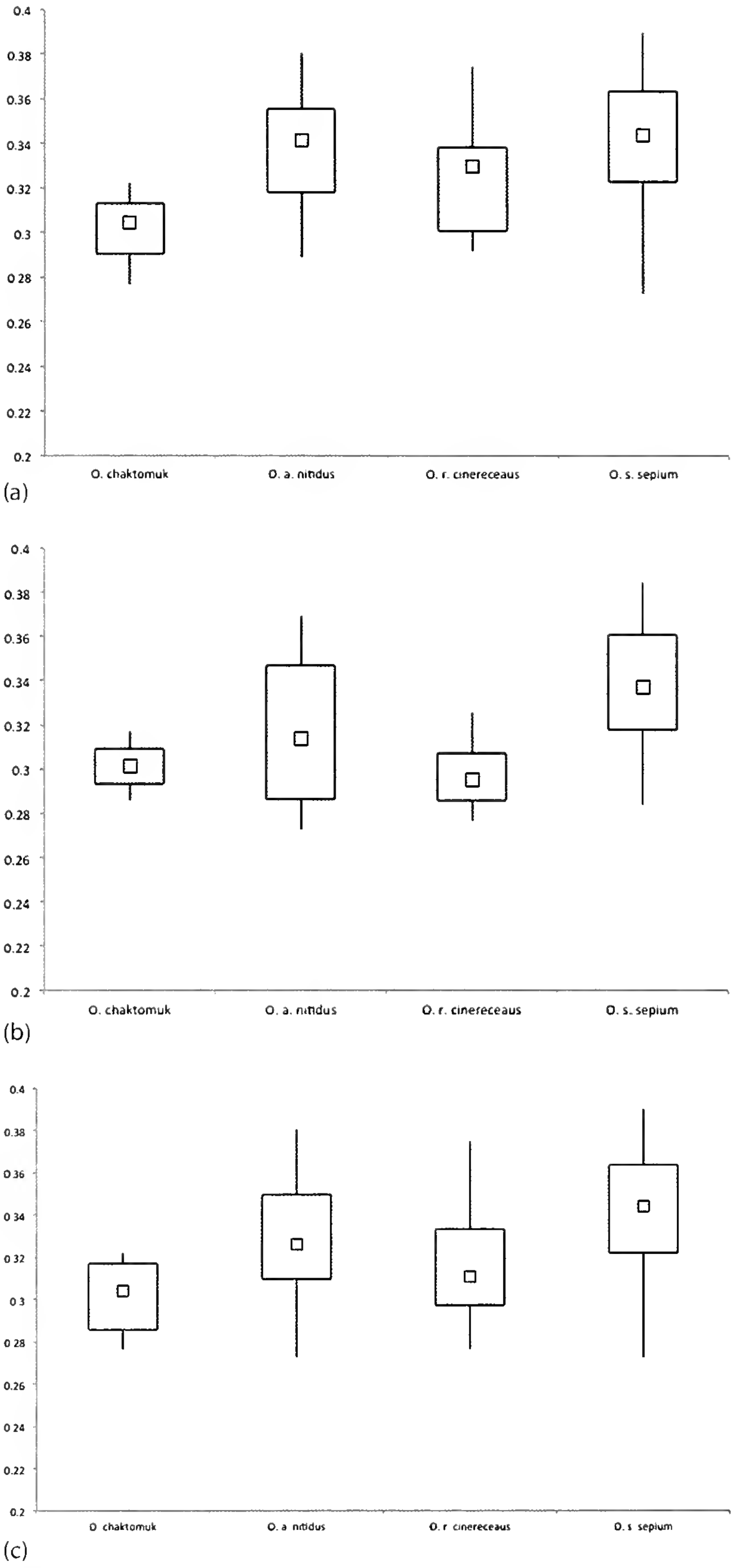

Figure 2. Box plots of bill-length (to skull) divided by wing-length of (a) males of *Orthotomus chaktomuk* (n = 3*)*, *O. atrogularis nitidus* (n = 15), *O. ruficeps cineraceus* (n = 14) and *O. sepium sepium* (n = 20); (b) females of *O. chaktomuk* (n = 2), *O. a. nitidus* (n = 10), *O. r. cineraceus* (n = 6) and *O. s. sepium* (n = 8); (c) males and females of *O. chaktomuk* (n = 5), *O. a. nitidus* (n = 25), *O. r. cineraceus* (n = 20) and *O. s. sepium* (n = 28). Small squares represent the median; box indicates 50% of samples; bars indicate maximum and minimum.

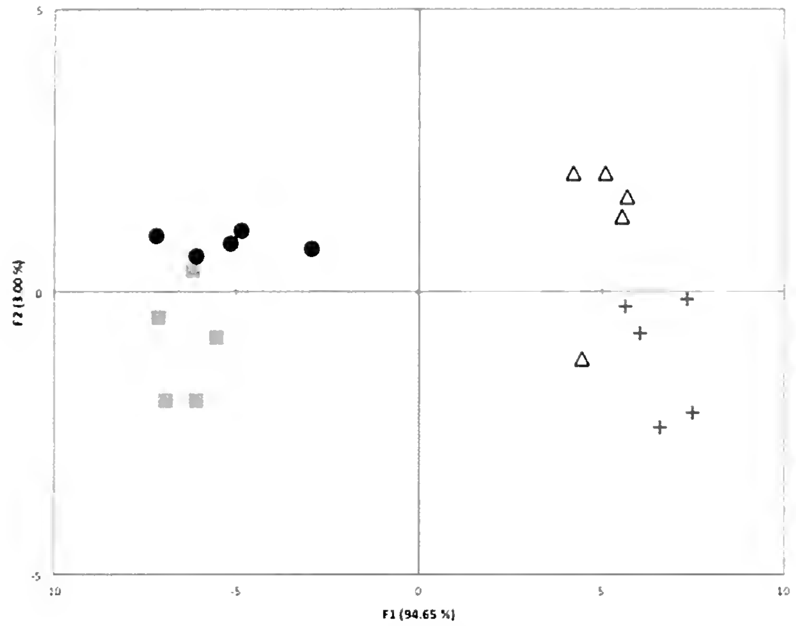

Figure 3. Multivariate vocal space of lowland tailorbirds in the *O. chaktomuk–O. atrogularis–O. ruficeps–O. sepium* clade from discriminant analyses based on twelve song traits. Scatter plot of the first two canonical functions that discriminated songs of *O. chaktomuk, O. atrogularis, O. ruficeps* and *O. sepium*. ● represent *O. chaktomuk*; ■, *O. atrogularis*; △, *O. ruficeps*; +, *O. sepium*.

Table 4. Results of discriminant analyses of songs of species in the *O. chaktomuk–O. atrogularis–O. ruficeps–O. sepium* clade, based on 12 acoustic variables, showing first three (of four) canonical functions.

	Canonical function		
Acoustic variable	**1**	**2**	**3**
Notes per strophe	-0.742	-0.196	-0.155
Strophe length (seconds)	0.221	0.265	-0.524
Strophe pace	0.721	0.331	-0.270
Maximum frequency	0.227	-0.147	-0.009
Minimum frequency	-0.021	-0.087	-0.183
Bandwidth	0.247	-0.105	0.112
Length of longest note (one per strophe)	0.873	0.187	-0.289
Strophes per phrase	-0.015	0.391	0.457
Inter-strophe interval (seconds)	-0.179	0.172	-0.006
Phrase length (seconds)	-0.103	0.507	0.156
Phrase pace	-0.131	0.405	-0.075
Inter-phrase interval (seconds)	-0.330	-0.152	-0.117
Eigenvalue	43.01	1.362	1.071
% variance explained	94.6	3.00	2.36

Most of the analysed songs of *O. chaktomuk* and *O. atrogularis* clustered separately in multivariate vocal space and could be discriminated from each other and from the songs of *O. ruficeps* and *O. sepium* (Wilks's $\lambda = 0.005$, $F = 2.222$, $P = 0.047$; Figure 3). Overall, the analysis assigned songs to the correct species with 60% accuracy. Songs of *O. chaktomuk* were classified with 60% accuracy and songs of *O. atrogularis* were classified with 40% accuracy. Songs of *O. ruficeps* and *O. sepium* were classified with 40% and 100% accuracy, respectively. The discriminant analysis was mainly influenced by the length of the longest note, strophe pace and the number of notes per strophe (Table 4).

In accordance with their acoustic similarities, *O. chaktomuk* and *O. atrogularis* respond to playback of each other's vocalisations, indicating that inter-specific territoriality is common. There is individual variation in the magnitude of response, but this is poorly understood at present. Interspecific territoriality is a common trait in avian sister species whose ranges come into contact (e.g. Orians & Willson 1964, Murray 1971, Murray 1976). At locations where *O. chaktomuk* is sympatric with *O. sutorius*, the latter sometimes also responds to broadcast of vocalisations of the former by ascending the vegetation and singing.

Taxonomic implications from ecology

The apparently restricted distribution of *O. chaktomuk* differs from those of other *Orthotomus* species on the Asian mainland, which are typically wide (Madge 2006). Lowland tailorbirds are thought to have originated in southern Asia or possibly Sundaland. They rapidly spread widely in Sundaland and the Philippines and, more recently, additional species have evolved in both island groups (Sheldon *et al.* 2012). The *O. chaktomuk–O. atrogularis–O. ruficeps–O. sepium* clade emerged relatively recently, and, in contrast to the clade containing Philippine endemics, exhibits lower species richness (four versus six species), presumably owing to the lack of opportunity for speciation in lowland populations in a continental mainland versus an oceanic island setting. Lowland passerines in mainland Asia typically have large distributions. Those with smaller distributions are largely confined to successional habitats in the floodplains of large rivers, such as Black-breasted Parrotbill *Paradoxornis flavirostris* and Marsh Babbler *Pellorneum palustre* (Rasmussen & Anderton 2005).

Tailorbird habitats are notoriously difficult to define (e.g. Mitra & Sheldon 1993), although lowland tailorbirds within the *O. chaktomuk–O. atrogularis–O. ruficeps–O. sepium* clade have slightly clearer habitat preferences. In this clade, greater specialisation is thought to have helped these younger species avoid competition with the pre-existing generalist species *O. sutorius* and *O. sericeus* (Sheldon *et al.* 2012). The habitat preferences of *O. chaktomuk* are thought to be somewhat intermediate between *O. atrogularis* and *O. sutorius*. In addition, *O. chaktomuk* is apparently confined to successional floodplain habitat. Vegetational patterns in what is now its distribution have been shaped by cyclical ice-ages and interglacials over the past two million years. During glacial maxima, the sea-level was much lower than today and southern Vietnam and Cambodia were connected by land to what is now Peninsular Malaysia by the now submerged Sunda Shelf (Sathiamurthy & Voris 2005). It is thought that there were four large river basins on the Sunda Shelf and these great river systems connected the freshwater riverine faunas of many of today's rivers (such as the Mekong) that are now restricted to Indochina, the Malay Peninsula or one of the greater Sunda Islands (Voris 2000). Floodplain habitats were therefore probably much more extensive during glacial maxima and it is possible that *O. chaktomuk* evolved on the Sunda Shelf. *Orthotomus chaktomuk* is now restricted to a much smaller area, constrained by the reduced availability of suitable habitat during an interglacial.

The known distribution of *O. chaktomuk* lies within the distribution of *O. atrogularis*. No parts of the distribution of *O. chaktomuk* are more than a few tens of kilometres from locations where *O. atrogularis* is found. The two species are locally syntopic (Figure 1, Table SOM 1); for instance, c.200 m from the type locality a pair of *O. atrogularis* was observed in the same bush as a single *O. chaktomuk* (SPM, AJIJ, HC pers. obs.; photographed). Although nearly 50 *O. chaktomuk–O. chaktomuk* male–female associations have been observed, neither mixed pairs nor birds that are phenotypically identifiable as hybrids have been detected.

Taxonomic implications from molecular analyses

Within the genus *Orthotomus*, superficial morphological and vocal similarities between taxa have frequently clouded their taxonomic status. In this context, molecular techniques can provide a useful tool to infer relationships between taxa. To determine the position of *O. chaktomuk* in the molecular phylogeny of *Orthotomus* we compared DNA sequences of mitochondrial ND2 and nuclear MUSK and TGFβ2 genes of the type specimens with all other species of lowland tailorbird (Sheldon *et al.* 2012) (see Table SOM 5 for details of all specimens used in the genetic analyses). Tissues from the five *O. chaktomuk* specimens (Table 1) were preserved in 95% ethanol and stored in the University of Kansas Natural

History Museum (KUNHM) and Louisiana State University Museum of Natural Science (LSUMNS) tissue collections. DNA was extracted and sequenced following the protocol described in Sheldon *et al.* (2012), and the sequences deposited in GenBank: accession numbers KF015230–KF015247. The total number of DNA nucleotides was 1,041 of ND2, 614 of MUSK, and 613 of TGFβ2. Separate and concatenated Bayesian phylogenetic analyses of these sequences using MrBayes ver. 3.2.1 (Ronquist *et al.* 2012) as in Sheldon *et al.* (2012) placed the novel taxon in a clade with *O. atrogularis*, *O. ruficeps* and *O. sepium*; all trees except TGFβ2 placed *O. atrogularis* and *O. chaktomuk* as sisters (Figure 4). This arrangement concurs with morphological and vocal analyses.

The ND2 sequences of the four taxa had 90 variable and 78 parsimony informative sites. Between the one sample of *O. atrogularis* and the five samples of *O. chaktomuk* were 22 variable sites of which 12 consistently differed. The ND2 p-distance from *O. chaktomuk* to *O. atrogularis* averaged 1.3% (range 1.1%–1.4%), to *O. ruficeps* 5.0% (4.6%–5.2%), and to *O. sepium* 6.5% (6.3%–6.8%). Variation in the MUSK and TGFâ2 sequences between *O. chaktomuk* and *O. atrogularis* was negligible (three and six sites, respectively). These genetic data are insufficient to resolve the relationship between *O. chaktomuk* and *O. atrogularis* owing to the small number of samples of *O. atrogularis* compared (one) and because that sample was not of the subspecies sympatric with *O. chaktomuk*. Instead, the *O. atrogularis* sample was of the nominate subspecies collected in Sarawak, which is restricted to the Sundaic region (except Sabah, north Borneo). The genetic divergence between *O. chaktomuk* and the *O. atrogularis* sample (1.3%) is small and broadly comparable to that between other lowland taxon-pairs on Borneo and mainland Asia that are considered subspecies, although there is considerable inter-species variation in genetic distances (e.g. Lim *et al.* 2010, Sheldon *et al.* 2012). A phylogeographic study including samples from all subspecies and biogeographically relevant populations of *O. ruficeps*, *O. atrogularis* and *O. chaktomuk* is required to clarify their evolutionary relationships.

Relationship of *Orthotomus chaktomuk* to species within *Orthotomus*

Orthotomus chaktomuk is locally syntopic (Figure 1, Table SOM 1) with the only species from which it shows apparently relatively low genetic divergence, *O atrogularis*. We have found no evidence of hybridisation, and the taxa satisfy the precepts of the biological species concept because they behave like separate species when they come into contact (e.g. Mayr 1963, 1999). Classification of the new taxon as a subspecies or highly localised colour morph of *O. atrogularis* is therefore untenable. Because *O. chaktomuk* is on a distinct evolutionary trajectory it also satisfies the phylogenetic species concept (Cracraft 1989).

Although reported genetic divergence among sister species is typically lower in temperate regions than in the tropics this may be an artefact of incomplete sampling and incorrect taxonomy (Tobias *et al.* 2008, Sangster 2009). Recent studies are overturning the trend for lumping distinctive taxa into polytypic species and revealing cryptic diversity in widespread species (e.g. Collar 2006, 2011, Rheindt & Eaton 2010, Leader 2011, Moltesen *et al.* 2012, Rasmussen *et al.* 2012). By taking an integrated approach to taxonomy (as here), sister species are being recognised in tropical regions that differ in sampled regions of nuclear DNA by levels that are in line with those used in temperate regions (e.g. Irestedt *et al.* 2013).

There are a number of plausible explanations for the apparently low genetic divergence between *O. chaktomuk* and *O. atrogularis*. The molecular phylogenies suggest that *O. chaktomuk* might be a relatively young lineage. Its diagnostic phenotypic traits that apparently prevent modern hybridisation might be encoded by a small number of genes that evolved rapidly under sexual selection (cf. Uy *et al.* 2009). This process might have occurred too rapidly for significant additional genetic differences to accumulate in parts of the genome not under intense selection or which are selected for other purposes (as are mitochondrial genes). If *O. chaktomuk* is indeed a Sunda Shelf species, now confined to relict habitat in Indochina, then it might have been derived from Sundaic *O. atrogularis* rather than mainland populations. If this were the case then it might be expected to show greater genetic divergence from mainland *O. atrogularis* to which it is now locally syntopic than to the Sundaic nominate used here in the genetic analyses. An alternative explanation is that the apparent low genetic divergence between the species is a result of genetic introgression sometime during the last two million years (Rheindt & Edwards 2011). Periods of peak sea-level might be the most plausible time for genetic introgression to have occurred. A higher sea-level might have constrained suitable habitat for *O. chaktomuk* into a narrow band between the distributions of *O. ruficeps* and *O. atrogularis*. This process perhaps drove *O. chaktomuk* through a population bottleneck and increased the chances of hybridisation with *O. atrogularis*, leading to genetic introgression. If a comprehensive study of relationships within the *O. chaktomuk*–*O. atrogularis*–*O. ruficeps*–*O. sepium* clade reveals that *O. chaktomuk* is more closely related to *O. a. nitidus* than to Sundaic taxa, then this is perhaps a more likely explanation for the low genetic divergence.

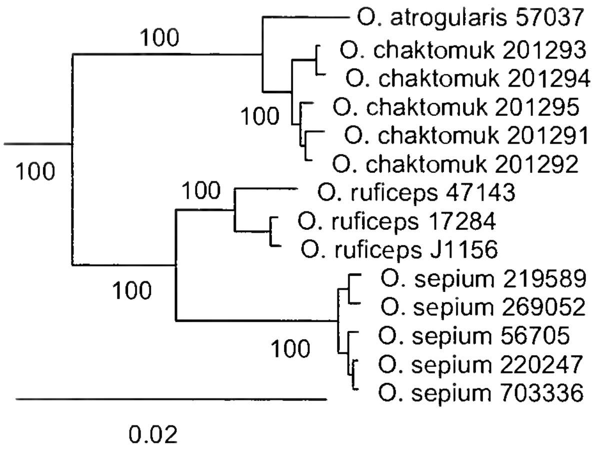

Figure 4. The *Orthotomus chaktomuk*, *O. atrogularis*, *O. ruficeps*, and *O. sepium* clade extracted from the entire *Orthotomus* phylogeny, which was constructed from concatenated DNA sequences of ND2, MUSK, and TGFβ2 via Bayesian phylogenetic inference as described in Sheldon *et al.* (2012). Numbers along branches indicate Bayesian posterior probabilities. The topology is the same as ND2 and MUSK trees by themselves.

Final remarks

The modern discovery of an undescribed bird species close to sea-level within the limits of a large city in a populous country is extraordinary, but not unprecedented (cf. *Stymphalornis sp. nov.*, an as-yet undescribed taxon restricted to marshes close to São Paulo, Brazil, discovered in 2005: Reinert *et al.* 2007). At least three interacting factors probably account for *O. chaktomuk* having gone unnoticed for so long. It inhabits a very small geographic range, and within this it is restricted to a very specific habitat type: dense floodplain scrub. This habitat is of little interest to birdwatchers and ornithologists because the other species that it supports are some of the most widespread and abundant birds in tropical South-East Asia. Even if its habitat were to attract more attention, the denseness of the habitat and the species's skulking habits would more often than not render it invisible to the casual would-be observer.

Vocalisations of *O. chaktomuk* are similar to those of *O. atrogularis*, which has a perplexing array of vocalisations with which birdwatchers rarely attempt to familiarise themselves fully. *Orthotomus atrogularis* is a common species within suitable habitat across a fairly broad range, and therefore there is little *a priori* reason for a birdwatcher or ornithologist to invest effort in trying to see a hidden, vocalising tailorbird in dense scrub in mainland South-East Asia. Moreover, collecting effort in Cambodia has been low: we have been able to trace only two *O. atrogularis* and one *O. sutorius* specimens (NHMUK 1928.6.26.1210, Eames & Ericson 1996) (the identification of all these specimens has been verified by the primary author, either first-hand or using photographs). Modern birdwatching effort in Cambodia is also limited and very localised. The factors discussed above also help explain why the first four individuals known were all mist-net captures. Their misidentification can be accounted for by the species's superficial similarity to other species, observer inexperience and the sheer unlikelihood of alternative options (cf. Woxvold *et al.* 2009). The discovery of *O. chaktomuk* indicates that new species of bird may still be found in familiar and unexpected locations.

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Available on Oriental Bird Club website, links at http://www.orientalbirdclub.org/publications/forktail29
Tables SOM 1 to SOM 5
Figure SOM 1
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Simon P. MAHOOD*, Wildlife Conservation Society Cambodia Program, PO Box 1620, Phnom Penh, Cambodia. Email: smahood@wcs.org*

Ashish Joshia Ingty JOHN*, Wildlife Conservation Society Cambodia Program, PO Box 1620, Phnom Penh, Cambodia. Email: ajohn@wcs.org*

Jonathan C. EAMES*, BirdLife International Cambodia Programme, PO Box 2686, Phnom Penh, Cambodia. Email: Jonathan.Eames@birdlife.org*

Carl H. OLIVEROS*, Biodiversity Institute and Department of Ecology and Evolutionary Biology, University of Kansas, Lawrence, KS 66045, USA. Email: oliveros@ku.edu*

Robert G. MOYLE*, Biodiversity Institute and Department of Ecology and Evolutionary Biology, University of Kansas, Lawrence, KS 66045, USA. Email: moyle@ku.edu*

HONG CHAMNAN*, Forestry Administration, Ministry of Agriculture, Forestry and Fisheries, Cambodia and Wildlife Conservation Society Cambodia Program, PO Box 1620, Phnom Penh, Cambodia. Email: chong@wcs.org*

Colin M. POOLE*, Wildlife Conservation Society Singapore, 352 Tanglin Road, Strathmore Block #01–08, Tanglin International Centre, Singapore 247671. Email: cpoole@wcs.org*

Howie NIELSEN*, 193 Hollywood Blvd, Whitefield, Maine, USA. Email: birderhowie@gmail.com*

Frederick H. SHELDON*, Museum of Natural Science and Department of Biological Sciences, Louisiana State University, Baton Rouge, LA 70803, USA. Email: fsheld@lsu.edu*

Notes for the conservation of the Rufous-fronted Laughingthrush *Garrulax rufifrons*

N. J. COLLAR & S. VAN BALEN

The Rufous-fronted Laughingthrush *Garrulax rufifrons*, endemic to Java, has been recorded from a total of 15 montane sites, 14 in West Java (nominotypical *rufifrons*) and one in Central Java (subspecies *slamatensis*). It occupies montane forest generally in the range 1,000–2,000 m, although this may vary with site, and occurs in monospecific parties of birds but also in bird waves, and has or had an association with Javan Green Magpie *Cissa thalassina*. Breeding appears to be extended through the year, but lack of records in January–February and July–August may reflect real breaks in the cycle. A lack of recent records from bird markets and a recent hike in prices of captive birds supports other concerns that the Javan bird trade may have affected the species, which in the past 20 years appears only to have been observed at Gunung Gede-Pangrango. Surveys of known sites and of several montane forest reserves are needed before a heavy investment in captive breeding is made.

INTRODUCTION

Of all the species bearing the English name 'laughingthrush', now proposed as components of a large subfamily of babblers named Leothrichinae (Moyle *et al.* 2012), Rufous-fronted Laughingthrush *Garrulax rufifrons*—called Red-fronted in Andrew (1985) and MacKinnon (1988) and Plain-brown in Hellebrekers & Hoogerwerf (1967)—is the southernmost, being confined to the island of Java, Indonesia (Collar & Robson 2007). This fact, combined with its restriction to montane forest (Stattersfield *et al.* 1998), suggests a relictual distribution, and Berlioz (1930), in considering it 'truly aberrant', attributed this in part to its geographical isolation.

The species has received virtually no attention from biologists, ecologists and scientific ornithologists, and there are no studies of it in the wild, but because, by contrast, it has received considerable attention from bird trappers, it has been treated all this century as Near Threatened (Stattersfield & Capper 2000, BirdLife International 2001). Recent anecdotal evidence suggests that its conservation status may have declined further since the 1990s (Collar *et al.* 2012 and below). This paper is therefore an attempt to assemble basic information relevant to its long-term conservation and make some appropriate preliminary recommendations.

DISTRIBUTION

Mees (1996) listed and mapped 11 localities for the species (treating Gn [=Gunung] Endut and Gn Salak separately) and on this basis remarked that it 'may be assumed to occur throughout the highlands of West Java'. Our further collation of records (initials of museums are glossed in the Acknowledgements) suggests that this prediction was correct. Since its description in 1831 the Rufous-fronted Laughingthrush has been recorded at the following localities (listed as far as possible from west to east), increasing the total to 15 (but treating Gn Endut as part of Gn Salak):

- **Gn Karang** above Ciomas and Ujungtebu, 1–13 April 1920 (Robinson & Kloss 1924: 285) and at an unspecified locality in April 1991 (D. A. Holmes *in litt.* 1991);
- **Gn Halimun**, August and September 1922 (2 specimens in Naturalis), July 1982 (K. D. Bishop *in litt.* 2013);
- **Gn Salak** (type locality designated by Deignan 1964), on the south-east slope, October 1882 (Vorderman 1886), at Gn Endut, 10 June 1897 (Bartels 1902, 1906, Mees 1996; 1 specimen in Naturalis), at Cianten, April–June 1932 (2 specimens in MZB), at Pasirreungit, 12–15 August 1981 (SvB), at Warungloa, heard once, 15 July 1981 (SvB), on the south-west slope at Awibengkok, 10 records of 1–3 birds, 3–9 September 1988 (SvB);
- **Gn Gede–Pangrango**, May 1889 (1 specimen in Naturalis; Vorderman 1892), 1900–1926 (34 specimens and 3 clutches in Naturalis, 4 specimens in MZB), 1943–1947 (8 clutches in Naturalis, 2 specimens in MZB; also Hoogerwerf 1948), specifically at Puncak, 1970s (W. G. Harvey in a list supplied by the late D. A. Holmes to SvB), Telaga Warna, 1979–1981 (SvB), Cibodas, October 1896 (1 specimen in Naturalis) and 21 September 1918 (Spennemann 1923), Cibodas and Kandangbadak, February–March 1916 (Robinson & Kloss 1924, Delsman 1927) and April 1941 (1 clutch in Naturalis), with many encounters 1979–1989 (Andrew 1985, SvB) including one at Cimungkat, July 1987 (SvB), sight records through the 1990s and 2000s (J. Chance *in litt.* 1991, J. A. Eaton, C. R. Robson *in litt.* 2013) and audio recordings in June–July 2009 (XC30475–76 by B. Cox, XC40473–74 by D. Edwards);
- **Cianjur**, Cibeber, in the period 1946–1949 (G. F. Mees notebooks seen by SvB);
- **Gn Patuha**, Koleberes, 1927–1929 (Bartels 1931: 336; hence Hoogerwerf 1948);
- **Situ Lembang**, 15 March 1984, 8 birds (P. Andrew *in litt.* 2013);
- **Gn Tangkubanprahu** (Mees 1996), July and October 1926, December 1955 and December 1957 (8 specimens in Naturalis);
- **Gn Malabar** at Tirtasari, 12 May 1910 (Mees 1996; 1 specimen in Naturalis);
- **Gn Wajang**, Cibitung (Mees 1996), April and May 1910 (3 specimens in Naturalis);
- **Gn Papandayan**, late 1920s (Stresemann 1930), 1941–1942 (2 specimens in MZB), with subsequent records specifically at Kawahmanuk, 2 birds, 3 September 1987 (SvB); Gn Kendang, flock of 10–15 birds tape-recorded, 6 September 1987 (SvB);
- **Gn Rakutak**, March 1900 (1 specimen in AMNH);
- **Gn Guntur**, Garut, October 1900 (2 specimens in AMNH), including Kawah Kamojang, May 1923 (1 specimen in MZB), and 'near Garut' (Siebers 1929);
- **Gn Ciremay** (Mees 1996), June 1930 (1 specimen in Naturalis); and
- **Gn Slamat** (type and only locality for race *slamatensis*) at Kaligua, 1916–1917 (Siebers 1929; type specimen in Naturalis, 3 paratypes in MZB), and at Purwokerto, March 1925 (Voous 1948, Mees 1996; 2 specimens in Naturalis).

ELEVATIONS, ECOLOGY AND NATURAL HISTORY

The species is resident in and confined to 'mixed original forest' or 'broadleaved evergreen forest' at 900–2,500 m (Sody 1956, Collar & Robson 2007), this being a minor shift from elevations of 1,000–2,400 m (Stattersfield *et al.* 1998, BirdLife International 2001). However, these limits represent extremes amalgamated from individual sites, and may vary considerably at each known site depending on ecological conditions, mountain height (the peaks of several mountains listed above lie below 2,400 m), and levels of deforestation. Moreover, nothing is known about the species's relative abundance at different elevations, although Hoogerwerf (1950) indicated that on Gn Gede–Pangrango it was a common bird from Cibodas up to near the tops of the mountains.

The site-specific elevations in Hoogerwerf (1948)—1,500–2,600 m on Gn Papandayan, 600–1,000 m at Ciomas on Gn Karang, 800–1,200 m at Cimungkat on Gn Gede, 600–1,000 m at Koleberes on Gn Patuha and 500–2,300 m on Gn Salak—are not intended to indicate the limits between which the species was certainly encountered; nor is there clear evidence to support Hoogerwerf's (1948) characterisation of the species as one 'in certain areas probably living permanently between 2500 and (above) 3000 m'. On Gns Endut and Pangrango, Bartels (1902) gave its elevation as '3,000–3,500 feet' (900–1,100 m), later changing this to '3,000–6,000 feet' (900–1,800 m) (Bartels 1906); records from Cimungkat on Gn Gede were at 1,200 m (SvB). Some specimens on Gn Tangkubanprahu were at 1,500 m (Naturalis label data), as was the first record from Gn Papandayan (Stresemann 1930), although subsequently birds were found in the latter locality at 1,900 m (Kawahmanuk) and at 2,525 m (Gn Kendang) (SvB). Records from Gn Salak are at 1,500 m (Vorderman 1886), and specifically at Pasirreungit at 1,350–1,900 m and Awibengkok at 1,000–1,150 m (SvB). It therefore appears that only one record, hitherto unpublished, pins the species to an elevation higher than 2,000 m; all other records traced come from below this altitude. The record from Situ Lembang was at 850 m (P. Andrew *in litt.* 2013), and those on Gn Karang were at 600–900 m (Robinson & Kloss 1924), these apparently being the lowest elevations recorded for the species.

The Rufous-fronted Laughingthrush occupies all strata of the forest but chiefly the undergrowth, and is 'very agile' (Hoogerwerf 1950). It occurs in loose, sometimes large monospecific groups but also participates in bird-waves (Hoogerwerf 1950, Andrew 1985), these latter sometimes comprising up to 15 different species on Gn Gede (van Balen 1992); in particular, it associates with the Javan Green Magpie *Cissa thalassina* (Koningsberger 1901, Bartels 1915–1931), such that on Gn Halimun in 1982 the two species were found together in a bundle of birds being carried by a poacher (K. D. Bishop *in litt.* 2013). Its presence is best determined by its noisy, whinnying call, earning it the local name 'horsebird' (van Balen 1992) and placing it with the group of laughingthrushes that possess a laughing call (Collar & Robson 2007). Various authors have given glancing accounts of the diet: 'berries and insects, mostly beetles' (MacKinnon 1988), beetles, snails and fruits of *Melastoma malabathricum* (Sody 1989), and these plus mantids and caterpillars (Collar & Robson 2007). Hoogerwerf's (1950) mention of small hard seeds and Sody's (1989) of *Melastoma* may well both refer back to Vorderman's (1886) account of stomachs 'coloured black by fruit pulp, and filled with small hard seeds' (our translation). The closest observer of the species described its diet as mainly and sometimes exclusively various forest fruits, supplemented with insects, mainly beetles including weevils, plus bugs, caterpillars, locusts, spiders, ants and small vertebrates such as frogs and lizards (Bartels 1915–1931; also Delsman 1927). Specimen labels in Naturalis mention *Anomala* beetles, small beetles, a large weevil, a phasmid, looper caterpillars and *Ficus* and *Lantana* fruit as stomach contents. In captivity, birds caught wild mice in their enclosure (Pithart 2009).

The nest is a sturdy, relatively small cup placed on a horizontal branch or in a fork usually fairly close (about 2 m) to the ground in smaller trees at the edge of forest (more details in Hoogerwerf 1950, Hellebrekers & Hoogerwerf 1967). The usual clutch is three (blue-green) eggs, but sometimes two; nests have been found in March, April, May, June, September, November and December (Hoogerwerf 1949, 1950, Hellebrekers & Hoogerwerf 1967). Whether the gaps in breeding in January–February and July–August represent real seasonal differences, random variation or temporal patchiness in observer coverage is an open question. However, breeding in Prague Zoo followed a roughly similar schedule, with nests in April–June and August–October (Pithart 2009). Naturalis possesses birds marked as juveniles from January (1), May (2), June (1) and August (1), but these are full size and it is impossible to pin them to a likely month of birth; it also contains four specimens labelled as having full-sized gonads in April (male and female) and May (two males). In captivity the female was noted to do almost all incubation, which lasted 14–15 days, while the nestling period was 15–16 days; moult occurred slowly from autumn (occasionally July) through to December (Pithart 2009). Indeed, birds at the end and start of the year have been described as 'gut im Gefieder' (Bartels 1902), which presumably best translates as 'in fresh plumage'.

POPULATION TRENDS AND THREATS

There has been no systematic monitoring of populations of this or any other forest bird species in Java, so a quantitative assessment of population trends is impossible. However, various items of qualitative information have accumulated to suggest that the Rufous-fronted Laughingthrush may now be in a more serious condition than has hitherto been realised, largely as a result of the singular Javanese tradition of bird keeping.

'I am afraid that aviculture is a major source of bird destruction in Indonesia', wrote Morrison (1980), having found Java to be 'a singularly birdless island'. This was over 30 years ago. At that time, however, the Rufous-fronted Laughingthrush, being a bird of high, remote forests, may still have been common. On Gn Gede–Pangrango it was common in the 1940s (Hoogerwerf 1950) and in the 1980s (Andrew 1985), and there is no reason to imagine that it was less common at the other localities listed above in the 1980s, although as a Javan endemic it was protected under Indonesian law in 1979 (Noerdjito & Maryanto 2001). Only once in the early documentation was there an indication of relative rarity: it was scarce at Gn Patuha in the years 1927–1929 (Bartels 1931), presumably for natural reasons ('only in the northern forests'). Extrapolation from experience at Gn Gede presumably lies behind MacKinnon's (1988) general description of the species as 'Locally not uncommon in montane forests' and behind Mees's (1996) remark that 'Where this species occurs it is common, noisy, and conspicuous.'

Nevertheless, only two years after this comment, the species was said to be 'fairly heavily exploited as a cagebird, which has rendered it uncommon in otherwise moderately secure habitat' (D. A. Holmes *in litt.* 1998 in BirdLife International 2001), leading to its designation as a Near Threatened species, and in the mid-2000s it was described as 'formerly common in Gede–Pangrango National Park... but now rare along main trail, reportedly owing to trapping' (Collar & Robson 2007), although inquiries of leaders taking bird tours to Gn Gede do not suggest that numbers have obviously declined there (C. R. Robson *in litt.* 2013, J. A. Eaton *in litt.* 2013).

Other evidence, however, certainly tends to support the notion that a real decline has been occurring for some years. Bird dealers in markets in Medan, Sumatra, recently reported that Rufous-fronted Laughingthrush is 'becoming increasingly rare or difficult to find in economically viable numbers' (Shepherd 2011). Independently, it has been reported to have 'vanished from the bird markets in Sumatra' (P. Hospodárský in Pithart 2009). Moreover, on Java at the start of the century the species 'could be found in bird markets as a cheap local songster, selling for Rp 150,000 ($16)', but in the past few years the price has increased tenfold and in 2012 no birds could be found in bird markets (R. Sözer in Collar *et al.* 2012 and *in litt.* 2013). This latter testimony was independently supported by C. R. Shepherd (*in litt.* 2013):

> Dealers in the Barito Market and the Pramuka Market [Jakarta, Java] stated in 2011 that this species was 'difficult to find, or all gone' (*susah* or *sudah habis*). These kinds of statements do usually mean trappers are rarely bringing them in and are not finding them in their usual trapping areas. In 2012, I only carried out one survey in Jakarta's three largest bird markets (June 2012) and did not see any.

Moreover, there are parallels with declines and near-disappearances in other species that have been attributed to the demands of Javan bird-keeping, most notably that of the Javan Green Magpie (van Balen *et al.* 2013; also Collar *et al.* 2012).

However, the current plight of the magpie, and the laughingthrush's reported association with it, opens up the plausible if very remote possibility that the laughingthrush's conservation status may not be so desperate. Since the magpie is a much more prized species in the Javan bird trade, it might conceivably be that when targeting the magpie trappers took many laughingthrushes simply as a 'bycatch', which could explain the latters' low prices and wide availability a few years ago. Moreover, now that trade has reduced the numbers of magpies to near-zero (van Balen *et al.* 2013), trappers are perhaps no longer visiting areas where magpies once occurred, in which case the sudden disappearance of laughingthrushes from markets might simply reflect lack of trapping effort rather than lack of birds. Nevertheless, the rather high prices now commanded by the laughingthrush tend to suggest that its rarity is real and, as V. Nijman (*in litt.* 2013) has commented, there are high numbers of montane bird species still available for sale in Java's markets, and 'not all of them are expensive'.

CONSERVATION NEEDS

If protected area status improves the chances of long-term habitat conservation, then Gn Halimun–Salak, Gn Gede–Pangrango and perhaps Gn Guntur are likely to be the best-preserved of the sites at which the laughingthrush occurs (although at Gn Gede in the past 10 years there has been 'shocking clearance' for vegetable plots, 'apparently inside the protected area, probably up to 2,100 m in a c.1 km belt above and east of the Cibodas Botanic Garden': F. R. Lambert *in litt.* 2013). The reserve at Kawah Kamojan on Gn Guntur covers 8,000 ha at 1,400–2,250 m (MacKinnon *et al.* 1982), but other sites at which the species has been recorded have very small areas protected: the only reserves larger than 100 ha are at Telaga Patengan on Gn Patuha (150 ha), Gn Papandayan (844 ha) and Gn Tangkubanprahu (1,660 ha) (MacKinnon *et al.* 1982), but it is not known if they encompass laughingthrush habitat and viable populations. An area of 15,000 ha on Gn Slamat was long ago recommended for protection (see Stattersfield *et al.* 1998) but only two reserves, both less than 20 ha, exist there (MacKinnon *et al.* 1982); since it is the sole locality for the highly distinctive subspecies *slamatensis* (Siebers 1929, Voous 1948, Mees 1996) of *Garrulax rufifrons*, formal protection of the site is clearly highly desirable.

Last records of the species from all known sites are: Gn Karang 1991, Gn Halimun 1984, Gn Salak (where on Endut it was 'not rare' at the start of the twentieth century: Bartels 1902, 1906) 1988, Gn Gede–Pangrango 2012, Cianjur at least 1949, Gn Patuha before 1931, Situ Lembang 1984, Gn Tangkubanprahu 1957, Gn Malabar 1910, Gn Wajang 1910, Gn Papandayan 1987, Gn Rakutak 1900, Gn Guntur 1923, Gn Ciremay 1930 and Gn Slamat 1925. D. Liley (*in litt.* 2013) spent 5–6 weeks at Cikuya, on the southern slopes of Gn Halimun, mostly at 1,000–1,200 m, without seeing the species, and K. D. Bishop (*in litt.* 2013) visited Gn Halimun in August 2011 after a gap of 29 years and found no laughingthrushes; however, it is fair to note that the one location that most birdwatchers go to at Gn Halimun, Cikaniki, probably never had the species (between 1996 and 2009 field teams never recorded it: Prawiradilaga *et al.* 2003, Noske *et al.* 2011). Even so, it appears to be at least 20 years since there was a record of the species away from Gn Gede–Pangrango.

Naturally, therefore, these sites need urgent surveying to determine the status of the forests and the continuing presence of the species (for which, given its noisiness, playback techniques would probably be highly effective). Other under-explored reserves which might hold the species are: Gn Burangrang (2,700 ha; 1,000–2,000 m); Gn Tampomas (1,250 ha; 1,000–1,700 m); Gn Sawal (5,400 ha; 600–1,764 m); Gn Simpang (15,000 ha; 600–1,600 m) and Gn Tilu (8,000 ha; 1,200–2,177 m). Preferably, however, such a survey would involve line-transect or point-count work to establish baseline densities at the sites, and would target other rare species such as Javan Hawk Eagle *Nisaetus bartelsi*, Javan Trogon *Apalharpactes reinwardtii*, Javan Cochoa *Cochoa azurea* and Javan Green Magpie, along with (e.g.) certain primates.

Study of the culture and economy of bird-keeping in Indonesia has led Jepson *et al.* (2011) to 'argue that, in Indonesia at least, conservationists need to move beyond the moralistic, animal rights and protectionist logic that dominate [*sic*] much wildlife trade discourse and embrace the development logic of pro-poor growth and more, better jobs'. Whatever one makes of this prescription it predicates a time-scale that completely mismatches the short-term needs of many species native to Java, and if acted on would merely vaporise their chances of survival. If conservationists do not focus on birds that are at greatest risk from trade activities on the island, the only logic they are likely to embrace is the logic of extinction.

Captive breeding for conservation purposes ('conservation breeding') may therefore now be a lifeline for the Rufous-fronted Laughingthrush (Collar *et al.* 2012). However, the species has been bred only with some difficulty and only, apparently, in two European institutions, Tierpark Berlin (Kaiser 2006) and Prague Zoo (Pithart 2009). It has proved an aggressive and problematic species to keep, and endeavours to develop a significant captive stock may only be worth making once the evidence is clearer about its status in the wild.

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***N. J. COLLAR**, BirdLife International, Girton Road, Cambridge CB3 0NA, UK. Email: nigel.collar@birdlife.org*

***S. (BAS) VAN BALEN**, Basilornis Consults, Muntendampad 15, 6835 BE Arnhem, Netherlands*

Species limits in the Golden Bulbul *Alophoixus (Thapsinillas) affinis* complex

N. J. COLLAR, J. A. EATON & R. O. HUTCHINSON

The Golden Bulbul *Thapsinillas affinis* of the Moluccan islands, Sula archipelago, Banggai islands, Togian islands and Sangihe, Indonesia, was until recently treated in *Alophoixus* before being placed in the resurrected genus *Thapsinillas* and shortly afterwards split into Northern and Southern Golden Bulbuls *T. affinis* and *T. longirostris*, but with a general consensus that a break-up into more species was required. We used plumage and morphometric analysis of museum specimens, supplemented by vocal samples, to determine where new species limits might be drawn. We found that the nine generally accepted subspecies break down into seven full species, five monotypic and two with two subspecies each: *T. chloris* on Morotai, Halmahera and Bacan (small, featureless; undifferentiated olive-green lores and ear-coverts, blackish base to submoustachial area; song reportedly a 'jumbled babbling'); *T. lucasi* on Obi (round yellow lores, yellow-tinged ear-coverts, seemingly simple often squeaky-toy-like vocalisations); *T. affinis* on Seram with race *flavicaudus* on Ambon (larger than previous two, with half-wedge yellow lores, broad yellow tips to tail, song a group of strong rich flat whistles); *T. mysticalis* on Buru (half-wedge yellow lores, partial yellow eye-ring, olive-green underparts, olive-grey tail, whistled phrases recalling domestic canary); *T. longirostris* on Sula with race *harterti* on Peleng and Banggai (longest-billed, large, undifferentiated olive-green lores, song a loud jumble); *T. aurea* on the Togian islands (golden-yellow underparts, vague half-wedge yellow lores, blackish frontal supercilial line, yellow-tinged rump, song seemingly more complex than in *longirostris*) and *T. platenae* on Sangihe (vivid yellow chin and submoustachial area to throat and breast, bright yellow triangular lores, almost-complete yellow eye-ring, song seemingly simple and nasal). Comprehensive vocal sampling and molecular work may shed light on the origins and colonisation routes of this geographically unusual cluster of species.

INTRODUCTION

The taxonomy of the Golden Bulbul *Alophoixus* (*Thapsinillas*) *affinis* complex of Wallacea, Indonesia, has long been considered problematic, owing to the considerable variation in plumage pattern and size shown by most of its subspecies (Hartert 1922, Delacour 1943, White & Bruce 1986). These subspecies possess an unusual and indeed unique distribution for a species in the region, in the geographic sequence given by White & Bruce (1986) as follows: *chloris* (North Moluccas: Morotai, Halmahera, Bacan); *lucasi* (Obi); *affinis* (Seram); *flavicaudus* (Ambon); *mysticalis* (Buru); *longirostris* (Sula); *harterti* (Peleng, Banggai); *aurea* (Togian Islands) and *platenae* (Sangihe).

It is perhaps a measure of the uncertainty surrounding this complex that it has appeared in so many generic guises in the past hundred years. Until at least 1922 it was largely treated in *Criniger* (e.g. Wallace 1862a,b, 1863, Blasius 1888, Hartert 1903, 1922), but Delacour (1943) placed it in *Microscelis* (subgenus *Iole*), Rand & Deignan (1960), Morony *et al.* (1975) and Andrew (1992) in *Hypsipetes*, White & Bruce (1986) and Coates & Bishop (1997) in *Ixos*, and Sibley & Monroe (1990) and Inskipp *et al.* (1996) in *Alophoixus*. Finally Dickinson & Gregory (2002) resurrected the genus *Thapsinillas* for the complex (a decision we follow hereafter), citing as diagnostic characters 'typically dark oily green [plumage], relieved by areas of yellow in some forms; crown not crested and feathers only slightly elongated; bill much like *Iole* but perhaps more hooked and with lower mandible deeper; rictal bristles fewer and weaker', but unaccountably omitting mention of the key criterion in the original description, namely that 'from all the related genera with lengthened nostrils *Thapsinillas* may easily be distinguished... by its very short tarsus, this being considerably less than the exposed culmen' (Oberholser 1905).

Continuing this theme of taxonomic hesitancy, both Dickinson & Gregory (2002) and Dickinson & Dekker (2002) suspected that the variation between the subspecies in this resurrected genus 'will justify subdivision into two to four species'. However, Delacour (1943) bluntly cited 'distribution' as the reason to resist a split into two species based on 'size and tail pattern' (larger taxa with 'particolored tail, dark olive and bright yellow', smaller ones 'strangely similar to *M. ictericus*' (=Yellow-browed Bulbul *Iole indica* in Inskipp *et al.* [1996]). By contrast, Fishpool & Tobias (2005) took what they regarded as 'a preliminary measure' by separating the 'Northern Golden Bulbul' *T. longirostris* (with *chloris*, *lucasi*, *harterti*, *aurea* and *platenae*) from 'Southern Golden Bulbul' *T. affinis* (with *flavicaudus* and *mysticalis*) on account of reported vocal differences between these groups, thereby 'drawing attention to the broadest rift in the complex, and paving the way for appropriate fieldwork and research into the song, morphology and genetics of all taxa involved'. These authors, like Dickinson & Dekker (2002), judged that 'further subdivision' would almost certainly be required, 'in view of significant differences between the various island populations'. This was partially achieved by Rheindt & Hutchinson (2007), who, without going into detail, considered 'Southern Golden Bulbul' to comprise two morphologically and vocally distinct species, Buru Golden Bulbul *T. mysticalis* and Seram Golden Bulbul *T. affinis* (including *flavicaudus*).

Steadily accumulating evidence on apparent differences in vocalisations of most of the taxa in the *Thapsinillas affinis* complex now prompts a more detailed review of their morphological and morphometric characters in order to attempt to reach a further stage in the revision of the Golden Bulbul complex. As Fishpool & Tobias (2005) observed, this is important not least because 'some island races would prove to be very rare...' such that 'taxonomic review is vital for the compilation of a realistic conservation strategy for Wallacea, and must be made a priority'.

METHODS

We considered one line of hard evidence in this review, namely plumage and mensural characters from museum material, and supplemented it with morphological evidence from photographs as well as recordings and reports of vocalisations.

Museum specimens of Golden Bulbuls were examined (NJC) in the Natural History Museum, Tring, UK (NHMUK), Naturalis, Leiden, Netherlands (Naturalis), Staatliches Museum für Tierkunde, Dresden, Germany (SMTD), Staatliches Naturhistorisches Museum, Braunschweig, Germany (SNMB) and Zoologisches

Museum (Museum für Naturkunde), Berlin, Germany (ZMB). Each specimen was measured (by NJC) for length of bill (skull to tip), tarsus, wing (curved) and tail (tip to point of insertion), the characters of each taxon were logged in a matrix, and representative specimens were photographed. From these collections the numbers of specimens by taxon and island were:

- *chloris*—North Moluccas: 39 specimens, 10 from Morotai, 16 from Halmahera, 13 from Bacan (11 males [m], 8 females [f], 20 unsexed [u])
- *lucasi*—Obi: 13 (7 m, 5 f, 1 u)
- *affinis*—Seram: 12 (4 m, 3 f, 5 u)
- *flavicaudus*—Ambon: 8 (6 m, 1 f, 1 u)
- *mysticalis*—Buru: 21 (4 m, 10 f, 7 u)
- *longirostris*—Sula (Taliabu & Mangoli): 23 (7 m, 2 f, 14 u)
- *harterti*—Banggai (Banggai & Peleng): 13 (1 m, 2 f, 10 u)
- *aurea*—Togian: 2 (1 m, 1 f)
- *platenae*—Sangihe: 3 (3 m)

The large number of unsexed specimens and an occasional numerical bias in the sexed specimens prompted a comparison of males only (Table 2), but the full figures and standard deviations given in Table 1 are used in the analysis of character difference below.

Photographs of live birds were assembled from our own collections (JAE, ROH), from those of colleagues, contacts and friends, and (with due care as to identification and provenance) from the internet (notably Oriental Bird Images). Sound recordings were likewise assembled from our own collections (JAE, ROH), those of others and the internet (AVoCet [AV], Xeno-Canto [XC] and the Internet Bird Collection [IBC]). They were compared qualitatively and informal descriptions and transcriptions of them prepared. Use of capitals in the transcriptions indicates emphasis (volume).

Table 1. Means and standard deviation (in brackets) of four morphometric variables in all specimens of the *Thapsinillas* complex. Notes: ^{a} = sample size reduced by 1; ^{b} = sample size reduced by 2; ^{c} = sample size reduced by 6. These reductions were caused by damage to the parts being measured or (in the case of tarsi) their inaccessibility (being tucked tightly against the body).

Taxon	n	Bill	Wing	Tarsus	Tail
chlaris	39	22.3 (1.06)^{a}	98 (3.44)^{a}	18.6 (0.6)	82.9 (2.36)^{a}
lucasi	13	23.4 (0.53)^{a}	104.8 (3.11)	18.6 (0.69)^{b}	86.3 (2.06)
affinis	12	27.8 (1.17)	109.2 (4.35)	20 (0.78)^{a}	86.8 (3.49)
flavicaudus	8	28.4 (0.94)	111.4 (3.25)	20 (0.95)	93.5 (2.93)
mysticalis	21	25.7 (0.88)	104.4 (4.48)	19.6 (0.82)^{a}	92.4 (3.37)
langirastris	23	29.8 (1.31)^{a}	115.6 (4.62)	21.2 (0.56)^{c}	106.9 (4.56)
harterti	13	28.9 (1.24)^{a}	120.7 (5.11)	21.2 (0.72)^{a}	108.7 (3.61)^{b}
aurea	2	27.1^{a}	117	20.5	108
platenae	3	27.7	121	20	109.3

Table 2. Means of four morphometric variables in male specimens of the *Thapsinillas* complex. Note: ^{a} = sample size reduced by 1.

Taxon	n	Bill	Wing	Tarsus	Tail
chlaris	11	22.7^{a}	99.8	18.6	82.8
lucasi	7	23.6^{a}	106	18.7	86.3
affinis	4	28.4	109.5	20^{a}	87.3
flavicaudus	6	28.1	110.5	19.8	92.7
mysticalis	4	25.8	109.3	19.8	92.8
langirastris	2	28.7	112.5	21.5	105.5
harterti	1	29.5	123	22	113
aurea	1	27.1	124	21	111
platenae	3	27.7	121	20	109.3

We measured the degree of phenotypic differentiation between each taxon using a system in which an exceptional difference (a radically different coloration, pattern or vocalisation) scores 4; a major character (pronounced difference in body part colour or pattern, measurement or vocalisation) scores 3; a medium character (clear difference reflected, e.g. by a distinct *hue* rather than different colour) scores 2; and a minor character (weak difference, e.g. a change in shade) scores 1; a threshold score of 7 is set to allow species status; species status cannot be triggered by minor characters alone, and only three plumage characters, two vocal characters, two biometric characters (assessed for effect size using Cohen's *d* where 0.2–2 is minor, 2–5 medium, 5–10 major and >10 exceptional), and one behavioural or ecological character may be counted (Tobias *et al.* 2010). Where additional characters are apparent but under these rules cannot be scored, the formula 'ns [1]' is used, signalling 'not scored' but giving in parenthesis the estimated value of the difference in question.

RESULTS

We review each taxon in turn for its diagnostic morphological, morphometric (Tables 1 and 2) and acoustic distinctiveness. However, the acoustic component of the analysis remains qualitative, because the vocalisations of each taxon appear to be variable and complex, so that only tentative and general comments on their diagnostic distinctiveness can be ventured from the limited and fragmentary material available. From this evidence a shared pattern of song nevertheless seems to exist between all taxa, which involves a hesitant series of staccato nasal or guttural notes that accelerate and switch abruptly either to a short jumble of babbled and fluty notes on often widely differing pitches or to a short series of fairly even whistles; but most taxa sound in varying degrees different, and if these findings are replicated widely by other recordings in future then they will add substantially to the case made below for the redrawing of species limits based on morphology.

Photographs and museum label data indicate that there are no significant differences in the bare-part colours of any of the taxa: basically the bill is shiny black to plumbeous, reflecting light and looking whitish at some angles or in some photographs; the legs are brownish-grey; and the iris is reddish-brown to brown. There are slight variations in how museum labels report iris colour: for example, for the taxon *mysticalis* NHMUK 1969.29.203 gives 'iris brown', 1923.9.15.91 'iris dark crimson' and 1923.9.15.92 'eye red', while the describer, Wallace (1863), also gives 'iris red', although photographs repeatedly show reddish-brown irides. Hombron & Jacquinot (1841) likewise gave '*iris rouge*' for their new species *affinis*, but in photographs it is reddish-brown. Two of the three known specimens of the very rare *platenae* are labelled by the collectors as having '*iris: rot-braun*'.

Sample sizes of specimens of *aurea* and *platenae* were respectively two and three; and recordings of all taxa were inadequate in number, duration and representativeness. However, no clinching evidence depends on data stemming from these limited sources.

In the following account, the size and shape of (yellow) lores are mentioned and require definition here. 'Round' (taxon *lucasi*) lores means that the shape of the yellow patch is large and relatively circular, and comes into contact with the leading edge of the eye. 'Half-wedge' (taxa *affinis*, *flavicaudus*, *mysticalis* and *aurea*) indicates that the patch of yellow is compressed into a flat triangular bar close to the line of the upper mandible and separated from the eye by an olive-green area. 'Triangular' (taxon *platenae*) describes a fuller area of yellow than the wedge, extending to the eye.

Taxon *chloris* (Morotai, Halmahera, Bacan)

This form is characterised by its small size (it is the smallest of the taxa in the complex) and its relatively featureless plumage; no differences were apparent between the three island populations. It differs from its geographically and morphologically closest relative, *lucasi* of Obi, by its olive-green *vs* yellow lores (3), olive-green *vs* olive-yellow ear-coverts (1), blackish base to submoustachial area *vs* all olive-green (2) and slightly smaller size and distinctly shorter wing (effect size −2.28) (2)—total score 8.

Originally described by Wallace (1862a) under the pre-occupied name *simplex*, this form was renamed and further described by Finsch (1867), who pointed out that Wallace failed to mention the blackish submoustachial line. Finsch found this a very distinctive ('*ganz besonders*') character, but in specimens examined for this review it proved to be constant but somewhat variable in strength.

Fishpool & Tobias (2005) provided a description ('a hurried, cheery, jumbled babbling') that conforms closely with the general structure of *Thapsinillas* songs available to us. However, brief recordings by ROH of two consecutive song strophes consist (after 2–3 brief staccato introductory *twís* notes) of three or so simple clear paired whistles, high-pitched at the start but each pair slightly lower than the preceding, morphing subtly into a slightly more drawn-out double-whistle with the stress on the first syllable, each again slightly lower than the last: *pí-pí, pí-pí, pí-pí, wíwi, wíwi, wíwi, wíiwii*, thus fairly closely resembling the falling-pitch song of *T. affinis* (below). Otherwise the only recording we have found is of a bird giving quiet thin *sii* calls in apparent mild alarm or for contact (IBC video under *T. longirostris*, 'A bird softly calling from a branch').

Taxon *lucasi* (Obi)

Hartert (1922), while itemising Rothschild's type specimens and therefore not reviewing the Golden Bulbul complex in any detail, remarked of *lucasi*, which he himself established as a full species (Hartert 1903), that 'though differing by its yellow lores and larger size, [it] can hardly be anything but a subspecies of *chloris*', and lumped it accordingly (albeit keeping *chloris* separate from *affinis*). However, the morphological differences with *chloris*, as scored above, gainsay this judgement.

The island of Obi is roughly equidistant from Seram, Buru and Taliabu, where three further relatives of *lucasi* occur, respectively *affinis*, *mysticalis* and *longirostris*. Of these, *lucasi* is closest in size and general structure to *mysticalis* and remotest from *longirostris*, but differs in turn from

- *mysticalis* by its shorter bill, tarsus and tail (effect size for bill −3.22) (2); larger, much rounder yellow lores (2); lack of yellow partial eye-ring (2); largely yellow chin to vent *vs* largely (yellow-tinged) olive chin to vent (3); yellower ear-coverts (ns [1])—total score 9;
- *affinis* by its smaller size (effect size for bill −4.83) (2); larger, rounder yellow lores (2); yellower ear-coverts and submoustachial area (at least 1); paler and less extensive olive-green on breast and flanks (ns [1]); lack of yellow tips to uppertail-coverts (ns [1]); olive-grey *vs* broadly yellow-tipped and -edged rectrices with entire undertail bright yellow (3)—total score 8;
- *longirostris* by its smaller size (effect size for bill −6.03) (3); large round yellow *vs* olive-green lores (3); all-olive-grey *vs* bright yellow-fringed (on inner webs) rectrices (3); narrow whitish *vs* narrow yellow inner fringes to tertials (1); yellower ear-coverts (ns [1])—total score 10.

Recordings kindly sent by M. Thibault reveal only very simple calls: (a) a flat nasal penetrating *tuuu-tuuu-tuuu-tuuu* (3–4 notes separated by short pauses); (b) a high, thin, dropping-then-rising *TSIIiuuuuii*, starting like a squeaky toy but ending more richly whistled, this evidently the *tweeuwip* described by Linsley (1995) and mentioned in Coates & Bishop (1997); and (c) an equally high thin squeaky toy *zu-WIIIT! zu-WIIIT! zu-WIIIT!*—these last sounds not dissimilar to those recorded from *platenae* (see below) but much thinner in tone, lacking the latter's thrush-like richness. Linsley (1995) also mentioned groups giving 'raucous calls reminiscent of *Charmosyna placentis* although without the harsh or scratchy quality of that species'.

Taxon *affinis* (Seram)

Morphological differences from *lucasi* (and by extension *chloris*), *aurea* and *platenae* are scored above and below. It differs from

- *chloris* by its greater size (effect size for bill length 4.68) (2); half-wedge yellow lores *vs* all olive-green lores (2); yellow tips to uppertail-coverts (1); rectrices broadly tipped and edged yellow (entire undertail bright yellow) *vs* olive-green (3)—total score 8;
- *mysticalis* by its slightly larger size (effect size for bill length 1.99) (1); lack of partial yellow eye-ring (2); yellow *vs* olive-green belly to vent (3); rectrices broadly tipped and edged yellow (entire undertail bright yellow) *vs* olive-green (3); yellow tips to uppertail-coverts (ns[1])—total score 9;
- *longirostris* by its rather smaller size and notably shorter tail (effect size for latter −4.82) (2); half-wedge yellow *vs* olive-green lores (2); darker and more extensive olive-green breast (2); different tail pattern, with broad yellow tips and all-yellow undersides *vs* broad yellow edges on both surfaces (3)—total score 9.

A recording by F. R. Lambert (AV4805, XC67566) captures a single song strophe which starts with some scratchy clucking calls and then abruptly turns into a sequence of seven strong rich flat whistles, each longer and perhaps a shade lower in pitch than the previous, the last note most obviously lower: *p'túpwupwúd'p-p'TI-WI-WII- WIII-WIIII-WIIIII-WÜÜÜÜÜ*. Another, by JAE, involves a very similar song but with the last two notes rolled throatily. Rheindt & Hutchinson (2007) also describe this song ('a clean descending melodious whistle') and present a sonogram of it. Isherwood *et al.* (1997) found that at one of their study sites (Wae Salas) 'this species was found to possess a distinct variety of the usual call', and Coates & Bishop (1997) independently mentioned two types of song (see 'Conclusion and conservation').

Taxon *flavicaudus* (Ambon)

Bonaparte (1850) gave a nugatory diagnosis of this taxon (translated from Latin: 'olivaceous green, greenish-yellow below; throat, undertail mostly strong yellow'), but his scientific name nails the only discernible plumage difference from *affinis*: in the rather small sample in NHMUK the specimens appear to have less olive markings in the rectrices than those of *affinis* and hence seem more fully yellow-tailed. White & Bruce (1986) suggested that *flavicaudus* males 'tend to be lighter and yellower dorsally and on the breast, with a deeper yellow throat', but admitted that 'it is only a slightly differentiated form'. Measurements suggest that *flavicaudus* is also marginally larger than *affinis* (Tables 1 and 2). Consequently, always accepting that a larger sample of *flavicaudus* may show all these slight differences to be inconstant, *flavicaudus* is provisionally retained here as a valid taxon, but it is clearly conspecific with *affinis*. Given the proximity and biogeographical unity of Seram and Ambon, this is hardly surprising.

Recordings of *flavicaudus* could not be found.

Taxon *mysticalis* (Buru)

Differences from *lucasi* (and by extension *chloris*) and *affinis* (including *flavicaudus*) are scored above; those from *aurea* and *platenae* are given below.

Wallace (1863) gave this taxon the name *mysticalis* (not, incidentally, *mystacalis*), meaning moustached (Jobling 2010), evidently because of its 'remarkable half-yellow gape-bristles'. This character (rictal bristles yellow basally, black distally) is not particularly striking in specimens or photographs, nor is it unique within the complex, being shared with *platenae* and to a lesser degree with other taxa which show yellow lores; but olive-lored member taxa have all-black rictal bristles). Unique to *mysticalis*, however, is the extent of olive-green on the undersides, with only vague areas on the chin and vent being distinctly shaded yellow, the rest having the merest yellow tinge (score 3). It further differs from *longirostris* (including *harterti*) by its considerably smaller size and notably shorter tail (effect size –3.62) (2); half-wedge yellow *vs* olive-green lores (2); partial yellow eye-ring (ns [2]); dark olive-grey *vs* bright yellow-fringed rectrices (3); narrow whitish *vs* narrow yellow inner fringes to tertials (ns [2])—total score 10.

A recording by F. R. Lambert (AV4147, XC 67565) consists of single nervous low clucks, with occasional higher, very rapid chatters, and three times a drawn-out, flat whistle with a very curt downward inflection at the end, *tweeeee(uh)*. These three calls also feature in recordings by JAE, but with the drawn-out whistle starting with a distinct short higher strangled tone, *tswiUUUUUU(uh)*. However, other recordings by JAE also capture a series of song-phrases, starting with hesitant staccato accelerating notes before breaking into longer, musical whistles on (sometimes greatly) varying pitches and sometimes with glissandos, somewhat reminiscent of a domestic canary: *pip up... pip-up... pipup-pipupipu WEE-WEE-WEE-puu-puu-puu-WEE-puii-PII-WEE-WEE-WEE*. Jepson (1993) reported: 'Call comprised a descending "si-si-seeow seeow seeow", and typical bulbul chattering notes'.

Taxon *longirostris* (Sula)

As the name given it by Wallace (1862b) indicates, this form is the longest-billed taxon in the complex, although *flavicaudus* runs it close, and it is altogether the largest form, with the possible exception of *aurea*. It differs from *lucasi* (and by extension *chloris*), *affinis* (including *flavicaudus*), *mysticalis*, *aurea* and *platenae* by the characters scored under those taxa. It differs little from *harterti* (see below).

Recordings of *longirostris* by ROH all contain a song that consists of a throaty, rolling *ch(a)rrrr*, rapidly repeated several times and accelerating before breaking into a loud jumble of short whistled notes, some very clear: *charrr... charrr... charrr-charrr-charrr-didlyDOOdidlyDOOdidlyDOO*; or *charrr... charrr... charrr-charrr-charrr-wididlyWAAbeDIbeDI*, etc. However, the *charrr* component may not be obligate, given the evidence under *harterti* below.

Taxon *harterti* (Peleng, Banggai)

Stresemann (1912) separated this form from *longirostris* on account of the darker olive coloration of the breast, less yellow upperparts and narrower yellow edges to the outertail. Specimens in SMTD, where 10 *harterti* are held alongside 7 *longirostris*, confirm this diagnosis; but as Eck (1976) observed, *harterti* is 'only subtly differentiated' (which is true also of its morphometrics: see Table 1) and on morphological grounds it must remain a subspecies of *longirostris*, as biogeography might predict.

Recordings by ROH reveal song-phrases similar or identical to those of *longirostris*; however, two by P. Verbelen (AV3344, 3345) are of a singer that gives several clucks and only one very brief *charrr* before launching into its song, suggesting that the *charrr* component may be a separate call that is sometimes run together with the song.

Taxon *aurea* (Togian)

While noting the morphological proximity of this form to *longirostris* (which is indeed the closest taxon in plumage and size), Walden (1872) diagnosed it on its smaller size, 'much shorter bill' and 'bright golden colouring of its plumage'. However, while a female specimen (ZMB 2000/26784) conforms in these respects, the type of this taxon, a male, actually has wing and tail longer and bill only 1.6 mm shorter than the mean for two male *longirostris* (Table 2). Both specimens are distinguished by their notably more golden-yellow underparts (2); much reduced yellow fringes to the tips and inner vanes of the rectrices (2); vague half-wedge yellow lores below a very narrow blackish-brown frontal supercilial line and notably darker olive-green crown (2); rump a shade yellower, less green (ns [1], well shown but perhaps a shade too obvious in Fishpool & Tobias 2005: 236); and presumed shorter bill (allow 1)—total score 7.

Acoustically, *aurea* seems rather close to *longirostris*/*harterti*. However, multiple recordings by ROH on different dates suggest that (a) the homologous call in *aurea* to the '*ch(a)rrr*' call of *longirostris* lacks the latter's rolling throaty quality, and (b) the short fluty babbling song is somewhat abrupt and simple in *longirostris* whereas in *aurea* it can be more protracted and typically ends with a set of very rich notes, slightly tailing off in pitch and volume, vaguely recalling the yaffling cadence of a Green Woodpecker *Picus viridis*.

Taxon *platenae* (Sangihe)

This is the most isolated, most threatened and in some ways most distinctive form in the Golden Bulbul complex. Blasius (1888), working with two syntypes (illustrated, with a photograph of one of them, in Hevers 2004), accurately characterised this bird as closest to *aurea* and *longirostris* but distinguished by its shorter bill (this is true for *longirostris* but not for *aurea*), almost entirely uniform olive-green upperparts, and vivid yellow colour of the chin, throat, submoustachial area, eye-ring and inner vanes of all five outer rectrices. Our own examination of the only three specimens in existence (SNMB N13945 and N43300, and RMNH [Naturalis] 84768) indicates that it is distinguished from all other taxa by its bright yellow triangular lores (much fuller and brighter than the yellow triangular lores of *mysticalis* against which it is here scored on this feature) extending to and contiguous with the eye-ring (2); bright yellow eye-ring, only broken by a narrow gap at the rear of the eye (much more obvious and complete than in *mysticalis*, in which it is confined to the 'brow' and a short arc on the lower rear edge) (3); yellowish ear-coverts and yellow submoustachial area, producing a broad yellow throat (ns [2]); and very broad yellow fringes to the inner vanes of the rectrices extending the length of the feathers, creating a different pattern from other taxa (2)—total score 7.

A recording by P. Verbelen (AV3347) consists of a vigorously delivered series of fairly short, simple strophes composed of little groups of repeated thrush-like whistles. Recordings of this form by ROH reveal a consistent pattern of song, comprising two short abutting components, (a) four nasal but rich notes, each rising in pitch but each lower than the previous, the last cutting to (b) usually three high whistled notes, approximately: *cui-cui-cui-cui-DEEP-pDEEP-pDEEP!* (As noted above, in structure these sounds vaguely resemble those on a recording of *T. lucasi*, but are much richer and less strangled in tone.)

CONCLUSION AND CONSERVATION

Fishpool & Tobias (2005) separated the Golden Bulbul into Northern *longirostris* (with *chloris*, *lucasi*, *harterti*, *aurea* and *platenae* as races) and Southern *affinis* (with *flavicaudus* and *mysticalis* as races) on account of their songs, the former lacking the 'long sliding notes and descending cadence' of the latter, *affinis* and *flavicaudus* possessing 'a distinctive mournful series of sweet and minor-key notes, lasting 2–4 seconds, slightly erratic or meandering in pace and note length, but essentially slow and leisurely, sliding down scale almost throughout', *mysticalis* 'vaguely similar but much more complex'—and hence a reason why Rheindt & Hutchinson (2007) recommended its separation from *affinis*. However, while Coates & Bishop (1997) support the account of the voice of *affinis* ('main song... a lovely descending series of *c.* 15 short, clear, mellow whistles... slightly slurred as the song dies away') they also mention a second song type, 'a rapidly swelling series of 20–30 pure, high-pitched whistled notes that climbs to a notably high pitch and ends abruptly'. Moreover, the clear resemblance of songs of *chloris* and *affinis* tends to confound the notion of a north-south divide in song types. This all suggests that the vocalisations of the taxa in this complex may be considerably more varied but also perhaps ultimately more homologous than we yet know, and that the sample used in descriptions above should not be considered anything more than partially representative.

Even so, from the very limited material available to us we derive the impression that vocal differences largely support the seven-way split of the Golden Bulbul complex which the morphological evidence indicates, using the scoring system of Tobias *et al.* (2010):

- Halmahera Golden Bulbul *Thapsinillas chloris*
  - Morotai, Halmahera, Bacan
- Obi Golden Bulbul *Thapsinillas lucasi*
  - Obi
- Seram Golden Bulbul *Thapsinillas affinis*
  - *T. a. affinis* Seram
  - *T. a. flavicaudus* Ambon
- Buru Golden Bulbul *Thapsinillas mysticalis*
  - Buru
- Sula Golden Bulbul *Thapsinillas longirostris*
  - *T. l. longirostris* Sula
  - *T. l. harterti* Peleng, Banggai
- Togian Golden Bulbul *Thapsinillas aurea*
  - Togian Islands
- Sangihe Golden Bulbul *Thapsinillas platenae*
  - Sangihe

The conservation status of these seven species will require formal assessment against the IUCN Red List criteria, but a few preliminary remarks may be made here. From evidence in Fishpool & Tobias (2005), our own observations in the field (JAE and ROH) and material cited below, the first six species in the list above are relatively common in their various woodland/forest habitats. Poulsen & Lambert (2000) tabulated records of *chloris* (Halmahera) indicating a high encounter rate, with birds found (albeit less commonly) even in mangrove. Linsley (1995) saw *lucasi* (Obi) in 'small numbers (less than ten)... daily', with two instances of breeding evidence 'in scrub on the edge of disturbed forest'. Bowler & Taylor (1989) reported *affinis* (Seram) 'common and widespread... in forested areas' from sea-level up to c.900 m, while JAE saw them up to at least 1,300 m; Isherwood *et al.* (1997) also found the species common. Jepson (1993) called *mysticalis* (Buru) 'common and widespread... in all types of forest' (confirmed in Poulsen & Lambert 2000, and by JAE, ROH pers. obs.). Stones *et al.* (1997) found *longirostris* (Sula, specifically Taliabu) 'abundant at each study site, in all habitat types surveyed, but most common in primary forest, both lowland and montane' (confirmed by JAE, ROH pers. obs.), while Indrawan *et al.* (1997) reported *harterti* (Peleng) as 'commonly seen' in 'groups of three to four birds... in degraded forest at Monggias' (confirmed by JAE, ROH pers. obs.). Coates & Bishop (1997) were concerned that *aurea* (Togian Islands) was 'apparently rare and local', but Indrawan *et al.* (2006) documented records from three of the seven larger islands in the group, finding it 'relatively frequently' on Togian itself and 'relatively common' on Walea Bahi (confirmed by ROH pers. obs., and J. Riley *in litt.* 2013).

The status of *platenae* (Sangihe) is, however, worrying. Although Bishop (1992) observed it 'commonly in secondary woodland and mixed tree crop plantations' during a visit over 16–19 May 1986, others have not been able to repeat this finding (Riley 1997a,b). A year before, on 30 May 1985, a male specimen (RMNH 84768) was collected on Gunung (Gn) Sahendaruman in 'primary forest on eastern slope: 750 m: S of Liwung and SW of Kuma' (Naturalis label data) by F. G. and C. M. Rozendaal, but it took until November 1996 before the species was seen again, with records of three birds twice and one bird once on three days, all evidently in the same area on Gn Sahengbalira (Riley 1997b). These records were the only ones in four months' fieldwork in 1995 and 1996, when the only local people to recognise photographs of the species (presumably from museum skins) were 'in the village closest to the forest on Gunung Sahengbalira' (Riley 1997b). Further fieldwork on Sangihe between August 1998 and March 1999 led Riley (2002) to suggest that *platenae* 'is one of the island's most endangered species', being found only on Gn Sahendaruman with an estimated population of 50–230 birds. However, he noted that it was missed at one locality when not calling but found to be common there when it became vocal (Riley 2002), thereby confirming an earlier remark that 'this can be a cryptic species, despite its bright coloration' (Riley 1997b). Even so, visits to its small fragment of remaining habitat on Gn Sahengbalira in recent years have not produced any evidence to revise the view that this species is in trouble: JAE and ROH found four birds in August 2004, although a subsequent visit over two days in 2012 by ROH failed to record any. Of other observers visiting the area this century, P. Verbelen saw several in November 2008 but B. Demeulemeester, P. Gregory, J. Hornbuckle, C. Robson and M. Thibault (*in litt.* or verbally to JAE, ROH) all failed to find it. Consequently, we judge that the Sangihe Golden Bulbul now requires urgent attention in order to secure its future.

Clearly it would be valuable if this new arrangement of *Thapsinillas* were to be tested and corroborated by molecular study. Such work might also reveal the biogeographic history and colonisation routes of the taxa across this unusual range (which no other species or genus shares). Moreover, a far more comprehensive sampling of vocalisations would also be of great interest, in part simply to determine the variation within individual taxa, in part to assess more confidently the degree of difference between taxa, and in part to test whether such differences correspond to the hoped-for molecular evidence.

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***N. J. COLLAR**, BirdLife International, Wellbrook Court, Girton Road, Cambridge CB3 0NA, UK; and Bird Group, Department of Life Sciences, Natural History Museum, Akeman St, Tring, Herts HP23 6AP, UK. Email: nigel.collar@birdlife.org*

***J. A. EATON**, A-3A-5 Casa Indah I, Persiaran Surian, Petaling Jaya, Selangor, 47410, Malaysia. Email: jameseaton@birdtourasia.com*

***R. O. HUTCHINSON**, 26 Sutton Avenue, Chellaston, Derby DE73 6RJ, UK. Email: robhutchinson@birdtourasia.com*

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Birds of Mys Shmidta, north Chukotka, Russia

VLADIMIR YU. ARKHIPOV, TOM NOAH, STEFFEN KOSCHKAR & FYODOR A. KONDRASHOV

A survey of avifauna was carried out in the Mys Shmidta area, north Chukotka, Russia from 8 June to 12 July 2011. A total of 90 species was recorded in the area, which together with literature data made a final list of 104 species. For several species this area is beyond the northern, north-eastern or north-western limits of their known distribution. We collected new data for 19 globally or locally threatened species. Tundra Swan *Cygnus columbianus*, Emperor Goose *Anser canagica*, American Golden Plover *Pluvialis dominica*, Western Sandpiper *Calidris mauri*, Semipalmated Sandpiper *C. pusilla*, Northern House Martin *Delichon urbica* and Barn Swallow *Hirundo rustica* were all confirmed to be breeding. Breeding of Brent Goose *Branta bernicla nigricans*, Spectacled Eider *Somateria fischeri* and Steller's Eider *Polysticta stelleri* was judged to be 'very likely'. There was no evidence for breeding of Ross's Gull *Rhodostethia rosea* despite several records. Two Eurasian Dotterels *Eudromias morinellus* were recorded displaying for the first time in the area, but the status of the species is unclear. The area is important for Snowy Owl *Nyctea scandiaca*, and as moulting grounds for Emperor Goose. Canada Goose *Branta canadensis*, Baikal Teal *Anas formosa*, Bar-tailed Godwit *Limosa lapponica*, Slaty-backed Gull *Larus schistisagus*, Thayer's Gull *L. thayeri*, Black-headed Gull *L. ridibundus*, White-tailed Eagle *Haliaeetus albicilla*, Steller's Sea Eagle *H. pelagicus*, Osprey *Pandion haliaetus*, Arctic Warbler *Phylloscopus borealis* and House Sparrow *Passer domesticus* are more likely to be rare vagrants or migrants. An observation of a Pine Siskin *Carduelis pinus* is the first record for Eurasia.

INTRODUCTION

Mys Shmidta or the Cape of Shmidt is a prominent headland on the Arctic coast of Chukotka, Russia. It is a remote place with a very harsh climate. Information on birds from this area is difficult to obtain but has inherent value because several globally or locally threatened species breed here and human impact on the habitat has been small. No systematic checklist of birds of the area has been made until now.

Since Portenko (1972, 1973) worked on the birds of the Chukchi Peninsula, few ornithological papers have been published on the region and no avifauna surveys have been made. Existing publications include a short note by Tomkovich *et al.* (1991) on the area around Mys Shmidta airport, several notes by Stishov (1991, 1992, 1997) including one on the bird community of the Ekvyvatap river, two papers by Stishov & Maryuhnich (1991a, b) on particular species and short communications on brief visits by Andreev & Kondratyev (1996), Dorogoi (1996, 1997, 1998), Dorogoi & Beaman (1998) and Menyushina (2000).

In this paper the results of an avifauna survey carried out in the Mys Shmidta area, north Chukotka, Russia, in summer 2011 are presented. Together with data from the literature the final list of birds for the area is 104 species. The purpose of the investigation was to survey this area for potential breeding grounds and suitable habitats for the Spoon-billed Sandpiper *Eurynorhynchus pygmeus* and to document the avifauna of this remote and hard-to-reach region, which had previously received little ornithological attention.

STUDY AREA AND METHODS

During an ornithological expedition to the Mys Shmidta area between 8 June and 12 July 2011 to survey breeding areas of the Spoon-billed Sandpiper, the other avifauna was also surveyed. Birds were identified mainly using binoculars and telescopes, and the species, number of individuals and habitat was noted in each case. Overall, research was focused on the Akatan lagoon and the Ekvyvatap river delta, plus as much of the Kosa Dvukh Pilotov Spit (Spit of Two Pilots) as could be accessed on foot or by kayak, the area immediately surrounding Mys Shmidta settlement and an area to the north-west of Mys Shmidta around the Erokynmanky lagoon (Table 1). There were four main habitat types in the area: gravel-sand, tussock tundra, grassy tundra and polygonal tundra. The spits running north-west to south-east were mainly gravel and sand, either pure gravel-sand or only sparsely covered with lichens and grass, at least on the main narrow sections running immediately parallel to the ocean. About 60% of the spits visited were covered by this type of vegetation. The higher ground on the spits and the areas around the lagoons were generally cotton-grass tussock tundra, and grassy tundra was found on lowlands surrounding the spits, which were still flooded until almost the end of June, being frequented by different species of geese. Dried polygonal tundra was found in patches around the Ekvyvatap river delta. Small hills around the settlement were covered by typical tussock tundra.

The temperature in the region is generally cold; the highest temperature experienced during the day was 14°C and the typical daytime temperature was 5–7°C. Storms were frequent, with a week-long storm in the first week of July with strong winds and heavy snow.

Table 1. Main survey sites in the Mys Shmidta, north Chukotka area, 2011.

Site	Coordinates
Mys Shmidta, airport area	68.872°N 179.386°W
Mys Shmidta, Kozhevikova cliff	68.931°N 179.490°W
Mys Shmidta, sea coast	68.902°N 179.425°W
Mys Shmidta, base of Kosa Dvukh Pilotov spit	68.872°N 179.358°W
Mys Shmidta, settlement	68.890°N 179.409°W
Tundra near Ryrkaypiy settlement	68.896°N 179.458°W
Tundra near Mys Shmidta settlement	68.889°N 179.431°W
Ekvyvatap River Delta & nearby tundra	68.783°N 178.991°W
Akatan lagoon & Kosa Dvukh Pilotov spit	68.753°N 178.983°W
Akatan lagoon mouth, Kosa Dvukh Pilotov spit	68.780°N 178.956°W
Tynkergynpil'gyn lagoon, Kosa Dvukh Pilotov spit	68.683°N 178.689°W
Tynkergynpil'gyn lagoon mouth, Kosa Dvukh Pilotov spit	68.573°N 178.449°W
Erokynmanky lagoon, coast	68.951°N 179.918°E
Erokynmanky lagoon, Odnobokiy stream	68.969°N 179.949°E
Erokynmanky lagoon, Nutechikun spit	68.992°N 179.925°E
Erokynmanky lagoon, tundra	68.944°N 179.986°E
Erokynmanky lagoon, hills	68.903°N 179.867°E

RESULTS

Ninety species were recorded in the area which together with literature data yielded a final list of 104 species (Appendix 1). Details of the most interesting and significant are given below, including new records, new breeding records, regional rarities and globally threatened species.

Whooper Swan *Cygnus cygnus*

Two records: one across the Akatan lagoon on 18 June was pursued by a Tundra Swan that appeared to strike it on the head and neck. Another Whooper Swan stayed near a tundra lake with a Tundra Swan on 23 and 24 June, in the Ekvyvatap delta. Images were obtained as these records are far to the north of known nesting areas (Krechmar & Kondrat'ev 2006).

Tundra Swan *Cygnus columbianus*

A common breeding species around Mys Shmidta: six nesting pairs within 25 km^2 were recorded in the Ekvyvatap delta tundra. Some non-breeding pairs were also recorded, but no large groups were seen. A considerable number of birds had a mix of traits attributable to *Cygnus columbianus bewickii* or *C. c. columbianus*; some individuals that could be reliably identified as either *bewickii* or *columbianus* belonged to mixed pairs. Of note, in all such mixed pairs the males appeared to possess *columbianus* traits. Possibly the study area is located in the area of overlap of the two forms (Rees 2006). Overall three nests with eggs were found: a nest in the Ekvyvatap River delta with one egg on 14 June and three eggs on 19 June; a nest in the same area found on 23 June but not checked for eggs; and a nest with three eggs found on 7 July on the Nutechikun spit.

Snow Goose *Anser caerulescens*

Breeding was not recorded. From 9 to 28 June Snow Geese were seen regularly with a maximum of 64 birds in several flocks on 13 June in the mouth of the Ekvyvatap River and 60 birds in four flocks on 14 June; all flocks were flying north-west. All observed individuals belonged to the white morph. Residents of Mys Shmidta reported that there is a pronounced autumn migration, occasionally reaching thousands of birds per day. Three Snow Geese rings were obtained from local hunters; two individuals, a male and a female, had been ringed as adults on Wrangel Island and one male as a juvenile in Alaska, 45 km east of Deadhorse.

Emperor Goose *Anser canagica*

Near Threatened. Common breeding species in the Ekvyvatap delta and surrounding area. We observed several pairs holding territories, including one chasing away a Parasitic Skua *Stercorarius parasiticus*. A nest with three eggs was found in the Ekvyvatap delta on 14 June and a second nest was found nearby on 26 June. A pronounced migration of Emperor Geese to the north-west of Mys Shmidta was observed from 17 to 29 June. A maximum of 1,670 flew north-west between 10h00 and 16h00 on 27 June. It appears that this species is expanding its range westwards, as it was not observed in the vicinity of Mys Shmidta in the early twentieth century, but by 1970 it was breeding to the west of Ukouge lagoon (Portenko 1972) about 100 km south-east of the eastern part of the surveyed area. Hunters handed over a ring from a male bird collected at nearby Ryrkaypiy settlement; the bird had been ringed as an adult in Alaska 37 km south-east of Chevak.

Canada Goose *Branta canadensis*

A solitary Canada Goose was observed on 19 and 20 June in the Ekvyvatap delta. It was flying with two Greater White-fronted Geese *Anser albifrons* and was slightly larger than them. Judging by several traits, such as the relatively short bill and neck, it may be the *parvipes* subspecies, common in northern Alaska. It appears that this is the first record of this form in Russia, apart from the introduced population in Eurasia (Koblik *et al.* 2006). Prior to this observation there was only one record of a wild Canada Goose in East Asia, seen on Hokkaido, Japan, in 2006, which was also presumed to be a *parvipes* form (Brazil 2009). The form *minima* was also observed in the vicinity of Anadyr airport in Chukotka. A solitary bird was seen in a flock of Brent Geese on a lagoon near the airport from 3 to 5 June 2011. Images of both birds were obtained.

Brent Goose *Branta bernicla*

Observed daily from 9 to 27 June in flocks and pairs in the Ekvyvatap delta and nearby on the Akatan lagoon with up to 143 birds on 17 June. On 11 June one pair was observed to be possibly breeding, but the birds were not seen on subsequent days. However, breeding is possible, as sporadic breeding pairs were observed in the first half of the twentieth century in the vicinity of Mys Shmidta (Portenko 1972). This species is commonly hunted by the local population; in the late 1990s one female shot in the vicinity of Polyarniy settlement had been ringed as a juvenile in Alaska, 20 km to the south of Chevak.

Baikal Teal *Anas formosa*

A single male was swimming on a lake near Mys Shmidta on 21 June. The area is outside the current breeding range (Krechmar & Kondrat'ev 2006), although in the first half of the twentieth century the species was observed in the area relatively frequently (Portenko 1972).

Spectacled Eider *Somateria fischeri*

Uncommon, possibly breeding in the tundra near the sea. Three pairs were observed on 26 June on lakes in the Ekvyvatap delta. Overall it was observed on 12 days with a maximum daily count of 32; all were flying to the north-west on 16 June, and 30 birds, mostly young males, were observed on the sea near Mys Shmidta on 10 July. Stishov (1992) found the species to be common on lakes and bogs around the lower reaches of the Ekvyvatap River.

Steller's Eider *Polysticta stelleri*

Vulnerable. Common to uncommon at the time of migration. Possibly breeding in the tundra on coastal lakes. Four pairs were holding territories on 14 June in Ekvyvatap delta. The species was regularly seen in the vicinity of Mys Shmidta, with a maximum of 60 birds, including some pairs, on 9 June. Unfortunately the species, which is Vulnerable, is hunted in the area; eight rings were collected from individuals shot near Mys Shmidta; all had been ringed in Alaska.

Bar-tailed Godwit *Limosa lapponica*

Vagrant; only one record of a female feeding on tundra near the Ekvyvatap delta on 26 June. It is also a rare vagrant to Wrangel Island (Stishov *et al.* 1991).

Red Knot *Calidris canutus*

Seven observations were made, all on the sand spits or mudflats nearby: flocks of nine and five birds on 11 and 14 June on mudflats near the mouth of the Akatan lagoon; three flew north across the Akatan lagoon in the direction of Wrangel Island on 18 June; two were in tundra on the Spit of Tynkergynpil'gyn lagoon on 20 June with two more 1.5 km away; in the same area on 21 June a bird was resting and also in the same area two birds were seen on 22 June; finally on 27 June three birds were in tundra on the spit of Akatan lagoon. Although most records were made on lichen tundra—suitable breeding habitat—displays were not seen or heard. Three individuals had colour flags and had been ringed in Australia—two with yellow flags in north-west Australia, and one with a green flag at Moreton Bay, near Brisbane, Queensland.

Western Sandpiper *Calidris mauri*

Late arrivals; during the first survey on 14 June in Ekvyvatap delta no more than five displaying males were seen, and on the following days, several other birds appeared in nearby areas. Two breeding areas were found near Mys Shmidta. The first included 10 territories on the Ekvyvatap delta tundra, where a nest with four eggs was found on 25 June. The second area was to the north-west of Mys Shmidta on the Nutechikun spit, where a nest with four eggs was found on 7 July.

Spoon-billed Sandpiper *Eurynorhynchus pygmeus*

Critically Endangered. During the surveys the species was not recorded. However, the expedition found suitable habitat in the region, although limited in extent, and obtained invaluable information on the habitat in the area. The last record of this species in the area was in mid-June 1990 when several displaying males and at least two pairs were found in the Ekvyvatap delta (Stishov & Maryuhnich 1991a). In the 1970s Kishchinski (1988) found it to be a common breeder at the Ukouge lagoon about 100 km south-east of the eastern part of the area surveyed.

Semipalmated Sandpiper *Calidris pusilla*

Near Threatened. A rare breeding species in Eurasia, it was found nesting in areas with sparse vegetation on gravel and sandy patches of the tundra near lagoons. Breeding was recorded in two areas: Ekvyvatap delta (2–3 territories) and in the vicinity of Mys Shmidta, where on 9–11 June up to 10 males were displaying. A brood with four two-day-old chicks was observed on 25 June on the edge of the town. On 28 and 29 June in the vicinity of Mys Shmidta three more broods were observed and one pair was making alarm calls.

The first nest of this species in this area was found on 8 June 1993 near the Mys Shmidta airport (Andreev & Kondratyev 1996). In 1997 at least three pairs were breeding between the airport and the town; a nest at an advanced stage of incubation found on 1 July 1997, and on 4 July 1997 the same nest already had chicks. Two more nests with chicks were observed nearby on the same day, and one pair was observed between the airport and the town on 6 July 1997 (Dorogoi & Beaman 1998). Thus, the population of the Semipalmated Sandpiper in the vicinity of Mys Shmidta continues to thrive and, possibly, is growing slightly.

American Golden Plover *Pluvialis dominicus*

One territorial pair near a nest with a clutch of four eggs was found in the Ekvyvatap delta, with observations continuing between 23 June and 25 June. Images of adults and nest were obtained. This is the first documented breeding record in the Palearctic with both birds confirmed as American Golden Plovers. Prior to this observation an unsuccessful breeding attempt by an American Golden Plover with a Grey Plover *Pluvialis squatarola* was reported (Taldenkov 2006). In 1987–1990 on the lower reaches of the Ekvyvatap River about 30% of plovers had traits that resembled American Golden Plovers (Stishov 1991) and the same author mentioned breeding of the American Golden Plover in the same area in 1990–1993 without further details (Stishov 2004).

Eurasian Dotterel *Eudromias morinellus*

Three records in 2011. A solitary bird was displaying over the Ekvyvatap delta tundra on 14 June. On 15 June in the same area two displaying birds were seen about 1 km from each other, but during later surveys in this area the species was not seen. On a flat hilltop near the Odnobokiy stream a flock of nine was seen on 2 July. This species is regarded as rare since prior to our observations it was reported in Chukotka only once since 2000 (Tomkovich 2007a; P.S. Tomkovich *in litt.*). Records of Eurasian Dotterels near Mys Shmidta are contained in reports on breeding tundra birds in Russia (Dorogoi 1996, 1997).

Thayer's Gull *Larus thayeri*

On 17 June, one bird was resting on the ice of Akatan lagoon with Vega Gulls *Larus vegae*. The bird was about a third smaller than the Vega Gulls. This is the third record of Thayer's Gull for Russia.

Black-headed Gull *Larus ridibundus*

Vagrant. On 18 June a bird in second-summer plumage was seen near the mouth of the Akatan lagoon and on 20 June two adult birds were swimming in a small bay near Kozhevnikova Cliff.

Ross's Gull *Rhodostethia rosea*

A summer visitor and migrant. Over 10 days between 10 June and 25 June juvenile and adult Ross's Gull were observed at the confluence of the Akatan lagoon with up to eight birds on 11 June.

Common Murre *Uria aalge* or Thick-billed Murre *U. lomvia*

We observed seven murres flying north-west over the sea on 10 July, but unfortunately too far away for definitive identification to species level. The predominant species on Wrangel Island is Thick-billed Murre, but several hundred Common Murre also breed there (Stishov *et al.* 1991).

Osprey *Pandion haliaetus*

On 3 July an Osprey was seen attempting unsuccessfully to catch fish on Erokynmanky lagoon. Images were obtained. This is the most north-easterly record of the species in Eurasia and approximately 600 km from its known breeding range (Chereshnev 2008).

White-tailed Eagle *Haliaeetus albicilla*

The Mys Shmidta area is about 500 km from the known breeding range of the White-tailed Eagle (Chereshnev 2008). In June 2011 there were three records of White-tailed Eagles: a subadult was sitting on the sea ice in the mouth of Akatan lagoon on 13 June, an adult was seen in the mouth of Tynkergynpil'gyn lagoon on 23 June, and a first-year was flying along Two Pilot Spit on 27 June.

Steller's Sea Eagle *Haliaeetus pelagicus*

Vulnerable. An adult was observed on 27 June on the sea ice in the mouth of Akatan lagoon, and images were obtained; after about 10 minutes, the bird flew away to the north-west. This is the northernmost record of Steller's Sea Eagle in Asia (BirdLife International 2001, Chereshnev 2008).

Barn Swallow *Hirundo rustica*

Two pairs of Barn Swallows were regularly observed in the settlements of Mys Shmidta and Ryrkaypiy. The pair in Mys Shmidta was nest building on 29 June inside an abandoned house. After the severe weather in early July, the nest was empty and birds were not seen again. One and two Barn Swallows were seen on 12 and 17 June respectively, on the spit near the mouth of the Atakan lagoon. Most of these records were of white-bellied birds. However, in Mys Shmidta settlement birds with bright red bellies were recorded alongside the white-bellied form: one bird on 8 June and two on 29 June, it is possible that these birds were the American subspecies *H. r. erythrogaster*. Unfortunately all observations of red-bellied birds were too brief for identification to subspecies to be confirmed.

Northern House Martin *Delichon urbica*

Breeding species in Mys Shmidta settlement. Nine nests were found on two four-storey buildings in June 2011. Following the severe storm at the beginning of July only two nests were still occupied. This record is the most north-easterly breeding record of this species in Eurasia.

House Sparrow *Passer domesticus*

Vagrant. On 17 June, an adult male was seen on Kosa Dvukh Pilotov Spit near an abandoned hut; an hour later it was seen again near another abandoned hut about 3 km to the east. The closest breeding location is Pevek where breeding was reported in previous years (Tomkovich 2007b) and at least 10 families with broods were seen there on 13 July 2011.

Pine Siskin *Carduelis pinus*

On 9 and 10 June 2011 we found a Pine Siskin on a sandy gravel spit near Mys Shmidta (68.872°N 179.358°W). The bird was not shy and it was possible to approach to a few metres and images were obtained. This is the first documented record for Russia and Eurasia (Arkhipov *et al.* in press).

DISCUSSION

During the 2011 expedition to northern Chukotka 90 species were recorded, 30 of which were first records for the wider region. Overall, this confirms the paucity of previous studies of this area. Including additional data from the literature, a total of 104 species has been recorded for the region indicating a relatively complete list in comparison with nearby areas. Near Pevek town 75 species have been recorded (Tomkovich 2007b) and 152 species have been found on Wrangel Island (Stishov *et al.* 1991). Nevertheless, the list may be far from exhaustive and be expanded by subsequent visitors, especially in respect of migrant birds. Northern House Martin and Barn Swallow were recorded attempting to breed around the settlements; these species had never previously been recorded breeding this far to the north-east.

Breeding of several other species on the borders of their known western or north-western breeding range was recorded: Emperor Goose, American Golden Plover, Western Sandpiper and Semipalmated Sandpiper. Several other rare or endangered species were observed that were suspected to be breeding but without direct evidence, including two displaying Eurasian Dotterels and many Snowy Owls *Nyctea scandiaca*, with up to 13 individuals recorded per day. Emperor Geese moult in the area and a maximum day count of 1,670 was recorded. Finally, several species were observed which may be migrants, including Canada Goose, Baikal Teal, Bar-tailed Godwit, Slaty-backed Gull *Larus schistisagus*, Thayer's Gull, Black-headed Gull, White-tailed Eagle, Steller's Sea Eagle, Osprey, Arctic Warbler *Phylloscopus borealis* and House Sparrow. An observation of Pine Siskin is the first record for Eurasia.

Disappointingly, in 2011 neither the Critically Endangered Spoon-billed Sandpiper nor the Near Threatened Yellow-billed Loon *Gavia adamsii*, both of which have been recorded in the area in previous years, were seen.

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***Vladimir Yu. ARKHIPOV**, Institute of Theoretical and Experimental Biophysics RAS, Pushchino, Moscow 142290, Russia; State Nature Reserve Rdeysky, Kholm, Novgorod 175270, Russia. Email: v.arkhipov@rambler.ru*

***Tom NOAH**, Bergstr.14 D - 15910 Schlepzig, Germany. Email: tomnoah@t-online.de*

***Steffen KOSCHKAR**, Liebigstraße 91, D-35392, D-Gießen, Germany. Email: fasciolata@web.de*

***Fyodor A. KONDRASHOV**, Bioinformatics and Genomics Programme, Centre for Genomic Regulation, Dr. Aiguader 88, Barcelona, 08003 Spain; Universitat Pompeu Fabra (UPF), 08003 Barcelona, Spain; Institució Catalana de Recerca i Estudis Avançats (ICREA), 23 Pg. Lluís Companys, 08010 Barcelona, Spain. Email: Fyodor.Kondrashov@crg.eu*

Appendix

Annotated checklist of birds recorded in Mys Shmidta area

*Indicates a species not recorded during surveys and added from the literature.

Status: R=Resident, P=Passage, S=Summer visitor, B=Breeder, B? = Possible breeder, V=Vagrant, U=Unclear, (Lit) indicates status according to the literature.

Species	Status	Previous records
*Willow Ptarmigan *Lagapus lagapus*	R (Lit)	7, 16
Rock Ptarmigan *Lagapus mutus*	R	7
Whooper Swan *Cygnus cygnus*	U	First record
Tundra Swan *Cygnus calumbianus*	B	9
Bean Goose *Anser fabalis*	P	7
Greater White-fronted Goose *Anser albifrans*	PB	7, 10, 16
Snow Goose *Anser caerulescens*	P	7, 16
Emperor Goose *Anser canagica*	PB	First record
Canada Goose *Branta canadensis*	V	First record
Brent Goose *Branta bernicla*	P B?	7
Northern Pintail *Anas acuta*	PB	7, 10
Baikal Teal *Anas farmasa*	P	7
Common Teal *Anas crecca*	P	First record
Greater Scaup *Aythya marila*	PB?	7
Common Eider *Samateria mallissima*	PB	7, 10, 16
King Eider *Samateria spectabilis*	PB?	7, 10
Spectacled Eider *Samateria fischeri*	PB?	10
Steller's Eider *Palysticta stelleri*	P	7
Harlequin Duck *Histrianicus histrianicus*	P	First record
Long-tailed Duck *Clangula hyemalis*	PB	7, 10, 16
Black Scoter *Melanitta nigra americana*	P	First record
White-winged Scoter *Melanitta fusca steinegeri*	P	First record
Red-breasted Merganser *Mergus serratar*	P	First record
Snowy Owl *Nyctea scandiaca*	R	4, 6, 8, 11
Short-eared Owl *Asia flammeus*	PB?	8
Sandhill Crane *Grus canadensis*	PB	7, 10, 16
Common Snipe *Gallinaga gallinaga*	PB	3, 4, 10
Bar-tailed Godwit *Limasa lappanica*	V	First record
*Spotted Redshank *Tringa erythrapus*	V (Lit)	2, 3
Wood Sandpiper *Tringa glareala*	V	16
*Terek Sandpiper *Xenus cinereus*	PB? (Lit)	9
*Grey-tailed Tattler *Heterascelus brevipes*	V (Lit)	7
Ruddy Turnstone *Arenaria interpres*	PB	3, 4, 10, 16
Long-billed Dowitcher *Limnadramus scalapaceus*	PB	10
Great Knot *Calidris tenuirastris*	V	First record
Red Knot *Calidris canutus*	PB?	First record
Western Sandpiper *Calidris mauri*	PB	First record
*Spoon-billed Sandpiper *Eurynarhynchus pygmeus*	PB? (Lit)	9, 13
Little Stint *Calidris minuta*	PB?	9
Red-necked Stint *Calidris ruficallis*	PB	2, 3, 4, 7, 9, 15, 16
Temminck's Stint *Calidris temminckii*	PB	4, 15, 16
Semipalmated Sandpiper *Calidris pusilla*	PB	1, 5
*Baird's Sandpiper *Calidris bairdii*	PB? (Lit)	10
Pectoral Sandpiper *Calidris melanatas*	PB	3, 4, 7, 10
*Sharp-tailed Sandpiper *Calidris acuminata*	V (Lit)	7
Dunlin *Calidris alpina*	PB	3, 4, 10, 16
*Curlew Sandpiper *Calidris ferruginea*	P (Lit)	3, 16
Buff-breasted Sandpiper *Tryngites subruficallis*	PB	9, 10, 14
Ruff *Philamachus pugnax*	PB	2, 3, 10
Red-necked Phalarope *Phalarapus labatus*	PB	3, 4, 10, 15
Red Phalarope *Phalarapus fulicaria*	PB	3, 7, 10
Pacific Golden Plover *Pluvialis fulva*	PB	7, 9, 10, 16
American Golden Plover *Pluvialis daminicus*	PB	9, 12
Grey Plover *Pluvialis squatarala*	PB	10, 16
Common Ringed Plover *Charadrius hiaticula*	PB	4, 7, 10, 16
*Semipalmated Plover *Charadrius semipalmatus*	PB? (Lit)	12

Species	Status	Previous records
Eurasian Dotterel *Eudramias marinellus*	PB?	2, 3
Pomarine Skua *Stercorarius pamarinus*	PB	4, 8, 10, 15
Parasitic Skua *Stercorarius parasiticus*	PB	2, 4, 8, 10
Long-tailed Skua *Stercorarius langicaudus*	PB	2, 4, 8, 10
Mew Gull *Larus canus*	PS	First record
Glaucous Gull *Larus hyperbareus*	PB	8, 10, 16
Slaty-backed Gull *Larus schistisagus*	V	First record
Vega Gull *Larus vegae*	PB	8, 10, 16
Thayer's Gull *Larus thayeri*	V	First record
Black-headed Gull *Larus ridibundus*	V	16
Ross's Gull *Rhadastethia rasea*	PS	8
*Sabine's Gull *Xema sabini*	P (Lit)	8
Black-legged Kittiwake *Rissa tridactyla*	PB?	8
Arctic Tern *Sterna paradisaea*	PB	8
Common Murre *Uria aalge* or Thick-billed Murre *U. lamvia*	PS	First record
Black Guillemot *Cepphus grylle*	PB	8
Osprey *Pandian haliaetus*	V	First record
White-tailed Eagle *Haliaeetus albicilla*	V	First record
Steller's Sea Eagle *Haliaeetus pelagicus*	V	First record
Rough-legged Buzzard *Butea lagapus*	PB	2
Merlin *Falca calumbarius*	U	First record
*Gyrfalcon *Falca rusticalus*	U (Lit)	7
Peregrine Falcon *Falca peregrinus*	PB?	First record
Pelagic Cormorant *Phalacracarax pelagicus*	PB	7
Red-throated Loon *Gavia stellata*	PB	7, 10
Black-throated Loon *Gavia arctica*	PB	7, 10
Pacific Loon *Gavia pacifica*	PB	7, 10
*Yellow-billed Loon *Gavia adamsii*	U (Lit)	7
Common Raven *Carvus carax*	PB	8
*Grey-cheeked Thrush *Catharus minimus*	V (Lit)	8
*Dusky Thrush *Turdus naumanni*	V (Lit)	16
Bluethroat *Luscinia svecica*	P	16
Northern Wheatear *Oenanthe aenanthe*	PB	10, 16
Barn Swallow *Hirunda rustica*	PB	First record
Northern House Martin *Delichan urbica*	PB	First record
Arctic Warbler *Phyllascapus barealis*	P	First record
Horned Lark *Eremaphila alpestris*	U	First record
House Sparrow *Passer damesticus*	V	First record
White Wagtail *Matacilla alba*	PB	8, 10
Yellow Wagtail *Matacilla flava tschutschensis*	PB	8, 16
Red-throated Pipit *Anthus cervinus*	PB	10, 16
Pine Siskin *Carduelis pinus*	V	First record
Hoary Redpoll *Carduelis harnemanni*	PB	8, 10, 16
Common Redpoll *Carduelis flammea*	V	First record
Little Bunting *Emberiza pusilla*	V	First record
Pallas's Bunting *Emberiza pallasi*	V	First record
Lapland Longspur *Calcarius lappanicus*	PB	8, 10, 16
Snow Bunting *Plectraphenax nivalis*	PB	8, 10, 16

Previous records: 1: Andreev & Kondratyev (1996), 2: Dorogoi (1996), 3: Dorogoi (1997), 4: Dorogoi (1998), 5: Dorogoi & Beaman (1998), 6: Menyushina (2000), 7: Portenko (1972), 8: Portenko (1973), 9: Stishov (1991), 10: Stishov (1992), 11: Stishov (1997), 12: Stishov (2004), 13: Stishov & Maryuhnich (1991a), 14: Stishov & Maryuhnich (1991b), 15: Tomkovich (1998), 16: Tomkovich *et al.* (1991)

Species limits within *Rhopophilus pekinensis*

PAUL J. LEADER, GEOFF J. CAREY & PAUL I. HOLT

Rhopophilus pekinensis is a passerine endemic to north-east Asia occurring primarily in China; two or three subspecies are variously recognised. A review of museum material and fieldwork on the breeding grounds indicates that only two taxa (_R. p. pekinensis_ and _R. p. albosuperciliaris_) are valid, and using criteria that grade morphological and vocal differences between allopatric taxa (Tobias _et al._ 2010), both achieve the threshold for species status. The English names Beijing Babbler and Tarim Babbler are proposed reflecting both the type location of each and the recently elucidated taxonomic affinities of _Rhopophilus_.

INTRODUCTION

The White-browed Chinese Warbler *Rhopophilus pekinensis* is a passerine endemic to north-east Asia, occurring from north-west China to north-east China and North (and previously also South) Korea (Cheng 1987, Dickinson 2003, Duckworth & Moores 2008, Brazil 2009, Moores *et al.* 2009, BirdLife International 2013a). Whilst placed in the family Cisticolidae (Dickinson 2003), it was included in the Timaliidae, in a clade with *Sylvia* and *Paradoxornis*, by Alström *et al.* (2006), based on myoglobin and cytochrome *b* sequence data. In light of this, it was placed within the Timaliidae by Collar & Robson (2007) and Gill & Donsker (2012), using the English name Chinese Bush-dweller to reflect the fact that it was no longer considered a warbler. Subsequently Gelang *et al.* (2009) and Moyle *et al.* (2012) proposed treatment of the Sylviidae (which includes *Rhopophilus*) as a family rather than a subfamily within the Timaliidae.

Most authorities (Cheng 1987, Dickinson 2003, Zheng 2011, Gill & Donsker 2012) recognise three subspecies: *pekinensis* (eastern part of the range, type locality Beijing, China), *leptorhynchus* (central part of the range, type locality Gansu, China) and *albosuperciliaris* (western part of the range, type locality Xinjiang, China). The validity of *leptorhynchus* was questioned by Vaurie (1955), who suggested treatment as a synonym of *pekinensis*, and this is followed, albeit tentatively, by Collar & Robson (2007). Two further taxa, '*beicki*' (type locality north-west Nei Mongol, China) and '*major*' (type locality Qinghai, China) are not currently recognised and both have long been treated as synonyms of *albosuperciliaris* (Vaurie 1955, 1959).

In this paper the relationship between *pekinensis* and *albosuperciliaris* and the validity of *leptorhynchus* are reviewed based upon an examination of museum material and fieldwork conducted in China; the taxa '*beicki*' and '*major*' are also discussed.

METHODS

Museum specimens were examined at the Natural History Museum, Tring, UK (NHMUK) and the Museum für Naturkunde, Berlin, Germany (ZMB). The type specimens of *pekinensis*, *albosuperciliaris* (NHMUK), *leptorhynchus* and '*beicki*' (ZMB) were examined, as was material from the type locality of '*major*' (NHMUK). In total 55 specimens were examined comprising 29 *albosuperciliaris* (including one '*beicki*' and three '*major*'), 15 *pekinensis* and 11 *leptorhynchus*. The following biometrics were taken: wing (maximum chord), tail length (to base of tail measured under the undertail-coverts) and bill length (to skull); measurements taken accord with standard procedures (Redfern & Clark 2001). All measurements were taken by PJL. No plumage differences between males and females exist, but plumage differences attributable to age and especially feather wear were noted (juvenile birds were characterised by very fresh plumage and loose contour feathering).

During fieldwork on the breeding grounds, sound recordings were obtained from Beijing, Hebei, Qinghai and Xinjiang. Recordings were made using Telinga Pro 5 or Pro 7 parabolic microphones with either a Sound Devices 722 or an HHB Portadisc MDP 500, and a Sony PCM-M10 with a Sennheiser ME66. Spectrograms were produced and analysis of various parameters carried out using Raven Pro 1.4 (Cornell Laboratory of Ornithology 2003–11). Contrast was adjusted for each recording to ensure all elements (defined as any continuous line on a sonogram) were retained, while minimising reverberation. Measurements were made using a spectrogram window size of 512.

In all 122 strophes were analysed, comprising 67 from nine *pekinensis* and 55 from eight *albosuperciliaris*. Analysis of parameters of each strophe was based on those proposed by Tobias *et al.* (2010), and comprised:

- start and finish times (from which duration was calculated);
- lowest and highest frequency (from which frequency range was calculated);
- peak frequency (the frequency at which peak power occurs);
- pace (calculated by dividing strophe length by number of elements).

For each individual, we calculated the mean of each parameter; we then used the mean and standard deviation of all individuals of each taxon to calculate Cohen's *d* values (see below). Due to their regular occurrence in flocks, the exact number of different individuals recorded was not always certain, although the figures provided are considered conservative estimates.

In order to review species limits between taxa we applied the quantitative scoring system proposed by Tobias *et al.* (2010) to assess the degree of phenotypic difference between allopatric taxa. These criteria were summarised by Collar (2011a, b) thus: an exceptional difference (a radically different colouration or pattern) scores 4; a major character (a pronounced and striking difference in the colour or pattern of a body part, or in measurement or vocalisation) 3; a medium character (clear difference reflected, e.g. by a distinct hue rather than a different colour) 2; and a minor character (a weak difference, e.g. a change in shade) 1. Tobias *et al.* (2010) set a threshold score of 7 to allow for species status; species status cannot be triggered by minor characters alone, and only three plumage characters, two vocal characters (one spectral and one temporal), two independent biometric characters and one behavioural or ecological character may be counted. Vocal and biometric characters were assessed for effect size using Cohen's *d* computed via the online calculator at http://www.uccs.edu/~faculty/lbecker/, where 0.2–2 is minor, 2–5 medium, 5–10 major and >10 exceptional.

RESULTS

Morphological differences between taxa

As noted elsewhere (Vaurie 1959, Collar & Robson 2007), there are pronounced plumage differences between *pekinensis* and *albosuperciliaris*. In general, *albosuperciliaris* is much paler and more uniform than *pekinensis*; the key differences between the two are detailed in Table 1 and illustrated in Plates 1–4. During fieldwork it became apparent that there is a highly distinct difference in iris colour, with *albosuperciliaris* having a dark brown iris and *pekinensis* a glaring pale yellow iris.

Table 1. Plumage and bare part differences between adult *Rhopophilus pekinensis pekinensis* and *R. p. albosuperciliaris*.

	pekinensis	***albosuperciliaris***
Head pattern	Blackish lores, pale grey supercilium, grey-buff ear-coverts, bold blackish submoustachial stripe.	Greyish lores, off-white to buff supercilium, buff ear-coverts, blackish submoustachial and mid-brown post-ocular stripe.
Upperparts	Crown and upperparts grey-brown with broad darker brown streaks, streaks longer and broader on mantle. Nape and crown flecked rufous.	Crown and upperparts sandy-grey with narrow mid-brown streaks, streaks slightly longer and bolder on mantle. Nape uniform sandy-grey.
Underparts	Chin, throat and belly white, sides of breast and flanks boldly streaked rufous, lower flanks and undertail-coverts rich buff and contrasting strongly with upperparts.	Chin, throat and belly white or off-white, sides of breast diffusely streaked apricot-buff, lower flanks and undertail-coverts pale buff.
Tail	Central rectrices pale brown, outer rectrices dark brownish-grey and with pale greyish tips.	Central rectrices sandy-grey, outer rectrices mid brownish-grey and with whitish tips.
Iris	Glaring pale yellow, clearly paler than pupil.	Very dark brown, similar in colour to pupil.

Plate 1. Adult male *R. p. pekinensis*, Shanxi, China, April 2012.

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Plate 2. Adult male *R. p. albosuperciliaris*, Xinjiang, China, June 2012.

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Plate 3. Adult male *R. p. pekinensis*, Shanxi, China, April 2012.

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Plate 4. Adult male *R. p. albosuperciliaris*, Xinjiang, China, June 2012.

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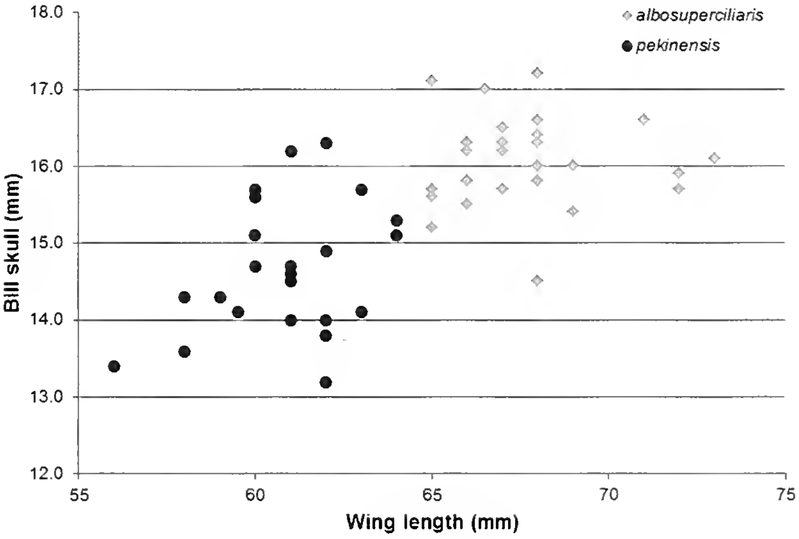
Consistent structural differences also exist with *albosuperciliaris* being larger than *pekinensis* in terms of wing, tail and bill length (Table 2), such that when wing and bill lengths are plotted there is no overlap between the two (Figure 1).

Table 2. Average wing length, tail length and bill to skull (all measurements in mm) and standard deviation (SD) of *pekinensis* (*n* = 26) and *albosuperciliaris* (*n* = 29).

	pekinensis		***albosuperciliaris***	
	Mean	**SD**	**Mean**	**SD**
Wing	61.1	2.01	67.7	2.42
Tail	89.3	4.84	95.3	4.22
Bill (skull)	14.6	0.80	16.0	0.58

Figure 1. Bill to skull (mm) and wing length (mm) of *pekinensis* and *albosuperciliaris*.



The validity of *leptorhynchus* and comments on *'major'* and *'beicki'*

As noted above the treatment of *leptorhynchus* is inconsistent. Vaurie (1955) recognised *leptorhynchus* but noted that it was poorly differentiated from *pekinensis* and concluded that 'it is a matter of opinion whether or not it should be recognised in the nomenclature'. Specimens of *leptorhynchus* examined as part of this study were on average slightly smaller than *pekinensis* (0.8 mm shorter-winged, 0.9 mm shorter-tailed and 1.0 mm shorter-billed). There was, however, extensive overlap in biometrics (Figure 2). In addition there were no consistent plumage differences between the two, and plumage of the type specimen fell within the range of *pekinensis sensu stricto*. As such, we concur with Collar & Robson (2007) and consider *leptorhynchus* a synonym of *pekinensis*.

Vaurie (1955) concluded that *'major'* was comparable to *albosuperciliaris* and not larger and more densely streaked as noted by Meise (1937) and that birds from the type locality of *'major'* fell within the range of plumage variation and size of *albosuperciliaris* from Xinjiang. An examination of specimens from the Qaidam Basin, Qinghai (the type locality of *'major'*), and of birds in the field there provides nothing with which to contradict Vaurie's conclusion.

Meise (1937) described *'beicki'* from a single specimen collected in north-west Nei Mongol, China (note: Vaurie [1995] correctly mapped the type locality of *'beicki'*, but incorrectly labelled the province as Ningxia), and considered it similar in colouration to *'major'* but smaller in size. Vaurie (1955) regarded any differences insufficient to establish the validity of *'beicki'* and questioned the wisdom of recognising it based on just a single specimen. Examination of the type specimen as part of this study established that in terms of plumage it falls within the range of variation of *albosuperciliaris*. Differences in biometrics are limited to wing length (62.0 mm), with values for tail (90.5 mm) and bill to skull (16.2 mm) falling within the range of *albosuperciliaris*. Examination of the type also suggested nothing unusual regarding the condition or preparation of the specimen which may have resulted in the smaller wing measurement and, whilst further material may prove otherwise, there appears no reason at this stage to recognise *'beicki'*.

Vocalisations

Both *pekinensis* and *albosuperciliaris* are garrulous and gregarious, and are most often found in small foraging flocks, the members of which frequently utter contact and other vocalisations. Both taxa have a wide repertoire of vocalisations, comprehensive comparative analysis of which would require a very large dataset of recordings.

Both taxa appear to have more than one territorial song, although we collected insufficient samples to clarify the situation. However, in the samples taken for this study, a single common vocalisation that appears to have the same territorial and/or advertising function was identified, and both taxa were seen perched prominently uttering it; based on this, we regard it as song. As a result, it has been possible to carry out the analysis described above. The relevant vocalisation is a short series of 2–5 very similar notes transcribed as *pyoo*, each descending in pitch; typical examples for each of the taxa are illustrated in Figures 3 and 4. The mean, standard deviation and Cohen's *d* values of the various

Figure 2. Tail length (mm) and wing length (mm) of *pekinensis* and *leptorhynchus*.

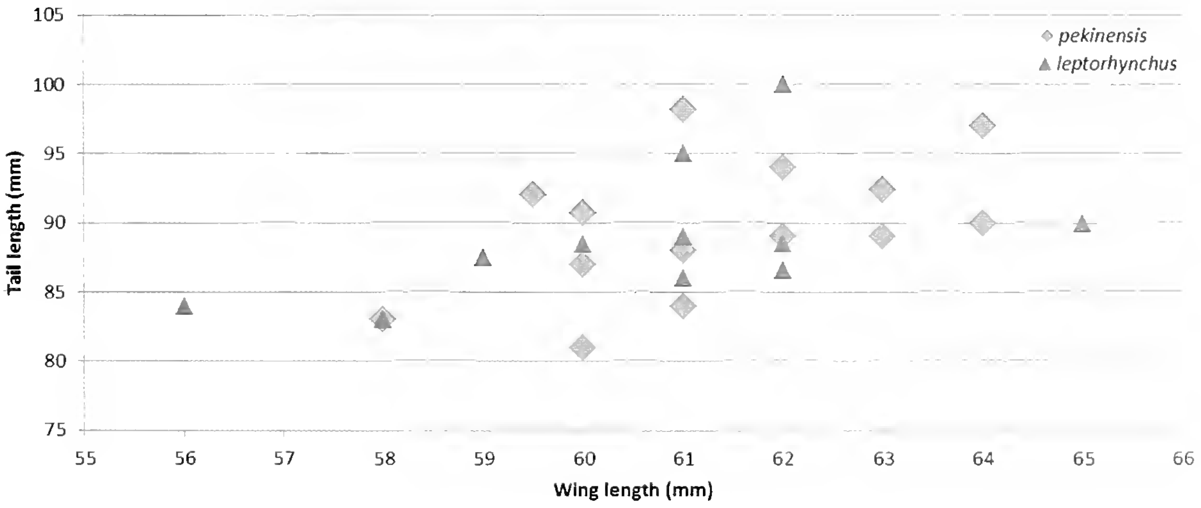


Figure 3. Typical *pyoo* vocalisation of *pekinensis*, Miyun Reservoir, Beijing, 4 November 2009. (Paul I. Holt)

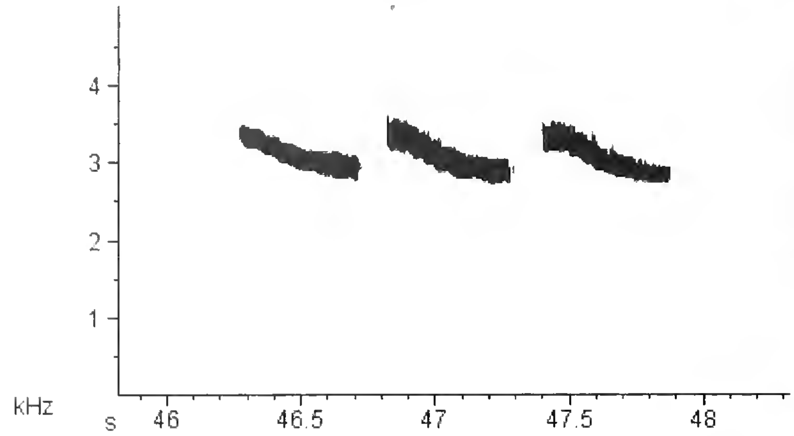
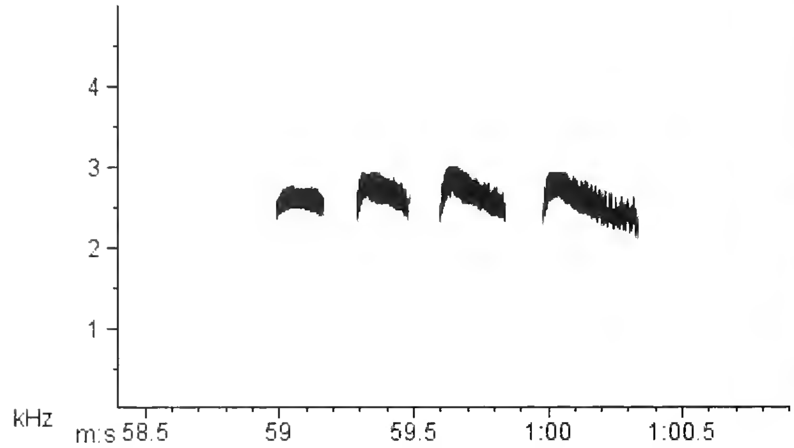


Figure 4. Typical *pyoo* vocalisation of *albosuperciliaris*, Aksu, Xinjiang, 10 August 2005. (Paul I. Holt)



measurements are presented in Table 3. Sample sizes of other vocalisations were insufficient to allow comparison in the absence of a thorough understanding of their function.

Table 3. Mean, standard deviation (SD) and Cohen's *d* values of parameters (see text) selected for analysis of *pekinensis* and *albosuperciliaris*.

	pekinensis		*albosuperciliaris*		Cohen's *d*
	Mean	SD	Mean	SD	
Low freq (Hz)	2093	145	2730	139	4.48
High freq (Hz)	2914	79	3630	202	4.67
Freq range (Hz)	821	108	900	172	0.55
Peak freq (Hz)	2670	108	3309	151	4.86
Duration (s)	1.34	0.17	1.32	0.32	0.08
No. of elements	3.51	0.83	2.96	0.52	0.79
Pace (elements/s)	0.39	0.06	0.44	0.05	0.91

From the summary statistics in Table 3, it can be seen that for low frequency, high frequency and peak frequency the mean values are higher in *albosuperciliaris* than *pekinensis*, with little overlap between the two taxa; these differences are clearly audible in recordings.

Habitat differences

A bird of dense secondary shrubland, *pekinensis* ranges from sea level (where generally rare) to at least 1,200 m and is found in degraded hill slopes, forest edge and forest clearings (Plate 5). Species regularly recorded in the same habitat include Vinous-throated Parrotbill *Paradoxornis webbianus*, Godlewski's Bunting *Emberiza godlewskii* and Meadow Bunting *E. cioides*. On the other hand, *albosuperciliaris* is a desert species occurring in areas of mature tamarisk and dense desert shrubland (Plate 6) particularly in areas where *Phragmites* are mixed with Chinese Date *Ziziphus jujuba* or 'Shazhao'—a central Asian xerophyte. It prefers low-lying, arid, sandy and often, but not always, well-drained areas and occurs from 780 to about 1,500 m in Xinjiang but up to 2,800 m in the Qaidam Basin, Qinghai. Lop Nur, Bayingol, is the lowest known site for this taxon but with the drying up of the lake and associated habitat changes there in recent years, it is quite possible that it is no longer present. It occurs alongside Eurasian Tree Sparrow *Passer montanus*, Saxaul Sparrow *P. ammodendri*, Desert Whitethroat *Sylvia minula*, with which it shares a very similar breeding distribution (Olsson *et al.* 2013), Isabelline Shrike *Lanius isabellinus* and even Biddulph's Ground Jay *Podoces biddulphi*.


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Plate 5. Typical habitat of *R. p. pekinensis*, Shanxi, China, April 2012.


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Plate 6. Typical habitat of *R. p. albosuperciliaris*, Xinjiang, China, June 2012.

DISCUSSION

Characters selected for comparison based on Tobias *et al.* (2010) were assessed (Table 4). Among biometric characters, only wing length was assessed because of the lack of clearly independent such characters (see Tobias *et al.* 2010). In terms of vocalisations, peak frequency and pace were selected; behavioural or ecological differences were represented by innate habitat. Geographical relationship (Tobias *et al.* 2010) is not applicable as the two taxa are allopatric, although Vaurie (1955) maps locations of both indicating that the two occur within approximately 300 km of each other. Overall, a score of 13 easily surpasses the threshold score of 7 for species status set by Tobias *et al.* (2010).

Of the features listed above, the differences in iris colour is considered major and therefore ranks highly. Iris colour varies with

Table 4. Characters selected for comparison of *pekinensis* and *albosuperciliaris* based on Tobias *et al.* (2010), with score (see text) in brackets.

	Character	Score
Plumage and bare parts		
Underparts	Medium	2
Upperparts	Medium	2
Iris colour	Major	3
Vocal		
Peak frequency (Cohen's *d*)	4.48	2
Pace (Cohen's *d*)	0.91	1
Biometric		
Wing length (Cohen's *d*)	3.0	2
Behavioural or ecological differences	Innate habitat	1
Total score		13

age in many passerine species, typically being duller in juveniles, so whilst it is possible that young *pekinensis* may show dull irides similar in colour to those of *albosuperciliaris*, the difference between *pekinensis* and *albosuperciliaris* appears to be consistent when breeding season adults are compared. The dark iris of *albosuperciliaris* was noted in the historical literature (Richmond 1896) but has been overlooked in recent times (Collar & Robson 2007).

A comparable situation in two taxa closely related to *Rhopophilus* exists in Vinous-throated Parrotbill and Ashy-throated Parrotbill *P. alphonsianus*, which have a dark brown and whitish iris respectively (Robson 2007). Whilst usually treated as separate species (Penhallurick & Robson 2009, Gill & Donsker 2012), recent genetic studies (e.g. Crottini *et al.* 2010) found these two taxa to be very closely related and suggested that *alphonsianus* may be a clinal morph of *P. webbianus*. In addition, in Silver-eared Mesia *Leiothrix argentauris*, the subspecies *laurinae* from Sumatra is unlike other subspecies in that it has pale irides, and the subspecies *orientalis* (from south Vietnam and east Cambodia) of Blue-winged Minla *Minla cyanouroptera* can also be distinguished from other subspecies by its pale irides. However, species limits within Silver-eared Mesia and the taxonomic status of *orientalis* require further evaluation (Collar & Robson 2007). Other examples in which iris colour varies between subspecies include Masked Booby *Sula dactylatra* (O'Brien & Davies 1990), whilst Kemp & Delport (2002) described a new subspecies of Red-billed Hornbill *Tockus erythrorhynchus* largely on the basis of iris colour and their proposal that the Red-billed Hornbill complex is better treated as five separate species (based on consistent differences in the colour of signal areas between geographically discrete populations) has been adopted elsewhere (Gill & Donsker 2012). In this study, it is noteworthy that even without the score for iris colour a score of 10 would still readily achieve the threshold for species status.

Based upon these results the following taxonomic treatment of two monotypic species is proposed:

Beijing Babbler *Rhopophilus pekinensis* (Swinhoe, 1868)

Tarim Babbler *Rhopophilus albosuperciliaris* (Hume, 1873)

The English names reflect the geographical origin of the type specimens and the use of 'Babbler' reflects recent taxonomic studies which place *Rhopophilus* within the Timaliidae. 'Bush-dweller' (Collar & Robson 2007) is not adopted as we feel that 'Babbler' is more accurate and that 'Bush-dweller' gives little or no insight into the taxonomic relationships of the two species. We acknowledge that some authorities treat the Sylviidae as a separate family rather

Figure 5. Map showing the approximate ranges of the two species *Rhopophilus albosuperciliaris* and *R. pekinensis* including the type localities.

than a subfamily within the Timaliidae (Gelang *et al.* 2009, Moyle *et al.* 2012), but refer to the use of the English name Sylviid Babblers for the Sylviidae (Gill & Donsker 2012) and note that the family includes a number of species which have 'Babbler' in their English name (e.g. African Hill Babbler *Pseudoalcippe abyssinica*).

The Beijing Babbler occurs from North Korea, north to southern Jilin and then west across north China to Gansu and eastern Qinghai. According to BirdLife International (2013a), the range continues south through northern Sichuan, western Henan and north-eastern Hubei as far as south-western Anhui; however, we are unaware of any records from Sichuan, Hubei or Anhui and these provinces are omitted by Zheng (2011), although it has been recorded from Henan since the 1930s (Fu 1937). The Tarim Babbler occurs in southern Xinjiang from the western part of the Tarim Basin (restricted to the rivers and oases around the margins of the Tarim Basin and avoiding the Taklamakan Desert proper) east to the Qaidam Basin, Qinghai. The ranges of the two species are shown in Figure 5.

Beijing Babbler is a fairly common and widespread species found in shrubland and although its range has contracted and it is no longer recorded in South Korea (Moores *et al.* 2009) and has declined in North Korea (Duckworth 2006), it is probably not globally threatened. Tarim Babbler, whilst sometimes locally common, is probably facing similar threats to Biddulph's Ground Jay and may be declining due to fragmentation and degradation of desert habitats caused by intensive grazing of livestock, extraction of fuelwood and conversion of suitable habitat to irrigated land (BirdLife International 2013b) and may qualify as Near Threatened.

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***Paul J. LEADER**, AEC Ltd., 127 Commercial Centre, Palm Springs, New Territories, Hong Kong. Email: pjl@aechk.hk*

***Geoff J. CAREY**, AEC Ltd., 127 Commercial Centre, Palm Springs, New Territories, Hong Kong. Email: gjc@aechk.hk*

***Paul I. HOLT**, Bracken Dean, Pendleton, Clitheroe, Lancashire, UK. Email: piholt@hotmail.com*

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Nesting of the Large-billed Reed Warbler *Acrocephalus orinus*: a preliminary report

PAVEL KVARTALNOV, ABDULNAZAR ABDULNAZAROV, VERONIKA SAMOTSKAYA, JULIA POZNYAKOVA, IRINA ILYINA, ANNA BANNIKOVA & EUGENIA SOLOVYEVA

Large-billed Reed Warbler *Acrocephalus orinus* has a limited breeding distribution. It is known to inhabit valleys of the Panj river and its tributaries in Gorny Barakhshan Autonomous Republic (Tajikistan) and Badakhshan province (Afghanistan). Here we give descriptions of nests and eggs of this species based on 18 fresh nests found in Panj and Ghund valleys (Tajikistan) in 2011. Unlike the closely related species *A. dumetorum* and *A. scirpaceus*, Large-billed Reed Warbler has nests built with a layer of wool and seed tufts. Nests are placed on twigs of sea-buckthorn, willow and other bushes, herbs and reed stems over dry soil. Large-billed Reed Warbler clutch size is relatively small (on average, 3.77 ± 0.83 eggs (n = 13)). The ground colour of eggs is usually white, not bluish, greenish or rosy as in the related species.

INTRODUCTION

Until recently Large-billed Reed Warbler *Acrocephalus orinus* remained one of the least studied bird species of the Palaearctic fauna. A. O. Hume discovered the first specimen on 11 November 1867 in the Sutlej valley, Himachal Pradesh, India (Hume 1869, 1870). He described the bird as *Phyllopneuste macrorhynchus*, and later referred to it as *A. macrorynchus*. Oberholser (1905) changed the name to *A. orinus*.

The taxonomic status of this form remained uncertain until the beginning of the twenty-first century when Bensch & Pearson (2002) studied the type specimen in detail, including sequencing of mitochondrial and nuclear DNA. This study confirmed the specific status of Large-billed Reed Warbler, although some doubts remained (McCarthy 2006) until the moment when P. D. Round caught a live bird near Bangkok, Thailand (Round *et al.* 2007). Further studies of museum collections and searches for living individuals helped to elucidate possible breeding, moulting and wintering areas (Svensson *et al.* 2008, 2010, Timmins *et al.* 2009, Koblik *et al.* 2010, 2011).

In 2009, a bird feeding fledglings was caught in south-east Tajikistan, not far from the border with Afghanistan, in the Shakhdara river valley (Ayé *et al.* 2010). Museum specimens in the Zoological Museum of Moscow University (Moscow, Russia) and the Institute of Zoology and Parasitology (Dushanbe,Tajikistan) reveal that previous records of Blyth's Reed Warbler *Acrocephalus dumetorum* breeding in the Vanj and Ghund river valleys in fact refer to Large-billed Reed Warbler (Kvartalnov *et al.* 2011a,b, Kvartalnov & Garibmamadov 2012). Although fledglings were recorded in 1961 by A. V. Popov in the Vanj valley, near the village of Ghijovast (Abdusalyamov 1973, Kvartalnov *et al.* 2011b) and in 2009 by R. Ayé and colleagues (Ayé *et al.* 2010), and birds collecting nest material were observed in 1976 by V. V. Kashinin in the lower Ghund valley, near the village of Barsem (unpublished manuscript – see Kvartalnov *et al.* 2011a), no nests of this species have ever been described.

The mystery of the Large-billed Reed Warbler could have been solved in the mid-twentieth century. When in 1937 A. B. Kistyakovsky took part in a Pamir expedition, he found that reed warblers in the south-western Tajik Pamir mountains (in the environs of the town of Khorog) were not typical Blyth's Reed Warblers. He therefore prepared a description of a new *A. dumetorum* subspecies, but his manuscript and the intended type series were destroyed in a fire together with all zoological collections in Kiev University during the German occupation in the Second World War (Nowak 2001). Kistyakovsky (1950) wrote his opinion of the systematic position of this form, which he thought to be endemic to Gorny Badakhshan, Tajikistan. Other naturalists who had visited the Pamir mountains in the twentieth century did not distinguish those birds from typical Blyth's Reed Warblers.

In 2010–2011 we studied spring migration of Blyth's Reed Warbler and breeding biology of Large-billed Reed Warbler in Tajikistan. Blyth's Reed Warbler was found to be common during spring passage in the vicinity of Dushanbe and in the south-west part of the republic, but we failed to prove its breeding in Tajikistan, although this was suspected by Abdusalyamov (1973), Portenko & Stübs (1976) and other ornithologists. There is no doubt that Blyth's Reed Warbler is a transient in all regions to the south of Almaty in south-east Kazakhstan, and that all nests found there that had been attributed to that species belong to others, including Paddyfield Warbler *Acrocephalus agricola* and Sykes's Warbler *Hippolais rama* (Ivanitskii *et al.* 2012).

Data about phenology, breeding biology, social behaviour, acoustics and morphometry of the Large-billed Reed Warbler collected in 2011 are presented in this article with additional data from 2012. This information is to help other ornithologists to search for and distinguish nests of Large-billed Reed Warbler.

MATERIALS AND METHODS

The main field observations were conducted in the Panj valley near the village of Zumudg, Ishkashim region, Gorny Badakhshan Autonomous Region, Tajikistan (36.917°N 72.183°E) between 10 June and 11 July 2011. Additional data were collected in the Apharv forest area in the Panj valley (36.800°N 71.550°E) and near the village of Langar in the lower Pamir river valley (37.033°N 72.667°E). AA inspected riverside forests in the Ghund valley near the villages of Charthem (37.717°N 72.167°E), Vuzh (37.717°N 71.933°E) and Dehmiyona (37.700°N 71.917°E) (Figure 1). From 23 May to 23 July 2012 PK and colleagues studied breeding biology and social behaviour of Large-billed Reed Warbler near the village of Dehmiyona; the resulting data are not included here.

Nine adult Large-billed Reed Warblers were caught in mist-nets and traps at nests near Zumudg (Plate 1). The birds were identified by measurements of bills, wings, tails and legs according to Svensson *et al.* (2010), Koblik *et al.* (2010) and from our experience of working with series of Large-billed and Blyth's Reed Warblers in collections of the Zoological Museum of Moscow University (Ivanitskii *et al.* 2012). Adults were marked with metal and colour rings and by grease paint colouring on breast and head for individual identification (a harmless method that we used previously with other warbler species). Blood samples were taken

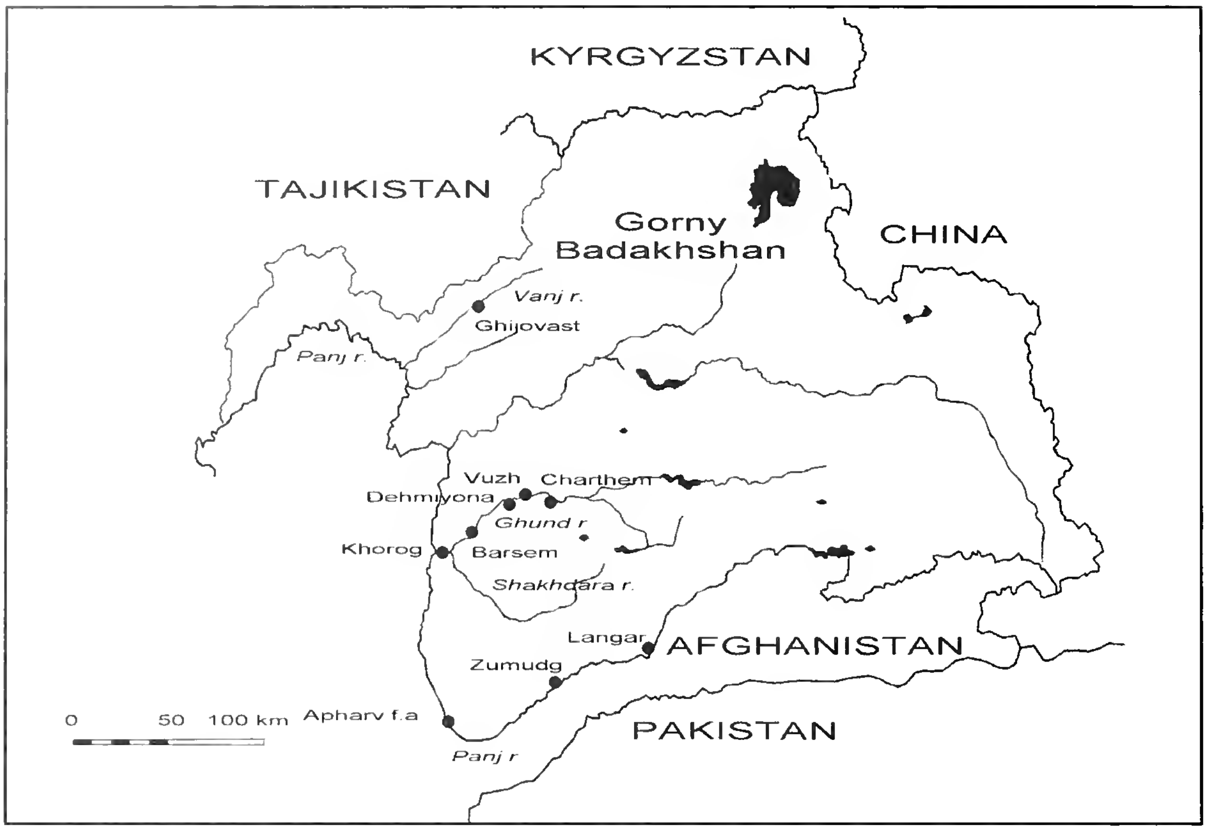

Figure 1. A map of localities of some historical and recent observations of Large-billed Reed Warbler *A. orinus* in Tajikistan.

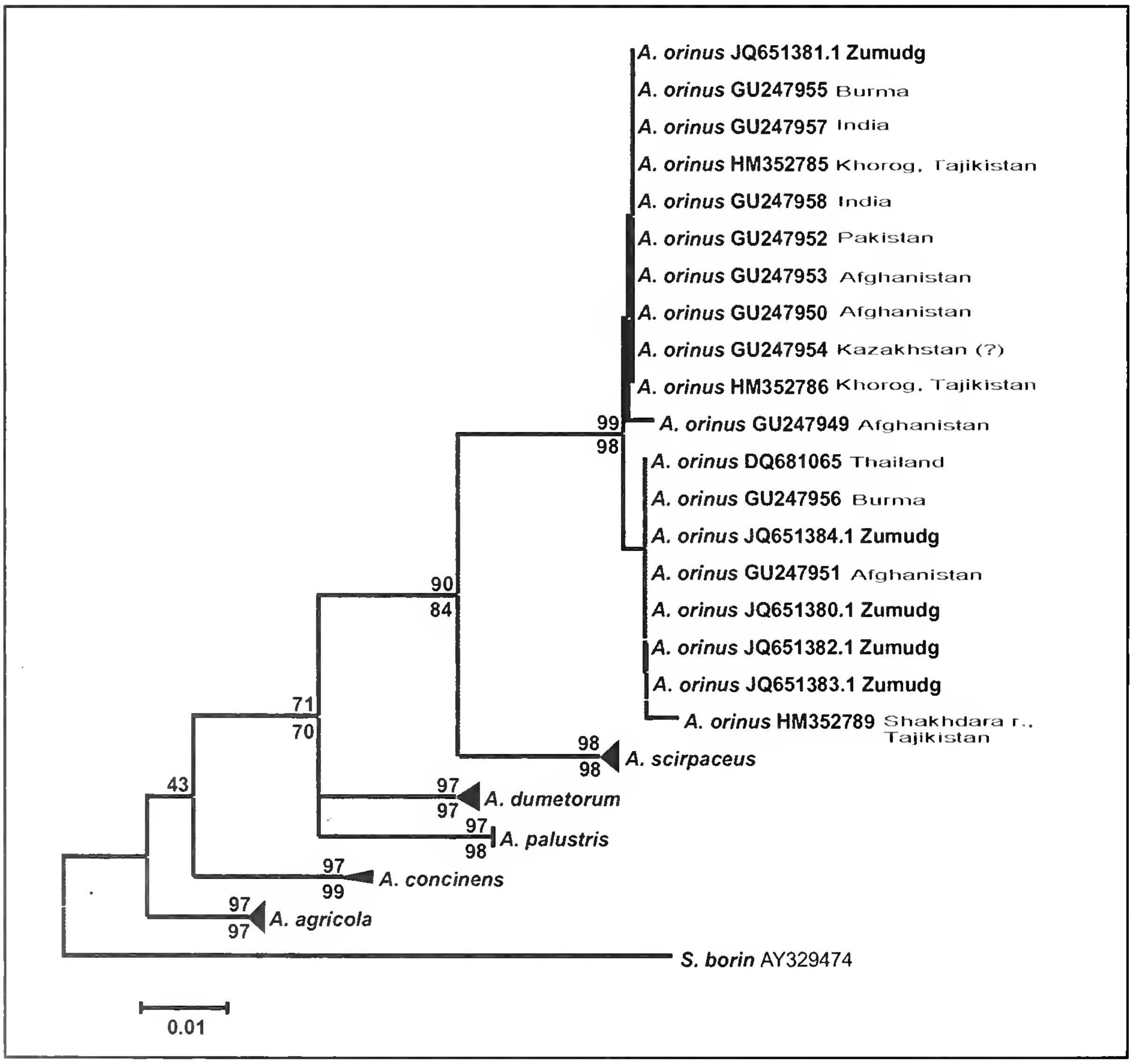

Figure 2. The relationships between Large-billed Reed Warbler and closely related species of the genus *Acrocephalus* based on NJ and MP analyses. Genbank accession numbers for Eurasian Reed Warbler *A. scirpaceus*, Marsh Warbler *A. palustris* etc. are given in the text.

from all caught adult birds and eight nestlings (also marked with metal rings). Specific identification was supported by analysis of mt DNA (Figure 2).

Total DNA was extracted from dried blood samples using the standard protocol of proteinase K digestion, phenol–chloroform deproteinisation and isopropanol precipitation (Sambrook *et al.* 1989). Mitochondrial DNA sequences were obtained from five Large-billed Reed Warblers caught in 2011 near Zumudg. The partial cytochrome *b* gene (207 bp) was amplified in one polymerase chain reaction (PCR) with the forward/reverse primer combination L14841/H15149 (Kocher *et al.* 1989). Typical conditions for cyt*b* amplification included initial denaturation at

PAVEL KVARTALNOV

Plate 1. Panj river valley near Zumudg village, 25 June 2011.

94°C for 3 min, 35 cycles of 94°C for 30 s, annealing at 51°C for 1 min, and extension at 72°C for 1 min, followed by a final extension at 72°C for 10 min and an indefinite hold at 4°C. PCR products were visualised on 1% agarose gel and then purified using DEAE (Whatman) or NH$_4$EtOH. Approximately 10–50 ng of the purified PCR product were used for sequencing with each primer by the autosequencing system ABI 3100-Avant in conjunction with ABI PRISM®BigDyeTM Terminator, version 3.1.

Cyt*b* sequences were aligned by eye using BioEdit 7.0. The final alignment of the mitochondrial region included 207 bp, of which 54 sites were variable and 40 sites were parsimony-informative. For the analysis we also used GenBank data (*A. dumetorum*, *A. orinus*, *A. agricola*, Eurasian Reed Warbler *A. scirpaceus*, Marsh Warbler *A. palustris* and Blunt-winged Warbler *A. concinens*). Phylogenetic neighbour-joining (NJ) and maximum parsimony (MP) analyses were performed using MEGA 4.0.0.4083. The NJ tree was reconstructed using the uncorrected p-distance. Unweighted MP analysis was performed using heuristic search starting with stepwise addition trees (random addition sequence, 10,000 replicates). To assess clade stability in the MP and NJ trees, 1,000 bootstrap pseudoreplicates were analysed.

GenBank accession numbers of obtained sequences are JQ651380–JQ651384. Genbank accession numbers of other sequences used in this work comprise: *A. agricola* AJ004245–AJ004248, AJ004330, AJ004331, AJ004775, AJ004776, FJ883021, Y15694; *A. concinens* AJ004260–AJ004262, FJ883027; *A. dumetorum*: AJ004263, AJ004264, AJ004336–AJ004340, AJ004773, FJ883028; *A. orinus*: DQ681065, GU247949–GU247958, HM352785, HM352786, HM352789; *A. palustris*: AJ004293, AJ004294, AJ004344, AJ004345, AJ004774, EU861031, FJ883036; *A. scirpaceus*: AJ004301–AJ004304, AJ004771, AJ004772, AM889139, FJ883039, NC 010227, Z73483.

The identification of uncaught birds was based on characteristic songs (Timmins *et al.* 2010, Ivanitskii *et al.* 2012). Recordings of songs of five marked males proved that the song described by Timmins *et al.* (2010) belongs to the Large-billed Reed Warbler (Ivanitskii *et al.* 2012). Nests that AA found in the Ghund valley were identified by comparison with known Large-billed Reed Warbler nests from the Panj valley. For comparison we also used unpublished data from 51 Blyth's Reed Warbler nests found and described by PK in 2007–2009 in the Kostroma region, Russia.

RESULTS AND DISCUSSION

The Large-billed Reed Warbler is a common species in suitable habitat in the Panj, Ghund and lower Pamir valleys. We found nests near the villages of Zumudg, Charthem, Vuzh and Dehmiyona, observed actively singing males in the Apharv forest area, and saw singing males and territorial pairs at the village of Langar (Figure 1). The birds inhabited thickets of sea-buckthorn *Hippophae ramnoides* and willow *Salix turanica*, *S. shugnanica* and *S. wilhemsiana* intertwined with clematis *Clematis hilariae*, with sparse ground cover of liquorice *Glycyrrhiza uralensis*, reed *Phragmites australis* and other species. Other bird species observed in the same habitat of Panj valley include Hume's Lesser Whitethroat *Sylvia althaea*, Mountain Chiffchaff *Phylloscopus sindianus*, Common Rosefinch *Carpodacus erythrinus*, Cetti's Bush Warbler *Cettia cetti*, Common Nightingale *Luscinia megarhynchos*, Bluethroat *Luscinia svecica*, Black-billed Magpie *Pica pica*, Isabelline Shrike *Lanius isabellinus phoenicuroides* and Citrine Wagtail *Motacilla citreola calcarata*. The only other *Acrocephalus* warbler recorded around Zumudg during our observations was Clamorous Reed Warbler *A. stentoreus* (a single transient bird). According to observations of PK in 2012, in the Ghund valley Large-billed Reed Warblers also breed in *S. turanica*, wild rose *Rosa beggerana* and honeysuckle *Lonicera stenantha* thickets with *Astragalus longistipitatus, Potamogeton cariatum* and other herbs along canals among crop fields on alluvial fans.

Most Large-billed Reed Warblers were found near river banks, canals or other wet localities. The birds breed in monogamous pairs, although attempted extra-pair copulations by at least three paired and two unmated territorial males were observed. We described 15 nests and one abandoned construction built in June and July 2011 in the Panj valley (Plates 2, 3), plus seven remains of nests built in 2009–2010 in the same area, and three recent nests in the Ghund valley in 2011. Thirteen nests had complete clutches. Nests are built by females (based on observations of building of nine nests in 2011, including two nests observed from the first day of construction). Most were in sea-buckthorn thickets, but one was in a willow bush. Nearly all nests were placed over dry soil, except one that was built on a branch over a canal temporarily filled by water.

Large-billed Reed Warblers attached nests to sea-buckthorn twigs at forks (six nests), stems of *Artemisia* (three nests), liquorice stems (three nests), thin willow stems (two nests), willow twigs at forks (two nests), twigs of clematis at forks (two nests), reed stems (one nest), reed stems and willow twigs (one nest), reed and liquorice stems (one nest), liquorice stems and willow twigs (one nest), sea-buckthorn and willow twigs (one nest), reed, liquorice stems and a sea-buckthorn twig (one nest).

Females began nest construction with a platform of dry plant debris, but from the first day they braided vertical supports (stems, etc.) with plant fibres. Nests were fastened to stems more firmly than the nests of Blyth's Reed Warbler. The principal material consists of bast and bark fibres of clematis, willow, liquorice and *Artemisia*, fibres of reed sheath, dry leaves, stems and ears of grasses, goat wool and clematis seed tufts. Bast strips also form an outer covering that disguises the nest in thickets. An inner part of the structural layer is made with wool and seed tufts, and rarely includes bird feathers. Nests of Blyth's Reed Warbler usually lack such soft materials (Plate 5).The upper edges of Large-billed Reed Warbler nest cups are made usually with ears of grasses. Nests are lined with clematis bast fibres or (rarely) with thin dry grass stems, with the addition of mammal hairs.

Nests found near Zumudg (n = 15) had the following measurements (average and standard deviation): outer diameter 81.7 ± 8.0 mm; height 68.6 ± 9.4 mm; inner diameter 54.8 ± 2.0 mm; depth 45.1 ± 3.0 mm. The height of nests above ground or water was 30–168 cm (average 82.1 cm). Nests inspected in the Ghund valley in 2011 were placed at 110–210 cm above ground.

Most full clutches in the Panj valley were of four eggs (n = 7), rarely two (n = 1), three (n = 3) or five eggs (n = 2); on average, 3.77 ± 0.83 (n = 13), including a replacement clutch that contained three eggs (the first clutch consisted of four eggs). We also found a nest with three nestlings. Nests found in Ghund valley had three (two nests) and four (one nest) eggs. The usual clutch size of the Blyth's Reed Warbler in Kostroma region was 5–6 eggs, rarely four eggs, on average (n = 37) 5.53 ± 0.56 eggs.

Plate 2. Nest 5-11 of the Large-billed Reed Warbler *A. orinus* with full clutch (two unhatched eggs from this nest are now held in the Natural History Museum, Tring, UK), 21 June 2011.

PAVEL KVARTALNOV

Plate 3. Nest 11-11 of the Large-billed Reed Warbler with full clutch (now held in the Zoological Museum of Moscow University), 9 July 2011.

PAVEL KVARTALNOV

Plate 4. A clutch from nest 13-11 of the Large-billed Reed Warbler showing markings on eggs, 11 July 2011.

PAVEL KVARTALNOV

Plate 5. A nest of Blyth's Reed Warbler *A. dumetorum* with full clutch, Kostroma region, Russia, 14 June 2007.

PAVEL KVARTALNOV

Clutches of Blyth's Reed Warbler from South Siberia had on average 4.8–5.2 eggs (Totunov 1981) or 5.1–5.76 eggs (Kuranov 2008) in different years.

Eggs of Large-billed Reed Warbler have a dirty-white (rarely creamy white or pure white) shell covered with small olive-brown superficial spots that usually (but not always) form a sparse cap or a ring at the larger end, and with more sparse dark-brown superficial specks which rarely (as opposed to eggs of Blyth's Reed Warbler) lay over larger spots (Plates 4 & 5). Sparse and small deep bluish spots also form a cap or a ring at the larger end. Some eggs are covered not only with sparse spots but also with dense small olive brown specks that can hide the basic shell colour. Fresh eggs are dull or with a weak gloss. Eggs of Blyth's Reed Warbler are greenish or rosy, usually with no white background (Chernyshov 1998; our data). Measurements of eggs (in mm; n = 58): 17.72 ± 0.55 (16.8–19.1) × 13.14 ± 0.31 (12.3–13.8). Egg weight (n = 48): 1.51 ± 0.15 (1.13–1.76) g. One Large-billed Reed Warbler nest with a complete clutch (three eggs) is now deposited in the Zoological Museum of Moscow University (ZMMU Q-8036); two unhatched eggs were sent to the Natural History Museum, Tring, UK (NHMUK E/2012.5.1).

Eurasian Reed Warbler has been found in Gorny Badakhshan and nearby Afghanistan, although it is not known to breed there (Abdusalyamov 1973, Timmins *et al.* 2010). It has nests without the layer built with wool and seed tufts (Kvartalnov *et al.* 2006), and eggs with bluish or olive-greenish basic shell colour, not white (Nikiforov *et al.* 1989).

Only female Large-billed Reed Warblers have brood-patches, but both partners incubate eggs and provide food to nestlings and fledglings (Plates 6, 7, 8).

Large-billed Reed Warblers in the Panj valley have a relatively wide range in dates of arrival on the breeding grounds (compared with Mountain Chiffchaff and other passerines inhabiting the Pamir Mountains: our observations). The nest found on 5 July with young birds ready to fledge must have been built during the first days of June. Most other nests near Zumudg were built after 10 June. Several new birds reached the breeding grounds at the end of June and the beginning of July. The latest of the first clutches found near Zumudg was finished on 7 July. On the last day of investigations (11 July) we observed a female in the territory of a male which was singing from 9 July. Of two nests built for replacement clutches, one was still empty on 11 July. In the lower Pamir river valley on 2 July we found several actively singing bachelor males, newly formed pairs and apparently non-territorial birds. AA found nests with clutches on 23 June, 16 July (nestlings hatched 17 July) and 17 July in the Ghund valley. V. V. Kashinin in the lower Ghund valley (37.550°N 71.733°E) observed the peak of nest building to be in mid-June (Kvartalnov *et al.* 2011b). A. V. Popov saw fledglings on 22 June 1961 in the Vanj valley (38.550°N 71.733°E) (Abdusalyamov 1973, Kvartalnov *et al.* 2011b); fledglings possibly of this species were recorded by A. V. Popov in the Shakhdara valley on 26 July (birds were not collected, and the year is unknown) (Abdusalyamov 1973). Ayé *et al.* (2010) saw fledglings near the Shakhdara River on 19 July 2009. According to museum collections (Koblik *et al.* 2010, 2011) and our observations in 2012, Large-billed Reed Warblers reach breeding grounds in Gorny Badakhshan in the final third of May. AA saw the last birds that he thought to be this species in the first ten days of September in the Panj valley, but this needs to be confirmed by mist-netted birds.

Plate 6. A newly-hatched nestling of Large-billed Reed Warbler from nest 5-11, 3 July 2011.

PAVEL KVARTALNOV

Plate 7. Female Large-billed Reed Warbler feeding nestlings, nest 1-11, 10 July 2011.

ABDULNAZAR ABDULNAZAROV

Plate 8. A young Large-billed Reed Warbler ready to fledge, nest 12-11, 5 July 2011.

PAVEL KVARTALNOV

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***Pavel KVARTALNOV**, Vertebrate Zoology Department, Faculty of Biology, Lomonosov Moscow State University, Leninskiye Gory, Moscow 119991, Russian Federation. Email: cettia@mail.ru*

***Abdulnazar ABDULNAZAROV**, Pamir Biological Institute, Khorog 736002, Tajikistan. Email: abdu_70@mail.ru*

***Veronika SAMOTSKAYA**, Vertebrate Zoology Department, Faculty of Biology, Lomonosov Moscow State University, Leninskiye Gory, Moscow 119991, Russian Federation*

***Julia POZNYAKOVA**, Vertebrate Zoology Department, Faculty of Biology, Lomonosov Moscow State University, Leninskiye Gory, Moscow 119991, Russian Federation*

***Irina ILYINA**, Vertebrate Zoology Department, Faculty of Biology, Lomonosov Moscow State University, Leninskiye Gory, Moscow 119991, Russian Federation*

***Anna BANNIKOVA**, Vertebrate Zoology Department, Faculty of Biology, Lomonosov Moscow State University, Leninskiye Gory, Moscow 119991, Russian Federation*

***Eugenia SOLOVYEVA**, Vertebrate Zoology Department, Faculty of Biology, Lomonosov Moscow State University, Leninskiye Gory, Moscow 119991, Russian Federation*

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First records of Chinese Sparrowhawk *Accipiter soloensis* wintering in Papua (Indonesian New Guinea)

FRANCESCO GERMI, AGUS SALIM & ANDREA MINGANTI

Chinese Sparrowhawks *Accipiter soloensis* were found for the first time wintering in mainland Papua (Indonesian New Guinea) during a field survey carried out between December 2010 and March 2011. A combination of 39 road, boat and foot transects were completed in the provinces of Papua and West Papua, covering a total of 2,303 km, of which 1,948 km were on roads or footpaths and 355 km on rivers. Transects were supplemented by frequent spot counts and stops to broadcast recordings of Chinese Sparrowhawk vocalisations. Routes covered eight sample areas in the most representative habitats of the region. A total of 10 Chinese Sparrowhawks were recorded at four locations, all close to the coast. The new records are up to 1,200 km east of the easternmost extent of the previously known wintering range, thus proving that this species does winter in Indonesian New Guinea, although most likely at low density. Seventeen other raptor species were recorded on the transects. In addition, 12 days were spent between 6 and 17 March 2011 at a suitable coastal watch site at the westernmost point of West Papua, but no visible migration of Chinese Sparrowhawk was observed.

INTRODUCTION

The Chinese Sparrowhawk *Accipiter soloensis* is a small-sized accipiter, whose breeding grounds, although imprecisely known, are in China, Korea and Ussuriland, and whose wintering grounds are thought to be mainly in the Philippines and eastern Indonesia. Despite this being the most numerous migratory raptor in East Asia, with an estimated global population running well into six figures (Ferguson-Lees & Christie 2001), very few records exist from the presumed wintering range, suggesting that the winter distribution remains largely unknown (Wattel 1973, White 1976, Mees 1982, White & Bruce 1986, Beehler *et al.* 1986).

Recent migration research (Germi 2005, Germi & Waluyo 2006, Nijman *et al.* 2006, Germi *et al.* 2009) showed that at least 350,000 individuals of this species are streaming into eastern Indonesia each autumn, through both the Sangihe-Talaud

Plate 1. The five Chinese Sparrowhawks collected in New Guinea in the nineteenth century at unspecified localities, held at the Natural History Museum, Tring, UK. From left to right: NHMUK 1955.6.N.20.2635; 1873.5.12.1638; 1955.6.N.20.2636; 1955.6.N.20.2633 and 1955.6.N.20.2632.

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Archipelago in the north and Bali in the west. Nevertheless, other than scattered records from Sulawesi's northern peninsula, winter observations of Chinese Sparrowhawk elsewhere on this island are negligible, despite some areas having been relatively well surveyed (Hartert 1896, Meyer & Wiglesworth 1898, Rozendaal & Dekker 1989). Likewise, there are very few winter records of this species from the Moluccas and the Lesser Sundas. A handful of specimens and records provide solid, albeit scarce, evidence that this species occurs further to the east in Wallacea and at least in the extreme western tip of New Guinea (Coates 1985, Beehler *et al.* 1986, Coates & Bishop 1997, Gjershaug & Røv 2000). Only four records from the islands off western Papua are known in the literature: Meyer & Wiglesworth (1898) quoted Salvadori (1880–1882) with two specimens collected at Gagi (by Bernstein) and Waigeo (by Platen) islands and one from an unspecified locality in '*Nova Guinea*' (by Wallace). Ripley (1964) reported one female collected at Efman (Jefman) Island near Sorong. Additionally, we located five specimens held in the ornithological collections at the Natural History Museum (formerly British Museum of Natural History), Tring, collected in New Guinea in the nineteenth century at unspecified localities (Plate 1). These specimens appear to have been overlooked in the relevant literature. As the islands of eastern Indonesia are regularly visited by birding tours, it is remarkable that such a large number of Chinese Sparrowhawks could have been so consistently unrecorded during the wintering months. Moreover, our observations on Sangihe Island (Germi *et al.* 2009) showed that when present the Chinese Sparrowhawk is easy to locate, both because of its strong diurnal vocal activity and when perched or hunting from prominent tree branches. The possible explanation for the fact that the species has been so widely 'overlooked' in Wallacea, may be: (1) it has been genuinely unrecorded due to an absence of observers present at the right time of year; or (2) the lack of suitable wintering areas in parts of Wallacea, so that a large proportion of the migrants disperse into remote and poorly surveyed areas as far as Papua (Indonesian New Guinea), or both. In order to address the paucity of winter records in Wallacea, we undertook this survey in Papua to establish if Chinese Sparrowhawk overwinter on the island, simultaneously carrying out the first raptor road counts in New Guinea.

METHODS

Study area

Papua, the Indonesian half of the island of New Guinea, covers an area of 416,129 km². It is still largely covered in relatively undisturbed primary forests, the largest tropical forest wilderness remaining in the Asia-Pacific region. For the past 50 years it was essentially inaccessible to all but a few field researchers, and thus a *terra incognita* (Marshall & Beehler 2007). Dominated by the massive Central Cordillera (more than 3,000 m high) that generates abundant rainfall, rivers drain into vast forested interior basins and alluvial floodplains. In the far south-east, near the Papua New Guinea border, is a swath of savannah known as the Trans-Fly, ecologically resembling northern Australia rather than New Guinea. To the west, the heavily logged Vogelkop and Bomberai peninsulas are dominated by small mountain ranges and island groups. Papua's equatorial climate is dominated by the North-west

Figure 1. Map of Papua, Indonesia. Black lines show all transects carried out during December 2010 – March 2011 in the numbered sample areas: (1) Merauke; (2) Kimaam; (3) Asmat; (4) Timika; (5) Wamena; (6) Manokwari; (7) Sorong; (8) Biak. Black stars: new Chinese Sparrowhawk records January–March 2011. White stars: old Chinese Sparrowhawk records 1880–1964. Black asterisk: migration watch site at Tanjung Kasuari, March 2011.

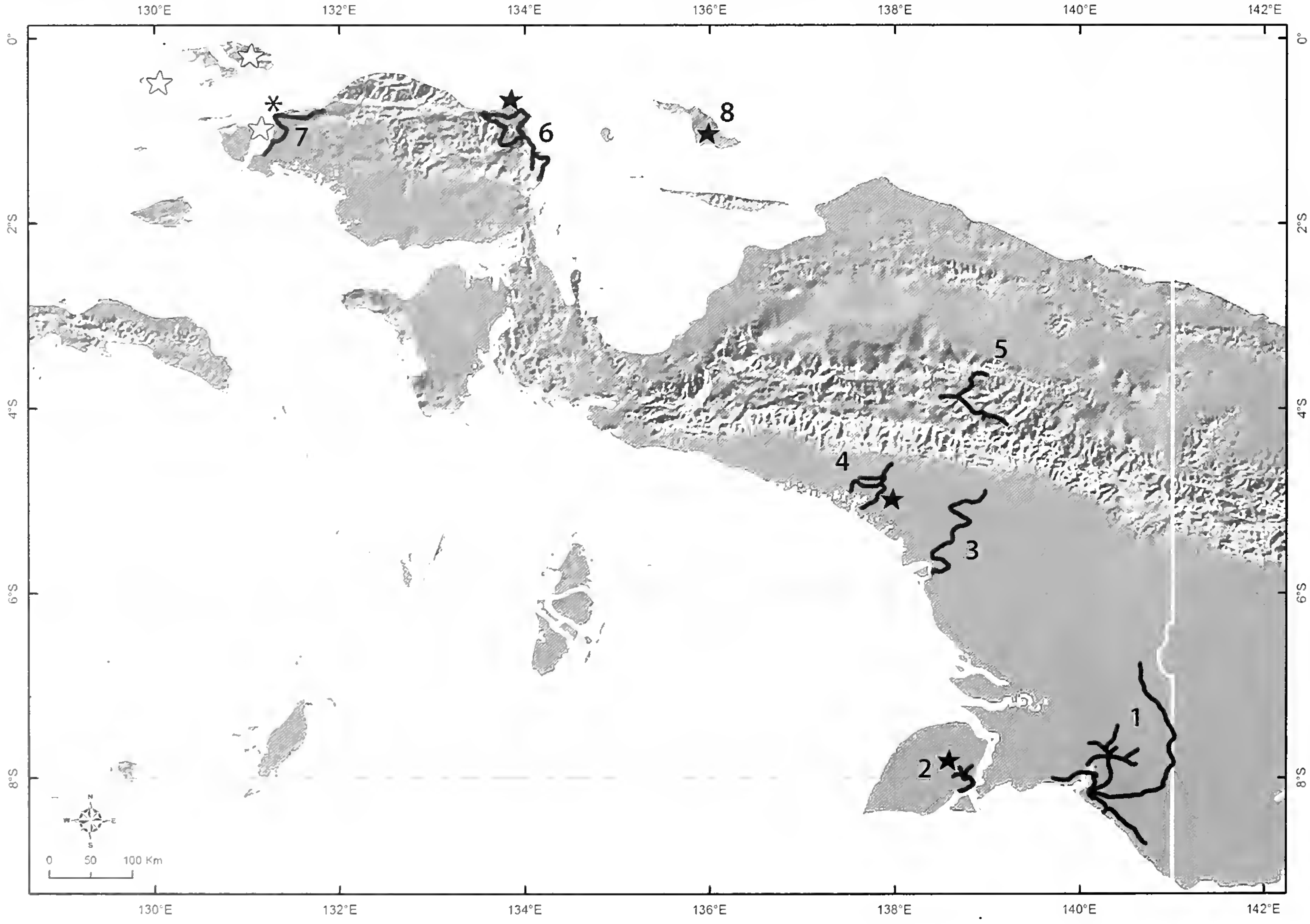

Table 1. Sample areas, transects and Chinese Sparrowhawk records, Papua, December 2010–March 2011.

Sample area	Coordinates	Habitat types	Transects	Chinese Sparrowhawk records
Merauke	8.479°S 140.580°E	1,3,4,5,13,14,15	road 454 km; foot 22 km	
Kimaam	7.957°S 138.862°E	1,5,6,14	foot 48 km; river 28 km	7.980°S 138.853°E, one on 10 January roosting at Kimaam airstrip
Asmat	5.518°S 138.117°E	4,6,7,14	foot 17 km; river 327 km	
Timika	4.755°S 136.865°E	4,6,7,10,14, 15	road 708 km; foot 13 km	4.691°S 136.887°E, a flock of six in westward migration on 3 March over coastal swampland
Wamena	3.964°S 138.946°E	2,8,13,14	road 160 km; foot 11 km	
Manokwari	0.791°S 134.023°E	9,10,13,14,15	road 175 km	0.808°S 134.053°E, one on 12 February roosting in secondary forest
Sorong	0.823°S 131.231°E	10,13,14,15	road 328 km; foot 12 km	
Biak	1.048°S 135.959°E	11,12,14,15	point counts	1.094°S 136.330°E, two singles at the same locality, 14 and 15 February, roosting in degraded woodland

Habitat types: 1 Trans-Fly savannah, 2 Grassland, 3 Inundated grassland , 4 Swampland, 5 Monsoon forest , 6 Mangrove forest , 7 Lowland rainforest, 8 Montane forest, 9 Coastal forest, 10 Secondary forest , 11 Degraded woodland, 12 Semi-arid scrub, 13 Agricultural landscapes, 14 Villages, 15 Transmigration settlements.

Monsoon and the South-east Trade Winds. The main rainy season occurs from November to March; however in the wetter areas the seasons are reversed, and most rain falls in the April–October period. The highest rainfall is recorded in the southern scarp of the Central Cordillera, with more than 5,000 mm/year. Temperature varies little, with elevation being the key variable. At sea level, where most of our survey areas were located, the average temperature is 25–27°C (Marshall & Beehler 2007).

Survey techniques

Our general methodology followed a combination of classic survey techniques described in the literature (Fuller & Mosher 1987, Bibby *et al.* 1998, Bibby *et al.* 2000, Bird & Bildstein 2007, Malan 2009). We also reviewed specific literature on previous raptor road surveys from other parts of the world in order to adapt our own protocols to local conditions (Millsap & LeFranc 1988, Ellis *et al.* 1990, Hanowsky & Niemi 1995, Vergara 2010).

Thirty-nine road, boat and foot transects were carried out in eight sample areas in the Indonesian administrative provinces of Papua and West Papua (Figure 1), chosen by habitat type and for their accessibility. The following main habitats were surveyed: Trans-Fly savannah and grassland, swamp forest, mangrove forest, lowland rainforest, secondary forest and agricultural landscapes (Table 1). Logistical difficulties such as lack of roads and suitable transport, high cost of transport, access restrictions due to oil and mining exploration and floods due to the rainy season hindered the fieldwork. The resulting poor accessibility and the insecurity of some areas restricted the number of study sites and the time spent in them. All 39 transects were carried out in the middle of the wet season (December–late February) and recorded as GPS tracks, and all raptor sightings as GPS waypoints. The length of routes was measured by using a GPS, the vehicle odometer and topographic maps. As habitat structure, detectability of raptors and driving conditions were too variable, we did not follow a strict methodology protocol (i.e. strip, line or point transects), but a combination of the three. To facilitate relocation of the routes for future surveys, we downloaded all recorded tracks in a GPS navigation software (Touratech QV). Sample segments were arranged by habitat type. To minimise differences in detectability among transects, we standardised the time of day and weather conditions. Driving speed was 40–60 km/hr on paved road and 20–40 km/hr or less on dirt roads, although road conditions and habitat type were too variable to permit a uniform driving speed. Roadside counts were conducted by 1–2 observers assisted by one driver. Observers looked carefully for accipiters while driving slowly (<50 km/hr), and during frequent stops to identify distant birds or scan the landscape, from after sunrise to before sunset (07h00–18h00), using 10× binoculars and a 20–60× telescope. All accipiters seen perched or flying were counted and identified if possible. As habitat structure in the proximity of the roads affected detectability of birds, we stopped at points spaced about 1–3 km in suitable habitats to look and listen for accipiters during a 5–10 minute period, or to conduct foot transects when necessary. During these stops we broadcast three different recordings of Chinese Sparrowhawk vocalisations in an effort to elicit vocal responses or approaches, using a standardised protocol (Parker 1991).

Twelve days from 6 to 17 March 2011 were spent at a peninsular migration watch site, Tanjung Kasuari (0.823°S 131.231°E), near the westernmost point of West Papua, in the proximity of the town of Sorong, to assess whether migratory movements were visible at this site. Methods were similar to those used in previous migration studies in Indonesia (Germi *et al.* 2009).

RESULTS

Transects covered a total length of 2,303 km, of which 1,948 km were on roads or footpaths and 355 km on rivers. Transects in forest habitats resulted in very few raptor sightings, probably due to poor detectability in dense forest, thus suggesting that this habitat type requires a different methodological approach to carry out raptor counts (Thiollay 1989, Whitacre 1991, Whitacre & Turley 1991). Eighteen raptor species were recorded during transects, all at low density (Table 2), and including three species (Black-shouldered Kite *Elanus caeruleus*, Bat Hawk *Macheiramphus alcinus* and Brown Goshawk *Accipiter fasciatus*) from areas outside their known distribution, thus extending their range within New Guinea.

Chinese Sparrowhawk was observed five times at four sites (Kimaam, Timika, Manokwari and Biak), 10 individuals in all (Table 1), up to 1,200 km east of the previously known limit of the wintering range, thus proving that this species does winter in Papua. These are the first records for the species in mainland New Guinea. All five records were at sea level, near coasts, in degraded habitats and swampland. Individuals were observed at sufficiently close range to permit positive identification using diagnostic field characters. The authors are very familiar with the identification of this species from previous field studies in the region (Germi 2005, Germi & Waluyo 2006, Germi *et al.* 2009).

New records

Kimaam, Dolok island: 10 January 2011, one adult male observed and photographed at short distance, roosting on a light pole at Kimaam airstrip (7.980°S 138.853°E) in Trans-Fly savannah.

Manokwari: 12 February 2011, one adult male roosting on a tree branch in secondary coastal forest in the proximity of the town of Manokwari (0.808°S 134.053°E).

Table 2. Raptor species recorded during transects, Papua, December 2010–March 2011.

Species	Merauke	Kimaam	Asmat	Timika	Wamena	Manokwari	Sorong	Biak	Total
Black-shouldered Kite *Elanus caeruleus*		12							12
Bat Hawk *Macheiramphus alcinus*			1						1
Pacific Baza *Aviceda subcristata*				4		3			7
Long-tailed Honey-buzzard *Henicopernis longicauda*	2			6		4			12
Whistling Kite *Haliastur sphenurus*	67	8		11					86
Brahminy Kite *Haliastur indus*	15	9	6	11	1	8	6	4	60
White-bellied Fish-eagle *Haliaeetus leucogaster*	2	3	4	5		1			15
Papuan Harrier *Circus spilothorax*	4	4		3	10				21
Chinese Sparrowhawk *Accipiter soloensis*		1		6		1		2	10
Grey Goshawk *Accipiter novaehollandiae*			1	4					5
Varied Goshawk *Accipiter hiogaster*	1	1		3	1				6
Collared Sparrowhawk *Accipiter cirrhocephalus*	3	2	2	5	1	3	1		17
Brown Goshawk *Accipiter fasciatus*	3	2							5
Gurney's Eagle *Aquila gurneyi*		1	1						2
Wedge-tailed Eagle *Aquila audax*	3								3
Oriental Hobby *Falco severus*			1						1
Brown Falcon *Falco subniger*				2					2
Peregrine Falcon *Falco peregrinus calidus*	1						8	2	11

Note: The taxonomy of *Accipiter novaehollandiae* and *A. hiogaster* remains controversial among authors. Here they are treated as separate species.

Biak island: 14 and 15 February 2011, two single females (possibly the same bird) observed at the same site, roosting on a tree branch in degraded woodland (1.094°S 136.330°E).

Timika: 3 March 2011, a flock of six individuals soaring and gliding at low altitude, apparently in westward migration, observed and photographed over swampland (4.691°S 136.887°E) along the mining road between the town of Timika and the port of Amamapare.

From previous observation in Sangihe (Germi *et al.* 2009), we found that Chinese Sparrowhawk can be conspicuously vocal when perched on exposed tree branches, especially in the early morning. Although we broadcast Chinese Sparrowhawk vocalisations on numerous occasions in seven sample areas (excluding Biak) and towards the individual observed in Manokwari, we never obtained any response or approach.

During 12 days spent at a suitable watch site at the westernmost point of Papua during the migration season, no movements of Chinese Sparrowhawk were observed, although dates were chosen to precede by a few days the known passage period in North Sulawesi.

DISCUSSION

We plotted the known records of migrating Chinese Sparrowhawks in Wallacea and the handful of historical winter records from the islands off the westernmost tip of Papua. This hinted at a probable winter distribution in poorly surveyed but ecologically suitable areas in Papua, particularly in the open habitats of the south-east. As this territory is subject to heavy flooding during the rainy season, its wintering avifauna is poorly known, partly because of the inaccessibility of much of the region. Moreover, very few formal surveys have been published from Papua in the past 20 years and only a handful of informal accounts from short visits by ornithologists and birdwatchers have appeared (Marshall & Beehler 2007).

Records of wintering Chinese Sparrowhawks in other parts of Indonesia show that this accipiter is not a closed-canopy forest species; instead it occupies a variety of open habitats ranging from forest edge, secondary forest and scrub to agricultural landscapes. Previous observations in central Flores (Germi *et al.* 2009) showed that wintering Chinese Sparrowhawks feed primarily on cicadas, and the majority of birds leave the island in late November once cicada emergences cease, and only small numbers remain through the winter. Interestingly, large emergences of cicadas are known to occur at the beginning of the rains in October–November in Papua and in October–February in the Moluccas, suggesting that Chinese Sparrowhawks move east when insect abundance shifts with the advancing rainy season (Germi *et al.* 2009). The south-east of Papua, part of the Greater Trans-Fly, is characterised by an extensive mosaic of monsoon forest, secondary forest, swampland and swathes of savannah, thus potentially ideal wintering habitat. Although this region was initially the focus of our study, lack of accessibility and the subsequent paucity of records (only one individual at Kimaam, Dolok island) prompted us to extend the survey into different parts of Papua. Most areas surveyed presented several logistical constraints and difficult access. Suitable habitat covered large inaccessible areas, and the scarcity of records during this study suggests that the species disperses at low density within the vast region. However our records, although small in number, clearly indicate that an unknown proportion of this accipiter population overwinters in Papua, apparently in coastal areas.

The absence of migrating Chinese Sparrowhawks in March (migration season) at the watch site of Tanjung Kasuari (Figure 1) might reflect the use of a different route further to the south. We assumed that migrants would travel from the Sorong area to Waigeo and Halmahera islands, but the lack of migrants at Tanjung Kasuari could indicates that migrants leave Papua via Salawati Island, where shorter water crossings are available, and continue east through Kofiau, Obi and the Sula islands before reaching

Sulawesi. Access restrictions on the Papua coast in the proximity of Salawati prevented us from testing this hypothesis.

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Francesco GERMI*, 46 (2F2) Elm Row, Edinburgh EH7 4AH, UK. Email: fgermi@yahoo.co.uk*

Agus SALIM*, Jl. Palem Putri VIII No. 5–7, Taman Jasmin 5, Bogor, 16113, West Java, Indonesia. Email: salim@asalim.org*

Andrea MINGANTI*, Via Monti di Primavalle 96/a, 00168 Rome, Italy. Email: andming@alice.it*

Spatial distribution of the Tawny Fish Owl *Ketupa flavipes* shaped by natural and man-made factors in Taiwan

SHIAO-YU HONG, YUAN-HSUN SUN, HSIN-JU WU & CHAO-CHIEH CHEN

This study investigated the distribution of the Tawny Fish Owl *Ketupa flavipes*, a rare top predator in Taiwan, and examined natural and man-made factors that affect it. Records of Tawny Fish Owls from 1993 to 2006 were compiled from field studies, literature surveys, museum notes and specimens, and interviews with researchers, birdwatchers and indigenous hunters. In total, 91 Tawny Fish Owl territories were identified, widely distributed along mountain streams in the Central Mountain Range between 48 and 2,407 m—more than half of them were below 700 m. The upper altitudinal range of the owls is probably limited by food availability and stream size. Territories were on average 431 m higher on the west side of the Central Mountain Range than on the east. Habitat selection analysis further indicated that, in proportion to the land area available, the Tawny Fish Owl was absent from areas below 500 m. This is apparently due to extensive deforestation of lowlands for agriculture and urbanisation on the west side of the island. It is recommended that a protected area be established in the north-east part of Taiwan, to preserve the remaining lowland streams and riparian forests still inhabited by the species.

INTRODUCTION

Fish owls are top predators in freshwater food chains and are important indicator species for healthy stream ecosystems (Duncan 2003, Wu *et al.* 2006). The Tawny Fish Owl *Ketupa flavipes* is widely distributed in the Himalayas, eastern Indochina, south China and Taiwan (Voous 1988, Marks *et al.* 1999). It reaches 58 cm in body length (Sun 1996), making it one of the largest raptors within its range. However, it is so rarely observed in the wild that it is considered to be rare over most of its range (Marks *et al.* 1999). It is currently listed in CITES Appendix II (UNEP-WCMC 2009).

The species was first reported from Taiwan by Kuroda (1916). Since then its natural history has remained poorly known (Voous 1988). In 1989, when the Wildlife Conservation Law was first implemented in Taiwan, the Tawny Fish Owl was listed as an Endangered Species (Class I) due to poaching (Sun 1996) and destruction of riparian forests (Severinghaus 1987). Even though its population was still considered very small (Fang 2005), Tawny Fish Owl was down-listed to Rare and Precious Species (Class II) in 2008, due to better knowledge of its population size (Sun 1996, Sun *et al.* 2000, 2004).

As the distribution and population size of the Tawny Fish Owl in Taiwan remained unclear, further investigation was needed to correctly assess its protection status. The aims of this study were to determine its spatial distribution and to evaluate factors affecting its distribution by identifying locations throughout Taiwan where Tawny Fish Owl had been recorded recently.

METHODS

Study area

Taiwan is a mountainous island lying between 21 and 25°N and 120 and 122°E in subtropical East Asia, about 150 km off the coast of south-east China. It is 394 km long and 144 km wide with a total area of 36,000 km^2. Hills and mountains with elevations higher than 100 m cover about 70% of the island (Taiwan Forestry Bureau 1995). The Central Mountain Range, with more than 200 peaks over 3,000 m in height, runs from north to south. The rivers that originate from the mountain range are short and steep with rapid currents, particularly on the east side. A lower Coastal Mountain Range is present between the east coast and the Central Mountain Range.

Forests cover 59% of the island, of which 73% is natural forest (44% of the island) (Taiwan Forestry Bureau 1995). Broad-leaved forests predominate below 1,500 m, coniferous forests above 2,500 m, with mixed forests in between. The coastal plains are much wider on the west side than on the east, and most of them have been converted to urban or agricultural areas. Only small remnants of the original riparian forests remain on the peripheral hilly areas on the west side of the mountain range, whereas most forests on the east side remain little affected because of access difficulties (Taiwan Forestry Bureau 1995). Annual precipitation is between 1,000 mm and 4,800 mm, and decreases gradually from north-east to south-west because of monsoon rainfalls and incidence of typhoons (Chiu 2006). Annual average temperature is about 25°C at sea level and 4°C at about 3,800 m (Chiu 2006).

Data collection and analysis

Tawny Fish Owl records between 1993 and 2006 were collected using the following approaches to identify locations where it occurred. First, faunal reports and the bird-sighting databases of wild bird societies were searched for records, and the collection data for Tawny Fish Owl specimens preserved in the Academia Sinica (AS), the National Taiwan Museum (NTM), National Museum of Natural Science (NMNS), and Taiwan Endemic Species Research Institute (TESRI) were examined. A total of 42 records were obtained: nine records from faunal reports, 15 from wild bird societies, two from AS, five from NTM, six from NMNS, and five from TESRI.

Second, 19 birdwatchers and 119 hunters from 27 indigenous villages located near rivers where there were no or very few records of Tawny Fish Owls were interviewed. All information indicating the presence of owls was collected, including hunting captures, sightings, calling birds, pellets, feathers, droppings and food remains. Tawny Fish Owl calls are easily distinguished from those of other owls in Taiwan (Sun 1996). Interviewees had to describe the sound of the owl clearly before each record was considered valid. As a fish-eater, the droppings and food remains of Tawny Fish Owls were easily identifiable (Wu *et al.* 2006). We obtained 52 records from the interviewees.

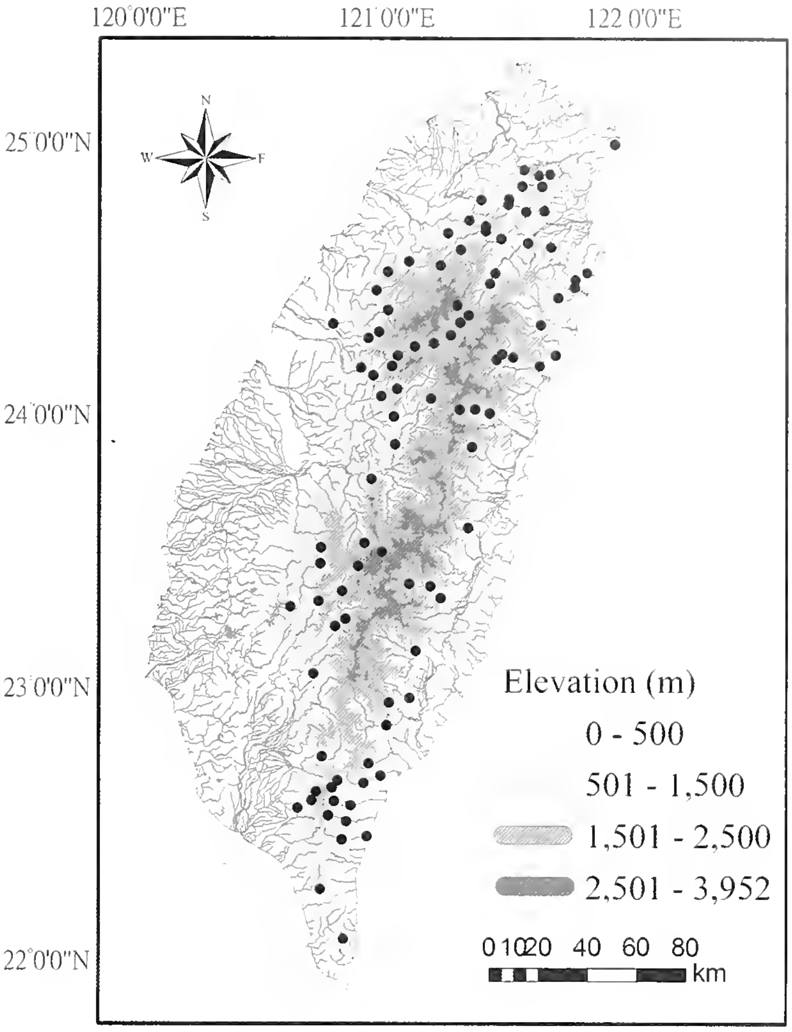
Third, field surveys were conducted to identify Tawny Fish Owl sites, using the same clues as above to detect the presence of owls. The sites surveyed included 15 coldwater fish farms (Rainbow Trout *Oncorhynchus mykiss* and smelt [Osmeridae spp.]) near mountain streams, mostly in northern Taiwan. The owls preyed on fish in the farms and often left remains, such as fish scales, bloodstains and internal fish organs, along with their own feathers, near the predation sites (Sun *et al.* 2004).

The Tawny Fish Owl has a strong territorial habit (Fogden 1973, Sun 1996, Sun *et al.* 2000). A territory of a pair of owls was estimated to be about 6.2 km along a river and less than 550 m from the bank, derived from two territories measured by radio-tracking (Sun *et al.* 2000). In this study any owl records obtained within a 6.2 km length of river were considered to refer to a single pair, and the midpoint of the two outermost records was used to represent the territorial site.

To construct the Tawny Fish Owl's altitudinal distribution chart, the elevation of each of the owl territories was obtained by using coordinates under Identify (ArcGIS) on a Digital Terrain Model (DTM) of Taiwan (precision 40 m × 40 m). The perpendicular distance of each owl territory from the crest line of the Central Mountain Range was calculated, to illustrate how altitudinal distribution varied across the island. A 50 m interval contour map was created from the DTM by 3D Analyst, and then transformed to a 3D topographic chart in ArcScene. The 3D topographic chart was rotated to calculate the altitudinal profile of the island (between 25 and 375 km south of the northern tip of the island), as viewed by an observer standing on the south end of the island. Elevations of territories to the east and west sides of the Central Mountain Range were compared with an independent t-test.

The altitudinal range of the island from sea level to 3,950 m was divided into four bands: <500 m, 500–1,000 m, 1,000–1,500 m and >1,500 m. The proportion of owl territories in each altitude band was compared with the proportion of the land area in each altitude band. A use and availability analysis (Litvaitis *et al.* 1994) was conducted using a chi-squared test and multiple simultaneous comparisons between Bonferroni confidence intervals of observed use and the proportion of land area in each altitude band. All statistical analyses were conducted with SPSS 10.0.7C for Windows with an α-level set at 0.05.

Figure 1. Locations of 91 verified Tawny Fish Owl territories in Taiwan, 1993 to 2006.



RESULTS

A total of 153 owl records were obtained. Of these, 15 museum specimens and 11 records from wild bird societies had no clear location and were excluded from the study. The 127 valid records consisted of 37 from birdwatchers, 28 from indigenous hunters, 35 from field surveys along rivers, 15 from fish farms, 9 from fauna reports and 3 from museum collections. Of these, 39 records were direct sightings of owls, 35 hunting captures or owls found dead, 28 sites with owl pellets, 17 calling birds and 8 records of feathers, food remains, droppings or other signs (Table 1).

Taking owl records found within a 6.2 km section of a river to represent single pairs, the 127 valid records indicate 91 owl territories. Two of these territories had four records and 70 territories contained only one. The territories were distributed along mountain streams in the Central Mountain Range (Figure 1). There were no records from either of the coastal plains or the Coastal Mountain Range in the east.

The altitudinal distribution of the owl territories ranged between 48 m and 2,407 m with mean 687 m and the middle 50% range between 300 m and 1,100 m (Figure 2). The distribution was skewed toward low elevations (skewness = 0.97), implying that most of the owl territories were located at lower altitudes.

The transverse altitudinal distribution of the owl territories in relation to the Central Mountain Range is shown in Figure 3. There was significant difference ($t = 3.04$, df = 55, $P < 0.01$) between the

Table 1. Sources and categories of 127 Tawny Fish Owl records obtained in 1993–2006 for this study. Captured birds included those caught by hunters or found dead by birdwatchers and those preserved as specimens in museums and research institutions.

	Sources						
Categories	**Birdwatchers**	**Field survey**	**Hunters**	**Fish farm**	**Reports**	**Museums**	**Total**
Sightings	13	13	11		2		39
Captures	2		15	15		3	35
Pellets	10	14			4		28
Calling birds	8	5	2		2		17
Feathers/ food remains	3	1					4
Droppings		2					2
Others	1				1		2
Total	37	35	28	15	9	3	127

Figure 2. Frequency distribution of the elevations of 91 verified Tawny Fish Owl territories in Taiwan, 1993–2006.

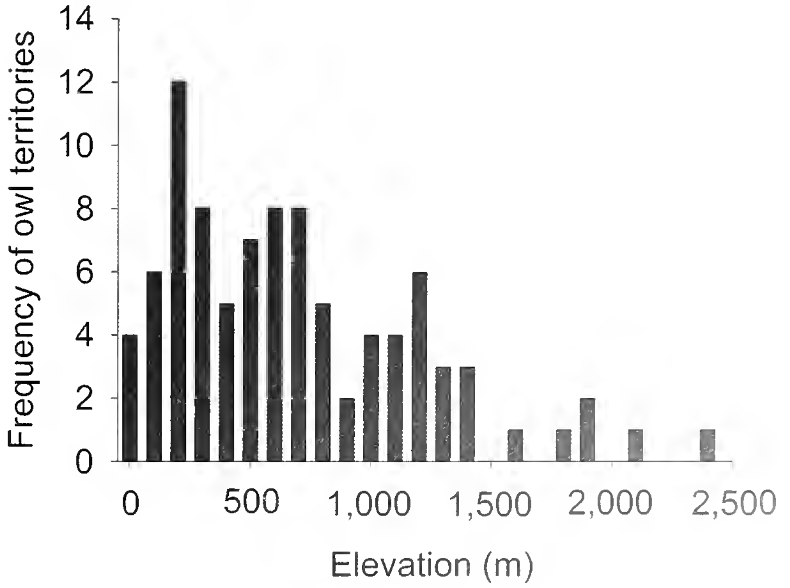
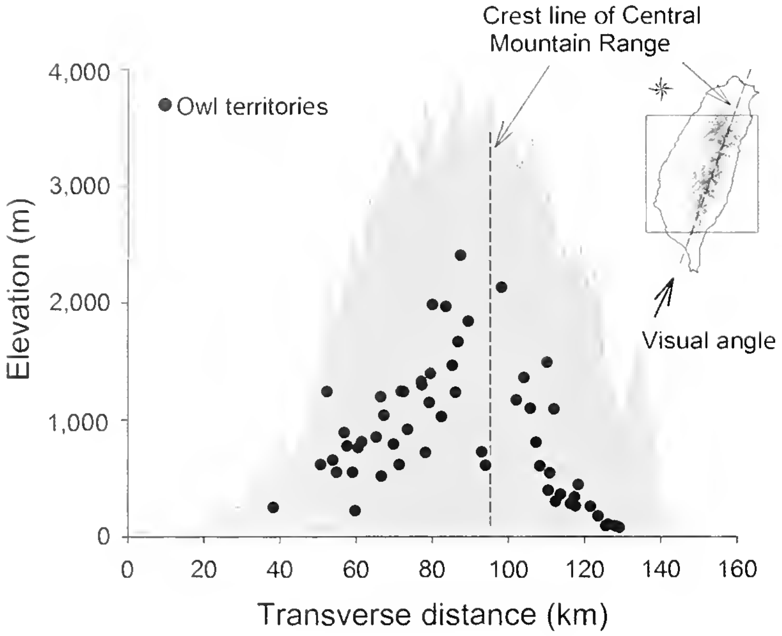


Figure 3. Altitudinal distribution of Tawny Fish Owl territories relative to the crest line of the Central Mountain Range. The grey outline shows the altitudinal profile of the island, viewed from the south end. (The vertical scale is magnified 30-fold as the elevation of Mount Yushan, the highest peak of Taiwan, is relatively small [4 km] compared with the width [144 km] of the island.)



east and west side of the mountain range. Most of the territories on the west side were above 500 m, whereas more than half of the territories on the east side were below 500 m. The former averaged 431 m higher than the latter. Territories were generally situated in deep valleys, well below the surrounding mountain ridges (Figure 3).

Tawny Fish Owls did not use the four altitude bands in proportion to the land area of the island ($\chi^2 = 41.57$, df = 3, $P < 0.0001$). Multiple comparisons showed that the owls appeared in land below 500 m and above 1,500 m in a significantly lower proportion compared with the land area of these altitude ranges (Table 2). In contrast, the proportion of owl territories was twice the proportion of the land area between 500 and 1,500 m, indicating that the owls selected this altitude range.

DISCUSSION

The Tawny Fish Owl mainly takes prey from streams (Sun 1996, Wu *et al.* 2006). Its upper altitudinal range may be constrained by the distribution of stream fishes (Voous 1988, Marks *et al.* 1999). In Taiwan, the highest reported elevation for stream fish is 2,400 m (Tzeng 1986, Wang 2010), which coincides with the upper limit of the owl's altitudinal range (Figure 2). Fish abundance and diversity increase at lower elevations, for example 10 fish species occur at 1,500 m (Wang 2010) and only six owl territories were recorded above 1,500 m suggesting that fish abundance and diversity is important to the species. However, amphibians and crabs were found to be the most important prey items for Tawny Fish Owls at Sakatang Stream, eastern Taiwan (Wu *et al.* 2006), and the abundance and diversity of these taxa also increase at lower altitudes.

The occurrence of the Tawny Fish Owl was also related to the distribution of mountain streams. Streams with stable flow above 1,500 m are only found in central regions where large mountains occur. Tawny Fish Owls seldom forage in small creeks less than 5 m wide, perhaps due to food scarcity and the poor manoeuvrability of a bird with a wingspan of 1.5 m (Sun *et al.* 2000). As a result, the highest parts of the range mainly occurred around the largest mountains. The latter phenomenon was possibly enhanced by the Massenerhebung effect, which predicts that locations at the same elevation are warmer on large mountains compared to smaller ones, because the large mountains release heat more slowly (Flenley 1994).

Conversely, local differences between the altitudinal range of the owls and the surrounding mountain ridges were larger in small mountains and mountains with steep slopes. For example, the owl's upper altitudinal limit on the east side of the Central Mountain Range, where rivers are much smaller, steeper and often dry up, was lower than that on the west side. This may partly explain why owl territories on the east side of the island were lower than those on the west side. In addition, no Tawny Fish Owls were recorded in the Coastal Mountain Range where rivers are short and small. Similarly, the owls were seldom found in streams on low mountains in the south of Taiwan. In contrast, streams in the north of Taiwan have regular water flow all year round, due to the north-east monsoon rainfalls (4,000 mm/year) (Chiu 2006), so the owls occurred further upstream, closer to the mountain ridge.

The distribution of Tawny Fish Owls in Taiwan was also influenced greatly by habitat loss due to human activities. Destruction of lowland habitat is widespread, especially on the west side of the island, due to the conversion of natural forests to farmland and urbanisation over the last 200 years. The habitat selection analysis indicated that there were fewer owls in lowland areas, even though lowlands should have more suitable streams than the hills—wider, with more reliable flow, and greater prey abundance and diversity. Most Tawny Fish Owl territories to the east of the Central Mountain Range were below 500 m, but only two owl territories were found below that elevation on the west side. The lower altitudinal limit on the west side is likely to have retreated into higher, mountainous areas, as is the case for many forest birds and mammals on the island (Liu *et al.* 2003, Shiu 2003). It is likely that the loss of natural forests below 500 m has eradicated Tawny Fish Owls from the western lowlands, since riparian natural forests are the main habitat type used by fish owls (Hayashi 1997, Sun *et al.* 2000).

Poaching is one of the most serious threats to the Tawny Fish Owl population (Severinghaus 1987) and at least 61 records of hunting have been reported since the species was legally protected in Taiwan in 1989 (Wang *et al.* 1995). Of the 28 owl records obtained from indigenous hunters, 54% were the result of poaching. Only a small proportion of indigenous hunters were interviewed, suggesting that poaching is likely to be widespread across the island.

More than 60% of the owl territories found in this study were situated outside areas protected for wildlife (Hong 2007). The lowlands are largely unprotected and those on the developed western part of the island are already deforested, therefore we recommend the establishment of a protected area for the Tawny Fish Owl along lowland streams in north-east Taiwan, where the original riparian forests still remain nearly intact (Taiwan Forestry

Table 2. The effects of altitude on territory selection by Tawny Fish Owls in Taiwan ($\chi^2 = 41.57$, $P < 0.0001$). The Bonferroni confidence intervals show that the % use of each altitude band is higher (selected) or lower (avoided) than the % availability.

Altitude band (m)	*N*	Use %	Availability %	Selection index	Standardised index	Bonferroni confidence intervals
<500	35	0.3846	0.5276	0.7290	0.1307	$0.2571 < Pi < 0.5121$
500–1,000	30	0.3297	0.1542	2.1379	0.3835	$0.2065 < Pi < 0.4529$
1,000–1,500	20	0.2198	0.1071	2.0521	0.3681	$0.1113 < Pi < 0.3283$
>1,500	6	0.0659	0.2112	0.3122	0.0560	$0.0009 < Pi < 0.1310$

Bureau 1995). This is possibly the only place in Taiwan where the Tawny Fish Owl range still reaches the coastline. This recommendation is in accordance with other studies that have recommended low-elevation protected areas for threatened species including Clouded Leopard *Neofelis nebulosa*, Leopard Cat *Prionailurus bengalensis*, Small Indian Civet *Viverricula indica*, Formosan Pangolin *Manis pentadactyla* and Fairy Pitta *Pitta nympha* (Liu *et al.* 2003, Chiang & Pei 2004, Lee *et al.* 2006).

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***Shiao-Yu HONG**, Institute of Wildlife Conservation and Graduate Institute of Bioresources, National Pingtung University of Science and Technology, Pingtung 912, Taiwan*

***Yuan-Hsun SUN**, Institute of Wildlife Conservation, National Pingtung University of Science and Technology, Pingtung 912, Taiwan*

***Hsin-Ju WU**, Department of Life Science, National Taiwan Normal University, Taipei 117, Taiwan*

***Chao-Chieh CHEN** (Corresponding author) Department of Biomedical Science and Environmental Biology, Kaohsiung Medical University, Kaohsiung 807, Taiwan. Email: chen5123@kmu.edu.tw or chenkmu@gmail.com*

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Population, breeding and threats to the White-rumped Vulture *Gyps bengalensis* in Bangladesh

M. MONIRUL H. KHAN

The population of the White-rumped Vulture *Gyps bengalensis* in Bangladesh has declined very rapidly in recent years, so a research-cum-conservation project was launched in July 2008 that continued until June 2012. Three species of vultures were found during the survey—White-rumped Vulture, Himalayan Vulture *Gyps himalayensis* and Cinereous Vulture *Aegypius monachus*. Based on nesting sites and frequent sightings of vultures, a total of six 'hotspots' were identified in the areas of Moulvibazar, Habiganj, Haor Basin, Mymensingh, Sundarbans (northern end) and Barisal. The total population of the White-rumped Vulture in suitable habitats across the country shows that numbers have drastically declined from 1,972 to 816 (nearly 60% drop) in four years. In two consecutive breeding seasons only 5 out of 32 and 8 out of 31 nests were successful in producing fledglings (one from each nest). The overall breeding success was very low (15.6–25.8%). The reason for such poor breeding success was sudden death or disappearance of parent birds, apparently due to poisoning by diclofenac, a veterinary drug used to treat livestock ailments. The project identified poisoning as the principal cause of vulture decline. Although the Government of Bangladesh banned use of veterinary diclofenac from 25 October 2010, 53% of the veterinary drug stores still sell it illegally. Awareness campaigns have made people aware of vulture conservation and the adverse effects of diclofenac.

INTRODUCTION

Historically, seven species of vultures—White-rumped *Gyps bengalensis*, Himalayan *G. himalayensis*, Griffon *G. fulvus*, Slender-billed *G. tenuirostris*, Cinereous *Aegypius monachus*, Red-headed *Sarcogyps calvus* and Egyptian *Neophron percnopterus*—have been recorded in Bangladesh (Khan 2008, Siddiqui *et al.* 2008). However, only the White-rumped Vulture, Himalayan Vulture and Cinereous Vulture have been seen in the last four years and only the White-rumped Vulture is now known to breed in Bangladesh.

Populations of the White-rumped Vulture and other resident *Gyps* vulture species have declined very rapidly since the mid-1990s across the Indian subcontinent (Prakash 1999, Gilbert *et al.* 2006, Prakash *et al.* 2007, Chaudhary *et al.* 2012). Declines in numbers of the White-rumped Vulture have exceeded 99.9% in India (Prakash *et al.* 2007) and the species is classified as Critically Endangered (BirdLife International 2001, BirdLife International 2012). If the rate of decline cannot be arrested, the species will disappear from the Indian subcontinent in the next few years. This species not only plays a key role as a scavenger but is also part of the heritage of the Bengal region. The people of Bangladesh are not hostile to vultures, but they have been almost totally unaware of the threats and dire situation that vultures are facing. A decade ago the White-rumped Vulture was a common and widely distributed bird in Bangladesh (Harvey 1990, Thompson & Johnson 1996). Recent studies in India, Nepal and Pakistan confirm that vultures are poisoned when they feed on the carcasses of cattle treated with the veterinary drug diclofenac shortly before their death (Green *et al.* 2004, Oaks *et al.* 2004, Shultz *et al.* 2004). This is also likely to be the main cause of the decline in the vulture population in Bangladesh, but there may be other factors contributing to the decline.

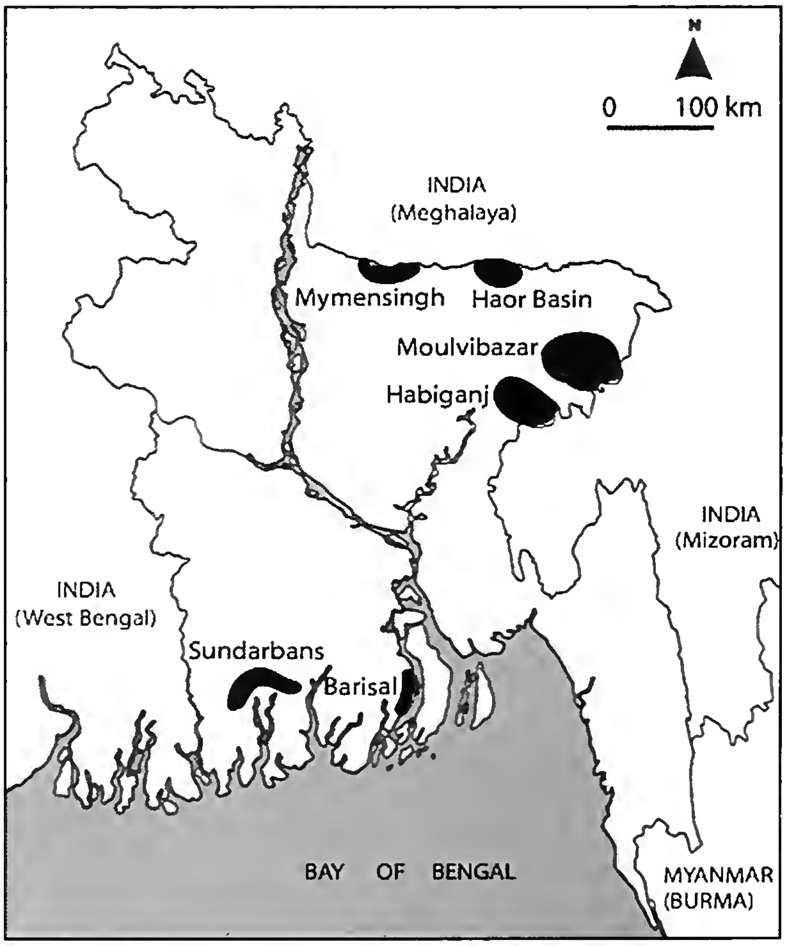
Because the White-rumped Vulture is a globally and nationally threatened species (BirdLife International 2001, BirdLife International 2012) it was necessary to take measures to save it from local extinction. Here the findings of a research-cum-conservation project focusing on this species, started in 2008, are reported. The aim was to understand the conservation status of the White-rumped Vulture in Bangladesh and to implement ways of reducing population decline. The specific objectives were to estimate the relative abundance of populations in different parts of the country, assess the population trend, identify important vulture 'hotspots' (where they nest and are frequently sighted), record breeding success and assess the threats (focusing mainly on the availability and use of veterinary diclofenac). Moreover, vulture conservation awareness programmes were conducted to spread knowledge of the dire situation faced by the vulture population and discourage the use of diclofenac to treat cattle.

METHODS

Study area

The project was implemented in different parts of the country, but focused on Greater Sylhet (north-east), Greater Khulna (south-west), Greater Mymensingh (north) and Greater Barisal (south)

Figure 1. Bangladesh showing hotspots (shaded black) for the White-rumped Vulture *Gyps bengalensis*.



where the White-rumped Vulture was known to nest and roost regularly (Figure 1). Geographically, Bangladesh is located between 20.567°–26.550°N and 88.017°–92.683°E. The total area of the country is 147,570 km^2, with a population of around 160 million people. The climate is tropical monsoon, characterised by marked seasonal variations. Abundant rainfall during the monsoon (July–October) is followed by a cool winter period (November–February), and then a hot and dry summer (March–June). Bangladesh can be divided into three main physiographic divisions—Tertiary hills, Pleistocene terraces and recent plains (Khan 2008).

Field methods

A small team of researchers carried out the surveys, but local people were also involved in most areas. Five members of the research team had been trained in different aspects of wildlife biology. The project team worked closely with villagers and labourers on tea plantations, since the vultures mainly occur and breed in and around villages and tea estates. Journalists, veterinarians and other professional people were also involved with various activities. The project team liaised closely with the Bangladesh Forest Department. Work was carried out from July 2008 to June 2012 (hence 2008–2009 is the period between July 2008 and June 2009, so that each breeding season falls in one slot), but not all the activities were carried out each year of the project. Some data were collected during 2005–2008 to confirm the relative abundance of vultures in different areas and find the hotspots.

Surveys to assess relative abundance and identify vulture hotspots

Between 2005 and 2008, vulture sightings by 50 local people were recorded every year in each of the seven administrative divisions (Dhaka, Chittagong, Sylhet, Rajshahi, Rangpur, Khulna and Barisal) so that division-wise the relative abundance of vulture populations could be estimated. In order to get the best output from the limited resources available for awareness and conservation activities, hotspots were identified on the basis of the occurrence of nesting sites and frequent sightings (where interviewees have seen vultures at least once in every two-month period).

Population surveys

To determine the population trend, the team selected potential survey areas throughout the country and systematically visited the known roosting sites in the morning and in the afternoon to count White-rumped Vultures in roosting colonies. Sightings of other vulture species were recorded during these surveys. The survey team interviewed local people about their vulture sightings and, in areas where interviewees claimed recent sightings of roosting vultures, the survey team stayed and counted the vultures when they returned to roost. In areas where the interviewees said that there were no recent sightings at roosting colonies, the survey team quickly moved on to new areas. The same roosts visited during 2008–2009 were visited again in 2009–2010, 2010–2011 and 2011–2012. Since the count was conducted in all the potential sites for vultures, although not in each and every part of the country, the annual counts can be considered as total counts for the country or a very close representation of it. More importantly, however, the count has been repeated in a standardised way so that the data are comparable year on year.

Monitoring breeding success

The breeding success of vultures was documented by periodically (at least once every two weeks) observing every known nest during the breeding season (dry season: October to March). Telescopes and binoculars were used for these observations. A commercially made camouflaged hide was often used so that the nesting vultures were not disturbed by the presence of observers. The main information recorded was the fate of nests—if the nestling from a particular nest flew (fledged), the nest was treated as successful. Information on nesting trees (species, nest height from the ground) was also recorded.

Surveys for diclofenac

The availability of veterinary diclofenac and other non-steroidal anti-inflammatory drugs (NSAIDs) was assessed in two ways. First, undercover surveys (posing as buyers) of the veterinary drug stores throughout the country were undertaken (70 drug stores every year), from 2008–2009 to 2011–2012. Second, the use of diclofenac was recorded by interviewing local cattle-owners (86 individuals in total) in different areas of the country. This was done openly (since the cattle-owners were not as secretive as the veterinary drug salesmen) by using a standard questionnaire that also included a question on what the cattle-owners do with dead cattle.

RESULTS

Based on sightings of the White-rumped Vulture during 2005–2008 surveys by local people in suitable habitats of the seven administrative divisions, the highest relative abundance was found to be in Sylhet (5.1 sightings/interviewee/year) and the lowest in Chittagong (0.7 sightings/interviewee/year) (Table 1). This gives an average for the country of 2.8 sightings/interviewee/year. Based on nesting sites and frequency of sightings, a total of six hotspots were identified: the areas of Moulvibazar, Habiganj, Haor Basin, Mymensingh, Sundarbans (northern end) and Barisal (Figure 1).

Table 1. Relative abundance of the White-rumped Vulture in suitable areas of seven divisions of Bangladesh.

Division	Total no. of sightings during 2005–2008 by 50 interviewees	Average no. of sightings/ interviewee/year
Dhaka	645	3.2
Chittagong	141	0.7
Sylhet	1,022	5.1
Rajshahi	443	2.2
Rangpur	420	2.1
Khulna	640	3.2
Barisal	466	2.3

Survey data from 2008–2009 to 2011–2012 demonstrate that the White-rumped Vulture declined by nearly 60% over the four-year study period throughout the country, and that other species of vultures are extremely rare. The total population of the White-rumped Vulture in suitable habitats across the country (which can be treated as the total Bangladesh population) shows that the population drastically declined from an estimated 1,972 in 2008–2009, 1456 in 2009–2010, 991 in 2010–2011 and 816 in 2011–2012.

Other than the White-rumped Vulture there were 16 sightings of Himalayan Vulture from Moulvibazar (north-east), Sunamganj (north-east), Habiganj (north-east), Jamalpur (north), Sirajganj (west) and Rangpur (north-west). All sightings were between October and March indicating that they were winter visitors. Most of the sightings were small flocks, but the largest roosting flock of 21 birds was sighted in a tall Silk Cotton *Salmalia* sp. tree at Dawrachara Tea Estate, Moulvibazar, on 3 March 2012. Himalayan Vultures were seen roosting, soaring, or feeding with White-rumped Vultures six times. There were only four sightings of Cinereous Vulture from Rajshahi (north-west), Madhupur Tract (central), Narshingdi (north-east) and Moulvibazar (north-east). All were solitary birds, including two juveniles, sighted at different seasons, indicating that they were probably vagrant individuals.

Table 2. Breeding status of the White-rumped Vulture in seven divisions of Bangladesh

Division	Number of nests observed Season-1	Number of nests observed Season-2	Unsuccessful (nesting birds died/ vanished) Season-1	Unsuccessful (nesting birds died/ vanished) Season-2	Successful (nestling left nest) Season-1	Successful (nestling left nest) Season-2	Breeding success (%) Season-1	Breeding success (%) Season-2
Dhaka	8	6	7	5	1	1	12.5	16.7
Chittagong	0	0	–	–	–	–	–	–
Sylhet	14	13	12	10	2	3	14.3	23.1
Rajshahi	0	0	–	–	–	–	–	–
Rangpur	0	0	–	–	–	–	–	–
Khulna	10	9	8	7	2	2	20.0	22.2
Barisal	0	3	–	1	–	2	–	66.7
Total/Overall for Bangladesh	**32**	**31**	**27**	**23**	**5**	**8**	**15.6**	**25.8**

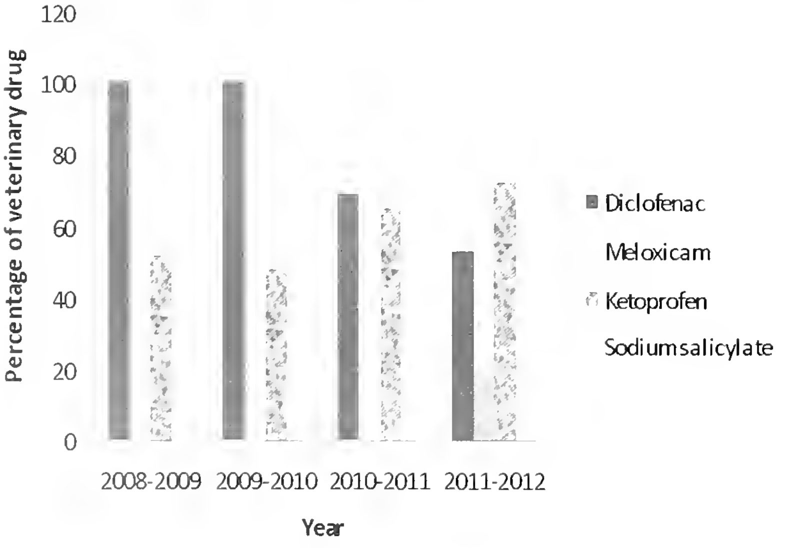
NB. Season 1 (October 2009–March 2010) and Season 2 (October 2010–March 2011) were the two consecutive breeding seasons of vultures.

Breeding success of the White-rumped Vulture for all nests in all the known breeding areas in Bangladesh was documented. In Season 1 (October 2009 to March 2010), a total of 32 nests were observed of which only five birds from five nests successfully fledged (clutch size is one), giving an overall breeding success of 15.6% (Table 2). In Season 2 (October 2010 to March 2011), a total of 31 nests were observed from which eight birds fledged (25.8% success rate). At unsuccessful nests the parent birds were found dead, either on the ground near the nest (n = 11) or on/beside the nest (n = 4), or the parent birds just vanished suddenly (n = 35), indicating that they had probably died elsewhere. Although no post-mortems were undertaken, the dead vultures were apparently in good health, indicating sudden death that can be caused by poisoning. It was observed that, whether the nest had an egg or nestling, one parent almost always attended the nest to guard against crows (House Crow *Corvus splendens*, Large-billed Crow *C. macrorhynchos*) and other raptors (Pallas's Fish Eagle *Haliaeetus leucoryphus*, Steppe Eagle *Aquila nipalensis*). The parents take shifts so that both can feed and bring food for the nestling.

Vulture nests were found in the following trees: *Albizia lebbeck*, *Albizia procera*, *Anthocephalus chinensis*, *Bombax ceiba*, *Borassus flabellifer*, *Cocos nucifera*, *Ficus benghalensis*, *Ficus religiosa*, *Mangifera indica*, *Swietenia mahagoni*. Vultures had no preference for nesting tree species, but all nesting trees were large. Nests were constructed at heights ranging from 7 to 17 m.

The veterinary drug stores were surveyed for four years, from 2008–2009 to 2011–2012, and it was found that the availability of diclofenac in stores has decreased from 100% to 53% and the availability of three other NSAIDs (meloxicam, ketoprofen and sodium salicylate) had increased (Figure 2). This is in response to the ban on production of veterinary diclofenac from 25 October 2010 and the banning of the use of veterinary diclofenac from six months after the banning of production (25 April 2011). Diclofenac is most commonly used in the form of injection vials, but it is also available as a suppository and tablet. Each 30-ml vial costs Taka 80 (US$1). Today, meloxicam, the safe alternative to diclofenac (introduced after the diclofenac ban), is available in the market, but diclofenac is still illegally sold in veterinary drug stores (Figure 2, 2011–2012). Other than NSAIDs, paracetamol and dexamethasone are also available in veterinary drug stores as anti-inflammatory drugs. Various steroids and ureas for cattle fattening are also available, which are normally used before the cattle are sold, so the highest use is before the Eid-ul-Azha when many cattle are ceremonially slaughtered by Muslims.

Figure 2. Availability of different NSAIDs in veterinary drug stores in Bangladesh. N.B. Other than NSAIDs, paracetamol and dexamethasone were available, which are used for the same purposes.



During 2008–2009, i.e., before the diclofenac ban, cattle-owners from different areas were interviewed and it was found that 57% of them used diclofenac when the cattle suffered from fever or at the early stage of any disease. Except in remote areas, and areas where cattle are scarce (in Chittagong Hill Tracts and parts of Chittagong and Cox's Bazar), diclofenac was found to be the most commonly used cattle medicine. In 59% of cases the cattle owners said they use diclofenac on their own without following a veterinarian's prescription. Although other similar drugs are available, diclofenac is more popular because people believe that it is a more effective cure. This medicine was used throughout the year, but most commonly in early monsoon (April–May) when cattle diseases are common.

Alarmingly, a very high proportion (61%) of cattle-owners said that when cattle died they skinned them, sold the hide and buried the body in order to control the smell. In the past, the smell would not reach human habitations because there were many distant open areas, but today there are very few areas as such where dead cattle can be disposed in the open. Some cattle owners (9%) also use the dead cattle as food for prawn and catfish. Therefore, it is likely that a reduction in vulture food supply has also taken place. In some of the areas that were surveyed there were very few large trees suitable for vultures to nest, but this scarcity did not appear critical in limiting the breeding of vultures.

DISCUSSION

Previous reports on the status of the White-rumped Vulture mainly quote the sizes of flocks that were regularly sighted at particular roosting and nesting areas (Sarker 1983, 1987, Harvey 1990, Thompson *et al.* 1993, Khan 2009, 2011), so it is difficult to compare the present population or relative abundance with those of the past. However, based on the scattered records mentioned above it is certain that the present population, estimated to be around 816 birds, is considerably less than the population of 20 years ago. Sarker (1987) arbitrarily estimated that the population density in the Sundarbans was 0.03 to 0.91 individuals/km^2, which is higher than the inferred density today. It is not surprising that the lowest relative abundance was estimated in the Chittagong division. Mountfort & Poore (1968) had reported that vultures are common in all areas except the Chittagong hills. This is probably because there are fewer cattle in the hilly areas of Chittagong.

Areas like the Sundarbans interior and Aricha (Manikganj), where vultures used to breed (Sarker 1983, 1987), were checked and it was found that they are no longer resident there. Vultures were reported to breed colonially (Sarker 1987, Ali & Ripley 1989, Grimmett *et al.* 1998), but during this survey it was found that they nest either alone or there are just a few nests in an area, but not very close together (except in one case). This is probably simply the result of the severe decline in the population. Like the previous reports (Sarker 1987, Ali & Ripley 1989, Grimmett *et al.* 1998), it was found that the White-rumped Vulture traditionally uses trees for nesting and the breeding peak is October to March. Even in the 1980s the breeding success of vultures was reported to be low (Sarker 1983), but this might be the result of a limited field survey.

The slowing of the rate of decline of the White-rumped Vulture population appears to be the result of lower availability of diclofenac in veterinary drug stores (Figure 2) following the ban. Similar results were found in India (Cuthbert *et al.* 2011a,b). Following the decrease in availability of diclofenac, however, the availability of other NSAIDs, including ketoprofen that is also known to be poisonous for *Gyps* vultures (Naidoo *et al.* 2009, Taggart *et al.* 2009), has increased. Sodium salicylate is believed to be harmless, but it has never been tested on vultures. It is now very well established that diclofenac poisons and causes the death of *Gyps* vultures (Green *et al.* 2004, Oaks *et al.* 2004, Shultz *et al.* 2004, Cuthbert *et al.* 2011c), so based on wide availability, even after the ban, it can be concluded that veterinary diclofenac is the biggest threat to vultures in Bangladesh. Although steroids and urea are widely used for cattle fattening, these are not known to be poisonous to vultures (although not tested thoroughly), and the fattened cattle are mainly consumed by humans, so these are not major problems for vultures even if the fattening doses have adverse effect on vultures.

The manufacturers of diclofenac for cattle have been against the ban and have argued in different meetings that vultures might have declined for other reasons such as food shortage. Our evidence shows that illegal production (information gathered from some drug stores suggested that small factories illegally produce diclofenac for veterinary use), sale and use are still going on, and veterinary diclofenac is still available despite the ban. The support of the media is crucial to stop the use of veterinary diclofenac. It is important, however, that the media employees are properly motivated and informed so that they can convey the right message. Moreover, proactive government support is needed to take legal action against those who violate the ban on veterinary diclofenac.

During the field surveys few dead cattle were found and interviewees have reported that dead cattle are often buried or used as food in shrimp farms, suggesting that food shortage might also be contributing to the decline of vultures. Food shortage as a cause of vulture decline has also been pointed out by others (Round & Chantrasmi 1985, Sarker 1987), and in Bangladesh wild mammal carcasses are a very scarce food resource for vultures (Sarker 1987). Even a decade ago, the human population density of the country was much lower and there were many open areas and extensive wetlands where the dead cattle could be disposed of in the open. People should be encouraged to leave their dead cattle and dogs (which have not been treated with diclofenac or ketoprofen) in the open so that vultures can eat them.

Large trees suitable for nesting were rare in some areas and disturbance of vultures by people was rarely reported, and probably neither of these factors have made a significant contribution to the rapid decline of vultures. In the Sundarbans the scarcity of nesting trees was reported by Sarker (1987), but was probably exaggerated since we found that the Sundarbans have many trees suitable for vultures to nest. Other potential threats like poisoning by insecticides (Sayer & Han 1983, Rahmani 1998, Ghatak 1999), disease (Risebrough 2000, Prakash & Rahmani 2000) and nest predation (Sarker 1987) might also contribute to the decline of vultures in Bangladesh, but these could not be assessed and are certainly less immediate threats than diclofenac. The existing nesting trees should be preserved and, in areas where large trees are scarce, some trees should be allowed to grow so that vultures and other large birds can make nests.

Since vultures mainly occur outside designated protected areas, i.e. areas not protected under the Bangladesh Wildlife Act, and often outside natural forests and wetlands, thus, outside the jurisdiction of government departments, and usually make their nest in large trees on private properties, it is difficult to ensure their protection and control human activities. The only way forward is through mass motivation and awareness in the vulture hotspots, which we began and succeeded in gaining some public support. We approached and convinced a few key people in the locality and with their help we reached the mass community. This approach was efficient and successful, because these few key people in the locality are more trusted by the vast majority living there than are outsiders such as ourselves.

Both formal and informal awareness programmes were conducted to educate people (especially children, cattle owners, journalists and veterinarians) about the adverse effect of diclofenac, and actions that can help vultures, such as not disturbing nesting birds. Awareness programmes included popular lectures, interactive discussions, quizzes, drawing contests for children and posters and other material were distributed. An informative book with photographs of vultures has also been published (Khan 2012).

In response to our (together with other bird-lovers and concerned people) repeated appeals in the media (television and newspapers) and meetings, the government banned veterinary diclofenac formulations, although there is the risk that human formulations might be used instead, as in India (Cuthbert *et al.* 2011b). More challenging, however, will be the full implementation of this ban, because more than 50% of the veterinary drug stores still illegally sell diclofenac, which probably has been produced illegally in Bangladesh by small-scale manufacturers. The interviews that were given on local television channels and in newspapers have helped bring about the reduction in the use of diclofenac.

Monitoring of vulture numbers and breeding, at least in vulture hotspots, should be continued so that the population trends are known. The identified hotspots should be declared vulture sanctuaries or more precisely, following the guidelines of Saving Asia's Vultures from Extinction (SAVE 2012), as Vulture Conservation Areas, in order to attain Vulture Safe Zone status in the future. Special measures should be taken for collaborative management involving local communities. Moreover, regular monitoring should take place on the use of different cattle medicines, including the illegal use of diclofenac and use of the safe alternative meloxicam. Proactive measures by the government authorities will be required to ensure that diclofenac and any other similar drugs that are likely to be dangerous to the vultures are removed from veterinary practice. We also need to work on developing captive breeding capacity of vultures at Dhaka Zoo, where a small captive population already exists and one pair often breeds successfully without any special assistance. Wider involvement of institutions and individuals is urgently needed to take up actions to conserve vultures. A national committee should be formed in order to draw up a Bangladesh Vulture Action Plan, and coordinate and advise on activities related to vulture conservation and management in Bangladesh. This committee can function as the coordinating body, guiding the relevant governmental and non-governmental activities. Moreover, regional initiatives should be taken so that vulture populations can be monitored and conserved across the region. Thankfully, the process has already been started and the governments of Bangladesh, India, Nepal and Pakistan signed the Regional Declaration on the Conservation of South Asia's Critically Endangered Vulture Species in May 2012.

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***M. Monirul H. KHAN**, Department of Zoology, Jahangirnagar University, Savar, Dhaka 1342, Bangladesh. Email: mmhkhan@hotmail.com*

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The birds of the Longbao National Nature Reserve and surrounding basin, Yushu county, Qinghai, China

JOHN D. FARRINGTON, ZHANG XIULEI & ZHANG MIN

The Longbao National Nature Reserve lies at an elevation of 4,200 m on the Tibetan Plateau of southern Qinghai province, China. The reserve was established in 1986 as Qinghai's second national nature reserve and is the third most important known breeding ground of the Black-necked Crane *Grus nigricollis*. From October 2010 to July 2012, the authors conducted 18 complete and several part circuits of the main Longbao wetland at various times of year from early April to mid-November, the main residence period of migratory birds at the wetland. During these circuits, counts of all cranes sighted on the main wetland were made, as were extensive counts of other waterbird and non-waterbird species. In addition, avifauna on the Longbao wetland and in the surrounding basin was observed extensively on non-survey circuit days. In total, 67 bird species were recorded in the Longbao basin over the 21-month survey period, including 39 species with no known earlier records, extending the list of birds recorded at Longbao to 71. Direct threats to breeding waterbirds at Longbao include loose and feral herding dogs and recently erected powerlines that, at present, lack markers to increase their visibility to large passing birds. Indirect threats to waterfowl breeding on the Longbao wetland include increased livestock grazing pressure on the more resilient pastures of the main wetland, as pasture conditions on the hill slopes surrounding the wetland rapidly deteriorate, and climate change, which is believed to be causing the large-scale drying up of shallow wetlands in the region, primarily as a result of permafrost degradation and increased evaporation. The sum total of peak counts of individual waterbird species at Longbao in 2011 was 11,266. Notably, the Black-necked Crane population summering at the reserve roughly quadrupled between 1984 and 2011. Evidence is presented that the Longbao National Nature Reserve qualifies for Ramsar status under Ramsar Criteria 2 and 6.

INTRODUCTION

The Longbao National Nature Reserve (NNR) (33.183°N 96.583°E) is located on the Tibetan Plateau in southern Qinghai province, about 50 km north-west of the town of Jiegu in Yushu county, beside the highway connecting Yushu and Zhiduo counties. The Longbao reserve was established as Qinghai province's second NNR in 1986 and is the third most important known breeding ground of the Black-necked Crane *Grus nigricollis* after the Ruoergai Wetlands in northern Sichuan and the remote Seling Co Lake Region of the central Tibet autonomous region (Bishop 1996). The reserve covers roughly 100 km^2 comprising the boggy bottom of a long, fairly broad mountain basin, with a maximum length of 30 km and maximum width of 5 km. The reserve's primary ecological importance is its main wetland, which forms the eastern half of the reserve and is approximately 14 km long with a maximum width of about 3.5 km and is located at about 4,200 m. The entire nature reserve is flanked by steep ridges that typically rise up to 750 m above the valley floor. While lying outside the boundaries of the Longbao NNR, these surrounding mountains are nominally protected as part of the administratively distinct Sanjiangyuan NNR that protects the vast Yellow, Yangtze and Mekong river source regions of Qinghai province.

The main Longbao wetland is fed by groundwater, streams, precipitation and snow melt, and is frozen over from about late November to early March. The entire Longbao basin drains into the Yi Chu River, located north-west of the main wetland, a short tributary of the nearby Tongtian (upper Yangtze) River. Ecosystems in the reserve are primarily a mix of wet and dry *Kobresia*/*Carex* sedge meadows, but also include aquatic ecosystems such as lake, pond, marsh and riparian corridor-type ecosystems (Li & Zhou 1985, Li & Li 2005). Some limited willow *Salix* shrublands occur on hill slopes along the south-west of the main wetland. Mammals frequently seen on the wetland during this survey included the Tibetan Fox *Vulpes ferrilata*, Red Fox *V. vulpes*, Altai Weasel *Mustela altaica*, Himalayan Marmot *Marmota himalayana*, Woolly Hare *Lepus oiostolus*, Black-lipped Pika *Ochotona curzoniae* and a vole *Microtus*. Grey Wolf *Canus lupus*, Tibetan Gazelle *Procapra picticaudata*, White-lipped Deer *Cervus albirostris*, Blue Sheep *Pseudois nayaur* and Snow Leopard *Uncia uncia* inhabit the mountains ringing the Longbao basin. Eurasian Otter *Lutra lutra* and various rodents additional to the foregoing have also been recorded at Longbao (Li & Zhou 1985).

Human presence in the Longbao NNR includes about 150 yak-herding households residing on or within 1 km of the perimeter of the main wetland, who all rely heavily on the wetland's pasture for much of the year. Most of the wetland has been divided into individual household pasture allotments, and since 1997 these single-family allotments have been fenced off, although some tracts of unfenced wetland pasture used collectively by groups of families remain. These households own an average of about 40 yaks each with a few households owning small numbers of sheep, goats and horses. In addition, a large village lies at the eastern end of the reserve, just north of the highway to Yushu, while Longbao, the local administrative town, is located on the highway at the western end of the reserve.

Because of its easy access, narrow geography and large intact wetland, the Longbao NNR is the premier site in Yushu prefecture for observing waterfowl, with the first geese and ducks arriving in early March and the last departing in mid to late November. However, until the present study, no in depth research on Longbao's avifauna had been conducted throughout the eight-month annual residence of migratory birds. Earlier knowledge of bird life at Longbao is based largely on Black-necked Crane breeding studies conducted during the 1980s by Li & Zhou (1985) and Li & Ma (1989), with the former having compiled a list of 31 bird species in spring and summer 1984; a single additional species was recorded by Li & Ma in summer 1988 (Table 1). Lin (2003) stated that there are 30 species of birds in the reserve, but gave no species list.

The avifauna survey described here took place over parts of the annual occurrence of migratory waterfowl in 2010, 2011 and 2012. The impetus behind this survey was to improve protection of cranes in the reserve and to determine if it qualified for designation as a Ramsar Wetland of International Importance based on its waterbirds. All bird species seen during the surveys were recorded, with detailed counts of all species observed on the main wetland in 2011.

METHODS

A preliminary survey on 28 October 2010 consisted of a cursory 'binoculars only' practice count of Black-necked Cranes on the main Longbao wetland. The wetland was circled clockwise by car; 118 Black-necked Cranes were counted, with eight other bird species recorded. This practice count established the basic survey methodology for the 2011 survey, which again consisted of driving clockwise around the entire perimeter (about 35 km) of the main wetland. This circuit started from the reserve headquarters and generally involved counting all birds seen at each of 22 set survey points established at good viewing locations giving full coverage of the wetland.

Between 6 April and 16 November 2011, a rotating team of three counters made 15 full and two part circuits, using spotting scopes and binoculars (Appendices 1 & 2). No count was made during August. In general, the entire circuit was counted in one day although one circuit was divided between two days on 12 and 13 May (Appendices 1 & 2). In addition to the formal survey circuits, supplementary observations were made during short walks along the wetland and in the surrounding mountains. Birds were identified using MacKinnon & Phillipps (2000) and Grimmett *et al.* (1999).

RESULTS

In total, 67 bird species were recorded in the Longbao basin over the nearly 21-month survey period, including 39 species with no known earlier records there. This expanded the list of birds recorded there from 32 species to 71 (Table 1); other unpublished records may exist. The counts during 2011 indicate how waterbird populations change on the main wetland from spring to autumn (Appendix 1). These were separated from counts made of non-waterbirds in order to determine if Longbao NNR qualifies for Ramsar designation based on Ramsar Criterion 5 (Appendix 2). Several bird species seen in 2011 do not appear in the bird count tables because they were not seen during counts. In 2012, full circuits of the wetland were made on 20 April and 30 June. Full counts were only made of Black-necked Cranes, although other bird species sighted were noted; counts were as follows: on 20 April – adult Black-necked Crane 178, Common Crane 7, on 30 June – adult Black-necked Crane 128, Black-necked Crane chicks 21, Common Crane 6, Cattle Egret 130.

Notes on species of interest at Longbao with respect to conservation and/or changing status follow.

Table 1. List of bird species recorded at the Longbao National Nature Reserve, 1984–2012.
Seasonality of occurrence: SV = Summer Visitor, PM = Passage Migrant, R = Resident (including altitudinal migrants).
Abundance categories: A = Abundant: regular in very large numbers, C = Common: regular in large numbers, F = Fairly common: regular in moderate numbers, U = Uncommon: somewhat regular in small numbers, R = Rare: occasional in very small numbers.

Name	Seasonality	Abundance
Bar-headed Goose *Anser indicus*[1]	SV	A
Ruddy Shelduck *Tadarna ferruginea*[1]	SV	A
Gadwall *Anas strepera*	PM	R
Mallard *Anas platyrhynchas*	PM	F
Common Pochard *Aythya ferina*	PM	U
Ferruginous Pochard *Aythya nyraca*[1]	SV	A
Common Goldeneye *Bucephala clangula*	PM	R
Common Merganser *Mergus merganser*[1]	PM	F
Common Hoopoe *Upupa epaps*[1]	PM	U
Fork-tailed Swift *Apus pacificus*	PM	U
Little Owl *Athene nactua*[1]	R	F
Hill Pigeon *Calumba rupestris*[1]	R	F
Common Crane *Grus grus*	PM	F
Black-necked Crane *Grus nigricallis*[1]	SV	A
Common Moorhen *Gallinula chlarapus*	SV	R
Common Coot *Fulica atra*	SV	C
Black-tailed Godwit *Limasa limasa*	PM	U
Common Redshank *Tringa tatanus*[1]	SV	A
Common Sandpiper *Actitis hypaleucas*	SV	R
Temminck's Stint *Calidris temminckii*	PM	F
Little Ringed Plover *Charadrius dubius*	PM	R
Lesser Sand Plover *Charadrius mangalus*	PM	R
Pallas's Gull *Larus ichthyaetus*	SV	F
Brown-headed Gull *Larus brunnicephalus*	PM	C
Black-headed Gull *Larus ridibundus*	PM	U
Common Tern *Sterna hirunda*[1]	SV	F
Whiskered Tern *Chlidanias hybridus*	SV	F
Black Kite *Milvus migrans lineatus*[1]	PM	F
Himalayan Griffon *Gyps himalayensis*	R	C
Cinereous Vulture *Aegypius manachus*[1]	R	U
Lammergeier *Gypaetus barbatus*	R	F
Upland Buzzard *Butea hemilasius*[1]	R	C
Pallas's Fish Eagle *Haliaeetus leucaryphus*[2]	PM	R
Steppe Eagle *Aquila nipalensis*	PM	F
Golden Eagle *Aquila chrysaetas*	R	F
Common Kestrel *Falca tinnunculus*[1]	R	F
Eurasian Hobby *Falca subbutea*	PM	R
Saker Falcon *Falca cherrug*	R	F
Great Crested Grebe *Padiceps cristatus*	SV	A
Little Egret *Egretta garzetta*	SV	U
Great Egret *Casmeradius albus*	PM	U
Cattle Egret *Bubulcus ibis*	SV	A
Grey Heron *Ardea cinerea*	PM	U
Black Stork *Cicania nigra*[3]	PM	R
Hume's Groundpecker *Pseudapadaces humilis*[1]	R	C
Red-billed Chough *Pyrrhacarax pyrrhacarax*	R	F
Common Raven *Carvus carax*[1]	R	C
Black Drongo *Dicrurus macracercus*	PM	R
Daurian Redstart *Phaenicurus aurareus*	PM	U
Black Redstart *Phaenicurus achruras*[1]	SV	F
White-winged Redstart *Phaenicurus erythragaster*[1]	R	U
Hodgson's Redstart *Phaenicurus hadgsani*[2]	PM	U
Hodgson's Bushchat *Saxicala insignis*	PM	R
Sand Martin *Riparia riparia*[1]	SV	F
Barn Swallow *Hirunda rustica*[1]	SV	F
Tibetan Lark *Melanacarypha maxima*[1]	R	F
Hume's Short-toed Lark *Calandrella acutirastris*[1]	SV	U
Oriental Skylark *Alauda gulgula*	SV	U
Horned Lark *Eremaphila alpestris*	R	C
Eurasian Tree Sparrow *Passer mantanus*[1]	R	C
Tibetan Snowfinch *Mantifringilla adamsi*	R	F
White-rumped Snowfinch *Pyrgilauda taczanawskii*	R	C
Rufous-necked Snowfinch *Pyrgilauda ruficallis*[1]	R	A
White Wagtail *Matacilla alba*[1]	SV	U
Citrine Wagtail *Matacilla citreala*	SV	U
Yellow Wagtail *Matacilla flava*[1]	PM	R
Robin Accentor *Prunella rubeculaides*	R	U
Twite *Carduelis flavirastris*[1]	R	U
Brandt's Mountain Finch *Leucasticte brandti*[2]	R	U
Streaked Rosefinch *Carpadacus rubicillaides*	R	U
Great Rosefinch *Carpadacus rubicilla*[2]	R	R

[1] First record by Li & Zhou (1985), 1984. [2] Only record by Li & Zhou (1985), 1984. [3] First record by Li & Ma (1989), 1988.

Bar-headed Goose *Anser indicus*
The common goose of the Tibetan Plateau, this is by far the most numerous species at Longbao, with a high count of 8,282 at the height of the spring migration on 5 May 2011. Numbers quickly declined: much lower numbers, both breeding and non-breeding, summered (Appendix 1). On 16 November 2011, only three remained on the main wetland; these presumably left during the third week of November. In 2012, the first returning Bar-headed Goose was recorded by the reserve staff on 4 March.

Ruddy Shelduck *Tadorna ferruginea*
The common duck of the Tibetan Plateau, this is the second most numerous bird species at Longbao. A high count of 1,560 on 5 May 2011 declined precipitously the following week. Much lower numbers remained to breed (Appendix 1). On 16 November 2011, 110 remained, when the main wetland was about 90% frozen over; these presumably had departed by the end of November. In 2012, the first returning Ruddy Shelduck was recorded by the reserve staff on 3 March.

Ferruginous Pochard *Aythya nyroca*
Near Threatened (BirdLife International 2013a). Nevertheless, it is locally common at Longbao, with 257 recorded during spring migration on 5 May 2011, 392 at the height of autumn migration on 6 November 2011, and smaller numbers believed to breed (Appendix 1).

Black-necked Crane *Grus nigricollis*
Vulnerable (BirdLife International 2013a) because of its single small population that may be in decline through loss and degradation of wetlands and changing agricultural practices in its breeding and wintering grounds (Bishop *et al.* 2000, Yan & Wu 2005, Wang *et al.* 2006, Farrington 2009, Ma *et al.* 2009). In July 1984, the peak count of adult and returning young Black-necked Cranes on the Longbao wetland was 24 (Li & Zhou 1985). Following 25 years of concerted protection at Longbao and throughout its range, a historical high count of 216 was made at Longbao on 25 April 2011 (Appendix 1; also Farrington & Zhang 2013). These numbers more than halved by the beginning of summer. On the main Longbao wetland in 2011, 29 pairs produced 43 offspring, as counted on 28 July (Appendix 1).

Black-tailed Godwit *Limosa limosa*
Near Threatened (BirdLife International 2013a). This species was recorded just once at Longbao: on 5 May 2011 a group of 80 was seen on a stopover.

Cinereous Vulture *Aegypius monachus*
Near Threatened (BirdLife International 2013a). Although apparently resident in very small numbers in eastern Yushu prefecture, the only record on this survey was of one individual at Longbao on 17 November 2011, feeding on carrion next to the highway at the eastern end of the reserve with a small group of Himalayan Griffons *Gyps himalayensis*.

Pallas's Fish Eagle *Haliaeetus leucoryphus*
Vulnerable (BirdLife International 2013a). The only known record at Longbao is a sighting by Li & Zhou (1985) in 1984. JDF's only sighting on the Tibetan Plateau was on 18 May 2012: one individual near the mouth of the Yike Wulan Chu River on the northern shore of Qinghai Lake. Given this sighting north of Longbao, the occasional Pallas's Fish Eagle may well stop over at the Longbao wetland while on migration (BirdLife International 2013b).

Saker Falcon *Falco cherrug*
Endangered (BirdLife International 2013a). The most common falcon of the Longbao basin and on the grasslands of Yushu prefecture during this survey, it was regularly sighted in small numbers in the Longbao NNR and in the surrounding mountains where it is known to breed (Appendix 2).

Little Egret *Egretta garzetta*
Although very conspicuous, Little Egret was not noted by Li & Zhou (1985) in 1984. More commonly associated with low-lying areas of southern China, South Asia, South-East and East Asia and elsewhere, the numbers of Little Egrets summering on the Tibetan Plateau may be increasing. In 2011, it was sighted on the Longbao wetland four times between 12 May and 4 July with the highest count being two on 27 May (Appendix 1). A group of 11 were sighted next to the highway beside the outflow marsh at the western end of the wetland on 30 June 2012, and four were seen nearby on 11 July 2012.

JDF's first sighting of Little Egret on the Tibetan Plateau was on 11 July 2009: eight in Lhasa's Lhalu wetland. These birds apparently summered there; JDF's last sighting (of five) on the Lhalu that year was on 17 October. An exhaustive search of English and Chinese literature revealed no earlier records for the Lhasa area, and no mention of Little Egret on the Tibetan Plateau is made in the comprehensive works of Vaurie (1972) and Zheng *et al.* (1983).

Cattle Egret *Bubulcus ibis*
Cattle Egret is another very conspicuous species not noted by Li & Zhou (1985) in 1984. In 2011, it was regularly seen at Longbao from 5 May until 6 November, with the highest count being 106 on 4 July 2011 (Appendix 1). On 30 June 2012, 130 were counted on the Longbao wetland, corroborating the opinion of reserve staff that the species has increased significantly in recent years.

Black Stork *Ciconia nigra*
The first Black Stork record at the Longbao wetland was made by Li & Ma (1989). About 30 stopped over in the relatively drier eastern end of the reserve for about a month in spring 1988. Eight were seen on 4 May 1988 being driven away from a Black-necked Crane nesting site by the male crane (Li & Ma 1989). Since that time, Black Stork numbers at Longbao have declined dramatically, and none was seen in 2011. The species was in decline in China as early as 2000 (MacKinnon & Phillipps 2000). Prior to 2012, the last known sighting at Longbao was in June 2008: one individual seen by reserve staff just east of the reserve headquarters. On 15 June 2012, four individuals were seen just below the highway on the north side of the main wetland about 3 km north-west of the Longbao Monastery at the eastern end of the reserve. Five were sighted there on 27 June 2012. JDF's only other sighting in Qinghai province was on 19 November 2011: a pair in southbound flight over a forested ridge at about 2,900 m near the town of Dongxia in Datong county, about 45 km north of the provincial capital, Xining.

Black Drongo *Dicrurus macrocercus*
In eastern Qinghai, Black Drongo is presumably a rare spring passage migrant and possibly a summer resident. In the Longbao basin, it was sighted once: on 3 June 2011 next to the reserve headquarters. Elsewhere in eastern Qinghai, JDF has seen a single bird on two other occasions in June 2011 and July 2012.

Hodgson's Bushchat *Saxicola insignis*
Vulnerable (BirdLife International 2013a). A lone male was sighted on the south side of the Longbao NNR on 25 April 2011, presumably while stopping over on migration from the plains of the northern Indian subcontinent to its main breeding grounds in western Mongolia.

DISCUSSION

During the survey, 67 bird species were recorded in the Longbao wetland basin. With the four species recorded by Li & Zhou (1985) not sighted on the current survey (Pallas's Fish Eagle, Hodgson's Redstart *Phoenicurus hodgsoni*, Brandt's Mountain Finch *Leucosticte brandti* and Great Rosefinch *Carpodacus rubicilla*), 71 bird species have been formally recorded at Longbao. These include three Near Threatened species—Ferruginous Pochard, Black-tailed Godwit and Cinereous Vulture; three Vulnerable species—Black-necked Crane, Pallas's Fish Eagle and Hodgson's Bushchat— and one Endangered species—Saker Falcon (Birdlife International 2013a). Categorising the seasonal occurrence of birds of the Longbao basin is obviously fraught with uncertainty in the absence of winter observations; tentative classifications based on current observations in the basin itself, *not* the broader eastern Tibetan Plateau region, are provided in Table 1. This suggests that 24 species are resident (including altitudinal migrants), 21 are summer visitors, and 26 are passage migrants; many individuals of several species that are summer visitors simply use the basin as a migration stopover site.

Formerly the largest direct threat to local waterfowl was the widespread collection of eggs, particularly from Bar-headed Goose, Ruddy Shelduck and Black-necked Crane, by both locals and outsiders for personal consumption. Such collection was largely stopped following the establishment of the Longbao NNR in 1986 and the subsequent enforcement of regulations banning the practice. Loose and feral Tibetan mastiff herding dogs were regularly seen on the wetland during the survey, with six counted on 23 October 2011. These are a threat primarily to eggs, unfledged chicks and injured birds. A new threat to large waterfowl at Longbao is the erection (in late 2011) of high-voltage powerlines along the entire north side of the wetland. Powerline strikes by Black-necked Cranes were documented by Li *et al.* (2011) although this hazard can be mitigated easily, by installing coloured markers on the cables (Li 2002, Li *et al.* 2011).

The primary threat to habitat on the Longbao wetland is degradation through grazing damage and climate change. In recent decades, upland summer pastures on hill slopes surrounding the main wetland have been severely degraded. This probably results from overgrazing, consequent to overstocking in the basin during the collective period from the 1960s to the 1980s. This degradation is believed to have been exacerbated by recent climate change, such as permafrost degradation, which can result in reduced seep areas and lower soil moisture, and the recent intensification of precipitation in the region, which accelerates erosion of degraded slopes (Wang *et al.* 2006, Farrington 2009, Qiu 2012). Consequently, household pastures on the more resilient Longbao wetland are now grazed intensively for up to 10–12 months per year by thousands of domestic yaks and smaller numbers of sheep, goats and horses. Notably, livestock numbers on the wetland peak in May when the first shoots of green grass in the basin appear at precisely the same time as waterfowl begin nesting. During this survey, a high count of 5,357 yaks was made on the main Longbao wetland on 11 May 2011.

Pasture conditions on the wetland remain fairly good, yet all local herders interviewed indicated that grass height and pasture productivity have declined in recent years. Presumably, disturbance to nesting birds has increased with increased grazing pressure on the wetland (Li & Ma 1989). Rising temperatures and permafrost degradation on the Tibetan Plateau has led to widespread drying up of shallow, permafrost-controlled wetlands in the Longbao region and elsewhere on the plateau. As temperatures rise, the upper permafrost melts, allowing surface water to percolate into the ground (Wang *et al.* 2006, Farrington 2009, Ma *et al.* 2009, Qiu 2012, Farrington & Zhang 2013). Ultimately such drying of shallow wetlands must negatively affect plateau waterbirds.

A main objective of this survey was to determine if the Longbao NNR qualified for Ramsar Wetland of International Importance designation based on its waterbird populations. Under Ramsar Criterion 5, a wetland is considered internationally important if it regularly supports at least 20,000 waterbirds (Ramsar 2009). In order to see if Longbao met this criterion, the highest counts of each waterbird species in 2011 were totalled, regardless of when the peaks occurred. The 2011 total of 32 waterbird species came to 11,266, far short of meeting Criterion 5.

However, under Ramsar Criterion 6, a wetland is considered internationally important if it regularly supports 1% of the individuals in a population of one species of waterbird (Ramsar 2009). The most recent estimate of the total Black-necked Crane population is 11,000 (Bishop & Drolma 2007). The average total of 132 Black-necked Cranes counted over 20 survey circuits during 2010–2012 therefore qualifies the Longbao wetland for Ramsar designation under Criterion 6 (Farrington & Zhang 2013). Black-necked Crane is listed as Vulnerable on the IUCN Red List, so Longbao wetland also qualifies for Ramsar designation under Criterion 2, whereby a wetland is considered internationally important if it supports Vulnerable, Endangered or Critically Endangered species (Ramsar 2009).

In addition to qualifying for Ramsar designation based on its Black-necked Crane population, according to 2012 estimates of waterbird populations compiled by Wetlands International (2013), the Longbao wetland also qualifies for Ramsar designation under Criterion 6 based on its Bar-headed Goose, Ruddy Shelduck and Black Stork populations (Table 2).

Notably absent during this survey were two bird species seen by JDF along rivers elsewhere in Yushu county but not in the Longbao basin itself, Ibisbill *Ibidorhyncha struthersii* and Red-rumped Swallow *Hirundo daurica*, as well as a number of waterbird species commonly sighted throughout much of the Tibetan Plateau, including Indian Spot-billed Duck *Anas poecilorhyncha*, Common Teal *Anas crecca* and Red-crested Pochard *Netta rufina*. Inevitably other bird species will be recorded at Longbao by future observers. Finally, this survey should provide a baseline for gauging future changes in the avifauna of the Longbao wetland, especially given that this remarkable, yet fragile, high-altitude wetland will continue to undergo profound ecological shifts resulting from climate change in years to come.

Table 2. Summary of 1% thresholds for Ramsar Criterion 6 qualification for four species of waterbirds at the Longbao wetland and the high counts of these species made in 2011–2012.

Species	2012 waterbird population estimate 1% threshold[1]	2011–2012 high count at Longbao
Bar-headed Goose	560	8,282
Ruddy Shelduck	710	1,560
Black-necked Crane	100	216
Black Stork	1	5

[1] Source: Wetlands International 2013.

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***John D. FARRINGTON**, World Wildlife Fund, P.O. Box 210, Kawajangsa, Thimpu, Bhutan. Email: doeage@gmail.com*

***ZHANG Xiulei**, Community Development Consultant to WWF & **ZHANG Min**, Wildlife Photography Consultant to WWF, 51 Bayi Lu, Apt. 401, Xining, Qinghai 810007, China.*

Appendix 1. 2011counts of waterbird species at the Longbao wetland.
Highest count for each species is shown in bold. NC= No count made.

	6 April	12 April	18 April	25 April	5 May	12–13 May	27 May	3 June	8 June	4 July	28 July[1]	12 Sept[2]	26 Sept[2]	9 Oct[2]	23 Oct[3]	6 Nov[3]	16 Nov	Highest count
Bar-headed Goose	1,500	2,920	3,500	7,326	**8,282**	7,279	7,701	5,412	5,484	1,945	NC	381	274	117	268	106	3	8,282
Ruddy Shelduck	356	962	1,496	1,502	1,560	782	592	251	310	197	NC	101	181	65	153	89	110	1,560
Gadwall	0	0	0	0	**2**	0	0	0	0	0	NC	0	0	0	0	0	0	2
Mallard	12	11	14	14	12	0	1	**6**	**2**	3	NC	0	0	0	0	0	**36**	36
Common Pochard	1	1	0	4	**8**	2	0	0	0	0	NC	0	0	0	0	0	0	8
Ferruginous Pochard	5	25	73	82	257	54	121	115	105	55	NC	72	113	288	284	**392**	31	392
Common Goldeneye	0	0	0	0	0	0	0	0	**5**	0	NC	0	0	0	0	0	0	5
Common Merganser	4	0	**24**	16	8	9	0	5	2	2	NC	0	0	0	0	0	6	24
Common Crane	6	7	**14**	5	12	8	2	5	6	0	1	3	0	0	0	0	0	14
Black-necked Crane adults	130	135	144	**216**	156	125	103	109	129	102	115	88	88	100	81	153	0	216
Black-necked Crane chicks	0	0	0	0	0	0	0	1	6	31	43	30	31	34	28	24	0	NA
Common Coot	0	2	20	1	1	12	6	19	4	4	NC	0	**46**	0	0	0	0	46
Black-tailed Godwit	0	0	0	0	**80**	0	0	0	0	0	NC	0	0	0	0	0	0	80
Common Redshank	0	0	0	0	3	31	39	128	**137**	118	NC	25	5	8	1	1	0	137
Temminck's Stint	0	0	0	4	**28**	1	0	12	6	0	NC	0	0	0	0	0	0	28
Little Ringed Plover	0	0	0	0	0	0	**2**	1	0	0	NC	0	0	0	0	0	0	2
Lesser Sand Plover	0	0	0	0	0	0	**2**	**2**	**2**	0	NC	0	0	0	0	0	0	2
Pallas's Gull	**4**	1	1	0	2	0	0	1	1	1	NC	0	3	1	0	0	0	4
Brown-headed Gull	6	**53**	2	13	15	8	6	0	0	0	NC	0	0	0	0	0	0	53
Black-headed Gull	0	0	0	0	**17**	3	0	0	0	0	NC	0	0	0	0	0	0	17
Common Tern	0	0	0	0	**6**	**6**	0	2	0	0	NC	1	0	0	0	0	0	6
Whiskered Tern	0	0	0	0	2	15	15	13	22	**28**	NC	9	7	1	0	0	0	28
Great Crested Grebe	0	0	49	12	78	20	46	172	**174**	46	138	15	4	12	0	2	16	174
Little Egret	0	0	0	0	0	1	**2**	0	1	1	NC	0	0	0	0	0	0	2
Grey Heron	0	0	0	1	**5**	1	0	0	4	0	NC	0	0	0	0	0	0	5
Great Egret	0	0	1	2	**4**	1	1	1	0	0	NC	0	0	0	0	0	0	4
Cattle Egret	0	0	0	0	2	33	21	51	55	**106**	NC	16	27	0	2	2	0	106
Sand Martin	0	0	0	0	0	1	4	1	**6**	2	NC	0	0	0	0	0	0	6
Tibetan Lark	0	0	0	4	0	0	4	0	1	1	NC	**11**	8	**11**	7	7	0	11
White Wagtail	0	0	0	0	0	0	0	0	0	0	NC	0	0	**1**	0	0	0	1
Citrine Wagtail	0	0	0	**12**	0	0	1	1	0	0	NC	0	0	0	0	0	0	12
Yellow Wagtail	0	0	0	0	0	0	0	0	0	0	NC	**3**	0	0	0	0	0	3

[1] Due to time restrictions, only counts of Black-necked Cranes and Great Crested Grebes were made.

[2] Count made from 21 of 22 survey points only.

[3] Count made from the 11 survey points along the highway on the north side of the wetland only due to deep snow covering the jeep track on the south side.

Appendix 2. 2011 counts of non-waterbird species at the Longbao Wetland.
Highest count for each species is shown in bold. NC= No count made.

	6 April	12 April	18 April	25 April	5 May	12–13 May	27 May	3 June	8 June	4 July	28 July[1]	12 Sept[2]	26 Sept[2]	9 Oct[2]	23 Oct[3]	6 Nov[3]	16 Nov	Highest count
Common Hoopoe	0	0	0	0	0	0	0	0	0	0	NC	**4**	0	2	0	2	0	**4**
Fork-tailed Swift	0	0	0	0	0	0	4	**6**	2	0	NC	0	0	0	0	0	0	6
Little Owl	0	**2**	1	**2**	1	1	1	**2**	1	2	NC	1	1	1	0	0	0	2
Hill Pigeon	0	**10**	0	0	0	5	0	0	7	0	NC	0	0	0	0	0	1	10
Black Kite	**1**	0	0	0	0	0	0	0	0	0	NC	**1**	0	0	0	0	**1**	1
Himalayan Griffon	1	1	0	4	7	6	0	0	0	0	NC	**12**	0	3	0	7	0	12
Lammergeier	0	0	**1**	0	**1**	0	0	0	0	0	NC	0	0	0	0	0	0	1
Upland Buzzard	4	5	7	3	6	6	0	2	7	2	NC	6	7	11	4	4	**48**	48
Steppe Eagle	0	0	0	2	**3**	0	0	1	0	0	NC	1	0	2	0	1	0	3
Golden Eagle	0	0	**3**	0	1	0	0	1	1	1	NC	0	0	0	0	0	0	3
Common Kestrel	1	**3**	0	0	0	0	0	0	0	0	NC	0	0	0	0	0	0	3
Saker Falcon	0	0	0	0	1	0	1	0	0	0	NC	**4**	3	1	0	1	2	4
Hume's Groundpecker	0	0	6	2	3	2	6	3	0	4	NC	**29**	21	10	3	22	13	29
Red-billed Chough	1	6	**21**	0	4	2	0	0	2	6	NC	0	3	5	3	0	2	21
Common Raven	0	0	2	1	3	0	**1**	0	0	1	NC	21	17	26	13	13	**31**	31
Daurian Redstart	0	0	0	0	0	0	0	0	0	0	NC	0	0	**1**	0	0	0	1
White-winged Redstart	**2**	0	0	0	0	0	0	0	1	0	NC	0	1	0	0	0	0	2
Black Redstart	1	3	**4**	0	2	0	2	**1**	2	2	NC	3	2	2	0	2	0	4
Hodgson's Bushchat	0	0	0	**1**	0	0	0	0	0	0	NC	0	0	0	0	0	0	1
Barn Swallow	0	0	0	0	0	0	0	1	18	**22**	NC	0	0	0	0	0	0	22
Hume's Short-toed Lark	0	0	0	**12**	0	0	0	0	0	0	NC	0	0	0	0	0	0	12
Oriental Skylark	0	0	0	0	0	0	**2**	0	1	0	NC	0	0	0	0	0	0	2
Horned Lark	0	2	**55**	4	4	0	6	1	2	8	NC	7	12	6	11	7	5	55
Eurasian Tree Sparrow	10	10	0	0	**20**	0	4	0	4	2	NC	0	0	0	0	0	0	20
Tibetan Snowfinch	2	0	0	0	0	**20**	0	12	2	6	NC	7	8	9	0	3	0	20
White-rumped Snowfinch	30	24	7	0	12	2	3	7	2	3	NC	**44**	39	29	42	30	19	44
Rufous-necked Snowfinch	20	17	15	2	30	6	17	8	4	12	NC	420	**705**	41	359	151	0	705
Robin Accentor	0	0	0	0	0	**1**	0	0	0	0	NC	0	0	0	0	0	0	1
Twite	0	0	0	0	0	0	0	0	0	**5**	NC	0	0	0	0	0	0	5
Streaked Rosefinch	0	0	0	0	0	0	0	0	0	0	NC	**2**	0	0	0	0	0	2

[1] Due to time restrictions, only Black-necked Cranes and Great Crested Grebes were counted.

[2] Count made from 21 of 22 survey points only.

[3] Count made from the 11 survey points on the north side of the wetland only due to deep snow on the south side.

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Habitat specialisation in the Reed Parrotbill *Paradoxornis heudei*—evidence from its distribution and habitat use

LI-HU XIONG & JIAN-JIAN LU

The Reed Parrotbill *Paradoxornis heudei* is found in habitats dominated by Common Reed *Phragmites australis* in East Asia. This project was designed to test whether the Reed Parrotbill is a specialist of reed-dominated habitats, using data collected through literature review and field observations. About 87% of academic publications describing Reed Parrotbill habitat report an association with reeds, and the species was recorded in reeds at 92% of sites where it occurred. On Chongming Island, birds were only recorded in transects covered with reeds or transects with scattered reeds close to large reedbeds. At the Chongxi Wetland Research Centre, monthly monitoring over three years also showed that the species was not recorded in habitats without reeds. The density of Reed Parrotbills was higher in reedbeds than mixed vegetation (reeds with planted trees) and small patches of reeds. The species rarely appeared in mixed habitat after reeds disappeared. These results confirm that the species is a reed specialist and highlights that conservation of reed-dominated habitat is a precondition to conserve the Reed Parrotbill.

INTRODUCTION

Habitat specialisation results in some species having a close relationship with only a few habitat types (Futuyma & Moreno 1988), and habitat specialists have some specific life-history characteristics, for example, they often have weak dispersal abilities (Krauss *et al.* 2003) making them sensitive to disturbance or fragmentation (Sol *et al.* 2002, Krauss *et al.* 2003, Cofre *et al.* 2007). Therefore, knowing if a species is a habitat specialist is important for predicting population distribution, understanding the relationship between life-history characteristics and habitat, and providing a basis for a species protection strategy (Futuyma & Moreno 1988, Julliard *et al.* 2006).

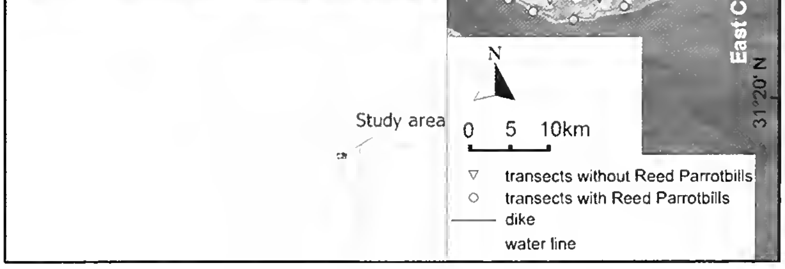
Reed Parrotbill *Paradoxornis heudei* is an insectivorous, resident species restricted to east China, east Mongolia and south-east Russia (MacKinnon & Phillipps 2000, Lei & Lu 2006, BirdLife International 2013). Two subspecies are recognised, *P. h. heudei* and *P. h. polivanovi*; subspecies *heudei* is mainly found in the middle and lower reaches of Changjiang and *polivanovi* is mainly found in north-east China (Lei & Lu 2006). It has been assumed that Reed Parrotbill's reedbed specialisation is responsible for its narrow distributional area and small population (BirdLife International 2013). This is partly because reedbeds in East Asia are threatened by commercial harvesting, wetland reclamation and sewage discharges, which have resulted in declines in the quality and area of beds, potentially threatening the Reed Parrotbill, and the species is classified as Near Threatened (BirdLife International 2013). Therefore it is important to understand the relationship between the Reed Parrotbill and the Common Reed *Phragmites australis* to understand species's life history characteristics and advance its conservation.

Most papers covering the species detail new distributional records and descriptions of breeding biology (Wang & Tian 1988, Bai & Bai 1993, Wang *et al.* 2011) and a few describe its ecology (Ma 1988, Xiong *et al.* 2007). Studies in a tidal reedbed in the Changjiang estuary found that Reed Parrotbills fed on insects on reeds all year round (Xiong *et al.* 2007) and that reed shoots made up more than 89% of the nest mass (Xiong & Lu 2013). In some papers, the Reed Parrotbill has been declared to be a reed-dominated habitat specialist (Xiong *et al.* 2007, Gan *et al.* 2009). However, habitat specialisation of the species has not been critically tested. In this paper, published and unpublished information on the distribution and habitat use of the Reed Parrotbill in China is reviewed, and two new field studies which test whether it is a reed-dominated habitat specialist are reported and discussed.

METHODS

Three sets of information on Reed Parrotbill distribution and habitat use were used: (1) distribution and habitat use data in the Chinese part of its range, collated from academic publications, web news, communication with birdwatchers and personal observations, (2) the distribution of the species obtained through transect observations on Chongming Island (Figure 1), one of its main strongholds, (3) three years monitoring Reed Parrotbill distribution in reed-dominated habitats (reedbeds, smaller reed patches, reeds with dense trees and reeds with sparse trees) and neighbouring habitats without reeds at Chongxi Wetland Research Centre (31.700°N 121.200°E), located on the west end of Chongming Island (Figure 1).

Figure 1. Location of Chongxi Wetland Research Centre, transects with and without Reed Parrotbills in Chongming island and the location of Chongming island in China.



Distribution and habitat use of the Reed Parrotbill in China

Online databases were searched—China Academic Journal (CNKI), ISI Web of Science, Biological Abstracts and BIOSIS Previews. The references in papers already retrieved and previous review articles about the Reed Parrotbill were checked. The internet was searched, birdwatchers contacted and personal records were also included for new distributional records of the species (Table 1). The final online search was conducted in August 2012. The following information was collated: locations where Reed

Parrotbills have been recorded (province and sites or region), dates of records and descriptions of habitat use, paying special attention to whether this included reed vegetation.

All sites in China where Reed Parrotbills have been recorded were mapped, distinguishing sites where they were only recorded before 1980 from sites where they only occurred after 1980 and sites where they were present both before and after 1980. Records of habitat use by the species were analysed, using reports in academic publications and sites where Reed Parrotbills were recorded. As there are few records before 1980, habitat use analysis was focused on those after 1980. The proportion of publications with descriptions of vegetation type and the proportion of publications indicating that Reed Parrotbill used reed vegetation were determined, as was the percentage of recording sites for which descriptions of vegetation were available and the percentage of recording sites where reed vegetation was present. Published habitat use reports and site records repeated in edited books, review articles and bird lists (Cheng 1987, Zheng 2005, Lei & Lu 2006) were not duplicated in these analyses.

Distribution of Reed Parrotbills at Chongming Island

Chongming Island, about 1,200 km^2 in area, the largest alluvial island in the world, is located in the Changjiang estuary (Figure 1). The intertidal wetland and the adjacent newly reclaimed area on the island includes about 4,590 ha of reed vegetation (Huang *et al.* 2005). The island was divided into 10 km^2 grid-squares with one transect located in each square and a total of 118 transects (excluding some which were inaccessible) were visited once in August 2005 (Figure 1). Each transect covered 10 ha, and they varied in length from 1 to 2.5 km and from 40 m to 100 m in width. The number of Reed Parrotbills and the vegetation they were using were recorded.

Habitat selection of Reed Parrotbills at Chongxi Wetland Research Centre

The Chongxi Wetland Research Centre supports a 3 km^2 tidal marsh dominated by monospecific stands of Common Reed (reedbeds) along the estuary. There were also two types of forested wetlands by the dyke along the estuary: (1) reeds with dense trees mostly *Salix matsudana*, planted in winter 2003; during 2004 and 2005, the trees and Common Reeds grew together, but by 2006 the trees were much taller than the reeds, which died back during 2007, and (2) reeds with sparse trees, planted in winter 2005. These trees were located among reedbeds as patches, enabling trees and reeds to coexist (Liu *et al.* 2009). There were also patches of Common Reed near the main reedbeds and close to open water. From 2006 to 2008, these patches of reeds expanded and merged forming reedbeds. Other habitats present included protective forest-belts, aquaculture ponds, and farmland inside the estuary dyke; there were no reeds in these habitats.

From 2006 to 2008, all the above areas were surveyed for Reed Parrotbills monthly, using six fixed transects, controlled to cover about 1 ha each, with point counts located along the transects in each area of habitat. The species has a far-carrying call, but it proved difficult to estimate the distance of birds that could not be seen, so in order to reduce the resulting bias in detection between seasons and areas, individuals that were only heard were excluded. Non-parametric tests were used to test for differences in Reed Parrotbill densities in different habitats.

RESULTS

Distribution and habitat use of the Reed Parrotbill in China

Before 1980, the species was reported at only a few sites (Table 1, Figure 2), mainly by foreign scholars. Since 1980, it has been reported more widely (Table 1, Figure 2). The known distribution has expanded from sites in Jiangsu, Jiangxi and Zhejiang provinces to over 60 sites in 10 provinces (Figure 2), but there have been no records since 1980 from Jiujiang city near Poyang Lake in Jiangxi province, Hangzhou city in Zhejiang province or Jiangyin city in Jiangsu province, where they had previously been recorded (Gould 1874, Gee *et al.* 1929, Shaw 1934, Rank 1989). In the Chinese part of its range, the species mainly inhabits coastal, lakeside and riverside wetlands where the Common Reed is found. Some early publications indicated that the species was recorded in reeds (David 1872, Lynes 1914, Gee & Moffett 1917, Table 1).

Of the 37 academic publications published after 1980 examined in the study, 31 mentioned the vegetation used by Reed Parrotbills, 27 indicating that the species used reeds or reed-dominated vegetation. The other four indicated that the species used habitats that included 'farmland and protective forest-belts near residential area' (Su *et al.* 1987), 'dense bushes near stream and marsh' (Hou

Figure 2. Distribution of Reed Parrotbill in China. See Table 1 for details of marked sites.

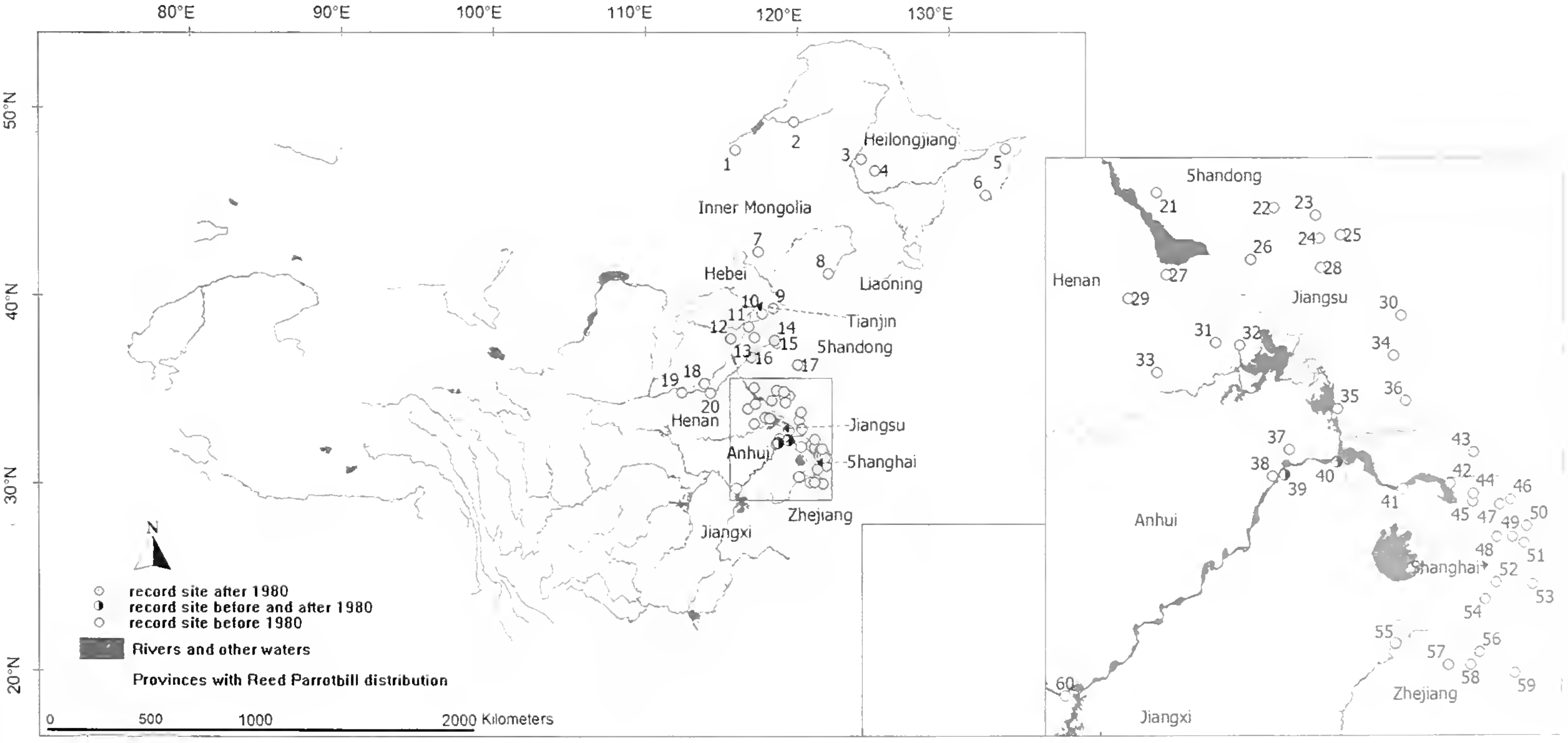


Table 1. Records and habitat use of the Reed Parrotbill in China.

Province	Sites or region	Description of habitat	Recording year	Source	Site
Records before 1980					
Jiangsu province	Along Changjiang river between Nanjiang & Zhenjiang	'the reed-beds cover a total area of about 200 square miles' 'outside the reed-bed zone the species has never been observed and almost certainly does not occur'	ns	Lynes 1914	
	Jiangyin	Unknown	Unknown	Gee *et al.* 1929 (see Rank 1989)	41
	Nanjing city	Reed vegetation 'a few reed-covered islands on the Yangtze in the neighborhood of Nankin'	1871 ns	David 1872 Styan 1891	39
	Zhenjiang city	'very common in winter in the reed-beds a few miles below Chinkiang', 'in the bare reed-fields after the crop has been cut, and in bushes and trees in the vicinity'	ns	La Touche 1906	40
Jiangxi province	Jiujiang city	Unknown	Unknown	Gould 1874 (see Rank 1989)	60
Unsure	East China	ns	ns	La Touche 1925	
	Middle China	'Resident in the reed beds along the Yangtse River'	ns	Gee & Moffett 1917	
Zhejiang province	Yunsi, Hangzhou	'It frequents bamboo thickets and Ilex, the so-called Tung Ching shrubs'	1932	Shaw 1934	55
Records after 1980					
Anhui province	Donghu Wetland Park, Huaibei city	Reed vegetation	Jan 2010	Wang *et al.* 2011	29
	Shilonghu Wetland Park, Suzhou, Sixian county	Reed vegetation	Mar 2011	Wang *et al.* 2011	31
	Tuohu Wetland Nature Reserve, Bangbu, Wuhe county	Reed vegetation in lakeside of Tuohu lake	May 2006 & Feb 2009	Zhou 2010	33
Hebei province	Hengshuihu NNR, Hengshui city	Wetland with reed vegetation Agricultural areas and artificial forest Reed bed, meadow and bushes	Jun 2007 Oct 2001–Dec 2006 Oct 2001–Sep 2002	Lin *et al.* 2008 Han *et al.* 2007 Gao 2003	12
	Nandagang wetland, Cangzhou	Reed marshes	Mar 2001–Jul 2003	Zhang 2004	11
	Saihanba National Forest Park, Weichang, Chengde	Dense bushes near stream and marsh ns	Jun 1992 Jun 1992	Hou *et al.* 1997a Hou *et al.* 1997b	7
	Tanghai county	Reed vegetation	Feb 2009–Oct 2011	Han *et al.* 2011	9
Heilong-jiang province	Honghe NNR, Jiamusi	ns	ns	Ai *et al.* 2001	5
	Longfeng wetland nature reserve, Daqing	Reed vegetation	May 2008	Pers. obs.	4
	Xingkaihu NNR, Jixi	Reed vegetation	May 2008	Pers. obs.	6
	Zhalong NNR, Qiqiha'er	Farmland and protection forest near agricultural area Common in reed vegetation Reed marshes	1983–1986 May 1996 May 2005	Su *et al.* 1987 Li *et al.* 1998 Kong 2006	3
Henan province	Huanghe Wetland, Xinxiang	ns	Jan 2012	Web news	18
	Yellow River riverside, Kaifeng	ns	Oct 2009	Pers. comm.	20
	Yellow River Wetland NNR, Mengjin, Luoyang	Reed vegetation in bank of Huanghe River east to the Huanghe highway	Jan 2006	Niu 2007	19
Inner Mongolia	Huihe NNR, Ewenke Qi, Hulunbei'er	Riverside wetland in Huihe district	ns	Lu 1990	2
	Wulannuoer reservoir, New Barag Youqi, Hulunbei'er	ns	Sep 2008	Pers. comm.	1
Jiangsu province	Yancheng, Dongtai county	ns	Apr 2010	Pers. comm.	36
	Lianyungang, Ganyu county	ns	Sep 2009	Pers. comm.	23
	Gaoyou Lake, Yangzhou, Gaoyou county	ns	Jul 2012	Web news	35
	Lianyungang, Guangyun county	ns	May 2010	Pers. comm.	28
	Nantong, Haimen county	Reed vegetation along the Changjiang River	Aug 2007	Pers. obs.	44
	Haizhou district, Lianyungang	Shallow water area with short reed shoots Reed vegetation in low land	1985–1987 Jul 1986	Wang & Zhou 1988 Wang 1990	25
	Hongzehu Wetland NNR, Sihong, Suqian	Reed vegetation Riverside and reed vegetation in south Hongze lake ns	Jul 2005–May 2006 2005–2007 2003–2004	Ji 2007 Tang 2007 Zhai *et al.* 2008	32

Table 1 ... continued.

Province	Sites or region	Description of habitat	Recording year	Source	Site
	Lianyungang	Reed vegetation in tidal flat along coast, reed vegetation in ponds, in scattered reed vegetation along the canal and near the farm house after reed cutting	1984–1986	Wang & Tian 1988	24
	Liuhe district, Nanjing	Reed vegetation along Changjiang River	Sep 2011	Pers. obs.	37
	Luomahu reservoir, Xinyi, Xuzhou	ns	1984–2005	Feng *et al.* 2006	26
	Nanjing	Reed along the Changjiang River	Sep 2011	Pers. obs.	39
	Nantong	Reed vegetation along the river and coast	Apr 2003	Pers. obs.	42
	Pukou district, Nanjing	Reed vegetation along Changjiang River	Sep 2011	Pers. obs.	38
	Nantong, Qidong county	Reed vegetation along the coast	Apr 2003	Pers. obs.	46
	Nantong, Rudong county	ns	Apr 2010	Pers. comm.	43
	Yancheng, Sheyang county	ns	Apr 2008	Pers.comm.	30
	Xinglong Is,Nantong Qidong county	Bushes along the dyke	Nov 1990–Feb 2002	Zhao et *al.* 2004	47
	Xuzhou	ns	Jul 1985	Zou & Qin 1989	27
	Yancheng	Reed vegetation in the tidal flat Reed vegetation in tidal flat, along the river & ponds	Mar 1983 1986–1988	Wang & Tian 1988 Shi & Cui 1989	34
	Zhenjiang	ns	Jan 2012	Web news	40
Liaoning province	Shuangtaizi Hekou NNR, Panjin	Reed marsh in Dongguo Reed vegetation	Apr 1991 Jul 2005	Jin *et al.* 1991 Pers. obs.	8
Shandong province	Daguhe estuary, Jiaozhou	ns	Jul 2012	Web news	17
	Huanghe Delta NNR, Dongying	Marshes with reed vegetation and *Tamarix* vegetation	1997	Zhu *et al.* 2001	15
	Huanghe Forest Park, Jinan	ns	Dec 2007	Pers. comm.	16
	Zaozhuang, Tengzhou county	ns	Aug 2011	Web news	21
	Dongying , Kenli county	ns	Aug 2007	Pers. comm.	14
	Dezhou, Leling,	ns	Feb 2010	Pers. comm.	13
	Linyi, Linmu county	Reed vegetation	1989	Bai & Bai 1993	22
Shanghai	Changxing Island, Chongming county	Reed vegetation along the coast	2002–2011	Pers. obs.	49
	Chenhang reservior, Baoshan district	Reed vegetation along the coast	Nov 2006	Pers. obs.	48
	Chongming Dongtan Birds NNR, Chongming county	Reed vegetation along the coast Found only in reed vegetation zone 'the dominant species in the *Phragmites* and *Spartina-Phragmites* habitats, accounting for 49 & 29% of the total numbers recorded in the two habitats' *Phragmites* habitat, *Spartina-Phragmites* habitat and *Spartina* habitats *Phragmites* vegetation and *Spartina* vegetation	Sep 1984 Spring 2003 Spring 2008 Nov 2008–Mar 2009 Winter 2004 & 2005	Ma & Sun 1988 Xu *et al.* 2006 Gan *et al.* 2009 Dong *et al.* 2010 Gan *et al.* 2010	50
	Chongxi Wetland Reserch Center, Chongming county	Reed vegetation Reed vegetation	Jan–Apr. 2007 Dec 2005–Nov 2006	Xiong *et al.* 2007 Xiong & Lu 2008	45
	Fengxian district	Tidal flat with reed vegetation along the coast Tidal flat with reed vegetation along river and coast	Apr 1983 1985–1986	Ma & Sun 1988 Ma 1988	52
	Hengsha Island, Chongming county	Reed vegetation along the coast	2002–2011	Pers. obs.	51
	Jinshan district	Reed vegetation along the coast	Apr 2006	Pers.obs.	54
	Jiuduan Shoal*	'99.3% of Reed Parrotbill preferring reed vegetation'	Nov 2003–Feb 2004	Ma et *al.* 2007	
	Pudong district	Reed vegetation near Luchao port	Jan 1984	Ma & Sun 1988	53
Tianjin	Lushandao, Qilihai and Beidagang	Reed vegetation near rice paddy and ponds	1995,1998,1999	Wang *et al.* 2002	10
Zhejiang province	Hangzhou Bay National Wetland Park, Ningbo Cixi county	Reed vegetation along the Hangzhou Bay	Sep 2005	Pers. obs.	56
	Shaoxing, Shangyu county	Reed vegetation along Qiantangjiang river	Sep 2009	Pers. obs.	57
	Ningbo, Yuyao county	Reed vegetation along Qiantangjiang river	Sep 2009	Pers. obs.	58
	Zhenhai district, Ningbo	Reed along the coast wetland	Sep 2009	Pers. obs.	59

'Unknown' means that authors did not read the reference and were not sure about this item.

*Ma *et al.* (2007) indicated that they observed many Reed Parrotbills in Jiuduan Shoal (271 individuals in total) in winter 2003. However, the author and the staff of Jiuduansha National Nature Reserve did not find any Reed Parrotbills in Jiuduan Shoal during our field work from July 2009 to April 2010 in this new island.

NNR=National Nature Reserve.

ns = 'not stated in source'.

et al. 1997a), 'bushes along the sea dike' (Zhao *et al.* 2004) and 'dense bushes near streams and marshes' (Han *et al.* 2007).

The species has been recorded in 57 localities since 1980 in academic publications (26 sites), our observations (16 sites), personal communications (10 sites) and internet news (5 sites) (Table 1). In 39 of the 57 sites or areas, the habitat types were described and in 36 of them the habitat used by Reed Parrotbills was reeds or reed-dominated vegetation.

Distribution of Reed Parrotbills at Chongming Island

A total of 625 Reed Parrotbills was recorded in 22 transects (Figure 1). Nineteen of these transects were in intertidal mudflats and the other three in newly reclaimed areas close to intertidal mudflats.

All the birds were recorded in reeds. Transects in intertidal mudflats were covered with reedbeds and those in newly reclaimed areas had reeds scattered around aquaculture ponds or in planted woodland. No Reed Parrotbills were recorded in the remaining transects, which included farmland, riversides, residential areas, woodlands and aquaculture ponds away from the intertidal mudflats. These transects either had no reedbeds or only had small patches of reeds isolated from larger reedbeds.

Habitat selection of Reed Parrotbills at Chongxi Wetland Research Centre

During three years observation, no Reed Parrotbills were recorded in areas without reed vegetation (farmland, aquaculture ponds and protective forest belts). The species was only recorded in areas with reed vegetation: including reedbeds, reeds with dense trees (RDT), reeds with sparse trees (RST) and patches of Common Reeds (PCR). In these areas, Reed Parrotbills was recorded almost year round (Figure 3). There were significant differences in Reed Parrotbill density between the four types of reed habitat (Friedman test, Chi-square = 60.729, df = 3, $P<0.001$). Wilcoxon Signed Ranks Test indicated that Reed Parrotbill density in reedbeds was significantly higher than in PCR, RDT and RST (all $P< 0.01$), but there were no significant differences among PCR, RDT and RST (all $P> 0.05$). In RDT, the Reed Parrotbill was not recorded after May 2007 when the reeds died back, but it was recorded in almost all months in RST (Figure 3), indicating that presence of the Common Reed is a necessary precondition for survival of the Reed Parrotbill.

DISCUSSION

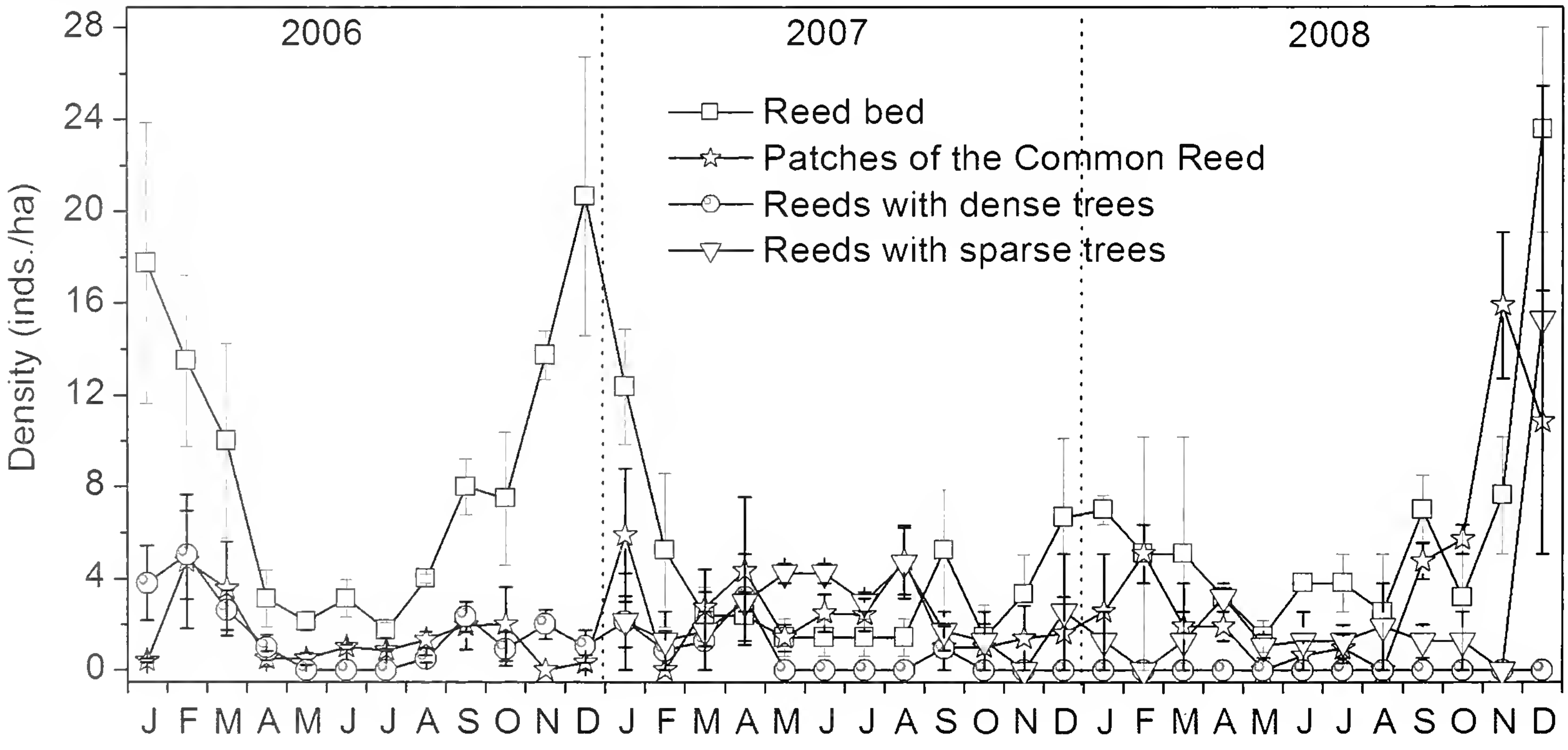
The use of reed vegetation by Reed Parrotbills is reported frequently in published literature. These reports, combined with the observations from Chongming Island, indicate that the species uses reedbeds or reed-dominated vegetation as habitat throughout its Chinese distribution. Detailed local observations at Chongming Island and Chongxi Wetland Research Centre also indicated that the species was almost exclusively associated with reeds and that birds were not found in nearby areas without reeds. It was concluded that the Reed Parrotbill is a reed-dominated habitat specialist.

The species's distribution map for China (Figure 2) includes many new records. In the south, the range extends to the southern shore of Hangzhou Bay but the northern extent cannot be determined yet, as there are records of Reed Parrotbills in south-east Russia. This study revealed that the species has a larger range than previously thought. Further changes to the known range are anticipated, as research and birding activities increase.

At Chongxi Wetland Research Centre, when reed shoots disappeared from mixed vegetation, Reed Parrotbills were rarely recorded in the reed-free vegetation. They were unable to persist in these areas by utilising more distant patches of reeds and disappeared along with the reeds. This implies that the species is dependent on reed vegetation and this dependence on reeds might constrain their ability to use other vegetation in the absence of reeds. There are published accounts of Reed Parrotbills using non-reed vegetation close to large areas of reeds (Su *et al.* 1987, Hou *et al.* 1997a, Zhao *et al.* 2004, Han *et al.* 2007). The species has been observed using bushes and woodland close to reeds when the reed-vegetation was disturbed by, for example, reed harvesting (La Touche 1906, Wang & Tian 1988). In the absence of disturbance, birds occasionally visit nearby non-reed vegetation, for example *Spartina*, but the number of individuals and their density were much lower than in reeds (Dong *et al.* 2010, Gan *et al.* 2010). Birds evidently disperse readily into non-reed vegetation near reeds, but it is not known whether they use resources within the non-reed vegetation or make only transitory visits. Birds visiting *Spartina* close to reeds only spent very short periods of time there (Dong *et al.* 2010).

Records of the species in non-reed vegetation indicate that the degree of habitat specialisation is not fully understood. It is

Figure 3. Monthly variation of Reed Parrotbill density (±SE) in reedbeds, reed patches, reeds with dense trees and reeds with sparse trees during 2006 to 2008, at Chongxi Wetland Research Centre.



important to understand the relationships between the species and the reed vegetation. Studies have shown that Reed Parrotbills feed on insects, insect eggs and larvae on reed shoots year round, in a tidal marsh in Changjiang Estuary (Xiong *et al.* 2007, 2010). The species may have special morphological adaptations in its bill, which facilitate breaking reed stems to retrieve insects within (Xiong *et al.* 2010) but which compromise its ability to use food resources in other vegetation. Similar extreme specialisation is seen amongst the bamboo-specialist insectivores, which feed on insects in, on and around living bamboo (Cockle *et al.* 2009). Although the Reed Parrotbill is limited to reed vegetation and it feeds on insects in and on reeds (Xiong *et al.* 2007), it is not yet certain that their prey is also restricted to reed vegetation.

It is not known whether the two recognised subspecies differ in habitat use or other life history characteristics. Subspecies *heudei* occurs on Chongming Island, where the fieldwork was carried out. At sites where *polivanovi* is found, such as Zhalong National Nature Reserve (site 3 in Figure 2), Longfeng Wetland Nature Reserve (4) and Xingkaihu National Nature Reserve (6), the Reed Parrotbill habitat was described as reed vegetation or reed marsh. Thus, it seems likely that the two subspecies have the same habitat requirements.

CONCLUSIONS

This review of Reed Parrotbill distribution in China revealed that its range and the number of locations where it occurs are larger than previously thought. This does not indicate an improvement in the conservation status of the Reed Parrotbill, as the study also confirmed the species's strict habitat specialisation. Given that existence of Common Reeds is a precondition for Reed Parrotbills to survive, more attention must be paid to the conservation of reed-dominated habitat, such as coastal wetlands, lakeside wetland and marshes, and corridors in reed-dominated habitats should be designed and maintained to reduce the effects of habitat fragmentation.

Corridors might also be useful to link areas of reedbeds without Reed Parrotbill populations to nearby locations that are already populated and this could be used in the selection and development of protected areas.

It would be useful to learn more about how the Reed Parrotbill uses and has adapted to reed vegetation, to help understand the evolutionary history of the species and likely threat mechanisms. The distribution of Reed Parrotbills may be predicted based on its strong relationship to the Common Reed. Large areas of reed vegetation close to or linked by corridors to reed vegetation with Reed Parrotbill populations could be potential habitat.

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***Li-Hu XIONG**, Zhejiang Institute of Hydraulics & Estuary, 50E Fengqi Rd, Hangzhou, Zhejiang Province 310020, China. Email: lihuxiong@126.com*

***Jian-Jian LU**, Chongxi Wetland Research Centre, The State Key Laboratory of Estuarine and Coastal Research, East China Normal University, 3663N Zhongshan Rd, Shanghai 200062, China.*

Increasing variation in population size and species composition ratio in mixed-species heron colonies in Japan

MIYUKI MASHIKO & YUKIHIKO TOQUENAGA

Long-term population dynamics of colonial herons and egrets are well documented in Europe and the USA, but not in East and South-East Asia. Here the population dynamics of mixed-species colonies from 2002 to 2011 in Ibaraki prefecture, east Kanto, Japan, are reported. From censuses based on a combination of aerial and ground surveys, the number of breeding colonies was found to vary from 15 to 20. The population dynamics of Great Egret *Casmerodius albus* and Black-crowned Night Heron *Nycticorax nycticorax* remained relatively constant, while Grey Heron *Ardea cinerea* and Intermediate Egret *Mesophoyx intermedia* increased, but Little Egret *Egretta garzetta* and Cattle Egret *Bubulcus ibis* decreased. When data for the six species were combined, the sum of their populations was almost constant, but variation increased in colony size, species composition ratio and the number of years that individual colonies existed. The population of colonies typically ranged from 200 to 2,000 individuals up to 2004, but smaller (under 200 individuals) and larger (over 2,000 individuals) colonies appeared after 2006. Increased variation in the number of consecutive years colonies existed was closely related to increased variation in colony size. Increased variation in species composition ratios in colonies was not a by-product of the increased variation in colony size, and the occurrence of colonies dominated by Grey Heron, Intermediate Egret or Black-crowned Night Heron after 2006 played an important role in the structural changes of mixed-species colonies.

INTRODUCTION

Herons and egrets (Ardeidae) are commonly found in aquatic habitats worldwide (Kushlan & Hafner 2000). In Europe, long-term population trends of such species have been well investigated, and some factors that explain how and why population sizes fluctuate at regional level have been revealed: cold winters (Stafford 1971, Reynolds 1979, Hafner & Fasola 1997, Fasola *et al.* 2010), rainfall (McKilligan 2001), water level (Grüll & Ranner 1998), habitat conditions (Tourenq *et al.* 2000, 2004), aquaculture (Fleury & Sherry 1995) and human disturbance (Fasola *et al.* 2010). In East and South-East Asia, long-term records of breeding populations of colonial nesting herons and egrets only exist in Hong Kong and Vietnam (Kushlan & Hafner 2000, Wong & Young 2006). Lack of local information makes it difficult to assess the current status of these birds.

In Japan Grey Heron *Ardea cinerea*, Great Egret *Casmerodius albus*, Intermediate Egret *Mesophoyx intermedia*, Little Egret *Egretta garzetta*, Cattle Egret *Bubulcus ibis* and Black-crowned Night Heron *Nycticorax nycticorax* breed in mixed-species colonies. Nationwide research was carried out in 1980 and 1992 (Research Division of the Wild Bird Society of Japan 1981, Environmental Agency of Japan 1994), and it was reported that single- and mixed-species colonies were distributed throughout Japan's lowlands. Although there are many observations of colonies in various areas, long-term local population trends have only been reported by Narusue (1992) and Matsunaga *et al.* (2000).

Narusue (1992) argued that both the populations and the average colony size of these species declined from the 1940s to 1992 in Saitama prefecture, west Kanto Plain, due to loss of foraging areas and use of agricultural chemicals. Changes in the irrigation of rice fields from shallow earth ditches to deep concrete-walled channels and the decline in aquatic prey caused the decline of Intermediate Egret (Narusue & Uchida 1993, Lane & Fujioka 1998), the commonest egret until the 1960s, but now categorised as 'near threatened' (Ministry of the Environment 2002). In contrast, a long-term study of Grey Herons in Hokkaido by Matsunga *et al* (2000) reported an increase in population and the number of colonies. There are currently no other reliable data to assess population trends of herons and egrets in Japan.

The Environmental Agency of Japan (1994) showed that in Ibaraki prefecture, east Kanto, Japan, both the average colony size and the population of Intermediate Egret were large compared to elsewhere in Japan, and this suggested that data from this area could provide important information for future assessment of populations of colonial breeding herons and egrets in Japan and other parts of Asia. In this study, colony censuses were carried out from 2002 to 2011 in Ibaraki prefecture to investigate trends in these populations using a combination of aerial and ground surveys. The changes are discussed here with reference to the trends in population dynamics of each species, changes in the nesting vegetation and the number of consecutive years that colonies existed.

METHODS

Study area

The study focused on Ibaraki prefecture and parts of Tochigi and Chiba prefectures in Honshu, central Japan (35.783°–36.767°N 139.767°–140.683°E) (Figure 1). The area is in the east Kanto Plain, near Lake Kasumigaura, and includes six major rivers: Kuji, Naka, Sakura, Kokai, Kinu and Tone. The north is mountainous, but the predominant land use in other areas is farming, with large areas along the rivers being used for rice production. There are also lotus fields near Lake Kasumigaura, areas of lowland forest and human habitations. Japan started a national project to consolidate rice production in 1963; this included extending irrigation ditches, improving service roads, and enlarging fields to facilitate mechanised farming equipment. It was largely complete by 1980 (Himiyama & Kikuchi 2007), but continued in part of the study area into the last decade, being 78% complete by 2010 in Ibaraki prefecture. The climate of the region is moderate with an annual average air temperature of 14.0 ± 0.1°C and an annual precipitation of 1,388.2 ± 54.3 mm. Despite a small annual decrease in rice cultivation, neither climate nor land use showed obvious changes during the study period (Figure 2).

The herons and egrets breed from March to August, but there is considerable variation from species to species (Figure 3). The Grey Heron arrives first in March, Great Egret, Little Egret, and Black-crowned Night Heron arrive in April; these species are residents and wanderers, and some individuals winter in this area. Finally, the migrant species arrive, Intermediate Egret in late April and Cattle Egret by early May (A. Abe *in litt.* 2006). Usually Grey

Figure 1. Locations of colonies from 2002 to 2011. Grey regions show an altitude greater than 100 m where the distribution of egrets is lower. Dots enclosed by a circle are considered to be historically identical colonies. Exceptionally, there are two cases in which the nearest-neighbour distance is shorter than 6.47 km; (1) $\mathbf{I}_{20} - \mathbf{L}_{30}$: because **L** was newly established in 2010 and consisted of Grey Herons *Ardea cinerea* and Great Cormorants *Phalacrocorax carbo*, we assumed **L** was different from **I**. (2) $\mathbf{Q}_{40} - \mathbf{R}_{41,42}$: **Q** was newly established in 2006, whereas Koshida (2007) reported that **R** has existed since 1984. It is difficult to accept that **Q** and **R** are one colony.

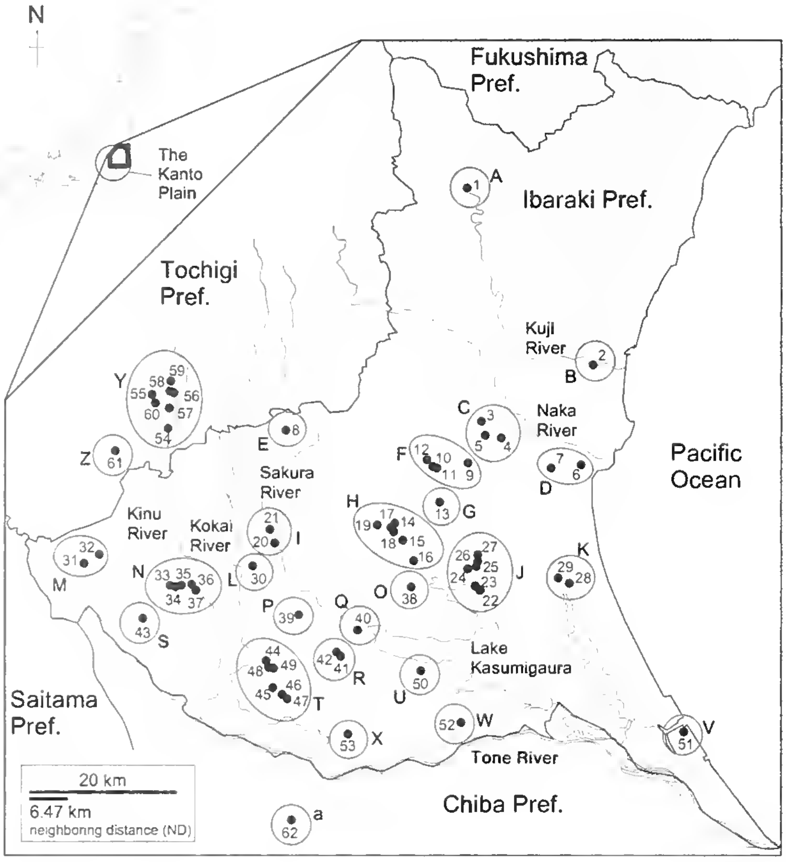
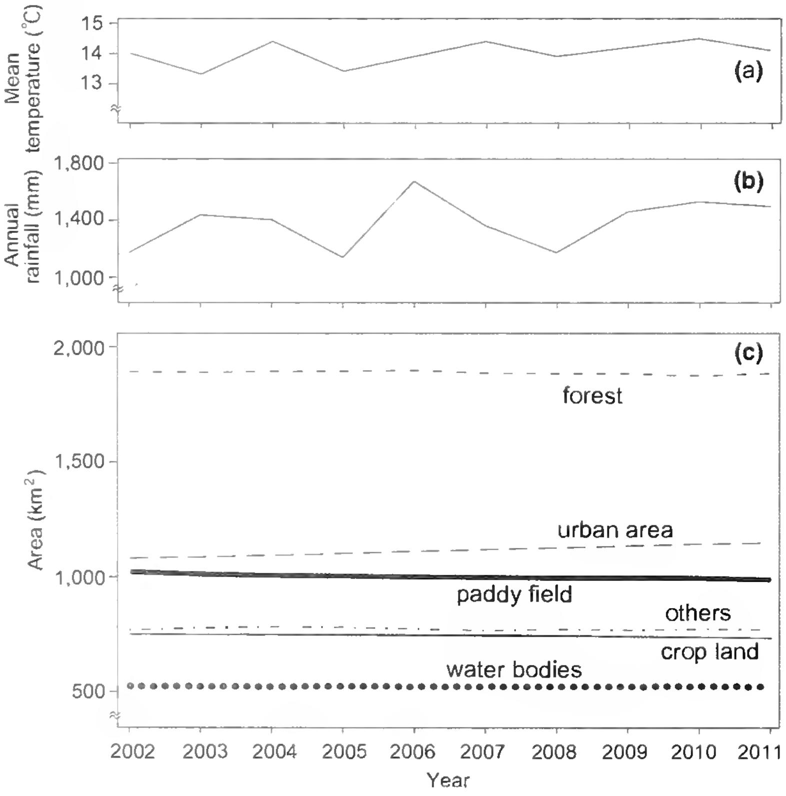


Figure 2. Changes in **a.** mean temperature, **b.** annual rainfall, and **c.** areas of six land-use types from 2002 to 2011 in Ibaraki prefecture, which was the main region of the study area (6,096 km^2). 'Paddy field' includes both rice paddies and lotus fields, and 'others' includes parks, golf courses, and uncultivated fields. Data were downloaded 8 June 2013 from http: //www.data.jma.go.jp/obd/ stats/etrn/index.php for climate and http: //www.pref.ibaraki.jp/bukyoku/kikaku/mizuto/ibarakinotochi/25/ibarakinotochi.htm for land use.



Heron and Black-crowned Night Heron are nocturnal, but during the breeding season they are also active during the day.

Colonies were located in bamboo thickets, trees or a mixture of both. Bamboo thickets were composed of Moso Bamboo *Phyllostachys pubescens*, Simon Bamboo *Pleioblastus simonii* or Dwarf Bamboo *P. chino*. Coniferous tree sites consisted mainly of Japanese Red Pine *Pinus densiflora*, Japanese Cedar *Cryptomeria japonica* and Japanese Cypress *Chamaecyparis obtusa*; broadleaf tree sites were mainly Japanese Zelkova *Zelkova serrata*, Japanese Oak *Quercus serrata* and Yoshino Cherry *Prunus* × *yedoensis*.

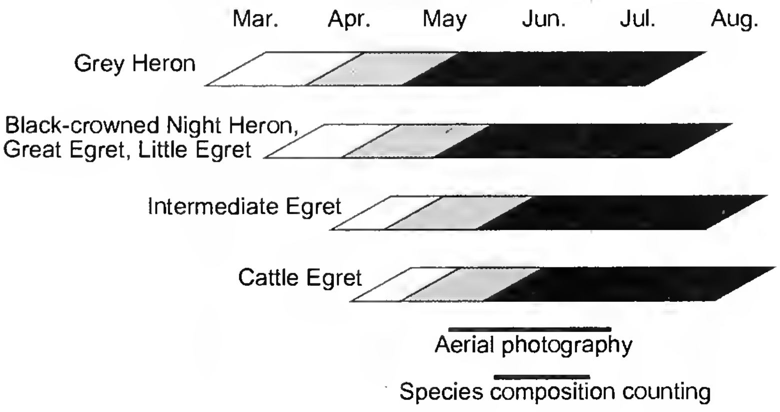
Census of colonies

Colonies have been recorded in the area over the last 25 years (Koshida 2007) and have high site fidelity (Custer *et al.* 1980, Frederick *et al.* 1996); between March and early May, 93 ± 0.02% of the colony sites were found by checking the places where colonies had been located in previous years. When a colony was abandoned, checks were made to determine whether other colonies had formed nearby. Local literature and personal communication were used to locate colonies that had not been found during the authors' own field work. Site vegetation was recorded by identifying bamboo or tree species holding at least one nest.

In small colonies of fewer than about 50 nests, if all the nests were visible from outside or within the site, the nests of each species were counted directly from the ground, and the breeding population estimated by doubling the number of nests counted. In most cases, ground-based counts were impossible due to colony size, the impenetrable nature of dense bamboo thickets, or other vegetation, such as tall trees, that made nests invisible. Hence, counts were made using a combination of aerial and ground surveys, following the method of Fujioka *et al.* (2001).

For aerial surveys, a small 'Sky Surfer' radio-controlled paraglider was used (Green Corporation, Japan, Plate 1a). This equipment is quieter than fixed-wing aircraft or helicopters commonly used for bird colony censuses (Kushlan 1979, Rodgers *et al.* 2005), and very suitable in this case where more than 80% of the colonies were close to residential areas. Aerial photographs of each colony were taken at an altitude of 30–50 m just before sunrise (about 04h00) when most birds were in the colony. Photography was started in mid-May after arrival of Cattle Egrets, and was continued until early July when distinguishing between growing nestlings and adults became difficult (Figure 3). Aerial photographs were taken once during that period at each site. All individuals of the four light-coloured species (Great Egret, Intermediate Egret, Little Egret, and Cattle Egret) in the images were counted (Plate 1b). For large colonies, several photographs were used to obtain a complete composite image of the colony.

Figure 3. Breeding period of each species in the study area showing the timetable of aerial surveying and species composition counts. White, grey, and black shading show arrival and nest building, incubation, and chick-rearing periods, respectively. The parallelogram shapes indicate the variation in individual breeding periods. After breeding is over, some birds continue to roost in the colonies but all disperse by October.



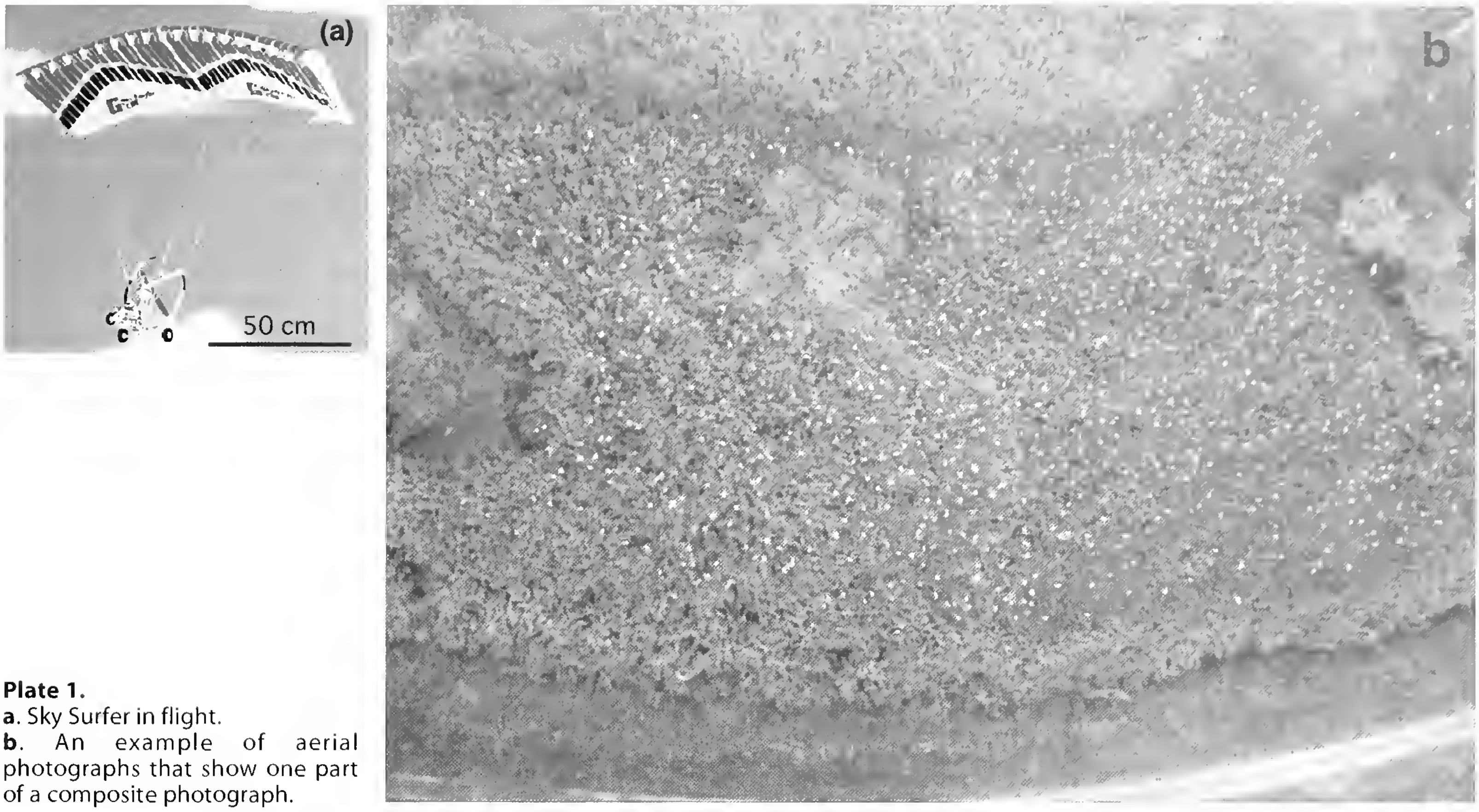


Plate 1.
a. Sky Surfer in flight.
b. An example of aerial photographs that show one part of a composite photograph.

GREEN CORPORATION

M. MASHIKO

Because it was not feasible to identify the light-coloured species only from the photographs, and because the two dark-coloured species (Grey Heron and Black-crowned Night Heron) were difficult to count in the photographs, species composition ratios—the proportion of each species within a colony—were estimated using data from ground surveys. The number of individuals of all species going in and out of each colony for a period of 30 minutes in the daytime were counted using binoculars. It was very difficult to identify to species level white egrets flying in and out at the same time, so the viewing range of each observer was restricted by setting a common range of observation, approximately a 30° field of vision. In the case of large colonies, surveys were carried out from two or three different directions. Ground surveys were made once or twice in June, the peak chick-rearing period (Figure 3), when all species engage in frequent foraging flights. Thirty minutes is much shorter than the typical duration of one foraging flight and it was assumed that each individual counted, whether arriving or departing, was observed only once during the observation period and therefore the observed proportion of each species reflects the species composition ratio of the colony.

The total estimated number of individuals in the colony (T = colony size) was calculated using $T = \frac{A}{1-x}$, where A is the actual number of light-coloured individuals counted from aerial photographs, and x is the sum of the proportion of Grey Herons and Black-crowned Night Herons obtained from the ground survey. The estimated population size of each species in the colony was obtained by multiplying the colony size by the proportion of each species.

Data analyses

To determine the number of colonies each year, the number of observed colony sites was first counted. But the number of sites itself was not taken to be the number of colonies because a few colony sites were very close to each other despite foraging ranges having radii of about 10 km, and sometimes over 20 km (Nabeya 2011). An earlier study showed that heron colonies are evenly distributed to avoid overlap of foraging sites (Gibbs *et al.* 1987). Consequently if colony sites were located close together, they were grouped together and counted as a single colony because their foraging areas overlapped substantially. To determine which sites should be counted as a single colony, the half of the mean nearest-neighbour distance (ND) of observed colony sites for each year was used. If more than one colony site was located within the ND, colony censuses were carried out at each site, the data were combined and it was counted as a single colony.

Colonial birds have been found to have high site fidelity (Custer *et al.* 1980, Frederick *et al.* 1996); every year some colonies returned to the same locations as the previous year, some birds were abandoned and new ones were established. To obtain the number of consecutive years (NCY) each colony existed, the number of years from first establishment at the location was counted. The movement of a colony was also considered and when abandonment and new establishment occurred in neighbouring locations in successive years, the new site was assumed to be a descendant of the abandoned one, e.g. abandonment was sometimes caused by vegetation loss through natural causes or felling and the colony was often re-established nearby. The ND was used to determine a reasonable displacement distance of a colony and it was assumed that each colony had a domain of attraction of half the average distance between the next nearest sites. Thus, colonies consecutively established at the same site or at a different site within a radius of the ND were counted as a single colony. Koshida (2007) was used as data source of the NCY of colonies established before 2002; consequently the NCY ranged from 1 to 36 years rather than being limited to the period of this study.

The population of each species was calculated annually using the mean population size per colony rather than summing the population sizes for all colonies with census data. This approach was used because aerial and ground surveys produced only partial data due to practical difficulties—problems in taking aerial photographs and/or delays in detecting colony sites. The simple sum of colony population sizes would have been inappropriate because it is an increasing function of the number of colonies with census data. The percentage of colonies surveyed increased from 78% in 2002–2004 to 94% in 2006–2011. (Data from 2005 were excluded because aerial and ground surveys were limited to only 5 out of 18 colonies.) Thus, the overall total population of the target species reflect the mean colony sizes rather than the total number of individual birds in the study area.

To evaluate difference in colony size, species composition ratio, and NCY among colonies, the coefficient of variance (CV) for each year was calculated. For species composition ratio, the proportional similarity index (Whittaker 1952) was calculated for each colony every year as $\frac{\Sigma|p_i - \overline{p_i}|}{2}$, where p_i is the proportion of species i in one colony and $\overline{p_i}$ is the mean proportion of that species in all colonies surveyed in that year. The index ranges between zero and unity: zero means completely different and unity means completely equal. Then the CV of proportional similarity of the species composition ratio was obtained for each year.

Ten years is too short for ordinal time series analyses, so randomisation tests were done to assess temporal trends in the number of colonies, population sizes of each species, sum of the population sizes of the six species, colony sizes and CVs of three variables (colony size, species composition ratio and NCY). In a randomisation test, the linear regression coefficient (β) of a target variable based on the original data was obtained first. Next the data were shuffled 30,000 times and compared beta with the linear regression coefficients (β's) of the shuffled data to obtain one-sided *P*-values to assess whether the target variable was increasing or decreasing. Sensitivity analyses of the population of each species against the three CVs (colony size, species composition ratio and NCY) were performed. Generalised linear models specifying population sizes of the species as explanatory variables and CVs as dependent variables were constructed, using Gaussian distribution with an identity link function for all model fitting. The most suitable models based on Akaike's information criterion values were chosen and the coefficients of explanatory variables of the models as sensitivity against dependent variables were considered.

If the CVs of colony size and species composition ratio show parallel changes, there is a possibility that the variation in species composition ratios increased as a by-product of the increase of variation in colony sizes. To examine this possibility, a randomisation test was performed to determine whether the variation in species composition ratios was solely caused by a sampling bias according to the variation in colony size. First a hypothetical total number of herons that consisted of the six species was prepared. The species composition ratio of the whole number of herons was arbitrary. Next multiple colonies with equal colony sizes from the total number of herons were sampled. Then proportional similarities of species composition ratios of these hypothetical colonies against the species composition ratio of the whole number of herons were calculated. Proportional similarities for hypothetical colonies of the same number but with different colony sizes were also calculated. Finally, the variance of the proportional similarities between equal and unequal size colonies were compared, and the probability that proportional similarities of unequal size colonies were larger than or equal to those of equal size colonies with 10,000 iterations was obtained.

To evaluate changes in nesting vegetation, the Friedman test was used to analyse whether the vegetation of colony sites changed from year to year. Nesting vegetation consisted of one or a mixture of the following three types: bamboo thickets, coniferous trees and broadleaf trees; there were seven types in total.

Finally, a randomisation test was performed to determine whether there was a positive correlation between NCY and colony size among colonies by reshuffling the year record so as to randomise the consecutive colony-size dynamics of each colony.

All statistical analyses were conducted using R ver. 2.13.0 (R Development Core Team 2011). Data are presented as mean ± SE throughout. The randomisation test on the relationship between the variation of population sizes and that of species proportion ratios was also conducted with R. All R scripts for the above statistical analyses are available from the authors.

RESULTS

During the 10-year period, there was an average of 19 colony sites in the study area every year (19.10 ± 0.72 colony sites, n = 10); cumulatively 191 colony sites were used over the 10 years. Some colonies were in the same locations for more than one year, and a total of 62 colony sites were used (1 to 62 in Figure 1). Colony sites were separated by an average of 13 km (mean ND over 10 years 12.95 ± 8.39 km, n = 191), so the ND was defined as within 6.47 km. Hence, these 62 colony sites were categorised into 27 colonies (**A** to **a** in Figure 1) because colony sites consecutively established at different locations within a 6.47 km radius were considered a single colony. Six of 27 colonies were made up of two or three colony sites in at least one breeding season, and the median distance between them was 1.44 km (range: 0.32–5.12 km, 10 combinations of colony sites in all). Finally, the annual number of colonies increased gradually (β = 0.382, P = 0.006) from 15 to 20 (Figure 4a).

In the case of Intermediate Egret and Black-crowned Night Heron, the average population per colony was relatively large (about 300 individuals) and these species remained dominant throughout the 10-year period (Figure 4b). Conversely, it was small (about 50 individuals) for Great Egret and Grey Heron, and intermediate (about 100 individuals) for Cattle Egret and Little Egret. The sum of the population of the six species (mean colony size) ranged from 726 to 966 individuals and remained almost constant (β = −4.301, P = 0.342).

The population trends of each species varied (Figure 4b). Grey Heron and Intermediate Egret increased (Grey Heron: β = 9.575, P < 0.001; Intermediate Egret: β = 9.519, P = 0.033), whilst Little Egret and Cattle Egret decreased steadily (Little Egret: β = −2.069, P = 0.002; Cattle Egret: β = −20.672, P < 0.001). The Black-crowned Night Heron population fluctuated over the years but remained almost constant (β = 9.311, P = 0.145). The Great Egret population was small but almost constant (β = 0.036, P = 0.492).

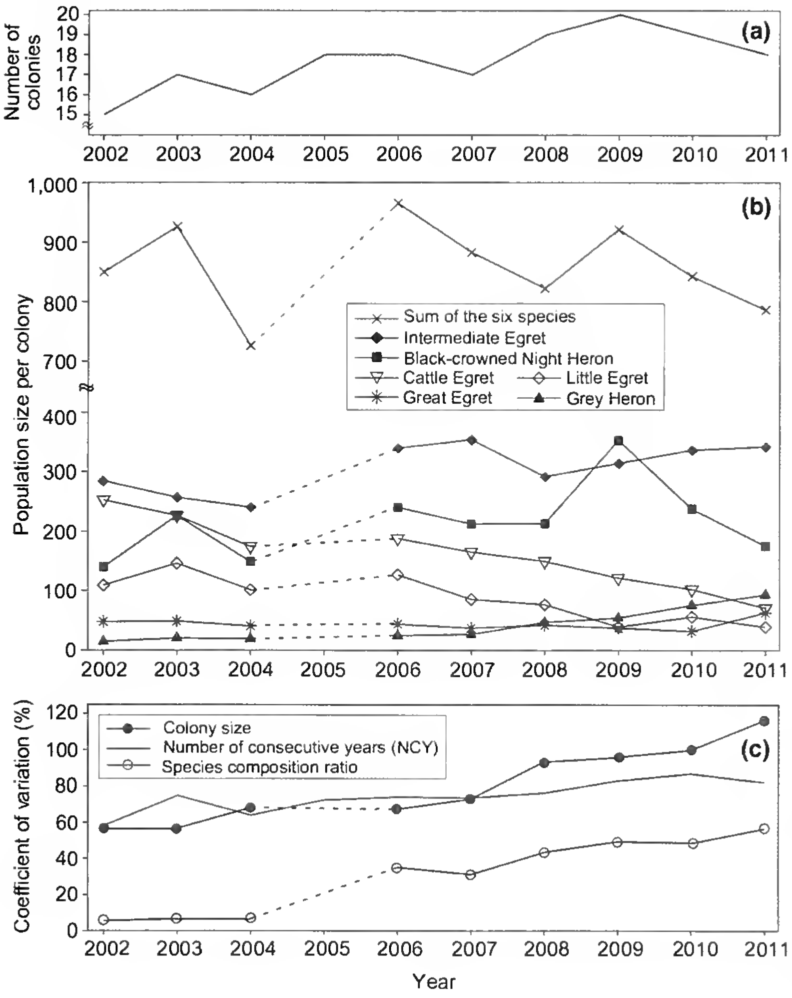
Colonies were very variable in size, and the CV of colony size continuously increased (Figure 4c) over the ten years (β = 7.510, P < 0.001). Colonies ranged from 200 to 2,000 individuals until 2004, while smaller (under 200 with minimum 8 individuals) and larger (over 2,000 with maximum 3,280 individuals) colonies appeared after 2006. Between 2008 and 2011, the smaller and larger colonies increased from 33% to 41% of colonies surveyed.

In parallel with the increase in the CV of colony size, the CV of proportional similarity of species composition ratios increased (Figure 4c), especially after 2006 (β = 7.002, P < 0.001). Until 2004, most colonies consisted of five species (Great Egret, Intermediate Egret, Little Egret, Cattle Egret and Black-crowned Night Heron), and the composition ratio was similar among surveyed colonies (mean proportional similarity = 0.86 ± 0.02, n = 43). Grey Heron bred in only three, six and seven colonies in 2002, 2003 and 2004, respectively. Until 2004, the composition ratios of the Intermediate Egret and the Cattle Egret were higher than those of other species in half of the surveyed colonies in accordance with their large population (Figure 4b), but no species became dominant (over 50% of the composition ratio). After 2006, 37% of all surveyed colonies were dominated by the Grey Heron, Intermediate Egret or Black-crowned Night Heron, and differences in the species composition ratios among colonies increased.

The CV of the NCY also increased gradually (Figure 4c) (β = 2.453, P < 0.001). Eight colonies persisted between 2002 and 2011; the remainder were abandoned or newly established. Every year 1–4 colonies were abandoned and 0–3 were established. Considering the period prior to this study, 14 out of 27 colonies had existed before 2002 and 4 had persisted for over 25 years.

Table 1 shows the results of the sensitivity analyses of population of each target species against three CVs. Increase in the

Figure 4.
a. Changes in the number of colonies between 2002 and 2011.
b. Changes in population of each species per colony of and the sum of the six species.
c. Changes in the coefficient of variation (CV) of colony sizes, number of consecutive years (NCY), and species composition ratios. For the changes in population size and CVs of colony sizes and species composition ratios, the year 2005 is not shown because aerial and ground surveys were limited to only 5 out of 18 colonies.



CV of colony sizes was explained by the increasing Grey Heron population, and the increase in the CV of species composition ratios was also explained by the increasing Grey Heron population, and marginally explained by the increasing Intermediate Egret population. The increase in the CV of NCY was explained by the increasing Grey Heron population and the fluctuating, though statistically constant overall, population trend of the Black-crowned Night Heron.

The randomisation test to determine whether the variation in species composition ratios increased as a by-product of the increase in variation of colony sizes did not reveal a significant result: the probability that the proportional similarities between unequal size colonies would be larger than or equal to those of equal size colonies was almost even (0.538). The increase of variation in species composition ratios could not solely be caused by the increase of variation in colony sizes.

Changes in vegetation of the colonies were significant over the years ($\chi^2 = 25.2$, df $= 6$, $P < 0.001$) (Figure 5). While the vegetation in most colonies included bamboo until 2004, after 2008 more than half the colonies were located in trees.

The slope obtained by a linear regression analysis of colony sizes against NCY (43.05 ± 5.43) was significantly larger ($P < 0.001$) than slopes obtained by the randomisation test where the year record was shuffled for each colony so as to randomise consecutive colony-size dynamics (Figure 6). This randomisation test indicates that there was a positive correlation between colony sizes and the NCY for the colonies.

Table 1. Sensitivity of population sizes against CVs. βs are coefficients of the best fit generalised linear model with Gaussian distribution and identity link function. R^2 = (null deviance - residual deviance)/(null deviance). CS: colony size, SCR: species composition ratio, NCY: number of consecutive years.

	CV of CS		CV of SCR		CV of NCY	
	β	P	β	P	β	P
Grey Heron	0.351	0.054	0.449	0.009	0.307	0.016
Great Egret						
Intermediate Egret			0.168	0.077	0.047	0.193
Little Egret	−0.133	0.169			0.124	0.101
Cattle Egret	−0.119	0.179				
Black-crowned Night Heron			0.081	0.116	0.072	0.020
Akaike's information criterion	56.329		65.833		59.157	
R^2	0.975		0.920		0.902	

Figure 5. Changes in colony vegetation. See description of study area for details of species.

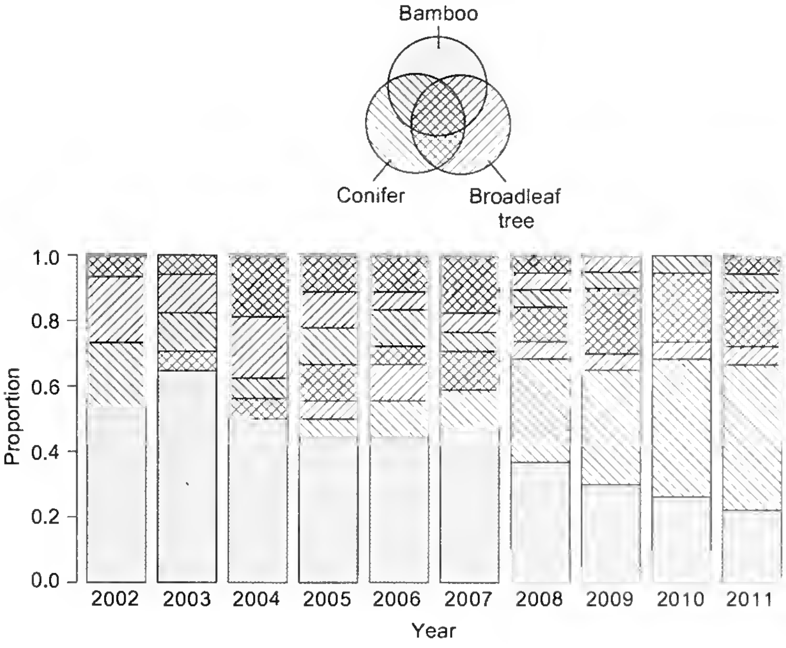
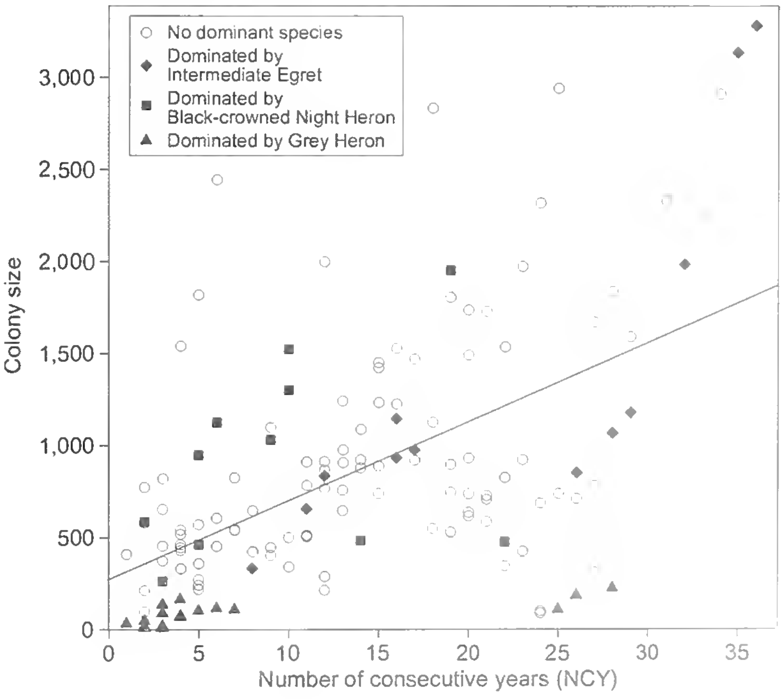


Figure 6. Relationship between colony size and longevity. Each dot represents a colony censused in a particular year ($n = 141$). The regression line was obtained by a linear regression analysis of colony sizes against longevity assuming that each annual colony was established independently.



DISCUSSION

The survey in Ibaraki prefecture from 2002 to 2011 indicated that the number of breeding colonies (average 19) increased slightly and mean colony size was almost constant. These results accord well with the report by the Environmental Agency of Japan (1994): there were 20 colonies in 1992 in Ibaraki prefecture, ranging in size from 15 to 2,990 individuals (CV = 112.5), and the population of these species has been relatively constant in the area for at least two decades to 2011. However, variations in size, species composition ratio and NCY among colonies increased significantly. Colony vegetation changed from predominantly bamboo thickets to tall trees. Trends in population dynamics differed: Grey Heron and Intermediate Egret increased, Little Egret and Cattle Egret decreased; and Great Egrets and Black-crowned Night Herons were relatively constant—the population of both the latter species were similar to previous reports (Research Division of the Wild Bird Society of Japan 1981, Environmental Agency of Japan 1994) and unchanged for three decades. Overall, there was no significant change in population of these colonial species in the study area during the decade, but variation in the structure of colonies and population dynamics clearly increased.

In contrast to Great Egret and Black-crowned Night Heron, the population of the other four species changed during the period (Figure 4b). Grey Heron showed the greatest population growth, which is in line with earlier reports that its population is growing in other parts of Japan (Narusue 1992, Environmental Agency of Japan 1994, Matsunaga *et al.* 2000, Sasaki 2001). In Hokkaido, Matsunaga *et al.* (2000) suggested that recent climatic warming and increase in aquaculture have provided the species with additional food resources. It is not known whether the increase of this species in other more temperate parts of Japan also depends on these factors, but its ability to respond quickly to changes in food availability (Adams & Mitchell 1995) would be expected to boost populations. The other increasing species, Intermediate Egret, was a predominant species in this area even though it has been designated as a 'near threatened' species in Japan (Ministry of the Environment 2002). Owing to the lack of current data from other parts of Japan, it is not clear whether the population has been recovering, but the abundant population in this area may be of conservation significance in Japan; monitoring of this species should continue.

Little Egret and Cattle Egret both showed a steady decline over the period; the Environmental Agency of Japan (1994) considered them to be predominant and numerous throughout Japan, including Ibaraki prefecture in 1992, and the population of both has decreased during the last two decades. Although mild winter weather contributed to their increase in France (Hafner & Fasola 1997) and rainfall drove the changes in Cattle Egret population in Australia (McKilligan 2001) and Hong Kong (Wong & Young 2006), climatic variables are unrelated to the decrease of these species in the study area because both temperature and rainfall have been almost constant (Figure 2). It seems likely that changes in food resources or foraging habitats may be contributory factors. In northern Japan, Shimada *et al.* (2005) suggested that Little Egrets might be strongly affected by the increase in population of the introduced Black Bass *Micropterus psalmoides*, which has caused a decrease of the smaller native fish species they prefer. In the absence of historical and quantitative data in Japan, monitoring studies in other regions are needed to make a complete assessment of population dynamics of these declining species.

During the study period, variations in size, species composition ratio and NCY increased (Figure 4c). Since these temporal trends showed parallel changes, there is a possibility that the variation in species composition ratios increased as a by-product of the increased variation in colony sizes; but a randomisation test contradicted this possibility, and it was concluded that the observed increased variation in proportional similarities of species composition ratio could not be solely caused by the increased variation in colony size. Another change that coincided with the study period was the change in nesting vegetation; the majority of colonies changed from bamboo thickets to trees (Figure 5). More colonies were newly established in tall trees even though bamboo thickets persisted in the area. The decrease in the number of colonies in bamboo may be due to the increase in Grey Herons because they prefer to nest near the top of tall trees. However, those results contradict the general knowledge that the target species use a wide range of nest sites, including trees, bushes, reeds and on the ground. No other species shows a particular preference for specific substrates (Kushlan & Hancock 2005). Hence, there is no strong support for the possibility that the vegetation of established colony sites affected the size or species composition ratios of colonies.

Increasing variation in NCY may help explain the increased variation in colony size and species composition ratios. These results showed that the variation in the NCY among colonies grew from year to year (Figure 4c), and there was a significant positive correlation between colony size and the NCY that a colony existed (Figure 6). Although food availability, measured as the area of potential foraging habitat around the colony, has often been thought to be the most important factor affecting colony size (Fasola & Barbieri 1978, Gibbs *et al.* 1987, Gibbs 1991, Baxter & Fairweather 1998), previous studies in this locality showed that variables related to foraging sites (areas around ponds, rivers, paddy fields and lotus fields) did not have a major impact on colony size; instead the NCY had a significant positive relationship with colony sizes (Fujioka *et al.* 2001, Tohyama 2005). Increasing variation in a colony's size is therefore closely related to the colony's longevity. As for increasing variation in species composition ratio among colonies, variations were due to the occurrence of colonies dominated by Grey Heron, Intermediate Egret, or Black-crowned Night Heron after 2006. In particular, the dominance of Grey Heron was notablet in small, recently established colonies (Figure 6). It is well known that the Grey Heron often breeds in small colonies of only 2–10 nests, while the other five species are more gregarious and usually breed in large mixed-species colonies (Kushlan & Hancock 2005). Thus, the Grey Heron population growth after 2007 might contribute significantly to the increasing variation in the species composition ratio and colony size despite its relatively small overall population (Table 1).

Overall, the local population of herons and egrets in eastern Japan seems to have remained constant for at least the last decade, in parallel with the constant climate and land use variables. Nonetheless, population dynamics of constituent species have been changing, and variations in colony sizes and species composition ratios have also increased. Such changes are revealed only by long-term and comprehensive colony census. Continuing studies are required not only to reveal the factors affecting the population dynamics of each species at a regional level, but also to establish a better understanding of relationships between each species's population and the sizes or composition ratios of mixed-species colonies.

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***Miyuki MASHIKO** and **Yukihiko TOQUENAGA**, Graduate School of Life and Environmental Sciences, University of Tsukuba, Ibaraki 305-8572, Japan. Email: mashiko@pe.ies.life.tsukuba.ac.jp*

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Phenotypic evidence for the specific and generic validity of *Heteroglaux blewitti*

P. C. RASMUSSEN & N. J. COLLAR

The genus *Heteroglaux* was established for the Forest Owlet *H. blewitti* when the species was first described, but owing to certain similarities with Spotted Owlet *Athene brama*, the use of *Heteroglaux* fell into disuse in the twentieth century until the species was rediscovered in 1997, and is still not universal; moreover, perceptions appear to linger that *blewitti* might even be conspecific with *brama* owing to a recent claim of interbreeding. In reality *blewitti* is distinct from *brama* on external morphology (plumage described elsewhere; narial position related to bill width; bill height; more heavily feathered toes; length of middle and hind claws; wing formula) and osteology, in which *blewitti* is distinct from all three species of *Athene* (multiple cranial elements, especially the greatly widened and inflated frontal, and the extremely stout tarsometatarsus). Lateral tail-flicking and direct, non-undulating flight further support generic separation.

INTRODUCTION

For well over a century the Forest Owlet *Heteroglaux* [*Athene*] *blewitti* remained as much a taxonomic as a conservation enigma. It was discovered in central India 140 years ago, and at once placed confidently in its own genus *Heteroglaux* by Hume (1873):

> At first sight it would certainly be classed as an *Athene*; but the head is much smaller [*sic*: evidently a *lapsus* for 'larger'] than in any of the *Athene*'s I possess, *viz*., *brama*, *radiata*, *malabarica*, *cuculoides*, *castaneonota*. The nostrils are not pierced from the front, backwards at the margin of a swollen cere, but are well inside the margin, and are pierced straight in. The upper surfaces of the toes, too, are not covered with bristles, but thickly feathered.

In the decade that followed, only six further specimens were taken (enumerated in Rasmussen & Collar 1998), and then the species disappeared. Perhaps as a consequence of this, its generic placement by Hume was never widely accepted. Although *Heteroglaux* continued to be used by Hume himself and some contemporaries (e.g. Hume 1879, Murray 1887, Sharpe 1891, 1899), from an early stage the Forest Owlet was also treated as congeneric with the Little Owl *Athene noctua* and Spotted Owlet *A. brama*, first in the genus *Carine*—even as early as Ball (1878), writing in Hume's own *Stray Feathers*—and more recently *Athene*. Although Gurney (1894) retained it in *Heteroglaux*, he cited Hume's (1873) view that it looks much like *A. brama* and added that Blanford considered it to belong to *Athene*; and the following year Blanford's (1895) treatment as such appeared. Dubois (1904) retained it in *Heteroglaux*, albeit without comment, but within a few decades virtually all works treated *blewitti* as an *Athene* (e.g. Baker 1934, Peters 1940, Biswas 1953, Ripley 1961, Abdulali 1972, Marshall & King 1988). Without explanation, Wolters (1975) assigned both *blewitti* and *brama* to the subgenus *Heteroglaux*, with *noctua* and Burrowing Owl *A.* (*Speotyto*) *cunicularia* occupying separate subgenera within *Athene*; otherwise *Heteroglaux* has only ever been used for *blewitti*. Voous (1989: 191) suggested that *blewitti* 'might provide a clue to understanding these relationships [between *Athene, Ninox* and *Glaucidium*], though the Forest Owlet may already be too close to the Spotted Owlet for that purpose'. Recent molecular phylogenies of owls (e.g. Wink *et al*. 2004, 2009) have not included *blewitti*.

Indeed, some considered the similarity of *brama* and *blewitti* so great as to render them conspecific. Baker (1923) treated *blewitti* as well as most subspecies of *brama*—all except, inexplicably (perhaps as a *lapsus*), *A. brama tarayensis* of the north-western areas of the subcontinent—as races of *A. noctua*. This view, although not elsewhere accepted, may explain the listing in the NHMUK specimen register of the Davidson specimen (NHMUK 1925.12.23.958) that was stolen and remade by Richard Meinertzhagen (Rasmussen & Collar 1999) as '*Carine noctua blewetti*' [*sic*], although the other *blewitti* in the same accession (then NHMUK 1925.12.23.1, now MCZ 236630) was listed as *Athene blewitti*. The fictitious locality of the stolen specimen, which came to the (now) Natural History Museum, Tring, UK, in the late 1960s in Meinertzhagen's posthumous bequest (Rasmussen & Collar 1999), may in turn explain why it took until 1997 before the Forest Owlet was seen in the twentieth century (King & Rasmussen 1998). Over much of the intervening period, however, in the absence of clear diagnostic illustrations and texts, the species was speculated or judged to be so close in appearance to *A. brama* that it would be difficult and perhaps impossible to distinguish it (Ripley 1976, Ali 1978, Ali & Ripley 1981), and consequently the few reports or claims of *blewitti* that appeared in the interim were shown upon scrutiny to be *brama* (Rasmussen & Collar 1998).

Following the rediscovery of the species there has been a degree of conservation-oriented research focusing on its distribution and ecology (Jathar & Rahmani 2002, 2004, Rahmani & Jathar 2004, Ishtiaq & Rahmani 2005, Kasambe *et al*. 2005, Mehta *et al*. 2008, Chavan & Rithe 2009, Yosef *et al*. 2010). However, one aspect of its resurrection has remained unexplored: the issue of its generic identity. Publications at the time of the rediscovery and in its immediate aftermath mentioned both *Athene* and *Heteroglaux* in their titles (King & Rasmussen 1998, Rasmussen & Collar 1998, 1999, Rasmussen & Ishtiaq 1999). The two major monographic treatments of owls that appeared at this time (del Hoyo *et al*. 1999, König *et al*. 1999), both of which cited the preceding references, elected to retain the species in *Athene*, although the latter entered a caveat that its tail-flicking habit 'argues against a close relationship with other *Athene* owls and suggests closer affinity with pygmy owls (*Glaucidium*)', and consequently proposed 'placing this species in the subgenus *Heteroglaux*'.

In the twenty-first century the trend has clearly been towards accepting *Heteroglaux* as a valid monotypic genus. Collar *et al*. (2001: 1775) remarked that despite the species's 'strong superficial resemblance' to *Athene* 'its original placement in its own genus appears well justified based on osteological evidence (Rasmussen & Collar in prep.) and on recent behavioural observations including flight pattern and song (Rasmussen & Ishtiaq 1999)'. Thereafter, world lists (Dickinson 2003, Gill & Wright 2006), Indian avifaunas (Rasmussen & Anderton 2005, Grimmett *et al.* 2011), one monograph (Mikkola 2012) and many journal papers and reports (preceding paragraph) have used *Heteroglaux*. Nevertheless, some sources have retained *Athene* (e.g. Clements 2007, König *et al.* 2008, Yosef *et al.* 2010), one even with the cryptic entry 'Remarks: Spurious use of the generic name *Heteroglaux*' (Weick 2006). This is perhaps unsurprising given that a clear case for the acceptance of this genus has never been made, and the osteological evidence referred to above never published. Here we seek to rectify these deficiencies.

This need is rendered all the more pressing following a recent report (Pande *et al.* 2011), albeit rejected (Ishtiaq 2011, Jathar & Patil 2011), of hybrid Forest Owlets × Spotted Owlets. For this reason, we also consider the extensive structural differences between *blewitti* and *brama* beyond the plumage distinctions established in Rasmussen & Collar (1998). However, the exercise further requires the osteological analysis to extend beyond differences between these two species to cover not only all members of *Athene* but key representatives of other related owl genera (including *Surnia*, *Glaucidium*, *Xenoglaux*, *Micrathene*, *Athene*, *Aegolius* and *Ninox*: Ford 1967, del Hoyo *et al.* 1999).

METHODS

We considered two types of evidence: external morphology (focusing on the differences between *blewitti* and *brama*) and osteology (considering the differences between *blewitti* and *Athene*, thence to other genera). Plumage comparisons between *blewitti* and *brama* have previously been presented in Rasmussen & Collar (1998), and we therefore here restrict our comparisons of external morphology to mensural characters. We also briefly review data reported elsewhere for acoustics and behaviour.

External morphology of *blewitti* and *brama*

For the external morphological analysis we assembled for examination at the Natural History Museum, UK (NHMUK) all known specimens of *blewitti* (seven; four males, three females), and used the opportunity to compare them with other owl species, most importantly *Athene brama*, with which *blewitti* is ostensibly so closely allied as to have been considered conspecific (as noted above). We measured all specimens of *blewitti* (data in Rasmussen & Collar 1998) and specimens of *brama* at NHMUK; American Museum of Natural History, New York (AMNH); Academy of Natural Sciences of Philadelphia (ANSP); Museum of Comparative Zoology, Harvard University (MCZ); National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM); University of Michigan Museum of Zoology, Ann Arbor (UMMZ); and Zoological Survey of India, Calcutta (ZSI). This sample includes numerous representatives of each of the races of *brama* recognised by Peters (1940).

The specimens of *blewitti* were measured, x-rayed, photographed and videotaped in detail. Comparative measurements were also taken from 84 *brama* skins (37 males, 35 females, 12 unsexed) at AMNH (n = 19), ZSI (10), NHMUK (26) and USNM (29). Of the *brama* skins measured, 27 originated near known localities for *blewitti*, but specimens were included from throughout the range of *brama*. Measurements (in mm) taken from skin specimens were: culmen from base of skull; culmen from distal edge of cere; minimum width between nares; height of upper mandible at distal edge of cere; length of longest rictal bristle (straightened); tarsus; wing (straightened and flattened); tail (callipers inserted between central rectrices at insertion point); middle claw (digit 3) and hindclaw (digit 1, both claw measurements taken from the distal edge of scutes).

To compare wing formulae, shortfalls from the wing-tip of each of the primaries (P1–P10, numbered from the outside) were measured (in mm) for six *blewitti* (one *blewitti*, NHMUK 1886.2.1.544, was excluded as its wing-tip is heavily worn) and 23 *brama* from USNM. The distances from the notches in the inner web to the tip of each of the outer four primaries (P1–P4) were also measured (in mm), as was the distance from the distal end (narrowest point) of the emargination on the outer webs to the feather tip for P2–P4. The notch for P4 was often not obvious in specimens of *brama*, and in these cases it was not measured.

Osteology

Measurements of skeletal features were taken directly from x-rays of *blewitti* and *brama* specimens, in which multiple views taken at various angles allowed direct comparisons with skeletal elements of *brama* and with the actual skin specimens x-rayed to ensure that the bones were oriented along the correct axes to avoid size distortion due to foreshortening. Only elements lying close to the film surface were measured to minimise parallax. Measurement options were limited by bone preservation and the fact that they are articulated in skin specimens of *blewitti*. Measurements taken were: greatest width of skull; lengths of humerus and ulna; length of carpometacarpus from proximal end to distal articular surface; length and minimum width of tibiotarsus, and width of its condylar end; and length and minimum width of tarsometatarsus.

Univariate statistics and principal components analysis (PCA) using correlation matrices were done separately on external, skeletal and wing formula measurements using SYSTAT for Windows (version 5). Variables used in PCA were chosen partially to maximise the number of specimens of *blewitti* that could be included without estimation of missing data. Because of the small sample of *blewitti*, sexes were combined.

Intergeneric skeletal comparisons

To allow osteological comparisons, several skeletal elements (the entire humerus, radius, ulna, tibiotarsus and tarsometatarsus; a femur missing the head; and the skull missing part of the posterior and caudal regions) were removed by J. P. Angle from the left side of a *blewitti* skin specimen (NHMUK 1886.2.1.546) using the techniques in Olson *et al.* (1987); casts were retained at USNM, as USNM 261299. These elements were compared directly with USNM skeletons of *A. brama* (n = 6); Little Owl *A. noctua* (10); Burrowing Owl *A. cunicularia* (5); Jungle Owlet *Glaucidium cuculoides* (7); White-browed Owl *Ninox superciliaris* (1); Brown Hawk Owl *N. scutulata* (3); Boreal Owl *Aegolius funereus* (1); and indirectly with *noctua* (4) and *brama* (2) from UMMZ. The UMMZ osteological specimens were examined the week following the USNM comparisons, and were videotaped to allow further study. In addition, important osteological features that were observed in the extracted *blewitti* skeletal elements were then examined (as possible) in the x-rays of all seven *blewitti* specimens and the x-rayed *brama*. Osteological terminology follows Howard (1929) and Baumel & Witmer (1993). Measurements taken of the above specimens, along with *brama* (9), *noctua* (4), *N. scutulata* (1) and Philippine Hawk Owl *N. philippensis centralis* (1) were: skull (including culmen) length; minimum widths of the frontal both anterior and posterior to the supraorbital processes; maximum skull width; height of lateral rim of frontal; width of distal half of lacrimal (maximum medio-lateral width); length of lacrimal (maximum antero-posterior length of caudal edge); maximum width across both palatines *in situ*; maximum length and minimum width of ulna; for humerus, femur, tibiotarsus and tarsometatarsus, maximum lengths, minimum widths and distal widths, and for the last two elements maximum proximal widths as well. For tibiotarsus, length was from the proximal articular surface, and proximal width did not include the fibula.

RESULTS

External morphology of *blewitti* and *brama*

The characters that separate *blewitti* from *brama* in the field are summarised in Rasmussen & Collar (1998). Even within a race, *brama* presents great variability in plumage and in most (but not all) of the characters distinguishing the two species a few individuals of *brama* closely approach the condition in *blewitti*, especially when the latter species is in worn plumage.

The nares are situated more widely apart in *blewitti* than in *brama*, owing largely to the broader culmen ridge of *blewitti* (Table 1). Moreover, the nares of *blewitti* are positioned more obliquely, not facing directly anteriad as in *brama*. The cere of *blewitti* is less inflated and the nares are situated well inside the cere, instead of right at the edge of the more swollen cere, as in *brama*.

Compared to *brama*, *blewitti* has more heavily feathered toes (Hume 1873, Rasmussen & Collar 1998), except in the extremely worn specimen (NHMUK 1886.2.1.544). In most *blewitti* the white tarsal feathering continues uninterrupted onto the toes, while in *brama* the more mottled, dingier tarsal feathering stops more abruptly at the top of the toes, with only sparser bristles on the toes themselves. Although the extent of feathering on the tarsus and toes is often highly variable within an owl species (as it is in both Little and Burrowing Owls), the difference in this feature between the Forest and Spotted Owlets seems quite constant, allowing for the effects of wear. The toes and claws of *blewitti* appear noticeably heavier (and the latter longer; see below) than those of *brama*.

Although the four traditional external measurements (culmen, wing, tarsus and tail lengths) overlap broadly between *blewitti* and

Table 1. Summary statistics for measurements[a] (mm) of *Heteroglaux blewitti* and *Athene brama* skin specimens (sexes combined) and results of Principal Components Analysis[b] on these variables.

	blewitti				*brama*				Component loadings		
Measurements	**Mean**	**SE**	**Range**	**N**	**Mean**	**SE**	**Range**	**N**	**PC1**	**PC2**	**PC3**
External measures											
Culmen from skull	21.2	0.8	19.9–22.0	7	20.5	1.1	17.4–23.7	83	0.31	−0.44	0.83
Culmen from cere	14.7	0.6	13.7–15.8	7	13.7	0.7	11.9–15.8	81	–	–	–
W between nares	5.4	0.4	5.0–6.0	7	3.4	0.4	2.6–4.3	63	0.87	0.07	0.02
H upper mandible at cere	10.7	1.0	9.0–11.7	7	7.6	0.3	7.0–8.3	28	0.91	0.15	0.06
Max. rictal bristle l	18.9	1.2	17.2–20.2	7	18.3	2.4	13.7–23.5	65	–	–	–
Tarsus l	28.0	1.7	26.2–31.2	7	29.3	2.0	23.8–33.8	81	−0.40	−0.72	−0.26
Wing l	147.8	3.2	144.0–154.0	7	153.2	5.8	139.0–169.0	80	−0.78	0.16	0.44
Tail l	69.0	3.4	62.3–72.0	7	72.2	3.6	65.7–82.0	78	−0.69	0.55	0.17
Middle claw (D3) l	14.1	0.8	13.1–15.2	7	10.6	0.6	9.5–12.1	62	0.92	0.67	0.03
Hindclaw (D1) l	13.1	0.5	12.6–13.7	6	9.7	0.6	8.5–11.2	58	–	–	–
Skeletal measurements from x-rays											
Skull w	36.2	1.49	33.8–37.5	5	33.3	1.25	31.4–34.8	16			
Humerus l	53.9	1.64	51.6–55.4	4	46.2	5.92	41.8–52.9	3	–	–	
Humerus distal w	9.5	0.34	9.0–9.8	4	8.5	0.39	7.7–8.9	9	–	–	
Ulna l	60.5	4.02	53.3–63.6	6	55.2	3.24	48.0–63.1	17			
Carpometacarpus l	38.6	1.64	27.2–31.4	7	26.6	1.22	23.6–28.2	21	0.73	0.52	
Tibiotarsus l	54.7	3.82	47.9–59.5	7	51.9	2.97	46.1–56.9	11	–	–	
Tibiotarsus w (min.)	3.5	0.35	3.1–3.9	7	2.9	0.16	2.7–3.3	17	0.91	−0.06	
External condyle w	8.0	0.68	7.5–9.3	7	6.8	0.61	5.4–8.1	17	0.88	0.22	
Tarsometatarsus l	26.8	1.47	24.7–28.2	7	28.9	1.55	25.7–31.8	20	−0.38	0.88	
Tarsometatarsus w (min.)	5.1	0.14	4.8–5.2	6	3.4	0.27	2.9–3.9	19	0.89	−0.20	
Wing formula measurements											
Shortfalls of each primary from wing point											
P1	26.7	2.7	23.0–30.1	6	25.5	3.0	19.6–29.5	23	−0.36	0.58	0.36
P2	6.0	1.6	3.8–8.3	6	5.9	1.9	2.9–9.8	23	−0.34	0.80	0.07
P3	0.3	0.6	0.0–1.5	6	0.3	0.6	0.0–2.1	23	0.02	0.04	0.82
P4	0.2	0.3	0.0–0.5	6	0.5	0.8	0.0–2.5	23	0.34	−0.27	−0.58
P5	3.4	0.7	2.7–4.6	6	4.6	1.7	1.0–7.9	23	0.67	−0.51	0.23
P6	12.2	2.1	9.8–15.3	6	14.5	1.8	11.7–18.2	23	0.81	−0.47	0.08
P7	19.3	2.3	16.7–22.2	6	24.3	2.8	20.1–30.7	24	0.87	−0.29	0.15
P8	23.4	2.3	21.0–26.3	6	31.2	3.5	23.3–37.1	22	0.90	−0.13	0.21
P9	27.8	3.2	24.0–33.5	6	36.2	3.4	29.7–42.0	22	0.92	−0.06	0.21
P10	32.3	2.5	29.0–35.6	6	41.3	2.7	34.4–47.0	22	0.92	0.16	0.16
Distance from notch to tip											
P1	32.3	4.2	28.0–39.7	6	39.1	3.0	31.0–45.8	23	0.82	0.08	−0.29
P2	35.8	2.1	33.0–38.1	6	42.6	2.3	39.0–48.2	23	0.78	0.34	−0.17
P3	33.3	1.9	30.9–36.0	6	39.4	2.2	35.4–43.4	23	0.78	0.42	−0.23
P4	27.0	2.5	25.2–32.0	6	32.3	2.9	28.3–36.8	9	–	–	–
Distance from emargination to tip											
P2	50.5	1.4	49.0–52.1	6	56.2	2.5	52.6–61.4	21	0.84	0.11	0.19
P3	40.5	1.8	38.0–43.0	6	47.9	2.1	43.9–51.4	21	0.84	0.49	−0.10
P4	31.8	1.6	30.0–34.0	6	39.1	1.6	35.5–41.5	21	0.81	0.52	−0.07

[a] l = length, w = width, h = height

[b] Eigenvalues and percent variance explained for PC1–3 on external measures: 4.0, 44.3%; 1.6, 17.9%; 1.3, 14.3%, respectively; for PC1–2 on skeletal measures: 3.1, 61.6%; 1.1, 23.0%, respectively; for PC1–3 on wing formula measures: 8.7, 54.4%; 2.5, 15.6%; 1.6, 9.8%, respectively.

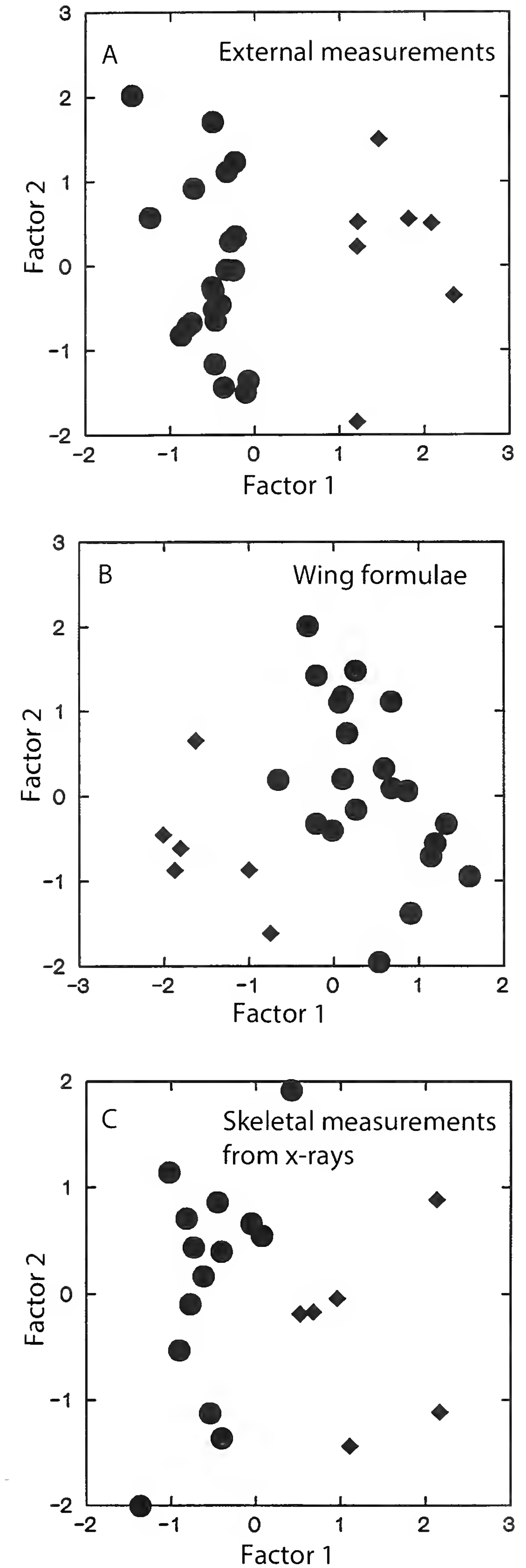

Figure 1. Graph of individual component scores on PC 1 and 2 for principal components analysis on measurements of *Heteroglaux blewitti* (diamonds) and *Athene brama* (circles). (A) external; (B) wing formula; (C) skeletal from x-rays.

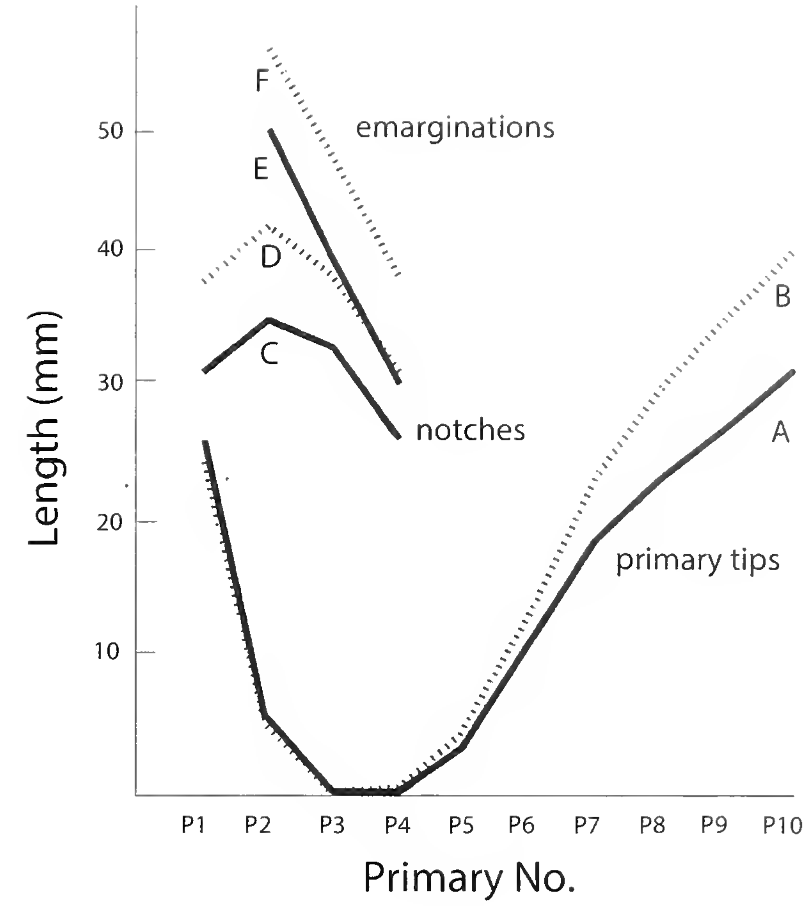

Figure 2. Wing formulae of *Heteroglaux blewitti* (solid lines, A,C,E) and *Athene brama* (dotted lines, B,D,F). (A,B) shortfalls from wing point of P1–10; distance from tips of individual feathers to (C,D) notches on inner webs of P1–4 and (E,F) emarginations on outer webs of P2–5 (descriptive statistics presented in Table 1).

brama, the taxa differ strongly in several other external mensural characters, even though sexes were combined owing to the small sample of *blewitti* (Table 1). External measurements that do not overlap between the two species are: width between nares, bill height and lengths of middle and hindclaws (Table 1). A PCA of external measurements (Table 1, Figure 1A) shows that by far the greatest proportion of the variance is explained on PC 1 by a contrast between middle claw length, width between nares, and upper mandible height *vs* tail and wing lengths. Complete separation between the species is attained on this axis (Figure1A).

Several differences exist between the wing formulae of *blewitti* and *brama*, although most measurements overlap at least minimally between the species, and the sample of *blewitti* is small (Table 1, Figure 1B). In *blewitti*, P7–P10 each have a smaller shortfall, i.e. the feather tips fall closer to the wing-point, making the inner wing broader than in *brama* (Figure 2A,B). In *blewitti*, P7 is never as short as P1, while in *brama* P1 and P7 are approximately equal. The emarginations on the outer webs of P2–P4 and the notches on the inner webs of P1–P4 are all closer to the tips of the individual feathers in *blewitti* (Figure 2C–F); measurements of emargination position did not even overlap between the species (Table 1). Finally, 14 of 23 *brama* do not show a distinct notch on P4, whilst all six *blewitti* examined have a definite notch on the inner web of this primary.

A PCA of wing formulae showed that by far the greatest percentage of the variance was explained by Factor 1 (Table 1), which was mainly a size axis, on which shortfalls of P3 and P4 were not strongly correlated, and those of P1 and P2 were weakly negatively correlated. All *blewitti* had negative Factor 1 scores, while the scores of all *brama* fell above −1 on Factor 1, reflecting the smaller shortfalls of the inner primaries and notch and emargination distances of *blewitti* (Figure 1B).

Osteology

Despite the similarity in plumage of *blewitti* and *brama*, there are several major osteological differences (Plate 1) between *blewitti* and all three species normally recognised in *Athene* (including the highly polytypic *A.* [*Speotyto*] *cunicularia*).

Relative to *Athene*, the nasal process of the premaxillary of *blewitti* (Plate 1 A,B) is expanded anteriorly; the culmen ridge (Os nasale) of the premaxillary is more arched; the distal tip of the premaxillary is longer and more caudally directed, so the rostrum of *blewitti* is heavier and more strongly hooked; the narial openings are larger and more ovoid; the mandibular symphysis is broader; and the entire mandible is somewhat heavier.

The frontals of *blewitti* are much broader both anterior and posterior to the supraorbital process than for any *Athene* (Plate 1 A,B), so that the skull of *blewitti* strikingly resembles that of *Glaucidium* and *Ninox superciliaris*; the latter Malagasy species has been wrongly placed in *Ninox*, and is closer to *Athene*: H. F. James and S. L. Olson, pers. comm. 1997; Wink *et al.* 2004). The posterior portion of the interorbital roof of *blewitti* is not wider than the anterior portion, unlike *Athene*. The lateral rim of the frontal anterior to the supraorbital process is greatly inflated in *blewitti* compared to members of *Athene*, similar to but even more so than in *G. cuculoides*, *N. superciliaris* and most other small owls. The great inflation of this region is visible in x-rays of other *blewitti* specimens as well. The lacrimals of *blewitti* are very large relative to those of *Athene*, but like them (Ford 1967) are short and do not contact the jugal bar; those of the extracted skull of *blewitti* are detached from the skull, but their position relative to the jugal bar is confirmed by x-rays of all *blewitti* specimens. The maxillopalatines of *blewitti* are large, with straight medial edges that nearly contact each other for most of their length, unlike in *Athene*, where the maxillopalatines are more triangular in shape so that they only contact each other at the apex. The palatines of *blewitti* are relatively short anteroposteriorly as in *Athene* but are more expanded posteriorly, in the latter respect being similar to *G. cuculoides*. The supraorbital processes of *blewitti* are better developed than in most other *Athene* specimens we examined. The temporal fossa is much deeper in posterior view in *blewitti* than in *brama*.

The quadrate of *blewitti* has no intercapitular groove, the lack of which is apparently otherwise autapomorphic for *Athene* including *Speotyto* (Ford 1967); but the articular surface of the external capitulum is longer than in *Athene*, being similar to that of *G. cuculoides*. The otic process of the quadrate of *blewitti* is longer than in other owls examined, and the mandibular articulation is broad. The socket for the quadratojugal of *blewitti* is long and more strongly twisted externally than in *brama*, similar to that of *G. cuculoides*.

The humerus of *blewitti* is slightly longer and heavier than in *brama*, while the ulna of *blewitti*, although not longer, is substantially more robust. The leg proportions of *blewitti* (Table 2, Plate 1 C,D) are unusual in that the hindlimb is much more gracile proximally than distally: the femur and the proximal end of the tibiotarsus are heavier than those of *brama*, but not markedly so; however, the distal end of the tibiotarsus and the entire tarsometatarsus are greatly enlarged and especially broadened relative to those of *brama*. In addition, the single measurable femur of *blewitti* is longer than that of *brama*; the tibiotarsus is approximately the same length in both; and the tarsometatarsus of *blewitti* is shorter than that of *brama*, while the combined length of these three elements is roughly the same for the two species. The shaft widths of each of the leg elements in *brama* are very similar to one another, in strong contrast to the situation of *blewitti*, in which the tarsometatarsus shaft is much wider than that of the femur. In comparison to *blewitti*, *G. cuculoides* has all leg elements more uniformly stout: the femur and proximal tibiotarsus heavier, the tarsometatarsus similar in breadth but considerably longer. The

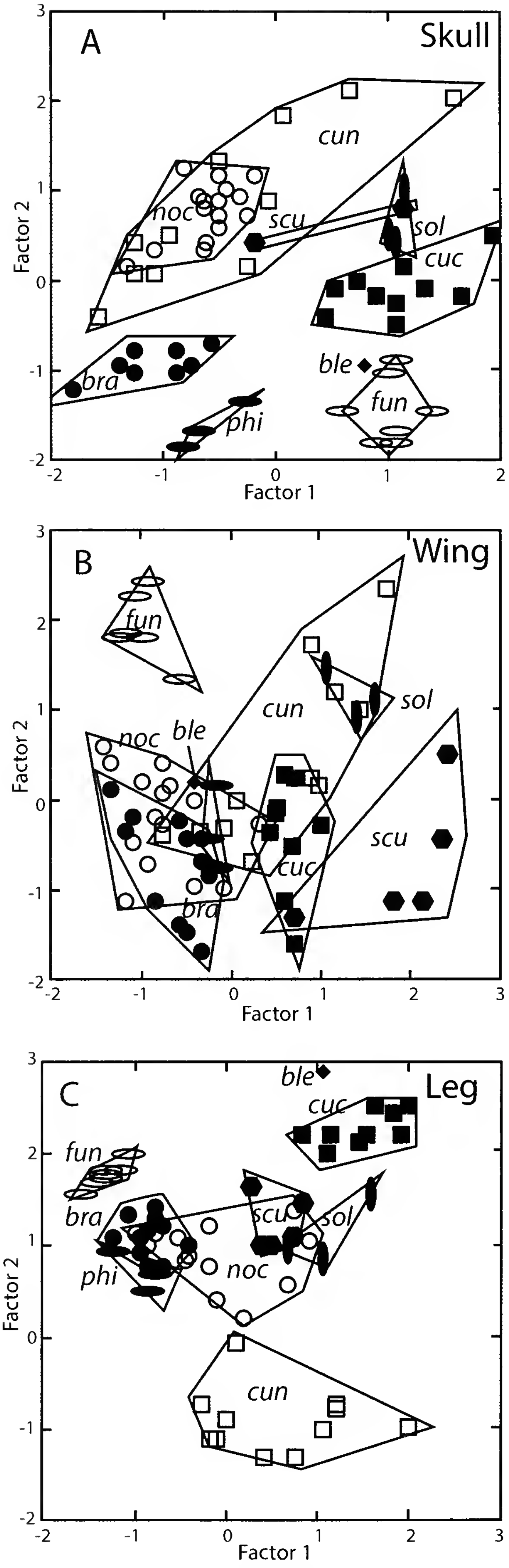

Figure 3. PCAs of skeletal measurements of selected surniine owls. *Athene noctua*, noc; *A. brama*, bra; *Heteroglaux blewitti*, ble; *A. cunicularia*, cun; *Ninox philippensis*, phi; *N. solomonis*, sol; *N. scutulata*, scu; *Aegolius funereus*, fun; and *Glaucidium cuculoides*, cuc. (A) skull; (B) forelimb; (C) hindlimb.

Table 2. Limb proportions of *Heteroglaux blewitti*, *Athene brama*, *Athene noctua*, *Glaucidium cuculoides*, and *Ninox superciliaris*. Ratios are of mean measurements.

Species	*blewitti* (n = 1)	*brama* (n = 6)	*noctua* (n = 10)	*cuculoides* (n = 7)	*superciliaris* (n = 1)
Wing proportions					
Hum l/distal w	5.76	5.64	5.64	5.37	
Hum l/ulna l	0.91	0.83	0.84	0.82	
Wing l[a]	107.8	104.5	106.3	119.0	
Leg proportions					
Femur l/distal w	4.88	5.23	5.12	4.78	
Tibiotarsus l/distal w	6.78	8.01	7.94	7.36	7.45
Tarsometatarsus l/distal w	2.95	4.33	4.53	3.32	3.71
Femur l/tib. l	0.74	0.67	0.68	0.71	
Tib. l/tar. l	1.98	1.71	1.66	1.96	1.91
Femur l/tarsometatarsus l	1.46	1.15	1.13	1.39	
Leg l[b]	115.6	115.7	123.5	125.8	
Wing l/leg l	0.93	0.90	0.86	0.95	

[a] Humerus l + ulna l + carpometacarpus l
[b] Femur l + tibiotarsus l + tarsometatarsus l

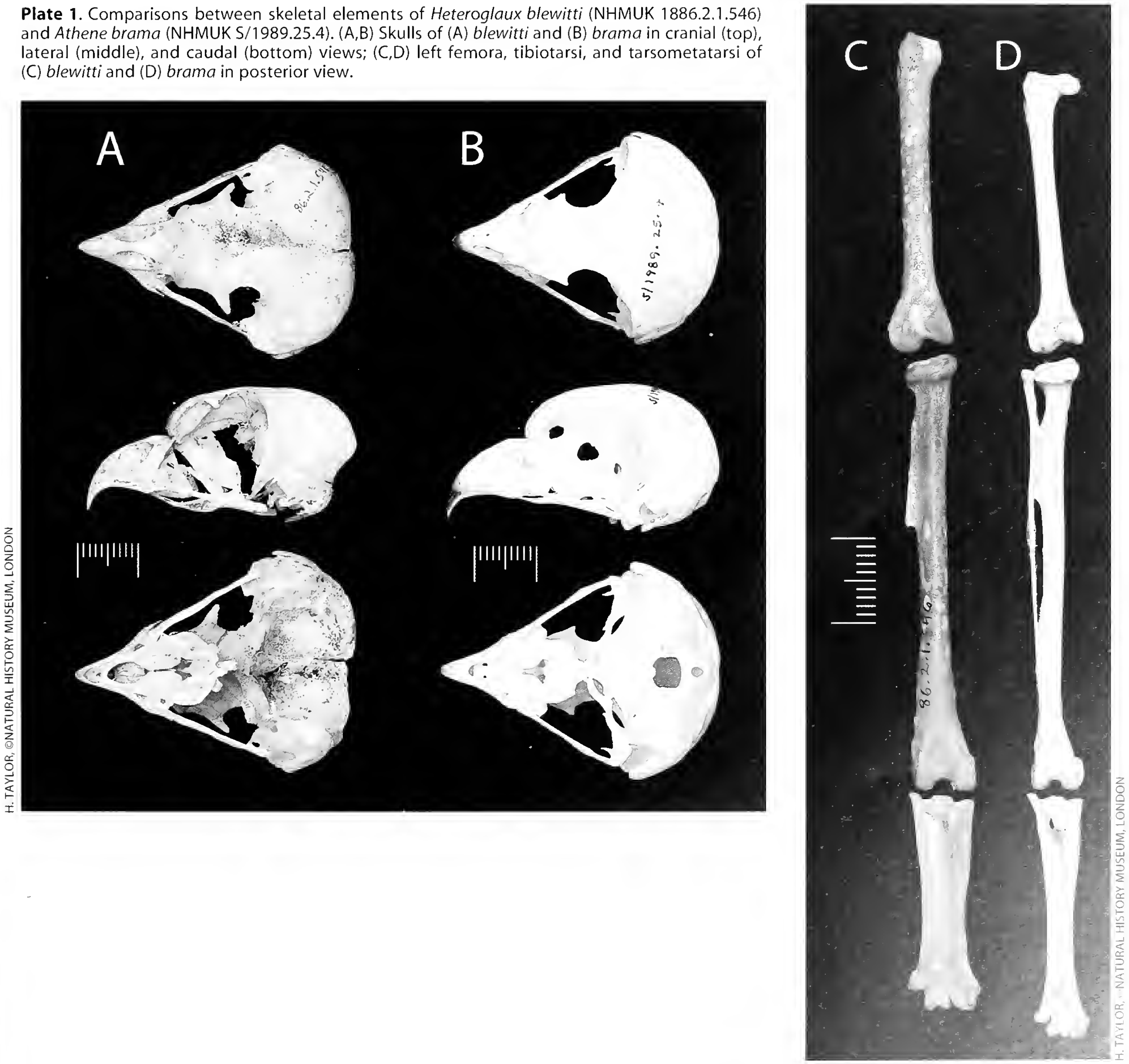

Plate 1. Comparisons between skeletal elements of *Heteroglaux blewitti* (NHMUK 1886.2.1.546) and *Athene brama* (NHMUK S/1989.25.4). (A,B) Skulls of (A) *blewitti* and (B) *brama* in cranial (top), lateral (middle), and caudal (bottom) views; (C,D) left femora, tibiotarsi, and tarsometatarsi of (C) *blewitti* and (D) *brama* in posterior view.

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Table 3. Summary statistics of measurements[a] (mm) and results of Principal Components Analysis[b] on osteological measurements of selected owls.

Variable	*blewitti*	*brama*	*noctua*	*cunicularia*	*cuculoides*	*funereus*	*superciliaris*	*scutulata*	*philippensis* (s.l.)	*novaezeelandiae*	*solomonis*	Component loadings	
N	1	10–15	16	10–11	4–11	6–7	1	1–5	2–4	1	2–3	PCI	PCII
Skull													
Total l[c]	47.1+	46.1±1.3	48.0±0.9	49.0±3.2	50.6±0.8	47.8±0.5	52.5	51.4±5.5	46.4±0.3	47.8	51.3±0.5	0.73	0.53
		44.0–49.0	46.7–49.8	45.7–55.7	49.4–52.4	47.0–48.4		47.5–59.4	46.1–46.8		5.8–51.8		
Anterior frontal w	13.0	10.1±0.7	11.7±0.6	11.1±1.1	14.3±1.8	11.0±0.8	13.6	10.6±1.3	9.4±1.2	9.2	11.0±0.3	0.62	0.27
		8.9–11.4	10.6–12.9	9.2–13.1	11.7–17.0	9.5–12.0		12.3–14.4	13.2–15.1		10.8–13.3		
Posterior frontal w	13.0	10.1±0.9	8.5±0.8	8.5±1.2	15.8±1.2	15.7±0.6	14.6	13.5±1.0	14.4±0.9	11.7	12.0±1.2	0.79	-0.53
		8.9–12.1	7.3–9.8	7.1–11.1	13.7–17.5	14.7–16.5		12.3–14.4	13.2–15.1		10.8–13.3		
Maximum w	36.4	34.7±1.0	35.2±0.9	37.1±2.4	35.9±0.9	39.5±0.8	37.5	35.9±2.0	34.8±0.6	34.7	38.9±0.4	0.69	0.08
		33.2–35.9	33.1–36.8	34.5–41.6	33.7–37.0	38.6–40.6		34.0–39.0	34.4–35.5		38.4–39.1		
Lat. rim frontal ht	4.4	2.5±0.4	1.9±0.2	1.9±0.4	3.5±0.3	4.3±0.5	4.6	2.5±0.3	3.0±0.2	2.8	3.3±3.4	0.75	-0.61
		1.8–3.1	1.5–2.4	1.5–2.7	3.2–4.1	3.7–4.8		2.1–2.8	2.8–3.2		3.3–3.4		
Distal lacrimal w	4.4	2.5±0.5	2.6±0.3	2.7±0.6	2.5±0.3	3.2±0.4	2.7	2.5	2.6±0.3		2.9±0.2		
		2.1–3.8	1.8–3.0	1.8–4.1	2.2–3.0	2.7–3.8		2.4–2.8			2.8–3.1		
Lacrimal l	9.5	7.8±0.5	8.1±0.8	8.9±0.7	9.6±0.9	9.5±0.8	10.1	7.6	6.3±1.1		8.8±1.0		
		6.9–8.6	6.5–9.1	8.1–10.3	8.6–10.5	8.7–10.7			5.6–7.1		8.1–9.5		
Palatine w	11.8	10.1±0.8	11.5±0.6	11.3±0.7	11.8±0.6	11.9±0.3	12.9	12.7±0.3	10.7±0.2		12.8±0.4	0.72	0.38
		8.5–11.1	10.0–12.6	10.1–12.7	10.8–13.0	11.4–12.2		12.4–12.9	10.5–10.8		12.6–13.3		
Humerus													
Total l	51.3	47.4±1.2	48.5±1.7	55.9±4.0	53.7±1.4	47.6±0.5		60.9±3.0	52.3±1.1	55.3	59.9±0.9	0.96	0.12
		45.6–49.9	45.8–51.5	49.7–62.5	50.9–55.3	46.8–48.3		56.6–64.1	51.1–53.4		59.1–60.8		
Shaft w	3.4	3.5±0.2	3.4±0.2	3.6±0.2	3.8±0.2	3.2±0.1	4.1	4.4±0.3	3.5±0.6	4.0	4.2±0.1	0.93	-0.20
		3.1–3.8	3.0–3.7	3.3–3.9	3.6–4.2	3.0–3.4		3.9–4.7	3.5–3.6		4.1–4.3		
Distal w	8.9	8.4±0.3	8.6±0.5	9.2±0.6	10.0±0.4	8.4±0.1	10.4	11.0±0.8	9.3±0.2	10.1	10.7±0.4	0.94	0.01
		7.9–8.9	7.8–9.6	8.2–10.2	9.4–10.5	8.2–8.6		9.8–11.6	9.1–9.5		10.3–11.0		
Ulna													
Total l	56.5	57.1±1.6	57.8±2.0	70.0±4.9	65.3±1.9	54.4±1.0	68.0	70.7±4.4	60.1±2.1	63.4	68.4±1.3	0.92	0.06
		55.2–59.4	54.9–61.7	61.5–76.4	62.3–68.5	53.0–56.1		63.6–74.5	58.0–62.3		67.0–69.7		
Shaft w	2.6	2.5±0.2	2.5±0.2	2.7±0.2	2.8±0.1	2.3±0.2	3.1	3.0±0.1	2.4±0.2	2.6	2.6±0.1	0.81	-0.33
		2.2–2.9	2.1–3.0	2.4–3.0	2.6–3.0	2.2–2.7		2.9–3.1	2.3–2.7		2.5–2.7		
Femur													
Total l	38.1	34.5±0.6	36.9±1.5	39.1±2.6	40.2±1.0	36.3±0.7		38.5±0.8	34.6±1.3	37.6	40.8±1.4	0.88	-0.10
		33.1–35.4	35.0–39.6	35.8–44.2	38.3–42.4	35.1–37.3		37.3–39.5	33.1–35.6		39.6–42.4		
Shaft w	3.5	2.9±0.1	3.1±0.3	3.3±0.2	3.6±0.2	2.7±0.1		3.30.1	2.8±0.1	3.1	3.6±0.2	0.94	0.03
		2.7–3.1	2.7–3.7	2.9–3.6	3.3–3.9	2.5–2.9		3.2–3.5	2.7–2.9		3.4–3.8		
Distal w	7.8	6.6±0.2	7.2±0.4	7.2±0.4	8.4±0.4	6.2±0.1		8.0±0.3	6.9±0.2	7.3	8.2±0.3	0.96	0.03
		6.4–7.1	6.5–8.0	6.5–8.0	7.8–9.0	6.0–6.4		7.6–8.4	5.5–5.8		7.9–8.5		
Tibiotarsus													
Total l	51.5	51.3±1.6	54.0±2.7	67.7±3.0	56.7±1.3	48.0±0.5	59.6	60.2±2.2	55.7±1.8	59.3	61.4±1.7	0.64	-0.73
		48.7–54.3	50.2–59.2	62.9–73.5	55.2–58.8	47.4–49.0		57.3–63.3	53.5–57.8		60.3–63.4		
Prox. w	6.4	53.±0.4	5.8±0.3	6.1±0.6	6.8±0.4	5.2±0.1	6.1	6.5±0.3	5.6±0.2	5.9	6.9±0.3	0.90	0.08
		4.7–5.9	5.3–6.2	5.4–7.0	6.2–7.7	5.1–5.4		6.2–6.9	55.5–5.8		6.6–7.1		
Shaft w	3.4	2.7±0.2	2.9±0.3	3.2±0.5	3.5±0.1	2.5±0.1	3.0	3.2±0.2	2.7±0.1	3.1	3.2±0.4	0.89	0.03
		2.4–3.1	2.6–3.5	3.0–3.5	3.3–3.7	2.4–2.8		3.1–3.5	2.6–2.8		2.9–3.6		
Distal w	7.6	6.4±0.2	6.8±0.4	7.1±0.5	7.7±0.3	5.9±0.2	8.0	6.7±0.33	6.1±0.3	3.4	7.5±0.4	0.93	0.01
		6.1–6.7	6.2–7.5	6.5–8.1	7.3–8.2	5.7–6.2		6.4–7.1	5.8–6.6		7.1–8.0		
Tarsometatarsus													
Total l	26.0	29.9±1.1	32.6±2.7	47.7±3.1	28.9±0.8	22.1±0.3	31.2	28.6±2.5	30.9±1.7	31.6	31.0±1.0	0.34	-0.90
		28.5–31.7	28.9–38.0	41.5–53.1	28.0–30.7	21.8–22.6		25.3–32.3	29.1–33.0		30.1–32.1		
Prox. w	7.8	6.7±0.2	7.0±0.6	7.3±0.6	8.2±0.4	6.1±0.1	7.5	7.3±0.4	6.3±0.5	7.0	7.8±0.3	0.93	0.09
		6.4–7.1	6.2–8.1	6.5–8.5	7.7–8.7	5.9–6.3		7.0–7.9	5.6–6.6		7.6–8.1		
Shaft w	5.3	3.2±0.1	3.3±0.3	2.9±0.4	5.0±0.2	3.4±0.2	4.3	3.8±0.2	3.0±0.1	3.4	4.0±0.3	0.65	0.72
		2.9–3.4	2.9–39	2.5–3.6	4.8–5.2	3.0–3.7		3.5–4.0	3.0–3.1		3.7–4.3		
Distal w	8.8	6.9±0.2	7.2±0.4	7.6±0.7	8.7±0.6	6.5±0.1	8.4	7.9±0.3	6.8±0.1	7.3	7.9±0.4	0.92	0.19
		6.5–7.1	6.6–8.0	6.9–8.9	7.2–9.3	6.2–6.6		7.6–8.4	6.7–6.9		7.6–8.3		

[a] l = length, w = width, d = depth, ht = height, lat = lateral, prox = proximal

[b] eigenvalues and percent variance explained for PC1–2 on skull measures: 3.1, 51.5%; 1.1, 19.2%, respectively; on wing and skull length: 4.2, 70.8%; 1.0, 17.3%, respectively; on leg measures: 7.7, 70.1%; 1.9, 17.4%, respectively.

[c] also included in PCA of wing measures; component loadings on PC 1, 0.29; on PC 2, 0.93.

tibiotarsus and tarsometatarsus of *N. superciliaris* are much longer and more gracile than for any of the above species. The only osteological feature of the limbs listed by Ford (1967) as diagnostic of *Athene* (including *Speotyto*) is the pointed posterior edge of the outer rim of the middle trochlea of the tarsometatarsus; however, unlike *Athene* and like other owls examined, this is rounded in the single *blewitti* specimen.

Skull widths, length of wing elements (humerus, ulna and carpometacarpus) and widths of leg elements (tibiotarsus and tarsometatarsus) are all considerably larger in *blewitti* than in *brama* (Tables 1 and 3, Figure 1C). The tarsometatarsi of *blewitti* are no longer (averaging shorter) than in *brama,* but are considerably more robust (Tables 1 and 2). In a PCA of skeletal measurements (Table 1, Figure 1C), Factor 1 is a strong size axis on which tarsometatarsus length is negatively correlated; all *blewitti* scores fall above 0 on Factor 1, while most *brama* scores fall below 0.

Intergeneric skeletal comparisons

In PCAs of skull and hindlimb measures (Table 3, Figure 3A–C), scores for the single available *blewitti* skeleton fall well apart from those of any *Athene* species. On skull measurements (Table 3), *blewitti* is closest to *Aegolius funereus* and *Glaucidium cuculoides,* both of which have relatively large measurements on the variables included in the analysis (particularly so for width of frontal posterior to supraorbital process and height of lateral rim of frontal), and all have Factor 1 scores well above 0. *Athene* species, conversely, have small measurements on these variables, and all but a few large *cunicularia* fall below 0 on Factor 1. Factor 2 principally contrasts skull length with posterior frontal width and lateral rim height, and on this axis *blewitti* and *A. funereus* differ strongly from large *cunicularia.*

Wing proportions of *Athene* species and *blewitti* are very similar (Table 2, Figure 3B), with scores of all but large *cunicularia* falling below 0 on Factor 1, a strong size axis on which skull width is uncorrelated, indicating that, compared to other genera sampled, most *Athene* and *blewitti* have small wings relative to head size.

On a PCA of hindlimb measures (Table 3, Figure 3C), Factor 1 is a general size axis on which tarsometatarsus explains most variance, and on this axis *cunicularia* is the most distinctive group due to its extremely long legs, while *blewitti* is well separated from *Athene* and close to *G. cuculoides.* Factor 2 is basically a contrast between tibiotarsus and tarsometatarsus length with tarsometatarsus width, and on this axis *blewitti* has the highest score, again reflecting the stoutness of this element (see Table 2).

DISCUSSION

The specific validity of *blewitti*

There ought to be no question about the status of *blewitti* as a full species, but in the light of a recent report of a pair composed of a male *brama* and a female *blewitti* producing a supposedly fertile offspring, and indeed of a population of hybrids which 'may have a much wider distribution that could equal or surpass the very limited one of the Forest Owlet' (Pande *et al.* 2011), all of which could be taken to imply the conspecificity of the taxa, we briefly here recapitulate and expand the evidence.

First, *blewitti* differs in plumage and external structure from *brama* on multiple characters, including the narial and cere characters given in the species description by Hume (1873), and others enumerated in Rasmussen & Collar (1998); our elaboration above of the external structural differences involves much greater width between nares, bill height and claw length, plus a somewhat different wing-shape. It is interesting to note how, albeit with tiny sample sizes, the seemingly small size advantage of *blewitti* over *brama* translates into a doubling of body mass (241.0 g, n = 1 [based on '8.5 oz' on label of type specimen and in Hume 1873] *vs* 110–114 g, n = 2) (Dunning 1993). Second, *blewitti* possesses a wide range of osteological distinctions from not only *brama* but all members of *Athene,* including *cunicularia.* These involve many cranial characters (some on fused elements) on the nares, premaxillary, frontal, mandible, lacrimal, maxillopalatine and quadrate. Of these, the much broader frontal (on cranial view) with its greatly inflated lateral rim anteriorly is most striking. There are also differences between *blewitti* and *Athene* in hindlimb proportions, especially the short, very stout tarsometatarsus of *blewitti,* and in the conformation of the middle trochlea of the tarsometatarsus. Third, the song of *blewitti* is very dissimilar to vocalisations of *brama,* and does not support its treatment as a close relative (Rasmussen & Ishtiaq 1999, Jathar & Rahmani 2002, Rasmussen & Anderton 2005). Fourth, behavioural differences include the direct flight and lateral tail-flicking habits of *blewitti* (King & Rasmussen 1998, König *et al.* 1999, Rasmussen & Ishtiaq 1999, Pande *et al.* 2011, Mikkola 2012).

Finally, even if these many differences between the taxa are somehow not considered sufficient justification for the specific distinctness of *blewitti* from *brama,* the two forms are broadly sympatric: *brama* occurs wherever *blewitti* occurs. While the microhabitat where he collected them probably differed, J. Davidson collected at least 11 *brama* (all now in NHMUK) in the same region where he took his five *blewitti* (and other unattributed Khandesh and 'Candesh' specimens in the Hume and Seebohm collections may have also been collected by Davidson). Although Davidson took numerous egg sets of *brama* (Davidson MS) he never found a nest of *blewitti* (Barnes 1888), unsurprisingly since even in Khandesh in the 1880s the Spotted Owlet was clearly much the commoner species.

Sympatric occurrence is, of course, a prerequisite of hybridisation, but the evidence presented in Pande *et al.* (2011) is impossible to interpret owing to shortcomings in figure labelling, description and photograph quality. In our experience no specimens of *blewitti* or *brama* can be said to be intermediate in more than a few characters, and we have seen no specimens of either for which there is any doubt as to their specific identity. Based on the data presented above on plumage, other external morphological, mensural, mass and osteological differences, and the lack of intermediates, it is evident that *blewitti* is a well-marked, distinct species. Its coexistence with *brama* in areas where both are resident strongly reinforces this view. Thus, under any widely accepted species concept, the Forest Owlet must be considered specifically distinct from the Spotted Owlet. Until far better evidence is produced we take the view that hybridisation is unproven and, given the wide range of differences between the taxa, very unlikely. Even if occasional hybridisation were proven, wild intrageneric hybrids are known for several avian taxa (see McCarthy 2006), and these are not generally taken as evidence of exceptionally close relationship.

Baker's (1923) notion of the conspecificity of *blewitti* with *noctua* has never been taken seriously elsewhere, but has never been explicitly dealt with; hence, we do so here. Although *A. noctua* is a variable species, it is considerably more different in appearance from *blewitti* than is *brama.* This is most evident in: the pattern of the underparts (streaked in *noctua,* barred in *blewitti*); crown pattern (streaked in *noctua,* nearly unmarked in *blewitti*); broader, spotted frontal semi-collar; less white on face; less banded wings and tail; smaller bill and claws; and tarsal length and shape (long and much more gracile in *noctua,* short and stout in *blewitti*). We can find no features in which *blewitti* resembles *noctua* more than it does *brama,* except for the streaked underparts of juvenile *blewitti* (Rasmussen & Anderton 2005). In osteology, *brama, noctua* and, except for tarsometatarsus length, *cunicularia* are very similar to each other, far more so than any is to *blewitti.*

The generic validity of *Heteroglaux*

Clearly the plumage differences between *blewitti* and established members of *Athene* are insufficient alone to justify the maintenance of *Heteroglaux*. Moreover, while the song of *blewitti* is very different from *brama* in its high pitch, tone and modulation, it does resemble the male song of *noctua* in overall quality; and even the song of *cunicularia* is somewhat intermediate between *blewitti* and *brama*. As a consequence we abandon the pursuit of generic limits in *blewitti* through acoustic evidence: such a line of taxonomic inquiry is untried elsewhere for fairly obvious reasons of interpretation (especially as convergence may play a part), and would require the discovery of very strong differences to be considered in any way informative. However, we note that while some vocalisations have been documented for *blewitti* (Rasmussen & Ishtiaq 1999, Ishtiaq & Rahmani 2005), to our knowledge only one recording is available online (AV 16764; http://avocet.zoology.msu.edu/ recordings/ 16764), so detailed further analysis of vocalisations of *blewitti* cannot in any case be made until a more complete sample of recordings becomes available.

This then leaves morphological and behavioural differences to consider. In terms of external morphology, *blewitti* would not appear out of place within *Athene*. However, many osteological differences involving multiple cranial elements (especially the greatly widened and inflated frontal and the large, straight-edged maxillopalatines) and the hindlimb (the extremely stout tarsometatarsus) separate it from other *Athene*, and indicate that plumage convergence or perhaps even mimicry may have resulted in the relative similarity of external phenotype between *blewitti* and *brama*. It is unusual to find many marked qualitative (as opposed to mensural or quantitative) osteological differences within an avian genus, and it is even occasionally difficult to distinguish closely related genera osteologically.

Extinct island owls placed in *Athene* show great variation in size and length of extremities: one (*A. cretensis* of Crete) was relatively large, with very long tarsometatarsi (Weesie 1982), while another (*A. angelis* of Corsica) had unusually long femora and robust tarsometatarsi (Mourer-Chauviré *et al.* 1997), and a third (*A. vallgornerensis* of Mallorca) was small, with short, robust tarsometatarsi (Guerra *et al.* 2012). However, judging from figures (Guerra *et al.* 2012), even *A. vallgornerensis* had a distinctly less robust tarsometatarsus than does *blewitti*. Living and fossil island owls show no trend in overall size, but do tend to have somewhat larger feet and claws than closely allied continental species (Louchart 2005), as does the mainland *blewitti* to a striking degree.

Behaviourally, *blewitti* differs from other members of *Athene* in its direct, non-undulating flight, and in its lateral tail-flicking. While these differences by themselves may not suggest distinctness at the generic level, they provide significant corroborating evidence to the osteological data.

In summary, the numerous (and in some cases major) differences in skull and tarsometatarsus morphology between *blewitti* and all other species of *Athene* (including *Speotyto*)—involving many cranial elements, especially the frontals, and the extremely stout tarsometatarsus—indicate that (although a rapid evolution cannot be excluded) *blewitti* seems likely to be distantly related to the others. Because of this distinctness, coupled with its unusual flight and tail-flicking behaviours, we consider the resurrection of the monotypic genus *Heteroglaux* fully justified, and far from 'spurious' (Weick 2006). Even those predisposed to recognise very broad genera, and who may thus prefer to maintain *blewitti* in *Athene*, should at least be aware that it is osteologically much the most distinctive of the group and quite possibly evolved from an ancient divergence event. Further study involving more owl taxa, such as phylogenetic analyses based on morphology and/or DNA, is likely to shed more light on the relationships of *blewitti*, but in the meantime we contend that the generic distinctiveness of *blewitti* only increases the urgency with which the conservation needs of this Critically Endangered species must be addressed.

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***P. C. RASMUSSEN**, Department of Zoology and Michigan State University Museum, Michigan State University, East Lansing, MI 48824, USA; and Bird Group, Department of Life Sciences, Natural History Museum, Akeman St, Tring, Herts HP23 6AP, UK. Email: rasmus39@gmail.com*

***N. J. COLLAR**, BirdLife International, Wellbrook Court, Girton Road, Cambridge CB3 0NA, UK; and Bird Group, Department of Life Sciences, Natural History Museum, Akeman St, Tring, Herts HP23 6AP, UK. Email: nigel.collar@birdlife.org*

The Moluccan Woodcock *Scolopax rochussenii* on Obi Island, North Moluccas, Indonesia: a 'lost' species is less endangered than expected

H. EDEN W. COTTEE-JONES, JOHN C. MITTERMEIER & DAVID W. REDDING

The Moluccan Woodcock *Scolopax rochussenii* is an enigmatic forest wader endemic to the North Moluccas, Indonesia. Until recently, the species was known from fewer than ten confirmed records and it is currently considered to be endangered under the criteria of the International Union for the Conservation of Nature (IUCN). In July–August 2012, field surveys were conducted at 20 sites and semi-structured interviews held in seven villages to assess the status of the Moluccan Woodcock on Obi Island, Maluku Utara province. Field surveys resulted in 51 records of minimum 13 individuals, and the findings suggest that this species is widespread on Obi, occurring from 15–1,150+ m. Contrary to the existing assumption that the Moluccan Woodcock is a montane species, the data indicate that it is primarily a lowland species, and that population densities decline with altitude. The species tolerates minor habitat disturbance, such as selective logging and small-scale agriculture, and does not appear to be hunted or frequently trapped by local people. A Maxent species distribution model indicates that Moluccan Woodcock distribution correlates strongly with the presence of rivers and streams and predicts 9,530 woodcock territories on Obi. The primary threats to the species are severe habitat disturbance from mining and logging, and better environmental mining regulations need to be enforced to safeguard habitat on Obi. It is recommended that the Moluccan Woodcock be reassessed as vulnerable following IUCN criteria, and that surveys following the same protocol should be conducted on Bacan to clarify the status of the species on that island.

INTRODUCTION

The woodcock (genus: *Scolopax*) consist of eight extant species; two migratory species with large ranges in North America (American Woodcock *S. minor*) and Eurasia (Eurasian Woodcock *S. rusticola*), and six inhabiting islands in tropical East Asia and New Guinea (Olson 1979, Piersma 1996). Of these, the Ryukyu Woodcock *S. mira* is confined to a handful of small islands in the Ryukyu archipelago, Japan, and another four species (Bukidnon Woodcock *S. bukidnonensis*, New Guinea Woodcock *S. rosenbergii*, Javan Woodcock *S. saturata*, Sulawesi Woodcock *S. celebensis*) are restricted to montane forest on large islands in the Philippines, Indonesia and New Guinea (Piersma 1996, Kennedy *et al.* 2001). The final species, the Moluccan Woodcock *S. rochussenii*, is known from two small islands in the North Moluccas, Indonesia, and is the largest and least known member of the genus (Hayman *et al.* 1991, Coates & Bishop 1997).

The Moluccan Woodcock was first collected by Heinrich Bernstein, who obtained a single male specimen from Obi in 1862, but did not live to see the species named (Jansen 2008). Bernstein died of illness in New Guinea in 1865 and '*Scolopax rochussenii*' was not described until 1866 (Schlegel) when his specimen arrived back at the Museum of Natural History in Leiden, the Netherlands. Over the next 150 years, only seven additional individuals were recorded, six from Obi and a single individual from Bacan in 1902, and following two birds collected in 1982, the species disappeared for nearly 30 years. Ornithologists visiting Obi in 1989, 1992 and 2010 (Lambert 1992, Linsley 1994, Bashari 2011) failed to record the bird and a targeted search for the species on Bacan in 2010 also produced no records (Lagerveld 2010). In this same year, however, the species was 'rediscovered' at two localities on Obi by M. Thibault *et al.* (2013) and its vocalisations were recorded for the first time.

Given this paucity of records, virtually nothing is known of the distribution, breeding behaviour or feeding habits of the species. Most information regarding its ecology has been based on assumed similarities to other *Scolopax* species, in particular those on neighbouring islands in Indonesia and New Guinea. Despite the collection of at least one Moluccan Woodcock in lowland habitats (BirdLife International 2001), the species has been assumed to be a montane species restricted to high elevation forest, a distribution that would seemingly explain why it has been recorded so infrequently (White & Bruce 1986, Coates & Bishop 1997, BirdLife International 2013). As a result of the few known records and the relatively small area of montane habitat on Obi and Bacan, the Moluccan Woodcock is currently considered Endangered (BirdLife International 2013).

From 5 July to 27 August 2012 the first field study of the Moluccan Woodcock on Obi Island was conducted and the species was observed on 51 occasions. Here the distribution, display behaviour and population size of this enigmatic species are reported and the impact of these findings on its conservation status are discussed.

METHODS

Field surveys

Field surveys were conducted at 20 sites around Obi. Localities included all major habitat types on the island, and covered an elevational range from sea level to 1,550 m (Mittermeier *et al.* 2013). At each site, dawn and dusk survey points (n=60) were coupled with daily field observations (total 630 hours). Surveys were designed to maximise the possibility of encountering a Moluccan Woodcock and, when possible, dawn and dusk surveys were carried out along ridgelines or in open areas (such as river beds or forest clearings) where observers could scan for displaying birds. Morning observations began about 10 minutes before first light and continued until about 10 minutes after sunrise (05h30–06h10); evening observations were from about 20 minutes before sunset to about 10 minutes after dark (18h40–19h15).

At each location, the number of individuals, detection method, and observation times were recorded along with habitat information including elevation, level of disturbance and the presence of nearby streams or swamps. Displaying woodcock were almost always detected by their call, and therefore the field of view at survey points could not be controlled. At three locations where it was possible to track a Moluccan Woodcock over the course of its entire display, the GPS points at the territory boundaries were marked in order to estimate the size of the territory (see Discussion). Sites with swamps, streams with a width of greater than 3 m, or swamp forest located within 100 m of the point count were classified as wetlands. Level of disturbance was qualitatively assessed with primary forest defined as 'undisturbed', areas with small agricultural clearings and light logging defined as 'minor disturbance' and areas with mining, extensive cultivation or extensive and recent logging (within the last 5 years) defined as 'major disturbance'. A generalised linear model with a log-link function and a Poisson error structure was used to identify any significant relationships between these variables and the number of Moluccan Woodcock recorded at the survey sites.

Distribution and population assessment

Field data were used to construct a model predicting the distribution of the Moluccan Woodcock on Obi and Bacan. The data for the model was downloaded as raster layers: 19 climatic variables relating to temperature and rainfall (Worldclim, 30 arc second resolution, WGS84 projection; Hijmans *et al.* 2005), altitudinal data (Worldclim, 30 arc second resolution, WGS84 projection; Hijmans *et al.* 2005), land cover data (Globcover, 300 m × 300 m resolution, WGS84 projection; Globcover 2009), world geopolitical boundaries (Digital Chart of the World, 1 km^2 resolution, WGS84 projection; Danko 1992), and hydrological information (Hydro1K, 1 km^2 resolution, WGS84 projection; Verdin *et al.* 2011). All input layers were resampled to 300 m × 300 m cell size using linear interpolation (resample, R package raster; Hijmans & van Etten 2012) to maintain the resolution of the finest scale data (Globcover), and cropped with a bounding box of latitude 0–2°S and longitude 127–129°E (crop, R package raster; Hijmans & van Etten 2012). Rather than using raw values for two of the Hydro1K data layers, the distance of each grid cell to either a river (flow accumulation) or wet area (compound topographic index) was calculated (distance, R package raster; Hijmans & van Etten 2012).

Species distribution models were estimated using Maxent (Phillips *et al.* 2004) with presence-absence points taken directly from the field data. All the 19 Worldclim, Hydro1k and land cover data layers were entered as predictor variables; a total of 21 variables. A total of 100 Maxent runs were done, each time using a random subset of the data as either training (4/5) or testing sets (1/5), and then a mean probability surface was calculated across those 100 runs. The ability of each of the 100 training datasets to predict the locations of the corresponding test datasets was measured using the 'area under operating curve' approach. This gives a value between 1, where the locations of testing sets are perfectly predicted by the niche model that was created using the training set, and 0 where the probability of occurrence of the niche surface is random with respect to the testing set.

Given that the approximate area of each territory estimated in the field was close to 10 ha, the probability of occurrence grid output from Maxent was used to create a rough estimate of population size. The assumption was made that every thousand grid cells covering land was a potential range site and that the probability of occurrence taken from Maxent was the chance that this site was occupied by a single individual. Based on these assumptions, therefore, the summed probability from the model equated to an estimate of minimum population on the island. Although ranges will not, in reality, be shaped or arranged in such a uniform manner, given that occupancy will in many cases be greater than a single individual, this approach remains a conservative estimate of population size and means that errors resulting from the assumptions will be unlikely to cause an overestimation of the number of woodcock on the island.

Interviews

Field surveys were supplemented by 46 semi-structured interviews in seven villages around Obi. Interviews were conducted in Bahasa Indonesia with the help of three students from the University of Indonesia (Christine Endang Purba, Eka Hesdianti and Nova Maulidina Ashuri). Interviewees were selected opportunistically or following recommendations from the local village head. Interviews commenced with several background questions including religious affiliation, age, hometown, activities pursued in the forest, estimated frequency of visits to the forest and the amount of time spent there. Next, interviewees were shown a series of pictures of Indonesian birds and asked whether the species occurred on Obi and if so what the local name was and where it could be found, and whether they hunted or caught it. Pictures were colour photocopies taken from plates in Coates & Bishop (1997) and featured the Moluccan Woodcock, Drummer Rail *Habroptila wallacii*, White Cockatoo *Cacatua alba*, Dusky Megapode *Megapodius freycinet*, Maleo *Macrocephalon maleo* and Common Sandpiper *Actitis hypoleucos*, in no particular order.

Respondents' familiarity with the Moluccan Woodcock illustration was analysed for significance using a chi-squared test, and their ability to correctly identify the Moluccan Woodcock compared to the other illustrated species was analysed using Cochran's Q test. Using a binary logistic regression model, several variables were tested against the ability to correctly identify the Moluccan Woodcock, namely: whether someone had lived their entire life on Obi, how often they visited the forest, how well they identified other species in the interview, whether they hunted or trapped birds, their religion, and their village of origin.

RESULTS

Display behaviour

During display a single bird would fly quickly with shallow wing beats at a height of about 10 m above the canopy, vocalising at regular intervals (Plate 1). Vocalisations consisted of an explosive even trill, lasting 0.1–0.6 seconds in duration and given at intervals of 1.9–3.2 seconds. When two Moluccan Woodcock encountered each other during display flights (believed to be territorial conflicts), interactions included short parallel flights and a descending, twittering call, without overlapping into the adjacent bird's display area (Macaulay Library of Natural Sounds LNS 182223). Display areas followed the course of a river or stream or circled above areas of swampy habitat. In the highlands, displaying birds were observed flying up to the headwaters of a stream before looping back to follow the course of a valley. Displays covered a large area, and flight patterns were either generally circular (in more open environments) or linear (following narrow valleys), but did not appear to follow a consistent pattern. In open areas, displaying birds were recorded passing above an observer on average every 3.8 minutes (n=15 display flights), and disappearing out of sight in the intervening period. In other conditions, birds would double back and fly over more frequently. Displaying Moluccan Woodcock were not disturbed by people, and would occasionally fly directly overhead with heads tilted to look down at observers. While there was a slight variation in timings, morning display flights would typically run from 05h25–06h02 (mean length 21 minutes), and evening display flights would usually take place from 18h47–19h06 (mean length 13 minutes). Ambient recordings of complete dawn and dusk display flights recorded by JCM are available online from the Cornell Lab of Ornithology Macaulay Library of Natural Sounds (http://macaulaylibrary.org).

Distribution and population

The Moluccan Woodcock was recorded on 51 occasions at 11 sites (Figure 1). They were recorded almost exclusively during their dawn and dusk display flights, during which they were both consistent and conspicuous. At seven sites where several survey days

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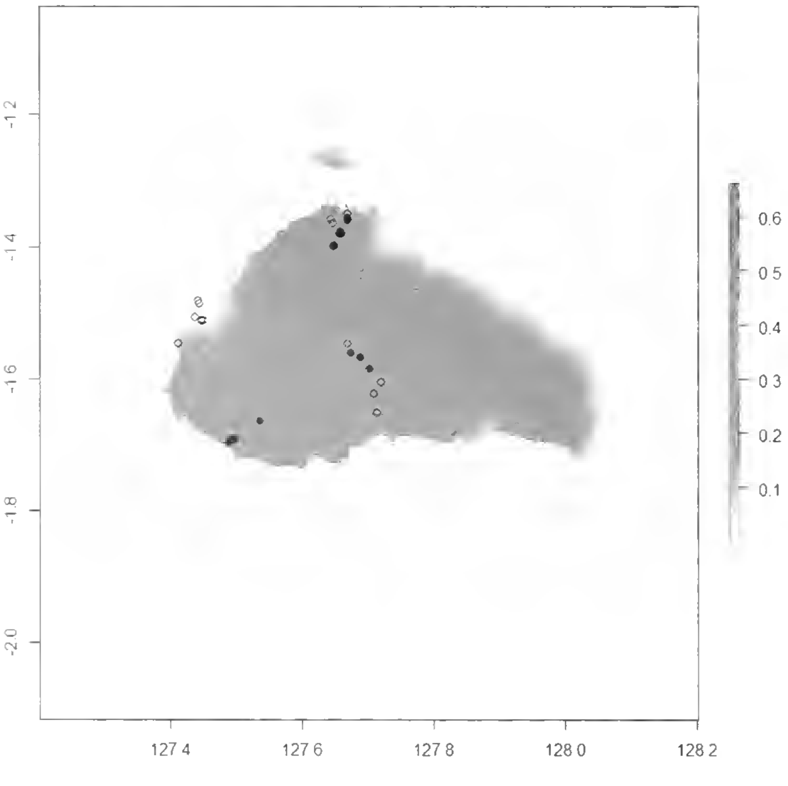
Plate 1. Moluccan Woodcock photographed during display flights over the Cabang River, south of Kampon Buton, Obi, 26 August 2012.

were spent near a displaying bird, it was recorded every day at both dawn and dusk regardless of weather conditions. Non-displaying birds, on the other hand, were extremely inconspicuous and difficult to locate. During 630 hours of field surveys, only one non-displaying individual was observed. This bird was flushed by JCM from an area of mossy boulders and pools along the edge of a stream, in primary montane forest at 930 m on 3 August (Plate 2).

Figure 1. A species distribution model for the Moluccan Woodcock on Obi Island. Darker colours indicate areas of more suitable habitat, and circles identify field survey sites where woodcock were present (closed circles) and not recorded (open circles).



The Moluccan Woodcock was recorded at sites between 15 and 1,150 m elevation in a range of habitats including primary lowland forest, selectively logged secondary forest, swamp forest, secondary forest with small agricultural clearings and montane forest. A generalised linear regression model found no significant difference in Moluccan Woodcock densities in areas with minor disturbance relative to undisturbed habitats (Table 1); indeed the birds were frequently present in selectively logged forest and areas with small-scale agriculture and agroforestry. Moluccan Woodcock were not, however, recorded in areas with major disturbance (e.g. extensive agriculture and mining). While the model found no significant relationship with altitude, raw point count data illustrate that the Moluccan Woodcock was more frequently recorded in the lowlands than the highlands (Figure 2). The strongest correlation identified by the generalised linear model was with the presence of streams and rivers (Table 1).

The Maxent models created using the training data showed a good ability to predict the testing data, with a mean receiver operating characteristic (ROC) value of 0.833 with a standard deviation of 0.11 over 100 replicates. The influence of waterways was also reflected in this distribution model (Figure 1) where 'distance to major river' explained more than 80% of the variation using both the Hydro1K data set and the Digital Chart of the World. The remaining variation in the model was explained by land cover type (~20%), and in a few models, by mean diurnal temperature range (~5%). The variable 'Distance to rivers' was consistently the highest loading variable (with an average of 95%), with habitat type (2%) and daily temperature range (2.5%) also being consistently important.

Based on data from individual displaying birds at three sites, the mean territory size for a Moluccan Woodcock was estimated to be 10.67 ha (SE = 2.3, range=7.6–13). By applying this territory size to the modelled distribution, a mean estimate of 9,530

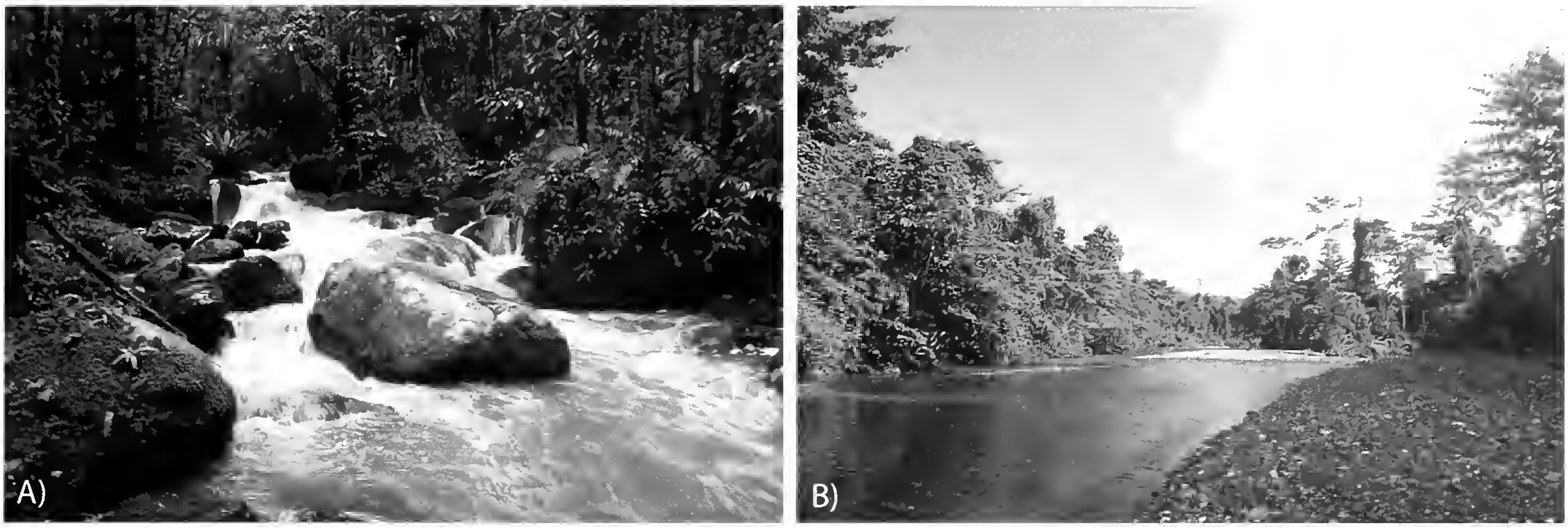


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Plate 2. Two habitats where Moluccan Woodcock were found on Obi: a) a fast-flowing mountain stream in primary forest at 930 m and b) logged forest bordering the Cabang River at 35 m, July 2012.

Figure 2. The mean number of Moluccan Woodcock recorded at survey sites in lowland and highland elevations.

Table 1. Generalised linear regression model results for Moluccan Woodcock habitat associations.

Parameter	*B* (SE)	p-value
Intercept	0.71 (0.79)	0.37
Altitude	−0.001 (0.0)	0.17
Water absence	−28.9 (–)	–
Light disturbance	0.03 (0.8)	0.97
Severe disturbance	−2.22 (1.26)	0.08
Deviance=0.83, Pearson Chi-square$_{(14)}$=10.17, p=0.73		

(standard deviation=282, n=100) woodcock territories on Obi was obtained.

Interviews

Interview results indicate that the majority of Obi residents are unfamiliar with the Moluccan Woodcock. With the exception of Maleo, which does not occur on Obi, all species in the survey were identified significantly more often than the woodcock (Figure 3). This even included Drummer Rail, a notoriously secretive species that until this study was unknown on Obi (Mittermeier *et al.* 2013). Almost 83% of respondents did not identify the Moluccan Woodcock, while nearly 11% identified it as a coastal shorebird found on the beach or in open areas along waterways ($X^2_{(1)}$=34.78, p<0.005). The lack of respondents accurately identifying the species constrained the ability of the model to select predictors, and none of the explanatory variables was significant. In total, only three people stated that they were familiar with the woodcock and that it was found in the forest on Obi. Of these, one reported that he had caught a bird in a snare and then released it because it did not look good to eat, and a second said that he saw it frequently flying at dawn and dusk near his rice fields, but that he believed it ate fruit in the treetops and that he had never seen it on the ground. The third, a parrot trapper and a very astute observer, noted that he occasionally saw the species eating worms in muddy areas along the margins of rivers and that he called the woodcock *wapichu* (transcribed phonetically). No interviewees reported hunting or eating this species.

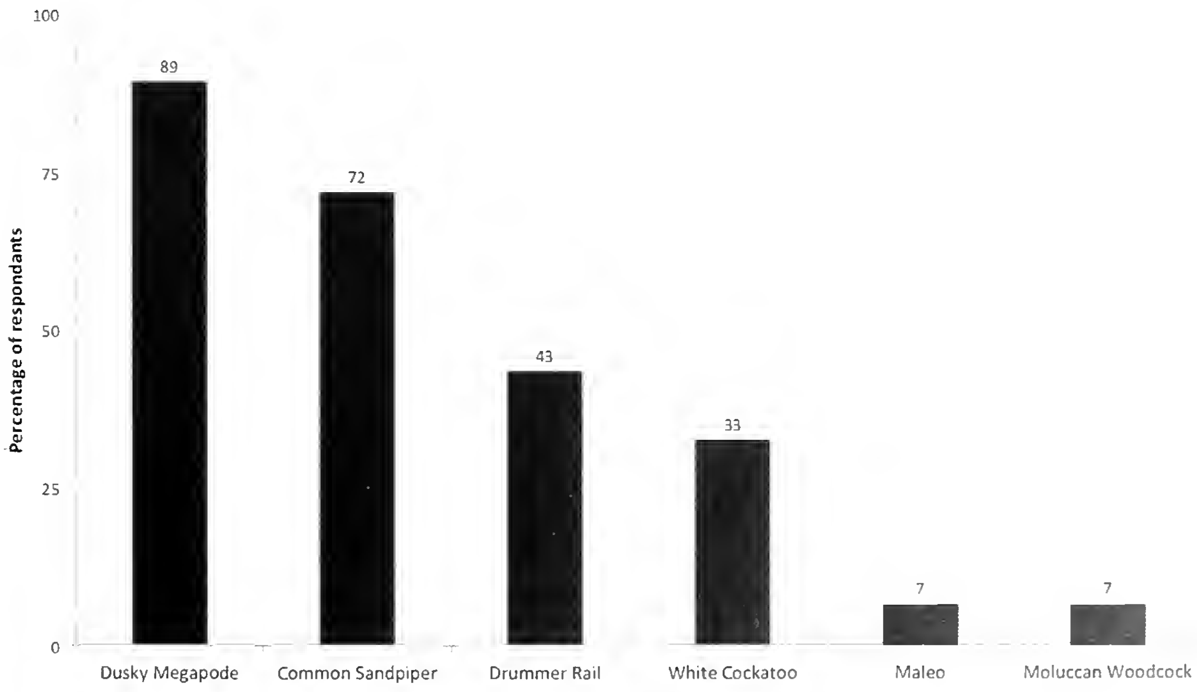

Figure 3. The percentage of interviewees (n=46) who correctly identified Indonesian birds using picture prompts taken from plates in Coates & Bishop (1997).

Moluccan Woodcock *vs* Dusky Megapode: Cochran's $Q_{(1)}$=38.00*, *vs* Common Sandpiper: Cochran's $Q_{(1)}$=29.00*, *vs* Drummer Rail: Cochran's $Q_{(1)}$=16.00*, *vs* White Cockatoo: Cochran's $Q_{(1)}$=32.00*, *vs* Maleo: Cochran's $Q_{(1)}$=0.20. * p<0.005.

DISCUSSION

Ecology and display

The results indicate that the Moluccan Woodcock occurs throughout Obi. It is found at higher densities in the lowlands and favours areas near water particularly in the vicinity of streams and rivers. This close association with waterways reflects observations of the Sulawesi Woodcock, which has been reported to forage along forest stream banks (Mole & Wangko 2006). The elevational distribution of the Moluccan Woodcock, with the species notably more common in lowland habitats, contrasts with that of related *Scolopax* species on the larger islands of Sulawesi, Java, New Guinea and the Philippines. As the Moluccan Woodcock associates strongly with waterways, it is possible that this distribution reflects the lower density of large rivers at higher elevations. While this lowland distribution overturns existing assumptions, it is not overly surprising; many birds in the Indo-Pacific that are restricted to the highlands on large islands are found in lowland habitats on oceanic islands (Mayr & Diamond 2001).

The display flights of different woodcock species show substantial plasticity. The American Woodcock performs a unique display involving a terrestrial 'peenting' call followed by a vertical display flight (Duke 1966), several male Eurasian Woodcock perform 'roding' display flights over the same area of woodland competing for females polygamously (Hirons 1980, Hoodless *et al.* 2009), and the Ryukyu Woodcock does not seem to perform any display flight at all (BirdLife International 2001). In the absence of any evidence to suggest otherwise, this study indicates that the Moluccan Woodcock performs territorial display flights, and suggests that territories abut without overlapping, similar to the Bukidnon Woodcock (Kennedy *et al.* 2001).

Population

The lack of ecological data on the Moluccan Woodcock and the degree of variation in the breeding behaviour of other woodcock species makes it difficult to establish how many individual woodcock might be present in a single territory. At the most conservative, an estimate of one individual per territory predicts a total population of 9,530 individuals. A more realistic estimate, though still very conservative, would be two individuals per territory for a minimum population of 19,059 individuals. However, the relationship between the number of displaying individuals and the total population is unknown even in well-studied woodcock species (Hoodless *et al.* 2009), and so this population estimate for the Moluccan Woodcock should be regarded as preliminary. Obtaining a more accurate population estimate for the species will require a better understanding of the relationship between the number of displaying birds and the total number of individuals in a given area, the degree of variation in territory size, and clarifying the status of the bird in several areas not surveyed. Neither the eastern side of Obi nor the outlying island of Bisa were visited, as part of eastern Obi had been surveyed by F. Lambert in 1992, and current reports indicated that the rest had been converted into coconut groves. Due to the lack of rivers in these two areas, the distribution model indicates that they are unsuitable for woodcock. Whether this is accurate should be confirmed by future field surveys.

The status of the Moluccan Woodcock on Bacan is also important. Bacan (1,900 km^2) is smaller than Obi (2,500 km^2) and could theoretically hold a similar population of the woodcock. However, the only known record for Bacan is a female collected from an unspecified location in 1902 (BirdLife International 2001). Bacan has been surveyed more often than Obi (White & Bruce 1986), Alfred Russel Wallace spent six months collecting there in 1858-1859 (Wallace 1869) and it is rather surprising that it has not been recorded there again for more than a century. That said the distribution model does identify significant areas of suitable habitat on Bacan, particularly along large rivers in the central part of the island. Surveys on Bacan, and also Halmahera, using the same methodology should be undertaken to ascertain whether the Moluccan Woodcock occurs on other islands in the North Moluccas. If Moluccan Woodcock are not present on these islands, it would be appropriate to revert to the former common name of Obi Woodcock.

Local knowledge

People on Obi often had a detailed knowledge of the local avifauna, particularly of species that were trapped, such as parrots, and terrestrial birds caught in snares, such as rails and megapodes. For example, several forest workers near Kampon Buton and Wayaloar readily identified 5–6 species of rail. In this context, the limited knowledge of Moluccan Woodcock is somewhat surprising. This may partly be due to the survey method (Diamond & Bishop 1999). The illustration of Moluccan Woodcock in Coates & Bishop (1997) displays the species in daylight on the ground, a context in which it is apparently rarely seen. In the wild, the vast majority of observations are of a silhouetted bird, flying in poor light and giving its distinctive call. It is recommended that any future interviews to determine local knowledge of Moluccan Woodcock use photographs and sound recordings rather than the standard illustrations. An important implication of this result, however, is strong support for the fact that people do not regularly hunt or eat the species and therefore have limited opportunities to see it in the hand. This is critical to the conservation of the species. In other parts of the world, woodcock are frequently hunted and considered a good source of meat. Given the conspicuous nature of the Moluccan Woodcock's display flights, a change in attitudes coupled with an increase in hunting on Obi could lead to a rapid decline in the bird's population.

Conservation

The population and distribution estimates for the Moluccan Woodcock indicate that the number of individuals and area of occupancy for this species are both above the established thresholds for listing as Endangered (IUCN 2012). With an area of occupancy of more than 2,000 km^2 on Obi and the number of territories estimated to be 9,530, this species qualifies to be reassessed as Vulnerable under the IUCN criteria.

Although the species can tolerate minor habitat disturbance, the current spread of mining on the island could represent a significant threat. The ultrabasic rock formations are rich in nickel ore, and nickel mining currently takes place on a large scale in the Kawasi area of western Obi. Moluccan Woodcock was not found in this degraded mining landscape, and the expansion of mining on Obi poses a major threat to the Moluccan Woodcock and other species. Industrial nickel mining was due to expand into the foothills north of Tapaya village, but this has been suspended, possibly due to a recent government quota on the export of unprocessed material; however, it seems likely that it may soon commence. More sophisticated approaches to the regulation of the impact of mining on biodiversity and the restoration of mined areas need to be a priority for conservation on Obi.

A protected area has been proposed in the mountainous centre of Obi, but these results demonstrate that a highland protected area is unlikely to contain a high density of Moluccan Woodcock. Conservation efforts need to consider both montane and lowland habitats (see Mittermeier *et al.* 2013). Fortunately, Moluccan Woodcock appear to tolerate a relatively high degree of habitat degradation including selective logging, agroforestry, and small-scale agriculture, and these habitats should also be considered in devising a conservation plan for the species. In addition the display behaviour of the Moluccan Woodcock makes it potentially vulnerable to hunting. While no evidence of hunting was observed, high rates of immigration to the island, linked to the expansion of mining, could change this.

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***H. Eden W. COTTEE-JONES**, Conservation Biogeography and Macroecology Programme, School of Geography and the Environment, Oxford University Centre for the Environment, South Parks Road, Oxford OX1 3QY, UK. Correspondence address: H.E.W. Cottee-Jones, St Edmund Hall, Queen's Lane, Oxford, OX1 4AR, UK. Email: henry.cottee-jones@seh.ox.ac.uk*

***John C. MITTERMEIER**, Museum of Natural Science, 119 Foster Hall, Louisiana State University, Baton Rouge, LA, 70803, USA. Email: john.mittermeier@gmail.com*

***David W. REDDING**, Department of Genetics, Evolution and Environment, University College London, Gower Street, London WC1E 6BT, UK. Email: dwredding@gmail.com*

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Taxonomic status of Blackthroat *Calliope obscura* and Firethroat *C. pectardens*

PER ALSTRÖM, GANG SONG, RUIYING ZHANG, XUEBIN GAO, PAUL I. HOLT, URBAN OLSSON & FUMIN LEI

The Chinese endemic breeders Blackthroat *Calliope obscura* and Firethroat *C. pectardens* are two of the world's rarest and least known 'chats' (Muscicapidae). They have been considered colour morphs of the same species (Firethroat, by priority), although they are nowadays usually treated as separate species. The taxonomic status of these two taxa is here investigated based on analyses of mitochondrial and nuclear DNA, vocalisations and reassessed distributions. Phylogenetic analysis confirms that they are sisters. Their genetic divergence (cytochrome *b* 6.4%, GTR+Γ+I corrected) is comparable to several other species pairs of 'chats'. Discriminant function analysis of songs correctly classified 88% of the recordings. The breeding ranges appear to be mainly parapatric. Based on congruent differences in morphology, songs and molecular markers, it is concluded that Blackthroat and Firethroat are appropriately treated as separate species.

INTRODUCTION

The Blackthroat *Calliope obscura* and Firethroat *C. pectardens* are two of the world's rarest and least known 'chats'. Males are uniformly blue-grey above, with blackish tail with white sides basally. As the names imply, male Blackthroat has a black throat, breast and side of the head, whereas male Firethroat has a 'shining' orange throat and breast with black sides, and black sides of the head. Male Firethroat also has a small white patch on the side of the neck. Females are, as usual in chats, much more cryptically coloured (Meyer de Schauensee 1984, MacKinnon & Phillipps 2000, Collar 2005, Rasmussen & Anderton 2012, Song *et al.* in press). Both breed in the mountainous regions of central China, Firethroat also in south-east Tibet and perhaps Arunachal Pradesh (Meyer de Schauensee 1984, Cheng 1987, MacKinnon & Phillipps 2000, Collar 2005, Rasmussen & Anderton 2012, BirdLife International 2013a,b). The non-breeding ranges are poorly known, but there are records of Blackthroat from north-west Thailand and of Firethroat from north-east India, northern Myanmar and Bangladesh (Cheng 1987, Collar 2005, Rasmussen & Anderton 2012, BirdLife International 2013a,b). Both species were described in the late nineteenth century, but there have been rather few records since then, especially of the Blackthroat, whose breeding grounds were only rediscovered in 2011 (Song *et al.* in press). The Blackthroat is classified as Vulnerable and Firethroat as Near Threatened (BirdLife International 2013 a,b).

Blackthroat and Firethroat are usually placed in either *Luscinia* (Sibley & Monroe 1990, Dickinson 2003, Collar 2005, Gill & Donsker 2013) or *Erithacus* (Ripley 1964). However, *Luscinia sensu* Dickinson (2003) was recently shown to be non-monophyletic and proposed to be divided into the genera *Luscinia* (*sensu stricto*), *Larvivora*, *Tarsiger* and *Calliope*, with Firethroat in the *Calliope* clade (Sangster *et al.* 2010). Blackthroat was not included in that study, but it was placed in *Calliope* due to its assumed close relationship with Firethroat (Sangster *et al.* 2010). The species status of Blackthroat has been questioned, and it has been considered a colour morph of Firethroat (Goodwin & Vaurie 1956, Cheng 1958, Vaurie 1959, Etchécopar & Hüe 1983). This view was rebutted by Ripley (1958) based on morphological differences, and later authors have treated it as a distinct species (e.g. Ripley 1964, Sibley & Monroe 1990, Dickinson 2003, Collar 2005, Gill & Donsker 2013). However, the relationship between the Blackthroat and Firethroat has not yet been properly studied. As both are very rare (BirdLife International 2013a,b, Song *et al.* in press), it would be helpful for conservation purposes if their taxonomic status could be clarified.

Here the taxonomic status of the Blackthroat and Firethroat is discussed, based on analyses of mitochondrial and nuclear DNA and songs, and the distributions of the two species are reviewed. It is concluded that Blackthroat and Firethroat are best treated as separate species.

MATERIAL AND METHODS

Sequencing and phylogenetic analyses

Total genomic DNA was extracted from an adult male Blackthroat collected in Foping, Shaanxi province (33.693°N 107.849°E), in June 2011 (Institute of Zoology, Chinese Academy of Sciences, Beijing No. IOZ 62531) using the QIAamp DNA Mini Kit (Qiagen) following the manufacturer's protocol.

Partial sequences of the mitochondrial cytochrome *b* and flanking tRNA-Thr (hereafter cyt*b*) were obtained through PCR amplification. The primer pair L14851 and H16058 (Groth 1998) was used for cyt*b*, with annealing temperature 46–48°C. We also amplified two nuclear markers, myoglobin intron 2 (Myo) and ornithine decarboxylase (ODC). Primer pair myo2 and myo3F (Kimball *et al.* 2009) were used for Myo, and primer pair OD6 and OD8R for ODC (Allen & Omland 2003), with annealing temperatures 55°C and 59°C, respectively. PCR products were purified using QIAquick PCR purification Kit (Qiagen). Sequencing was carried out using an ABI 3730 automatic sequencer following the ABI PRISM BigDye Terminator Cycle Sequencing protocol. Both strands were sequenced using the same primers as for PCR. All sequences have been submitted to GenBank (Table S1). For the phylogenetic analyses, sequences of Firethroat and 10 other chats, all of which have been placed in the genus *Luscinia* (Dickinson 2003), and two more distant outgroup species (choice based on Sangster *et al.* 2010), were obtained from GenBank (Table S1).

Sequences were aligned and checked manually in MEGA4 (Tamura *et al.* 2007). The phylogeny was estimated by Bayesian inference using MrBayes 3.2 (Huelsenbeck & Ronquist 2001, 2010; Ronquist *et al.* 2011). All loci were analysed separately, as well as concatenated. In the multi-locus analyses, the data were partitioned by locus, using rate multipliers to allow different rates for the different partitions (Ronquist & Huelsenbeck 2003, Nylander *et al.* 2004). Appropriate substitution models were determined based on the AIC (Akaike information criterion: Akaike 1973) as calculated in MrModeltest2 (Nylander 2004). For cyt*b*, the general time-reversible (GTR) model (Lanave *et al.* 1984, Tavaré 1986, Rodríguez *et al.* 1990), assuming rate variation across sites according to a discrete gamma distribution with four rate categories (Γ; Yang 1994) and an estimated proportion of invariant sites (I; Gu *et al.* 1995), was selected. For Myo, the HKY model (Hasegawa *et al.* 1985) + Γ and for ODC the GTR + Γ model were selected. Two simultaneous runs of four incrementally heated Metropolis-coupled MCMC (Markov Chain Monte Carlo) chains were run for 5 million generations and sampled every 1,000 generations in MrBayes. Convergence to the stationary distribution of the single chains was inspected using a minimum threshold for the effective sample size. Joint likelihood and other parameter values were inspected in Tracer 1.5.0 (Rambaut & Drummond 2009) and indicated large effective sample sizes (> 1,000). Good mixing of the MCMC and search reproducibility were established by running each analysis at least twice, and topological convergence was examined by eye and by the average standard deviation of split frequencies (<0.01). The first 25% of the generations was discarded as 'burn-in', well after stationarity of chain likelihood values had been established, and the posterior probabilities were calculated from the remaining samples.

Pairwise sequence divergences among all 12 chats were calculated in PAUP* (Swofford 2002) for all individual loci, following the recommendations of Fregin *et al.* (2012), i.e. by comparing homologous parts of the genes (same parts, same lengths), deleting all positions with any uncertain base pairs from the matrix, and using the best-fit model (same as the model used in phylogenetic analyses; choice of model determined in MrModeltest2 [Nylander 2004] with the two distant outgroup species, Oriental Magpie Robin *Copsychus malabaricus* and Spotted Flycatcher *Muscicapa striata*, excluded). The shape parameter alpha and estimated proportion of invariable sites were obtained from a Bayesian Inference, since PAUP* cannot estimate these parameters under the distance criterion.

Vocalisations

Songs of a total of 18 male Blackthroats (17 from Foping, one from Changqing) were recorded in June 2011 and May 2012 using a Marantz PMD661 solid state recorder and a Telinga Pro Twin Science microphone (five individuals, by PA), a Marantz PMD661 solid state recorder and Sennheiser MKH416 (five individuals, by XG), and a Sound Devices 722 hard drive recorder with a Telinga Pro 7 parabolic microphone (eight individuals, by PIH). These recordings were compared by ear and by inspection of sonograms to 11 recordings of songs of Firethroat, all from Sichuan, China (seven from Wolong, one from Longcangguo, two from Jiuding Shan and one from Hailuogou—six by PA, three by PIH and two from www.xeno-canto.org). Sonograms were produced in Raven Pro 1.4 (Cornell Laboratory of Ornithology 2012). The following measurements were taken on entire song strophes of 14 Blackthroats and eight Firethroats: Δ time (s) = duration; Δ frequency (Hz) = frequency range; minimum frequency (Hz); maximum frequency (Hz); and number of elements. Discriminant function analysis (DFA) of the song variables was carried out in SPSS Statistics version 20 (IBM Corp.); mean values for each male were used as input in these analyses, as there were few individuals but several different strophes recorded per individual. Three of PA's recordings of Blackthroat are available on-line at www.xeno-canto.org (XC91803, XC1804, XC143220) as well as www.slu.se/per-alstrom-research; two of PA's recordings of Firethroat are available on Xeno-canto (XC143218, XC143219); and all of PIH's recordings have been deposited at the National Sound Archive, London.

Distributions

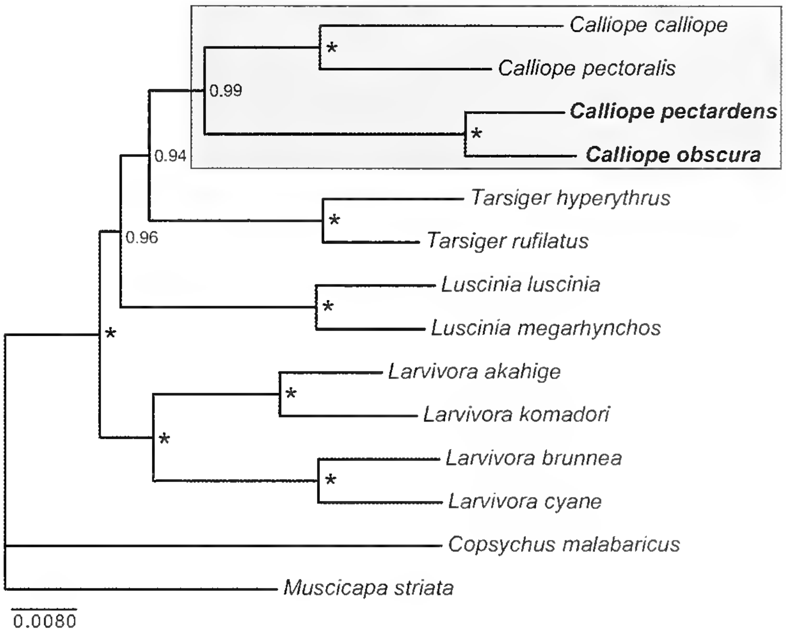
Records of Blackthroat were taken from Song *et al.* (in press). To revise the distribution of Firethroat we reviewed the literature, as well as the BirdLife International species database (http://www.birdlife.org/), China Bird Report (http://birdtalker.net/birdtalker/report/index.asp?lan=0), a database of the birds of China (http://www.cnbird.org.cn/first.htm), Chinese bird gallery (http://www.wwfchina.org/birdgallery), Oriental Bird Images (http://orientalbirdimages.org), the Internet Bird Collection (http://ibc.lynxeds.com) and museum collections that we thought might hold specimens of Blackthroat or Firethroat (museums in the USA searched through ORNIS: http://ornis2.ornisnet.org).

RESULTS

Molecular analyses

We obtained 1,076 bp of cyt*b*, 664 bp (674 bp aligned) of Myo and 705 bp (737 bp aligned) of ODC from Blackthroat. The tree based on the concatenated sequences (Figure 1) showed Blackthroat and Firethroat to be sisters with strong support. These were, in turn, inferred to be sisters to Siberian Rubythroat *Calliope calliope* and White-tailed Rubythroat *C. pectoralis*, with high support. The sister relationship between Blackthroat and Firethroat was strongly supported in single-locus analyses of all three markers (not shown).

Figure 1. Blackthroat *Calliope obscura* and Firethroat *C. pectardens* are sister species, as shown in this phylogenetic tree of all *Calliope* species *sensu* Sangster *et al.* (2010) (grey shade) and a selection of outgroup species. The tree is based on concatenated mitochondrial cytochrome *b* and nuclear myoglobin intron 2 and ODC introns 6–7 sequences (see Sangster *et al.* [2010] and Zuccon & Ericson [2010] for a broader taxon sampling within Muscicapidae). Values at nodes represent Bayesian posterior probabilities; * indicates posterior probability 1.00.



The genetic divergences between Blackthroat and Firethroat (cyt*b* 6.4%, Myo 0.32%, ODC 0.35%) were considerably lower in all three loci than in the majority of pairwise comparisons between the chats in the present dataset (Figure 2). However, they were comparable to the divergences between the well-accepted species pairs *Larvivora cyane*/*L. brunnea*, *L. akahige*/*L. komadori*, *Luscinia luscinia*/*L. megarhynchos* and *Tarsiger rufilatus*/*T. hyperythrus* (Figure 2).

Vocalisations

The song of Blackthroat consists of rather short, rapidly delivered, varied strophes that include both whistles and harsh notes, and masterful mimicry of other species (Song *et al.* in press; Figure 3). The song of Firethroat (Figure 3) is very similar, and due to the complexity of the songs (including mimicry), fairly large repertoire sizes of individual males (Blackthroat 5–22 strophes recorded per male, mean 10.1±4.2; Firethroat 4–30, mean 13.6±7.9) and pronounced variation among males in both species, as well as limited sample sizes, we were unable to differentiate safely between

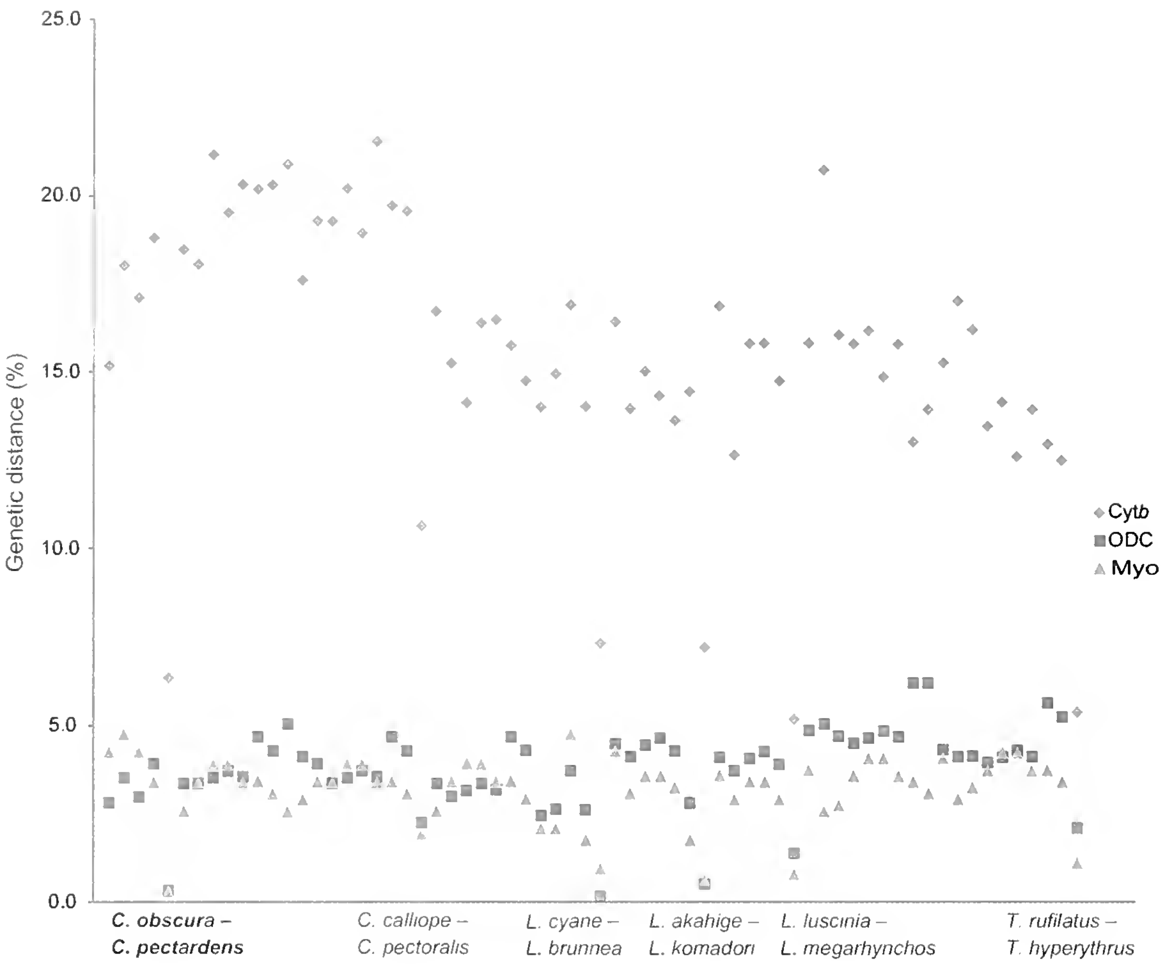
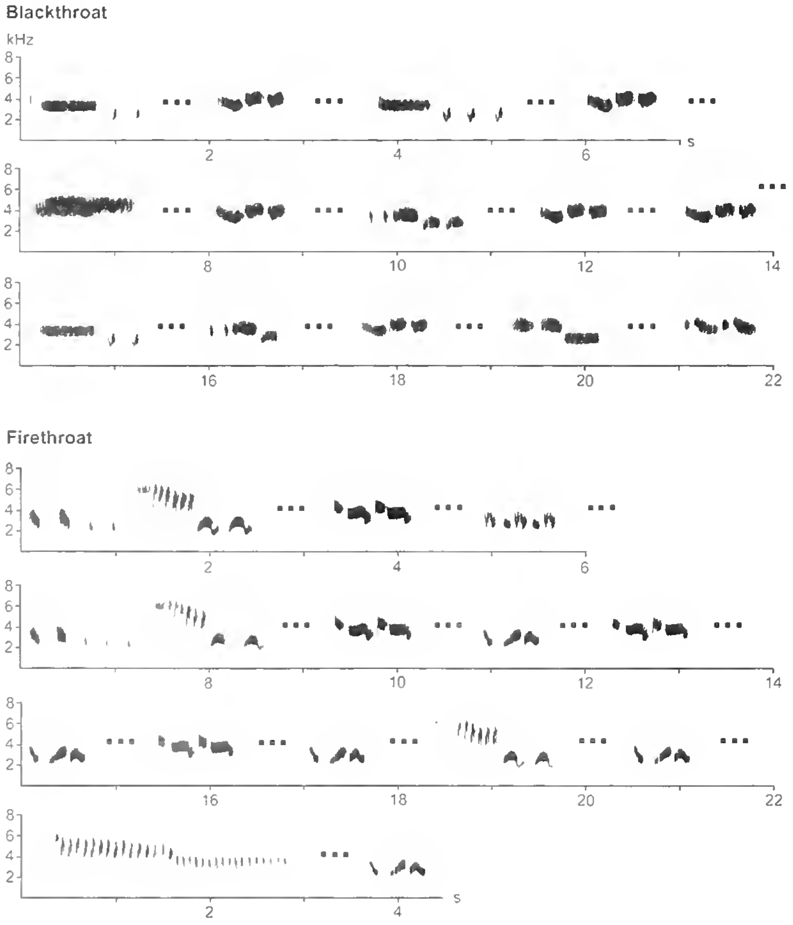


Figure 2. The genetic distances between Blackthroat *Calliope obscura* and Firethroat *C. pectardens* are comparable to the divergences between other chat sister species (highlighted by blue lines). The symbols represent genetic distances for all pairwise comparisons among the 12 chats in Figure 1; distances corrected (*cytb* GTR + Γ + I, Myo HKY + Γ, ODC GTR + Γ). As expected, the mitochondrial *cytb* is overall more divergent than the two nuclear introns Myo and ODC.

Figure 3. Songs of Blackthroat (top) and Firethroat are hard to distinguish owing to the fairly large repertoire sizes of individual males and extensive variation among males of both species (differences hence exaggerated in sonograms; a sonogram of another male Blackthroat appears in Song *et al.* in press). However, statistical analyses of songs reveal differences (see Table 1). Blackthroat recorded at Foping, Shaanxi province, China (June 2011) and Firethroat at Wolong, Sichuan province, China (May 1990), both by Per Alström (recordings available at www.xeno-canto.org, XC143220 and XC143219, respectively). Pauses between strophes have been shortened (indicated by dots).



them by ear or by sonograms. However, DFA correctly classified 88% of the recordings (Wilks's Lambda = 0.379, Chi-square = 20.364, P = 0.000), and identified the top frequency and number of elements as the variables most important in the discrimination (Table 1).

Table 1. Standardised canonical discriminant function coefficients for song variables in Blackthroat and Firethroat.

Function 1	
Mean low frequency	0.201
Mean top frequency	0.844
Mean delta time	–0.972
Mean number of elements	0.855
Eigenvalue	1.637
Variance explained	100%

Distributions

The breeding areas of Blackthroat and Firethroat appear to be mainly non-overlapping (Figure 4, Table S2). Blackthroat has been recorded at presumed or proven breeding localities in southern Shaanxi (Qinling Mountains), southern Gansu and northern Sichuan, whereas records of Firethroat at presumed breeding localities are from central Sichuan, north-western Yunnan, south-east Xizang (Tibet) and Arunachal Pradesh (a single record from latter area). One old and one recent record of Firethroat were made in Shaanxi, at localities where Blackthroat has been found to breed (Figure 4, Table S2). Records from wintering areas are completely segregated, with Blackthroat only observed in Thailand and Firethroat reported from north-east India, Bangladesh and northern Myanmar (Figure 4, Table S2). Observations of birds assumed to be migrating (at places unsuitable for breeding, during August to October and March to May) were made of Blackthroat in Thailand

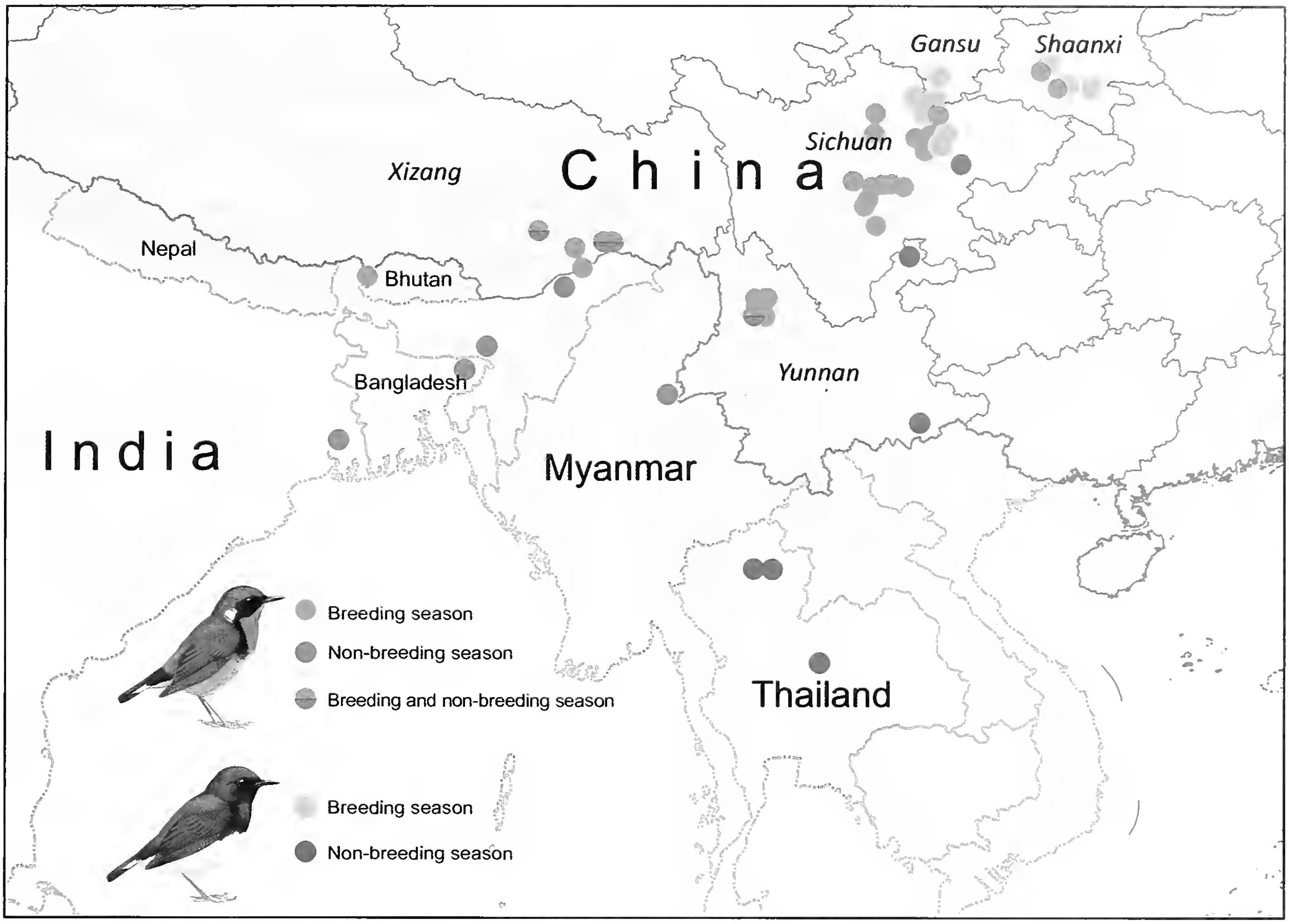


Figure 4. Blackthroat and Firethroat are mainly parapatric, with only limited evidence of sympatric breeding. Breeding season is defined as May–August, but records during this period of birds obviously on migration have been placed in the 'non-breeding season' category; for further details, see Table S2. Paintings by Hilary Burn from Collar (2005), reproduced with permission from the publishers.

and Yunnan, China, and of Firethroat in north-east India and Sichuan, China (Figure 4, Table S2).

DISCUSSION AND CONCLUSION

The close relationship between Blackthroat and Firethroat, which has been assumed by all previous workers (e.g. Ripley 1964, Dickinson 2003, Collar 2005, Sangster *et al.* 2010), is confirmed by the molecular data and further supported by the similarity in song between these two taxa. Their mainly parapatric distributions (see below) might call into question their status as separate species, and support earlier suggestions that they are conspecific (Goodwin & Vaurie 1956, Cheng 1958, Vaurie 1959, Etchécopar & Hüe 1983). However, the cyt*b* divergence is actually greater than in the two sympatrically breeding species pairs *Luscinia luscinia*/*L. megarhynchos* and *Tarsiger hyperythrus*/*T. rufilatus*, and only marginally lower than the allopatric *Larvivora cyane*/*L. brunnea* and parapatric *L. akahige*/*L. komadori*. The cyt*b* divergence also agrees well with pairwise comparisons between 69 parapatric, non-hybridising species (mean 6.17% Kimura 2-parameter [K2P] corrected distances: Aliabadian *et al.* 2009) (however, as different correction methods and different datasets have been used in these two studies, the genetic distances are not directly comparable; see Fregin *et al.* 2012). Although the present genetic analyses are based on only one individual per taxon, the cyt*b* divergence between Blackthroat and Firethroat is far greater than normal intraspecific variation in birds (mean 0.74% K2P divergence in 656 species investigated by Aliabadian *et al.* 2009).

The plumage differences between Blackthroat and Firethroat are of a similar magnitude to the differences between *L. cyane* and *L. brunnea* and between *L. akahige* and *L. komadori*, and much more pronounced than the difference between *L. luscinia* and *L. megarhynchos*. The songs of Blackthroat and Firethroat may seem surprisingly similar for different species (see Alström & Ranft 2003). However, 88% of the analysed recordings were correctly identified by the DFA, and it should also be noted that especially *L. cyane* and *L. brunnea* have closely similar songs (Rasmussen & Anderton, 2012, pers. obs.; recordings on www.xeno-canto.org).

Based on present knowledge, the breeding distributions of Blackthroat and Firethroat appear to be mainly parapatric. There are two undocumented records of Blackthroat from potential breeding sites in Sichuan province, a female in June 1931 and a male in May 1991 (Song *et al.* in press). The latter is from Wolong, which is a stronghold for Firethroat, indicating potential sympatry. However, as both are undocumented, and the earliest record is the first report ever of a female Blackthroat, they should be considered uncertain. Moreover, a 'May' record could represent a bird on migration (Song *et al.* in press). According to Goodwin & Vaurie (1956), on 12 July 1905 a Firethroat and four male Blackthroats were collected at the same locality and by the same collectors on Taibai Shan, Shaanxi province. On 8 and 24 May 2013, a singing male Firethroat was observed in Changqing, Shaanxi province, in close proximity to singing Blackthroats (P. Morris and T. Townshend *in litt.*). These reports indicate sympatric breeding of the two taxa, although both Firethroat records could have concerned individuals that had strayed north of their usual breeding range, and nothing is known of the interactions between Blackthroat and Firethroat in these places. Although hybridisation is a possibility, it seems unlikely in view of the large genetic distances between them.

In conclusion, the congruence between morphological, vocal, genetic and distributional data show that Blackthroat and Firethroat represent independently evolving lineages, and it is reasonable to treat them as separate species under both the 'phylogenetic' (Cracraft 1983, 1989) and 'biological' (Mayr 1942, 1963) species concepts. More research is needed on their distributions and possible geographical overlap, as well as on their numerical status and potential threats.

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SUPPLEMENTARY ONLINE MATERIAL

Available on Oriental Bird Club website, links at http://www.orientalbirdclub.org/publications/forktail29

Table S1. Sequences used in the present study

Table S2. Records of Firethroat

Per ALSTRÖM, *Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, 1 Beichen West Road, Chaoyang District, Beijing 100101, China; and Swedish Species Information Centre, Swedish University of Agricultural Sciences, Box 7007, SE-750 07 Uppsala, Sweden. Email: per.alstrom@slu.se (corresponding author)*

Gang SONG *and* ***Ruiying ZHANG***, *Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, 1 Beichen West Road, Chaoyang District, Beijing 100101, China. Email: songgang@ioz.ac.cn, zhangry@ioz.ac.cn*

Fumin LEI, *Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, 1 Beichen West Road, Chaoyang District, Beijing 100101, China; and School of Life Sciences, Shaanxi Normal University, Xi'an 710062, China. Email: leifm@ioz.ac.cn (corresponding author)*

Xuebin GAO, *Shaanxi Institute of Zoology, No. 88, Xingqing Road , Xi'an 710032, China. Email: gaoxb63@163.com*

Paul I. HOLT, *Bracken Dean, Pendleton, Clitheroe, Lancashire, BB7 1PT, England. Email: piholt@hotmail.com*

Urban OLSSON, *Systematics and Biodiversity, Department of Biology and Environmental Sciences, University of Gothenburg, Box 463, SE-405 30 Goteborg, Sweden. Email: urban.olsson@bioenv.gu.se*

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Bonelli's Eagle *Aquila fasciata renschi* in the Lesser Sundas, Wallacea: distribution, taxonomic status, likely origins and conservation status

COLIN R. TRAINOR, STEPHEN J. S. DEBUS, JERRY OLSEN, JANETTE A. NORMAN & LES CHRISTIDIS

Records of Bonelli's Eagle *Aquila fasciata renschi* on 18 islands in the Lesser Sundas, from Lombok to the Tanimbar islands, in Indonesia and Timor-Leste are reviewed, and its taxonomic status examined. The species is resident on many islands, known to breed on several of the larger islands and is most abundant on Flores and Timor. It appears to be rare on Lombok and Sumba. There is minimal genetic differentiation between local subspecies *A. f. renschi* and nominate *A. f. fasciata*, suggesting only recent geographic isolation and that it should not be afforded species status. The species may have been introduced to the Lesser Sundas by traders or colonists in the past. The species's biology and ecology are poorly known in Wallacea. It occurs in a wide range of sites from sea level to about 2,000 m, in wooded habitats with a preference for tropical forest. The sparse data on diet show that it feeds on introduced wild junglefowl *Gallus* sp., but presumably it also feeds on large-bodied frugivorous pigeons, other birds and small mammals. The two reports of nesting were in May and June–July. The frequency of records on Flores and Timor suggests that these populations are currently secure, but may be threatened by hunting, capture and deforestation. A predator of village chickens, it is likely to be targeted by local communities. Conservation priorities include distribution and population density surveys and awareness projects throughout its range.

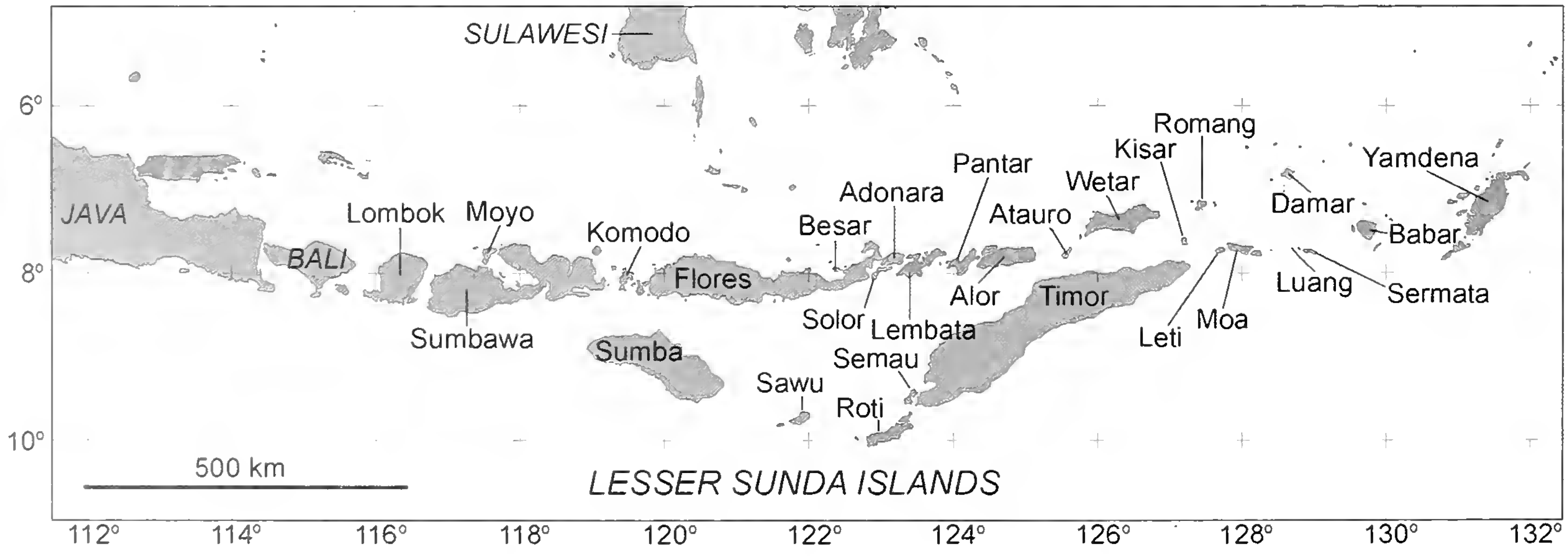
INTRODUCTION

It has been proposed that the isolated Lesser Sundas population of Bonelli's Eagle *Aquila fasciata renschi* should be regarded as a distinct species (Thiollay 1994, Ferguson-Lees & Christie 2001), partly based on biogeography. However, this has not prompted specific field or taxonomic studies of this taxon. According to recent evaluations the Wallacean subspecies is found on the Lesser Sunda islands of Sumbawa, Komodo, Flores, Besar, Timor, Wetar and Luang, and Yamdena in the Tanimbar islands (White & Bruce 1986, Coates & Bishop 1997, Ferguson-Lees & Christie 2001). The nominate form *fasciata* has a wide but fragmented distribution; it is resident, with little or no evidence of migration, in North Africa, the Iberian peninsula, the Mediterranean, parts of the Arabian Peninsula, the Middle East, Afghanistan, Pakistan, India and disjunctly to north Indochina and southern China (Thiollay 1994, Hernández-Matías *et al.* 2011). The Lesser Sundas are about 3,000 km from the nearest Asian population in Vietnam (Ferguson-Lees & Christie 2001). In Vietnam, Laos, Thailand and Myanmar there are very few records and it appears to be sedentary (Duckworth *et al.* in press).

Although the species has a relatively distinctive appearance there have been identification problems in the Lesser Sundas. The type specimen was originally identified by Rensch (1931) as a Changeable Hawk Eagle *Nisaetus cirrhatus*— the Lesser Sunda population of this species is now known as the Flores Hawk Eagle *N. floris* (Gjershaug *et al.* 2004), and a Wetar island record of 'Changeable Hawk Eagle' (Hartert 1904) was later identified as Bonelli's Eagle (Mees 2006). Bonelli's Eagle is now in the genus *Aquila* rather than *Hieraaetus*, based on DNA data (Wink & Sauer-Gürth 2004, Helbig *et al.* 2005, Lerner & Mindell 2005) demonstrating that *Aquila* and *Hieraaetus* as conventionally circumscribed were paraphyletic.

Recent observations confirming the species's presence on Lombok and Sumba, and on several other islands and islets in the Lesser Sundas, are reviewed, and substantial populations on at least Flores and Timor are documented. Records were collected from published and unpublished trip reports, bird tour reports and grey literature, and by canvassing individuals and the Orientalbirding e-group. The taxonomic status of *renschi* is assessed using DNA evidence. Some of the text of this paper was originally submitted as a book chapter in 2007 (still unpublished), which was split into two chapters by the editor (Christidis *et al.* in press, Debus *et al.* in press) and is expected to be published in late 2013. This opportunity is taken to substantially update those manuscripts, particularly in relation to distribution, ecology and taxonomy.

Figure 1. Map of the Lesser Sundas region, showing the islands mentioned in the text.



Study region

The Lesser Sundas are located in the extreme south-east of Asia, between continental Java and Bali and the Australo-Papuan region (Figure 1). Lying west to east in a 1,700 km arc, they comprise about 20 large oceanic islands and several hundred small islands and islets. The inner Banda arc includes young volcanic islands (Monk *et al.* 1997) from Lombok to Damar in Maluku province and the outer Banda arc, dominated by sedimentary rocks such as limestone, extends from Sawu (Sabu), Roti, Timor, Moa and Babar to the Tanimbar islands. Sumba is considered to be a continental fragment. Most islands are only a few kilometres apart and would have been contiguous during the last glacial period 9,000 to 18,000 years ago, thus aiding avian dispersal (Voris 2000), but Sumba, Wetar, the Tanimbar islands and Damar are separated from their nearest neighbours by tens of kilometres. The natural vegetation of the islands is closed-canopy tropical forest (tropical dry to evergreen) and various savannahs, including *Eucalyptus*, but on many islands, agriculture has repeatedly changed this to regrowth forest and savannah woodland (Monk *et al.* 1997). The main islands have been cleared to varying extents, many now being essentially deforested (Table 1). On large islands, forest fragments are often restricted to steep mountain slopes and peaks, but on some isolated islands in the Banda Sea (e.g. Wetar, Romang, Babar and Damar) forest cover is extensive.

Table 1. Area, climate (in relative terms), estimated remaining forest cover and relative biological survey effort, on Indonesian islands inhabited by Bonelli's Eagle (source: CRT unpubl. data, who has visited all islands mentioned, but has only sailed past Luang Island).

Island	Area (km^2)	Climate	Forest cover (%)	Survey effort
Lombok	4,625	wet (dry on coast)	10	Moderate
Sumbawa	14,386	dry	15	Moderate
Komodo	330	dry	40	Moderate
Flores	14,154	wet (dry on coast)	15	High
Besar	64	dry	75	High
Adonara	509	dry	5	Moderate
Pantar	728	dry	15	Low
Alor	2,864	dry	3	Moderate
Sumba	10,711	dry	12	High
Timor	28,418	dry	10	High
Wetar	2,684	dry	97	Moderate
Atauro	147	dry	10	High
Romang	184	wet	75	Low
Luang	5	wet	25	Moderate
Sermata	103	wet	35	Low
Damar	198	wet	75	Moderate
Yamdena	3,333 (+ satellites c.1,500)	wet	75	High

RESULTS

Summary of Bonelli's Eagle records in the Lesser Sundas

Islands are listed west to east.

Lombok: adult pairs observed in Gn Rinjani National Park, and between Sembalum and Sapit, in June–July 2003 (J. M. Thiollay *in litt.* 2007); the first records for the island. None was reported in a review by Myers & Bishop (2005) or during surveys for the Critically Endangered Flores Hawk Eagle (Raptor Conservation Society 2011).

Sumbawa: a single historical specimen is the *renschi* holotype (Stresemann 1932), a male (Mees 2006). Two birds were recorded by Johnstone *et al.* (1996), who considered it rare. J. M. Thiollay (*in litt.* 2007) observed it at four locations (Alas, Reloka, Ropang valley and Tambora peninsula), where it seemed common in June–July 2003. One bird was seen at Teluk Saleh in 2009 (V. Dinets *in litt.* 2013).

Moyo: a pair recorded in December 1999 (Trainor *et al.* 2006); first record for this almost land-locked island.

Sumba: observed at Lake Pambotanjara and Lewa on 14 July 1991 (Dreyer 1993), apparently the first records for the island. One bird was observed at Lewapaku in October 1998 (Trainor *et al.* 2006). It was not observed in four weeks by Olsen & Trost (2007), suggesting that it is uncommon or rare. None have been recorded by recent bird tour visits to the island. Sumba and Flores are visible from each other and separated by 45 km of sea, which should present little barrier to an eagle's flight. Sumba appears to hold suitable habitat: a dry limestone island cut by canyons, with abundant parrot, pigeon and junglefowl prey (JO, pers. obs.).

Komodo: recorded in semi-deciduous forest and savannah (Butchart *et al.* 1994). At least two observed in June–July 2003 (J. M. Thiollay *in litt.* 2007).

Flores: two fairly recent specimens, collected in 1971, identified as male and female (Mees 2006). Coates & Bishop (1997) considered it locally moderately common. Fourteen records mostly of pairs, mainly in hilly and mountainous terrain with cultivation, coconut plantations, scrub and secondary forest; also on a cultivated and scrubby plain (Verhoeye & King 1990). Recorded in moist and semi-deciduous forest, thorn scrub and montane forest, from sea level to 2,000 m (Butchart *et al.* 1994). Two observed in coastal scrub, gallery forest and grassland (Gibbs 1990). Verhoeye & Holmes (1999) reviewed about 20 records from cultivated and wooded hills; there are five additional records for forest and cultivated land (Pilgrim *et al.* 2000), and eight sightings (including a pair twice) from six localities in September–November 1998 (R. Drijvers unpubl. data). Recorded at 12 locations by Trainor & Lesmana (2000). Observed at eight locations in June–July 2003 and found to be widespread on the island; one nest found (J. M. Thiollay *in litt.* 2007). Observed throughout the island, from sea level to at least 1,600 m in forest, rice fields and valleys; common in central Flores; a captive juvenile (Plate 1) observed on 14 October 2004 originated from the slopes of Gn Iya, near Ende (M. Schellekens *in litt.* 2007). One bird was photographed at Riung in April 2012 (O. Hidayat *in litt.* 2013). The species is recorded regularly by tour groups and individual birdwatchers at several sites.

Besar: considered locally moderately common (Coates & Bishop 1997). Recorded in semi-deciduous, deciduous and coastal forest (Butchart *et al.* 1994).

Adonara: two over dry agricultural land and closed forest on mountain slopes, December 2000 (Trainor 2002); first record for the island.

Pantar: the only record was an adult observed by P. Verbelen at Gn Wasbila on 3 September 2009 (Trainor *et al.* 2012).

Alor: observed in *Eucalyptus* savannah in May 2002 (Trainor 2005a); first record for the island. Some records in 2002, 2009 and

2010 by CRT and P. Verbelen may have been confused with Flores Hawk Eagle, but pairs and singles were seen and confirmed with photographs at several sites up to about 1,100 m (Trainor *et al.* 2012).

Timor: single historical specimen, a male (Mees 2006). One sighting, over mountain forest and peaks at 2,000 m, East Timor, in 1972 (White & Bruce 1986). Three records in East Timor in 1974 (H. Thompson, J. McKean & I. Mason unpubl. data). Since the 1990s it has been regularly observed in West Timor, particularly at Bipolo and Camplong (Verbelen 1996, Mauro 1999, Van Biers 2004, N. Kemp *in litt.* 2007). Noted at four forested localities in West Timor by Noske & Saleh (1996). CRT had 36 sightings, 25 of single birds, 7 of two birds and 4 of three birds, from eight districts in Timor-Leste over four years 2003–2006; from sea level to 1,200 m in habitats ranging from coastal flats to village cultivation, freshwater lakes/swamps, secondary forest and primary forest (dry deciduous, semi-evergreen, evergreen and montane).

Atauro: pair over montane forest in December 2003, and a captive juvenile was said to have originated from a nest on Atauro (Trainor & Soares 2004); first records for the island.

Wetar: single historical specimen, originally sexed as male but probably a female (Mees 2006). Considered locally moderately common (Coates & Bishop 1997), although this assessment was based on a half day observation in west Wetar. In 2008, a 44-day survey recorded it from 8 of 12 sites up to about 500 m: the island is one of the least disturbed in insular South-East Asia (Trainor *et al.* 2009); there is at least one additional record of a bird photographed at sea level in September 2010 (CRT unpubl. data).

Romang: during the first ornithological visit to the island since 1902, a single bird and a displaying pair were observed over tropical forest at two sites at about 300 m, during two weeks in October 2010 (Trainor & Verbelen in press).

Luang: two historical specimens, both males (Mees 2006).

Sermata: one adult bird photographed at forest edge in November 2010 during the first ornithological exploration of the island since 1906 (Trainor & Verbelen in press).

Damar: two sightings over forest and forest edge, August 2006 (Trainor 2007); first records for the island.

Tanimbar islands: first observed on Yamdena, Tanimbar, by F. Rozendaal between August and November 1985 (F. G. Rozendaal unpubl. data). Also observed on Yamdena in August 1994 by Verbelen (1996); and in October 1998 by Mauro (1999). A pair was observed over tall subcoastal primary and secondary semi-evergreen forest and woodland in January 1996 (Coates & Bishop 1997, Bishop & Brickle 1999). Most recent tour group records are from the Lorulun area, 20 km north of Saumlaki, but there are records closer to Saumlaki.

Taxonomic status

In using levels of DNA differentiation to assess taxonomic assignments of species and subspecies, Norman *et al.* (1998) and Christidis & Norman (2010) advocated the requirement to include a relative hierarchical perspective of DNA divergences in the genus of interest. The relevant DNA data dealing with the taxonomy of the *Aquila fasciata* species-complex are summarised below.

The taxonomy of Bonelli's Eagle and the African Hawk Eagle *Aquila spilogaster* has been a contentious issue. Long regarded as a single species (Brown & Amadon 1968), the recent tendency is to treat the two as separate species (Thiollay 1994, Ferguson-Lees & Christie 2001). The consistent morphological, plumage and behavioural differences have been cited as evidence for species-level separation. Lerner & Mindell (2005) give a molecular perspective through their examination of mitochondrial DNA differentiation in a range of birds of prey, including Bonelli's Eagle and African Hawk Eagle. Between the two species there were 16 and 18 base-pair differences in cytochrome *b* and ND2, respectively. These figures were larger than those recorded between other species-pairs identified in the study: Wedge-tailed Eagle *Aquila audax* and Gurney's Eagle *A. gurneyi*; and Little Eagle *Hieraaetus morphnoides* and Booted Eagle *H. pennatus*. Although not conclusive, the DNA data support separate species treatment for *Aquila fasciata* and *A. spilogaster*.

Apart from the three individuals of *A. fasciata* examined by Lerner & Mindell (2005), cytochrome *b* data are available for a further six individuals. Haring *et al.* (2007) lodged a 264-base-pair fragment on GenBank (accession numbers EF459628–EF459631) from two individuals of *A. f. fasciata* (one from Italy and one with no locality information), and two individuals of *A. f. renschi* from Flores. Helbig *et al.* (2005) examined a 1,143-base-pair fragment from an individual of *A. f. fasciata* from Israel, and Bunce *et al.* (2005) examined 1,017 base pairs in another *A. f. fasciata* individual (no locality data). In addition, JAN & LC sequenced 409 base pairs of an individual *A. f. renschi* from Timor, feathers of which were collected by JO. A 217-base-pair fragment was common to all five studies, and this was compared across the three individuals of *A. f. renschi* and seven individuals of *A. f. fasciata* examined. There were only three variable sites, and this variation was limited to a unique base change in each of three individuals of *A. f. fasciata*. By excluding the four samples from Haring *et al.* (2007), it was possible to compare a 267 base-pair fragment across the remaining six individuals, but this did not reveal any additional variation. There were no differences recorded between *A. f. renschi* and the common *A. f. fasciata* haplotype. The negligible cytochrome *b* variation recorded was, therefore, limited to comparisons within *A. f. fasciata*. This lack of any molecular differentiation between the subspecies *A. f. fasciata* and *A. f. renschi* is consistent with a very recent separation.

Variation in a 253-base-pair fragment of the mitochondrial control region was assessed in 72 individuals of *A. f. fasciata* from Spain, Portugal and Morocco by Cadahía *et al.* (2007). They found four mitochondrial types each differing from the other by a single base-pair change. Moreover, there did not appear to be any geographic structure to the genetic variation observed across the populations surveyed. One explanation offered for the low levels of genetic variation was a loss of genetic variation caused by population reduction during the Pleistocene glaciations, and more recently through human activities such as habitat clearance and hunting.

Control-region sequence data for *A. fasciata* have also been lodged on GenBank (Accession Numbers EF459585–459588) by Haring *et al.* (2007). Unfortunately, the 237-base-pair fragment does not correspond to the region examined by Cadahía *et al.* (2007). The control-region data of Haring *et al.* (2007) was obtained from the same specimens that cytochrome *b* data were obtained (see above): two individuals of *A. f. fasciata* (one from Italy and one with no locality information) and two individuals of *A. f. renschi* from Flores. The *A. f. fasciata* individual from Italy differed by 5–6 changes from the other three individuals. The remaining three individuals differed from each other by 1–2 changes. Although the level of variation is low, there is nevertheless more variation recorded within *A. f. fasciata* than between *A. f. fasciata* and *A. f. renschi*.

Both the cytochrome *b* and control-region DNA datasets showed similar patterns: low levels of DNA variation across the range of *A. fasciata*; no diagnostic DNA marker distinguishing *A. f. fasciata* from *A. f. renschi*; and more variation within *A. f. fasciata* than between the two subspecies. Although this pattern of variation

MARK SCHELLEKENS

Plate 1. Captive juvenile Bonelli's Eagle *A. f. renschi* on Flores, Indonesia, 14 October 2004. The captive bird was kept tethered to a wooden plank, by a short rope tied to one ankle; the bird had a small wound on the underside of its carpal joint, and an overgrown bill.

could be indicative of a slow rate of mitochondrial evolution in *Aquila*, the comprehensive cytochrome *b* and ND2 datasets of Lerner & Mindell (2005) do not provide any such indication. The widely disjunct distributions of *A. f. fasciata* and *A. f. renschi* also make it unlikely that a lack of differentiation is caused by past bottlenecks. It is difficult to envisage similar genetic bottlenecks occurring in such widely separated populations.

Juvenile morphology

Colour photographs (Plates 1 & 2) and other unpublished images of the same birds show that juveniles of *A. f. renschi* are similar in plumage to juveniles of the nominate subspecies, with few evident differences (V. Hernández *in litt.* 2007). The photographic evidence shows colour variation within the range of that of juvenile Eurasian Bonelli's Eagles. However, Wallacean birds are more lightly built than Eurasian birds. Juveniles of each subspecies would be indistinguishable, and only separable by measurement (V. Hernández *in litt.* 2007).

Biology

There is little information on the feeding ecology or breeding biology of Bonelli's Eagle in Wallacea. A bird was observed feeding on a Green Junglefowl *Gallus varius* carcass at Gn Ranaka, Flores, in August 2007 (Myers 2007), an adult bird was photographed holding a village chicken *Gallus* sp. near Gn Ranaka in 2011 (Plate 3), and in September 2011 an adult Bonelli's Eagle at Pagal, Flores, delivered a chicken *Gallus* sp. or a rallid to a juvenile (Robson 2011). In Ruteng, west Flores, Bonelli's Eagle were twice (in separate years) observed flying low over the town, and were suspected to be searching for village chickens (J. Eaton *in litt.* 2013). Other likely prey within their range includes Pink-headed Imperial Pigeon

COLIN R. TRAINOR

Plate 2. Captive juvenile Bonelli's Eagle in Timor-Leste, 10 April 2003.

Plate 3. Adult Bonelli's Eagle in flight near Mt Ranaka, Flores, holding a village chicken, 30 August 2011.

MARC THIBAULT

Ducula rosacea, Green Imperial Pigeon *D. aenea*, Timor Black Pigeon *Turacoena modesta* and other forest pigeons, cuscus *Phalanger* sp., rats (Muridae) and medium-sized fruit-bats (Pteropodidae) that roost in caves, forests and savannah palms. A nest was found on 12 July 2003 on Gn Ranaka, Flores, at 1,420 m: an adult was sitting on the nest in a tree and the mate flew in with prey (J. M. Thiollay *in litt.* 2013). A second nest was found at Lermatang on Yamdena, Tanimbar islands, on 22 May 2008 (Yong & Lee 2008): it was about 20–25 m up in a forest tree, approximately 1.5 m in diameter and consisted of sticks and vines. It was unclear whether the pair were sitting on eggs or had young, but they were actively managing the nest.

DISCUSSION

This review confirms that Bonelli's Eagle is more widespread in the Lesser Sundas than previously believed; recent new records from nine islands in addition to the nine where it was previously recorded have extended its range to a land area of about 87,400 km^2. The distinctiveness of the isolated Lesser Sunda population has been subject to ongoing speculation, due to its smaller size and plumage differences compared with *fasciata*; the tail being more strikingly barred and belly, thighs and crissum more boldly marked (Ferguson-Lees & Christie 2001). However, the negligible levels of genetic differentiation between *A. f. renschi* and *A. f. fasciata* do not support the contention of Thiollay (1994) and Ferguson-Lees & Christie (2001) that *renschi* should be accorded full species status, although it is harder to argue against subspecific recognition for both forms. The patterns of DNA variation are more consistent with the relatively recent arrival of *renschi* in the Lesser Sundas and it may have been introduced from Eurasia (see below). Accordingly, the smaller size of *renschi* and the plumage differences between it and *fasciata* would also have evolved relatively rapidly.

Within the archipelago Flores and Timor appear to be strongholds, with many records from human-modified landscapes, but this may be partly a result of greater observer effort on these islands compared with elsewhere. The lack of earlier records from Sumba and Sumbawa, and recent records from other islands, may partly reflect bias of historical collectors and recent increase in survey effort (M. Bruce *in litt.* 2007). For example, there was a reluctance to collect cumbersome large specimens including raptors because of the relatively high shipping costs (Hartert 1904). Sumba is relatively well surveyed, and tour parties now visit annually, so the paucity of records suggests that it is either a rare resident, or that birds are occasional visitors from nearby islands. Knowledge of the avifauna of Roti is improving (Verheijen 1975, Trainor 2005b, Collaerts *et al.* 2011, P. Verbelen *in litt.* 2010), but there are no records of Bonelli's Eagle from this largely deforested island. Lack of records from other largely deforested islands (Sawu [Sabu], Semau and Kisar) suggests that a minimum level of forest cover is necessary to sustain populations of the species. This could be associated with the scarcity of large prey species, such as frugivorous pigeons (Newbold *et al.* 2013), in agricultural land or savannah woodland.

There are insufficient data to comment on population trends, but Bonelli's Eagle appears to be holding its own at present, although the extensive and rapid deforestation in Indonesia (Brooks *et al.* 1999) may adversely affect it. The species's Indonesian (at the time including East Timor) conservation status was assessed as 'no immediate danger' (van Balen 1994), and there seems no reason to amend this at present. The species currently occurs in cultivated lands and secondary forest as well as natural habitats.

Hunting either for food, or to reduce the perceived impact on village livestock, might also affect populations of Bonelli's Eagle. Hunting is part of life for many villagers in the Lesser Sundas. On some islands, hunters are often armed with powerful air-rifles (comparable with a .22 rifle) and children have powerful slingshots. They shoot a wide range of wildlife, including raptors, and climb trees to collect nestlings for food. As a predator of village chickens, Bonelli's Eagle is likely to be targeted to reduce the perceived impact on economically important village livestock. Raptor nestlings are commonly taken captive, and suffer casual, habitual cruelty in captivity. A captive juvenile Bonelli's Eagle was photographed tethered by a metal ring on one ankle attached to a short rope and, not surprisingly, the bird had bumblefoot (a bacterial infection and inflammatory reaction) in the shackled foot as well as cere damage and abraded carpals (Plate 1). Another captive juvenile/subadult bird owned by a foreign defence worker in Timor-Leste was housed in a chicken wire cage at a United Nations military compound for months. It had serious cere damage (CRT unpubl. data). CRT has also seen at least two other captive Bonelli's Eagles in Timor-Leste, although there may be many more out of sight.

Conservation priorities include further field surveys on the large islands of Sumba, Sumbawa, Wetar and Yamdena and on islands where there are no records (e.g. Babar, Moa, Roti, Solor and Lembata). The single largest tropical forest in the Lesser Sundas is in west Sumbawa (about 2,000 km^2) (Jepson *et al.* 2001), whilst Wetar retains more than 97% forest cover; both deserve specific surveys for Bonelli's Eagle. The breeding biology of this subspecies is essentially unknown, so it would be useful to monitor population levels and breeding success at selected sites on various islands. There is also a need for an environmental education campaign to discourage persecution of eagles in general, improve the lot of captive birds, and encourage local people to 'own' and value such iconic species (Burnham *et al.* 1994, Salvador 1994). In Timor-Leste, for example, the campaigns should also target foreign nationals (military and embassy staff). Effective conservation of Bonelli's Eagle and other raptors in Wallacea is likely to deliver broader biodiversity benefits (Sergio *et al.* 2006).

Origins of the Wallacean population

The isolated populations of Bonelli's Eagle, and Short-toed Snake-Eagle *Circaetus gallicus*, in Wallacea stand out as zoogeographically anomalous—usually explained as relicts from past climatic and sea-level changes (Voris 2000). But it may be important to consider the human history of these islands; the first Dutch ships arrived in Indonesia (East Indies) in 1596 and determined exploitation started around 1830. The first Europeans to visit Timor were Portuguese, perhaps as early as 1512, and the Dutch occupied Kupang in present-day West Timor in the mid-seventeenth century, beginning a long conflict for control of the sandalwood trade. The Dutch controlled most of the Lesser Sundas from the 1600s, but the Portuguese held Flores (especially east Flores with forts on nearby Adonara and Solor) and East Timor, including the Ambeno (Oecusse) enclave, for long periods (Fox 2003).

Before assuming that the eagle occurs naturally on these islands, it is important (but difficult) to rule out the possibility that Bonelli's Eagles were transported from Europe or South Asia (notably India where the Portuguese also had colonies) by Dutch or Portuguese traders or settlers. Europeans may have introduced eagles to their Indonesian colonies as mascots, pets or falconry birds, perhaps from Iberia, North Africa or South Asia. Other birds, junglefowl *Gallus* spp., and Red Avadavat *Amandava amandava* are thought to have been introduced to the Lesser Sundas several centuries ago. The Red Avadavat is represented in the Lesser Sundas by the subspecies *flavidiventris*, which occurs naturally in South Yunnan (China), Thailand and Myanmar (White & Bruce 1986). There was also much movement of various animals, by Asian and Melanesian peoples, between Asia, Wallacea and New Guinea (Heinsohn 2003). Alternative hypotheses that need to be investigated include vagrant Bonelli's Eagles from Asia settling in the Lesser Sundas.

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***Colin R. TRAINOR**, Research Institute for the Environment and Livelihoods, Charles Darwin University, Northern Territory 0909, Australia. Email: halmahera@hotmail.com*

***Stephen J. S. DEBUS**, Division of Zoology, University of New England, Armidale, NSW 2351, Australia. Email: sdebus@une.edu.au*

***Jerry OLSEN**, Institute for Applied Ecology, University of Canberra, ACT 2601, Australia. Email: jerry.olsen@canberra.edu.au*

***Janette A. NORMAN**, Department of Genetics, University of Melbourne, Parkville, Victoria, 3001, Australia. Email: janorman@unimelb.edu.au*

***Les CHRISTIDIS**, National Marine Science Centre, Southern Cross University, Coffs Harbour, NSW 2450, Australia. Email: les.christidis@scu.edu.au*

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The species of white-nest swiftlets (Apodidae, Collocaliini) of Malaysia and the origins of house-farm birds: morphometric and genetic evidence

EARL OF CRANBROOK, GOH WEI LIM, LIM CHAN KOON & MUSTAFA ABDUL RAHMAN

The taxonomy of South-East Asian swiftlets (Apodidae, Collocaliini) has proved challenging because of their limited variation in size and plumage colouration. Of particular interest are 'white-nest' swiftlets, whose nests, built almost entirely of hardened secretions from paired sublingual salivary glands, are valued in the edible birds'-nest trade. The natural breeding sites of white-nest swiftlets are caves or grottoes but, for over a century, there has been a progressive increase in numbers occupying man-made structures. Through most of South-East Asia there is now a developed industry, utilising sophisticated practices to attract and retain white-nest swiftlets in purpose-made buildings, known as 'house-farms'—a novel form of domestication. A review of the systematics of wild populations based on museum skins collected in late nineteenth and early twentieth centuries, before the expansion of house-farms, concludes that there are two largely allopatric species of white-nest swiftlet in Malaysia, identified as Grey-rumped Swiftlet *Aerodramus inexpectatus*, with subspecies *A. i. germani* and *A. i. perplexus*, and Thunberg's or Brown-rumped Swiftlet *Aerodramus fuciphagus*, with subspecies *A. f. fuciphagus* and *A. f. vestitus*. During 2003 to 2010, house-farm swiftlets in southern Thailand, east and west coasts of Peninsular Malaysia, Sarawak, Java and southern East Kalimantan, Indonesia, were photographed to show variability in plumage of the rump. House-farm birds of Sarawak resembled neither of the wild species occurring naturally in the state. Tissue samples from embryos in eggs were collected for genetic studies from house-farms in Medan, Sumatra, west and east coasts of Peninsular Malaysia, and Sibu, Sarawak. Results of phylogenetic analyses, *AMOVA* and pairwise F_{ST} comparison based on the partial cytochrome-*b* sequence are presented. Of the 11 haplotypes identified, two are restricted to a wild population of Brown-rumped Swiftlets *A. f. vestitus* of Middle Baram, Sarawak, thereby shown to be genetically distinct from house-farm birds. One haplotype is common among all house-farm birds, two are unique to Medan, three and one to Kuantan and Endau-Rompin, respectively. The birds from Sarawak share haplotypes with all other house-farm populations in Peninsular Malaysia and Medan, Sumatra. The evidence for two clades within house-farm samples indicates that Peninsular Malaysian birds combine genetic components from north (*A. inexpectatus germani*) and south (*A. f. fuciphagus*). Sarawak house-farm birds are similar to east coast Peninsular Malaysian populations in plumage characters and genes, and apparently arrived by spontaneous immigration from Peninsular Malaysia. If hybrids have arisen among Malaysian house-farm white-nest swiftlets, they are excluded from regulation by the International Code of Zoological Nomenclature.

INTRODUCTION

Swiftlets are small swifts Apodididae, subfamily Apodinae, tribe Collocaliini (Chantler 1999), inhabiting the Indo-Pacific region and reaching greatest diversity in South-East Asia. A shared character of most swifts, including swiftlets, is the production of a dense secretion from a pair of sublingual salivary glands that serves as structural or binding material to form the nest (Chantler 1999). Termed 'nest-cement', this salivary secretion is the edible component, and is sufficiently copious in the nests of some swiftlets to make them commercially valuable. Edible birds'-nests have been esteemed in Chinese society since at least the late sixteenth century, and there is a long history of harvesting from natural wild colonies (Medway 1963, Lim & Cranbrook 2002). Most sought-after and expensive are 'white' nests, composed wholly of the edible salivary material with, at most, the incorporation of a few small feathers from the body plumage of the adult birds, probably adhering accidentally.

Sequencing of genetic material (mitochondrial DNA; mtDNA) derived from commercial edible birds'-nests has distinguished authentic nests of Indonesian white-nest swiftlets from counterfeit products derived from nests of House Swift *Apus affinis* = *nipalensis* (Lin *et al.* 2009). However, this study did not attempt to discriminate between the nests of different swiftlet species.

One, two or three species of white-nest swiftlet?

Lack of distinctive external characters has caused persistent difficulty in defining species limits among swiftlets. For many years all were included in a single genus *Collocalia*. A series of papers by Stresemann (1914, 1925, 1926) culminated in a revision of species in the Malaysian subregion (Stresemann 1931). In this paper, the author acknowledged the loan of swiftlet skins from the Raffles Museum, Singapore, supplemented by specimens in the museums at Tring, Leiden and Berlin. Basing his taxonomy chiefly on wing length, tail length and furcation, and tarsal feathering, Stresemann (1931) combined a group of dull blackish-brown swiftlets in a single widespread Indo-Malayan species for which the prior name was *Collocalia francica* (Gmelin, 1789), the Mascarene Swiftlet. He noted that the type of nest was variable within this species, as defined, and listed subspecies building white nests: *germani*, *inexpectata*, *javensis*, *vestita* and *micans*. Of these, three occurred in localities now within Malaysia and Singapore.

First, Germain's Swiftlet *Collocalia francica germani* Oustalet, 1876, type locality Pulau Condore (=Con Son island), Vietnam (Plate 1A), was seen by Stresemann (1931) in the form of skins collected in 1913 by H. C. Robinson on Koh Pennan (= Koh Phangan), east coast of peninsular Thailand (Plate 1B). He characterised these birds as having tarsus invariably unfeathered, and rump much paler than the back, 'whitish grey with blackish shafts'; wing 113–121 mm, tail 5–53 mm, furcation 5–7 mm. Thus defined, *C. f. germani* extended through southern (peninsular) Thailand and Peninsular Malaysia 'nearly as far as Johore'. At this point, Stresemann considered that *C. f. germani* intergraded with a subspecies having rump 'as a rule of the same colour as the back'. However, in the transition zone, 'individual variation is great in some localities, specimens with dark rumps being found together with light-rumped ones' (Stresemann 1931: 87). The dark-rumped subspecies was identified as *C. f. vestita* (Lesson, 1843), type locality Sumatra, and the variable population in the transition zone as *germani* >< *vestita*. This nomenclature indicated a north–south cline among white-nest swiftlets in Peninsular Malaysia, from a subspecies that was pale grey-rumped with dark shaft-streaks to a uniformly dark-rumped subspecies, across a transition zone in the south where individuals of both patterns were mixed. Although shown below to be erroneous, this interpretation by a respected ornithologist proved influential on subsequent opinion.

Stresemann (1931) also applied the name *vestita* to dark-rumped specimens from Borneo, of which he saw six in the Berlin Museum from Tamaluang cave, East Kalimantan, and ten in the Raffles Museum from eastern North Borneo (now Sabah). He found no valid name for the dark-rumped white-nest swiftlets of Java, which he described as a new subspecies *C. francica javensis*, type locality Ceribon (Stresemann 1931: 89–90), distinguished by rump 'a little paler than the back but by no means as light as in *germani*', wing 109–116 mm, tail 49–53 mm, furcation 4–7 mm (*n*=6). He also noted that a series of eight swiftlets collected by Chasen in Singapore had 'mostly a very great similarity with the Javanese *C. f. javensis*', wing 113–118 mm, tail 47–52 mm, furcation 4–7 mm (Plate 2D).

The first modification of Stresemann's (1931) scenario followed a survey of the birds'-nest caves of Sabah by Chasen (1931). New specimens, not seen by Stresemann, showed that grey-rumped swiftlets occupied small caves and grottoes on the Mantanani Islands (Plate 1D), off the west coast, and Berhala Island in Sandakan harbour, on the east coast (Plate 1E), while the white-nest swiftlets in caves at Gomantong, 'only a few miles away and within sight of Berhala', were dark-rumped (Plate 2F). On the grounds that, despite the close proximity of Berhala and Gomantong, the grey-rumped and dark-rumped white-nest swiftlets remained distinct, Chasen (1935) treated the two populations as separate species. The grey-rumped swiftlets from Sabah islands he considered to be to be 'absolutely inseparable from true *germani*' (Chasen 1935), and followed Stresemann (1931) in listing these under the trinomial *C. francica germani*. He also recognised that the distinct dark shaft-streaks of the dull brownish grey rump of *C. francica perplexa* Riley, 1927 of Maratua Islands, East Kalimantan, Indonesia, confirmed affinity with *germani* and therefore included this as a subspecies among the grey-rumped swiftlets. For the dark-rumped birds, he raised the name *vestita* to species rank, with the English name Brown-rumped Swiftlet. He also noted that Brown-rumped Swiftlets occurred at other inland caves in Sabah, at Baturong, Madai, Tapadong and, once again not far from the coast, near Lahad Datu.

In Sarawak, white-nest swiftlets of the two kinds were recorded by Banks (1935), again separated by habitat but nonetheless treated as a single species. Grey-rumped Swiftlets (as *C. francica germani*) occurred 'in several suitable places around the coast, such as the two Pulo Satang and Pulo Lakei, nesting in the soft sandstone crevices'. At inland localities in Sarawak, Banks (1935) recorded dark-rumped white-nest swiftlets (as *C. francica vestita*) in limestone caves of the Middle Baram. The only other locality for *vestita* in Sarawak known to Banks (1935) was a small colony in a sandstone cave in Ulu Suai, yielding 'a couple of katties' of nests (i.e., around 140 nests).

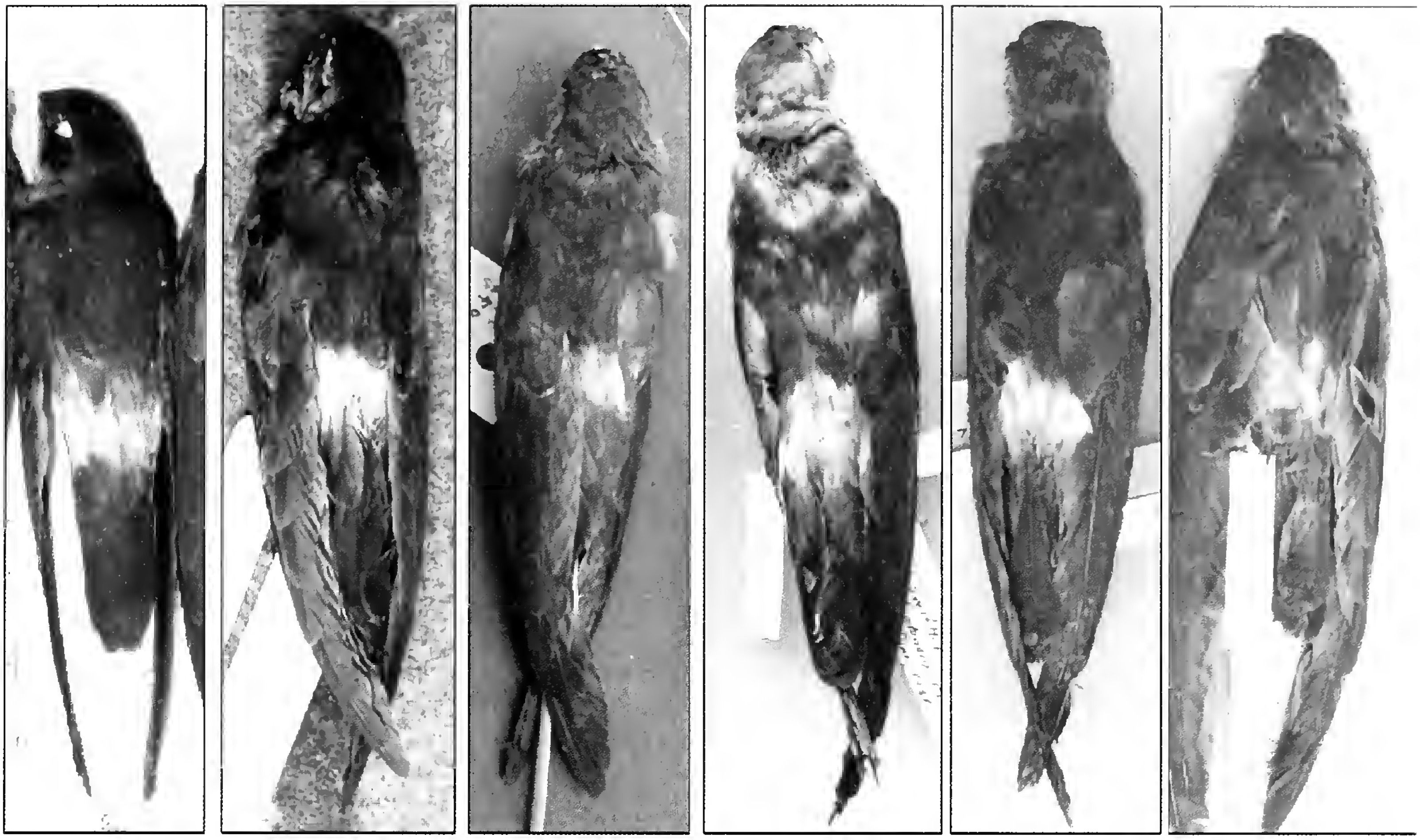
In Peninsular Malaysia all nesting records of white-nest swiftlets were from coastal or island locations. No occupied inland caves were known (and none has since been discovered). On the west coast Chasen (1935, 1939) and his successor at the Raffles Museum, Gibson-Hill (1948, 1949), agreed that white-nest swiftlets from peninsular Thailand and islands of northern Peninsular Malaysia were identical with topotypes of Germain's Swiftlet (Plate 1A, 1B), displaying a pale grey rump, almost white, with distinct, broad dark longitudinal stripes that involve both shafts and vanes of the rump feathers. The west coast range of these 'Northern Grey-rumped Swiftlets' (*C. francica germani*) included Penang and Selangor. On the evidence of Allen (1948), Gibson-Hill (1949) provisionally added the Sembilan Islands, Perak.

White-nest swiftlets of the south of Peninsular Malaysia, including east coast islands and rocky stacks of the Pahang-Johor archipelago (specifically, Tioman, Tinggi and Tokong Gantong), were characterised by Chasen (1939) as having the rump darker than Northern Grey-rumped Swiftlets. Judging that this character justified separation at subspecies level, Chasen (1939: 123) called these birds 'Southern Grey-rumped Swiftlets', and 'found it convenient to use for them the name proposed by Dr H. C. Oberholser, *amechana*'. At the same time, echoing Stresemann (1931), he reiterated the mixed appearance of the swiftlets in south Peninsular Malaysia: 'There is a considerable amount of variation in the colour of the rump: in some birds it is almost as pale as in the northern subspecies, *C. f. germani*, but in other specimens it is much darker and only slightly paler than the back'. In a later survey of the east coast islands Gibson-Hill (1948) found white-nest swiftlet colonies from Pulau Nyireh in the Tenggol group, Terengganu, through the Tioman archipelago, Pahang, to the Pulau Tinggi group and Pulau Batu Gajah, Johor. Following Chasen, he too identified these as *C. francica amechana* (Gibson-Hill 1949).

To be consistent with his discoveries in Borneo, Chasen (1935, 1939) recognised dark-rumped birds sympatric with Southern Grey-rumped Swiftlets in the south of Peninsular Malaysia as a second species, Brown-rumped Swiftlet *Collocalia v. vestita*, conspecific with those of interior caves of Borneo to which he applied the trinomial *C. vestita maratua* Riley, 1927. However, he was unwilling to overturn the views of Stresemann on the north–south cline in Peninsular Malaysia. Commenting on his decision to recognise the species *C. vestita*, Chasen (1935) wrote: 'but otherwise, in our arrangement of this very difficult genus, we follow the latest reviewer, Dr E. Stresemann in *Bull. Raffles Mus.* 6. 1931, p. 83.' Gibson-Hill (1949: 110) took a narrower view, identifying Brown-rumped Swiftlet 'only from Tioman [island], where it is breeding in the neighbourhood of Juara Bay, and the adjacent coast of Johore'.

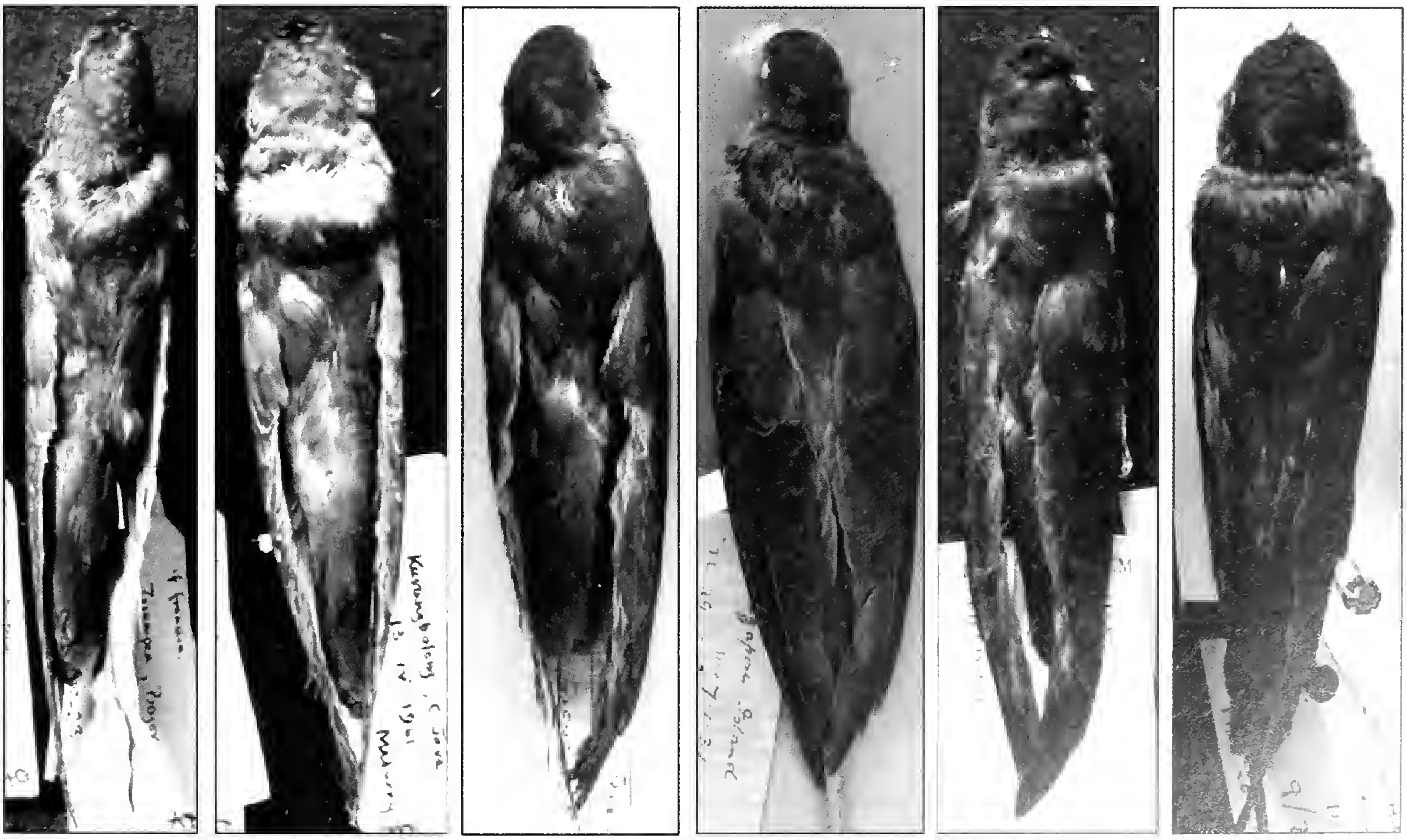
Opinion subsequently remained unsettled on species limits and nomenclature of the white-nest swiftlets of territories now comprising Malaysia. In Borneo, Smythies (1957) recognised two species, noting that among the grey-rumped group Hume's Swiftlet *Collocalia inexpectata* Hume, 1873, type locality Andaman Islands, had priority and therefore naming the birds of Sarawak and Sabah *C. inexpectata germani*, restricting *C. i. perplexa* to the type locality, Maratua Island. For the Brown-rumped Swiftlets, Smythies (1957) restricted *Collocalia vestita vestita* to the Natuna Islands, Indonesia, and *C. v. maratua* to Maratua Island, applying *C. vestita mearnsi* Oberholser, 1912 to birds of mainland Borneo. Later, Smythies (1960) retained this treatment of Brown-rumped Swiftlets, but placed the Grey-rumped Swiftlets in *Collocalia francica*, and subsequently in *C. fuciphaga* (Smythies 1968).

Meanwhile, Medway (1966a) showed that the type of nest is a reliable taxonomic indicator among swiftlets, and that an unmistakable illustration of a white edible nest accompanied the description of *Hirundo Fuciphaga* Thunberg, 1812, overlooked by Stresemann (1914). This is therefore the oldest available systematic name for white-nest swiftlets of Java, reducing Stresemann's *javensis* to synonymy. Nuclear and mitochondrial DNA sequencing has subsequently confirmed that Mascarene Swiftlet (now *Aerodramus francicus*) is a distinct species, confined to Mauritius and Réunion, Indian Ocean (Johnson & Clayton 1999). Medway (1966a) accepted the existence of a north–south cline through Peninsular Malaysia to Singapore, linking Germain's or Northern Grey-rumped Swiftlets with the dark-rumped swiftlets of Java, but differed from previous opinion by proposing that sympatry of grey-rumped and brown-rumped taxa in north and north-west Borneo could be explained if the two forms were the ends of a *Rassenkreis* or 'circle of overlap' (Mayr 1942), thereby justifying their inclusion in a single 'ring' species.



1A 1B 1C 1D 1E 1F

Plate 1. Grey-rumped Swiftlets *Aerodramus inexpectatus* from caves.
(**1A**) Topotype *A. i. germani* from Pulau Condore, Vietnam. 1882, USNM. (**1B**) Koh Phangan, Thailand. 1912, AMNH. (**1C**) Satang Kechil, Sarawak. 1932, RMBR. (**1D**) Manttanani, Sabah. 1931, RMBR. (**1E**) Berhala, Sabah. 1931, RMBR. (**1F**) *A. i. perplexus* from Maratua. 1927, RMBR.



2A 2B 2C 2D 2E 2F

Plate 2. Thunberg's Swiftlet *A. f. fuciphagus* and Brown-rumped Swiftlets *A. f. vestitus* from caves.
(**2A**) Thunberg's Swiftlet from inland cave at Jampea, Java. 1960, NHMUK. (**2B**) Thunberg's Swiftlet from coastal cave at Karangbolong, Java. 1960, NHMUK. (**2C**) Topotype of Brown-rumped Swiftlet from Sumatra. USNM. (**2D**) Thunberg's Swiftlet from Singapore. 1931, RMBR. (**2E**) Brown-rumped Swiftlet from Baram, Sarawak. 1957, NHMUK. (**2F**) Brown-rumped Swiftlet from Gomantong, Sabah. 1958, NHMUK.

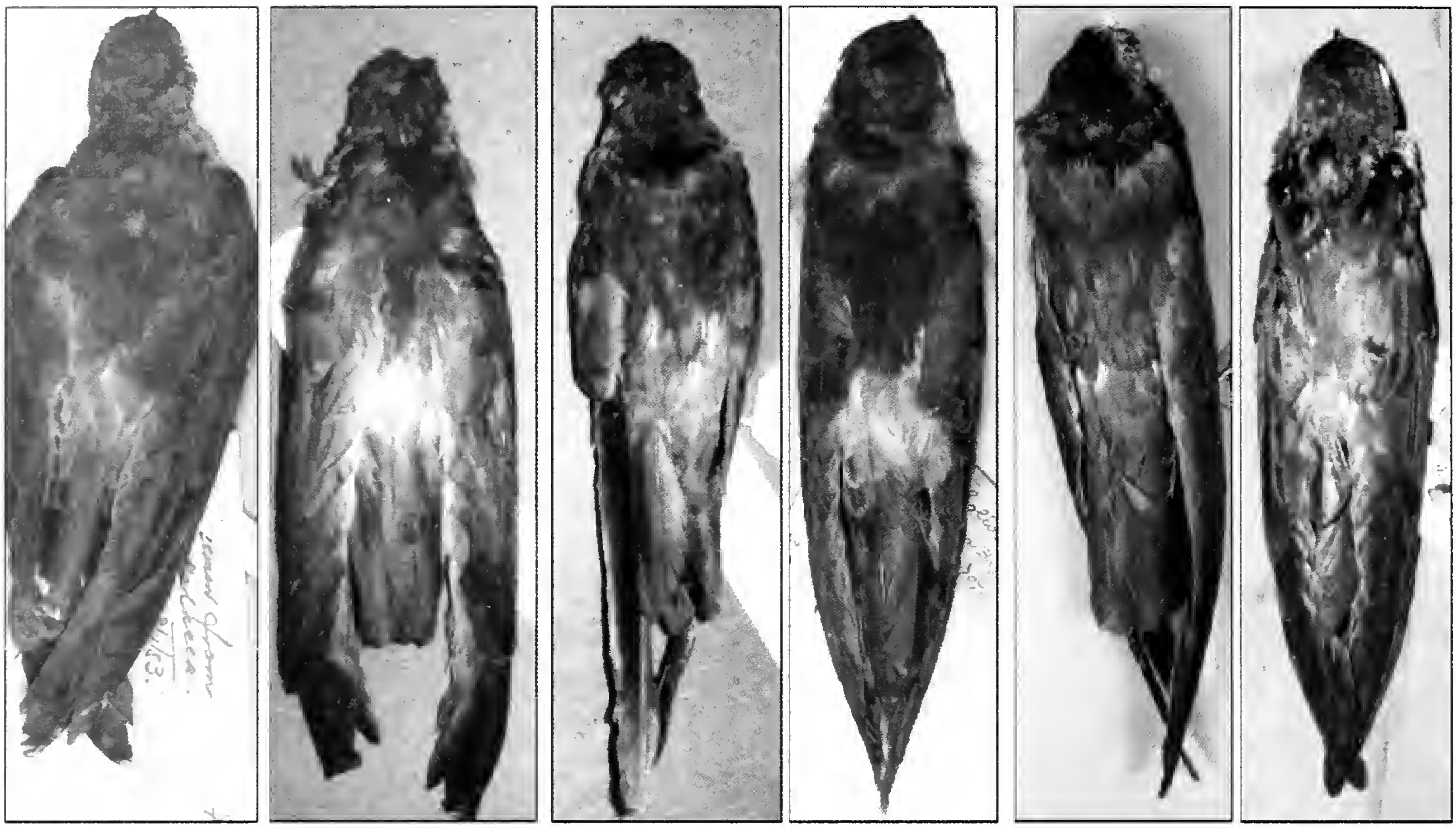


Plate 3. Sympatric specimens of Grey-rumped Swiftlet and Thunberg's Swiftlet collected around 3°N in Peninsular Malaysia.
(**3A**) *A. inexpectatus germani* from Malacca. 1953, RMBR. (**3B**) *A. inexpectatus* from Selangor. 1879, NHMUK. (**3C**) *A. fuciphagus* from Selangor. 1887, NHMUK. (**3D**) *A. inexpectatus* from Tioman. 1907, RMBR. (**3E**) *A. fuciphagus* from Tioman. 1907, RMBR. (**3F**) *A. amechanus* topotype from Anamba Is., Indonesia. 1899, USNM.

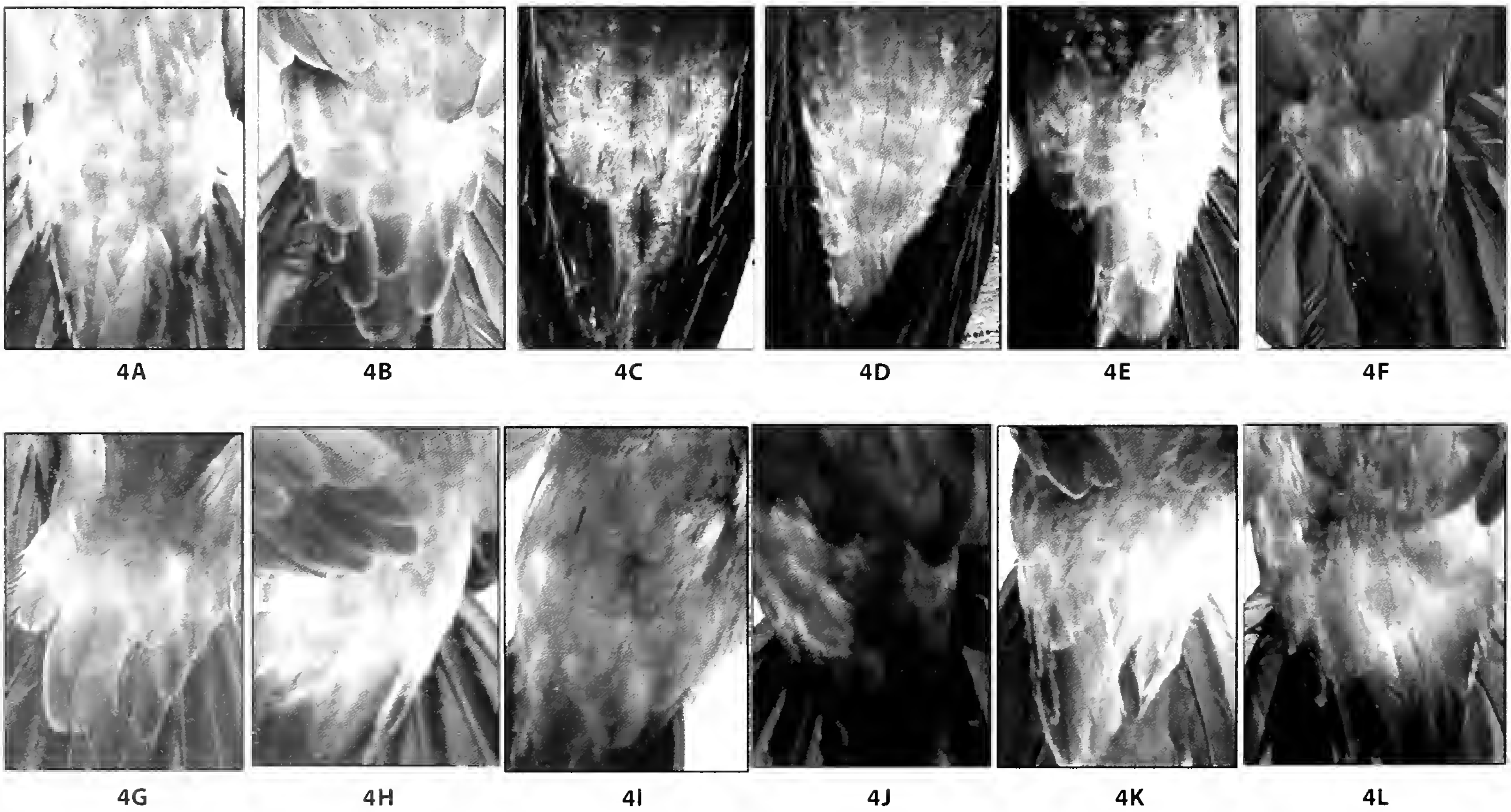


Plate 4. Variations in rump shade in house-farm birds.
(**4A**) Bukit Imbiah, Singapore. (**4B**) Sajira, Java. (**4C**) Pak Phanang, Thailand. (**4D**) Miri, Sarawak (**4E**) Kuching, Sarawak. (**4F**) Penang. (**4G**) Penang. (**4H**) Kota Bharu. (**4I**) Pusing, Perak. (**4J**) Johor Bahru. (**4K**) Johor Bahru. (**4L**) East Kalimantan.

Brooke (1970, 1972) divided the swiftlets into three genera, recognising the Giant Swiftlet (now Waterfall Swift) as monotypic *Hydrochous gigas* and, among the remainder, restricting *Collocalia* to the small swiftlets with glossy plumage and separating as *Aerodramus* the group of middle-sized drab blackish-brown species, to which white-nest swiftlets belong. Until the discovery that the Pygmy Swiftlet *Collocalia troglodytes* utters an echolocating call (Price *et al.* 2004), it was thought that the capacity to orientate in darkness by echolocation was a further defining character of *Aerodramus*. Monroe & Sibley (1993), Inskipp *et al.* (1996) and, following these checklists, regional field guides by Lim & Gardner (1997) and Robson (2002) continued to combine all species except the Waterfall Swift in the genus *Collocalia*. However, molecular studies have confirmed genetic boundaries between *Hydrochous*, *Aerodramus* and *Collocalia* (Lee *et al.* 1996, Thomassen *et al.* 2003, 2005), and these genera were recognised by Chantler (1999), Smythies (1999), Wells (1999), Strange (2001), Mann (2008) and Phillipps & Phillipps (2009).

Salomonsen (1983: 65) suggested that there could be three white-nest species: *Collocalia fuciphaga* (with *vestita*, *dammermani*, *micans* and *inexpectata* as subspecies), *C. germani* (with *amechana*) and possibly *C. perplexa* with *amelis* of the Philippines. Monroe & Sibley (1993) recognised two species: *Collocalia fuciphaga* (including *inexpectata* and *vestita*) and *C. germani*. In recent publications, Robson (2002) and Phillipps & Phillipps (2009) followed, listing two species: Grey-rumped (*germani*) and Brown-rumped (*vestita* grouped with *fuciphaga*), whereas others including Chantler (1999), Smythies (1999), Wells (1999) Lim & Cranbrook (2002) and Jeyarajasingam (2012) have treated all white-nest swiftlets as a single species under the prior name *Aerodramus fuciphagus*. Wells (1999: 459) criticised the arbitrary nature of species boundaries within clines of changing rump colouration, and called for more research where different-looking populations meet.

Origins of house-farming and house-farm white-nest swiftlets

The propensity of swiftlets to select hollows, rock-shelters or caves as nest sites is reflected throughout their range by many instances of occupation of similar man-made structures, such as culverts, multi-storey car-parks, houses, barns or other buildings. White-nest swiftlet 'farming' began with the spontaneous occupation of buildings by birds and the responses of people. The earliest instances arose in Java, with the first reputedly in 1880 at Sedayu, East Java (Lim & Cranbrook 2002). In western Java, in 1960 Medway (1961) was told that the birds nesting in outbuildings around three sides of a courtyard of a large country house, near Jakarta, had been present for about 60 years. Elsewhere in Java by that time there were already many buildings, domestic or industrial, in which colonising swiftlets had been encouraged by a variety of modifications to thrive and increase. From such beginnings, enterprises steadily developed. The buildings involved, whether modified from existing structures or purpose-built, have become known in English as 'house-farms', and the management of the swiftlet colonies within them as 'house-farming' (e.g. Nugroho & Whendatro 1994). The swiftlets occupying house-farms are normally allowed free egress to forage for food and water (Marzuki 1994). An important advance in Java was the discovery that eggs of house-farm swiftlets could successfully be transferred to nests of Linchi Swiftlet *Collocalia linchi*, which will hatch and rear the fostered chicks. The procedure was widely promoted and became standard practice (Nugroho *et al.* 1994).

In Peninsular Malaysia, an early house-farm colony in Penang was studied by Langham (1980). Although wildlife protection legislation covered all swiftlets, thereby rendering illegal any operation involving the handling of the birds or interference with their nests, clandestine house-farm developments continued. Trailing the process in Indonesia, the great expansion of swiftlet house-farming in Peninsular Malaysia was a phenomenon of the last decade of the twentieth century. The town of Sitiawan, Perak, became the foremost mainland centre, with more than 50 shophouses undergoing conversion by the end of 1999 (Ng 2000a). Simultaneously, public health and nuisance concerns were being raised (Ng 2000b). It was claimed that the repeal of Malaysia's Rent Control Act with effect from 1 January 2000 incentivised the process (Tan 2000).

At present, in 2013, few towns are without modified or specially constructed premises and, with government encouragement, others have been erected in rural areas. On the internet, many sites provide video clips of the birds and bird-houses, and several offer consultancies on management and manuals in English, Bahasa Malaysia and Chinese. Active associations of bird-house owners and nest traders have been established in most Malaysian States. A report on the industry by Merican (2007) provided guidance through current complexities and, following an initiative of the Federal Veterinary Department (Fadzilah A'ini 2007), in 2009 the Malaysian Department of Standards published provisional guidelines on good husbandry practice (MS2273:2009P). In the history of the relationship between humans and animals, house-farming of swiftlets has become a prominent and novel form of domestication. Where a systematic name is required, it has been customary to identify house-farm birds as *Aerodramus fuciphagus* or *Collocalia fuciphaga*.

The multiplication of house-farms has not been restricted to Malaysia. Through much of tropical South-East Asia there have been entrepreneurial developments in the adaptation of existing structures and the construction of new, purpose-designed buildings, coupled with practices to attract and hold new colonists, especially the use of recorded vocalisations. Many urban house-farms now exist in Vietnam, notably in Khanh Hoa and Tien Giang provinces and Ho Chi Minh City (Phach & Voisin 2007), and between 2003 and 2009 activity developed in Cambodia (Poole 2010).

The increase in numbers and expanding geographical range of house-farm white-nest swiftlets raise questions on the origins of these birds and their relations with natural wild populations. In Vietnam, Phach & Voisin (2007) found that urban house-farms swiftlets were not the native Germain's Swiftlets of island caves (Phach *et al.* 2002), but resembled the house-farm birds of Sumatra and Malaysia. They concluded that immigration and colonisation of buildings in towns occurred spontaneously during the 1970s. Occupying separate nesting habitats, with different breeding seasonality and dissimilar diets, the two forms behave as separate species. Yet in southern Thailand Aowphol *et al.* (2008), finding very low genetic diversity of mtDNA among swiftlets of ten house-farms along the coasts of the Gulf of Thailand and the Andaman Sea, concluded that this was a single panmictic population, and attributed the observed genetic homogeneity to regular mixing by natal dispersal between wild population in natural sites on coastal islands and house-farm birds on the adjoining mainland. It is an aim of the present paper to discover which, if either, of these contrasting scenarios prevails in Malaysia.

Since the skies are now crowded with house-farm swiftlets, evidence to determine the identity of potential wild ancestors must rely on collections made before the practice was so prevalent, i.e. before the mid-twentieth century. Thanks to good curation, many specimens on which taxonomic judgments can be based still exist in museums in USA, Europe and South-East Asia. A review of historic museum specimens, notably from the overlap zone in southern Peninsular Malaysia, leads to clarification of the original geographic boundaries of wild species and subspecies. A photographic survey of house-farm swiftlets of Malaysia has illustrated plumage variation within and between colonies that can be compared with museum skins. The extent to which this variation is matched by genetic diversity was investigated by sequencing mtDNA cytochrome-*b* (cyt-*b*). From the combined data, it becomes possible to form a view of the relations of house-farm white-nest swiftlets of Malaysia with putative source species.

Other than countries, provinces or states, localities mentioned are listed in a gazetteer (Appendix 1).

METHODS

Morphometric studies

Skins of swiftlets collected in the nineteenth and twentieth centuries, before the expansion of house-farming, were examined in the following museums: American Museum of Natural History, New York (AMNH), United States National Museum, Washington (USNM), National Museum of Natural History, Paris (MNHN), Naturalis, Leiden (RMNH), Sarawak Museum, Kuching (SM), Raffles Museum of Biodiversity Research, University of Singapore (RMBR), and the Natural History Museum, Tring (NHMUK), where loans from the Academy of Natural Sciences, Philadelphia (ANSP) were also seen. Particularly crucial have been skins in RMBR which include those originally seen by Stresemann (1931), Chasen (1935, 1939) and Gibson-Hill (1949). These are now very fragile, and liable to shed feathers at the lightest touch. It has been possible to take photographs but not to risk the handling necessary to check wing or tail measurements.

Between 2003 and 2010, with the agreement of owners or managers, juvenile house-farm birds were photographed on the nest at Pak Phanang, Thailand, and Miri and Kuching, Sarawak. To ensure that they were fully fledged, other birds were caught in flight inside, emerging from or returning to house-farms located in Peninsular Malaysia in the states of Penang, Perak, Kelantan, Terengganu and Johor, and in Sarawak at Miri, Bintulu and Sarikei; also in Indonesia at Sajira, Banten, Java and southern East Kalimantan. The number of swiftlets caught at each house-farm varied from one to four. Birds were held singly in cloth bags for short periods. Standard procedure was then to measure wing-length and tail, closed, note the state of moult in the primary tract and rectrices, photograph the dorsal and ventral aspects, and the feet, and then to release the bird. A dead bird from a new house-farm in Sulawesi was also measured and photographed. In addition, swiftlets in natural colonies occupying the former underground military works at Bukit Imbiah, Sentosa Island, Singapore, were caught and handled by these procedures.

Genetic studies

Eggs or nestlings of white-nest swiftlets were collected from: house-farms at Medan, Sumatra, Indonesia (nine individuals); the west coast of Peninsular Malaysia at Sitiawan, Perak, and Selangor (12 individuals); the east coast of Peninsular Malaysia at Kuantan (11 individuals) and Rompin (five individuals), Pahang, and Endau, Johor (six individuals); and Sibu, Sarawak (four individuals). Six samples were also taken from wild white-nest swiftlets occupying Salai cave, Middle Baram, Sarawak. The collected specimens were kept in 70% ethanol at room temperature at the sampling site and later at –20°C in the laboratory.

Total genomic DNA was extracted from tissue using Promega Wizard® Genomic DNA Purification Kit following manufacturer's instructions. The partial cyt *b* sequence was amplified using the primers Cyt523 (forward) and Thr (Reverse) (Thomassen *et al.* 2003). The polymerase chain reaction (PCR) mixture contains a final concentration of 0.5 μM of each primer, 1 × reaction buffer, 2.5 μM $MgCl_2$, 0.2 μM of each dNTP, and 2.5 unit of *Taq* polymerase and ~60 ng of DNA template. The reaction was run using a Perkin Elmer GeneAmp 9600 Thermocycler with the programme set at 94°C for 3 minutes; 29 cycles of 94°C for 35 seconds, 55°C for 45 seconds and 72°C for 1 minute; 72°C for 5 minutes; hold at 4°C. The PCR products were purified using the Promega PCR Clean-Up System following the manufacturer's instructions. Direct sequencing was commercially done by First Base Laboratories Sdn. Bhd. (Malaysia) (Goh 2007).

The DNA sequences were trimmed to readable bases on both ends of the strands. In most cases the scoring of the bases started by the light-strand complementing the light-strand towards the centre. All sequences obtained were deposited with GenBank (JF269226–JF269236). The cyt *b* haplotypes were defined by ARLEQUIN 3.1 (Excoffier *et al.* 2005) and DNaSP (Rozas *et al.* 2003). Haplotype sequences were aligned using the ClustalX v1.81 (Thompson *et al.* 1997).

The neighbour-joining (NJ) and most parsimonious (MP) trees were reconstructed using 1,000 bootstrap replicates in Molecular Evolutionary Genetic Analysis (MEGA) 4 (Tamura *et al.* 2007) and Phylogenetic Analysis Using Parsimony (PAUP) v4.0b (Swofford 2002), respectively, based on the cyt *b* haplotype matrix. The cyt *b* sequence of two white-nest swiftlet individuals, named as *Aerodramus fuciphagus germani* (DHC04; Price *et al.* 2004) and *Aerodramus fuciphagus vestitus* (DHC40; Price *et al.* 2004), were retrieved from GenBank (accession numbers AY294429 and AY294428, respectively) and incorporated into the phylogenetic analyses. Black-nest Swiftlet *Aerodramus maximus lowi* (Thomassen *et al.* 2003; Genbank accession number AY135623) was included as the outgroup in the phylogenetic trees. The genetic structure of the white-nest swiftlets was estimated using the analysis of molecular variance (AMOVA; Excoffier *et al.* 1992) and the pairwise comparison F_{ST}. Both analyses were performed using 10,000 permutations in the ARLEQUIN software.

RESULTS

Plumage characters and species limits

Historic collections confirm the presence of Grey-rumped Swiftlets on the Mantanani Islands (Plate 1D) and Berhala (Plate 1E) and Brown-rumped Swiftlets in Gomantong caves (Plate 2F), Sabah (NHMUK, RMBR, USNM). Further observations have found only Grey-rumped Swiftlets on other islands of north-west and north Borneo. Sabah records have confirmed Mantanani Islands (Sheldon *et al.* 1983), and Francis (1987) added Batu Mandi, off Kudat, Balambangan Island, and Gaya (Bodgaya) and Si Amil, Sempurna bay. Francis (1987) also noted that birds from the Mantanani Islands had a slightly paler back and whiter rump than those of Berhala, assigning the former to the subspecies *germani* and the latter, by implication, to *perplexus* (Plate 1F). No specimens are available of grey-rumped swiftlets from Gaya or Si Amil, but on geographical grounds these are also likely to be attributable to *perplexus*.

RMBR holds two skins taken in 1932 by Banks on Pulau Satang Kecil, Sarawak (Plate 1C), confirming his record of *germani* from this group of islands (Banks 1935). A specimen was obtained on Satang Kecil in 1957 (NHMUK); it is poorly skinned but nonetheless shows a distinct whitish rump. Tom Harrisson, quoted by Smythies (1957: 653), reported that 'about fifty pairs [have nested] most years since 1947 on Satang Besar and Kechil (two sea caves)'. Repeated searches around both islands from 1998 to 2008 by Lim & Cranbrook (pers. obs.) have failed to find occupied sea caves. Pulau Lakei, a site also mentioned by Banks (1935), and the nearby islet Batu Sarang, were investigated by Lim & Cranbrook (pers. obs.), but only Black-nest Swiftlets were found. These Sarawak colonies of grey-rumped white-nest swiftlets may now be extinct.

Banks's (1935) record of Brown-rumped Swiftlets in limestone caves of the Middle Baram is confirmed by specimens (Plate 2E). Lim (in Lim & Cranbrook 2002) has provided many photographs of this population. In November 1957, Cranbrook visited the sandstone cave in Ulu Suai noted by Banks (1935), and confirmed the presence of white nests. Two skins collected (NHMUK) are indistinguishable from Middle Baram Brown-rumped Swiftlets. In the altered landscape of modern Sarawak, the site has not since been rediscovered.

Skins in RMBR collected in 1953 at Melaka (Malacca), although faded and foxed, show the characteristic pale rump with dark shaft-streaks (Plate 3A), thereby extending the historic range of Germain's or Northern Grey-rumped Swiftlet southwards of previous records on the west coast of Peninsular Malaysia. In April 2009, on a brief visit to the Sembilan Islands, Cranbrook saw no swiftlets around Pulau Rembia, the site of Allen's (1948) observations. However, on the rocky islet known as Batu Putih, underneath the tumble of huge, angular granite boulders, there were separate groups of seven black nests and 11 white nests. There were no eggs, and (around midday) no swiftlets present in the vicinity, leaving the identity of the white-nest builders unverified. Further south and east, a specimen from Horsburgh Light considered a stray by Gibson-Hill (1949) is still in RMBR. This lighthouse (now commonly known at Pedra Branca) was visited on 28 August 2012 when about 40 nests, with young, were present in the building. All were Black-nest Swiftlets and there was no evidence of any other resident swiftlet species (Geoffrey Davison pers. comm.).

Skins in NHMUK are from Selangor around latitude 3°N, near the coast at Kelang and at interior locations. Of six collected (presumably shot in flight) in the vicinity of Kelang by W. Davison in 1879, mostly part of the Hume collection (Collar & Prys-Jones 2012), three (reg. nos 1887.8.1.297, 298 and 299), although faded and foxed with age, show pale rumps with distinct, dark longitudinal shaft-streaks, identifying them as Grey-rumped Swiftlets (Plate 3B). In three others, (1887.8.1.272, 300 and 301), the rump is uniformly coloured with the back, or slightly paler, with only the feather shafts dark, and no dark colour extending to the vanes (Plate 3C). Two other skins from interior Selangor also have dark rumps: 1887.8.1.296 collected April 1879 in Ulu Langat and 1908.12.15 collected in March 1907 (by H. C. Robinson) on Mengkuang Lebar at 4,300 ft (1,310 m) elevation.

On the east coast islands, three birds were collected in Juara bay, Tioman Island, Pahang, in September 1907 (RMBR), of which two have the characteristic streaked rump of Grey-rumped Swiftlets (Plate 3D) but one is dark-rumped (Plate 3E), likely to be the specimen identified by Gibson-Hill (1949) as Brown-rumped Swiftlet. Despite the assertion of breeding by Gibson-Hill, there is no indication on the labels that any of these birds was taken at the nest. Medway (1966b) was told that white-nest swiftlets nested on Tioman in sea-caves, but failed to find any, and Lee (1977) repeated this assertion, again without location. There is also in RMBR a dark-rumped bird collected by Robinson in 1915 on Tokong Gantong, Johor, presumably the specimen noted by Chasen (1939).

In Java, wild white-nest swiftlets collected in caves at coastal and inland sites in 1960 (Plate 2A & 2B) have rump feathers the same colour as the back or slightly paler, without prominent dark shaft-streaks, matching the description of *C. francica javensis* Stresemann, 1931, now recognised as a junior synonym of Thunberg's Swiftlet *Aerodramus fuciphagus fuciphagus*. Although old and faded, the dark-rumped swiftlets of southern mainland and islands of Peninsular Malaysia, identified by Chasen and Gibson-Hill as *vestita* (RMBR), are similar. As noted by Stresemann (1931), skins collected by Chasen in Singapore, in 1930–1931 (RMBR) are indistinguishable from Javan Thunberg's Swiftlets. Photographs of white-nest swiftlets occupying former military underground emplacements at Bukit Imbiah, Sentosa Island, Singapore (Kang *et al.* 1991, Kang & Lee 1993: 18) and measurements and photographs of living adults mist-netted at this site in 2005 (Plate 4A) show that, by plumage character, these white-nest swiftlets of a natural colony are also identifiable as Thunberg's Swiftlet.

Re-examination of historic collections has therefore confirmed that, as in the Borneo States, there are two original wild white-nest swiftlet species in Peninsular Malaysia, grey-rumped and dark-rumped, evidently sharing the same diurnal habitat in a zone around 3°N on the mainland and east coast islands. The former are confirmed as nesting on the Pahang-Johor islands of Peninsular Malaysia, but not at Horsburgh Light (Pedra Branca). The latter nest on Singapore, but there is no confirmation that they do also on the most southerly Johor rocky stacks.

The white-nest swiftlets of house-farms

Java was the site of multiple early instances of spontaneous occupation of buildings by white-nest swiftlets of the native population of Thunberg's Swiftlets. House-farm swiftlets of western Java, such as those handled in 2005 at Sajira, Banten (Plate 4B), are similar in size, plumage characters and tarsal feathering to wild Thunberg's Swiftlets from caves at interior sites, such as Jampea (Plate 2A), or on the south coast at Karangbolong (Plate 2B). By the transportation and cross-species fostering of eggs in the nests of Linchi Swiftlets, the distribution of house-farm swiftlets has been enlarged to many new areas within the island of Java. Eggs from Java have also been traded, to an unrecorded and unknown extent, to localities beyond the natural range of the subspecies *A. f. fuciphagus*. In Kalimantan successful fostering of eggs from Java by White-bellied Swiftlets *Collocalia esculenta cyanoptila* is known as far north on the west coast as Singkawang, West Kalimantan (Charles Leh pers. comm. 2006) and on the east coast at Bayangkara, East Kalimantan (Lim & Cranbrook 2002: 149).

In Singapore, Chasen observed prospecting swiftlets in the 1930s: 'In January of two years I have found large numbers seeking the shady shelter of large stone-walled rooms, or vaults in buildings, in the late afternoon for roosting purposes: they were then easily caught with a large butterfly net.' In a footnote he added: 'Later. There is now a breeding colony of these birds in a much-frequented large building in Singapore' (Chasen 1939: 119). These remarks are supported by skins in RMBR, collected on Singapore Island at various dates in January 1931, with a note on one label: 'Taken in a large building'. The dark rumps of these skins, concolorous with or slightly paler than the back, identify them as Thunberg's Swiftlets. Later, Gibson-Hill (1948, 1949) reported swiftlets occupying an office building on Robinson Road, Singapore. The fate of this colony is not known but it is clear that in Singapore, by this time, there had been more than one spontaneous occupation of buildings by Thunberg's Swiftlets.

In north-west Peninsular Malaysia the pioneer birds occupying buildings were grey-rumped swiftlets. Gibson-Hill (1949: 110) reported Northern Grey-rumped Swiftlets (as *C. francica germani*) nesting in a godown in Penang, first noticed in 1947, and 'Southern Grey-rumped Swiftlets' in the Federal Survey Office, Kuala Lumpur, along with grey-rumped swiftlets of uncertain subspecies in a building in Teluk Anson, Perak. In the 1960s, white-nest swiftlets (identity not determined) occupied government buildings in (then) Mountbatten Road, Kuala Lumpur, ultimately being excluded by the advent of air-conditioning and hence the glazing of all apertures (Cranbrook pers. obs. 1968). In the 1970s a small colony, defiantly persistent in the face of repeated nest removal, occupied the porch of Kuala Lumpur Town Hall (Medway & Wells 1976); no specimens were collected. On the east coast of Peninsular Malaysia, by 1974 swiftlets were nesting in six sea-front shophouses in Kuala Terengganu (Cranbrook pers. obs.). Specimens were not collected at that time, but the presumed origin of these birds would be 'Southern' Grey-rumped Swiftlets of the Redang or Tenggol groups of islands (Gibson-Hill 1949, Wells 1999).

Swiftlet house-farming is a private and confidential enterprise, and in Peninsular Malaysia there is no authoritative data source for innovation or development in husbandry. There is, however, no evidence that the progressive increase in house-farm colonies in Malaysia has involved egg-transfer and fostering to a significant extent. One case of cross-species fostering in the nests of White-bellied Swiftlets reported to us was carried out at the town of Bentong, Pahang, around 2000–2002. An established population persisted in 2012 in the building used. In addition, other colonies have established themselves in this town, probably involving birds fledged from this source.

There are no colonies of wild white-nest swiftlets in interior Peninsular Malaysia and, so far, no confirmed instance of swiftlets of the house-farm type establishing breeding colonies in natural sites. For instance, in the environs of Ipoh, Perak, there are numerous house-farms and abundant limestone caves that so far remain unoccupied (Cranbrook pers. obs., Tou Jing Yi *in litt.* 2011). The expanding population of house-farm swiftlets into new areas in Peninsular Malaysia therefore reflects an upsurge in recruits from pre-existing house-farms, reinforced by the imprinting of buildings as potential nest sites and the attraction of acoustic stimulus in the form of recorded swiftlet calls, now universally employed. No doubt, the increasing architectural sophistication of house-farm design also plays a part. But, essentially, Malaysian-fledged house-farm white-nest swiftlets seek familiar constructions to occupy, and do not look for natural sites. This behavioural trait can lead to ecological separation within common activity space, as has occurred in Vietnam (Phach & Voisin 2007).

As among house-farm birds in Vietnam (Phach & Voisin 2007), throughout their range from southern Thailand, at Pak Phanang ('Birds nest city'), through Peninsular Malaysia, and in Sarawak, at Miri and Kuching, nestling house-farm swiftlets in their first plumage have pale grey rumps (Plate 4C, 4D & 4E). Among adult house-farm swiftlets of Malaysia, our accumulated photo-record shows variability in rump colouration between and within colonies. At Penang, three from the same farm-house showed minor variation in rump shade, in all cases with moderately defined shaft-streaks (Plate 4F & 4G). At Kota Bharu, Kelantan, all three birds caught showed similar pale, brownish rumps with lightly defined shaft-streaks (Plate 4H). At Kuala Terengganu, poor pictures of four birds are sufficient to confirm similar rump patterns, varying slightly in lightness of shade. On the west coast, at Pusing, Perak, the general tone was darker, with two of four birds showing rump the same shade as the back but one paler, with dark shaft-streaks (Plate 4I). In southern Peninsular Malaysia, five birds from house-farms in the neighbourhood of Kota Tinggi and Johor Bahru, Johor, all had rumps more or less mottled with darker feather centres; one was distinctive, with a uniformly pale band and narrow dark shaft-streaks (Plate 4J & 4K).

In Sarawak, although there is anecdotal report of successful hand-rearing in Kuching of nestlings from an outside source (reputedly from Pontianak, West Kalimantan), house-farm owners have testified that there have been no transfers of eggs from Java or elsewhere. The dramatic spread of house-farm swiftlets into this state initially occurred in coastal locations, starting in the north-east. The first house in Miri was occupied in the mid-1990s. In Bintulu the first colonists noted were a pioneer group of 18 nests in the eaves of the MAS building in 1997 (Lim and Cranbrook pers. obs.), and by 2000 Mukah was colonised. These three towns now support many large colonies. The spread to south-west Sarawak was later: in 2000, an informant went every weekend all the way along the coast from Kuching westward to Sematan, testing with sound replay, and found no evidence of swiftlets (Tsai Mui Leong *in litt.* 2010). By 2011, this coastline contained at least five house-farms with substantial colonies.

Adult house-farm swiftlets in Miri, Bintulu, Sarikei and Kuching do not resemble either of the wild species of Sarawak, i.e. Germain's or Grey-rumped on the islands, or Brown-rumped of interior caves. The house-farm swiftlets of Sarawak appear to be generally uniform in appearance, in rump colouration resembling most closely those of east coast Peninsular localities such as Terengganu and southern Johor. The similarity in appearance and size points to a common origin, leading to the conclusion that pioneer birds crossed the South China Sea from west to east, i.e. from Peninsular Malaysia to northern Sarawak.

In the Kalimantan provinces of Indonesia, outside Malaysian borders, specialised house-farms have been constructed at many localities, urban and rural, not infrequently on a trial basis. Swiftlets from a house-farm on the coast of southern East Kalimantan, near Balikpapan, resemble the house-farm swiftlets of Sarawak (Plate 4L). A carcass from Sulawesi, brought from a new house-farm by Anton Hoo, was similar in size and appearance, representing a further trans-marine range extension by swiftlets of house-farm type.

Genetic studies

Cyt-b haplotypes and data matrix

Eleven haplotypes are defined among the 55 sequences obtained (Table 1). Haplotype 5 (H05) is the most common, shared by 31 individuals from all house-farm populations, but not by wild Brown-rumped Swiftlets *A. f. vestitus* of Middle Baram, Sarawak. Haplotypes H04 and H07 are unique to the Medan house-farm population; H02, H03 and H11 unique to that of Kuantan; H07 to Endau-Rompin; and H09 and H10 to the wild swiftlets of Middle Baram. The Sibu birds share haplotypes with all other house-farm populations. The aligned DNA matrix is 558 bp in length, with 20 variable sites and no alignment gap. Among the variation sites, 10 sites are parsimony-informative (Table 1).

Phylogenetic analyses based on the cyt-b haplotypes

As the NJ tree shows no major topological difference from the MP tree, the NJ bootstrap values were mapped on the MP tree (Figure 1). Both NJ and MP trees recover two moderately supported major clades, Clade 1 and Clade 2, among the ingroups. Together, both clades include all haplotypes of house-farm birds, but none of the wild swiftlets of Middle Baram. Haplotypes H09 and H10 are exclusive to these swiftlets of Middle Baram. The specimen DHC04, which was identified as *A. fuciphagus germani* in Price *et al.* (2004), is included in Clade 2, while the specimen DHC40, which was identified as *A. f. vestitus* in Price *et al.* (2004), is unresolved among the ingroups (Figure 1).

AMOVA and pairwise F_{ST} comparison

As there are two major clades of house-farm swiftlets recovered in the phylogenetic analyses (Figure 1), pairwise F_{ST} comparison and AMOVA were used to test the genetic structure suggested by the clustering pattern in the phylogenetic trees. Individuals represented by the haplotypes in Clade II were combined to define a population, while the remaining individuals define the other six populations according to their sampling sites (which are combined into six area groups), i.e. (1) Middle Baram, Sarawak, (2) Medan, North Sumatra, (3) combined west coast locations in Perak and Selangor of Peninsular Malaysia, (4) Kuantan, the central east coast of Peninsular Malaysia, (5) Endau-Rompin, the southern east coast of Peninsular Malaysia, and (6) Sibu, Sarawak.

Pairwise comparison analysis shows that F_{ST} values are significant between the Middle Baram population and all other populations, and between the Clade 2 population and all other

Table 1. Summary of the parsimony-informative sites and the distribution of the cyt *b* haplotypes in white-nest swiftlet. Site numbers of the parsimony-informative characters are shown vertically; dots indicate identity with DHC04 sequence and letters designate base substitutions.

	Parsimony-informative characters															
		1	1	1	1	2	2	3	3	4						
	3	0	1	3	7	4	9	5	8	7			Sampling areas			
Haplotype	3	6	1	2	4	6	7	1	1	7	West Coast	Kuantan	Endau-Rompin	Sibu	Middle Baram	Sumatra
DHC04	G	T	G	A	T	C	C	G	G	C	–	-	-	-	-	-
H11	.	.	.	.	.	.	.	.	.	.	-	1	-	-	-	-
H01	.	.	A	G	C	T	T	.	A	T	2	2	3	1	-	-
H02	.	.	A	G	C	T	T	.	A	T	-	1	-	-	-	-
H03	.	C	A	G	C	.	.	A	A	T	-	1	-	-	-	-
H04	.	C	A	G	C	.	.	A	A	T	-	-	-	-	-	1
H05	.	C	A	G	C	.	.	A	A	T	10	7	5	3	-	7
H07	.	C	A	G	C	.	.	A	A	T	-	1	2	-	-	-
H08	.	C	A	G	C	.	.	A	A	T	-	-	1	-	-	1
H06	.	C	A	G	C	.	.	A	A	T	-	-	-	-	-	-
H10	.	.	A	G	C	.	.	A	A	T	-	-	-	-	5	-
H09	A	.	A	G	C	.	.	A	A	T	-	-	-	-	1	-
DHC40	A	.	A	.	C	.	.	A	A	T	-	-	-	-	-	-

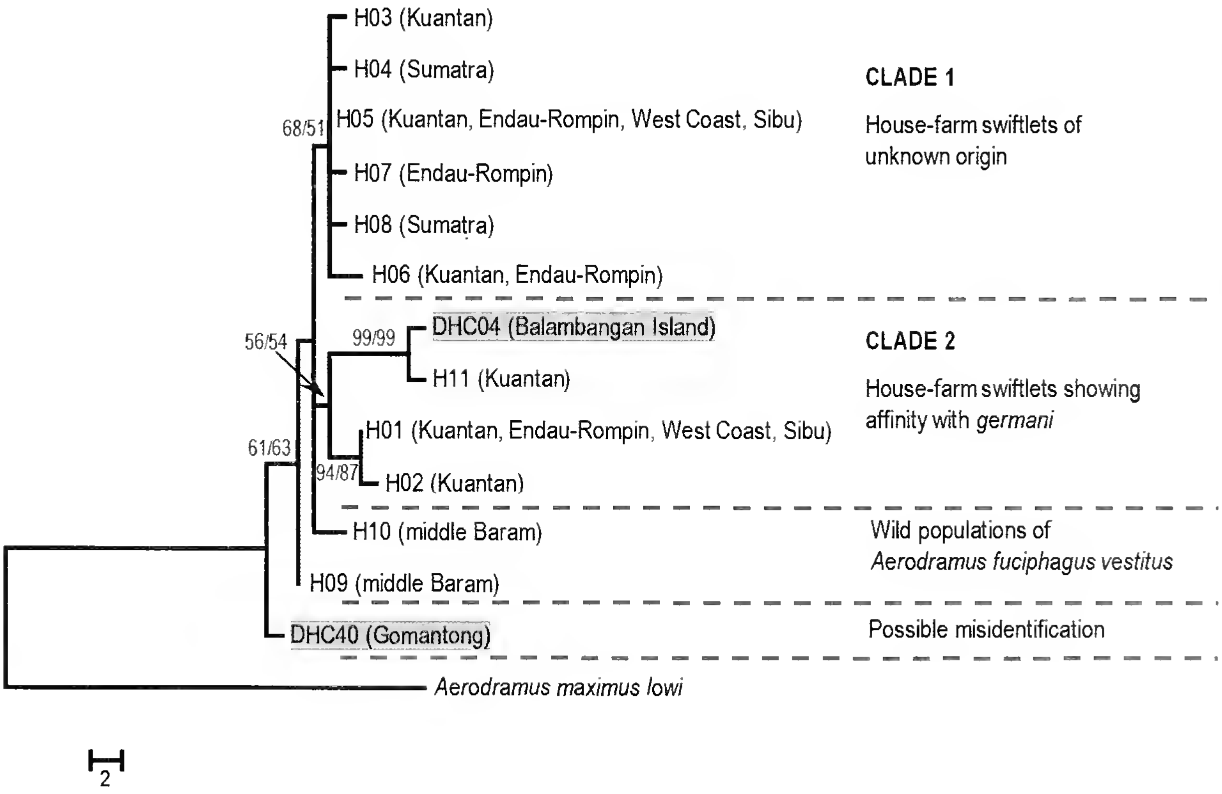


Figure 1. The phylogram of the most parsimonious (MP) tree based on cyt *b* haplotype sequence rooted by *A. maximus lowi*. Refer to **Table 1** for the haplotype distribution. Figures next to the nodes indicate the NJ bootstrap values / MP bootstrap values. DNA sequences obtained from Genbank are shown as highlighted individuals.

Table 2. Matrix of pairwise F_{ST} values among six populations of the white-nest swiftlets based on cyt *b* sequence. Figures with asterisk indicate the values which are significant at $p = 0.05$.

	Clade II	Endau-Rompin	Kuantan	Sibu	Sumatra	West Coast
Endau-Rompin	0.00010*					
Kuantan	0.00000*	0.71201				
Sibu	0.00356*	0.82398	0.99990			
Sumatra	0.00000*	0.16929	0.46481	0.99990		
West Coast	0.00000*	0.06871	0.08910	0.99990	0.20364	
Middle Baram	0.00000*	0.00020*	0.00040*	0.00980*	0.00010*	0.00010*

Table 3. Hierarchical AMOVA of the white-nest swiftlet populations. Fixation indices, i.e. the total variance (F_{ST}), the among population within group variance (F_{SC}) and among group variance (F_{CT}), are shown for the various structures tested. Figures with asterisk indicate the values which are significant at $p = 0.05$. The maximum F_{CT} is highlighted in bold.

Structure	Groups	F_{ST}	F_{SC}	F_{CT}
1	(Clade 2), (Endau-Rompin, Kuantan, Sibu, Sumatra, West Coast), (Middle Baram)	0.77595*	-0.02580	**0.78158***
2	(Clade 2), (Endau-Rompin, Kuantan, West Coast), (Sibu), (Sumatra), (Middle Baram)	0.69453*	0.00268	0.69371
3	(Clade 2), (Endau-Rompin, Kuantan), (West Coast, Sumatra), (Sibu), (Middle Baram)	0.67924*	-0.04615	0.69338*
4	(Clade 2), (Endau-Rompin, Kuantan, West Coast, Sumatra, Sibu), (Middle Baram)	0.74161*	0.60571*	0.34468

populations (Table 2). Among the various groupings tested in AMOVA, Structure 1 has the highest statistically significant F_{CT} value (Table 3), suggesting that it is the most plausible genetic structure among the white-nest swiftlets based on the cyt *b* sequence.

DISCUSSION

Stresemann (1931) considered the variable population of white-nest swiftlets of the south of Peninsular Malaysia to be transitional members of a north–south cline, *germani* >< *vestita*. From experience in the field and with skins before them, Chasen, Gibson-Hill and Banks recognised two species of white-nest swiftlet in this area, as well as in the Borneo territories, Grey-rumped and Brown-rumped. Re-examination of historic museum specimens has confirmed that the two species overlapped in diurnal activity range in the south of Peninsular Malaysia. Rather than a clinal transition, a zone around 3°N therefore represents an area of contact where the two species shared a common feeding zone. Sympatric breeding ranges are not proven. The single dark-rumped bird shot on Tioman many years ago may have nested on that island as asserted by Gibson-Hill (1949) but, given the mobility and extensive daily foraging ranges of all swiftlets, it could equally have originated from Singapore or elsewhere within the range of Thunberg's Swiftlet. Medway's (1966a) suggestion that the situation in Borneo could be explained in terms of a *Rassenkreis* is redundant. Moreover, the classic example of a supposed ring species, the Great Tit *Parus major*, has been invalidated by morphological, acoustic and molecular data (cyt-*b* sequences) by Päckert *et al.* (2005), thereby strengthening doubts about the place of this mechanism in speciation (Mayr 2002: 183).

Available molecular evidence reinforces this conclusion. With samples from Sabah, Grey-rumped Swiftlets of Balambangan Island (as *A. f. germani*) and Brown-rumped (*A. f. vestitus*) from Gomantong caves, Lee *et al.* (1996) showed separation equivalent to the genetic distance between morphological species (with an anomalous result suggesting possible misidentification). Thomassen (2005: 161, Fig. 1) amplified the results of Price *et al.* (2004), again showing as great or greater genetic distance between the two as between many clades recognised on behavioural and morphological grounds as distinct species.

The prior specific name for the dark- or brown-rumped swiftlets is *Aerodramus fuciphagus*. The observations of Stresemann (1931) are supported by historic specimens and recent photographs, confirming that Singapore white-nest swiftlets are indistinguishable from those of Java, and are therefore *A. fuciphagus fuciphagus*. The dark-rumped swiftlets in historic collections from the south of Peninsular Malaysia, in NHMUK and RMBR, are also identifiable as *A. f. fuciphagus*. The type of *Collocalia vestita maratua* Riley, 1927 has been shown to be a Mossy-nest Swiftlet *Aerodramus salanganus* (Medway 1966a). This name is therefore not available for a Borneo subspecies of white-nest swiftlets, as proposed by Chasen (1935). Measurements and plumage characters do not distinguish the Brown-rumped Swiftlets of Borneo from those of interior Sumatra, type locality of *Salangana vestita* Lesson. Although nominate *fuciphagus* appears to intervene between these two separate populations, many authors, including latterly Smythies (1999) and Mann (2008), have used the name *A. fuciphagus vestitus* for Borneo Brown-rumped Swiftlets. Further clarification, particularly genetic evidence, is needed to define the relationship of Bornean Brown-rumped Swiftlets with Thunberg's Swiftlets of Java and topotypical *vestitus* of Sumatra.

In Peninsular Malaysia, both Chasen (1935, 1939) and Gibson-Hill (1949) observed a darker and more variable rump-band among grey-rumped swiftlets of the east coast islands. As a subspecific name, Chasen (1935, 1939) chose *Collocalia fuciphaga amechana*, described by Oberholser (1912: 13) on the basis of two skins collected on Pulau Jemaja, Anamba Islands, Indonesia, by Dr W. L. Abbott in 1899. Oberholser compared these birds with white-nest swiftlets of Java (known by him as typical *Collocalia fuciphaga*), noting in particular that they were darker on the upperparts, with a metallic greenish sheen. This green sheen is clearly evident in a third skin, also from Pulau Jemaja (therefore a topotype), kindly loaned by ANSP (Plate 3F). Although Oberholser described the rump as 'decidedly paler' than the back, there is no demarcated pale rump-band with dark shaft-streaks. As Oberholser remarked, *amechana* is characterised by its unusual glossy colouration and, until details of its biology are known including the type of nest built, it is best regarded as an endemic of the Anamba Islands. If separable, the 'Southern Grey-rumped Swiftlet' of Peninsular Malaysia lacks a systematic trinomial.

Among the grey-rumped swiftlets, while the diagnostic dark shaft-streaks remain distinctive, there is a peripheral cline from the palest, most contrasting pattern of the rump of *germani* of Vietnam and peninsular Thailand to a darker background shade of grey of the rump-band. In northern Borneo this is evident from the Mantanani group, Sabah, eastwards to *perplexus* in the Maratua Islands, Indonesia, and in Peninsular Malaysia from west and north to the southern islands of the Pahang-Johor archipelago. An extreme westerly outlier, with the rump marked by the distinctive blackish shaft-streaks on a dark grey background colour, is Hume's (Edible Nest) Swiftlet *Aerodramus inexpectatus* of the Andaman and Nicobar Islands. As Smythies (1957) recognised, *inexpectatus* has priority as species name of the grey-rumped swiftlets. Malaysian representatives are therefore Germain's or Northern Grey-rumped Swiftlet *Aerodramus inexpectatus germani* and, on the eastern islands of Sabah, Riley's Swiftlet *Aerodramus inexpectatus perplexus*.

Historical sources show that, in the region, wild white-nest swiftlets spontaneously colonised urban buildings at multiple sites. In Singapore, colonies of Thunberg's Swiftlet were established in the 1930s. In Peninsular Malaysia, by 1949 grey-rumped swiftlets *Aerodramus inexpectatus* already occupied buildings in Penang, Telok Anson and Kuala Lumpur, and at Kuala Terengganu before 1974. There is no evidence that similar events occurred in the Borneo states and, in plumage characters, the house-farm swiftlets appearing in Sarawak during the 1990s resemble neither of the wild species of Borneo.

Although receiving only moderate statistical support, the genetic comparisons using mitochondrial cyt *b* sequence emphasise the distinctiveness of Brown-rumped Swiftlets from the Middle Baram caves, Sarawak (Figure 1). The uniqueness of this wild population is reflected in the pairwise distance matrix (Table 2) and the observation that the Middle Baram population shares no haplotypes with house-farm populations. Molecular analysis therefore matches plumage comparisons, and serves to stress that the lineage of house-farm swiftlets of Sarawak is distinct from the inland wild population of Bornean Brown-rumped Swiftlets. It is, however, of note that these results show a more distant relationship between the Middle Baram Brown-rumped Swiftlets and the Genbank specimen DHC40 from Gomantong, Sabah (identified as *A. f. vestitus* by Price *et al.* 2004). This apparent anomaly is possibly due to limitations of sampling design and molecular methods, but could also indicate misidentification of the specimen DHC40. It is not easy to distinguish in the hand between Brown-rumped and Mossy-nest Swiftlet *A. salanganus*, both of which occur at Gomantong, and the possibility of erroneous identification of the specimen from which the Genbank sequence derived has been raised elsewhere (Lee *et al.* 1996).

Among the sample of 49 house-farm individuals, phylogenetic and population genetic structure analyses show substantial gene-flow, but also suggest the existence of two clades. These clades, 1 and 2 (Figure 1), represent the grouping of house-farm swiftlets in the most plausible genetic structure (Table 3). Clade 1 includes house-farm swiftlets from the entire geographical range sampled, broadly between 2–4°N and 99–114+°E, covering North Sumatra, across Peninsular Malaysia and Sarawak, but excludes haplotypes of all wild birds, represented by Brown-rumped Swiftlets of Middle Baram, Sarawak, and the two GenBank sequences from Sabah. This result is evidence that the wild swiftlet population of the Borneo states was not implicated in the ancestry of this clade.

Clade 2 is significantly different from all separate populations sampled (Table 2). This clade includes nine house-farm swiftlets from the west and east coasts of Peninsular Malaysia and Sibu, Sarawak, i.e. approximately 2–4°N 100–114°E, along with specimen DHC04, collected on Balambangan Island, Sabah, 7.267°N 116.917°E, and reported to be Germain's Swiftlet (as *A. f. germani*) by Price *et al.* (2004). One individual from Kuantan (haplotype H11) shows a strong genetic relationship with DHC04, while the other eight from both coasts of Peninsular Malaysia and Sibu (haplotypes H01 and H02) show a moderately close relationship with DHC04 (Figure 1). The inference is that Germain's Swiftlet was implicated in the ancestry of Clade 2.

The existence of two clades is likely to reflect diversity of origins among the house-farm swiftlets. As well as Java, where houses were first occupied more than a century ago and many innovative management processes originated, the range of Thunberg's Swiftlets included Singapore, where buildings were occupied in the 1930s, and (at least in diurnal activity) southern Peninsular Malaysia to about 3°N as well. It is therefore expected that Thunberg's Swiftlets contributed to the genetic diversity of modern Malaysian house-farm populations, possibly augmented by the transportation of Javan genetic material as eggs or fostered young. At the same time, or a little later, on the west coast of Peninsular Malaysia the first records of white-nest swiftlets occupying buildings, in Penang, and at inland localities in Perak and at Kuala Lumpur, were attributed to Grey-rumped Swiftlets of two subspecies by Gibson-Hill (1949). Peninsular Malaysia, therefore, appears to have become a mixing ground where house-farm lineages from two species have met. Such a mixed ancestry is reflected in observed variation in plumage, notably in rump colouration (Plate 4), and is supported by the recognition of two genetic lineages.

In the Kalimantan provinces of Borneo, it is known that genes of Thunberg's Swiftlets were introduced in house-farms by the transfer of eggs for fostering in the nests of the local White-bellied Swiftlet at more than one location. Nonetheless, Sarawak house-farm swiftlets resemble those of Peninsular Malaysia, and genetic studies confirm that this is the case. It appears that Sarawak birds arrived by immigration from west to east across the South China Sea, not later than 1990. After the immigration event (or events) to the north-east of Sarawak, the population of house-farm genotypes expanded south-westwards along the coast. It is no longer possible to test the extent to which the progressive increase in the population of swiftlets drew solely on locally bred recruits or was augmented by supplementary immigration.

Long-distance movements across seas are not unexpected among swiftlets. The global distribution of *Aerodramus* species, embracing many remote islands from the western Indian Ocean to the Pacific (Chantler 1999), illustrates the natural mobility of this group of birds. The inclusion of Medan house-farm swiftlets in Clade 2 confirms genetic exchange across the Straits of Malacca. Phach & Voisin (2007) concluded that the colonisation of urban buildings in Vietnam by house-farm swiftlets was unassisted, representing a displacement of some 1,000 km, possibly including a sea-crossing. Further expansion in continental South-East Asia is shown by the appearance of house-farm birds in Cambodia (Poole 2010), in one direction, and eastwards to Sulawesi, Indonesia, again involving a sea crossing if not assisted by human intervention.

In Sarawak, there has been one observation of one pair of swiftlets of the house-farm type being found nesting in caves, in Batu Lebik at Bukit Sarang, Tatau. However, the pair did not return the following season. In Peninsular Malaysia, there is so far no confirmed record of white-nest swiftlets of the house-farm type occupying caves. That this has not occurred in more than half a century suggests decisive imprinting of many successive house-farm generations, to seek only buildings as nesting sites.

FUTURE PROSPECTS

This study has shown the potential of the mtDNA cyt-*b* gene as a marker in assessing genetic relationships among swiftlets, including comparisons between wild and house-farm populations. Firmer conclusions on the ancestry of Malaysian house-farm swiftlets could be achieved by sampling wild colonies of Grey-rumped Swiftlets of the east coast islands of Peninsular Malaysia and Sabah islands. As openness develops in the industry, it is to be hoped that there will be greater appreciation of the value of research and forthcoming sponsorship. As it was, our studies were self-funded, and therefore under-resourced. Results generated were limited, partly due to the small number of molecular markers and the lack of comprehensive sampling.

Further sampling of adult birds is needed to test the relations between plumage character and genetics. Investigation is needed to determine the number of independent entries from wild sources in different parts of Malaysia, and to discover the extent to which these have generated genetically distinct lineages of house-farm birds. Future studies should incorporate longer DNA sequences and more DNA regions so that the bootstrap support values can be improved.

Understanding the genetics of house-farm swiftlets could assist stakeholders in other ways. In the scenario of this newest domestication, with the backing of sound husbandry and good science, rational planning will be beneficial to ensure the perpetuation and sustainable management of this important avian resource. It may become possible to identify and propagate genotypes that show advantageous characters—for instance, those that are particularly productive, make nests of exceptional size or quality, or display strong fidelity to their home site. With disease inevitably threatening any birds kept in large numbers in close quarters, lineages offering genetic resistance may be identifiable. With enhanced understanding of the genome, it may even prove feasible to engineer deliberate crosses and thereby introduce other desirable characters.

An aspiration of this study was to decide the correct systematic name for house-farm swiftlets of Malaysia. A firm decision is prevented by evidence that the original pioneers were drawn from at least three wild sources of two species: Northern Grey-rumped Swiftlets *Aerodramus inexpectatus germani* in Penang and Southern Grey-rumped Swiftlets *A. inexpectatus* subsp. in Kuala Terengganu, and Thunberg's Swiftlet *A. fuciphagus fuciphagus* in Singapore, as also in Java. Further genetic evidence is needed, in particular from wild colonies of these three taxa. Future research may then provide a clearer understanding of the genetic relations between wild progenitors and, possibly, between local stocks of house-farm birds. Nuclear DNA markers will also be informative in determining whether house-farm swiftlets are products of hybridisation. If hybrids have been generated, they are excluded from regulation under the International Code of Zoological Nomenclature (ICZN 1999) Art. 1.3.3. Nonetheless, as a fertile, stable domesticate, a distinctive new form could be identified by an informal varietal name. We leave the choice of this name to the discretion of stakeholders.

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***EARL OF CRANBROOK**, Great Glemham House, Saxmundham IP17 1LP, UK. Email: lordcranbrook@greatglemhamfarms.co.uk (Corresponding author)*

***GOH Wei Lim**, Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia. Email: weilim_goh@yahoo.com*

***LIM Chan Koon**, 155 Lorong 4A, Off Jalan Stampin Timur, 93350 Kuching, Sarawak, Malaysia. Email: limchankoon@yahoo.com*

***Mustafa Abdul RAHMAN**, Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak (UNIMAS), 94300 Kota Samarahan, Sarawak, Malaysia. Email: rmustafa@rimc.unimas.my*

Appendix 1. Gazetteer: the coordinates of localities mentioned in the text.

Balambangan I., Sabah	7.267°N	116.917°E
Batu Mandi, Kudat, Sabah	6.917°N	116.950°E
Batu Putih, Sembilan I.	4.000°N	100.500°E
Baturong caves, Sabah	4.700°N	118.017°E
Bayangkara, East Kalimantan	2.850°N	117.283°E
Belitung I., Indonesia	2.900°S	107.933°E
Bentong, Pahang	3.517°N	101.900°E
Berhala I., Sandakan, Sabah	5.867°N	118.133°E
Bintulu, Sarawak	3.167°N	113.033°E
Bukit Imbiah, Sentosa I., Singapore	1.250°N	103.800°E
Bukit Sarang (Batu Lebik), Sarawak	2.650°N	113.033°E
Endau-Rompin, Johor	2.667°N	103.600°E
Gaya (Bodgaya) I., Sabah	4.617°N	118.733°E
Gomantong caves, Sabah	5.533°N	118.067°E
Horsburgh Light (Pedra Branca)	1.333°N	104.400°E
Ipoh, Perak	4.600°N	101.100°E
Jakarta, Indonesia	6.283°S	106.833°E
Johor Bahru, Johor	1.550°N	103.800°E
Koh Phangan, Surat Thani	9.750°N	100.017°E
Kota Bharu, Kelantan	7.417°N	102.250°E
Kota Tinggi, Johor	1.717°N	103.900°E
Kuala Lumpur (Mountbatten Road)	3.133°N	101.683°E
Kuala Terengganu (sea front)	5.317°N	103.150°E
Kuantan, Pahang	3.817°N	103.317°E
Kuching, Sarawak	1.550°N	110.350°E
Lahad Datu, Sabah	5.117°N	118.300°E
Lakei I., Sarawak	1.750°N	110.483°E
Malacca (Melaka)	2.250°N	102.233°E
Mantanani I., Sabah	6.700°N	116.333°E
Maratua I., East Kalimantan	2.233°N	118.567°E
Medan, Sumatra	3.583°N	98.667°E
Mengkuang Lebar, Genting Highlands	3.433°N	101.783°E
Middle Baram, Sarawak	3.650°N	114.417°E
Miri, Sarawak	4.250°N	113.950°E
Pak Phanang, Nakhon Si Thammarat	8.350°N	100.200°E
Pontianak, West Kalimantan	0.033°S	109.317°E
Pulau Batu Gajah, Johor	2.483°N	103.850°E
Pulau Jemaja, Anamba Is., Indonesia	2.917°N	105.750°E
Pulau Nyireh, Terengganu	4.867°N	103.067°E
Pulau Rembia, Sembilan I., Perak	4.000°N	100.533°E
Pulau Tinggi, Johor	2.300°N	104.117°E
Pusing, Perak	4.467°N	101.000°E
Redang I., Terengganu	5.717°N	103.800°E
Robinson Road, Singapore	1.267°N	103.833°E
Rompin, Pahang	2.800°N	103.483°E
Sajira, Banten, Java	6.483°S	106.367°E
Sarikei, Sarawak	2.117°N	111.517°E
Satang Besar I., Sarawak	1.783°N	110.150°E
Satang Kecil I., Sarawak	1.750°N	110.150°E
Sematan, Sarawak	1.800°N	109.767°E
Sembilan I., Perak	4.000°N	100.533°E
Si Amil I., Sabah	4.283°N	118.850°E
Sibu, Sarawak	2.300°N	111.317°E
Singkawang, West Kalimantan	0.900°N	108.983°E
Sitiawan, Perak	4.200°N	100.700°E
Suai, Sarawak	3.783°N	113.617°E
Tapadong caves, Sabah	5.083°N	108.133°E
Tamaluang cave, East Kalimantan	0.100°S	115.700°E
Teluk Anson (Teluk Intan), Perak	4.000°N	101.033°E
Tenggol I., Terengganu	4.783°N	103.950°E
Tioman I., Pahang	2.783°N	104.167°E

FORKTAIL 29 (2013): 120–123

Nesting period and breeding success of the Little Egret *Egretta garzetta* in Pattani province, Thailand

SOMSAK BUATIP, WANCHAMAI KARNTANUT & CORNELIS SWENNEN

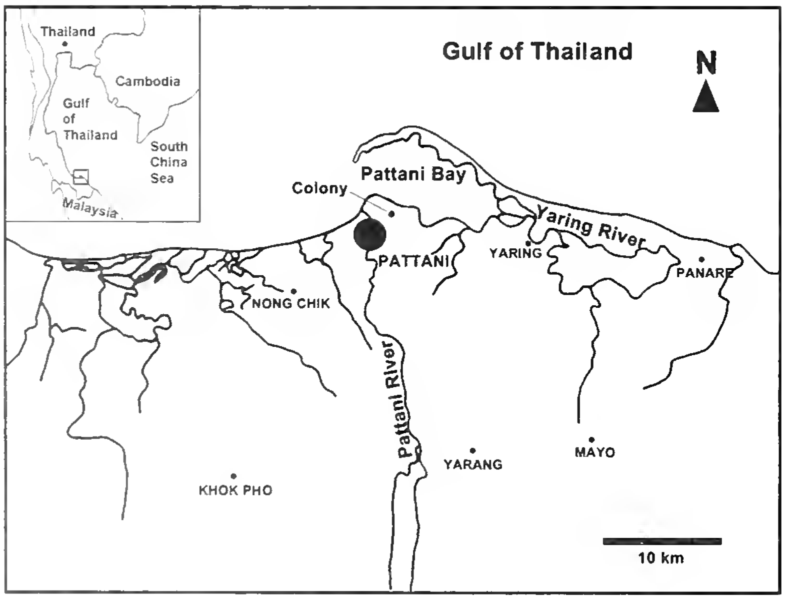
Nesting of Little Egret *Egretta garzetta* was studied between October 2008 and September 2009 in a colony near Pattani, southern Thailand, where the species is a recent colonist. Nesting was bimodal over a 12-month observation period. The first nesting period started in December in the middle of the rainy season (November–December). The second period started in March during the dry season (February–April). In the second period, nesting began in an area not occupied during the first period but gradually expanded into areas used in the first period. Egg and chick losses were high; the mean number of chicks that reached two weeks of age was 1.0 ± 1.2 ($n = 467$ nests), based on nests that had contained at least one egg. Considerable heterogeneity of clutch size and nest success was apparent between different locations within the colony. The main predator appeared to be the Malayan Water Monitor *Varanus salvator*.

INTRODUCTION

The breeding range of the Little Egret *Egretta garzetta* extends from western Europe (northern limit about 53°N) and North Africa across Asia south of the Himalayas to east Asia including Korea and Japan (northern limits about 40°N), with some isolated areas in southern Africa, the Philippines and north and east Australia (Hancock *et al.* 1978, Wong *et al.* 2000). Thus, the breeding range covers temperate, subtropical and tropical climate zones. The Little Egret is a colonial nesting species, constructing nests in trees, low shrubs and reedbeds. Several nesting studies have been conducted throughout the species's breeding range, e.g. in France (Hafner *et al.* 2008), Greece (Kazantzidis *et al.* 1997), Israel (Ashkenazi & Yom-Tov 1997), India (Hilaluddin *et al.* 2003), China (Ruan *et al.* 2003, Wei *et al.* 2003, Wong 2003), and South Korea (Kim *et al.* 2006).

Nesting success of the Little Egret in central Thailand was studied in the Wat Tan-en Non-Hunting Area (Keithmaleesatti *et al.* 2007) while the seasonality of breeding had previously been studied in the Thale Noi Non-Hunting Area, southern Thailand (Kaewdee 1999). Prior to this last-cited study, Little Egret was known only as as a winter visitor in the southern provinces of Thailand. However, in the second half of the 1990s it expanded its breeding range 160 km to the south of Thale Noi and started nesting near Pattani (Figure 1). Here, information on the breeding of the Little Egret in this relatively new colony in southern Thailand is presented. The objectives were to obtain descriptive metrics for breeding success; understand nesting synchrony; and finally document if breeding success parameters varied spatially within the focal colony.

Figure 1. Location of the study area near Pattani, Thailand.



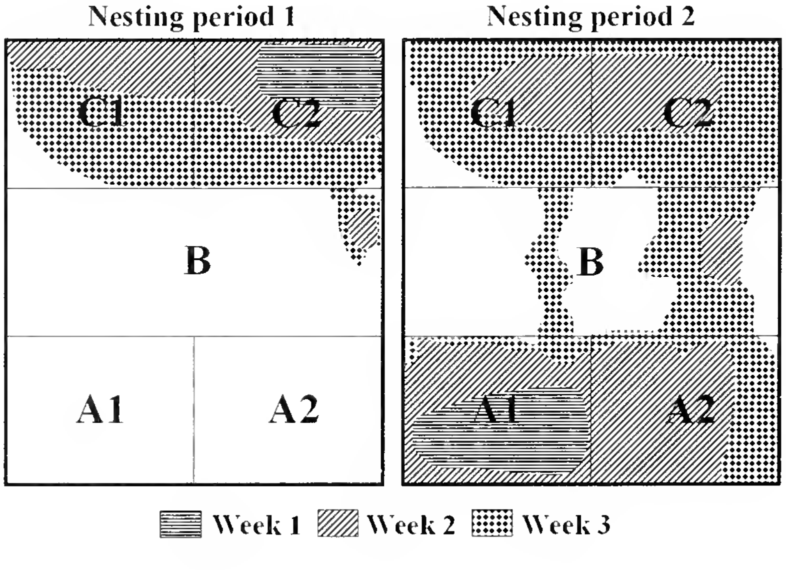
MATERIALS AND METHODS

Study area

The study was conducted at the Pattani waterbird colony, which is located next to the local Central Prison (6.867°N 101.250°E) near Pattani Bay, Gulf of Thailand (Figure 1). Pattani is a mixed colony which includes Little Egrets, Cattle Egrets *Bubulcus ibis* and Little Cormorants *Phalacrocorax niger*. About 4,000 Little Egret nests are located in this colony. Within the fence enclosing the prison is a small, brackish wetland measuring about 180 × 240 m (approx. 4.3 ha) with a maximum water depth of 0.8 m in the rainy season. The wetland contains short stature White Mangroves *Avicennia marina*, some Red Mangroves *Rhizophora mucronata* and open spaces. The area is surrounded on three sides by a wall with barbed wire on top and on the fourth by the high wall around the prison buildings.

The whole area is flat and largely covered by Holocene sand and clay deposits mainly of marine origin. The area has a tropical monsoon climate with the south-west monsoon from mid-May to mid-October and the north-east monsoon from mid-October to mid-February. The driest months are February to April, followed by moderate rain in May to September, while most precipitation occurs from October to December.

Figure 2. Spatial and temporal expansion by nesting Little Egrets of the Pattani colony during the two nesting periods in the 2008–2009 nesting season.



The nesting area was not homogeneous, with variation in both the density of the woodland and the tree species present. Prior to the nesting season, it was measured and divided into three sub-areas A, B and C of 1.44 ha (180 × 80 m). The outer two sub-areas were further subdivided into two parts of 0.72 ha each (90 × 80 m; see Figure 2). The middle part was not subdivided because it had large open spaces without trees. A total of five sections were therefore recognised, A1, A2, B, C1 and C2. This stratification was necessary to assess if breeding success parameters varied between strata.

Data collection

The colony was studied from October 2008 to September 2009. A fixed survey route that criss-crossed all sub-areas was delineated. A sample of nests were surveyed in each of the sub-areas in each nesting period. Sample sizes were determined prior to the study based on rough estimates of nest density. The sample sizes were as follows: Nesting period 1: 50, 100 and 100 nests for B, C1 and C2, respectively (there were no nests in the other sections during the first round of nesting); Nesting period 2: 100, 50, 30, 50 and 50 nests for A1, A2, B, C1 and C2, respectively. New nests without eggs were marked in each section until the predetermined sample size was reached. The colony was surveyed once every three days in the morning during the nesting season. Occupied nests along the route were marked with a numbered plastic tag placed below the nest to allow determination of nest outcomes. Surveys were temporarily stopped during brief, light rain showers. However, during heavy continuous rain, surveys were rescheduled for the next day. Surveys to check all marked nests took about four hours to complete. Nest content was checked using a mirror attached to a 2 m pole. The number of eggs and nestlings were recorded for each marked nest. Nestlings were aged each survey and placed in three age classes: hatchlings (1–4 days), young nestlings (5–9 days) and old nestlings (10–14 days) respectively. This classification by age is arbitrary. Surveys of nests containing nestlings older than 14 days were discontinued because these nestlings could move out of nests preventing individual identification. A nest was deemed to be successful if it contained at least one egg.

The total number of Little Egret nests in the colony was estimated towards the end of each of the two nesting periods by delimiting the proportion of each sub-area where nesting had occurred. For this purpose two possible states, 'nesting' or 'not-nesting', were assumed. The mean density of nests within areas identified as 'nesting' was estimated for each sub-area randomly using two 10 × 10 m survey plots within such areas (80 × 90 m) since the focus was not on individual trees. The total number of nests for each species was calculated by multiplying the mean density within each sub-area by the corresponding area that contained suitable nesting trees and subsequently summed over all sub-areas. Estimates are therefore very crude.

Data analysis

Homogeneity of variance was tested using Levene's test (SAS 2009). Generally, it was found that variances of measurements of nesting success (number of eggs and hatchlings) for each period and sub-area were homogeneous. Wilk-Shapiro tests were used to test for normality and it was found that measurements of success often deviated from normality. Therefore, non-parametric one-way analyses of variance (ANOVA) were also used (Kruskal-Wallis test) to test for differences among areas and among areas by nesting period for nest success (Tables 1 and 2). The results of these non-parametric tests were the same as the (parametric) analyses of variance results presented in this paper. This is not surprising, given the fact that the (parametric) analysis of variance is robust with respect to the assumption of the underlying populations' normality (Zar 1984). A considerable body of literature (see Zar 1984) has concluded that the validity of the ANOVA is affected only slightly by even considerable deviations from normality, especially with increasing sample sizes. Thus, given the fact that variances of populations are (generally) homogeneous, that parametric analysis of variance are robust (especially to even considerable deviations from normality), supported by the fact that results of non-parametric analyses of variances provided similar results, it is believed that both the one-way and two-way ANOVA results presented in this paper are accurate.

RESULTS

Little Egrets started using the study area as a night roost early in October 2008 and abandoned it in late July 2009. The first nests were built by 1 December 2008 in the middle of the rainy season. The first eggs were found on 5 December 2008 and the first chicks were seen on 30 December 2008. During this period, more pairs initiated nest building, laid eggs and hatched chicks. The last eggs were reported on 28 January 2009. Thus, the laying period extended over about 54 days, which includes replacement clutches after early egg loss.

About 3.5 months after the start of the first nesting period (Nesting period 1), a second nesting period (Nesting period 2) began around 12 March 2009 in the dry season. New nests were constructed in sub-areas not used during the first period, but soon thereafter also expanded into sub-areas that had been used in the previous nesting period (Figure 2). During both nesting periods colony growth occurred mainly during the first three weeks. The first eggs of Nesting period 2 were found on 15 March 2009 and the last eggs were laid around 12 May 2009, resulting in a laying period of 58 days, similar to Nesting period 1.

Clutch sizes ranged from 1 to 6 eggs, with an average clutch size of 2.8 ± 0.9 eggs. Clutch size was significantly different across nesting periods (two-way ANOVAs; $Ps<0.0001$) but not by sub-area, while chick rearing (all three stages) was significantly influenced by sub-area but not nesting period (Table 1).

For Nesting period 1, clutch size did not differ among sub-areas (Table 2). Although number of young hatched, and 7 and 14 day old nestlings did not differ between sub-areas C1 and C2, nest success in these sub-areas was significantly higher than in sub-area B (Table 2). Nesting period 2 showed somewhat different results for nest success among sub-areas (Table 2; Figure 3). Generally, the highest nest success was found for sub-areas C1 and C2, followed by A1, A2, and B (Table 2, Figure 3). Specifically, for all nesting stages, sub-areas A2 and B showed significantly lower nest success than sub-areas C1 and C2.

Clutch sizes were significantly lower in Nesting period 2 compared to Nesting period 1 for all sub-areas (B: $F_{1,59} = 22.27$, $P<0.0001$; C1 $F_{1,134} = 22.27$ $P<0.0001$; C2 $F_{1,133} = 22.27$, $P<0.0001$). No differences were found in nest success between Nesting periods 1 and 2 for either number of young hatched, or the number of 7- and 14-day-old young, respectively, for sub-areas B, C1 and C2 ($Ps>0.10$). The low nest success in sub-area B appears not to be the result of an initial small clutch size, but could be due

Table 1. Two way ANOVAs to determine effects of nesting period and sub-area on nesting stages of the Little Egret in the Pattani colony.

	Nesting period		Sub-area	
Nesting stage	$F_{1,7}$	P	$F_{4,7}$	P
Clutch size	128.48	<0.0001	3.24	0.01
Hatching	1.69	0.19	11.17	<0.0001
Nestlings 7-days	0.15	0.70	10.29	<0.001
Nestlings 14-days	0.14	0.71	8.44	<0.0001

Table 2. Mean (± SD) clutch size, young hatched and nestlings 7 and 14 days old, based on successful nests, during the two successive nesting periods of the Little Egret in the Pattani colony during the 2008–2009 nesting season.

Nesting period	Sub-area	$N_{Successful}$	Clutch size (× ± SD)	Young hatched (× ± SD)	Nestlings (7 days) (× ± SD)	Nestlings (14 days) (× ± SD)
1	B	33	3.3 ± 0.9a[2)]	0.8 ± 1.4b	0.6 ± 1.3b	0.5 ± 1.0b
	C1	87	3.3 ± 0.8a	1.7 ± 1.6a	1.5 ± 1.6a	1.1 ± 1.3a
	C2	84	3.3 ± 0.8a	2.0 ± 1.6a	1.6 ± 1.6a	1.2 ± 1.3a
	All	204	3.3 ± 0.8	1.7 ± 1.6	1.4 ± 1.6	1.0 ± 1.3
2	A1	92	2.5 ± 0.8a,b	1.5 ± 1.1a,b	1.3 ± 1.1a,b	0.9 ± 1.0a,b
	A2	46	2.2 ± 0.7b	1.0 ± 1.2b,c	1.0 ± 1.1b,c	0.7 ± 1.0b,c
	B	27	2.3 ± 0.7a,b	0.7 ± 1.1c	0.4 ± 1.0c	0.3 ± 0.7c
	C1	48	2.7 ± 0.7a	2.0 ± 1.2a	1.9 ± 1.2a	1.5 ± 1.2a
	C2	50	2.7 ± 0.7a	1.2 ± 0.2a	1.8 ± 1.2a	1.3 ± 1.2a,b
	All	263	2.5 ± 0.7	1.5 ± 1.3	1.3 ± 1.2	1.0 ± 1.1

1) Successful nests contained at least 1 egg.
2) Clutch sizes, young hatched and nestlings 7 and 14 days old with the same letter do not differ significantly within a nesting period among areas surveyed (Bonferroni multiple range test, $P = 0.05$).

to higher nest predation (Figure 3). In both periods, sub-areas C1 and C2 showed substantially higher success rates for young to 14 days averaging 45% survival for Nesting period 1 and 62% for Nesting period 2 (Figure 3). Sub-areas A1 and A2 showed survival rates intermediate between sub-areas B and C1, and C2 (Figure 3).

Little Egrets built nests more frequently in White Mangroves than in Red Mangroves in both nesting periods. Little Egrets nests had long thick twigs in the base and long thin twigs in the upper layer and were built at the lowest levels in the trees. Cattle Egrets constructed their nests of tiny twigs and in the middle layer of the foliage. Little Cormorants used thick short twigs in the base layer and twigs with leaves on top and placed their nests highest in the trees.

Various predators noted in the colony were suspected of predating eggs and nestlings, including Fishing Cat *Felis viverrina*, Brahminy Kite *Haliastur indus*, Large-billed Crow *Corvus macrorhynchos*, Malayan Water Monitor *Varanus salvator* and Siamese Cobra *Naja kaouthia*. Actual predation was not observed, but fresh nail scrapes on the bark of trees where nests were destroyed strongly suggesting that a large Malayan Water Monitor had climbed the tree and predated the nests. The effect of destruction of nests and the differences between sub-areas in different stages of the breeding process is summarised in Figure 3.

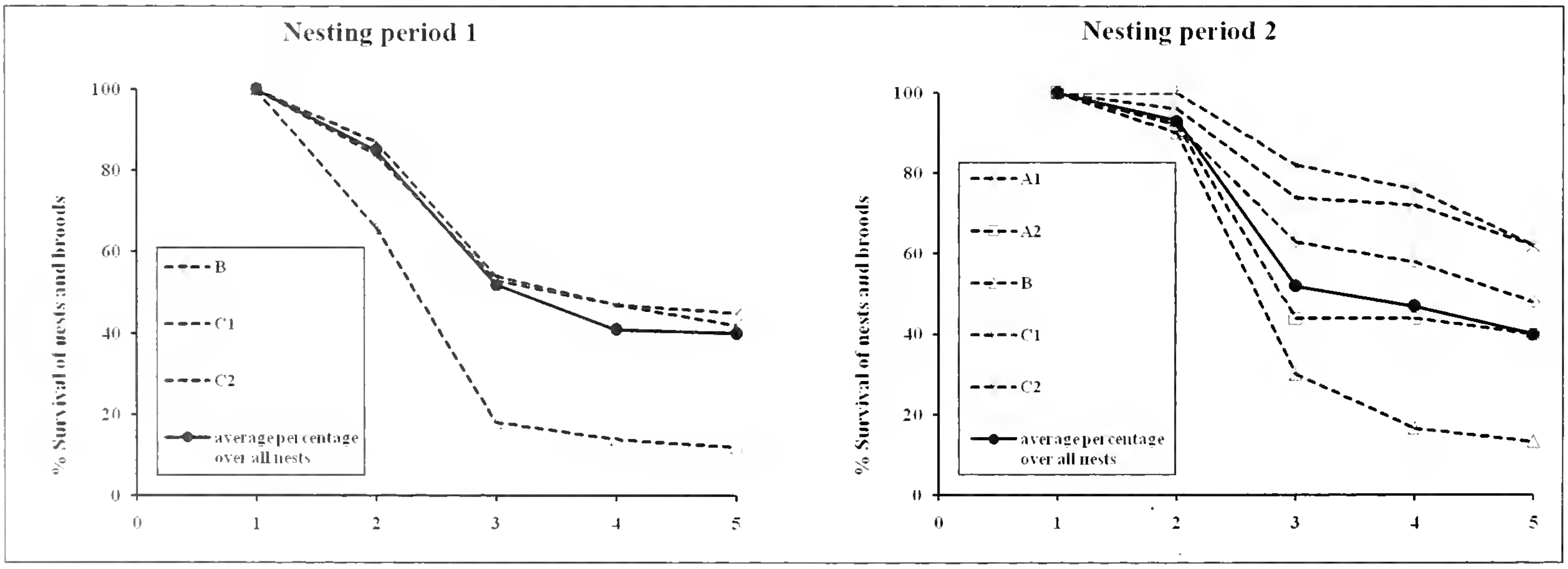
Predation of nests in the sub-areas showed similar patterns between Nesting periods 1 and 2 (Figure 3). The highest predation rates were found in sub-area B: only 12.0% and 13.3% survival rates of the selected nests that produced 14-day-old young for Nesting periods 1 and 2, respectively.

DISCUSSION

In temperate climatic regions, the reproductive season of Little Egrets starts in spring when increased temperature and day length induce nesting. The species has typically one brood per year, but re-nesting may occur after clutch loss (Bauer & Glutz von Blotzheim 1966). In tropical areas daylight and temperature do not fluctuate much over the year and the nesting period is related largely to the rainy season that varies both temporally and regionally (del Hoyo *et al.* 1992). The nesting seasons summarised in del Hoyo *et al.* (1992) also indicate a unimodal and not bimodal nesting pattern. No studies were found that describe the bimodal pattern observed in Thailand. Nesting periods 1 and 2 were similar in length (54 and 58 days, respectively). The interval between occupation of the colony and the start of egg-laying in both nesting periods was about 100 days. Hancock *et al.* (1978) and del Hoyo *et al.* (1992) estimated the interval between egg-laying and independence of the nestlings to be least 68 days (incubation about 23 days, hatching to independence/fledging of young about 45 days). In Nesting period 2, nesting started in the sub-areas not occupied in Nesting period 1 and gradually expanded to all sub-areas. Egrets avoided nesting in sub-areas B, C1 and C2 where some fledglings of relatively late broods of Nesting period 1 were present (pers. obs.).

Ali and Ripley (1987) summarised information from 'Egret Farms' in Sind (India), in which captive egrets were maintained to harvest valuable egret plumes. Captive, well-fed Little Egrets produced up to four or even five clutches between March and September when one-week old chicks were removed for hand rearing. This suggests that Little Egrets are neither genetically nor physiologically predisposed to one brood per year. Thus, food availability seems to be the driver for the start and continuation of nesting. There is little reason to presume that the Pattani colony was used by two different populations of Little Egrets. The fact that there were many more nests in Nesting period 2 than in Nesting period 1 may suggest that older and therefore more experienced birds nested in Nesting period 1. More experienced Little Egrets are likely to initiate the nesting cycle early and be able to nest twice, while less experienced birds start later and nest only

Figure 3. Little Egret nest success in the two nesting periods at the Pattani colony during the 2008–2009 nesting season. Points on *x*-axis, 1: nests surveyed; 2: nests with at least one egg; 3: nests with hatchlings; 4: nests with 7-day-old chicks; 5: nests with 14-day old chicks.



once per year (Nesting period 2). The slightly larger eggs and clutch sizes during the first breeding period might support these assumptions, which could be verified by longer-term studies using colour-banded birds. It is unclear why there is not a gradual transition between these two nesting populations, resulting in a single long breeding season. However, there seems a benefit of synchronous nesting that is triggered by an environmental cue that signals the start of a nesting season. Several authors have suggested a relationship between the onset of the rainy season or water conditions in tropical areas (Hancock *et al.* 1978, Ali & Ripley 1987, del Hoyo *et al.* 1992). In this area, precipitation patterns in November and December cause local flooding that may improve feeding conditions and induce birds to start nesting. The heavy rain showers did not seem to affect nesting in Nesting period 1. The adults protected their eggs well during incubation and the rainy season had ended by the time the young hatched. Weather conditions were dry during Nesting period 2 and it was not clear what prompted egrets to begin a second round of nesting.

Clutch sizes observed (average 2.8 ± 0.9 eggs) were similar to clutch sizes reported from other tropical areas summarised by Hancock *et al.* (1978). Nest, egg and chick losses were high at Pattani, resulting in a low number of nestlings surviving beyond 14 days. Most predatory attacks resulted in complete loss of a clutch or chicks and often partial destruction of the nest structure. The result was that a relatively low number of pairs reared chicks to 14 days (1.0 ± 1.2 young). Hilaluddin *et al.* (2003) reported a slightly higher success of 1.74 nestlings up to 15 days from India. The highest successes were reported from China, 3.86 young by Ruan *et al.* (2003) and 3.96 young by Zhang *et al.* (2000), but the authors did not report whether nest loss was incorporated in these numbers.

Partitioning the colony in sub-areas and carefully designing a survey route through the entire colony proved to be useful to determine spatial and temporal differences in nesting and nest success in the colony, even when initial clutch sizes did not differ by sub-area. This was an unexpected outcome, but suggests that studies of colonies should take into account that differences in nest initiation and establishment of pairs in a colony can have a strong spatio-temporal component which should be addressed in study design. Spatial heterogeneity within nesting sites of *E. garzetta* has not been reported, but has been seen in Cattle Egret *Bubulcus ibis* (Petry & Fonseca 2005). The cause of the differences in nesting success in different parts of the colony may be due to varying predation rates, but this requires confirmation using improved nest observation methods. In both nesting periods the losses in section B were highest while C1 and C2 had the best results. The difference may be due to the less dense vegetation in B where there was also a large area of water allowing easier access by the Malayan Water Monitor and raptors.

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***Somsak BUATIP, Wanchamai KARNTANUT** and Cornelis* ***SWENNEN**, Faculty of Science and Technology, Prince of Songkla University, Pattani 9400, Thailand. Email: kwancha@bunga.pn.psu.ac.th*

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The status of Brown-chested Jungle Flycatcher *Rhinomyias brunneatus* in Vietnam

SIMON P. MAHOOD, SÉBASTIEN DELONGLÉE, FLORIAN KLINGEL, FALK WICKER & RICHARD CRAIK

The number of records of some migratory species is so low that there are insufficient data to infer status, even in countries within their normal distribution. Brown-chested Jungle Flycatcher *Rhinomyias brunneatus*, a globally threatened bird, is one such species. We gathered data on the occurrence of this species and 13 other migrant flycatchers in the city of Hanoi, Vietnam, throughout autumn 2010. These data include the second to tenth records of Brown-chested Jungle Flycatcher in Vietnam, and it was the fifth commonest flycatcher recorded in Hanoi during autumn 2010. Records of the species spanned the period 2 September–4 October, thus suggesting that it is a relatively early migrant with a narrow migration period. We also comment on the incidence and patterns of occurrence of other flycatcher species in Hanoi.

INTRODUCTION

Compared with countries in temperate regions, the status of migrant birds in tropical countries is relatively poorly known. For most species, broad patterns of occurrence have been elucidated, and increasingly there are sufficient data to analyse seasonal, geographical and even trend data within certain areas or countries, such as Hong Kong and Thailand (Carey *et al.* 2001, Round 2010). In Vietnam, broad patterns of occurrence are known for most migrants, but are based on relatively few data and remain incomplete for some species.

One poorly known species in Vietnam is Brown-chested Jungle Flycatcher *Rhinomyias brunneatus*, which is unique in its genus in being a long-distance migrant (Taylor & Clement 2006). It is considered uncommon and localised within its breeding grounds in south-east China, and this is likely to have contributed to its listing as Vulnerable (BirdLife International 2012a). In common with other members of the genus *Rhinomyias*, it is a sluggish, unobtrusive forest interior species usually detected by voice (SPM pers. obs.); these traits render it liable to be under-detected. The species spends the non-breeding season in southern Peninsular Malaysia and Singapore (Wells 2007), and within this small range are found primarily in mature lowland moist evergreen forest; they show strong site-fidelity (Wells 2007). Small numbers are recorded annually on passage in Thailand (P. Round *in litt.* 2012). Assuming that it takes a direct migratory route, much of the global population estimated at 2,500–9,999 (BirdLife International 2012a) would be expected to pass through or over Vietnam.

Robson (2011) listed one vagrant record of the species for Vietnam, an individual collected on the campus of the Agricultural University, Hanoi, on 26 April 1981. The bird was initially identified as a Red-eyed Bulbul *Pycnonotus brunneus*, a species endemic to the Sundaic lowlands of Peninsular Thailand, Malaysia and Indonesia (Štusák & Võ Quy 1986). However, knowing this identification to be untenable, C. Robson examined the specimen and reidentified it as the first, and until 2010, the only record of Brown-chested Jungle Flycatcher for Vietnam (C. Robson *in litt.* 2011, Robson 2011).

The present paper re-evaluates the status of Brown-chested Jungle Flycatcher in Vietnam using data collected in Hanoi during 2010. Data are sufficient to document its status in East Tonkin (north-east Vietnam). Occurrence data for all other migrant flycatchers of the genera *Muscicapa*, *Ficedula*, *Eumyias*, *Cyanoptila* and *Cyornis* (genus limits following BirdLife International 2012b) in Hanoi are also presented for the first time, for the purpose of comparison with Brown-chested Jungle Flycatcher.

METHODS

Data collection

Data on the occurrence of migrant flycatcher species during autumn passage were collected between 27 August and 14 November 2010 in the only two accessible large green spaces in Hanoi, namely the Botanical Gardens (21.040°N 105.830°E) and Thonh Nhat Park, commonly called Lenin Park, (21.015°N 105.846°E). At both sites there are no resident populations of any flycatcher species (all authors pers. obs.), thus all flycatchers recorded can be considered migrants. Data were collected by most of the Hanoi-based birdwatchers (SPM, FW, FK, SD) and occasionally by the Ho Chi Minh City based RC. Observations were collated on the Vietnam Bird News blog (http://vietnambirdnews.blogspot.co.uk).

At least one of the two parks was visited on most days. On each visit the observer (very rarely observers) searched actively for flycatchers and recorded all individuals seen to species level. On the rare occasion that one of the parks was visited twice in one day (either twice by the same person or on separate occasions by different people) the highest single observer tally of each flycatcher species is used here. There is thought to be no (or negligible) exchange of birds between the two sites, based on observations of individually identifiable birds. Using the same method it is thought that all or almost all flycatchers remained for only one day.

All birds seen were identified to species with reference to Robson (2011) with the exception of Blue-and-white Flycatcher *Cyanoptila cyanomelana* / Zappey's Flycatcher *C. cumatilis*. Leader & Carey (2012) demonstrated that Zappey's Flycatcher is a species distinct from Blue-and-white Flycatcher. The latter is now considered to include only the nominate and *C. c. intermedia* (Leader & Carey 2012). Since not all males were photographed in 2010, and because identification criteria for females are not yet fully worked out, in this study we assign these birds to *Cyanoptila*. A more thorough review of the status of Blue-and-white and Zappey's Flycatchers in Vietnam is ongoing (Mahood *et al.* in prep.).

Visits to the parks by observers were temporally standardised—almost all visits took place during a one hour period between 07h45 and 08h45 (pre-work, but after the parks have been vacated by people partaking in mass organised exercise sessions), or, occasionally, between 12h00 and 13h00. Habitat in both parks is heterogeneous, but search efforts were spatially standardised because all observers focused on the best areas for flycatchers in the parks. In Lenin Park this was a scrubby area behind a permanently locked toilet block near the south entrance (people unable to access the toilet make use of the area behind it, thus attracting an abundance of flies) whilst in the Botanical Gardens this was a quiet scrubby area where a blocked drain overflowed and flooded shallow depressions in the grass, creating pools in which mosquitoes bred. In both of these areas the habitat was relatively open in structure, and consequently we believe that detection probabilities between species and observers were close to equal.

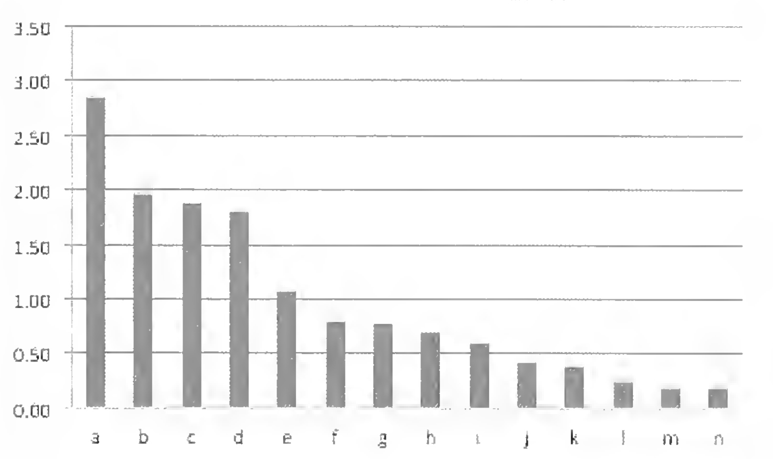
Data analysis

The study was divided into eight 10-day periods. To allow for variation in survey effort (the parks were not visited every day), data were corrected for number of visits, with each park treated separately. Within each period the number of records of each species in each park was divided by the number of visits to the park during that period, and then multiplied by ten (the number of days in the period). Corrected data from the two parks were combined to give an incidence of abundance for each species within each 10-day period. For each species, the incidence of occurrence within the 10-day periods was summed to give an incidence of occurrence over the whole study.

RESULTS

The Botanical Gardens were visited on 40 days (mean 0.5 visits per day) and Lenin Park on 37 days (mean 0.46 visits per day). Thirteen *Muscicapa*, *Ficedula*, *Eumyias*, *Cyanoptila* and *Cyornis* flycatcher species were recorded, consisting of six long-range migrants (originating in Siberian Russia), four medium-range migrants (originating in central or southern China) and three altitudinal migrants (originating from as close as the mountains of northern Vietnam about 50 km to the north and west) (Figure 1) (species limits following BirdLife International (2012b), except where discussed below).

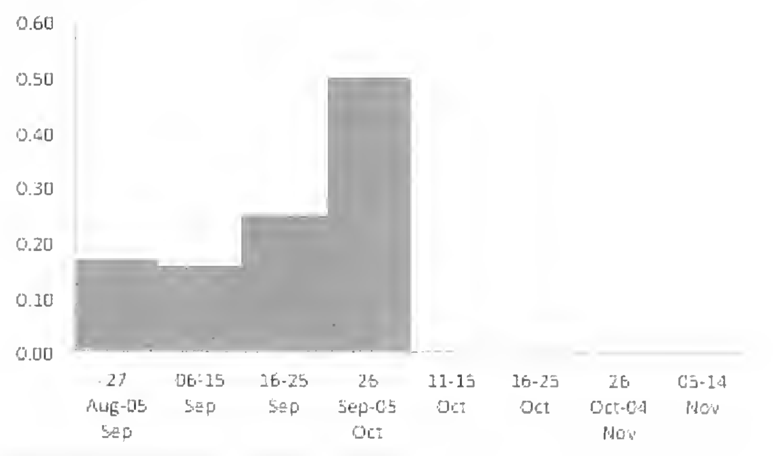
Figure 1. The incidence of occurrence of flycatcher species in Hanoi during autumn 2010, corrected for observer effort. Key: a. Brown Flycatcher *Muscicapa dauurica*; b. Yellow-rumped Flycatacher *Ficedula zanthopygia*; c. Taiga Flycatcher *F. albicilla*; d. Dark-sided Flycatcher *M. sibirica*; e. Brown-chested Jungle Flycatcher *Rhinomyias brunneatus*; f. *Cyanoptila* (see text); g. 'Chinese Blue Flycatcher' *Cyornis rubeculoides glaucicomans*; h. Hainan Blue Flycatcher *C. hainanus*; i. Snowy-browed Flycatcher *F. hyperythra*; j. Mugimaki Flycatcher *F. mugimaki*; k. Verditer Flycatcher *Eumyias thalassinus*; l. Brown-breasted Flycatcher *M. muttui*; m. 'Green-backed Flycatcher' *F. narcissina elisae*; n. Ferruginous Flycatcher *M. ferruginea*.



Brown-chested Jungle Flycatcher was the fifth commonest migrant flycatcher in Hanoi during autumn 2010 (Figure 1). It is a relatively early passage migrant (Figures 2 & 3). Nine individuals were recorded—in the Botanical Gardens on 2, 9, 14, 23 and 28 September and in Lenin Park on 21, 23 and 26 September and 4 October.

Three additional species often grouped with flycatchers, namely Black-naped Monarch *Hypothymis azurea*, Asian Paradise-flycatcher *Terpsiphone paradisi* and Grey-headed Canary-flycatcher *Culicicapa ceylonensis*, were also recorded during the study period, the first two as passage migrants and the last as a winter visitor, but were not systematically counted.

Figure 2. The incidence of occurrence per ten-day period of Brown-chested Jungle Flycatcher in Hanoi during autumn 2010, corrected for observer effort.



DISCUSSION

At least during 2010, Brown-chested Jungle Flycatcher was a fairly common autumn passage migrant in East Tonkin, Vietnam. Data corrected for effort indicate that this species was the most abundant short- or medium-range migrant flycatcher recorded during our study. It is difficult to account for the absence of records in earlier years. It seems unlikely that the recent upsurge in records reflects a genuine increase in abundance of the species on passage in Vietnam. Owing to its superficial similarity to Asian Brown Flycatcher *Muscicapa dauurica* it is plausible that birdwatchers overlooked the species in the past. However, given the number and quality of birdwatchers resident in or visiting Vietnam over the last 20 years this is unlikely. The almost complete absence of previous records can best be accounted for by a combination of migration strategy and birdwatcher behaviour. Most birdwatching aimed at observing passage migrants in Vietnam has taken place in coastal sites, where Brown-chested Jungle Flycatcher has not been recorded. It is possible that it avoids the coast during migration.

The number of Brown-chested Jungle Flycatchers recorded during our study is remarkable, considering that during the last 10 years the number of birds recorded in Thailand (where there are considerably more birdwatchers and photographers and a well established network of reporting and disseminating information) is typically less than five annually, and there are still occasionally years when none is recorded (P. Round *in litt.* 2012). Our data might represent a tiny sample of the number of Brown-chested Jungle Flycatchers that pass through Vietnam every year. The results indicate that the species passes through Hanoi during a relatively short window centred on September. Indeed, over half of the records were made during a one-week period spanning 21–28 September. However, it is possible that the timing of migration varies between years. Evidence that the occurrence of Brown-chested Jungle Flycatchers in Hanoi in 2010 was not a one-off phenomenon was provided in 2012 when two or three individuals were recorded between 13 and 16 September (Le Manh Hung and J. C. Eames *in litt.* 2012).

During the study Asian Brown Flycatcher was the most abundant migrant flycatcher and had a protracted migration period in keeping with a bird with a large source population and wide geographic range (although it was not recorded in August and there was an obvious peak in records in late September); it was followed by Yellow-rumped Flycatcher *Ficedula zanthopygia*, Taiga

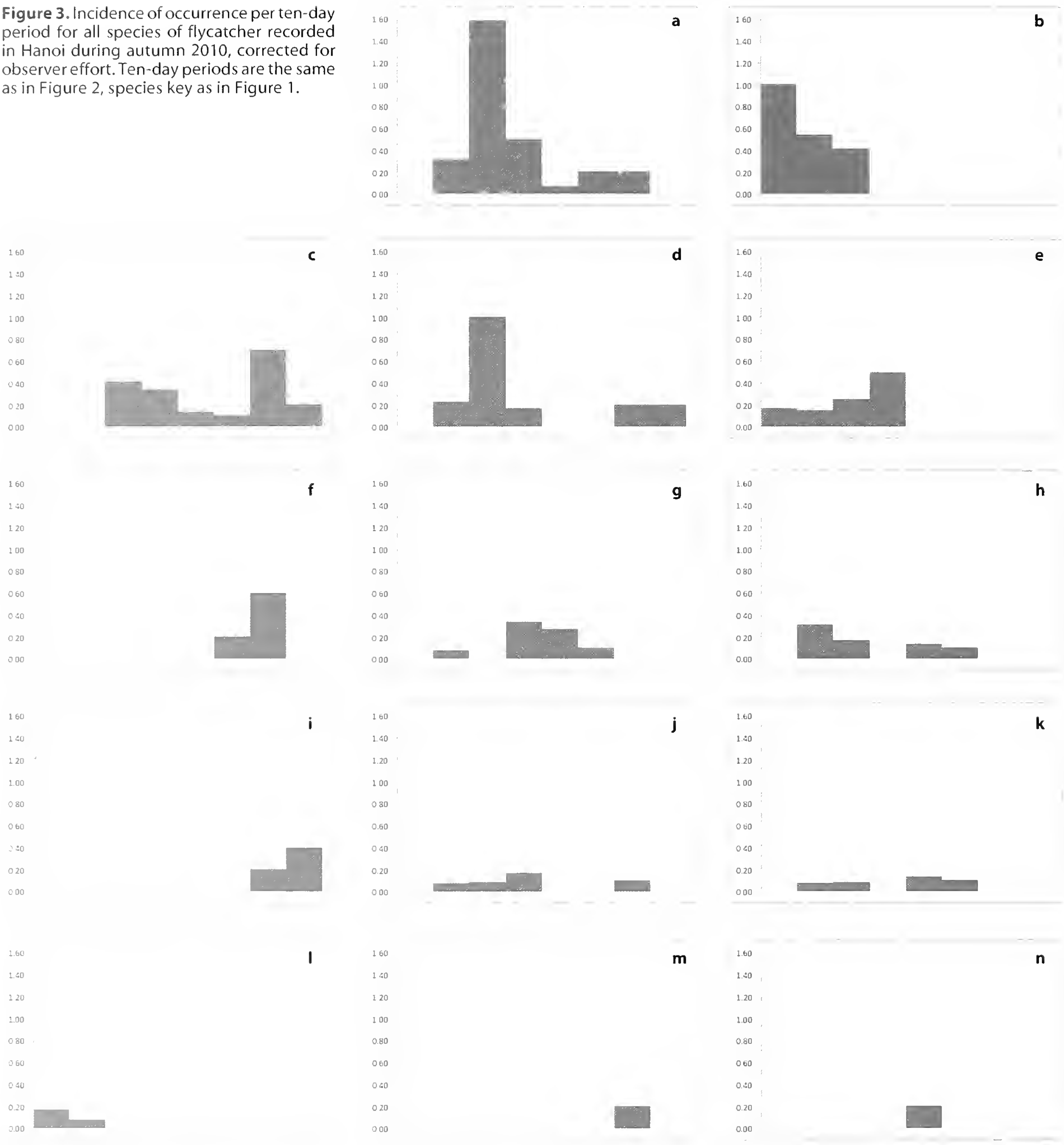


Figure 3. Incidence of occurrence per ten-day period for all species of flycatcher recorded in Hanoi during autumn 2010, corrected for observer effort. Ten-day periods are the same as in Figure 2, species key as in Figure 1.

Flycatcher *F. albicilla* and Dark-sided Flycatcher *Muscicapa sibirica*. All four species have relatively large source populations (Taylor & Clement 2006) and are long-range migrants, although Yellow-rumped Flycatcher breeds as far south as north-east China (Brazil 2009). Timing of migration differs between these species: Yellow-rumped Flycatcher was only recorded during the first half of the study period and Taiga Flycatcher was not recorded before the beginning of October, whilst Dark-sided Flycatcher showed a protracted migration period with a peak in records that corresponded to that of Asian Brown Flycatcher. This peak might represent either a genuine similarity in migration timing or favourable conditions for grounding migrants in Hanoi.

The remaining nine flycatcher species were recorded less often. Except for Mugimaki Flycatcher *Ficedula mugimaki* and potentially *Cyanoptila*, all of these species are exclusively short- or medium-range migrants. The small number of records of most of these scarcer species allows only tentative conclusions regarding the timing of their migration through Hanoi. Mugimaki Flycatcher records were spread out throughout the study period. In contrast, all of the *Cyanoptila* records were in mid- to late-October. The single record of 'Green-backed Flycatcher' *Ficedula narcissina elisae* was also relatively late (1 November 2010). The latter has a similar breeding and wintering distribution to Zappey's Flycatcher. Subsequently 'Green-backed Flycatcher' has been recorded in Hanoi in November 2012 (J. C. Eames *in litt.* 2012) and the species was recorded twice in Cambodia on 19 and 20 November 2012 (R. Martin verbally 2012, SPM pers. obs.). These data indicate that this species migrates later than the other northerly breeding species in the study. This correlation of migration timing perhaps provides some support for the theory that most of the *Cyanoptila* records constituted Zappey's Flycatcher rather than the more north-easterly breeding Blue-and-white Flycatcher *sensu stricto C. c. cyanomelana* and *C. c. intermedia*. Brown-breasted Flycatcher *Muscicapa muttui* has an atypical migration strategy for a China/ north Vietnam breeding species in that it overwinters in the Indian subcontinent (Rasmussen & Anderton 2005). Data indicate that it is a very early migrant in Hanoi, and this is reinforced by records made in subsequent years (SD pers. obs.). Our records of Snowy-browed Flycatcher *Ficedula hyperythra* are noteworthy because they are the first records of the species in the lowlands of Vietnam. They probably represent altitudinal migrants from the hills close to Hanoi.

The period of passage for Brown-chested Jungle Flycatcher in Hanoi is earlier than the bulk of the flycatcher species. It fits within the known pattern of occurrence of the species in Thailand, where birds are typically recorded during late September and early October. It is much earlier than other central Chinese breeding flycatchers except 'Chinese Blue Flycatcher' *Cyornis rubeculoides glaucicomans*. The closest known breeding population of Brown-chested Jungle Flycatcher to Vietnam is in adjacent Guangxi province, China (BirdLife International 2001). However, it is conceivable that the species breeds in the country close to the international border with China, but owing to a paucity of ornithological survey effort, particularly in extreme north-east Vietnam, this cannot be confirmed.

Brown-chested Jungle Flycatcher is currently unrecorded in Vietnam outside Hanoi and it has not been found in Laos or Cambodia. The pattern of occurrence of the species in Hanoi and Thailand indicates that it probably occurs as an autumn passage migrant in central Vietnam and perhaps southern Laos and Cambodia. Birdwatchers resident in or visiting those areas should be vigilant to the possibility of encountering the species in September and October. Brown-chested Jungle Flycatcher is recorded annually on spring passage in Thailand, typically during April and early May. The first record for Vietnam remains the only spring passage record for the country. The date of this record is similar to those in Thailand. The lack of subsequent spring records probably represents the limited observer effort at that time of year.

With the benefit of hindsight we should have started the study at the beginning of August, because the passage of flycatchers was already underway when the study began. This should probably not detract from conclusions regarding Brown-chested Jungle Flycatcher, because although passage was fairly high during the first 10-day period, the first record made during that period was quite late and the peak passage period was also the last period in which the species was recorded. There was very little observer attention given to the parks prior to the study, and it is consequently possible that some individuals were missed. The peak passage period for Yellow-rumped and Brown-breasted Flycatchers in 2010 was probably either during the first 10 days of the study period or preceded the study. However, any conclusions regarding the timing of migration of Brown-chested Jungle Flycatcher and other species refer strictly to these sites in 2010 only, and should be tested in subsequent years. After the study was complete, observers continued to visit the parks often until February and recorded only one or two overwintering Taiga Flycatchers and Asian Brown Flycatchers.

Although our study focused on a globally threatened species, data on abundance and distribution of most migrant bird species in Indochina remain sparse. This study demonstrates that useful data on bird species can be obtained even in the most unlikely places. It further indicates that in familiar and unexpected locations interesting species can be found.

ACKNOWLEDGEMENTS

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***Simon P. MAHOOD**, Wildlife Conservation Society Cambodia Programme, House 21, Street 21, Sangkat Tonle Bassac, Phnom Penh, Cambodia. Email: smahood@wcs.org*

***Sébastien DELONGLÉE**, 50 rue de la Pommerais, 35136 Saint-Jacques-de-la-Lande, France. Email: sebastiendlng140@gmail.com*

***Florian KLINGEL**, Hofstettenstrasse 9, 9012 St. Gallen, Switzerland. Email: florianklingel@gmail.com*

***Falk WICKER**, 9/3 Wardens Walk, Coburg, 3058 Victoria, Australia. Email: falk.wicker@gmail.com*

***Richard CRAIK**, 3rd Floor, 71–75 Hai Ba Trung Street, District 1, Ho Chi Minh City, Vietnam. Email: richard@vietnambirding.com*

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A survey of the avifauna of Obi island, North Moluccas, Indonesia

JOHN C. MITTERMEIER, H. EDEN W. COTTEE-JONES, ENDANG CHRISTINE PURBA, NOVA MAULIDINA ASHURI, EKA HESDIANTI & JATNA SUPRIATNA

The avifauna of eastern Wallacea remains little studied despite high diversity and endemism and basic knowledge of the ecology, taxonomy and distribution of species is lacking. Results of a two-month survey on Obi, North Moluccas, Indonesia, in July and August 2012 are presented here. General observations, point counts, mist-netting and interviews with villagers were carried out in five areas. A total of 109 species including 89 resident landbirds were recorded, of which 14 were new records for the island. Surveys up to 1,550 m extended the known altitudinal range of several species and resulted in the discovery of three montane species not previously recorded on Obi: Red-breasted Pygmy Parrot *Micropsitta bruijnii*, Mountain White-eye *Zosterops montanus* and Mountain Tailorbird *Orthotomus (Phyllergates) cucullatus*. Other notable records were five species of rail, including a surprising range extension of Drummer Rail *Habroptila wallacii* and observations of the poorly known Moluccan Woodcock *Scolopax rochussenii*. The biogeographical and conservation implications of findings and elevational turnover in bird communities on Obi are discussed. In line with recent surveys in other parts of Wallacea, this survey highlights the need for continued ornithological fieldwork in eastern Indonesia.

INTRODUCTION

Located at the boundary of two major biogeographical regions, Wallacea is exceptional for its diversity of species, conservation significance and opportunity to study evolution and speciation. Wallace's Line, marking the western boundary of Wallacea, is 'the most prominent and well-studied biogeographic division in the world' (Schulte *et al.* 2003) and the region is well known for inspiring Alfred Russel Wallace to develop his ideas on evolution by natural selection. Despite this, Wallacean birds remain poorly known: even basic distributional and life history information is lacking, and continued fieldwork is important for biological research and conservation in the region.

The mountainous island of Obi is the seventh largest in the North Moluccas, just over 2,500 km^2 in area and with a maximum elevation of 1,611 m. Even by Wallacean standards it has received little attention from ornithologists. It was not visited by Wallace although he spent considerable time on adjacent islands (Wallace 1869). H. A. Bernstein made the first ornithological collections in the early 1860s and there were visits by F. H. H. Guillemard in 1883, W. Doherty in 1897, a 'Mr. Lucas of Brussels' in 1898, J. Waterstradt in 1902, W. Goodfellow in 1907, A. M. R. Wegner in 1953, and R. Tatu and Y. Momou in 1982–1983 (White & Bruce 1986, P. M. Taylor pers. comm.). Recent records from Obi include observations by M. D. Linsley in 1989 (Linsley 1995), F. R. Lambert in 1992 (Lambert 1994), H. Bashari in 2010 (Bashari 2011) and M. Thibault and others in 2010 (Thibault *et al.* 2013). Obi was visited by a joint expedition from the Louisiana State University Museum of Natural Science, the University of Oxford, and the University of Indonesia between 5 July and 27 August 2012; here new and interesting observations resulting from this fieldwork are reported and discussed.

STUDY AREA AND METHODS

Obi is similar to other islands in the Moluccas in being primarily covered by humid evergreen forest with narrow areas of coastal mangrove, scattered swamp-forests and an area of montane forest in the interior. Historically, Obi was inhabited intermittently with human settlement restricted to a few sites along the coast. Guillemard (1885) noted the island was uninhabited in 1883, but stated that 'it is said that years ago there were many people living on the island, but pirates caused its desertion,' and Stibbe (1919) commented that 'permanent settlements [on Obi] are only found at Lawui river mouth (north coast) and at Akeklamo (south-west coast)'. Recently, however, human activity has transformed Obi—coconut plantations cover many lowland areas, with clove and nutmeg groves on the lower hills; logging has been extensive—no primary lowland forest was found during the visit, and a logging company manager doubted that any such forest remains on the island. In the highlands, selective logging was evident up to 1,100 m. Nickel ore deposits in the ultrabasic soils of west and south Obi have brought in large-scale mining operations which remove all native vegetation and topsoil, and have already caused serious degradation around Kawasi in the north-west.

In the Moluccas, south-east trade winds prevail in July and August and during the visit, the weather in north Obi—Jikotamo, Cabang Kiri River—was clear and sunny with predictable heavy downpours in the early afternoon. On the west coast—Danau Sagu, Kawasi—it was hot and dry with little to no rainfall, and in the south—Tanjung Rijang, montane areas north of Fluk—heavy rain was frequent, often beginning before dawn and continuing all day. Data collected in the southern highlands indicated rain or drizzle every day from 1 July to 4 August, with a total July rainfall of 792 mm.

Lambert (1994) had surveyed east Obi in 1992, and the 2012 expedition focused on the west of the island where five areas were studied (Jikotamo vicinity, Cabang Kiri River, Tanjung Rijang, Danau Sagu plus Kawasi, and the montane area north of Fluk) and 2–4 sites within each area were surveyed, 13 in all; in addition, more generally, we recorded birds in coastal and marine areas. Coordinates, dates, site details and descriptive notes are given in Table 1; see also Figure 1. Common forest plant species in the Telagabakti Persada logging concession at Tanjung Rijang included *Canarium balsamiferum* (Burseraceae) and dipterocarps *Shorea* spp., *Anisoptera thurifera*, *Hopea* spp. and *Vatica rassak*, similar to those in the lowlands of Seram (Marsden 1998).

Opportunistic observations were made by JCM and EC-J at all sites (total 630 hours), usually beginning just before dawn and continuing until after dark, with a break in the middle of the day. Sound recordings were made and are archived at the Macaulay Library, Cornell University. Point counts were carried out near the Cabang–Sumbali river confluence, at Plasma Nutfah, in the montane forest north of Fluk, and in the nickel mining area near Danau Sagu; unfortunately, however, although they contributed

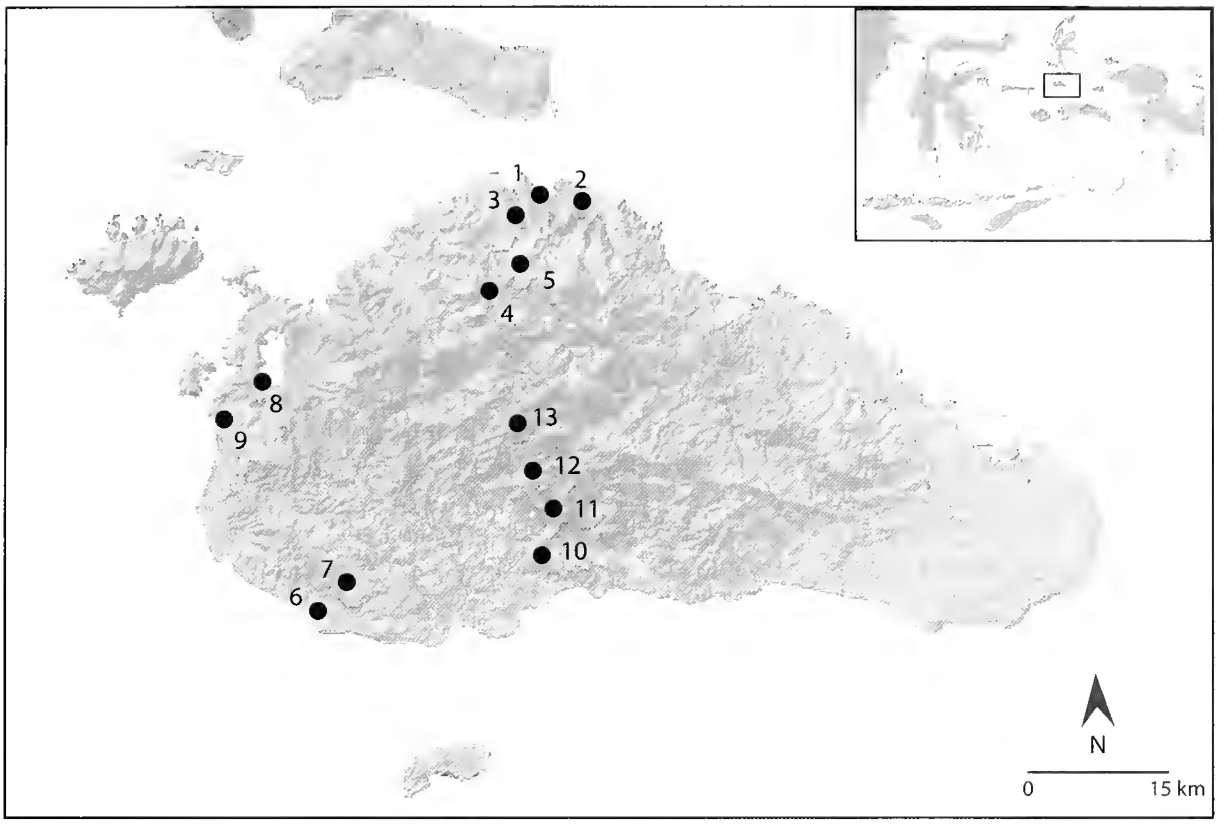


Figure 1. Map of Obi island, North Moluccas, Indonesia, showing locations of sites surveyed. Specific sites (see Table 1) are: (1) Jikotamo town, (2) Jikotamo–Sembiki Road, (3) Kampung Buton plantations, (4) Cabang–Sumbali confluence, (5) Cabang Kuning, (6) base camp Rijang, (7) Plasma Nutfah, (8) Danau Sagu lakeshore, (9) Kawasi town, (10) GPS mining camp, (11) ridge camp, (12) old logging road, (13) summit area.

Table 1. Individual sites visited between 5 July and 27 August 2012, showing dates of fieldwork and brief descriptions of habitat at each location (see Figure 1).

Specific site	Coordinates	Survey dates	Description; habitat and altitude (m)
Jikotamo vicinity			
1. Jikotamo town	1.344°S 127.655°E	6–8 July; 13, 20, 26–27 Aug	Large town and a principal port; coastline and village gardens (sea level).
2. Jikotamo–Sembiki Road	1.357°S 127.670°E	6–8 July; 26 Aug	Road from Jikotamo to Sembiki; coastal mangroves, coconut and clove plantations, secondary forest (sea level–35 m).
3. Kampung Buton plantations	1.346°S 127.644°E	6–9 July; 13 Aug	Agricultural land south of one of the largest towns; coconut plantations and open fields (sea level).
Cabang Kiri River			
4. Cabang-Sumbali confluence	1.398°S 127.649°E	10–13 July; 23–25 Aug	Cabang and Sumbali River confluence; lowland forest heavily logged in late 1990s, open gravel river beds, clove and cacao orchards (35–50 m).
5. Cabang Kuning	1.378°S 127.659°E	14–19, 21–23 Aug	Rice fields; wet rice paddies and swampy areas surrounded by flooded forest, clove and cacao plantations (30–45 m).
Tanjung Rijang			
6. Base camp Rijang	1.703°S 127.488°E	14–16, 18–22 July	Logging camp by the Rijang River mouth; extensive, selectively logged lowland forest, coconut plantations (sea level–100 m).
7. Plasma Nutfah	1.663°S 127.536°E	17–18 July	Lowland primary forest fragment (300 ha) along steep-sided gorge; designated as a seedbank. (110–300 m).
Danau Sagu and Kawasi			
8. Lakeshore	1.512°S 127.447°E	8–11 Aug	Largest freshwater lake; reed fringed open water, narrow strip of swamp forest, extensive dry savannah of the Kawasi nickel mine (160–350 m).
9. Kawasi town	1.547°S 127.413°E	11–12 Aug	Coastal town; coconut groves, freshwater swamp, extensive nickel mining area (sea level).
Montane area north of Fluk			
10. GPS mining camp	1.651°S 127.714°E	23–24 July; 5–6 Aug	Small exploratory mining camp; logged forest on sandy soil (370–550 m).
11. Ridge camp	1.604°S 127.721°E	26–28 July	Steep forest ridge: montane primary forest (850–950 m).
12. Old logging road	1.585°S 127.703°E	28 July–4 Aug	Abandoned highland logging road; montane primary forest, secondary growth along overgrown road (1,050–1,150 m).
13. Summit area	1.541°S 127.668°E	2–3 Aug	Ridgelines near the highest elevations in Obi's interior: montane primary forest (1,200–1,550 m).
Coastal and marine areas			
Obi coastline	–	5, 13, 23 July; 7, 13, 20, 28 Aug	Coastal boat trips between Fluk and Sembiki; beaches, inshore marine areas (sea level).

to the overall survey effort, insufficient data were obtained to do statistically significant analyses owing to the difficult terrain and weather conditions. Mist-netting was carried out in forest habitats at Plasma Nutfah and Tanjung Rijang (17 net hours), in the montane forest north of Fluk (416 net hours) and near Danau Sagu (271 net hours). A total of 46 local people from seven villages, particularly parrot-trappers, were interviewed. They were shown colour plates from Coates & Bishop (1997), asked to indicate species they were familiar with and occasionally also asked about species of specific interest. The interviews formed a part of more extensive, structured surveys focused on assessing local knowledge of the Moluccan Woodcock *Scolopax rochusseni* (Cottee-Jones *et al.* 2013) and gathering information about parrot-keeping and trapping on Obi (Cottee-Jones *et al.* in prep.).

RESULTS

A total of 109 bird species was recorded including 14 new for the island (Appendix), nine of them resident landbirds: Red-breasted Pygmy Parrot *Micropsitta bruijnii*, Red-necked Crake *Rallina tricolor*, Bare-eyed Rail *Gymnocrex plumbeiventris*, White-browed Crake *Porzana cinerea*, Drummer Rail *Habroptila wallacii*, Purple Swamphen *Porphyrio porphyrio*, Little Black Cormorant

Phalacrocorax sulcirostris, Mountain White-eye *Zosterops montanus* and Mountain Tailorbird *Orthotomus (Phyllergates) cucullatus*. The others were a seabird, Great Frigatebird *Fregata minor*, and four migratory species: Common Greenshank *Tringa nebularia*, Wood Sandpiper *T. glareola*, Australian Hobby *Falco longipennis* and Intermediate Egret *Mesophoyx intermedia*.

The species observed in each area varied from 42 to 78 with the four lowland areas showing higher richness (mean 65.5 species) than the one highland area (42 species). In the lowlands, diversity was increased by migratory species: 6–8 migrants were recorded in each area but none was found in the highlands. Nonetheless resident landbird diversity was greater in the lowlands (mean 57.75) than the highlands, with the highest overall species diversity in logged forest with subsistence orchards on the Cabang Kiri River (74) and in selectively logged forest at Tanjung Rijang (69). In lowland areas the number of species recorded correlated directly with survey effort, with the greatest number of species being found where most time was spent.

Selected species accounts

Moluccan Cuckoo *Cacomantis heinrichi*

The taxonomy of *Cacomantis* cuckoos in the Moluccas is poorly understood. Recently, however, Thibault *et al.* (2013) concluded that, based on voice and plumage, the 'Moluccan Cuckoo' consists of the taxa *aeruginosus* (Obi, Buru, Ambon, Seram; usually considered a subspecies of Brush Cuckoo *C. variolosus*) and *heinrichi* (Halmahera and Bacan). We tentatively accept this judgement here.

In 2012 *Cacomantis* cuckoos were widespread on Obi, and there appeared to be two, possibly three, distinct types (Plate 1) that differed according to habitat preference, vocalisations, extent of rusty underpart colouration and presence of a yellow eye-ring. These observations suggest that at least two *Cacomantis* taxa occur on Obi—'Moluccan Cuckoo' and one, possibly two (potentially resident and migratory) subspecies of Brush Cuckoo. In contrast to Halmahera, where 'Moluccan Cuckoo' has been recorded or suspected only infrequently in montane forest (White & Bruce 1986, Tebb *et al* 2008), on Obi it was widespread from sea level to above 1,150 m, relatively common and tolerant of moderate habitat disturbance. Further investigation of the taxonomy of this group is clearly necessary.

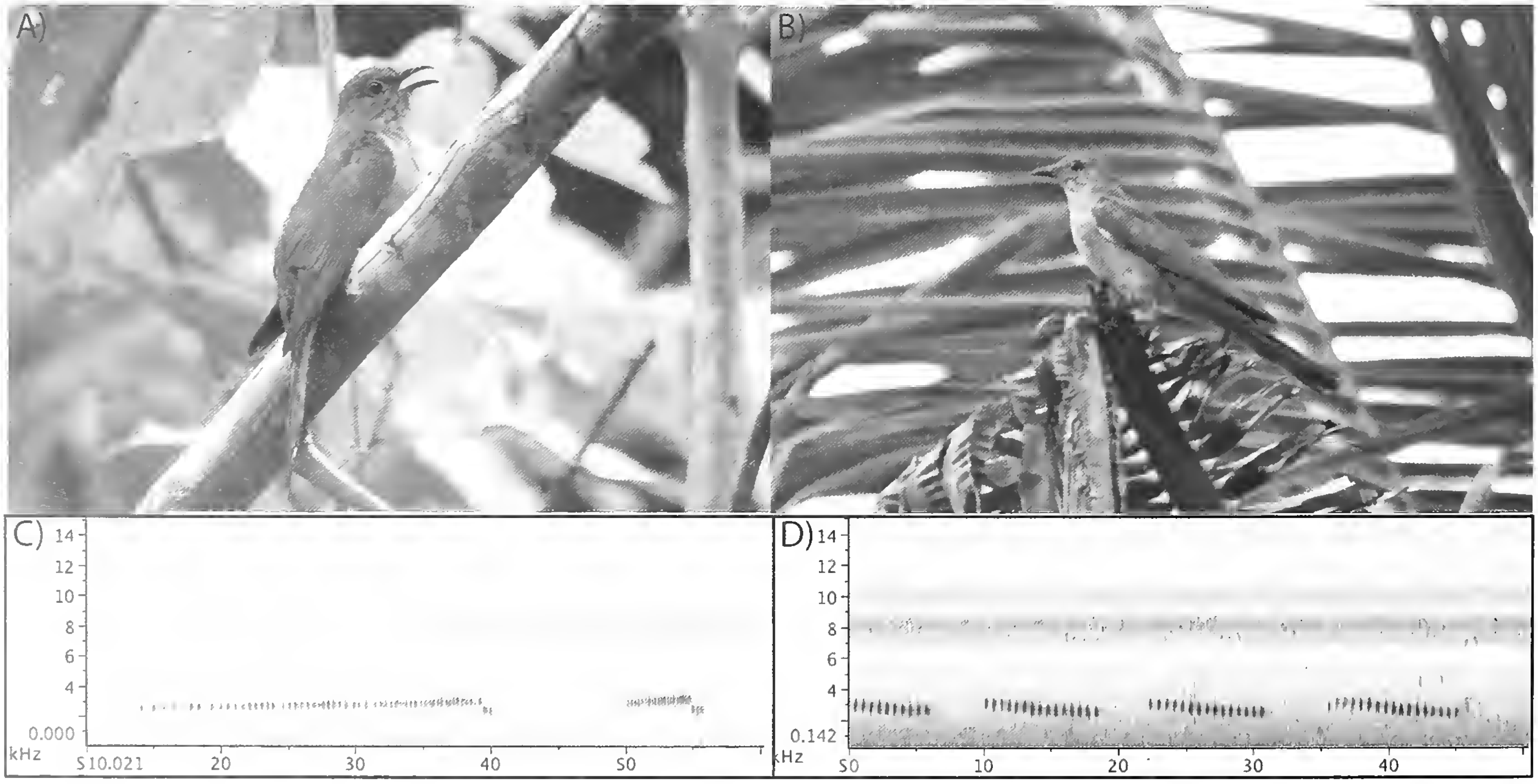
Chattering Lory *Lorius garrulus*

Vulnerable. A distinctive yellow-backed subspecies *flavopalliatus* is found only on Obi and Bacan. On Obi it is a popular village cage-bird and at least 40 individuals captured from the wild were seen in Kampung Buton and Jikotamo. The species is believed to be declining owing to trapping and habitat loss (BirdLife International 2013c), but was locally common where trapping was limited, specifically in the inaccessible montane forest north of Fluk and at Tanjung Rijang, where the Telagabakti Persada logging company enforces a trapping ban. It was seen from sea level to 1,100 m (and probably occurred higher), and around Tanjung Rijang was frequently found in selectively logged and primary forest fragments (Table 1). In contrast, it was not seen near Jikotamo or on the Cabang Kiri River. In this area, parrot trappers from Kampung Buton travelled inland beyond the study area to catch Chattering Lories in the mountains. On 13 July, for example, a trapper travelled upriver from the Cabang–Sumbali confluence at 06h00 and returned at 12h00 with three lories. Although trappers here claimed that the species had always been restricted to inland areas, it was common in similar habitat near the coast at Tanjung Rijang, suggesting that the species has been extirpated near Jikotamo, Kampung Buton and Laiwui.

Red-breasted Pygmy Parrot *Micropsitta bruijnii*

In Wallacea, this inconspicuous montane species was previously known only from Seram (subspecies *pileata*) and Buru (subspecies *buruensis*). On 3 August a group of six Red-breasted Pygmy Parrots was seen in montane primary forest between 1,350 and 1,550 m in central Obi. One was seen very well, perched in the open for 2–3 minutes. It had emerald-green upperparts and flanks, black spots on the wing-coverts, dull red underparts turning to orange on the undertail-coverts, a diffuse blue-green collar, creamy-

Plate 1. Two *Cacomantis* cuckoos found on Obi: (A) Moluccan Cuckoo *Cacomantis aeruginosus* and (B) Brush Cuckoo *C. variolosus*. Although similar in appearance these species differed in habitat use (former in lowland swamp-forest, dense secondary forest and montane forest, latter in open agricultural areas and coconut plantations) and vocalisations. Sonagrams (using Raven Lite 1.0) show: (C) a 50-second segment of vocalisations following playback of the Moluccan Cuckoo and (D) a 50-second segment of vocalisations following playback of Brush Cuckoo (in both cases, calls are from the individual bird shown above).



JOHN C. MITTERMEIER

JOHN C. MITTERMEIER

white throat and cheeks and a whitish-brown cap offset by a grey-brown band extending from the bill through the eye and to the side of the neck. The colour of the collar, crown, cheeks and eye-line of this bird differed from descriptions and images of both *pileata* and *buruensis* (Coates & Bishop 1997, Arndt & Persulessy 2010) and *bruijnii* from New Guinea (Juniper & Parr 1998) so this population may be an undescribed taxon meriting conservation concern.

Swiftlets *Collocalia* sp.

Apart from the omnipresent Glossy Swiftlet *Collocalia esculenta*, swiftlets in the north Moluccas are a field identification challenge because of the difficulty in distinguishing between Uniform Swiftlet *C. vanikorensis* and the dark-rumped *infuscata* subspecies of Moluccan Swiftlet *C. infuscata*. Lambert (1994) tentatively identified both Uniform Swiftlet and the white-rumped *ceramensis* subspecies of Moluccan Swiftlet, sometimes considered a distinct species, on Obi.

Dark-plumaged swiftlets were common and frequently seen flying high above the canopy. There appeared to be three morphotypes: (1) blackish upperparts and grey underparts with a distinct white rump-band; (2) brown upperparts and underparts with no obvious rump-band; (3) blackish upperparts and blackish-brown underparts with a hint of a brown rump-band. The white-rumped birds were the least common of the dark swiftlets and usually seen in flocks of 10–30 either alone or in multi-species flocks. Dark-rumped swiftlets occurred both in small flocks and, more frequently, in flocks of several hundred birds. The first two plumage types accord with Lambert's identification of Moluccan Swiftlet *ceramensis* and Uniform Swiftlet on Obi. The third type may simply be variation within Uniform Swiftlet or potentially the dark-rumped *infuscata* subspecies of Moluccan Swiftlet.

White-throated Pigeon *Columba vitiensis*

This species is known from all the nearby island groups (White & Bruce 1986), but was not recorded on Obi until Thibault *et al.* (2013) found it at 1,000 m in 2010. A single individual was seen flying along the forest edge at Cabang Kuning (20 m). This suggests that it is rare on Obi across a wide altitudinal range. Local parrot-trappers near Jikotamo were familiar with the species and reported that it feeds on the ground in the forest.

Scarlet-breasted Fruit Dove *Ptilinopus bernsteini*

Subspecies *micrus* (Jany 1955) diagnosed principally by its smaller size (White & Bruce 1986), is endemic to Obi. Lambert (1994) recorded it between 180 and 600 m. It was uncommon in lowland plantations in the Cabang Kiri River area (35–50 m) and relatively common in montane forest north of Fluk (800–1,550 m) where two males were mist-netted and measured on 27 July and 2 August. Wing measurements (140 mm) were slightly above the known size range for *micrus* wing (128–139 mm) (White & Bruce 1986).

Carunculated Fruit Dove *Ptilinopus granulifrons*

Endemic. Classified as Vulnerable (BirdLife International 2013d), this species was not seen from 1992 until 2011 (Bashari 2011). It was found to be widespread but inconspicuous in secondary forest near Cabang–Sumbali and in selectively logged forest near Tanjung Rijang. One was also seen in montane forest at 1,100 m. It was usually found feeding in fruiting trees in groups of 2–10 individuals; often the only indication of its presence was a distinctive wing-flapping as birds moved between branches. Although only one bird was found in montane forest, given its inconspicuous behaviour it is possibly found at higher altitudes than previously thought. These findings concur with the known distribution and habitat of the closely related Grey-headed Fruit Dove *P. hyogaster* on Halmahera (Gibbs *et al.* 2001). Although Carunculated Fruit Dove is not listed for the island of Bisa (Gibbs *et al.* 2001), local people reported its presence there, and this and other outlying islands are worth further investigation.

Cinnamon-bellied Imperial Pigeon *Ducula basilica*

The distinctive subspecies *obiensis* (Hartert 1898) is endemic to Obi and may warrant recognition as a full species. It was fairly common in disturbed and selectively logged habitats throughout the lowlands, where it appears to tolerate moderate habitat disturbance, and was common in montane forest above 800 m.

Pied Imperial Pigeon *Ducula bicolor*

The taxonomy of this species in the Moluccas remains poorly understood owing to confusion between the status of *Ducula bicolor* and '*D. melanura*' (White & Bruce 1986). Coates & Bishop (1997) listed *melanura* for Obi but Gibbs *et al.* (2001) concluded that *melanura* is either a morph of *bicolor* or the result of genetic introgression between *bicolor* and *spilorrhoa* of New Guinea. Birds observed on Obi showed some traits of *melanura*, including a greenish-horn bill and extensive black to the outer rectrices, but lacked black markings on the undertail-coverts. This mix of traits appears to support the conclusion of Gibbs *et al.* (2001).

Red-necked Crake *Rallina tricolor*

In the Moluccas this species is previously known from Ambon and Tayandu (White & Bruce 1986, Taylor 1998). It was common in wet, closed-canopy forest around Cabang Kuning (14–22 August), where substantial rainfall had left pools of standing water in many areas of the forest and uncommon along the Jikotamo to Sambiki road (26 August). Birds vocalised frequently, particularly at dusk, and responded strongly to playback. Elsewhere, Red-necked Crakes apparently migrate from New Guinea to the Cape York Peninsula in the wet season (Taylor 1998), and records from Ambon in June–July were also considered to be migrants from New Guinea (White & Bruce 1986). Given the lack of previous records, it may also be a seasonal visitor to Obi.

Bare-eyed Rail *Gymnocrex plumbeiventris*

In the Moluccas, this species occurs on Halmahera, Bacan and Morotai but has not previously been recorded on Obi. It is also found on Misool and New Guinea (White & Bruce 1986, Taylor 1998). It was uncommon in swamp-forest surrounding the Cabang Kuning rice-fields, where two were recorded on 18–19 and 22 August. It occurred in the same habitat as Red-necked Crake. Vocalisations included steady gulping noises while foraging, and a loud barking call followed by a bizarre, trumpeting *woooo-wooot* in response to playback (recordings at: macaulaylibrary.org).

White-browed Crake *Porzana cinerea*

This widespread species has been recorded in the Moluccas from Kai, Ambon, Seram, Bacan and Halmahera (White & Bruce 1986, Coates & Bishop 1997). It was heard and seen on 9 and 11 August in a dense reedbed on the south-west edge of Danau Sagu, where Purple Swamphen (see below) was also observed. One was flushed from the wet rice-fields at Cabang Kuning on 16 August. Although its presence on Obi is not surprising given its distribution, these are apparently the first records for the island.

Moluccan Bush-hen *Amaurornis moluccana*

First recorded on Obi by Lambert (1994), one was also heard in 2010 by Thibault *et al.* (2013). At lowland sites it was relatively common, although inconspicuous—at least four pairs were found along a 2-km stretch of river near Tanjung Rijang, and a minimum of three pairs was present in swamp-forest bordering the Cabang Kuning rice-fields. It was also found in secondary growth along an old logging road in montane forest at 1,150 m.

Drummer Rail *Habroptila wallacii*

This species was previously believed to be endemic to Halmahera (White & Bruce 1986, Taylor 1998). However two birds were observed and recorded in dense swamp-forest near Cabang Kuning on 17–18 August. Local people were familiar with the species and reported frequently catching it in snares set for scrubfowl. Six interviewees reported it in the Jikotamo–Kampung Buton area, one in Tanjung Rijang and one in Wayloar. This suggests it is relatively widespread in the lowlands. It is considered a delicacy on Halmahera (Taylor 1998, P. M. Taylor pers. comm.) and three local people confirmed eating them although others stated that they released rails from snares because of their strange appearance. Two hunters described collecting eggs from a nest on a palm stump about 0.5 m tall, a description that agrees with the record of a nest from Halmahera (Bashari & van Balen 2011). Given that the Drummer Rail is believed to be flightless (de Haan 1950, Taylor 1998), its presence on Obi is intriguing and warrants further study.

Purple Swamphen *Porphyrio porphyrio*

White & Bruce (1986) described this species as 'very local' in Wallacea—it occurs on most of the large islands (e.g. Sulawesi, Buru, Seram, Halmahera), but is absent from smaller islands such as Bacan, Morotai, Misool and the Sulas (White & Bruce 1986, Taylor 1998). Four Purple Swamphens were seen in dense reedbeds on the south-west edge of Danau Sagu, the only large freshwater lake, on 9 and 11 August. Parrot-trappers and local people near Jikotamo and Kampung Buton were not familiar with the species despite its large size and distinctive appearance and it may be very localised or restricted only to the marshes around Danau Sagu.

Moluccan Woodcock *Scolopax rochussenii*

Endangered (BirdLife International 2013e). An enigmatic species, known only from Obi (fewer than 10 records) and one specimen collected on Bacan in 1902. It went unrecorded from 1982 until 2010 when Thibault *et al.* (2013) observed it near Soligi and east of Jikotamo. The species was found to be uncommon but widespread and conspicuous when displaying at dawn and dusk. Birds were observed displaying over swamp-forest and along rivers and stream valleys from 15–1,150 m. The distribution and conservation status of this species are described by Cottee-Jones *et al.* (2013).

Migratory waders

A variety of shorebirds migrate through east Wallacea but in general the region supports relatively low numbers of migrants and does not appear to be a major wintering area (White 1975, Coates & Bishop 1997). Information on timing and distribution of migrants is sparse. A flock of three Wood Sandpipers *Tringa glareola* was near Kawasi on 11 August and a single on the rice-fields at Cabang Kuning from 18–22 August, with a single Common Greenshank *Tringa nebularia*. Both species are common passage and wintering migrants in the Moluccas but not previously recorded on Obi (White & Bruce 1986, Coates & Bishop 1997). Common Sandpiper *Actitis hypoleucos* was seen on 11 August at Danau Sagu and again on 13 August at Kampung Buton. Red-necked Phalaropes *Phalaropus lobatus* were seen on 27 August, when over 40 were just off the coast near Jikotamo and in the strait between Obi and Bacan, but were not observed on six boat trips through the same area between 6 July and 20 August. Both are common wintering species in the Moluccas, with several previous records from Obi.

Australian Hobby *Falco longipennis*

Non-breeding individuals of the nominate subspecies occur in small numbers in the Moluccas and have been recorded on Ternate, Ambon and Seram (White & Bruce 1986). A single bird was seen and photographed at dusk near Kawasi on 11 August—the first record for Obi.

Little Black Cormorant *Phalacrocorax sulcirostris*

Widespread in the Moluccas with reports from Bacan, Halmahera, Buru and Seram amongst others (White & Bruce 1986). A single flying over a river near the Cabang–Sumbali confluence on 11 July is the first record for Obi. In contrast, Little Pied Cormorant *P. melanoleucos* was relatively common in freshwater habitats around Kawasi and Danau Sagu.

Intermediate Egret *Mesophoyx intermedia*

In Wallacea, a widespread but generally uncommon non-breeding visitor from Australia, subspecies *plumifera*, and the Palearctic subspecies *intermedia* (White & Bruce 1986). In the Moluccas it has been recorded widely including Bacan, Buru and Seram but until now not Obi. One was foraging in a wet grassy field near the Cabang Kuning rice-fields on 16 August. The black tip to the bill and the entirely black legs suggested the subspecies *intermedia*.

Great and Lesser Frigatebird *Fregata minor* and *F. ariel*

Both Great and Lesser Frigatebird occur throughout Wallacea (White & Bruce 1986, Coates & Bishop 1997). Lesser Frigatebird appears to be more frequent around Obi and was reported by Linsley (1995). It was seen three times during coastal boat journeys and flying over the shore at both Tanjung Rijang and Kawasi. On 21 July, JCM observed two Great Frigatebirds soaring with six Lesser Frigatebirds over the coast at Tanjung Rijang. Great Frigatebird has been reported from Halmahera, Buru, Ambon and Seram in the North Moluccas but not previously from Obi.

Slaty Monarch *Myiagra galeata*

This Moluccan endemic is common on Obi (Coates & Bishop 1997) although information on its nesting behaviour is limited. A pair was nesting in an isolated tree near Jikotamo on 7 July. The tree, roughly 15 m high, was in a cattle pasture about 10 m from the forest edge. The nest was located on a fork in a branch about 12 m above the ground in the subcanopy. It consisted of a small woven cup approximately 5 cm in diameter with sides built up about 5 cm high and was constructed of neatly woven plant fibres mixed with bark and lichen. The male and female took turns in the nest and appeared to be incubating.

Mountain White-eye *Zosterops montanus*

This species is found in montane habitats above 1,000 m on Seram, Bacan, Ternate (subspecies *obstinatus*) and Buru (subspecies *montanus*), but has not previously been recorded on Obi. On 29 July, a dense flock of about 25 individuals was feeding with about 10 Cream-throated White-eyes *Z. atriceps*. along an old road-cut in montane forest at 1,120 m. The Mountain White-eyes were obviously smaller and more compact and had olive upperparts, head, flanks and undertail-coverts, with a bright yellow throat and underparts, conspicuous broken white eye-rings, dark irises, black legs and bill. On 1 August a flock of about 50 Mountain White-eyes was feeding in the same trees and on 2 August two flocks were seen at 1,100 m and a third flock at 930 m.

Cream-throated White-eye *Zosterops atriceps*

First discovered on Obi in 1992 by Lambert (1994) who reported it uncommon between 220 and 700 m and described birds as closely resembling nominate *atriceps* from Bacan, it was subsequently seen in 2010 by Thibault *et al.* (2013). It was common and conspicuous from 500–1,100 m in montane forest north of Fluk, but was not recorded below 500 m. Elsewhere it mainly occurs in lowlands up to 700 m (White & Bruce 1986, Coates & Bishop 1997).

Mountain Tailorbird *Orthotomus (Phyllergates) cucullatus*

In Wallacea previously recorded in montane forest on Bacan, (subspecies *batjanensis*), Buru and Seram (subspecies *dumasi*), and

Sulawesi, four subspecies. White & Bruce (1986) found little difference between these taxa and questioned their validity. Mountain Tailorbird was found in montane forest north of Fluk between 900 and 1,200 m on 27 July–4 August. It was common in patches of dense vegetation, often near old landslides or treefalls.

Island Leaf Warbler *Phylloscopus poliocephalus*

The subspecies *waterstradti* found on Obi and Bacan was originally described as a distinct species by Hartert (1903). It was one of the commonest species in forest from 500–1,550 m, where it was a frequent and vocal member of mixed-species flocks.

Species not recorded

Several species which were not observed deserve mention because they were either (a) familiar to local people but not seen during the fieldwork, or (b) reported or predicted in earlier accounts but were neither seen during fieldwork nor familiar to interviewees. The technique of showing interviewees plates in a field guide is known to have drawbacks (Diamond & Bishop 1999), but in some circumstances the results merit reporting. The people on Obi were particularly knowledgeable about large and conspicuous birds, parrots, terrestrial birds caught in snares, and nectarivores that visited the flowers of clove trees.

Species for which there were at least two independent local reports were: a large black eagle, presumably either Gurney's Eagle *Aquila gurneyi* or Black Eagle *Ictinaetus malayensis*, Buff-banded Rail *Gallirallus philippensis*, Barred Rail *G. torquatus*, Common Koel *Eudynamys scolopacea* and Sulawesi Myzomela *Myzomela chloroptera*. The myzomela was first collected on Obi in 1982 by R. Tatu and Y. Momou (White & Bruce 1986) and was observed in the highlands by Thibault *et al.* (2013). Clove harvesters near Kampung Buton reported that *cui merah* (a red sunbird) occasionally visited their trees.

Notable species not seen and unfamiliar to local people even after specific questioning, included: White Cockatoo *Cacatua alba*, Moluccan Scrubfowl *Eulipoa wallacii*, Goliath Coucal *Centropus goliath*, Ivory-breasted Pitta *Pitta maxima*, Red-backed Buttonquail *Turnix maculosus*, White-breasted Woodswallow *Artamus leucorynchus* and Long-billed Crow *Corvus validus*. All these have been listed for Obi in earlier accounts (White & Bruce 1986, Coates & Bishop 1997) and are distinctive in appearance. Failure to record them could be due to several factors, including inaccurate historical records, vagrancy or local extinction and their status warrants further investigation.

In the case of White Cockatoo, there has been confusion as to whether the species was once native (White & Bruce 1986) and has been extirpated or only ever occurred as an escaped population (Lambert 1994). Most parrot-trappers were familiar with it, but identified it as being from Bacan. Villagers in Air Mangga Indah in north Obi, however, reported several white cockatoos living in the nearby hills. These observations support Lambert's suggestion that the species is not native but may occur as small populations of escaped birds near human habitations.

DISCUSSION

The discovery of 14 new species for Obi is comparable with recent findings on other Wallacean islands (Trainor 2002, Rheindt *et al.* 2010, Trainor *et al.* 2012) and re-emphasises the need for on-going fieldwork in the region. On Obi a good example of data deficiency is provided by the Rallidae. Prior to the 2012 fieldwork, the family was known on the island only from records of Moluccan Bush-hen (Lambert 1994, Thibault *et al.* 2013). In 2012 the bush-hen and an additional five species were recorded, whilst local hunters reported up to four further species. Clearly Obi is not depauperate in rallids and, despite its relatively small size, hosts rail diversity comparable to larger Moluccan islands such as Buru (eight species), Seram (seven), and Halmahera (seven) (Coates & Bishop 1997). From a distributional standpoint, 10 of these records are of species that occur on islands both north (e.g. Halmahera, Bacan) and south (e.g. Seram, Buru) of Obi, so their presence is not surprising. Nine of the new records are resident breeding species and are of particular significance in understanding the island's ecology and biogeographical relationships. From a distributional standpoint, five of them occur on islands both north (Halmahera, Bacan) and south (Seram, Buru) of Obi, and consequently their presence is unsurprising. As Coates & Bishop (1997) pointed out, however, 'one of the more striking features of Moluccan birds is the seemingly haphazard occurrence of certain families and species'; therefore, confirming whether apparent range disjunctions are real or a sampling artefact is essential. Obi has been grouped with Halmahera, Bacan and Morotai in a North Moluccan biogeographical unit (White & Bruce 1986, Carstensen & Olesen 2009) and it is therefore tempting to conclude that Obi's avifauna is a subset of that of Halmahera. The remaining four additions to the Obi list are two species, Drummer Rail and Bare-eyed Rail, which appear to support the connection with Halmahera, but two that are apparently absent from Halmahera with their closest known populations to the south (Red-breasted Pygmy Parrot) and to the east (Red-necked Crake).

Elevational turnover

The difference between montane and lowland bird communities in Melanesia (Mayr & Diamond 1976) and Wallacea (Poulsen & Lambert 2000) has been of long-standing scientific interest, and in both regions the altitudinal range of a species may vary from island to island (Mayr & Diamond 1976, Arndt & Persulessy 2010). The altitudinal range of each species observed on Obi is reported in the Appendix. Many species recorded up to 1,150 m are probably found higher, as survey time above this elevation was limited.

Seven species were found to be common in the highlands but were not seen in the lowlands, and 25 species seen frequently in lowland forests were not seen in the highlands. The species restricted to the upland forests include three seen down to 300–500 m and four only found in the higher forests above 850 m (see Appendix). This may partly be due to sampling deficiencies, but it is clear that avian communities on Obi change substantially with increasing elevation—in contrast to Halmahera where the lack of a distinct montane bird community is attributed to the limited and fragmented nature of forest cover at higher altitudes (Poulsen & Lambert 2000).

Conservation implications

Obi is treated as Important Bird Area ID 202 (BirdLife International 2013a) within the Northern Maluku Endemic Bird Area (BirdLife International 2013b). A 45,000 ha nature reserve lying between 500 and 1,611 m in the central highlands has been proposed (MacKinnon & Artha 1981). It is unclear whether this reserve has been officially accepted and where exactly it is located. Most people questioned on Obi seemed unaware of it and logging appears to be on-going or to have taken place in most parts of Obi.

Four aspects of our results have particular conservation significance. (1) As elsewhere in the Moluccas, highland and lowland bird communities differ substantially and conservation programmes must take account of habitats at all elevations across the island. Some endemic taxa are rare in or absent from the lowlands e.g. Scarlet-breasted Fruit Dove, Pale Cicadabird *Coracina ceramensis hoogerwerfi* and Island Flycatcher *Eumyias panayensis obiensis*, whereas others are rare or absent from the highlands e.g. Common Paradise-kingfisher *Tanysiptera galatea obiensis* and Slender-billed Cicadabird *C. tenuirostris obiense*. The highlands hold the last significant area of intact primary forest on the island, but the small size of this forest and logging operations so far as high as 1,100 m place it under threat. (2) Many forest bird species on Obi seem to be resilient to moderate logging and habitat change. In particular, endemic taxa and species of conservation concern including Chattering Lory, Carunculated Fruit Dove and Moluccan Woodcock were observed on many occasions in selectively logged forest. This suggests that these degraded forests should be incorporated into conservation strategies on the island. Conservation measures may benefit from considering existing local cultural values. Survival of forest and reedbeds around Danau Sagu, for example, is primarily due to superstitions surrounding the lake. (3) The environmental impacts of nickel mining on Obi should be carefully evaluated before new areas, particularly in the southern highlands, are exploited. Unregulated nickel mining practices lead to a near-total transformation of the landscape and dramatic changes in the bird community. None of the three species of conservation concern or the endemic taxa with the exception of Drab Whistler *Pachycephala griseonota johni* and Northern Golden Bulbul *Alophoixus affinis lucasi*, was observed in the nickel mining area near Kawasi. (4) Parrot trapping on Obi continues on a significant scale for local and off-island sale and may threaten the survival of some species, in particular Chattering Lory. In 2012, no evidence of monitoring or regulation of the trade was seen. Lambert (1993) conducted an extensive study of the parrot trade in the North Moluccas and outlined clear catch and export quotas for both Chattering Lory and Violet-necked Lory *Eos squamata*. More recently, Crosby (2003) recommended that 'zero quotas' should remain in place for Chattering Lory until a reliable system of management is developed. It seems possible that habitat destruction and trapping have extirpated this species from parts of the island.

Future directions

It seems likely that more species will be added to Obi's bird list. Surveys in different seasons and with more focus on the eastern part of the island are recommended, and these should extend to the little-known satellite islands of Bisa, Obilatu, Tapat and Gomumu. From a taxonomic and biogeographic perspective, a top priority should be the targeted collecting of scientific specimens for morphological and molecular analyses—several species were encountered that may prove to be undescribed taxa or require clarification of their taxonomic status. A solid understanding of the taxonomy and biogeographical history of species on Obi will help set conservation priorities. From a conservation perspective, priorities include clarifying the status of the island's protected area, investigating the value of different types of human-modified habitats for birds, addressing the restoration of habitats following nickel mining, and monitoring and controlling the island's parrot trade.

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***John C. MITTERMEIER**, Museum of Natural Science, 119 Foster Hall, Louisiana State University, Baton Rouge, LA, 70803, USA. Email: john.mittermeier@gmail.com (correspondence)*

***H. Eden W. COTTEE-JONES**, Biodiversity Research Group, School of Geography and the Environment, Oxford University Centre for the Environment, South Parks Road, Oxford OX1 3QY, UK. Email: henry.cottee-jones@seh.ox.ac.uk*

***Endang Christine PURBA**, Biology Department, Pascasarjana Program, Faculty of Mathematics and Natural Science, Universitas Indonesia, Gedung E lantai 2 Kampus UI Depok, West Java, Indonesia. Email: endang.christine@yahoo.com*

***Nova Maulidina ASHURI**, Biology Department, Pascasarjana Program, Faculty of Mathematics and Natural Science, Universitas Indonesia, Gedung E lantai 2 Kampus UI Depok, West Java, Indonesia. Email: dina_ta_its@yahoo.com*

***Eka HESDIANTI**, Biology Department, Pascasarjana Program, Faculty of Mathematics and Natural Science, Universitas Indonesia, Gedung E lantai 2 Kampus UI Depok, West Java, Indonesia. Email: eka.hesdianti@ymail.com*

***Jatna SUPRIATNA**, Research Center for Climate Change, Universitas Indonesia, Gedung PAU UI lantai 8,5 Kampus UI Depok 16424, West Java, Indonesia. Email: jsupriatna@conservation.org*

Appendix

Birds recorded on Obi, North Moluccas, Indonesia, from 5 July–27 August, 2012.

Locations: (1) Jikotamo town, (2) Cabang Kiri River area including Cabang Kuning and Cabang-Sumbali river confluence, (3) Tanjung Rijang logging camp, (4) Danau Sagu and Kawasi Town, (5) montane forest north of the Fluk and (6) coastal and marine areas around the island. Relative abundance letters are: (C) greater than or equal to 10 individuals per day, (F) 4–10 individuals per day, (U) 1–3 individuals per day, and (R) less than 1 per day. Legend: (p) species photographed, (s) sound-recorded, (m) mist-netted; others were seen or heard only.

	Locations							
Species	**1**	**2**	**3**	**4**	**5**	**6**	**Legend**	**Altitudinal range (m)**
Dusky Scrubfowl *Megapadius freycinet*		R	U		R		s	0–1,100
Spotted Whistling Duck *Dendracygna guttata*		F		R			p, s, m	0–35
Papuan Hornbill *Aceras plicatus*	F	F	F	R	R		p, s	0–1,100
Dollarbird *Eurystamus arientalis*		R		R			p	0–30
Common Kingfisher *Alceda atthis*	U	U	U	U			p	0–160
Little Kingfisher *Alceda pusilla*	R			R				0–160
Variable Dwarf Kingfisher *Ceyx lepidus*	U	U		U			p, s	30–200
Blue-and-white Kingfisher *Tadiramphus diaps*	U	F	F	U			p, s, m	0–200
Beach Kingfisher *Tadiramphus sauraphaga*	R					U	p	0
Sacred Kingfisher *Tadiramphus sanctus*	F	U	U	U			p	0–200
Common Paradise-kingfisher *Tanysiptera galatea*	U	F	F				p, s	30–300
Rainbow Bee-eater *Meraps arnatus*	C	F	F	C			p, s	0–350
Brush Cuckoo *Cacamantis varialasus*	F	U	U				p, s	0–40
Moluccan Cuckoo *Cacamantis heinrichi*	U	U	U		U		p, s	0–1,150
Violet-necked Lory *Eas squamata*	C	F	C	U	F		p, s	0–1,550
Chattering Lory *Larius garrulus*			F		C		p, s	0–1,150
Red-flanked Lorikeet *Charmasyna placentis*	C	C	C	C	C		p, s, m	0–1,100
Red-breasted Pygmy Parrot *Micrapsitta bruijnii*					R			1,350–1,550

Species	Locations 1	2	3	4	5	6	Legend	Altitudinal range (m)
Red-cheeked Parrot *Geoffroyus geaffrayi*		F	F	U	U		p, s	30–1,550
Great-billed Parrot *Tonygnothus megolarynchos*			U	R				0–300
Eclectus Parrot *Eclectus rorotus*	U	R	R					0–35
Glossy Swiftlet *Collocolio esculento*	C	C	C	C	C		p, m	0–1,150
Moluccan Swiftlet *Callacalia infuscoto*		F		F			p, s	0–1,000
Uniform Swiftlet *Callacolio vonikarensis*		C	C	C				0–160
Dark swiftlet sp. *Collacolia infuscata/vanikarensis*	F	F	C	C	U			0–1,100
Moustached Treeswift *Hemiprocne mystocea*		C	F	R			p, s	0–300
Moluccan Scops Owl *Otus mogicus*	U	U	U		U		p, s	30–1,100
Barking Owl *Ninox connivens*		R	U	F			s	0–300
Large-tailed Nightjar *Coprimulgus macrurus*	U	U	U	U			s	0–300
Metallic Pigeon *Columba vitiensis*		R						30
Spotted Dove *Streptopelio chinensis*	R						p	20
Brown Cuckoo Dove *Macrapygia ambainensis*	U	U	C	F	C		p, s, m	0–1,150
Great Cuckoo Dove *Reinwardtaena reinwardtii*		R	R		R		s	30–1,100
Emerald Dove *Cholcophops indico*	C	F	F		R		p, s, m	0–1,100
Nicobar Pigeon *Colaenas nicabarica*			R				p	150
Scarlet-breasted Fruit Dove *Ptilinopus bernsteinii*		R			U		p, m	30–1,550
Superb Fruit Dove *Ptilinapus superbus*		U					p, m	30–200
Carunculated Fruit Dove *Ptilinopus granulifrons*		U	U		R		p	30–1,150
Black-naped Fruit Dove *Ptilinopus melonospilo*				R				300
White-spectacled Imperial Pigeon *Ducula perspicillata*	F	C	C	R			p, s	0–300
Cinnamon-bellied Imperial Pigeon *Duculo bosilico*	U	F	U	R	C		p, s	30–1,550
Pied Imperial Pigeon *Duculo bicolor*	U	U	U				p, s	0–150
Red-necked Crake *Rallina tricolor*	R	U					s	30–35
Bare-eyed Rail *Gymnocrex plumbeiventris*		U					s	30
Rufous-tailed Bush-hen *Amourarnis maluccanus*		F	F	R	R		s	0–1,150
White-browed Crake *Porzona cinereo*		R		U			s	30–160
Drummer Rail *Hobroptilo wollacii*		R					s	30
Purple Swamphen *Parphyria parphyria*				U			p, s	160
Moluccan Woodcock *Scolopox rochussenii*	U	U	U		U		p, s	15—1,150
Common Greenshank *Tringa nebularia*		R					s	30
Wood Sandpiper *Tringa glareola*		R		R			s	2–30
Common Sandpiper *Actitis hypoleucos*	R			R				0–160
Red-necked Phalarope *Phalaropus lobotus*						U		0
Great Crested Tern *Sterno bergii*	U					C		0
Black-naped Tern *Sterno sumotrono*						F		0
Bridled Tern *Sterna anaethetus*						F		0
Osprey *Pondion haliaetus*	U		U	U			p, s	0–300
Pacific Baza *Avicedo subcristoto*	R	R	R	R			p	0–200
Brahminy Kite *Haliostur indus*	C	F	F	U	R		p	0–1,100
White-bellied Sea Eagle *Haliaeetus leucogoster*		R				R		0–30
Variable Goshawk *Accipiter novoehollondioe*	U	U	U	U			p, s	0–200
Rufous-necked Sparrowhawk *Accipiter erythrauchen*		R						30
Spotted Kestrel *Folco moluccensis*	U	U	U	U	R		p	0–1,050
Oriental Hobby *Folco severus*				R				350
Australian Hobby *Folca longipennis*				R			p	0
Brown Booby *Sulo leucagaster*						U		0
Little Pied Cormorant *Pholacrocorox melonoleucas*				F			p	0–160

Species	Locations						Legend	Altitudinal range (m)
	1	2	3	4	5	6		
Little Black Cormorant *Phalacracarax sulcirastris*		R						30
Little Egret *Egretta garzetta*	U	U	U					35
Pacific Reef Egret *Egretta sacra*	R							0
Great-billed Heron *Ardea sumatrana*	R							0
Great Egret *Casmeradius albus*	F		U	U			p	0–160
Intermediate Egret *Mesaphayx intermedia*		R					p	30
Rufous Night Heron *Nycticarax caledanicus*	U	U	U				p	0–30
Black Bittern *Dupetar flavicallis*	R		R					0
Great Frigatebird *Fregata minar*			R					0
Lesser Frigatebird *Fregata ariel*			F			F		0
Red-bellied Pitta *Pitta erythragaster*	F	F	F		U		p, s, m	0–1,100
Dusky Myzomela *Myzamela abscura*	U	U	U	U	U		p	0–1,550
Golden Whistler *Pachycephala pectaralis*		C	U	F	C		p, s, m	30–1,550
Drab Whistler *Pachycephala griseanata*	F	F	F	F	F		p, s, m	30–1,550
Torresian Crow *Carvus arru*	U		U	U			p, s	0–200
Paradise-crow *Lycacarax pyrrhapterus*	F	C	C	U	C		p, s, m	30–1,550
White-bellied Cuckooshrike *Caracina papuensis*	U	F	F	F			p, s	0–350
Slender-billed Cicadabird *Caracina tenuirastris*		U	U				p, s	30–150
Pale Cicadabird *Caracina ceramensis*		R			F		p	30–1,550
Rufous-bellied Triller *Lalage aurea*	F	F	C	F	R		p, s	0–1,100
Willie-wagtail *Rhipidura leucaphrys*	F	U	U	F			p, s	0–350
Northern Fantail *Rhipidura rufiventris*	U	F	F	F	C		p, s, m	0–1,350
Rufous Fantail *Rhipidura rufifrans*					F		s	860–1,550
Hair-crested Drongo *Dicrurus hattentattus*	F	F	F	U	F		s	0–1,550
Island Monarch *Manarcha cinerascens*				R				200
Spectacled Monarch *Manarcha trivirgatus*	U	F	F	U	F		p, s	0–1,100
Slaty Monarch *Myiagra galeata*	U	F	F	F	F		p, s	0–1,150
Shining Monarch *Myiagra alecta*	F	F	F		R		p, s	0–950
Island Flycatcher *Eumyias panayensis*			R		F		p, s	300–1,150
Island Starling *Aplanis mysalensis*	U	U	F	C			p, s	0–350
Shining Starling *Aplanis metallica*	C	C	C				p, s, m	0–30
Barn Swallow *Hirunda rustica*	U		U	U				0–350
Pacific Swallow *Hirunda tahitica*	F		F	F				0–160
Golden Bulbul *Alaphaixus affinis*	F	C	C	U	C		p, s, m	0–1,150
Mountain White-eye *Zasteraps mantanus*					F		s	930–1,150
Cream-throated White-eye *Zasteraps atriceps*					F		p, s	500–1,150
Mountain Tailorbird *Orthatamus (Phyllergates) cucullatus*					U		p, s	950–1,250
Island Leaf Warbler *Phyllascapus paliacephala*					C		p, s	500–1,550
Flame-breasted Flowerpecker *Dicaeum erythratharax*		U	F	U	U		p, s	0–1,350
Black Sunbird *Nectarinia aspasia*	C	C	C	C	C		p, s	0–1,150
Olive-backed Sunbird *Nectarinia jugularis*	C	U	F	F			p, s	0–350
Eurasian Tree Sparrow *Passer mantanus*	C		C				p	0–35
Black-faced Munia *Lanchura malucca*	U	C	C				p, s	0–35

The seasonality of mixed-species bird flocks in a Sri Lankan rainforest in relation to the breeding of the nuclear species, Orange-billed Babbler *Turdoides rufescens*

ASHOKA JAYARATHNA, SARATH W. KOTAGAMA & EBEN GOODALE

Introduction

The seasonality of mixed-species bird flocks varies dramatically across the world. At one extreme are temperate flock systems that only form during the winter months or during migration (Morse 1970), and even some flocks in the subtropics appear to be formed mostly of migrant species (Ewert & Askins 1991, Gram 1998). At the other extreme are tropical systems that occur throughout the year and in which migrant species play a small role (Kotagama & Goodale 2004). Interestingly, however, there are some tropical systems that do show seasonal fluctuations in flock size and composition (Davis 1946, Develey & Peres 2000). These fluctuations could be influenced by the underlying density of arthropods and/or by the breeding season of the species involved (Develey & Peres 2000).

One open question is how flock systems are affected by the breeding season of a 'nuclear species', defined as a species that is important to the formation and/or maintenance of flocks (Moynihan 1962). Munn (1984) studied this question in Peru (see also Munn & Terborgh 1979) and found that flocks continue to function throughout the breeding season of the nuclear species—Bluish-slate Antshrike *Thamnomanes schistogynus*—with breeding individuals flying far from their nests in order to join flocks. Munn's system was somewhat atypical, however, in that the nuclear species was not particularly gregarious; in most flock systems, nuclear species are highly gregarious (Goodale & Beauchamp 2010), and in some Asian systems one species can compose a large percentage of the flock (Chen & Hsieh 2002). What happens to flocks that form around such gregarious species when these species breed?

In previous work on a flock system of a tropical rainforest in Sri Lanka, we have shown that flock size is seasonally stable, with only a few migrant species joining flocks in the winter months (Kotagama & Goodale 2004). However, we never measured seasonal changes in the density of flocks, so it is possible that flocks might actually still show seasonal fluctuations. This flock system is led by the nuclear species, the Orange-billed Babbler *Turdoides rufescens*, for which little breeding information is available. Therefore, we had two objectives in this study: (a) to measure seasonal changes in the density of flocks, and (b) to see if that seasonality was related to the breeding of the Orange-billed Babbler. We also aimed to chronicle some aspects of the nesting of this little-studied babbler (Henry 1998).

Study site

This study was conducted in the north-western sector of the Sinharaja World Heritage Reserve (6.433°N 80.350°E), Sri Lanka's largest remaining patch of lowland rainforest (450–600 m). This sector of the reserve was logged in the 1970s and the effects, including large gaps, are still visible near the main logging road, along which we walked. Annual rainfall is about 4 m with distinct dry (January to March) and wet seasons (April to December) (Kotagama & Goodale 2004).

Methods

To determine whether the density of flocks changes seasonally, we walked along 8 km of the main logging road that leads from the town of Kudava towards the mountain of Sinhagala. From November 2004 to December 2006, we walked this route three times a month at 07h30–11h00. The months of May and June were only sampled in one year each, because of extremely wet conditions.

We recorded all flocks seen or heard within 50 m of this transect, and estimated the number of Orange-billed Babblers present in the flock. Returning along the same route, we watched for any indication of breeding by Orange-billed Babblers, including mating, nesting or feeding of fledged chicks.

In conducting two-tailed t-tests, we used a method that does not assume equal variances (Ruxton 2006). Means are given ± one standard deviation.

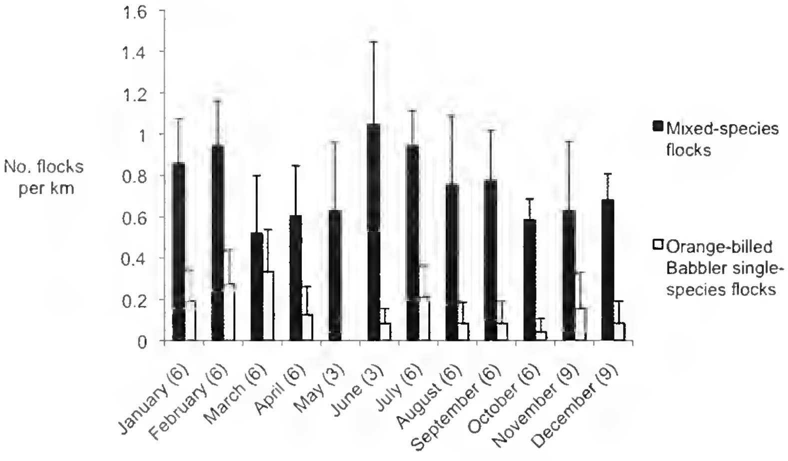
Results

Seasonal density of flocks

We recorded 492 flocks during the sampling period. In all of these, Orange-billed Babblers were present. Apparently, our transect method, which required relatively fast walking, failed to detect the approximately 8% of flocks that do not contain Orange-billed Babblers (Kotagama & Goodale 2004)—these flocks that do not include the noisy Orange-billed Babblers can be quite cryptic and difficult to detect.

The density of mixed-species flocks did not differ seasonally (Figure 1). The highest density of flocks (1.04 flocks per km) was recorded in June, and the lowest (0.52 flocks per km) was recorded in March. There was no significant difference between the density of flocks in the dry season from January to March (18 days sampled) and the rest of the year from April to December (54 days sampled), (t-test, $t_{27.37} = 0.71$, $P = 0.48$).

Figure 1. Seasonal variation in the density of mixed-species flocks and single-species Orange-billed Babbler flocks. Numbers in parentheses show the number of days sampled for each month during the study. Error bars indicate +1 standard deviation (data from November 2004 to December 2006).



In contrast, the occurrence of single-species flocks of Orange-billed Babblers was higher in the dry months (January–March) than during the rest of the year (Figure 1). The density of such single-species flocks was higher in these three months pooled together (n = 18) than during the rest of the year (n = 54, t-test, $t_{23.03} = 3.56$, $P = 0.0017$).

These single-species flocks, presumably composed of small breeding groups, were small, averaging 7.2 ± 2.6 babblers (n = 82). In contrast, mixed-species flocks usually included 20.0 ± 8.8 babblers (n = 397). One might hypothesise that if small groups of babblers occur in monospecific flocks during the dry season (January–March), then the average number of babblers in mixed flocks would be smaller during that time. This was indeed found to be the case (15.0 ± 8.7 babblers in the dry season, n = 116, versus 22.1 ± 8.0 babblers in the rest of the year, n = 281; t-test, $t_{200.78} = 7.65$, $P < 0.0001$).

Breeding behaviour of Orange-billed Babbler

Most of the Orange-billed Babbler breeding records (19 of 22) were during the months of January–March (Table 1). A total of 10 nests

Table 1. Independent observations of breeding in Orange-billed Babblers

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Nests	3	3	2									2
Fledgings	2	3	2				1					
Matings	2	2										

were found; these were placed at a variety of heights (range 5.5–35 m, mean = 15.4 m), in trees of several different species including large species such as *Syzygium rubicundum*, *Mesua thwaitesii* and *Shorea trapezifolia*, and fruiting trees such as rambutan *Nephelium lappaceum* in gardens near the forest edge. Nests consisted of a bowl made of fine vines, including the roots of ferns, on top of a small platform constructed from a few twigs. One nest examined after it was abandoned measured 83 × 90 mm inside, with an interior depth of 65 mm, and 153 × 172 mm outside, with a depth of 85 mm. Eggs were blue-green in colour, and one that was found broken on the ground measured 16.6 × 22.8 mm. The number of eggs was usually unknown, except for one nest that was observed to have five eggs; three nestlings hatched in another nest and two chicks fledged in a third.

Orange-billed Babblers were clearly cooperative in their breeding habits. For example, at three separate nest sites, three or more adults were observed to help with construction. At another site, four adults fed the chicks, and at another the fledglings were observed being fed by three adults. Given that the birds were not marked, the number of adults feeding young was probably even greater. Even in records where only one or two adults were attending the nest, or were seen to feed the chicks, there was usually a group of babblers within 25 m, and often within 10 m. The average size of babbler groups close to nests was 4.5 individuals (n = 9).

Discussion

We found that the density of mixed-species flocks did not change seasonally, although the density of small single-species Orange-billed Babbler groups, which are presumably breeding groups, did increase during the dry season in January to March, when babblers were nesting. Our survey method did not detect flocks without Orange-billed Babblers, and this could bias the result if the percentage of such flocks itself varies seasonally. However, reanalysing the 1990s seasonal data from Kotagama & Goodale (2004), we found that the proportion of such flocks did not change between the dry season (1 of 31 flocks) and the wet season (16 of 139 flocks), (Fisher's Exact Test, $P = 0.21$).

These flocks observed in the humid lowland rainforest of Sri Lanka are among the most aseasonal flock systems described in the world. Previous work showed that the number of species in flocks did not change seasonally and that the composition of flocks was also quite stable, with the exception of several migrant species that are found in flocks, only one of which is a regular member (Kotagama & Goodale 2004). This study demonstrates that the density of flocks also does not change seasonally. This lack of seasonal change is very different from temperate and subtropical systems that have been described (Morse 1970, Gram 1998), and the system appears to be more stable even than others in the tropics (Davis 1946, Develey & Peres 2000). It appears that even during the Orange-billed Babbler's breeding season there are enough non-breeding babblers to act as leaders for mixed-species flocks, so that these mixed-species flocks continue unabated.

This study adds to the evidence that the core of mixed-species flocks in the lowlands of Sri Lanka are small groups of Orange-billed Babblers. These groups most likely comprise closely related individuals, consisting of a mated pair of adults and their previous year's offspring, and they breed cooperatively, as has been described for other species of *Turdoides* babblers (Gaston 1978, Zahavi 1990, Ridley & Raihani 2007). Our observations suggest that these family groups roost together, and then join with other groups through the morning. Other species follow babblers (Kotagama & Goodale 2004), and larger babbler groups are clearly more attractive to other species than small groups. Usually the small groups of nesting babblers forage rather quietly in the proximity of the nest and do not attract other species. Further work is needed to understand the territoriality and use of space of both the babblers and other species in these mixed-species flocks.

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***Ashoka JAYARATHNA**, The Field Ornithology Group of Sri Lanka, Department of Zoology, University of Colombo, Colombo 3, Sri Lanka. Email: pjashoka@gmail.com.*

***Sarath W. KOTAGAMA**, The Field Ornithology Group of Sri Lanka, Department of Zoology, University of Colombo, Colombo 3, Sri Lanka. Email: fogsl@slt.lk*

***Eben GOODALE**, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun, Mengla, Yunnan 666303, China. Email: egoodale@xtbg.org.cn*

New distributional records of Philippine birds from Bohol, Mactan, Olango, Busuanga and Luzon islands

T. M. BRAILE & K. WINKER

New distributional records of birds are important in areas such as the Philippines, where not all islands have been fully surveyed and habitat alteration and forest loss are ongoing. These records from fieldwork on avian communities and diseases conducted in 2001, 2003, 2009 and 2010 are based almost entirely on specimens archived at the University of Alaska Museum (UAM) or the National Museum of the Philippines (NMP), a number of which are proving useful in taxonomic reassessments of species limits (e.g. Lohman *et al.* 2010). Island records were deemed new when not appearing in the synopses of Dickinson *et al.* (1991) or Kennedy *et al.* (2000). Nomenclature follows Dickinson (2003). This work was conducted with all required permits.

ARDEIDAE

Cinnamon Bittern *Ixobrychus cinnamomeus*: Busuanga Island, Bintuan: 18 April & 1 May 2008 (UAM 25232 & 25233).

Yellow Bittern *Ixobrychus sinensis*: Busuanga Island, Bintuan: 28 April 2008 (UAM 27084).

ACCIPITRIDAE

Crested Goshawk *Accipiter trivirgatus palawanus*: Busuanga Island, Bintuan: 9 & 28 April 2008 (UAM 24764 & 24765).

SCOLOPACIDAE

Little Stint *Calidris minuta*: Olango Island, Olango Island Wildlife Sanctuary: 27 & 28 October 2001 (NMP 19880, UAM 14416). Considered a vagrant or rare migrant (Dickinson *et al.* 1991, Kennedy *et al.* 2000), this species is likely to have a regular wintering population in the Philippines which is overlooked due to the difficulty of field identification.

CUCULIDAE

Plaintive Cuckoo *Cacomantis merulinus*: Busuanga Island, Bintuan: 29 & 30 March 2008 (UAM 27086, 25592 & 25993); 1, 8, 18, 27 & 29 April 2008 (UAM 25590, 25594, 27087, 25591 & 27088).

ALCEDINIDAE

Ruddy Kingfisher *Halcyon coromanda linae*: Busuanga Island, Bintuan: 2, 15, 16, 18, 21, 27–30 April (UAM 27076, 27077, 24940, 27078, 25465, 27079, 25091 & 27081); 1 May 2008 (UAM 27082).

Oriental Dwarf Kingfisher *Ceyx erithacus rufidorsa*: Busuanga Island, Bintuan: 15–18 March 2008 (UAM 25451, 25453, 25450 & 24908); 1 April 2008 (UAM 24906). Here we have chosen continued use of the subspecific name *rufidorsa* pending a thorough review of the proper subspecific name for the brown-backed forms of this region. Dickinson (2003) considered *rufidorsa* to likely be based on an intergrade and chose instead to use *motleyi*; it is not clear, however, that the latter name is the appropriate one.

Common Kingfisher *Alcedo atthis*: Mactan Island, Cordova: 23 November 2001 (NMP 19760).

ACANTHIZIDAE

Golden-bellied Gerygone *Gerygone sulphurea*: Olango Island, Olango Island Wildlife Sanctuary: 15 October 2003 (UAM 21479 & 21480); 18 October 2003 (NMP 19859).

CAMPEPHAGIDAE

Pied Triller *Lalage nigra nigra*: Mactan Island, Cordova: 2 December 2003 (UAM 21369). Olango Island, Olango Island Wildlife Sanctuary: 17 & 18 October 2003 (NMP 19881 & 19782; UAM 21766); 6 November 2003 (UAM 21763 & 21764).

LANIIDAE

Brown Shrike *Lanius cristatus*: Mactan Island, Cordova: 2 December 2001 (NMP 19742). Olango Island, Olango Island Wildlife Sanctuary; 5 October 2003 (NMP 19803); 14, 15 & 26 October 2003 (UAM 20995 & 20988; NMP 19844, 19868, 19806).

ORIOLIDAE

Black-naped Oriole *Oriolus chinensis chinensis*: Olango Island, Olango Island Wildlife Sanctuary: 16 October 2003 (UAM 21323).

DICRURIDAE

Japanese Paradise-flycatcher *Terpsiphone atrocaudata periophthalmica*: Luzon Island, Mountain Province, Mt. Kalawitan, Apa; 16 February 2010 (UAM 24085). No previous specimens of this species have been confirmed from Luzon (Dickinson *et al.* 1991). This subspecies, which breeds on remote Lanyu and Batan islands, had been treated as a certain migrant on Luzon; this specimen and a recent sight record (Nuytemans 1998) confirm that.

RHIPIDURIDAE

Pied Fantail *Rhipidura javanica nigritorquis*: Olango Island, Olango Island Wildlife Sanctuary: 14–17 October 2003 (UAM 21761, 21752, 21753, 21755, 21758 & 21759; NMP 19741, 19792, 19848 & 19793).

HIRUNDINIDAE

Barn Swallow *Hirundo rustica*: Mactan Island, Cordova: 28 November 2001 (NMP 19851); 3 December 2001 (UAM 14359).

CISTICOLIDAE

White-eared Tailorbird *Orthotomus cinereiceps*: Bohol Island, Rajah Sikatuna National Park: 19–20 November 2003. [Unconfirmed; sight record – K. Winker].

PYCNONOTIDAE

Yellow-vented Bulbul *Pycnonotus goiavier samarensis*: Olango Island, Olango Island Wildlife Sanctuary: 15–17 October 2003 (UAM 21321 & 21315; NMP 19774 & 19845); 5–8 November 2003 (UAM 21314, 21316 & 21313; NMP 19758, 19761 & 19846).

SYLVIIDAE

Clamorous Reed Warbler *Acrocephalus stentoreus harterti*: Olango Island, Olango Island Wildlife Sanctuary: 15 October 2003 (UAM 21020); 18 October 2003 (UAM 21018, NMP 19763). Mactan Island, Cordova: 23 November 2001 (UAM 21364 [feather sample only; included here as unconfirmed]).

Oriental Reed Warbler *Acrocephalus orientalis*: Mactan Island, Cordova: 22 November 2001 (UAM 14363).

Lemon-throated Leaf Warbler *Phylloscopus cebuensis cebuensis*: Olango Island, Olango Island Wildlife Sanctuary: 17 October 2003 (UAM 21000); 8 November 2003 (NMP 19770).

MUSCICAPIDAE

Narcissus Flycatcher *Ficedula narcissina narcissina*: Bohol Island, Rajah Sikatuna National Park: 17 & 23 November 2003 (UAM 21723 & 21724).

Philippine Magpie Robin *Copsychus mindanensis*: Olango Island, Olango Island Wildlife Sanctuary; 18, 27–28 October 2003 (UAM

21773 & 21769; NMP 19735); 5–8 November 2003 (NMP 19737, 19843 & 19783; UAM 21771 & 21775). This taxon, formerly regarded as a subspecies of *C. saularis*, is now recognised as an endemic species (Sheldon *et al.* 2009). Some of these specimens were used in that taxonomic reassessment.

NECTARINIIDAE

Olive-backed Sunbird *Cinnyris jugularis jugularis*: Olango Island, Olango Island Wildlife Sanctuary: 15–18 October 2003 (NMP 19772, 19786, 19860 & 19748; UAM 21778, 21779, 21789, 21785, 21787 & 21790).

MOTACILLIDAE

Pechora Pipit *Anthus gustavi gustavi*: Mactan Island, Cordova: 27 November 2001 (UAM 14360). ***Anthus gustavi***: Busuanga Island, Bintuan: 27 April 2008 (UAM 25225).

The specific localities of the sites above were: Bohol Island, Rajah Sikatuna National Park (9.700°N 124.117°E), Busuanga Island, Bintuan (12.032°N 120.122°E), Luzon Island, Mountain Province, Mt. Kalawitan, Apa (16.947°N 120.931°E), Mactan Island, Cordova (10.250°N 123.950°E) and Olango Island, Olango Island Wildlife Sanctuary (10.264°N 124.049°E).

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***Thomas M. BRAILE**, University of Alaska Museum, 907 Yukon Drive, Fairbanks, Alaska 9775 USA; and National Museum of the Philippines, P. Burgos St. & Taft Ave., Ermita, Manila, Philippines 1000. Email: thomasbraile@gmail.com*

***Kevin WINKER**, University of Alaska Museum, 907 Yukon Drive, Fairbanks, Alaska 9775 USA. Email: kevin.winker@alaska.edu*

Some interesting breeding records for Pong Dam Wildlife Sanctuary, Himachal Pradesh, India

MERWYN FERNANDES & JAN WILLEM DEN BESTEN

Introduction

Pong Dam Wildlife Sanctuary located in Himachal Pradesh, India, is an important staging site for migratory species, such as waterfowl and shorebirds (Pandey 1993, den Besten 2004). The area is situated on the border of two important biogeographic zones, namely the Western Himalaya, an endemic bird area (BirdLife International 2003), and the Indo-Gangetic Plain. The creation of the reservoir in 1975 caused marked changes in river flow and land use patterns, thereby dramatically altering the diversity of wintering birds (Whistler 1926, Pandey 1993). The resulting change is indicated by the 555 avian species recorded for the district (den Besten 2004) as compared to 395 species recorded in the early 1920s for the Punjab plains (Whistler 1926). The large congregations of wintering avifauna warranted the sanctuary to be recognised as a Ramsar site in 2002 (www.wetlandsofindia.org) and an Important Bird Area (Islam & Rahmani 2004). Apart from the large congregations of waterfowl, the area also has significant congregations of White-rumped Vulture *Gyps bengalensis*, with over 160 individuals as late as 2003 (JWdB pers. obs.) and nests in the adjoining forest (Dhadwal 2010). Sightings of Sarus Crane *Grus antigone* along with juveniles (den Besten 2004) suggest possible breeding in the areas. Here we report waterbird species and emphasise the tern species that utilise the area as a breeding ground, thus enhancing the importance of the area.

Study area and methods

This wetland (32.004°N 76.039°E) lies at the base of the Dhauladhar range in the Shiwalik hills where these open up to form a wide valley. The reservoir was created in 1975 by impounding the River Beas for the generation of electricity and flood control of downstream areas in the Punjab. Several perennial and seasonal tributaries that drain from the Dhauladhar range such as the Dehar, Bhul, Gaj and Baner also feed the reservoir. When the reservoir is filled to maximum level (423.67 m) the water body covers an area of 225 km^2 and at its minimum level (385.57 m) the coverage is 125 km^2. This wetland has two parts: the main reservoir along with the islands of Ranseer and Karu, and the outflow area, Sansarpur terrace with the Sahnehar barrage at Sathana. The surrounding hills are covered in mixed deciduous forest with *Pinus roxburghii*, *Anogeissus latifolia*, *Terminalia* sp., *Acacia catechu*, *Mallotus philippensis*, etc., but the reservoir area is devoid of woody vegetation. Along the shores of the reservoir, vegetation is limited with few aquatic macrophytes except algae, because of marked seasonal changes in the water levels. As water recedes most of the exposed areas show the presence of grasses, such as *Cyanodon dactylon*, while local farmers cultivate wheat *Triticum* spp. The Sansarpur terrace area (approx 3 km^2) has a shallow waterbody with an extensive swamp with reedbeds of *Typha* sp. and *Phragmities* sp. The fringe area has wooded vegetation comprising

A. catechu and plantations of *Leucaena leucocephala* while adjacent to the boundary are fields with seasonal crops bordered by a mix of fruit-bearing trees and *Eucalyptus* spp.

The area was visited during the period 15 April to 15 May 2006. Reconnaissance surveys within the main reservoir helped to delineate sites on the basis of the aggregation and feeding behaviour of the tern species. Nagrota Surian and Ranseer island in the main reservoir and Sansarpur terrace were selected for surveys to be carried out to locate nests. Species and clutch sizes were noted down and care was taken when nest(s) were located by tagging each site so as to prevent double counts.

Results and discussion

Nesting activity was recorded in all three main areas. The number of nests reported for River Tern *Sterna aurantia*, Little Tern *Sterna albifrons* and Small Pratincole *Glareola lactea* may be one of the largest nesting records for northern India, while nesting of Gull-billed Tern *Gelochelidon nilotica* and Indian Skimmer *Rynchops albicollis* are of significance. The nest characteristics recorded in the sanctuary are similar to those described from other nest sites in India (Waite 1917, Baker 1935, Ali & Ripley 1983).

River Tern *Sterna aurantia*

In total 383 nests were recorded. Nearly 23% of the nest had a clutch size of four or more, which is rarely recorded from other nesting colonies in India (Ali & Ripley 1983, Balachandran *et al.* 2005).

Little Tern *Sterna albifrons*

A total of 95 nests were recorded. This is the first inland breeding record for the species in the Indian Subcontinent. The only nesting records reported for this species in India are from the coastlines of India (Holloway 1993, Sashikumar *et al.* 2004, Balachandran *et al.* 2005).

Gull-billed Tern *Gelochelidon nilotica*

In total 17 nests were recorded making this the only recent inland nesting site for the species. The only other inland nesting site reported for this species was at the confluence of the River Beas and River Sutlej (Waite 1917). All other nesting records for this species are from the coastlines of India (Balachandran *et al.* 2005).

Indian Skimmer *Rynchops albicollis*

Although the number of recorded nests (4) is small, this is the only nesting report for the species in north-west India apart from National Chambal Wildlife Sanctuary (Sundar 2004), which is about 600 km south-east in Uttar Pradesh.

Small Pratincole *Glareola lactea*

Eighty-seven nests were recorded for this species. The other reported breeding sites in northern India are National Chambal Wildlife Sanctuary (Sundar 2004) and West Yamuna Canal, Haryana (http://www.delhibird.com/Checklists/West%20Yamuna%20Canal.html).

At Nagrota Surian and Ranseer island breeding was recorded for Indian Skimmer, Small Pratincole, River Tern, Gull-billed Tern and Little Tern, and nests of Red-wattled Lapwing *Vanellus indicus* and Great Thick-knee *Esacus recurvirostris* were recorded within the breeding colonies as well. Additionally, Yellow-wattled Lapwing *V. malabaricus*, Little Ringed Plover *Charadrius dubius* and Kentish Plover *C. alexandrinus* were recorded at Nagrota Surian and nests of Little Cormorant *Phalacrocorax niger* (200), Cattle Egret *Bubulcus ibis* (150), Little Egret *Egretta garzetta* (150), Indian Pond Heron *Ardeola grayii* (50) and Black-crowned Night Heron *Nycticorax nycticorax* (6) were recorded at Ranseer island. At Sansarpur terrace nests (4) and two broods of ducklings of Indian Spot-billed Duck *Anas poecilorhyncha* and three breeding Purple Swamphen *Porphyrio porphyrio* were recorded. Sightings of the following species suggest breeding that could not be confirmed because the reedbeds and marshes were not surveyed for nests: Grey Heron *Ardea cinerea*, Purple Heron *A. purpurea*, Yellow Bittern *Ixobrychus sinensis*, Cinnamon Bittern *I. cinnamomeus*, Black Bittern *Dupetor flavicollis*, Brown Crake *Amaurornis akool*, White-breasted Waterhen *A. phoenicurus*, Ruddy-breasted Crake *Porzana fusca*, Common Moorhen *Gallinula chloropus*, Greater Painted-snipe *Rostratula benghalensis*, Eurasian Thick-knee *Burhinus oedicnemus*, Black-winged Stilt *Himantopus himantopus*, Pheasant-tailed Jacana *Hydrophasianus chirurgus*, River Lapwing *Vanellus duvaucelii*, Black-bellied Tern *Sterna acuticauda*, Indian Pond Heron, Woolly-necked Stork *Ciconia episcopus*. Due to logistic constraints our surveys were limited to particular sites (three) within the area where the breeding colonies were located. Given the vastness of the area, systematic surveys covering larger areas including other habitats such as agricultural land, reedbeds, woodland, etc., were not done. The current survey is therefore in no way an indication of the numbers of pairs and species that in reality use the area for breeding.

The monsoon run-off and snow melt from the Himalayas feed the River Beas, and because both these fluctuate greatly from year to year, the water level and size of the wetland vary markedly from year to year. As a result, the exact locations of the colonies change from year to year, because they are always situated on freshly exposed mudflats. It means that a sudden rise in water level as a result of spring rains can wash away some nests. The ever-changing shoreline on the other hand also restricts development and construction along the shoreline and this enhances the suitability of the area for breeding shorebirds. Human disturbance may affect breeding success. Intentional destruction almost never occurs, but other human-induced disturbance includes pesticide usage, tilling of land and preparations for planting crops in the drawdown area, and the large numbers of grazing cattle; all these may have an impact on the nesting birds.

In the past two decades most river systems in northern India have been managed for multiple uses to meet the increasing demand for irrigation and power. Apart from industrial discharge and the development of towns, the utilisation of resources from the riverbanks is known to create conditions that are detrimental for shorebirds and other wetland species. Although there are many reservoirs in northern India that are listed as Important Bird Areas (Islam & Rahmani 2004), none has been reported to have such large congregations of breeding terns. We do not rule out that these tern species that prefer sandpits, sand banks and islets of perennial rivers may still be utilising riverbanks but as development and utilisation of resources along rivers continue unabated, reports of such large congregations in northern India will be scarce.

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***Merwyn FERNANDES**, Wildlife Institute of India, P.O.Box 18, Chandrabani, Dehradun 248001, India. Email: fernandesmerwyn@gmail.com*

***Jan Willem den BESTEN**, National Committee of IUCN in The Netherlands. Email: janwillem.denbesten@iucn.nl*

Population and diet of migratory Common Starlings *Sturnus vulgaris* wintering in agricultural areas of Sialkot district, Pakistan

TARIQ MAHMOOD, SYED M. USMAN-UL-HASSAN, MUHAMMAD S. NADEEM & AMJAD R. KAYANI

Introduction

The Common Starling *Sturnus vulgaris* is one of the most successful and widespread bird species, having large populations on five different continents. It is native to Europe and Asia, but has also been successfully introduced to three other continents (Feare *et al.* 1992). Migratory populations that breed in Siberia and Turkestan use the Central Asian Flyway to winter in Pakistan and India (Roberts 1992, Champ & Riess 1999). Common Starlings visit Pakistan from late October to early April and occur throughout the country, except in high-altitude, snow-covered areas. The earliest arrival recorded in southern Punjab was on 27 September (Roberts 1992).

Common Starlings forage in flocks during winter (Coleman 1977, Tyler & Kannenberg 1980). They are omnivorous, consuming a wide range of invertebrate and plant material, but in winter, they rely more on plant material and can become a crop pest (Feare 1984). Winter diet varies regionally. In Australia, Higgins *et al.* (2006) described the Common Starling as omnivorous, consuming grain, fruit, seeds, nectar and garbage. In Alabama, USA, it usually digs up seeds in sown fields, sprouting garden vegetables and other flowering plants (Imhof 1962). In temperate Europe, wintering Common Starlings also take large numbers of invertebrates, primarily soil-dwelling crane-fly larvae (Tipulidae) found in grasslands (Feare 1984).

The global conservation status of Common Starling is Least Concern (BirdLife International 2013), but a sharp decline has been reported in its northern and western European populations during the past two decades. Reduced availability of food sources as a result of agricultural intensification is suspected to be one of the major reasons for its decline in Europe (Crick *et al.* 2002). Given its increasing conservation importance, it has become necessary to monitor Common Starling populations and investigate their ecology in wintering areas. No such studies have taken place in Pakistan, where Common Starling is also a protected species, listed under Schedule III of the Wildlife Legislation of Punjab province (Shafiq 2005). In this paper, we describe a study of a wintering population in an agricultural area of Sialkot district.

Methods

The current study was carried out in an agricultural ecosystem in Sialkot district, central Punjab province. The district covers 3,016 km^2 and comprises four tehsils (administrative units). Four 1 km^2 study sites were selected: Sialkot (Site I: 32.425°N 74.588°E; 790 m), Pasrur (Site II: 32.282°N 74.692°E; 757 m), Daska (Site III: 32.295°N 74.502°E; 707 m) and Sambrial (Site IV: 32.496°N 74.376°E; 748 m), representing one site from each tehsil. The study sites were surveyed monthly from 27 September 2010 to the end of May 2011.

The Common Starling population size was estimated using line transects (Burnham *et al.* 1980). Freshly killed Common Starlings were obtained from local hunters and their gizzard contents were analysed following the method of Coleman (1977). Twenty gizzard samples were analysed: five in each month from November 2010 to February 2011. Invertebrate prey items were identified and the number of individual invertebrates consumed was calculated based on remains such as head capsules, abdomens, paired elytra or wings (Hartley 1948).

Results

Common Starlings were first sighted (15–50 birds per flock) at Site III (Tehsil Daska) near canal banks and rice mills on 2 November 2010. Subsequently, starlings occupied feeding sites near irrigation water sources including nullahs, canals and subcanals. In the mornings (two to three hours after sunrise), flock size was typically 15–25 birds, occasionally reaching 50 birds per flock. Smaller flock sizes (8–15) were recorded around noon. In the evenings, large roosting flocks of 200–500 birds were recorded. Common Starlings were recorded in agricultural areas until 27 February 2011, but small numbers remained in urban areas until the first week of April 2011.

Estimated densities of Common Starling populations are summarised by month in Table 1. The highest population density was found at Site III (39 birds/km^2) and the mean density was 26 ± 4 birds/km^2 (Table 1). Densities were significantly higher at Site III: Student's paired *t*-tests showed significant differences in numbers of birds between Sites I and III ($P < 0.01$; $t = -3.84$; df = 3) and between Site II and III ($P < 0.001$; $t = -8.42$; df = 3).

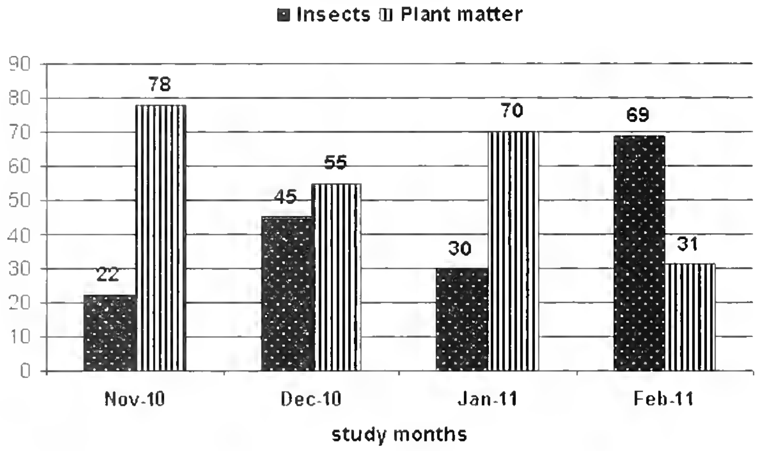
Common Starlings roosted in dense vegetation including bamboo, sugarcane fields and dense *Eucalyptus* trees. Large flocks congregated over the roost sites before entering them, just before sunset. Common Starlings generally started foraging an hour after sunrise and fed continuously until noon. While foraging, they dug up seeds and insects from the soft and wet soil by open-bill probing. About 30 to 45 minutes before sunset, they ceased foraging and flew back to their roosting sites. Starlings foraged on rice crops and also consumed sprouted wheat and lentil grains, spending roughly equal time in these crops. Brassica and *Trifolium* crops were visited less frequently than wheat and lentils. Among the vegetables crops, pea and potato fields were utilised. Starlings followed tractors ploughing fields to catch invertebrates. On rainy days, they foraged on uncultivated and unploughed fields.

Common Starling gizzards contained, on average, 42% invertebrates and 58% seeds and other plant matter by volume. There was a high incidence of adult insects in the gizzards and the groups found most frequently were Coleoptera (excluding weevils)

Table 1. Monthly densities of Common Starlings in each study site (estimated number/km^2 based on transect surveys).

Study sites	Nov 2010	Dec 2010	Jan 2011	Feb 2011	N	Density/km^2
Pasrur (Site I)	7	18	44	23	92	23.0
Daska (Site II)	20	28	38	12	98	24.5
Sambrial (Site III)	33	39	56	30	158	39.0
Sialkot (Site IV)	0	14	20	22	56	18.6
Total	60	99	158	87	404	105.6
Mean ± SE					**101 ± 21.14**	**26.29**

Figure 1. Monthly variation in diet of Common Starling in agro-ecosystem of district Sialkot during 2010/11.



(in 80% of gizzards), weevils (60%), Hymenoptera (55%) and Hemiptera (50%). No insect larvae were recorded, although unidentified insects were present in all samples. Seeds and other plant matter were present in all 20 gizzard samples and included wheat seedlings and wheat and rice grains. Small pieces of stone were also recovered from some gizzard samples. Plant matter dominated the diet from November to February, but in February the diet switched to insects (69% by volume) (Figure 1).

Discussion and conclusions

In many other parts of the world, wintering Common Starling is reported to be a crop pest (Imhof 1962, Tyler & Kannenberg 1980). We found evidence that Common Starlings also destroy newly planted crops. However, frequent consumption of insects that are harmful to crops, such as Hemiptera and weevils, may mean that Common Starlings are beneficial in the agricultural land of Sialkot district. The invertebrates comprising Common Starlings' diet in this study (Coleoptera, Hymenoptera and Hemiptera) have been reported in the diet of the species in Australia and New Zealand (Coleman 1974, Paton *et al.* 2005), but are less important in the European wintering range (Feare 1984). The observed variation in monthly diet composition can be explained partly by weather conditions. In severe weather during January 2011, the diet comprised 70 % seeds and only 30% insects. However, in February 2011 the weather became mild and the proportion of insects in the diet increased to 69%.

Roberts (1992) reported that Common Starlings arrived in Punjab in late September and departed in the first week of March. The arrival date in this study was one month later, but the departure dates were the same. No other recent observations are available so we cannot confirm whether there is a trend for later arrival. The mean density of wintering Common Starlings in Sialkot (26.6 birds/km^2) was similar to that on farmland in Great Britain (30 birds/km^2) according to Robinson *et al.* (2001).

Data were also collected from expert local hunters about population trends of Common Starling in the study area. They considered that the Common Starling population had declined sharply in the preceding 6–8 years. The reason behind this decline may be uncontrolled hunting for commercial purposes as starling meat dishes are marketed through local restaurants. The local hunters mainly captured starlings with nets at roosting and feeding sites. The high proportion of invertebrates in the diet suggests that food resources are still plentiful in Sialkot. In northern and western European populations, reduced availability of food as a result of agricultural intensification is suspected to be one of the major reasons for its decline (Crick *et al.* 2002). The use of fungicidal seed treatments prior to sowing crops could be another cause of population declines in the study area.

Illegal uncontrolled hunting of Common Starling may be the biggest threat to wintering populations in Pakistan. Strict implementation of wildlife laws is required. Further detailed studies are also needed to investigate the effects of pesticides and fungicides on populations of the Common Starling in its wintering areas.

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***Tariq MAHMOOD**, Department of Wildlife Management, PMAS Arid Agriculture University, Rawalpindi 46300, Pakistan. Email: tariqjanjua75@uaar.edu.pk (corresponding author)*

***Syed M. USMAN-UL-HASSAN**, Department of Wildlife Management, PMAS Arid Agriculture University, Rawalpindi 46300, Pakistan. Email: smuhassan@gmail.com*

***Muhammad S. NADEEM**, Department of Zoology, PMAS Arid Agriculture University Rawalpindi, 46300 Pakistan. Email: sajidnm@uaar.edu.pk*

***Amjad R. KAYANI**, Department of Zoology, PMAS Arid Agriculture University, Rawalpindi 46300, Pakistan. Email: ark120106@yahoo.com*

Causes of injury and mortality of Fairy Pitta *Pitta nympha* on Jeju Island, Republic of Korea

EUN-MI KIM, CHANG-YONG CHOI & CHANG-WAN KANG

Introduction

The Fairy Pitta *Pitta nympha* is a migratory species known to breed only in mainland China, Taiwan, Japan and Korea (Lambert & Woodcock 1996, Brazil 2009). It is listed as Vulnerable in the IUCN Red List (BirdLife International 2001, 2013). As a summer visitor to Korea, arriving in early May and departing in October (Kim 1964), it breeds mainly in coastal forests and on some islands off the southern part of the Korean peninsula, although new breeding records have been reported inland (for example Gwangneung forest in Gyeonggi province and on Mt Gyeryong in Daejeon). Given that the species's breeding range extends to the Shandong peninsula, China, and there is a record in North Korea (Lambert & Woodcock 1996, Tomek 2002), the breeding range on the Korean peninsula may extend to other as yet unknown areas. Currently, Jeju Island, the most southerly part of Korea, is its most important known breeding area in the peninsula, since more than 60 pairs are believed to breed there regularly (Kim 2006).

The world population of Fairy Pitta numbers only a few thousand birds and is suspected to be in rapid decline due to deforestation and habitat loss in its breeding range together with hunting and human disturbance (BirdLife International 2001, 2013). In Taiwan, where there is a significant breeding population, poaching and habitat degradation and destruction were previously regarded as important threats to this species (Severinghaus *et al.* 1991), with habitat loss, including dam construction projects in key breeding areas, remaining as a key threat (BirdLife International 2013). In spite of the species's vulnerable status and general knowledge of the threats it faces, quantitative data on the pressures affecting the Fairy Pitta are poor, resulting in an information gap hampering conservation efforts.

Urbanisation, road construction and reclamation throughout Korea cause habitat degradation (Ministry of Environment 2002), but no specific threats to the Fairy Pitta in Korea have ever been identified or reported. Threat assessment, involving the identification, evaluation and ranking of threats to species or habitats of conservation interest, is an essential part of conservation planning and management (Rao *et al.* 2007). In this study, in order to provide the first quantitative data that may facilitate the development of a conservation strategy and mitigation measures for the threatened Fairy Pitta, threats to the species over the last decade were identified and prioritised by documenting causes of injury and mortality on Jeju Island.

Methods

The study area was the whole of Jeju Island (33.367°N 126.533°E), Jeju Special Self-Governing province, Republic of Korea; this oval-shaped volcanic island, located 80 km south of the Korean mainland and approximately 230 km west of Kyushu, Japan, is also part of the breeding range. It is believed that Fairy Pitta also stop over there during their spring and autumn migrations.

Field records and the rescue database of the Korea Association for Bird Protection, Jeju Branch, were examined for details of the injury and mortality of Fairy Pitta from 2002 to 2012 and the date, locality, habitat and age or developmental stage of each individual were recorded. Causes of injury and mortality were categorised as: head trauma caused by collision with windows or other man-made structures, dehydration, traffic accident, natural predation and disasters such as floods and human disturbance. The age or developmental stage of each individual was defined as: egg, chick, first year and adult. Four habitat types were identified: forest, urban, suburban and coastal.

Results

Thirty Fairy Pitta casualties were recorded on Jeju Island in the study period (Table 1, Figure 1). Of these, 22 (71%) resulted in death while eight injured birds survived and were rehabilitated. Six causes of

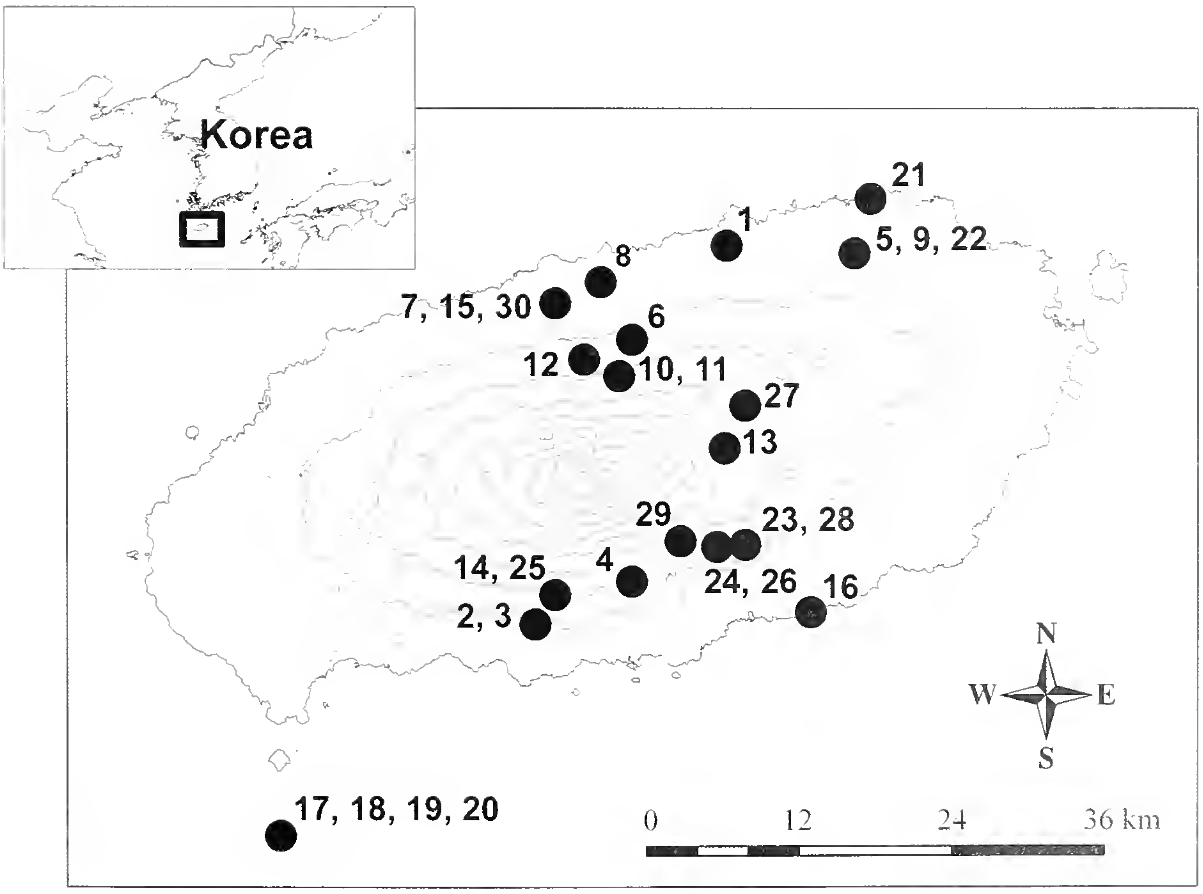

Figure 1. Locations of reported cases of dead or injured Fairy Pitta *Pitta nympha* from 2002 to 2012 on Jeju Island, Republic of Korea. Number at each location (filled circle) corresponds with the reports listed in Table 1.

injury and mortality were confirmed: predation by natural enemies (11 cases, 36.7%) and head trauma during window strikes (11 cases, 36.7%) were the most frequent causes, followed by traffic accidents (3, 10.0%), flooding (2, 6.7%), dehydration (2, 6.7%), and human disturbance (1, 3.3%). Fifteen casualties (50%) were attributed human activities, and the remaining cases were not.

Over the whole study period (2002–2012), most casualties were recorded during the time of migration and the early stages of breeding; monthly totals were: May, 8; June, 8, July, 9; August, 2; and September, 3. Casualties (17 cases) were most frequently reported in forests (the species's preferred habitat); five cases were recorded in coastal areas mainly during migration, and four cases were reported in urban and in suburban environments. Adult birds were most vulnerable, 18 cases (60%), followed by eight cases of egg destruction (26.7%), three cases involving first-year birds (10%) and only one case (3.3%) involved a chick.

Four predatory species were identified: Peregrine Falcon *Falco peregrinus*, Large-billed Crow *Corvus macrorhynchos*, Eurasian Magpie *Pica pica* and Steppe Rat Snake *Elaphe dione*. The main natural predators were Peregrine Falcons, which took five migrating adults, and Large-billed Crows, which predated 19 eggs from four nests (Table 1).

Discussion

Despite rapid infrastructure and resort development along the coast, the forests of Jeju Island have been well protected and managed for the past several decades (including strong natural and prescribed forest fire controls, no fuel-wood harvesting, and national park designation). Therefore, good habitat conditions for breeding Fairy Pittas on Jeju have been maintained, and thus habitat loss is not a major threat at this stage on the island (Kim *et al.* 2003). Neither hunting nor trapping was recorded during this study and predation and window strikes were found to be the most significant causes of injury and death.

Collisions between birds and man-made structures have been widely reported (Tanner 1954, Johnston & Haines 1957, Jones & Francis 2003, Martínez *et al.* 2010); in particular, collisions with windows can cause massive, non-selective mortality of birds (Klem 1990, Dunn 1993, Klem *et al.* 2004). Based on the 11 reported cases, window strikes were identified as the most serious threat to the pitta population on Jeju, other than natural predation. Just two buildings in forests caused 5 of the 11 window strikes. As the number of buildings in forests and the number and area of windows gradually grows, the threat of window strike also increases. Repeated incidences involving deaths of first-year birds at specific buildings in forests suggest that detrimental effects of window strike may be greater under certain conditions (e.g. when a high

Table 1. Fairy Pitta *Pitta nympha* injury and mortality records from 2002 to 2012 on Jeju Island, Republic of Korea.

No.	Date	Age class of pitta	Cause of injury and mortality	Outcome	Habitat	Related species
1	14 September 2002	Adult	Dehydration	Rehabilitated	Suburban	
2	23 June 2004	Adult	Car accident	Dead	Forest	Human
3	14 July 2004	Adult	Window strike	Rehabilitated	Forest	Human
4	2 July 2005	Eggs	Flooding	Dead	Forest	
5	7 July 2005	Adult	Window strike	Dead	Forest	Human
6	2 August 2005	1st year	Window strike	Dead	Suburban	Human
7	8 September 2005	Adult	Window strike	Rehabilitated	Urban	Human
8	27 May 2006	Adult	Window strike	Dead	Urban	Human
9	4 June 2006	Adult	Window strike	Dead	Forest	Human
10	28 June 2006	Eggs	Predation	Dead	Forest	Eurasian Magpie
11	17 July 2006	Eggs	Disturbance	Nest abandonment	Forest	Human
12	27 July 2006	Chick	Predation	Dead	Forest	Steppe Rat Snake
13	11 June 2007	Eggs	Predation	Dead	Forest	Large-billed Crow
14	29 July 2007	Eggs	Flooding	Dead	Forest	
15	21 May 2009	Adult	Dehydration	Rehabilitated	Urban	
16	24 May 2009	Adult	Predation	Dead	Coast	Peregrine Falcon
17	27 May 2009	Adult	Predation	Dead	Coast	Peregrine Falcon
18	27 May 2009	Adult	Predation	Dead	Coast	Peregrine Falcon
19	27 May 2009	Adult	Predation	Dead	Coast	Peregrine Falcon
20	27 May 2009	Adult	Predation	Dead	Coast	Peregrine Falcon
21	13 June 2009	Adult	Car accident	Dead	Suburban	Human
22	6 July 2009	Adult	Window strike	Dead	Forest	Human
23	15 June 2010	Eggs	Predation	Dead	Forest	Large-billed Crow
24	22 June 2010	Adult	Window strike	Rehabilitated	Forest	Human
25	9 July 2010	Eggs	Predation	Dead	Forest	Large-billed Crow
26	30 May 2011	Adult	Window strike	Dead	Forest	Human
27	14 June 2011	Adult	Window strike	Rehabilitated	Suburban	Human
28	19 July 2011	Eggs	Predation	Dead	Forest	Large-billed Crow
29	29 August 2012	1st year	Car accident	Rehabilitated	Forest	Human
30	14 September 2012	1st year	Window strike	Rehabilitated	Urban	Human

proportion of reflective windows have been used). Traffic accidents may cause local wildlife mortality (Hell *et al.* 2005, Gryz & Krauze 2008, Litvaitis & Jeffrey 2008), but such accidents (3 cases) were less frequent than collisions with windows. Nevertheless, head trauma caused by human-related accidents was the main cause of mortality or the main reason for rescuing pittas on the island.

The high proportion of adult birds involved in accidents, including nine window strike cases, may be significant in terms of impacting the pitta population on Jeju. The small proportion of casualties involving first-year birds, on the other hand, possibly suggests a lower mortality rate or higher survival rate of juveniles at least in natal areas, once they have successfully fledged avoiding predation and floods.

Most casualties were in the spring and early summer from May to July, coincident with the species's spring migration and the most active part of the breeding season for adults (Kim 1964, Kim *et al.* 2003); fewer casualties were reported during the autumn migration in October (Kim 1964, Kim *et al.* 2003). The spring migration coincides with the breeding season of Peregrine Falcons in coastal areas around Jeju Island, and many Fairy Pittas thus seem to be exposed to the danger of predation by Peregrines during their final sea-crossing to the island—a breeding pair of Peregrines on Mara islet killed four pittas in one day (Table 1), suggesting that natural predation during migration may have a significant effect.

Although predation is a natural ecosystem process, the observed rate of nest predation by corvids, including one case by a Eurasian Magpie—a species introduced into Jeju as recently as 1989— may not be entirely natural. Corvids are often attracted to garbage and invade forests along roads and man-made trails. Only one case of nest abandonment resulting from human disturbance (photographers) was reported. However, given the indirect effects of humans on corvid behaviour and distribution, the overall proportion of anthropogenic causes of mortality and nest failure may be higher than that of natural causes.

These results identifying current threats to the Fairy Pitta suggest several mitigation measures for this threatened species on Jeju:

1. Preventing window strikes is the most urgently required mitigation. This may include the identification of buildings threatening local populations and the use of typical anti-collision methods there (Dunn 1993, Klem *et al.* 2004): habitat modification, physical barrier setting, glass angling and glass patterning using bird saving stickers may all be appropriate. However, restriction on the construction of new buildings in key breeding areas must be a more fundamental solution. Pitta occurrence and numbers, and the expected effects of building construction on the species should be included in environmental impact assessment procedures on Jeju, particularly in forested areas. Developing new building regulations to limit the size or total area of windows in forested areas is applicable, and this kind of regulation would be more realistic and successful when the greater energy efficiency of buildings with smaller areas of window is also considered.
2. The construction of new roads or trails should be restricted in key breeding areas. This may also minimise traffic accidents with other key wildlife species, such as the Jeju Roe Deer *Capreolus pygargus*. More importantly, fewer and shorter roads and trails may reduce the access of newly introduced exotic predators (e.g. Eurasian Magpies) into pitta breeding habitat.
3. Predator control within pitta breeding habitat should be considered, with two common corvids, the native Large-billed Crow and the introduced Eurasian Magpie, as the main targets of the programme. Corvid control may mitigate the detrimental effects of predation on threatened species (Peery & Henry 2010). Specifically, the increasing numbers of invasive Eurasian Magpies at higher altitude and in forested areas should be controlled and managed as the highest priority.
4. Human disturbance at nesting sites should be minimised; although nest abandonment resulting from disturbance was recorded only once during this study, human access to nests may incidentally increase the predation risk. Construction or forest management (such as thinning and felling) near known nesting sites should only be carried out outside the breeding season. Access by inexperienced photographers should also be controlled. Strict adherence to the current domestic legislation relating to this species (Endangered Species Class II under the Protection and Management of Wildlife Act, and Natural Monument #204 under the Cultural Heritage Protection Act) (Ministry of Environment 2002) and to protected areas such as Mt Halla National Park should also be enforced.

In conclusion, in addition to the known threats to Fairy Pitta populations including habitat loss and lowland deforestation (BirdLife International 2013), the results of this study lead us to suggest that human-related mortality, including window strikes and traffic accidents as well as predation, may adversely and significantly affect the survival of individual Fairy Pittas, raising new conservation concerns in human-dominated environments.

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***Eun-Mi KIM**, Department of Biology, Jeju National University, Jeju, Jeju province 690-756, Republic of Korea & Warm-Temperate and Subtropical Forest Research Center, Korea Forest Research Institute, Seogwipo, Jeju province 697-050, Republic of Korea. Email: kptta@naver.com*

***Chang-Yong CHOI**, Research Institute for Agriculture and Life Sciences, Seoul National University, Seoul 151-921, Republic of Korea. Email: subbuteo@hanmail.net (corresponding author)*

***Chang-Wan KANG**, Korea Association For Bird Protection-Jeju Branch, Seogwipo, Jeju province 697-340, Republic of Korea. Email: jejubirds@hanmail.net*

House Crow *Corvus splendens* nesting on pylons, Kutch district, Gujarat, India

A. MOHAMED SAMSOOR ALI, S. RAMESH KUMAR & P. R. ARUN

Introduction

During the past 50 years, electric power transmission lines have become a conspicuous part of the landscape of industrialised countries. These powerlines and their supporting structures (pylons) are known to cause avian mortality, and in recent decades this has been increasingly documented throughout the world (Bevanger 1994, Brown & Drewien 1995, Winning & Murray 1997, Janss & Ferrer 2000, Sundar & Choudhury 2001, Shaw *et al.* 2010, Tere & Parasharya 2011). A recent review summarised some adverse effects of the electromagnetic fields around powerlines on avian reproductive biology and physiology (Fernie & Reynolds 2005). In contrast, power cables and supporting structures in open habitats benefit some bird species by providing perches offering commanding views of hunting areas (Lammers & Collopy 2007, Asokan & Ali 2010) and nest sites (Brown & Lawson 1989, Steenhof *et al.* 1993, Infante & Peris 2003). The use of these structures for nesting purposes is a fairly recent development and has enabled some species to expand their breeding ranges into areas where there are no natural nesting sites.

Published literature on the use of pylons (large vertical steel towers supporting high-tension powerlines) for nesting by Indian birds is sparse. Here, we report on House Crow *Corvus splendens* nesting on pylons in Kutch district, Gujarat, India. House Crows typically build stick nests, usually in large trees with spreading crowns, but nesting on pylons is a relatively recent phenomenon.

Materials and methods

The study was conducted in and around the Samakhiali region (23.303°N 70.507°3E) of Bhachau Taluk, Kutch district, in June and July 2012. The study area is flat terrain with scanty vegetation dominated by agricultural fields and human settlements with several scattered waterbodies of varying sizes. The area has a

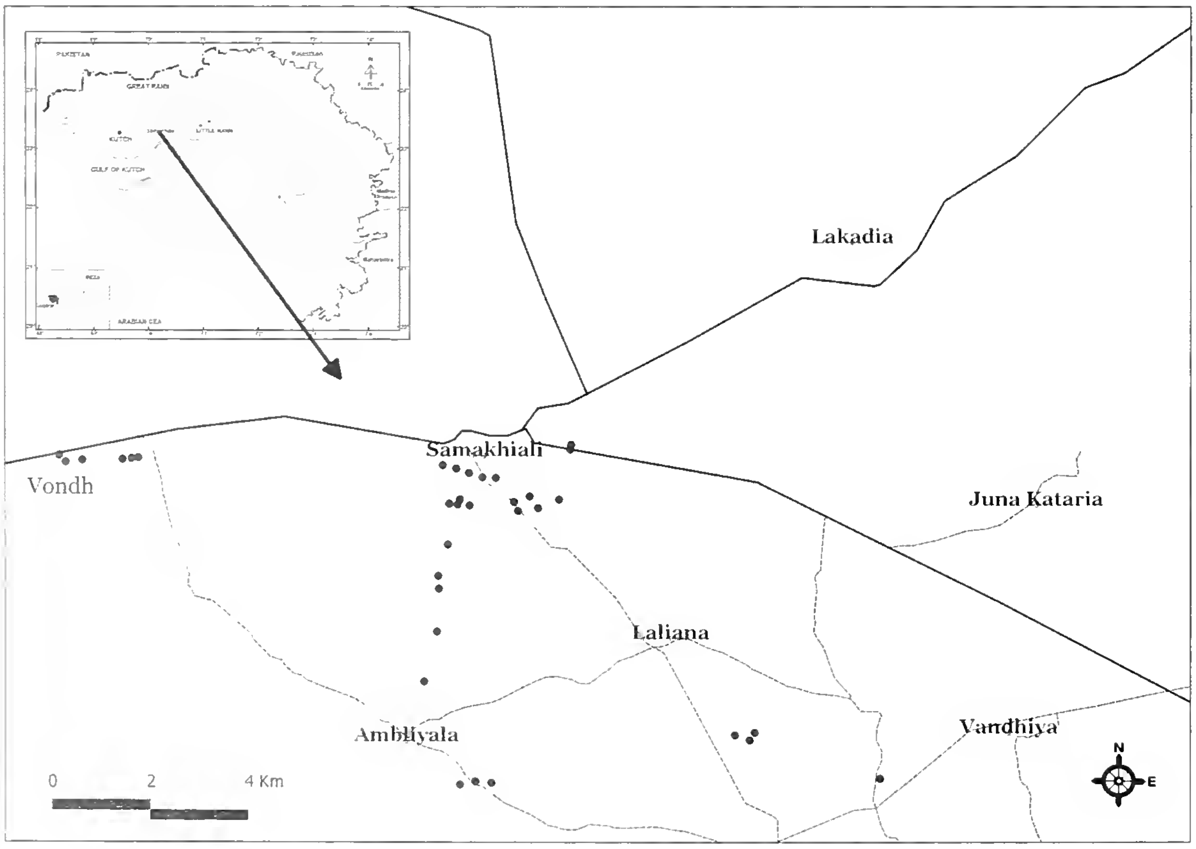


Figure 1. Map of the study area showing the localities of House Crow nest sites on pylons (black dots).

characteristic dry and hot climate, with average temperatures during the hottest months ranging from 17.6°C to 39.5°C and an annual rainfall of around 400 mm.

A visual survey was done at each pylon while following the transmission lines in the area either by vehicle or on foot. In total, 71 pylons were surveyed, all of which had three consoles (cross-member structures) carrying 110 to 400 kV lines; between one and six power cables were carried on each side of the consoles. Nest sites were located using 8×50 and 12×50 binoculars and the following information was recorded: pylon type, total height and height of nest(s) above ground (estimated visually), number of nests on the pylon and vegetation (trees, shrubs, herbs) around the nest site. Nests were considered active if a bird was incubating, exhibiting defensive behaviour (defensive vocalisations by a bird perched near the nest) or a juvenile was present at the nest. Coordinates of each nest site were recorded using a hand-held Global Positioning System.

Results and discussion

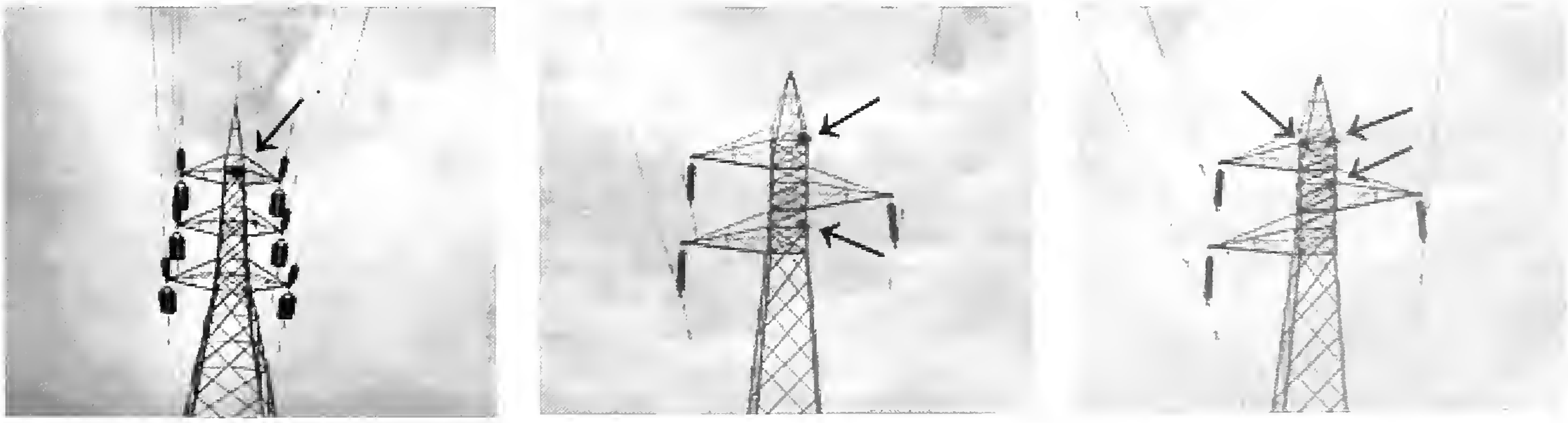
During the study period, a total of 34 active House Crow nest sites were recorded on pylons; 19 sites were in agricultural fields, 8 in scrublands and 7 within human settlements (Figure 1). Four different types of pylons are used to support transmission lines passing through the area, and based on the design, they were designated Type A ($n = 6$), Type B ($n = 18$), Type C ($n = 33$) and Type D ($n = 14$) (Plate 1). The House Crow nested on all four types with the majority of nests (41.2%) being found on Type C—the most common pylon type. This was followed by Type B (26.5%), Type D (23.5%) and Type A (8.8%); the proportion of nests found on the different types of pylon is similar to the proportion that would be expected by chance (Fisher's Exact Test, $P = 0.85$). The pylons used for nesting were between 20 and 50 m in height (mean 29.1 ± 7.53 m). The height of the location of House Crow nests on pylons varied from 15 to 49 m (mean 25.2 ± 7.2 m). The number of nests found on a single pylon varied between one and three (Plate 2); a single nest was recorded on 27 pylons, two nests on 5 and three nests on 2 pylons. Of the 34 House Crow nest sites examined, significantly more nests than expected by chance were placed in the top console (55.8%) of the pylon, followed by the middle console (29.4%), and the bottom console (14.7%) (Fisher's Exact Test, $P < 0.001$).

House Crows are well known to live commensally with humans (Ali & Ripley 1983) and usually construct their nests on large, well-branched dense canopy trees close to human settlements (Ali & Ripley 1983, Ryall 1990, Akter *et al.* 1994, Vyawahare 1998, Allan & Davies 2005, Ali *et al.* 2011, Chongomwa 2011). On Kharg Island in the Persian Gulf, Behrouzi-Rad (2010) recorded House Crows nesting on oil and gas pipes, window ledges of buildings, poles, TV antennae and also trees. A few authors have reported that ravens (*Corvus* sp.) nest on pylons in some parts of the world (Steenhof *et al.* 1993, Bednorz 2000, Agiæ 2006). However, based on our literature survey, House Crow nesting on pylons has not previously been reported in India and adjacent countries.

The preference of House Crows for using pylons for nesting in the study area may be due to lack of natural nest sites. Our basic vegetation survey of the area confirmed that there are no suitable nesting trees within a 200 m radius of the pylons. The tree species recorded in the area included *Azadirachta indica, Ficus benghalensis, Acacia nilotica, Balanites aegyptica, Delonix regia, Salvadora persica, Prosopis juliflora* and *P. cineraria*, none of which was observed to be more than 10 m in height. Thus, the pylons have provided suitable nesting sites for House Crows in the absence of natural sites. These new-found sites may allow the species to escape brood parasitism by Asian Koel *Eudynamys scolopaceus*, a common brood parasite (Ali *et al.* 2007), since the lack of vegetation may make it easier for the koels to be seen. It is also possible that sites on pylons


Type A Type B Type C Type D

Plate 1. Types of pylons in the study area.


Single nest—placed in top console

Double nests—placed in bottom and top consoles

Triple nests—placed in middle and top consoles

Plate 2. Nest locations (indicated by the arrow) on pylons.

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in this landscape where wind speeds are high may be cooler than those in other areas and have made it easier for the House Crows to adapt to these novel sites.

To fully assess the long-term costs and benefits to House Crows of locating their nests on pylons, further research on the nesting chronology (clutch size, incubation and breeding success) is needed as well as on the risks of collision with wires and electrocution on poles.

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***A. MOHAMED SAMSOOR ALI, S. RAMESH KUMAR** & **P. R. ARUN**, Division of Environmental Impact Assessment, Sálim Ali Centre for Ornithology and Natural History (SACON), Anaikatty, Coimbatore-641 108, Tamil Nadu, India. Email: amsamsoor@yahoo.co.in*

New waterbird count data from the Heihe river in Gansu province, western China

MARK R. BEZUIJEN

Introduction

The Heihe is China's second longest inland-draining river and lies within the Central Asian and East Asian–Australasian flyways for migratory waterbirds (Boere & Stroud 2006). No information on the Heihe is listed in the *Asian Waterbird Census 1987–2007* (Li *et al.* 2009), *Atlas of key sites for Anatidae in the East Asian flyway* (Miyabayashi & Mundkur 1999) or the *Asian-Australasian flyway site network* (DSEWPC 2009), and the river appears to be almost unknown in the international waterbird literature. Recent baseline species inventories (Chen *et al.* 2009, Zhangye City Government 2010) and a study of waterbird densities (Bao *et al.* 2012) established that the middle reaches of the river provide important habitat for waterbirds migrating across the arid regions of central-west China. Part of the river is designated an Important Bird Area, partly based on a report of 'more than 20,000 waterbirds' (BirdLife International 2009). In the early 1990s a small waterbird reserve was designated along the middle Heihe, and in 2010 this was expanded and upgraded to the Gansu Zhangye Heihe Wetland National Nature Reserve (NNR) (Zhangye City Government 2010) (Figure 1). In 2011 wetlands in and near the Gansu Zhangye Heihe Wetland NNR were visited by MRB and waterbirds observed. New waterbird count data for the Heihe are presented and the international importance of the Heihe for waterbird conservation is discussed.

Study area and methods

From its headwaters in the Qilian mountains of Gansu and Qinghai provinces, the Heihe flows north across a vast, arid plain, the Hexi corridor in Gansu province (the middle Heihe *c.*330 km), then drains

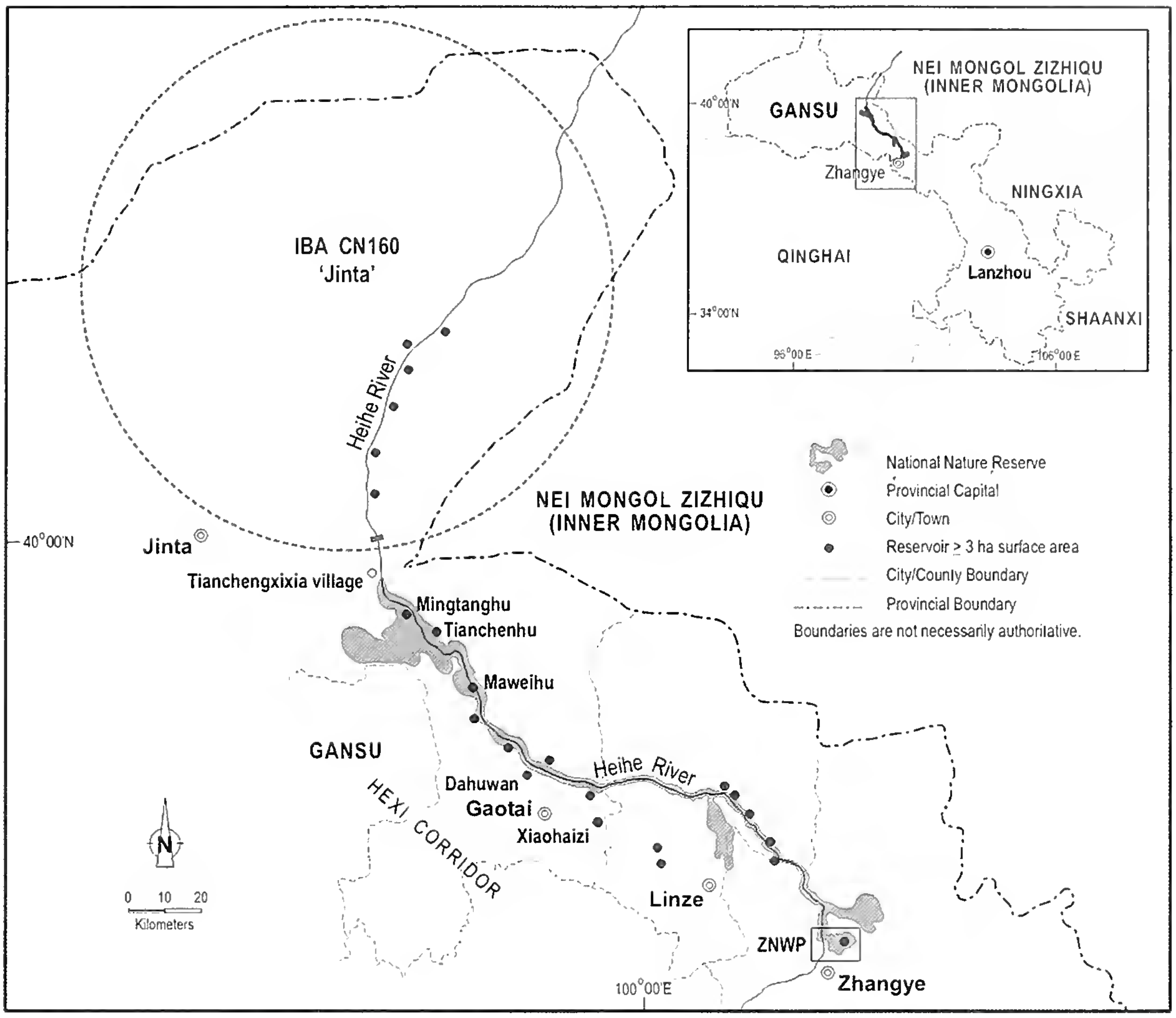

Figure 1. Localities mentioned in the text, including Important Bird Area CN160 Jinta (from BirdLife International 2009).

into Inner Mongolia province (the lower Heihe) (Figure 1). Waterbirds were counted at nine sites (elevations 1,278–1,460 m) in the middle Heihe: the Zhangye National Wetland Park (ZNWP), seven reservoirs and short sections of the Heihe between the ZNWP and the village of Tienchengxixia (Table 1, Figure 1). Six of these sites were within the Zhangye Heihe Wetland NNR (38.965°–39.875°N 99.323°–100.580°E; 41,164 ha) (hereafter 'the reserve'), which spans 160 km of the Heihe (Zhangye City Government 2010) (Figure 1). The reserve is characterised by low annual precipitation (mean 50–200 mm), high annual evaporation (mean 1,200–2,200 mm), extreme annual temperatures (–31°C, January to 41°C, July) and sandstorms (Zhangye City Government 2010).

The middle Heihe is a shallow, braided channel with rocky and alluvial substrates, gravel bars, marshes and sparse woodlands, bordered by a flat dry plain, and in the north-west, sand dunes and rocky gorges. Because of the regional scarcity of water, numerous reservoirs and irrigation networks have been constructed along the channel. Most riparian land is cultivated. The seven reservoirs surveyed were embanked structures with shallow and deep water, exposed mud, reeds *Phragmites*, reedmace *Typha* and/or stands of low shrubs or trees. The total surface area of the seven reservoirs was 1,505 ha. See Table 1 for details of elevation, surface area, length and width of all of the reservoirs, together with the distance from the Heihe. The 4,602 ha ZNWP (Zhangye City Government 2009) supports reed beds, woodland and farmland. Over one million people reside along the middle Heihe (Zhangye City Government 2010). Sites were initially identified from reserve maps. Reservoir dimensions and altitude were obtained from Google Earth satellite imagery, and field locations were recorded with a GPS. In total, 62.5 hours of field observations were made (Table 1). All sites were visited in early winter (October–November) and ZNWP was additionally visited in summer (July). Sites were traversed on foot.

Table 1. Sites visited in and near* the Gansu Zhangye Heihe Wetland National Nature Reserve, China, in 2011.

Name	Coordinates	Elevation (m)	Area (ha)	Length (km)	Width (km)	Distance to Heihe (km)	Dates[1]
ZNWP	38.974°N 100.455°E	1,460	n/a	n/a	n/a	0	17, 19 Jul, 16, 23–25, 28–29 Oct
Maweihu reservoir–east	39.586°N 99.635°E	1,313	163	2.35	0.8	0.57	1, 6 Nov
Maweihu reservoir–west	39.596°N 99.621°E	1,313	240	1.68	1.42	0.57	1, 6 Nov
Tianchenhu reservoir	39.709°N 99.567°E	1,300	202	3.81	0.77	0.05	1, 6 Nov
Mingtanghu reservoir	39.745°N 99.503°E	1,292	220	2.81	1.27	0.3	1, 6 Nov
Tienchengxixia village	39.823°N 99.436°E	1,278	n/a	n/a	n/a	0	1 Nov
Dahuwan reservoir–south*	39.401°N 99.744°E	1,340	191	2.28	1.23	0.78	31 Oct, 5 Nov
Dahuwan reservoir–north*	39.411°N 99.764°E	1,340	53	1.23	0.56	0.03	31 Oct, 5 Nov
Xiaohaizi reservoir*	39.290°N 99.889°E	1,370	436	4.86	2.27	5.72	7 Nov

[1] Survey effort: ZNWP: Jul = 10 hrs (05h00–10h45), Oct = 26.5 hrs (06h00–19h00), Dahuwan = 5.75 hrs (13h30–18h30), 'Gaotai' (Maweihu, Tianchenhu, Mingtanghu, Hei He, roadsides) = 16.5 hrs (08h30–17h00), Xiaohaizi = 3.75 hrs (08h40–12h25).

Waterbirds were counted using 10×42 binoculars and large flocks were counted at least twice to reduce count error. Because birds moving between sites may be double-counted, counts were pooled into four areas: Dahuwan (two reservoirs), Gaotai (Maweihu and Tianchenhu reservoirs, the Heihe, roadside wetlands), Xiaohaizi (three reservoirs) and ZNWP. For each area, a count estimate for each species was obtained by selecting the highest daily count recorded during visits to that area (Table 1). Counts for the four areas were summed to produce a total count. The risk of double-counting was considered low because: (i) 80% of the total count was made within a short time (three consecutive days, 5–7 November) and (ii) 26% of the total count comprised two flocks (see Results). Site visits only covered a small proportion of the middle Heihe, and 17 other large reservoirs along the channel, each with a surface area of 3 ha or more (Figure 1), were not visited. Counts for each species were compared against the 1% non-breeding population thresholds for East Asia given by Wetlands International (2012), to assess their conservation importance against criteria of the Ramsar Convention on Wetlands (Ramsar Convention Bureau 2008), to which China is a signatory.

Bird names, sequence and taxonomy follow Inskipp *et al.* (1996). IUCN Red List categories (Vulnerable, Near Threatened etc.) follow BirdLife International (2012).

Results

Forty waterbird species were observed in and near the reserve (Appendix 1); none was a new record for the middle Heihe. Compilation of available records yields an inventory of 71 waterbird species for the middle Heihe (Appendix 1); one species was excluded from this list, Black-necked Crane *Grus nigricollis*, mentioned by Ma & Ma (2001) but with no other details. These records include seven species of particular conservation concern: one Critically Endangered (Baer's Pochard *Aythya baeri*), three Vulnerable (Great Bustard *Otis tarda*, Relict Gull *Larus relictus*, Pallas's Fish Eagle *Haliaeetus leucoryphus*) and three Near Threatened (Ferruginous Pochard *A. nyroca*, Black-tailed Godwit *Limosa limosa*, Eurasian Curlew *Numenius arquata*). The bustard and eagle are not included as waterbirds for this study but are mentioned here for completeness. BirdLife International (2009) noted the Great Bustard bred along the middle Heihe in the 1950–1960s but has been 'extinct since the 1970s'; on 22 September 2008, two individuals were observed in the desert near Tianchenhu reservoir (Bao Xin-Kang *in litt.* 2012).

At least 8,504 individuals of 32 species were counted in early winter 2011, of which 7,023 (83%) were ducks, swans and geese of 15 species (Appendix 1). Mallard *Anas platyrhynchos* (2,804), Greylag Goose *Anser anser* (1,260) and Ruddy Shelduck *Tadorna ferruginea* (1,040) comprised 60% (5,104) of the count. Of the four survey areas visited in early winter, the highest count (all species combined) was in Gaotai (3,219) and the lowest was in ZNWP (325) (Appendix 1). Counts for three species exceeded the 1% non-breeding population estimates for East Asia: Greylag Goose (1,260 versus the 1% threshold of 710), Ruddy Shelduck (1,040 versus 710) and Black Stork *Ciconia nigra* (54 versus 1). Unpublished 2008 count data for Gaotai and Xiaohaizi (Bao Xin-Kang *in litt.* 2012) exceed the 1% thresholds for three species, Greylag Goose (810), Red-crested Pochard *Netta rufina* (4,214 versus 1,000 for South Asia) and Black Stork (81), and approach that for Whooper Swan *Cygnus cygnus* (420 versus 600). For Red-crested Pochard, which is mainly a species of the Central-South Asian flyway rather than the East Asian flyway (Miyabayashi & Mundkur 1999), no 1% threshold is available for East Asia (Wetlands International 2012). Comparison with the South Asia 1% threshold is appropriate and is given above.

Discussion

This appears to be the first assessment of the importance of the Heihe river for waterbirds against international conservation criteria. Comparison of count data with criteria of the Ramsar Convention Bureau (2008) indicates the middle Heihe satisfies at least one, and possibly two, criteria signifying a Wetland of International Importance. For at least four species, Greylag Goose, Ruddy Shelduck, Red-crested Pochard and Black Stork, the middle Heihe appears to meet criterion 6 (a wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird). The total early winter count in 2011 (8,504 individuals) suggests that criterion 5 (a wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds) may also be met. Given the limited sampling effort and coverage of the current observations, the low risk of double-counting and that counts of large flocks tend to underestimate total numbers (Rappoldt *et al.* 1985), it seems reasonable to conclude that the middle Heihe supports more than 20,000 waterbirds in the non-breeding season. Waterbird surveys in China have largely focused on coastal wetlands in the east (e.g. Barter *et al.* 2005, Cao *et al.* 2008), as have recent national censuses (Li *et al.* 2009, China Coastal Waterbird Census Team 2010). Cao *et al.* (2008) speculated that few waterfowl occur west of 110°E in the non-breeding season, because of limited habitat and cold winters. The current findings confirm that the Heihe, which extends from c.90.333 to 100.433°E (i.e. c.830 km west of 110°E) supports internationally important waterbird populations. Insufficient data are available to assess the current local status of the seven globally threatened and Near Threatened species recorded in the reserve.

Reservoirs along the middle Heihe provide important habitat for migratory waterbirds. At least 2,691 individuals (32%) counted in early winter 2011 were recorded in fewer than four hours within a single reservoir complex, Xiaohaizi, and many waterbirds were observed at other reservoirs (Appendix 1). This is notable compared with reservoirs in eastern China, which generally support few waterfowl (Cao *et al.* 2008), and recreational lakes, which often support large numbers of people, few wetland habitats, and low bird species richness (Zhao *et al.* 2008, Niu *et al.* 2011, MRB pers. obs.).

The timing of peak waterbird migration in the middle Heihe is unknown. Raw count data for Gaotai was 33% higher on 6 November (2,757) than on 1 November (1,834), and this increase could not be accounted for by numbers recorded on previous days in other areas, suggesting that migrants were continuing to arrive. Counts for Greylag Goose, Ruddy Shelduck and Mallard were higher in October–November than recorded by Bao Xin-Kang (*in litt.* 2012) in September (Appendix 1). In contrast, counts in September for Red-crested Pochard and in December for Whooper Swan, both by Bao Xin-Kang (*in litt.* 2012), were over seven and ten times higher respectively than counts in October–November 2011 in the same survey areas. No count data for the middle Heihe are available from January–February, possibly because most waterbodies are frozen at that time and few waterbirds may be present. Important Bird Area CN160 Jinta (BirdLife International 2009) encompasses the Heihe downstream of the reserve (Figure 1). The current findings suggest the IBA boundaries should be extended to the east to encompass the reserve.

Loss and degradation of wetlands are the key threats to waterbirds in the middle Heihe. Intensive industrial and agricultural development has resulted in declining water tables, vegetation dieback, pollution and salinisation (Qi & Luo 2006). Conservation priorities for waterbirds include habitat restoration (Chen *et al.* 2009) and a comprehensive survey of the middle and lower Heihe to determine seasonal waterbird numbers and identify key conservation sites.

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***Mark R. BEZUIJEN**, P.O. Box 183, Ferny Creek, Victoria, Australia 3786. Email: bezuijen@dodo.com.au*

Appendix 1

Waterbird records and available count data from within and near the Gansu Zhangye Heihe Wetland National Nature Reserve, China.

				This study		This study			
						Early winter (October–November)			
Species	Chen *et al.* (2009)	ZCG (2010)	Bao *et al.* (2012)*	Summer (July) ZNWP	ZWNP	Gaotai	Dahuwan	Xiaohaizi	Total no. early winter
Mute Swan *Cygnus alar*	x								
Whooper Swan *Cygnus cygnus*	x	x	x (Ma-420)			30		9	39
Tundra Swan *Cygnus calumbianus*	x	x[1]	x						
Bean Goose *Anser fabalis*		x	x (Ma-80)			1		50	51
Greylag Goose *Anser anser*	x	x	x (Xi-810)			60		1,200	1,260
Bar-headed Goose *Anser indicus*		x	x						
Ruddy Shelduck *Tadarna ferruginea*	x	x	x (Ma-428)		11	1,017	12		1,040
Common Shelduck *Tadarna tadarna*	x	x	x			15			15
Gadwall *Anas strepera*		x	x (Ma-102)		9	50	220		279
Eurasian Wigeon *Anas penelape*		x	x						
Mallard *Anas platyrhynchas*	x	x	x (Mi-780)		70	1,081	813	840	2,804

Species	Chen *et al.* (2009)	ZCG (2010)	Bao *et al.* (2012)*	This study Summer (July) ZNWP	This study Early winter (October–November) ZWNP	Gaotai	Dahuwan	Xiaohaizi	Total no. early winter
Spot-billed Duck *Anas paecilarhyncha*		x	x (Ma-54)	33	65	7	39	30	141
Northern Shoveler *Anas clypeata*	x	x	x						
Northern Pintail *Anas acuta*		x	x						
Common Teal *Anas crecca*	x	x	x (Ma-320)		41	50+	300		391
Red-crested Pochard *Netta rufina*		x	x (Ma-4214)		2	575		10	587
Common Pochard *Aythya ferina*		x	x (Ma-60)		1				1
Ferruginous Pochard *Aythya nyraca*	x	x	x (Ma-59)	5	35	60	20	105	220
Baer's Pochard *Aythya baeri*		x	x (Ma-12)						
Tufted Duck *Aythya fuligula*	x	x	x (Xi-22)		1	20	2		23
Common Goldeneye *Bucephala clangula*		x	x (Ma-67)			30	22	90	142
Red-breasted Merganser *Mergus serratar*	x								
Common Merganser *Mergus merganser*	x							30	30
Demoiselle Crane *Grus virga*	x^2								
Common Crane *Grus grus*	x	x							
Water Rail *Rallus aquaticus*		x	x	2					0
Baillon's Crake *Parzana pusilla*		x							
Common Moorhen *Gallinula chlarapus*		x	x (Mi-5)	5					0
Common Coot *Fulica atra*		x	x (Mi-1190)	28	45		200	272	517
Eurasian Woodcock *Scalapax rusticala*		x	x						
Common Snipe *Gallinaga gallinaga*	x	x	x		[10]		[3]		13
Black-tailed Godwit *Limasa limasa*	x	x	x (Da-73)				2		2
Eurasian Curlew *Numenius arquata*		x	x (Xw-2)						
Spotted Redshank *Tringa erythrapus*	x	x							
Common Redshank *Tringa tatanus*	x	x	x			6	1		7
Marsh Sandpiper *Tringa stagnatilis*		x	x						
Common Greenshank *Tringa nebularia*		x	x				10	1	11
Green Sandpiper *Tringa achrapus*	x	x	x		2		3		5
Wood Sandpiper *Tringa glareala*	x								
Common Sandpiper *Actitis hypaleucas*	x	x	x	1					0
Red-necked Stint *Calidris ruficallis*	x	x							
Temminck's Stint *Calidris temminckii*	x	x	x						
Long-toed Stint *Calidris subminuta*	x								
Dunlin *Calidris alpina*		x	x						
Curlew Sandpiper *Calidris ferruginea*	x	x	x						
Black-winged Stilt *Himantapus himantapus*	x	x	x	5					0
Pied Avocet *Recurvirastra avasetta*		x	x						
Pacific Golden Plover *Pluvialis fulva*	x^3	x^3	x						
Little Ringed Plover *Charadrius dubius*	x	x	x						
Kentish Plover *Charadrius alexandrinus*	x	x	x						
Northern Lapwing *Vanellus vanellus*	x	x	x		10	21	16		47
Grey-headed Lapwing *Vanellus cinereus*		x	x						
Pallas's Gull *Larus ichthyaetus*	x	x	x		1	10	23	12	46
Brown-headed Gull *Larus brunnicephalus*	x	x	x						
Black-headed Gull *Larus ridibundus*	x	x				10	111	7	128
Relict Gull *Larus relictus*	x	x							

Species	Chen *et al.* (2009)	ZCG (2010)	Bao *et al.* (2012)*	This study Summer (July) ZNWP	This study Early winter (October–November)				Total no. early winter
					ZWNP	Gaotai	Dahuwan	Xiaohaizi	
Common Tern *Sterna hirunda*	x	x	x	200					0
Little Tern *Sterna albifrans*		x							
Whiskered Tern *Chlidanias hybridus*		x	x	2					0
Little Grebe *Tachybaptus ruficallis*	x	x	x	16	6	8	20	2	36
Great Crested Grebe *Padiceps cristatus*	x	x	x	6	1	3	12	3	19
Great Cormorant *Phalacracarax carba*	x	x	x (Xi-60)		1	7	200	5	213
Grey Heron *Ardea cinerea*	x	x	x	1	3	12	18	1	34
Great Egret *Casmeradius albus*	x	x	x		9	93	168	24	294
Chinese Pond Heron *Ardeala bacchus*	x	x	x	1	2		2		4
Black-crowned Night Heron *Nycticarax nycticarax*		x	x	11					0
Yellow Bittern *Ixabrychus sinensis*	x	x	x	6					0
Black Bittern *Dupetar flavicallis*		x							
Great Bittern *Bataurus stellaris*	x								
Eurasian Spoonbill *Platalea leucaradia*		x	x (Xy-16)				51		51
Black Stork *Cicania nigra*	x	x	x (Xy-81)			53	1		54
Total				322	325	3,219	2,269	2,691	**8,504**

[1]Listed as '*C. bewickii*', [2]as '*Anthrapaides virga*', and [3]as '*P. dominica*'. [ ] = provisionally identified. *Species records are from Bao *et al.* (2012) and count data is from Bao Xin-Kang (*in litt.* 2012): their counts were made over 24–27 September 2008 except for Whooper Swan (12 December 2008) and Black-tailed Godwit (6 August 2008). Their survey sites were: 'Da' (Dahuwan), 'Ma' (Maweihu reservoir), 'Mi' (Mingtanghu reservoir), 'Ti' (desert near Tianchenhu reservoir), 'Xi' (Xiaohaizi), 'Xw' (Xiwan), 'Xy' (Xiyaodun); all sites are within the 'Gaotai' area of the current study.

Breeding biology of the Small Snowfinch *Pyrgilauda davidiana* on the Tibetan plateau

SHAOBIN LI, WEIJUN PENG, CHENG GUO & XIN LU

Introduction

The snowfinch complex, *Montifringilla*, *Onychostruthus* and *Pyrgilauda*, comprising eight species, has its central distribution on the Tibetan plateau (Qu *et al.* 2006, Summers-Smith 2009). Occurring from 2,000 to 5,500 m, snowfinches have the highest distributional elevation of all the passerines (Qu *et al.* 2002). They are well adapted to the open alpine meadow and rocky habitats of the Tibetan plateau. Adaptive radiation of snowfinches is thought to have occurred 2 million years ago with dramatic climatic changes caused by the uplift of the Tibetan plateau (Qu *et al.* 2006). However, data on the basic natural history of these species are sparse, although breeding of White-winged Snowfinches *Montifringilla nivalis*, White-rumped Snowfinches *Onychostruthus taczanowskii* and Rufous-necked Snowfinches *Pyrgilauda ruficollis* has been briefly described (Cramp & Perrins 1994, Zeng & Lu 2009a,b).

The Small Snowfinch *P. davidiana* weighing about 20 g, is one of the smallest snowfinches (Clement *et al.* 1993), distinguished from other snowfinch species by a black face mask continuous with a prominent black patch on the throat. It is found in the Russian Altai, Transbaikalia, Mongolia and north China, inhabiting meadow and semi-desert areas, mostly between 1,000 and 3,500 m. Little is known about the reproduction of this species. Here, we report the breeding biology of the Small Snowfinch at an altitude of 3,400 m on the north-east Tibetan plateau.

Study site and field procedure

This work was conducted during 2010–2011 in Tianjun county, north-east Tibetan plateau (37.283°N 99.017°E) at 3,400 m. The annual mean temperature in this area is −1.1°C and the total precipitation 345 mm (data from the weather records of a local weather station from 1990 to 2010). This site is an open, flat meadow landscape. More information on vegetation and other aspects is available in Wang *et al.* (2007) and Li & Lu (2012a).

We searched for snowfinch nests within a 180 ha study plot by following adults' breeding activities. The nests were located in abandoned burrows of Black-lipped Pikas *Ochotona curziona*. When a nest was discovered, we mapped the location with a GPS and recorded the direction of the burrow entrance. Adults were caught by mist-net at the burrow entrance during the nestling period, and ringed with colour rings and a numbered metal ring. We measured their body weight and the length of body, wing, tarsus and bill using an electronic balance and calipers. The sexes are similar, and adults were sexed by social behaviour, a female-specific incubation patch and the throat-patch (bigger and darker in males than females).

For some nests, we dug vertical inspection holes where the tunnel changed direction to find the nest. The inspection hole close to the nest was packed with soil-filled bags to facilitate subsequent inspections, and other holes were covered with original greensward to reduce the risk of predation. Egg size, clutch size, incubation period, nestling period and fledging success were estimated through checking nest contents. Hatchlings were marked by clipping specific tufts before they were eight days old; later they were ringed following the same procedure as for adults. Young from selected nests were weighed every three days. Nests were visited at least once a week to check nestling development and the current condition of the nest. When dates of egg laying, hatching or fledging were approaching, we increased nest visits to record these events as they occurred. Nest dimensions were measured after the young fledged. Nesting activities (nest building, copulation, incubation, brooding, provisioning and sibling competition behaviour) were recorded for selected nests. Parents delivering food almost invariably landed 20 cm or more from the entrance before coming in. This behaviour allowed us to identify the feeder's sex and nestling diet by direct observations at a distance of 20 m from the nests.

Data analysis

In total, 29 nests were located during the two breeding seasons. The date of laying the first egg was determined either by direct observations or by back-dating from the mean nesting parameters of the closely monitored nests. It was assumed that incubation had started if a female regularly stayed in a burrow for more than five minutes. A nest with one or more fledglings was considered successful. We pooled the data from the two seasons for analysis because of the small sample size in each year.

Chi-square tests were used to determine whether the direction of burrow entrances deviated from a random distribution. Independent- or paired-samples *t* tests were used to compare the means of two variables. The growth rate of nestling weight was fitted to a logistic curve. All the analyses were performed in SPSS (v 16). Statistical significance was set as $P < 0.05$ and values were expressed as mean±SD.

Results

Sexual dimorphism

Adult males were larger than females. Significant differences between the sexes were found in body weight, body length and wing length, while tarsus length and bill length were similar (Table 1).

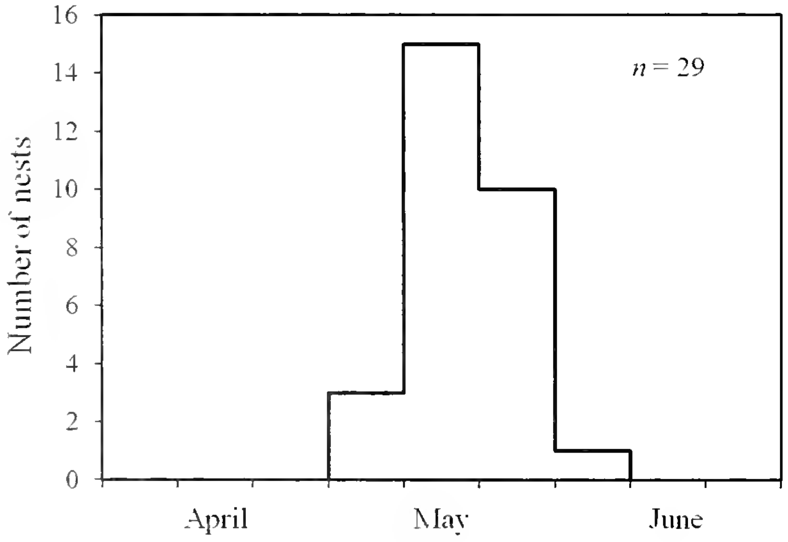
Table 1. Adult biometrics of the Small Snowfinch.

	Male (n = 12)		Female (n = 12)			
Body parameters	**Mean±SD**	**Range**	**Mean±SD**	**Range**	***t***	***P***
Body weight (g)	22.3±1.2	19.7–24.5	19.9±1.3	17.8–21.9	4.78	< 0.001
Body length (mm)	120.7±3.9	117–130	114.6±3.4	109–121	3.78	0.001
Wing length (mm)	86.4±1.1	84.9–88.5	83.0±2.0	80.1–86.1	5.13	< 0.001
Tarsus length (mm)	21.3±0.8	20.4–22.5	21.1±0.6	19.9–21.8	0.94	0.36
Bill length (mm)	10.2±0.3	9.5–10.7	10.3±0.3	9.5–10.7	0.18	0.86

Breeding season

This species is socially monogamous (based on observations of 12 marked pairs). Breeding density was 0.13 pair per ha. Eggs were laid from early May to early June with a peak in mid-May (Figure 1). No second nesting attempt was observed (n = 12 marked pairs). After the young fledged, adults foraged with their offspring and no further breeding was attempted.

Figure 1. Distribution of first egg dates for the Small Snowfinch. The data from the 2010 and 2011 breeding seasons are pooled and the dates arranged in 10-day periods.



Nest

Nests were in the chambers or at the end of a tunnel branch of pika burrows, 118±50 cm (range: 78–234 cm, n = 8) from burrow entrances. The directions of nest entrances did not deviate from a random distribution ($\chi^2 = 5.3$, $df = 3$, $P = 0.15$). The number of pika burrows within a 36 m^2 radius around snowfinch nests was 2.7±1.0 (1–5, n = 29), which is significantly lower than that of randomly selected burrows (6.0±2.4, 1–9, n = 26; t = 8.1, df = 53, $P < 0.001$).

Both sexes were involved in the construction of their nest. The nests were bulky, made of grass stems and lined with animal hair, feathers and fibres in the inner cup (Plate 1). Nests weighed 208± 47 g (124–267 g, n = 6 nests), with a mean external diameter of 16± 1.5 cm (13.5–17.8 cm), mean internal diameter of 7±1 cm (5.75–8.3 cm) and mean cup depth of 7.4±2.3 cm (4.5–10 cm). Eggs were white without spots (Plate 1). Mean length and width of 35 eggs was 18.8±0.6 mm (17.9–19.9 mm) and 14.4±0.2 mm (14.2–14.7 mm), respectively. Clutch size averaged 5.8±0.4 eggs (5–6, n = 6), and fresh eggs weighed 2.38±0.15 g (n = 17).

SHAOBIN LI

Plate 1. Adult, nest, eggs and chicks of the Small Snowfinch. May and June 2011.

Parental investment

Incubation was by the female only. The mean incubation period was 11.7±0.8 days (11–13 days, n = 6). Nestlings were brooded by the female alone for 3–5 days after hatching. Both the parents fed the offspring. Observation of nine pairs for 715 minutes showed that the female feeding rate per hour was similar to that of males (5.6±2.9 vs. 5.2±3.4, paired-samples test: t = 0.39, df = 32, P = 0.7). All the food delivered to nestlings were insects, consisting of 43% Diptera, 39% Hymenoptera, 10% Coleoptera and 8% Lepidoptera (n=100 feeding trips to nine nests). Nestlings fledged and left the nest burrow at 19.9±1.1 days (19–22 days, n = 8). The logistic growth equation for body weight of 17 nestlings from five nests was calculated: weight = $16.28/(1+e^{0.88-0.24d})$. Fledglings weighed 15.8±1.7 g (n = 13), 75.6% of the adult average weight. Fledged juveniles were fed by their parents for more than a week (n = 5 nests).

Nestling mortality

Eight broods had an average size of 3.75±0.95 (3–5) before the fifth day after hatching. Less than three days before fledging, brood size declined to 2.88±0.69 (2–4; Wilcoxon test, z = 2.33, P = 0.02). These nests suffered nestling mortality as the bodies were left in the nesting burrows. We observed the dominant nestling (the biggest in body weight) often sitting near the burrow entrance, waiting for the parents to arrive with food (9/16 cases in five nests). During the early post-fledging period, the young remained in tunnels near the burrow entrance. When parents provisioned, the dominant nestling was often the first one rushing out to beg for food (16/31 cases).

Breeding success

Of 29 known-fate nesting attempts, 86% successfully fledged at least one young. Nesting failure was due to excavating activities of pikas (1), predation by Mountain Weasels *Mustela altaica pallas* (2) or unknowns reasons (1).

Social behaviour

Once a pair formed, the male spent most of his time following his mate. We observed seven copulation attempts by five pairs during the egg-laying period, all of which were initiated by the male. Males fed their mates during the egg-laying and incubating period. Males exhibited territoriality throughout the breeding season, evicting any conspecific invaders and even heterospecifics, such as Oriental Skylarks *Alauda gulgula* and Horned Larks *Eremophila alpestris*, that approached their nest entrance (< 3 m). Both the male and female roosted in nesting burrows; after fledging, the family no longer used the nesting burrow as a roosting site ($n = 9$).

Small groups (5–20 individuals) formed as post-fledging families amalgamated in autumn. During the winter, large groups (more than 100 individuals) foraged on the ground, especially in snowy conditions. These groups often roosted at night in cliff cavities or in abandoned huts.

Discussion

Despite using abandoned pika burrows as nest sites, Small Snowfinches, like Rufous-necked Snowfinches (Lu *et al.* 2009), preferred nesting in areas where pika densities were relatively low. This might reduce disturbance due to pikas' excavation activities, which can block the tunnels of snowfinch burrows (Lu *et al.* 2009, Zeng & Lu 2009a,b). In contrast, the White-rumped Snowfinch prefers active pika burrows (Lu *et al.* 2009). This may be because this species is larger—at 40 g, the biggest snowfinch—compared to its two congeners (20 g and 27 g respectively) and more aggressive towards pikas (Lu *et al.* 2009).

The Small Snowfinch laid an average clutch of 5.8 eggs, compared to the 4.7 eggs of the White-rumped Snowfinch (Zeng & Lu 2009b). Snowfinch clutches are larger than those of several sympatric open-nesting passerines, e.g. Oriental Skylark and Horned Lark (2.4–3.2 eggs) (Zeng & Lu 2009b). Both snowfinch species have similar incubation periods (11.7 and 12.7 days) and nestling periods (19.9 and 21.0 days). The former is near to but the latter much longer than local open-nesting species (incubation period 11–12 days, nestling period 9–12 days). Longer duration of nestling growth is characteristic of cavity nesters (Martin & Li 1992), and could improve individual immune function (Ricklefs 1992).

Brood reduction was common in this snowfinch population. It implies insufficient food supply for nestlings in association with low temperature and poor rainfall in the high-altitude region (Mock & Forbes 1994, Parker *et al.* 2002, Roff 2002). However, brood reduction rarely occurs in a sympatric cavity nester, Hume's Groundpecker *Pseudopodoces humilis* (Lu *et al.* 2011). The interspecific difference may be due to different food availability to the two species. Snowfinches feed their nestlings mainly on adult arthropods found in grass, whereas larvae in soil, which are large and nutrition-rich, account for a larger proportion of the diet of groundpecker nestlings. Alternatively the cooperative breeding behaviour of the latter may increase the amount of food delivered to the nestlings. Despite the brood reduction, nesting success of the snowfinches, measured as the percentage of nests from which at least one nestling fledged was 86%, higher than its two congeners (Rufous-necked Snowfinch 56%, White-rumped Snowfinch 67%) (Zeng & Lu 2009a,b), and much higher than most open-nesting species in the study area (< 30%) (Li & Lu 2012b). This could be because nests in cavities suffer from lower nest predation and enjoy better microclimate conditions (Martin & Li 1992).

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Shaobin LI, Weijun PENG, Cheng GUO & Xin LU, *Department of Zoology, College of Life Sciences, Wuhan University, Wuhan 430072, China. Email: luxinwh@gmail.com (corresponding author)*

Nest, eggs and nest sites of the Andaman Crake *Rallina canningi*

NATARAJAN EZHILARASI & LALITHA VIJAYAN

Introduction

The rallid genus *Rallina* comprises eight species of distinctively plumaged rails which inhabit forest understorey or marshland inside forest and are confined to Asia and Australasia (Taylor 1998). Many rallids are little known, and the nest, eggs and young of more than 20 species remain undescribed (Taylor 1998). The previously little-studied Andaman Crake *Rallina canningi* is endemic to the Andaman islands; it is a large (34 cm) chestnut-coloured crake with dense but indistinct black-and-white bars on the belly, greenish legs and a bright green bill, whitish at the tip; the sexes are alike.

The Andamans, lying in the Bay of Bengal, India, are a group of 325 oceanic islands (21 inhabited) covering 6,408 km^2 (Saldanha 1989). They experience both south-west and north-east monsoons, having an annual average rainfall of 3,200 mm, with a monthly mean of 86–450 mm (Kumar & Gangwar 1985). The Andaman Crake had been thought to be common on South Andaman in the nineteenth century, when it was reportedly hard to see but easy to catch in snares (BirdLife International 2001). It continued to be hard to find during survey visits in the twentieth century because of its shy skulking habits, and as a result was classified Data Deficient (BirdLife International 2001). Recent studies by the Sálim Ali Centre for Ornithology and Natural History (SACON) resulted in reclassification to Near Threatened (BirdLife International 2013). We carried out a study of the ecology of the Andaman Crake between February 2004 and March 2007 (Vijayan & Ezhilarasi 2007, Ezhilarasi 2009) and from this we present the first detailed descriptions of nests, eggs and nest sites of this little-known species, aspects of its ecology not before described (Ali & Ripley 1969, Taylor 1998, BirdLife International 2001).

Part of the study involved population status surveys in selected localities on the four main islands and 37 of the outlying islands, using direct observation and calls, but an accurate population estimate was not possible. Crakes were not found on islands less than 10 km^2 in area and encounter rates were lower on small islands than on Little, South, Middle and North Andaman. The species was found most frequently inside and at the edges of moist deciduous and semi-evergreen forest, less frequently in evergreen forest, seldom in mangrove forest and not at all in littoral forest, plantation and cultivated areas (Vijayan & Ezhilarasi 2007).

Most rails breed seasonally in or near the wet season in the tropics (Taylor 1998) and, in common with other Indian and Australasian rails, the Andaman Crake was reported to breed between June and August (Taylor 1998). Two areas were selected for intensive study, Chidiyatapu (about 40 ha) on South Andaman and Pathilevel (about 30 ha) on North Andaman; this report is focused on studies at Pathilevel.

Study area and methods

The village of Pathilevel (Chalis Ek caves) on North Andaman is about 20 km south of Diglipur. The study was carried out between June and September in 2005 and 2006. The predominant habitat was moist deciduous forest with a somewhat irregular upper storey of mainly deciduous trees about 40 m or more in height, with many woody climbers. The understorey contained numerous species, some evergreen, below which a luxurious evergreen undergrowth of shrubby *Licuala peltata* was present.

A general search for nests was made in the area and a 10 ha area of forest was delineated which was searched systematically and intensively for nests (Martin & Geupel 1993). Local villagers were recruited to help during the breeding season. When breeding was finished, the nests were described with reference to size, materials used, position and degree of concealment, this last based on scores given for nest-site visibility from 16 vantage points at 1, 3, 5 and 7 m away in each of the four cardinal directions, with low concealment scoring 13–16 points (0–25%), medium 9–12 points (25–50%), high 5–8 points (50–75%), and very high 0–4 points (75–100%) (Martin & Roper 1988, Martin *et al.* 1996).

Results

The Andaman Crake breeds during the south-west monsoon between June and September and in 2006 a total of 120 crake nests were located; of these 59 were found in June, 40 during July, 16 in August and 5 in September. Most nests were located within 200 m of the forest edge and close to water; both sexes took part in nest-building and incubation. Of the 120 nests recorded, 17 held eggs (clutch size 5–6) and eggs hatched in only seven of these nests with an overall hatching success of 22%. The young were found in August, September and October, towards the end of the monsoon.

During the 2005/2006 study period, eight pairs and 39 nests were found in the 10 ha Pathilevel study plot. Each pair thus presumably makes several nests and one is selected for laying, although we could not determine which pair made which nests. Nests may be abandoned before completion, but rarely after laying has commenced. Failure of nests was due to poor weather, human disturbance and predation by monitor lizards, snakes and Andaman Coucal *Centropus andamanensis*. Crake families use other nests for roosting after leaving the incubation nest.

Nest structure and position

The nest used for laying was typically platform-shaped with a shallow cup, made of dried leaves and twigs on top of the leaf-litter. These nests have two distinct layers, an outer stratum of loosely arranged leaves and an inner one consisting of a tight cup made up of flexible soft twigs, whereas roosting nests were made only of soft leaves. The position of the shallow cup varied: asymmetrical in ground nests and in the centre in others.

Nearly 96% of the nests were composed of leaves and twigs only, with 4% also adding bark. The nest materials comprised leaves of 17 species of plants and trees. In all, 60 nests were measured: mean outer diameter was 26.5 cm, inner diameter 15 cm and depth 4.7 cm. Nests were recorded in four types of site:

1. *Between tree-buttresses.* Most nests, 105 of 120, were located between the buttresses of huge trees (Figures 1 & 2). All these nests were very well concealed by undergrowth (shrubs and climbers) (Figure 1) and the folds of the buttresses (Figure 2); concealment levels ranged from 75–100%. All nests placed on the ground were raised on a cushion of decaying leaves and they were devoid of attachment materials. The back of the nest was supported as well as concealed by the main trunk, and both sides of the nest were supported by the buttresses. In a few cases some stones or shrubs between the buttresses supported the nest from below. The nests were also protected from rain as they were concealed in the hollow of the buttresses. In all 23 different species of trees were used with *Tetrameles nudiflora* (23%), *Pterocarpus dalbergioides* (23%), *Terminalia bialata* (13%) and *Pterygota alata* (11%) predominating.
2. *On top of dead tree-stumps.* Four nests were placed on 1–1.5 m high dead tree-stumps, partly hidden by undergrowth or a nearby tree (Figure 3), but concealment levels were only medium (25–50%). Nests were placed in shallow depressions in the top of the stumps.

Figure 1. Nest placed between buttresses of a tree on ground.

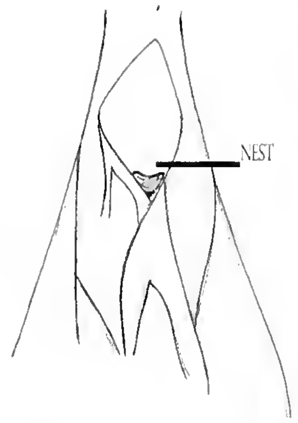

Figure 2. Nest placed between buttresses of a tree above the ground.

Figure 3. Nest placed on the top of a dead tree stump.

Figure 4. Nest placed on the top of a termite mound.

Figure 5. Nest placed on the branches of a tree.

3. *On top of termite mounds.* Seven nests were found on the top of termite mounds, four of the latter being located between buttresses and three free-standing (Figure 4), and were part-hidden by surrounding vegetation (concealment levels 25–75%). The height of the mound varied from 1 m to 5 m.
4. *Among vegetation branches.* Four of the 120 nests were found on the branches of a tree or bush, being supported from below by contact with two or more branches (Figure 5). In such a site, a nest may be secured simply by its weight, which lodges it in a tangle of branches, or by attachment materials to prevent it from being dislodged. One nest was in the centre of a huge *Licuala peltata* supported by nearby *Licuala* shrubs and branches of the nearby tree. The height of the nests ranged from 1–3 m, and the concealment levels were 0–75%.

After hatching, the family moved to one or a series of 'roost nests', where the birds stayed until the chicks became independent. These nests were similar to incubation nests but were usually more lightly constructed using only leaves.

Egg and clutch size

The eggs are glossy white in colour, ovoid and without spots (similar to those of domestic hens, but smaller). As incubation progressed, the eggs turned creamy-yellow and hatched synchronously within about two hours in the morning. Eighteen eggs from abandoned nests were measured: the mean weight, length and width were 24±3 g, 4.2 ±0.2 cm and 2.2±0.2 cm respectively. These measurements differ somewhat from earlier studies (Taylor 1998).

We observed 15 nests with completed clutches; clutch size ranged from 4–8, mean 5.7±1.7. Three nests held four eggs, eight nests held five eggs, three nests six eggs and one nest eight eggs. One clutch of one egg and one of three eggs were predated or abandoned and hence not considered as completed. Unhatched eggs were removed from nests by parents.

Chicks

Andaman Crake chicks are precocial and leave the nest within a day of hatching. We found that chicks then spent 30–32 days roaming the forest floor with their parents and returned to a nursery nest with them to roost, when the female joined the chicks in the chosen nest and the male roosted in a nearby tree. The female parent (colour-ringed) attended and looked after the chicks while the male frequently brought them food; chicks were generally fed bill-to-bill by both parents for several days or weeks. After about a month, parents chased the juveniles away and although a few individuals were marked, no information on their subsequent dispersal was obtained because they were very difficult to observe inside the forest and were rarely seen.

Measurements of a few chicks, young and adults were obtained (Table 1). Chicks from two nests were ringed: three chicks from one nest on the fifth day after hatching and three from a second nest on the eighth day; one of these was recaptured on the tenth day and remeasured.

Table 1. Mean measurements of the chicks of the Andaman Crake at different stages.

	Chicks				
Measurement	5th day (n=3)	8th day (n=3)	10th day (n=1)	Juvenile (n=3)	Adult (n=11)
Wing (mm)	12.3	12.6	12.8	143±30	158±4
Tail (mm)	–	–	–	75±27	79±16
Culmen (mm)	17	17±1	20	30±6	33±3
Tarsus (mm)	31±4	32±2	39	59±5	76±2
Weight (g)	49±4	52±2	53	195±42	253±43

Discussion

The breeding season of the Andaman Crake directly correlated with rainfall and relative humidity, and had a negative correlation with temperature. Nests were made from leaves, twigs and bark, the same materials as used by Red-necked Crake *Rallina tricolor* and Slaty-legged Crake *R. eurizonoides* (Taylor 1998). According to Ali & Ripley (1969) and Taylor (1998), the nest of the Andaman Crake is a collection of grass and leaves, placed at the foot of a forest tree or under tangled forest undergrowth. In our study, nests were found to be made of leaves, twigs and bark; no grass was used. The size (corner width) of the buttresses might have influenced the amount of nest material used as well as the size of the nest. Although the dead leaves of 17 plant species were recorded in the nests, no species consistently dominated, which suggests that birds used any available leaf materials at the site.

Most of the nests were found on the ground between buttresses, possibly for maximum concealment— since the nest is hidden on three sides by the buttresses and protection from rain, wind and direct sunlight.

Of the other *Rallina* species, Red-necked Crake has been found to nest between buttresses, while Slaty-legged Crake nests have been reported on tree-stumps (Taylor 1998), but the Chestnut Forest-rail *R. rubra* and White-striped Forest-rail *R. leucospila* of New Guinea build dome-shaped nests (Taylor 1998).

The egg colour and the clutch size of the Andaman Crake are similar to several other *Rallina* species—Forbes's Forest-rail *R. forbesi* lays 4–5 glossy white eggs, Red-necked Crake 3–7 white eggs, Red-legged Crake *R. fasciata* 3–6 chalky-white eggs and Slaty-legged Crake 4–8 creamy-white eggs (Taylor 1998).

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***Natarajan EZHILARASI**, Sálim Ali Centre for Ornithology and Natural History, Anaikatty, Coimbatore, Tamil Nadu, India. Email: ezhilarasinatarajan@gmail.com*

***Lalitha VIJAYAN**, Sálim Ali Centre for Ornithology and Natural History, Anaikatty, Coimbatore, Tamil Nadu, India.*

A newly described call and mechanical noise produced by the Black-and-crimson Pitta *Pitta ussheri*

TERESA M. PEGAN, JACK P. HRUSKA & JUSTIN M. HITE

Introduction

The Black-and-crimson Pitta *Pitta ussheri* is endemic to Sabah, Malaysia. It inhabits lowland rainforests from sea level to 300 m and is often found in dense undergrowth (Erritzoe 2003). It is tolerant of disturbance and can sometimes be found in selectively logged areas and overgrown plantations (Lambert & Woodcock 1996). Nonetheless, the species is classified as Near Threatened because of high rates of lowland deforestation and habitat loss (BirdLife International 2012).

The primary call of the Black-and-crimson Pitta has been well documented. Lambert & Woodcock (1996) describe it as 'a prolonged, relatively quiet whistle that gradually rises in power and pitch and then suddenly stops'.

Two previously undescribed sounds produced by the Black-and-crimson Pitta are documented here: a presumed mechanical noise (sonation) and a call similar to one produced by the Blue-headed Pitta *Pitta baudii* and hereafter referred to as the '*baudii*-like call'.

The observations were made between 27 June and 27 July 2012 at Tawau Hills Park, Sabah. The pittas occupied two different low (about 250 m) swampy areas of primary dipterocarp rainforest, each within 1 km of the park headquarters (4.399°N 117.889°E). How many pittas were in these areas was not determined.

Novel sounds

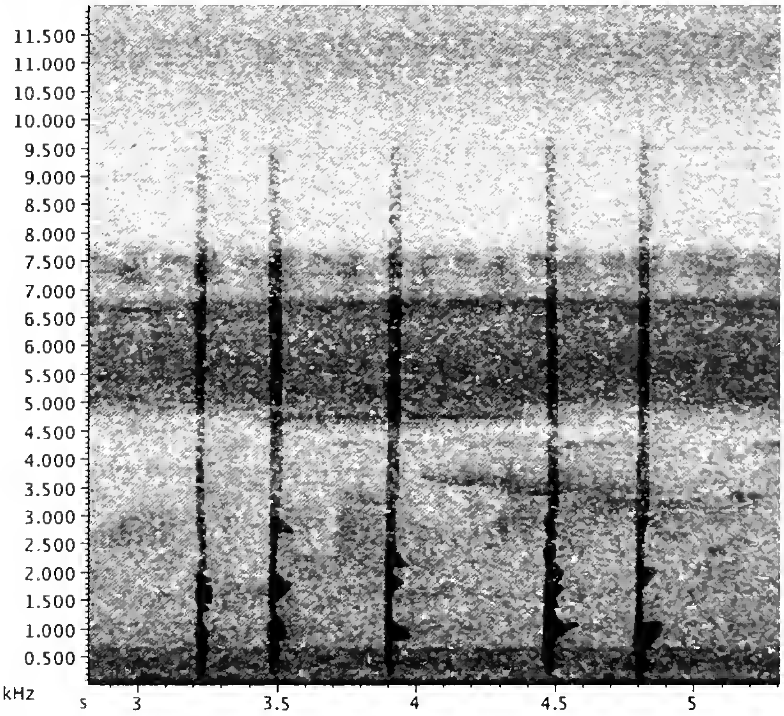
Sonation

A recording of this sound can be found at http://macaulaylibrary.org/audio/169900, whilst video recordings of the bird perched and calling, then flying away and producing the sound off-camera, can be seen at http://macaulaylibrary.org/video/471600 and http://macaulaylibrary.org/video/471609. This sonation sounds like a series of soft claps or pops.

In the recording, the mean frequency range of each of the five claps was 85 Hz to 9.7 kHz, and the duration of each clap was 0.1 second or less. Hereafter the noise is referred to as a non-vocal sonation, although this has not been confirmed conclusively.

The species was first seen making this sonation on 27 June 2012, when JMH encountered a Black-and-crimson Pitta after playing back this species's song. When the bird was found it was perched about 4 m up in a tree, where it sang at regular intervals. After about 10 minutes, JMH moved closer and the bird became slightly agitated but continued to call. It then flew to the ground and produced the sonation as it flew from tree to ground. It was unclear whether the presence of the observer had any effect on the behaviour of the bird.

Figure 1. The sonation. Each dark vertical bar represents one sonation. The horizontal band between 4.5 and 8 kHz is the result of background insect noise. This spectrogram was produced by Raven software using the same recording linked below. Recording by Justin Hite. Because of the quality of the recording, the sonations have been artificially highlighted with Photoshop for clarity.



Spectrogram parameters:
Type: Hann
Window size: 2762 samples
Overlap: 70%
Hop size: 829 samples
DFT: 8192 samples

The sonation was documented (i.e. recorded or described in written field notes) six times between 27 June and 27 July 2012, it was also observed regularly without being documented. Five of the six documented observations occurred in one general area, but birds in a different area were also observed to produce the sound. In every case, the sound was made as the bird left a perch from which it had been calling continuously for some time. In three observations, the bird left the perch, made the sonation as it flew, and then landed on a different tree where it resumed calling; in the other three observations the bird made the sonation as it flew to the ground. Pittas were also regularly observed flying from perch to perch and from perch to ground without producing the sound. The pulse interval of the sound was consistent with the rate of flapping observed when pittas were seen in flight.

Baudii-like call

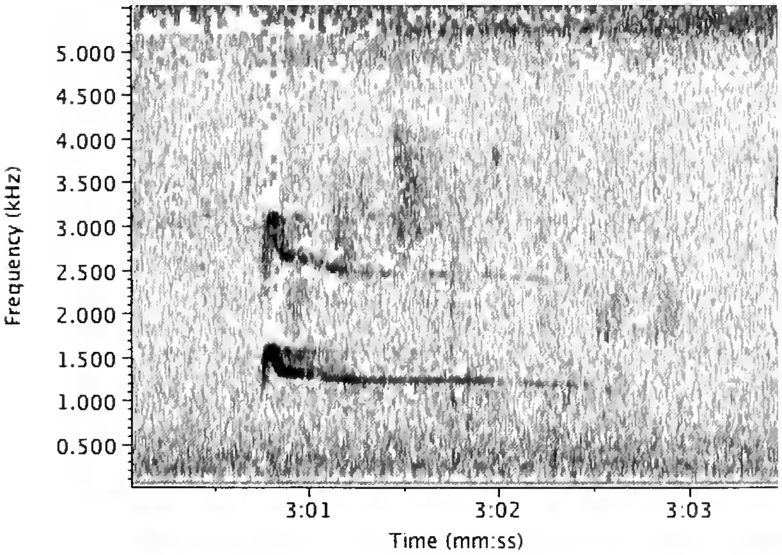
A recording of this call can be found at http://macaulaylibrary.org/audio/171509. This Black-and-crimson Pitta call is similar to the female alarm call of the Blue-headed Pitta, described as *hwee-oo* (Lambert & Woodcock 1996, Erritzoe 2003), as demonstrated in Figures 2 & 3. The Black-and-crimson Pitta call tends to be longer in duration than that of the Blue-headed Pitta; the average duration of 32 Black-and-crimson Pitta calls in the recording (calls made by one individual) was 1.7 seconds, compared to an average of 0.8 seconds for 36 Blue-headed Pitta calls measured (seven individuals).

The fundamental frequency of the Black-and-crimson Pitta call ranges from about 1.1 kHz to 1.7 kHz, and the average fundamental frequency of the Blue-headed Pitta call ranges from about 0.98 kHz to 1.6 kHz.

This call was heard on only two occasions, both times by JMH. On 9 July 2012 at around 16h00 he heard a Black-and-crimson Pitta calling and began playback. The pitta responded with the undescribed call and he was able to get close enough to record the call on his iPhone about 10 minutes later. The bird gave the call frequently and regularly, calling 42 times (at a rate of about once every 8 seconds) during the seven-minute recording. Another Black-and-crimson Pitta was calling nearby and later a second pitta was flushed.

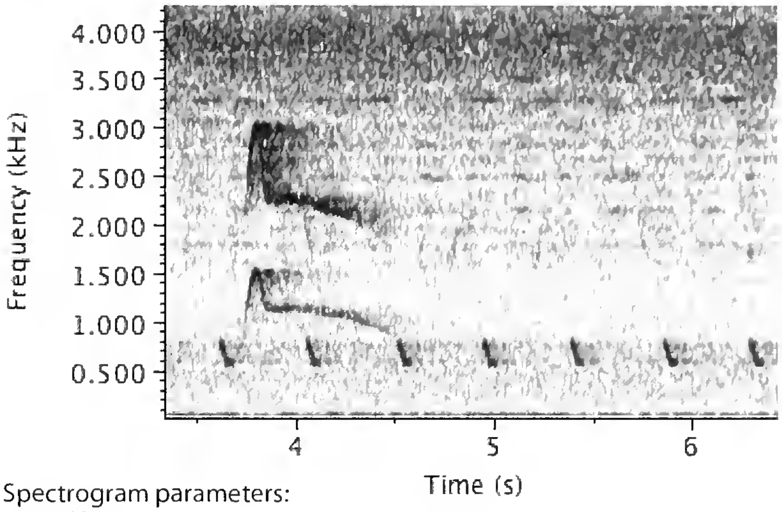
On the second occasion in the same area at about 16h00 on 15 July 2012, two Black-and-crimson Pittas were heard calling from different directions. The two birds approached each other over the next 15 minutes until they were about 10 m apart. Then one flew toward the other, making the sonation described above 2–3 times. The pittas were not visible at this point but soft, low warblings were heard from their estimated location. One bird flushed as the observer moved closer and the other bird gave the novel call three times and then hopped away. Both birds were seen briefly and appeared to be adult Black-and-crimson Pittas.

Figure 2. *Pitta ussheri* call. The spectrogram was produced by Raven software using the same recording linked above. Recording by Justin Hite.



Spectrogram parameters:
Type: Hann
Window size: 1000 samples
Overlap: 90%
Hop size: 100 samples
DFT: 1024 samples

Figure 3. *Pitta baudii* call. This spectrogram, was produced by Raven software using ML Audio 164150 (http://macaulaylibrary.org/audio/164150). The signals occurring between 0.5 and 1 kHz are background noise. Recording by Martjan Lammertink.



Spectrogram parameters:
Type: Hann
Window size: 1466 samples
Overlap: 90%
Hope size: 147 samples
DFT: 2048 samples

Discussion

Sonation

A sonation is a 'nonvocal acoustic signal' and evidence suggests that sonations are made by a wide variety of birds and may be more common than previously realised (Bostwick 2006). There is little literature on sonations in Old World suboscines, although mechanical noises have been described in many of the African suboscines, including members of Calyptomenidae and Philepittidae (Lambert & Woodcock 1996). Chapin (1953) noted that both the African Pitta *Pitta angolensis* and the Green-breasted Pitta *P. reichenowi* give a mechanical *prrrt* during short upward flights, which he believed to be produced by the wings.

In this case, the presumed sonation was always made when birds were flying quickly through dense vegetation, and direct visual observation was impossible. However, every time the sound was made the bird was in mid-flight, leading to the hypothesis that the noise is a nonvocal sound produced by movements of the bird's wings. Although we did not obtain definitive evidence that the clapping sound made by the bird is a sonation, it seems reasonable to assume that the sound is produced nonvocally, given the behavioural context and that the pulse interval of the sounds produced are consistent with passerine wing noise. We are unaware of any specialised morphology pertaining to the Black-and-crimson Pitta for this sort of sound production. It may be produced by a whole-wing movement, perhaps similar to that used by Rock Doves *Columba livia* when producing alarm sonations (Daanje 1950).

This sound is not produced every time the bird flies, which suggests that it is voluntary, meaning that it could be a signal although its meaning is unknown. Although the sonation was first heard when the bird was possibly alarmed, Black-and-crimson Pittas were flushed on many occasions without the sonation being heard. Most sonations occurred after the bird had been under observation for 10 or more minutes, suggesting that the noise is not related to the bird being alarmed by human presence. Because it was made consistently at times when the bird was calling from a perch, it may be related to breeding/ territorial behaviour.

Call

On the two occasions the *baudii*-like calls were heard more than one Black-and-crimson Pitta was present, suggesting some conspecific interaction e.g. a territorial border dispute.

Whether male pittas alone or both males and females call apparently has not been documented. If both sexes call, then the two birds approaching in the second observation could have been a pair, and the call could be related to courtship or pair bonding. Also, because of the time of year, the earlier incident on 9 July 2012 could have been related to interaction between a parent and a nearly fully-grown juvenile.

Acknowledgements

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***Teresa M. PEGAN, Jack P. HRUSKA** and **Justin M. HITE**, Cornell Expeditions in Field Ornithology, Cornell Universtity Museum of Vertebrates and Labratory of Ornithology, 159 Sapsucker Woods Road, Ithaca NY 14850 USA. Emails: tmp49@cornell.edu, jph239@cornell.edu, justinhite@gmail.com Website: http://cefo.cornell.edu*

White-shouldered Ibis *Pseudibis davisoni* population size and the impending threat of habitat conversion

HUGH L. WRIGHT, SOK KO, NET NORIN & SUM PHEARUN

Introduction

Cambodia boasts a rich diversity of large-bodied waterbirds and harbours globally significant populations of several threatened ibises and storks, and a crane (Critical Ecosystem Partnership Fund 2012). While the future of these species remains perilous, recent research has advanced understanding of their ecology and enhanced conservation responses (Keo 2008, van Zalinge *et al.* 2011, Wright 2012, Clements 2013). Greater search effort, collaborative and nationwide monitoring (White-shouldered Ibis Conservation Group 2012, Wright *et al.* 2012b) and species-specific research (Wright 2012) have improved knowledge of the White-shouldered Ibis *Pseudibis davisoni*.

This species was once widespread in South-East Asia but, following a decline in the twentieth century, is now confined to Cambodia and tiny areas of southern Laos and east Kalimantan, Indonesia (BirdLife International 2013). In 2000 the species was classified as Critically Endangered (BirdLife International 2001), with an estimated global population of fewer than 250 mature individuals. Since 2009 birds have been counted at wet-season roosts in Cambodia and in 2010 these revealed a minimum national population of 523 individuals (Wright *et al.* 2012b).

Conversion of habitat to agriculture is one of the greatest threats to the species (White-shouldered Ibis Conservation Group 2012) and to much of Cambodia's globally important forests and grasslands (Critical Ecosystem Partnership Fund 2012). Government land in Cambodia is classified into state public (land for public interest or use) and state private (not for the public and available for private purchase) property. The leasing of both types for economic development through various legal concession mechanisms, particularly as Economic Land Concessions (ELCs), is now the major driver of agricultural expansion in Cambodia (Poffenberger 2009). ELCs are leased to private companies for up to 99 years, and habitats are converted to the industrial-scale cultivation of commodity or energy crops, such as rubber, cassava, sugarcane and jatropha (Sukkasi *et al.* 2010, Open Development Cambodia 2013a). While many concessions have not yet commenced cropping, publicly available data (Open Development Cambodia 2013b) suggest that more than 2 million ha of ELCs have already been granted. Despite their scale, very few studies have quantified the potential impact of ELCs on threatened species.

This paper reports the latest White-shouldered Ibis censuses in 2011 and 2012, combining roost counts with supplementary data to revise estimates of the Cambodian and global populations. Comparison of the distribution of ELCs and roosting White-shouldered Ibis starkly highlights the imminent threat that the concessions pose to the species.

Methods

The White-shouldered Ibis is a solitary breeder in the dry season (November–April) but gregarious in the wet season (May–October), gathering to roost in tall dipterocarp trees in dry deciduous forest or on river-channel islands (Wright *et al.* 2012a). The species often shows roost fidelity, using many communal roosts repeatedly in both seasons and from year to year. To improve population estimates, White-shouldered Ibis were counted simultaneously at known roosting sites in the 2011 and 2012 wet seasons. Counts were made in five study areas: Kulen Promtep Wildlife Sanctuary, Lomphat Wildlife Sanctuary, Mekong Flooded Forest, Mondulkiri Protected Forest and Western Siem Pang Important Bird Area (Figure 1). Counts have been made here since 2009 (Wright *et al.* 2012b), with the exception of Mondulkiri where counting began in 2012.

Roost sites were located by local people and occasional active searching by field staff. Without doubt some roosts are still to be discovered: few sites were known before 2009, and the study area was large—more than 13,300 km^2. Total counts therefore provide minimum estimates of population size. The number of roosts surveyed in each study area (Table 1) probably varied due to both the differing capacities of local organisations and the size of the White-shouldered Ibis population in the area. However, knowledge of roost site locations improved with time so that the 32 sites surveyed in 2009 had risen to 68 in 2012. To improve accuracy,

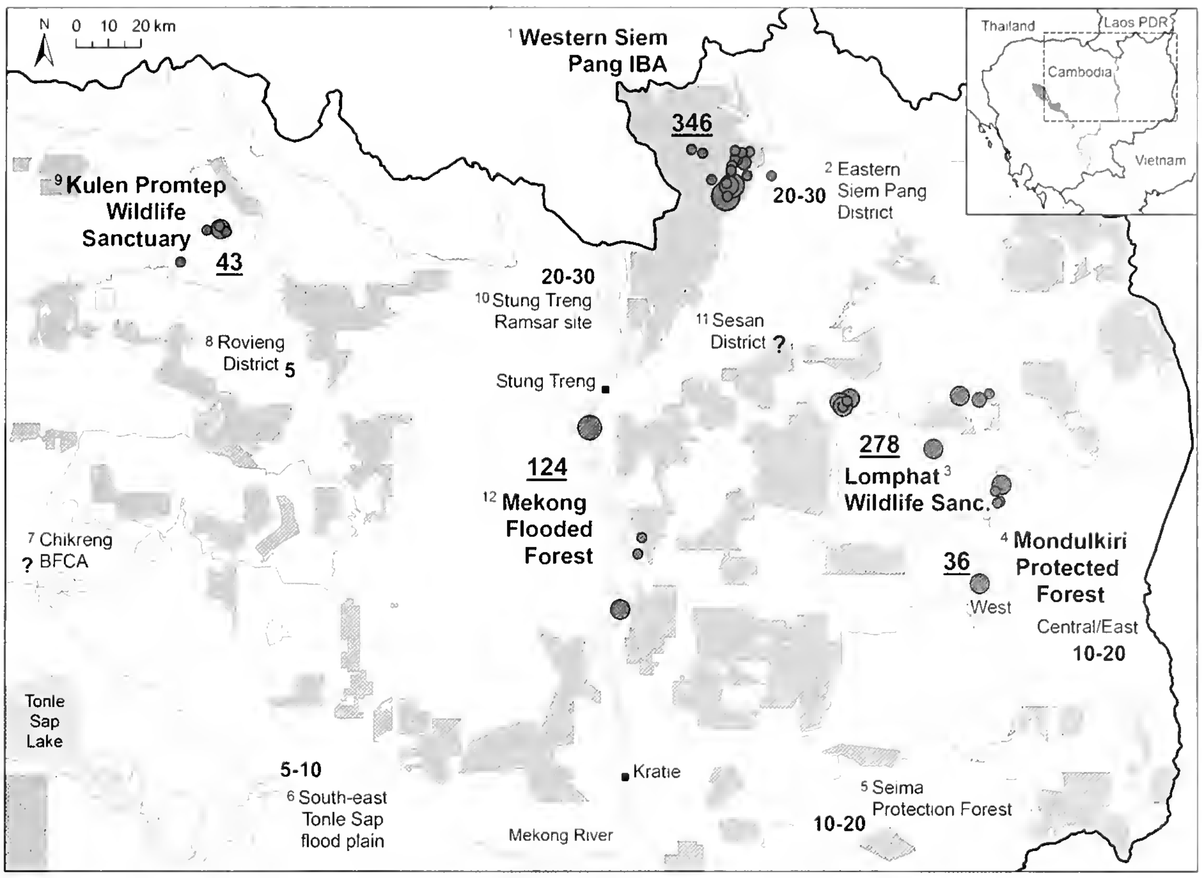

Figure 1. The distribution of Economic Land Concessions (mid-grey areas) in north and east Cambodia and White-shouldered Ibis roost sites (dark grey circles) surveyed in September 2012. Roost circle size (smallest to largest) denotes counts of 1–10, 10–25, 25–50, 50–75 and 75–150 birds. Protected areas are shown by mid-grey outlines. Bold numbers give population sizes; underlined numbers are the highest from roost counts between 2009 and 2012 and other numbers are estimates from supplementary sources. Numbers add up to the estimated Cambodian population. '?' denote locations where single sightings (of <3 birds) have occurred since 2009. The data sources are: [1,9] September 2012 roost count; [2] HLW unpubl. data; [3] August 2012 roost count; [4] west: September 2012 roost count, central/east: T. Gray (*in litt.* 2011); [5] Bird *et al.* (2007); [6,8] Wildlife Conservation Society unpubl. data; [7] Goes (2012); [10] Timmins (2006); [11] Evans & Goes (2010); [12] October 2010 roost count (Wright *et al.* 2012b).

roosts were surveyed both in the evening and on the following morning; the larger count at each site was used to calculate the total for the study area on each survey date.

Cambodian and global populations were estimated following Wright *et al.* (2012b): maximum roost counts in each study area from 2009 to 2012 were combined with documented evidence and expert assessment of numbers in other populations, including Laos and Kalimantan, where the species was not accurately counted. Maximum counts in study areas occurred on different dates, so population estimates assume that the five populations are mutually isolated. There is currently no evidence that White-shouldered Ibis travel the tens of kilometres between study areas and Pearson's correlations of all count occasions (excluding Mondulkiri with a low sample size) showed that the number of birds in a given study area was not related to the numbers in any other study area ($P > 0.34$).

To assess the level of threat posed by ELCs to the White-shouldered Ibis population, publicly available GIS datasets (Open Development Cambodia 2013b) were used to determine which roosts were located inside concessions, or within 5 km of concession boundaries, and how many birds were at these roosts during the highest overall count in September 2012. This assessment assumes that birds roosting inside concessions are likely to be severely affected by habitat loss and perhaps face increased disturbance and exploitation. Birds roosting close to concessions will probably be susceptible to loss of foraging habitat, because they may commute more than 5 km from roosts to foraging sites (HLW unpubl. data).

Results

The largest count of White-shouldered Ibis was 754 birds in September 2012 (Table 1). Total counts varied during 2011 and 2012 because (a) poor weather conditions made some roosts inaccessible, (b) some birds used unknown roosts and/or (c) at the time of October counts birds may have already started dispersing for the breeding season. Combining maximum counts in each study area with estimates for minor White-shouldered Ibis populations (Figure 1) suggests that Cambodia holds a population of between 897 and 942 birds. Using this estimate and those of 30 to 100 birds in Kalimantan and 10 to 20 birds in southern Laos (Wright *et al.* 2012b), 937 to 1,062 birds may remain globally.

Twenty-nine (37%) of the 79 roost sites surveyed in 2011 and 2012 were inside designated ELCs, with 27 of them in Western Siem Pang. Of the 754 birds found in September 2012, 40.8% were at roosts inside ELCs (Figure 1) and a further 15.9% were within 5 km of concession boundaries. Western Siem Pang contributed 99.4% of the birds inside ELCs and 72.3% of those within 5 km of ELCs. A total of 609 birds counted (80.8%) roosted outside protected areas, although 185 (30.4%) of them were at roosts close to the protected area boundary at Lomphat.

Discussion

Counts in September 2012 indicated that Cambodia's minimum known White-shouldered Ibis population was 754 birds, surpassing the previous highest count in October 2010 by 231 birds (Wright *et al.* 2012b). Previous estimates of Cambodian and global population sizes thus need upward revision. While the rise in numbers recorded is probably due to improved knowledge of roost sites rather than a population increase, the record count provides added hope that this species can be safeguarded in the future. Further birds may be found both in known populations (e.g. Mondulkiri, where roost searches have only recently started) and at new sites, such as under-surveyed areas of Stung Treng and Ratanakiri provinces. Nevertheless, additional birds in the five study areas will perhaps be in their tens not hundreds, as the year-to-year increase of maximum numbers at roosts has decelerated (69% more birds were found in 2010 than in 2009, compared with 17% more in 2012 than 2011).

Many White-shouldered Ibis roosted inside or within 5 km of ELCs in the wet (non-breeding) season, suggesting that much of the population is now threatened by habitat loss, increased disturbance and perhaps also exploitation associated with concessions (such as hunting by plantation workers). Most of these birds were found in Western Siem Pang, where concessions now endanger 33–37% of the estimated global population.

The location of roost sites inside or close to ELCs does not necessarily suggest that the species faces extirpation, because roosts occupy only a tiny part of each bird's home range and may

Table 1. Number of White-shouldered Ibis seen during simultaneous counts at roosts in north and east Cambodia, 2011–2012. Underlined numbers indicate when 2011–2012 counts were the highest for the site (or for all sites combined) since roost counts started in 2009 (the highest count for the Mekong was 124 in October 2010). The number of roost sites surveyed is shown in brackets.

Date	Western Siem Pang Important Bird Area	Lomphat Wildlife Sanctuary	Mekong Flooded Forest	Kulen Promtep Wildlife Sanctuary	Mondulkiri Protected Forest	Total
8–9 Aug 2011	230 (9)	186 (13)	82 (8)	37 (6)		535
8–9 Sep 2011	262 (7)	242 (12)	103 (8)	37 (6)		644
8–9 Oct 2011	208 (7)	223 (12)	121 (8)	39 (6)		591
17–18 Jul 2012	346 (19)	206 (10)	87 (4)	32 (5)	12 (3)	683
20–21 Aug 2012	338 (21)	278 (12)	47 (3)	35 (6)	4 (2)	702
17–18 Sep 2012	321 (22)	251 (11)	103 (4)	43 (6)	36 (1)	754
25–26 Oct 2012	260 (27)	243 (11)	57 (7)	42 (7)	13 (1)	615
Mean no.of roost sites (± SD)	16.00 ± 8.2	11.57 ± 1.0	6.00 ± 2.2	6.00 ± 0.6	1.75 ± 1.2	

not relate closely to the species's breeding season distribution, when pairs disperse widely. Nonetheless, ELCs are extensive in Western Siem Pang (Figure 1) and sightings and locations of known nest sites (Wright *et al.* 2012a, HLW unpubl. data) suggest that a significant number of birds are also inside the ELCs during the breeding season. Furthermore, the species's dependence on large dry forest landscapes (Wright 2012) and the scale of projected habitat loss across north and east Cambodia in the next 10–20 years suggest that the Western Siem Pang population will not be able to relocate to patches of habitat remaining elsewhere. Birds at other sites may be similarly affected if the spread of ELCs continues unabated.

This study probably underestimates the number of White-shouldered Ibis currently threatened by concessions. Publicly available data do not yet identify all ELCs, and roost counts provide only one measure of threat. In and around Lomphat, for example, many roost sites are outside and beyond 5 km from ELCs, but birds have still been found foraging inside concession areas (SP unpubl. data). Forest clearance has already begun in ELCs in Lomphat (BirdLife International 2012) and continued roost counting will help to monitor the effects of this. Mining concessions, hydropower dams and local-scale agricultural development are also expected to affect key parts of the species's Cambodian range (Bezuijen *et al.* 2008, BirdLife International 2010, Critical Ecosystem Partnership Fund 2012). The White-shouldered Ibis is therefore likely to remain severely threatened for the foreseeable future.

The threats posed to the species are indicative of the conflict between biodiversity needs and national policies for rapid economic development in Cambodia and much of the developing world (Millenium Ecosystem Assessment 2005). Mitigating habitat loss and restricting its effects to areas of lowest conservation value are now major challenges for conservationists (Margules & Pressey 2000, Sodhi *et al.* 2007). Efforts to maintain the integrity of existing protected areas, as well as to safeguard essential sites outside the protected area network (where most birds currently occur), will be vital. Opening dialogue and negotiating with the agro-industry over the use of concession lands is rarely attempted, but could be useful, especially where other approaches fail.

Acknowledgements

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Hugh L. WRIGHT, *School of Environmental Sciences, University of East Anglia, Norwich Research Park, Norwich, NR4 7TJ, United Kingdom. Email: hughlewiswright@gmail.com*

SOK Ko, *WWF-Cambodia, #21, Street 322, Sangkat Beoung Keng Kang I, Khan Chamcar Morn, Phnom Penh, Cambodia. Email: ko.sok@wwfgreatermekong.org*

NET Norin, *BirdLife International Cambodia Programme, #9, Street 29, Tonle Basac, Chamkarmon, Phnom Penh, Cambodia. Email: netnorint@yahoo.com*

SUM Phearun, *BirdLife International Cambodia Programme and People Resources and Conservation Foundation, #9, Street 29, Tonle Basac, Chamkarmon, Phnom Penh, Cambodia. Email: phearun.sum@birdlife.org*

Errata

Choki, T., Tshering, J., Norbu, T., Stenkewitz, U. & Kamler, J. F. (2011) Predation by leopards of Black-necked Cranes *Grus nigricollis* in Bhutan. *Forktail* 27: 117–119.

The paper stated that at least two different leopards had preyed on Black-necked Cranes during the study, based on spot patterns in two different photographs taken by a camera trap (Plates 1 & 2). A re-examination of the photographs has lead to the conclusion that the two images are of the same leopard. This does not affect the conclusions and recommendations in the paper. The authors thank Guntram G. Meier for pointing out that the photographs are of the same leopard.

Mahood, S. P. & Eaton, J. A. (2012) The vocalisations of Red-collared Woodpecker *Picus rabieri*. *Forktail* 28: 167–169.

Figures 1–4 accompanying the paper are incorrect. The correct versions are reproduced below. In each case, the first section is the waveform, the second is the sonagram and the third is the spectrum.

Figure 1. The *keck* call of Red-collared Woodpecker (JAE, March 2012, Phong Nha Ke Bang National Park, Vietnam).

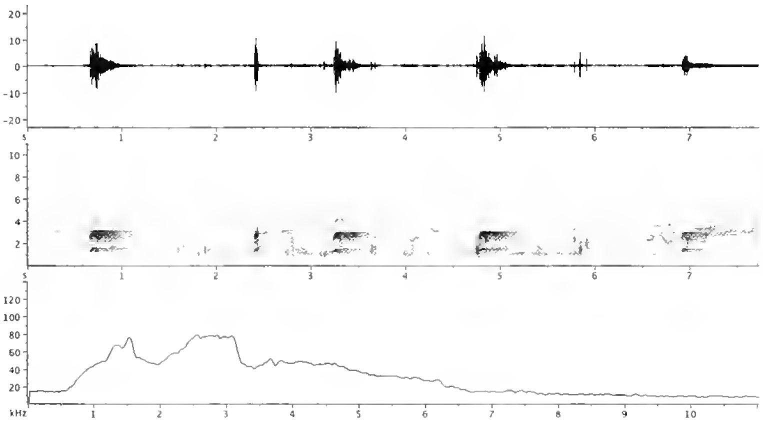


Figure 2. The 'Blue-naped Pitta' vocalisation of Red-collared Woodpecker (JAE, January 2011, Ban Nahin, Lao PDR).

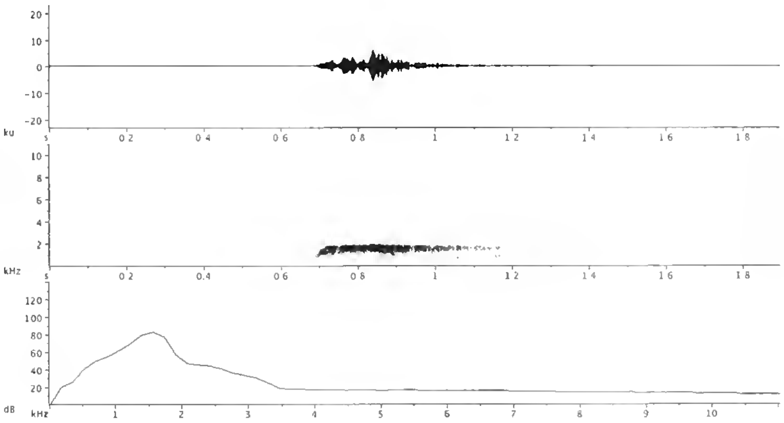


Figure 3. The territorial vocalisation of Blue-naped Pitta (JAE, March 2007, Tam Dao National Park, Vietnam).

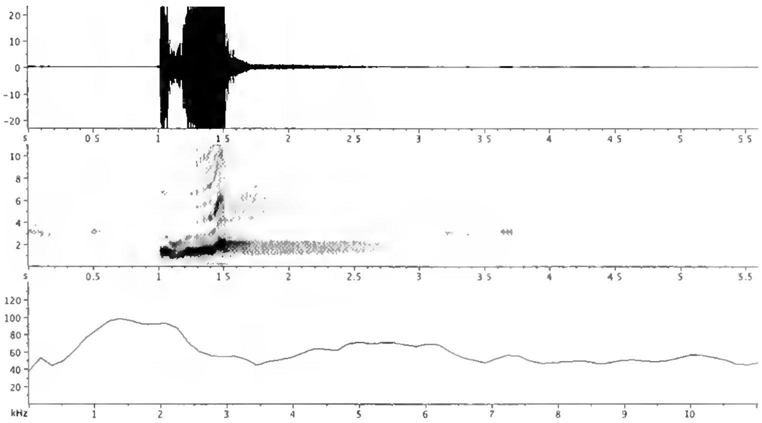
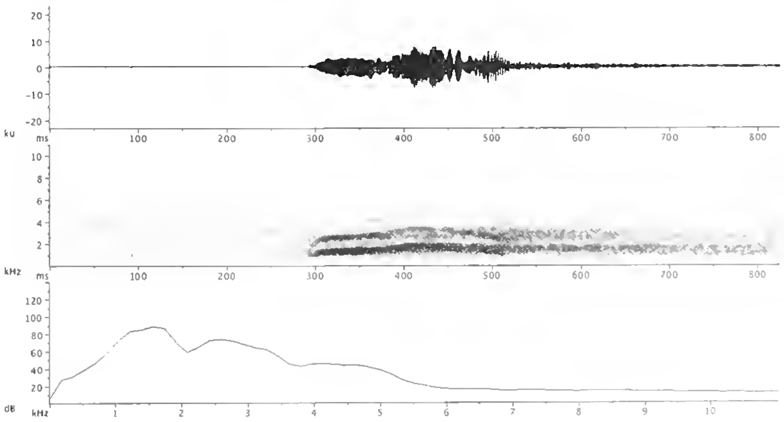


Figure 4. The 'Blue-rumped Pitta' vocalisation of Red-collared Woodpecker (JAE, March 2012, Phong Nha Ke Bang National Park, Vietnam).



Editorial notes

The notes written by Nigel Collar last year in *Forktail* 28 ring true today. The competition for space has again been intense in 2013 and OBC Council was asked for an addition to the budget in order to pay for extra pages, which they were able to agree to. But his remarks about the other costs that the journal incurs on the time of all those who play a part in its production are particularly relevant. Nigel sadly decided that after producing the exceptionally large 2012 issue he could not carry the load any longer, and the time to find ways of further redistributing the burden of editorship had arrived. He had during his 'second term' as senior editor tried hard to find a successor to take over the bulk of the burden but without success. Indeed, until one has had experience of the size and complexities of the load it is hard to comprehend, and it is all too easy to underestimate the time and dedication required. OBC owes a huge debt to Nigel, who has wrestled with the task twice, and to all the other senior editors across the years.

Events leading up to Nigel's standing aside had indicted that the existing *modus operandi* was under severe strain and changes were needed and had to be explored quickly 'on the run' whilst producing the 2013 issue. In fact, that it is late appearing is only partly due to the learning process, but does mean that steps that had been put in hand already to bring forward the deadline were absolutely right and essential. Indeed they may not yet have gone far enough. However for now the deadline for receipt of material for publication will continue to be **14 February**, although we will try to be as flexible as possible.

The objectives of OBC in seeking to publish *Forktail* have been reviewed, and basically we see no reason to move away from the central theme of being a 'middle of the road' independent scientific journal publishing papers on a broad spectrum of topics, with the material being available as hard copy and then 24 months after publication being available for online download completely free of charge. A new departure in 2013 has been the online publication of a major article well ahead of the print copy—another learning curve, and we must thank Stu Butchart for fathering this new venture. The 'Guidelines for contributors' have been revised and it is intended to put a more comprehensive version on the OBC website as soon as possible.

Some changes in personnel and the structure of the team have taken place and are ongoing. Jez Bird and Jack Tordoff have stood down but we are pleased to welcome new members. Nigel Collar has bounced back in the new role of Consulting Editor. Vicki Harley has already started work as Copy Editor. The team of Associate Editors has been strengthened and renamed the Editorial Committee and we are pleased to welcome Peter Kennerley and Gopi Sundar. We hope to have several more editors onboard over the next few months.

Thanks go to Dave Buckingham, Stuart Butchart, Nigel Collar, Will Duckworth, Eben Goodale, Vicki Harley, Peter Kennerley, John Pilgrim, Gopi Sundar and Margaret Sykes for all their help, advice and support. Too many people to mention have helped with refereeing and given a whole raft of advice freely and unstintingly. Finally thanks go to Peter Creed for his patience as well as for the stylish appearance of the end product.

B. R. Sykes
Acting General Editor

Guidelines for contributors

Forktail publishes original papers in the English language covering any aspect of the ornithology (e.g. distribution, biology, conservation, identification) of the Oriental region and nearby areas when appropriate; refer to the map of the region on the OBC website or on the inside back cover of the OBC publication *BirdingASIA*. If in doubt please contact the editors at mail@orientalbirdclub.org. Note: first national records of species and similar material are now largely carried by *BirdingASIA*. Submissions are considered on the understanding that they are offered solely for publication by the Oriental Bird Club, which will retain copyright. All submissions are reviewed by referees and the *Forktail* Editorial Committee, and those accepted are normally published as soon as possible. Authors are welcome to suggest appropriate referees, but the decision whether to approach them rests with the editors.

Submissions should be sent electronically as an email attachment to mail@orientalbirdclub.org . In the covering email, the corresponding (lead) author is requested to confirm that the submitted manuscript has not been published elsewhere, that all the authors have read it and agreed to its submission and that all research was conducted with the (necessary) approval/permission from appropriate authorities. Scripts should be submitted as a Word doc, typed in a standard, easy to read font such as Times New Roman, on point size 11 or 12. Text should be unjustified, run in one column, single line spacing (lines should not be numbered), with generous margins and with as little formatting as possible. Contributors are strongly advised to have the spelling and grammar checked by a native English speaker before the manuscript is submitted. Failure to follow the above basic instructions may result in manuscripts being returned immediately for modification.

The text, tables, figure legends and appendices should be combined as a single Word file. Figures (maps, diagrams, images etc) should be sent as low resolution jpg or tiff files; high resolution versions will be called for if a manuscript is accepted. Maps should be marked with a scale and north arrow. The approximate position of figures and tables in the text should be indicated. Papers should be concise and factual, take full account of previous relevant literature but avoid repetition of established information as much as possible; opinions expressed should be based on adequate evidence. Titles of papers must be concise and (for the benefit of abstraction services) include any relevant scientific (taxonomic) name. At the discretion of the editors long tables and appendices may be published as Supplementary Online Material (SOM) on the OBC website and not in the printed version of the paper. A full-length paper must include an abstract not exceeding 300 words. Abstracts should be a complete précis of the paper, its findings and ideas. In general, papers of 3,000 words or less are published as Short Notes (without an abstract), but the decision of whether to publish a manuscript as a Paper or a Short Note rests with the editors. Authors are encouraged to offer their work to one or more ornithologist or biologist for critical assessment prior to submission, such help as is received should be mentioned in the acknowledgement section.

Authors should consult a recent issue of *Forktail* for style and layout; issues are available to download from the OBC website. English, not American, spelling should be used. Spelling of place names accords with the most recent edition of the *Times atlas of the world*. English and scientific names and sequence should follow the latest version of *The BirdLife checklist of the birds of the world, with conservation status and taxonomic sources*, downloadable from http://www.birdlife.org/datazone/info/taxonomy. On first mention of a bird both English and scientific name should be given, thereafter only one, usually the English. Scientific trinominals need be used only if subspecific nomenclature is relevant to the topic under discussion. These recommendations also apply for any other animal or plant species mentioned.

Italics are used for words of foreign languages, including generic and specific scientific names. Metric units and their international symbols should be used; if it is necessary to cite other systems of measurement, these can be added in parentheses. Numbers one to nine are written in full except when linked with a measurement abbreviation or higher number, thus 'five birds' but '5 km' and '5–12 birds'; numerals are used for all numbers above nine, four-figure numbers and above using the comma thus: '1,234', '12,345'. Coordinates should normally be expressed to 3 decimal places unless there are good reasons otherwise (6.063°N 80.253°E). Single quotation marks are to be used. Details of experimental technique, extensive tabulations of results, etc., are best presented as appendices. Dates should be written 1 January 2013, times of day as 08h30, 17h55 (24-hour clock).

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BirdLife International (2012) Species factsheet: *Rhinomyias brunneatus*. Downloaded from http://www.birdlife.org on 24/01/2012.

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