

Population sizes, status and habitat associations of forest birds in Chu Yang Sin Nature Reserve, Dak Lak Province, Vietnam

MIKE HILL, JONATHAN C. EAMES, LE TRONG TRAI and NGUYEN CU

Summary

Chu Yang Sin Nature Reserve, Dak Lak Province, Vietnam, is within an area of high bird endemism and supports a number of globally threatened and restricted-range species. Data were collected on the bird communities of the Reserve and their habitat in 1995, to ascertain habitat associations of some of the endemic and threatened taxa. Birds were surveyed in circular plots around a recording point. Habitat associations were investigated using Discriminant Function Analysis, and populations estimated using DISTANCE.

Seven restricted-range species and 38 restricted-range subspecies were recorded in the survey. The number of contacts with some of the endemic species was low, which limited the statistical investigation of the habitat requirements of these species. When analysis was possible, altitude was the most important of the factors measured determining species distributions, while measures of forest architecture seemed less important. The area appears to support important populations of several restricted-range taxa and, provided that protection and management of the protected area can be enhanced, it remains one of the most important areas for bird conservation in southern Vietnam. Some drawbacks of the techniques used in the survey are discussed.

Introduction

Background to the research

Vietnam's Western Highlands support one of the largest remaining areas of relatively undisturbed natural and semi-natural forest vegetation in the country. The southern part of this area is particularly rich in endemic bird species, and has been recognized as the Da Lat Plateau Endemic Bird Area (EBA), one of three EBAs in Vietnam (Stattersfield *et al.* 1998). The area also appears to be an important centre of endemism for other taxa, including plants (Eames 1995).

Three endemic bird species (Collared Laughingthrush *Garrulax yersini*, Grey-crowned Crocias *Crocias langbianis* and Vietnamese Greenfinch *Carduelis monguilloti*) are confined to the Da Lat Plateau EBA, and at least six other restricted-range species (Germain's Peacock Pheasant *Polyplectron germaini*, Crested Argus *Rheinardia ocellata*, Black-hooded Laughingthrush *Garrulax milleti*, White-cheeked Laughingthrush *G. vassali*, Short-tailed Scimitar Babbler *Jabouilleia danjoui*, and Yellow-billed Nuthatch *Sitta solangiae*) also occur here (Eames and Nguyen Cu 1994: unpublished report). All except Vietnamese Greenfinch and

Crested Argus are known to occur in Chu Yang Sin (Eames and Nguyen Cu 1994: unpublished report). Grey-crowned Crocias was rediscovered at Chu Yang Sin in 1994 (Eames 1994, Eames *et al.* 1995) and is only known from one other site, Tuyen Lam Lake (11°52'N 108°25'E), 4 km south-southwest of Da Lat (Dymond 1998).

In addition to these restricted-range species, a further 28 bird subspecies are endemic to the Da Lat Plateau EBA (Eames 1995), and 35 subspecies have a restricted range which includes the Da Lat Plateau EBA. Of these endemic and restricted-range subspecies, 54 are represented at Chu Yang Sin.

Despite the importance of the Da Lat Plateau, the area was, until recently, under-represented in the protected area system of Vietnam. Two Nature Reserves, Thuong Da Nhim (Lam Dong Province) and Chu Yang Sin (Dak Lak Province) were established (along with much of Vietnam's national protected area system) on 9 August 1986 (Eames and Nguyen Cu 1994: unpublished report). However, action to protect and manage the areas for conservation was slow; a management plan was drafted in 1989, but no management regime or infrastructure were in place by 1993/94, when WWF prepared a management feasibility study for both Chu Yang Sin and Thuong Da Nhim (Eames and Nguyen Cu 1994: unpublished report). Today, there are three protected areas on the Da Lat Plateau, covering approximately 10% of the area of the EBA (Stattersfield *et al.* 1998).

In 1995 a joint project of Birdlife International and Vietnam's Forest Inventory and Planning Institute (FIPI), funded by the European Union, carried out research on the biodiversity of the Chu Yang Sin Reserve and gave recommendations for its management. Among the recommendations was a proposal that the Reserve be expanded from 32,000 to 59,280 ha, reaching the boundaries of the nearby Thuong Da Nhim Nature Reserve (Le Trong Trai *et al.* 1996: unpublished report).

This paper uses data on bird populations at Chu Yang Sin, collected during fieldwork conducted as part of the 1995 project. It aims to use these data to examine habitat associations and estimate population sizes of the birds inhabiting Chu Yang Sin Nature Reserve, and thus evaluate the conservation importance of this protected area on the Da Lat Plateau.

Methods

Study area

Chu Yang Sin Nature Reserve (12°14'–12°30'N, 108°17'–108°34'E) is located in Krong Bong and Lac Districts of Dak Lak Province, on the northern edge of the Da Lat Plateau (Figure 1). The boundaries of the Reserve are not marked, and the extent of the Reserve is unclear. When first declared a Nature Reserve, the protected area was around 18,000–20,000 ha, but it now covers 32,000–34,000 ha (Le Trong Trai *et al.* 1996: unpublished report). The altitude of the area ranges from around 600 m to 2,445 m above sea level and includes Chu Yang Sin Mountain (2,445 m) the third highest in Vietnam. At least 50% of the vegetation is composed of undisturbed broadleaved evergreen forest, but in much of the

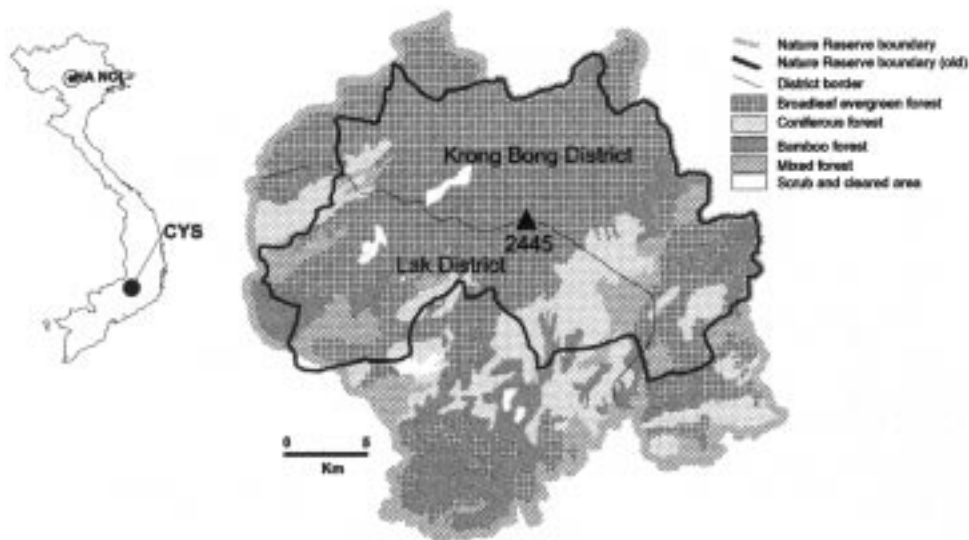


Figure 1. Map of Chu Yang Sin (CYS) Nature Reserve showing broad vegetation type. Insert: Vietnam, showing location of CYS.

protected area the natural vegetation has been modified by man, and replaced by secondary forest and bamboo (Le Trong Trai *et al.* 1996: unpublished report). Small areas of forest (especially on ridgetops) are dominated by pine *Pinus kesiya*. Data were collected from two study areas within Chu Yang Sin Nature Reserve: the lower slopes of Chu Pan Pham (CPP) in Lac District (an east–west mountain ridge, 12°22'N 108°22'E including the southern part of the nature reserve); and an area in Krong Bong District (KB), encompassing the area to the north of Chu Yang Sin Mountain (Figure 1). The vegetation of both study areas is a mosaic of forest types, dominated by broadleaved evergreen forest, but including areas of pine *Pinus kesiya* and bamboo forest. Levels of human disturbance vary, with higher-altitude sites usually suffering less disturbance.

Bird recording

Birds were surveyed by point counts, during March and April 1995. Point counts were made at stations situated at least 200 m apart, along established trails at both survey sites. Stations could be placed neither at exactly regular intervals nor completely at random, because of the difficulties of movement in dense forest on steep terrain. Data collection was carried out over a period of 18 days between the hours of 06h30 and 10h00 to coincide with the period of peak bird activity.

At each census station, two (occasionally three) observers recorded all birds seen or heard within a 30 m radius of the central point, including birds in flight (contacts for birds in flight were excluded from later data analysis). In earlier studies using Variable Circular Plot methods (Jones *et al.* 1995; Marsden *et al.* 1997), all bird contacts were recorded, but at Chu Yang Sin, contacts beyond 30 m were not recorded because the stations were generally positioned in dense

Table 1. Four-point scale to assess canopy/ground cover at point count locations at Chu Yang Sin Nature Reserve, Dak Lak province, Vietnam

Score	Percentage cover	Description	
		Canopy	Ground
4	> 60	Closed canopy	Extensive ground cover
3	25–60	Open canopy	Moderate cover
2	5–25	Scattered trees	Scattered cover
1	< 5	Very scattered trees	Very scattered cover

evergreen forest and visibility was poor. In addition, it was apparent that distances became difficult to record accurately beyond this distance. Observation continued for 10 minutes at each station, commencing two minutes after arrival at the station to reduce the effect of human activity on the count. For each individual bird contact, the following data were recorded: species; nature of contact (seen or heard-only); number of individuals; horizontal distance from origin to bird (metres, from centre of plot); and vertical height above ground (categorized as either ground-level (0 m), below 1.5 m, 1.5–4 m, or above 4 m).

Habitat structure

At each recording station the altitude (m a.s.l.), slope (degrees), aspect (N/E/S/W) and distance to nearest water source (m) were recorded. Forest canopy and ground cover were each recorded on a four-point scale (Table 1). In order to obtain more quantitative data on forest structure, the following were recorded from the 10 trees closest to the origin: species (or family); distance between tree and origin; height; diameter at breast height (DBH) 1.3 m from the ground; point of inversion (recorded as (A) first main branch above half tree height, or (B) first main branch below half tree height); phenology (0, no flowering or fruiting apparent; F, flowers present; FR, fruit present).

Habitat use

The importance of habitat features to each bird species was assessed using Discriminant Function Analysis (DFA), as described by Jones *et al.* (1995) and Marsden *et al.* (1997). This technique classifies stations on the basis of presence/absence of a bird species, and identifies any variables which are significantly associated with the positive/negative stations (i. e. may be indicators of the presence of a species locally). In order to increase sample size, data for CPP and KB were combined, and 13 habitat variables were entered into the analysis: altitude (m a.s.l.); aspect (degrees); canopy cover (on four-point scale); conifers (number of conifers, out of 10 trees); DBH (highest, m); DBH (mean, m); flowering (number of trees in flower, out of 10); fruiting (number of trees in fruit, out of 10); ground cover (on four-point scale); tree species (number of tree species in 10 individuals); point of inversion (number of trees with POI above half height, of 10); slope (degrees); and tree height (mean of 10 trees). Only bird species that were recorded at five or more stations (and the endemic Short-tailed Scimitar Babbler, recorded at only three stations) were included in the DFA.

Table 2. Forest cover of Chu Yang Sin Nature Reserve, Dak Lak province, Vietnam in 1994

Vegetation type	Hectares in altitude range (m a.s.l.)				Total (ha)
	0–900	900–1,200	1,200–1,500	> 1,500	
Evergreen/semi-evergreen forest	4,384	10,876	8,638	8,223	32,121
Plantations	114	198	92	52	456
Bare land	580	926	299	32	1,837
Total	5,078	12,000	9,029	8,307	34,414

Data for DFA are assumed to be quantitative and normally distributed, but variables that do not meet these criteria can also contribute to the success of a discriminant function; data collected for canopy and ground cover were therefore included in the analysis. Data that were recorded as proportions or percentages (conifers, point of inversion, flowering and fruiting) were normalized by arcsine transformation before analysis.

Further analysis was made to compare the average above-ground height and altitude distribution of each species (for species recorded at five or more stations, and endemics).

Calculation of bird population estimates

Data from VCP stations were converted into population estimates using the DISTANCE programme (Laake *et al.* 1994). The data used included both direct sightings and occasions where birds were heard only. Population estimates were only made for species that were encountered on more than 10 occasions.

To calculate estimates of actual populations at the Chu Yang Sin Nature Reserve, vegetation data compiled by FIPI were used. Over a total area of 34,414 ha, these divide the vegetation into five broad types (Table 2): *good* and *disturbed evergreen/semi-evergreen forest*; *plantations*; *cultivation and settlement*; and *bare land*. For the purposes of this study, figures for *good* and *disturbed forest* are combined, as are those for *cultivation and settlement* and *bare land*. The broad altitude preferences of bird species (see below, Table 5) were used to arrive at a maximum area of suitable (forest) habitat for each species, and thence, a population estimate. It was assumed that the birds identified would not be present in *plantations*, *cultivation and settlement* or *bare land*.

Results

Point counts were carried out at 175 stations (104 in CPP and 71 in KB) between 13 March and 6 April 1998. Station altitude ranged from 870 to 1,920 m a.s.l. (mean \pm SD = 1166.9 \pm 264.9 m a.s.l.). Most stations were in evergreen broad-leaved forest (having >75% broadleaf trees), although five were in coniferous forest (>75% coniferous trees) and two were in mixed forest.

A total of 621 contacts was recorded, mostly observations, but there were 265 heard-only contacts at stations where the species was not also identified by sight. Some species (e.g. Blue Pitta *Pitta cyanea*) were largely, or only, identified by their call. In total, 96 bird species were positively identified. For some groups (including green pigeons *Treron* spp., most *Phylloscopus* warblers, and sunbirds

Table 3. Plant families recorded during fieldwork in Chu Pan Pham (CPP) and Krong Boy (KB) sectors of Chu Yang Sin Nature Reserve, Dak Lak province, Vietnam, 1995

Family	Total NS	NI (CPP)	NI (KB)	Total NI
Araliaceae	1	2	116	118
Clusiaceae	10	34	16	50
Elaeocarpaceae	8	41	15	56
Fabaceae	5	32	33	65
Fagaceae	29	326	117	443
Hamamelidaceae	3	31	31	62
Lauraceae	29	105	76	181
Myrtaceae	6	66	14	80
Pinaceae	2	80	3	83
Symplocaceae	6	19	33	52
Theaceae	6	59	48	107

NS, Number of tree species; NI, number of individual trees recorded.

Aethopyga) consistent identification to species level proved impossible, and data for these birds were combined. Eleven such groups were used. Incorporating data from surveys in 1994, 211 bird species have been recorded in the Reserve (see Appendix 1). Subspecies recorded are shown in Appendix 2.

Plant communities

In all, 170 tree species of 48 families were recorded, 130 of which were recorded at CPP (104 stations) and 104 at KB (71 stations). Between one and 10 tree species were recorded at each station (mean = 5.7). Five stations had only one species, all *Pinus kesiya*. This species was also found in admixture with other tree species (10 stations had both pine and other species). Pine-dominated stations were only recorded in CPP. Eleven plant families were recorded with total number of individuals ≥ 50 (Table 3).

The most species-rich plant families were the Fagaceae and Lauraceae, but the families Araliaceae, Theaceae, and Pinaceae, although represented by fewer species, also constituted a significant part of the forest tree assemblages found. Plant families were not randomly distributed between the CPP and KB. The distribution of the 11 commonest families deviated significantly from regularity ($\chi^2_{(10)} = 288$; $P < 0.01$). This uneven distribution of trees may reflect variation in habitat factors (such as the different altitude distributions of stations) at the two sites.

There was no significant relationship between tree species richness at a station and the number of bird species recorded (Figure 2). Over 99% of the variation in bird species richness was influenced by factors other than tree species richness.

Heights of contact

Most of the frequently recorded and endemic species were found predominantly in the upper canopy (Table 4). Of those species recorded at five or more stations, 57% were found most commonly at 4 m or above, while 24.3% were only recorded in the upper canopy. In contrast, only 22% of species were recorded

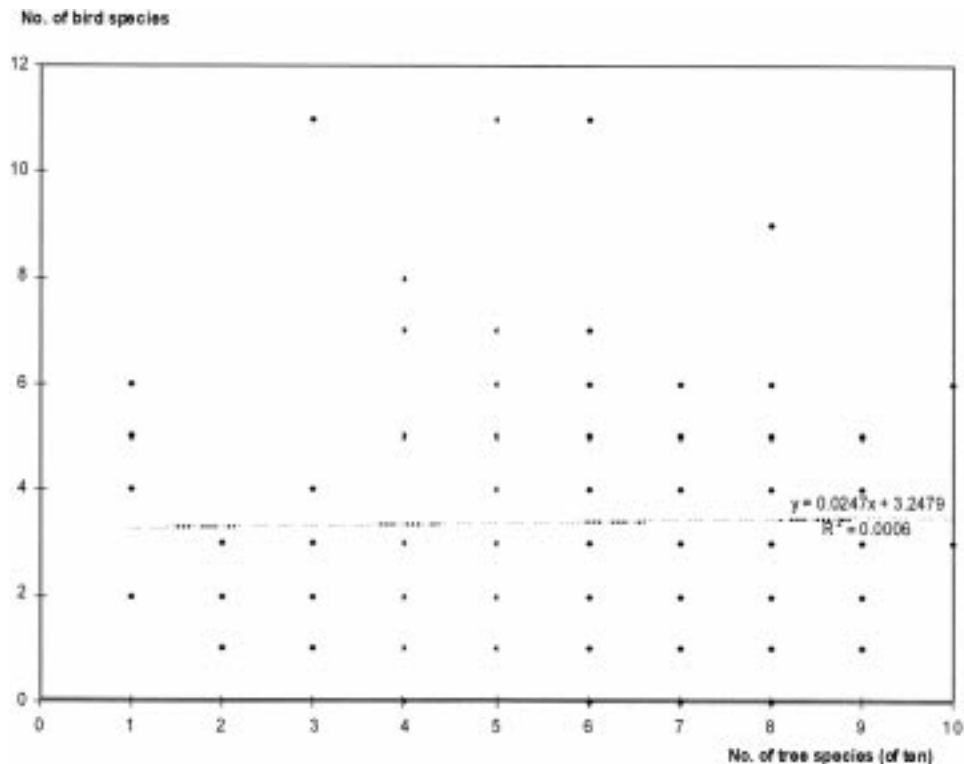


Figure 2. Variation of bird species richness with tree species richness from point counts carried out in Chu Yang Sin Nature Reserve, Dak Lak province, Vietnam, 1995.

most frequently at 1.5–4 m (e.g. small species such as Mountain Fulvetta *Alcippe peracensis*, Blue-throated Flycatcher *Cyornis rubecoloides* and Large Niltava *Niltava grandis*) and 11% of species occurred predominantly on the ground. However, none of the commonly recorded birds appeared to specialize in exploiting the 0–1.5 m layer. A few species (Laughingthrushes *Garrulax*) were observed at all levels of the forest structure.

Altitudinal ranges

Census stations covered the range of altitudes represented at Chu Yang Sin, with the exception of only the highest altitudes (over 2,000 m). Some of the bird species recorded (e.g. Mountain Fulvetta, Lesser Racket-tailed Drongo *Dicrurus remifer*, Golden-throated Barbet *Megalaima franklinii*, White-browed Scimitar Babbler *Pomatorhinus schisticeps* and White-browed Shrike Babbler *Pteruthius flaviscapis*) occurred over most of the altitude range surveyed (Table 5). However, most species were more common either at the lowest altitudes (e.g. Ochraceous Bulbul *Alophoixus ochraceus*, Blue-throated Flycatcher, White-cheeked Laughingthrush and Blue Pitta) or higher-altitudes (e.g. Mrs Gould's Sunbird *Aethopyga gouldiae*, Collared Laughingthrush, Black-headed Sibia *Heterophasia melanoleuca*, White-spectacled Warbler *Seicercus affinis*).

Table 4. Heights of contact for bird species recorded during point count at Chu Yang Sin Nature Reserve, Dak Lak province, Vietnam in 1995

Species	nC	Ground: 0 m	0–1.5 m	1.5–4 m	Canopy: > 4 m
<i>Coracina macei</i>	6				6 (100.0)
<i>Dicaeum ignipectus</i>	9				9 (100.0)
<i>Ducula badia</i>	11				11 (100.0)
<i>Hemixos flavala</i>	12				12 (100.0)
<i>Hypsipetes leucocephalus</i>	13				13 (100.0)
<i>H. mcclllandii</i>	9				9 (100.0)
<i>Megalaima franklinii</i>	28				28 (100.0)
<i>M. oorti</i>	30				30 (100.0)
<i>Paradoxornis gularis</i>	5				5 (100.0)
<i>Oriolus traillii</i>	27			1 (3.7)	26 (96.3)
<i>Psarismomus dalhousiae</i>	12			1 (8.3)	11 (91.7)
<i>Irena puella</i>	23			3 (13.0)	20 (87.0)
<i>Arachnothera magna</i>	10			2 (20.0)	8 (80.0)
Other <i>Phylloscopus</i> spp.	25			5 (20.0)	20 (80.0)
<i>Pteruthius flaviscapis</i>	10			2 (20.0)	8 (80.0)
<i>Heterophasia melanoleuca</i>	14		1 (7.1)	2 (14.3)	11 (78.6)
<i>Culicicapa ceylonensis</i>	20		1 (5.0)	4 (20.0)	15 (75.0)
<i>Blythipicus pyrrhotis</i>	13			4 (30.7)	9 (69.3)
<i>Dicrurus remifer</i>	40		1 (2.5)	12 (30.0)	27 (67.5)
<i>Alophoixus ochraceus</i>	21			7 (33.3)	14 (66.7)
<i>Phylloscopus davisoni</i>	6			3 (50.0)	3 (50.0)
Sunbirds	22			11 (50.0)	11 (50.0)
<i>Seicercus affinis</i>	17			9 (52.9)	8 (47.1)
<i>Yuhina zantholeuca</i>	9			5 (55.6)	4 (44.4)
<i>Rhipidura albicollis</i>	7		2 (28.6)	2 (26.6)	3 (42.8)
<i>Aethopyga gouldiae</i>	12			7 (58.3)	5 (41.7)
<i>Cyornis rubeculoides</i>	10			6 (60.0)	4 (40.0)
<i>Alcippe peracensis</i>	30		2 (6.6)	17 (56.7)	11 (36.7)
<i>Niltava grandis</i>	12		2 (16.7)	7 (58.3)	3 (25.0)
<i>Garrulax vassali</i>	13	3 (23.1)	2 (15.4)	5 (38.5)	3 (23.1)
<i>Pomatorhinus schisticeps</i>	5		2 (40.0)	2 (40.0)	1 (20.0)
<i>Garrulax milleti</i>	16	4 (25.0)	4 (25.0)	5 (31.3)	3 (18.7)
<i>Garrulax yersini</i>	4	2 (50.0)	2 (50.0)		
<i>Enicurus maculatus</i>	7	6 (85.7)	1 (14.3)		
<i>Arborophila brunneopectus</i>	10	9 (90.0)	1 (10.0)		
<i>Jabouilleia danjoui</i>	3	3 (100.0)			
<i>Pitta cyanea</i>	7	7 (100.0)			

Only those species recorded at five or more stations, and endemics recorded more than once, are included. Species are presented in order of percentage of contacts in canopy (> 4 m) category. nC, Number of contacts for which height data were recorded. Data in brackets represents the percentage of total contacts in this height category.

Among the three genera represented by more than one species (Laughingthrushes *Garrulax*, Bulbuls *Hypsipetes* and Barbets *Megalaima*), there appeared to be a separation of species over the altitude range surveyed (Table 5). Three *Garrulax* species (Black-hooded, White-cheeked and Collared Laughingthrushes) were observed at more than one station, and were separated by altitude. White-cheeked occurred at the lowest altitudes (mean altitude of stations recorded = 950 m; $n = 13$), Black-hooded generally occurred at mid-altitudes (mean = 1,070 m; $n = 16$), and Collared at the highest altitudes (mean =

Table 5. Altitude ranges for bird species recorded at five or more stations, and endemics recorded more than once, during point counts carried out at Chu Yang Sin Nature Reserve, Dak Lak province, Vietnam, in 1995

Species	nSt	Mean altitude	SE mean	Altitude range	
				Min	Max
<i>Garrulax vassali</i>	13	950	15.10	900	1,070
<i>Arborophila brunneopectus</i>	10	970	22.83	870	1,120
<i>Alophoixus ochraceus</i>	21	980	29.50	870	1,370
<i>Cyornis rubeculoides</i>	10	980	23.95	900	1,180
<i>Psaromus dalhousiae</i>	11	980	31.77	890	1,180
<i>Irena puella</i>	23	990	22.32	900	1,360
<i>Enicurus maculatus</i>	7	1,000	25.90	890	1,100
<i>Pitta cyanea</i>	7	1,000	51.24	910	1,290
<i>Hemixos flavala</i>	12	1,020	17.24	920	1,120
<i>Hypsipetes leucocephalus</i>	13	1,030	25.37	900	1,260
<i>Paradoxornis gularis</i>	5	1,060	75.92	900	1,320
<i>Culicicapa ceylonensis</i>	19	1,070	49.00	870	1,500
<i>Garrulax milleti</i>	16	1,070	45.44	900	1,460
<i>Arachnothera magna</i>	10	1,080	61.97	870	1,410
<i>Niltava grandis</i>	11	1,100	67.89	900	1,500
<i>Oriolus traillii</i>	26	1,100	51.10	900	1,560
<i>Megalaima oorti</i>	30	1,120	35.30	870	1,620
<i>Dicaeum ignipectus</i>	9	1,130	64.81	980	1,500
Sunbirds	5	1,130	127.18	900	1,620
<i>Blythipicus pyrrhotis</i>	12	1,140	55.83	890	1,410
<i>Ducula badia</i>	11	1,140	75.75	890	1,460
<i>Jabouilleia danjoui</i>	3	1,150	125.30	900	1,290
<i>Dicrurus remifer</i>	38	1,170	46.74	890	1,860
<i>Yuhina zantholeuca</i>	8	1,180	54.31	920	1,390
Other <i>Phylloscopus</i> spp.	14	1,190	62.99	900	1,570
<i>Phylloscopus davisoni</i>	6	1,200	116.64	900	1,540
<i>Alcippe peracensis</i>	27	1,220	50.23	900	1,860
<i>Coracina macei</i>	6	1,220	90.29	1,000	1,610
<i>Pomatorhinus schisticeps</i>	5	1,220	192.32	920	1,900
<i>Pteruthius flaviscapis</i>	10	1,250	121.64	920	1,890
<i>Rhipidura albicollis</i>	7	1,280	91.56	910	1,520
<i>Hypsipetes mcclllandii</i>	9	1,320	75.67	1,060	1,620
<i>Megalaima franklinii</i>	28	1,400	51.70	940	1,900
<i>Aethopyga gouldiae</i>	12	1,450	54.05	1,140	1,920
<i>Heterophasia melanoleuca</i>	14	1,580	44.41	1,400	1,920
<i>Seicercus affinis</i>	17	1,580	47.4	1,330	1,900
<i>Garrulax yersini</i>	4	1,600	106.96	1,400	1,900
All stations	172	1,170	264.05	870	1,920

Species are presented in order of mean altitude. nSt = Number of stations for which altitude data are available (altitude was not recorded for all stations).

1,600 m; $n = 4$). These were supported by significant differences between the median altitudes of all three species (Mann-Whitney U -tests between Black-hooded and White-cheeked, $U = 58$, $P = 0.045$; Black-hooded and Collared, $U = 1.5$, $P = 0.001$; and White-cheeked and Collared, $U = 0.000$, $P = 0.001$). Mountain Bulbul *Hypsipetes mcclllandii* (mean = 1,320 m; $n = 9$) occurred at significantly greater altitudes than Black Bulbul *H. leucocephalus* (mean = 1,030 m; $n = 13$) (Mann-Whitney U -test = 9.5, $P = 0.001$), and the median altitude of Golden-

Table 6. Results of Discriminant Function Analysis carried out on bird and habitat data from point counts carried out at Chu Yang Sin Nature Reserve, Dak Lak province, Vietnam in 1995

Species	Bird species						
	Ae.g	Co.m	Cr.o	He.m	Me.f	Se.a	sSun
Altitude	0.863	0.054	0.578	0.931	0.759	0.916	-0.158
Aspect	-0.002	-0.150	-0.102	-0.022	0.289	-0.075	-0.079
Canopy cover	0.144	0.059	0.716	0.107	0.323	0.315	0.105
Conifer	-0.129	0.775	0.194	-0.057	-0.121	-0.073	-0.066
DBH (highest)	0.205	-0.234	0.134	0.064	0.266	0.239	-0.067
DBH (mean)	-0.070	-0.073	0.064	-0.075	0.149	0.027	-0.049
Flowering	-0.140	0.721	0.171	-0.089	-0.185	-0.103	-0.023
Fruiting	-0.183	-0.043	0.152	-0.136	-0.018	0.056	-0.101
Ground cover	-0.032	0.093	0.003	0.056	-0.149	-0.097	0.896
Tree species	0.219	-0.378	-0.087	0.268	0.235	0.406	-0.126
Point of inversion	0.129	-0.189	-0.106	0.033	0.130	-0.069	-0.116
Slope	0.418	0.431	0.454	0.160	0.571	0.136	0.087
Tree height	-0.379	0.030	-0.053	-0.359	-0.141	-0.126	-0.050

Correlation coefficients of habitat variables with discriminant function are given for each species. Only species where a significant discrimination was achieved between positive and negative sites are shown. Large positive correlation coefficients indicate a high degree of correlation between large values of the variable, and species presence. Ae.g = *Aethopyga gouldiae*; Co.m = *Coracina macei*; Cr.o = *Criniger ochraceus*; He.m = *Heterophasia melanoleuca*; Me.f = *Megalaima franklinii*; Se.a = *Seicercus affinis*; sSun = sunbirds.

throated Barbet was significantly greater than that of Black-browed Barbet *Megalaima oorti* (Mann–Whitney U -test = 177, $P < 0.05$).

Discriminant Function Analysis

The Discriminant Function Analysis produced a significant discrimination (at $P = 0.05$) between groups in only seven (of 37) species (Table 6). Altitude appeared to be a major habitat variable affecting the distribution of birds in the sites studied at Chu Yang Sin, and was closely correlated to the discriminant function for five of the successfully separated species. In general, plant architecture variables (which would indicate undisturbed or secondary forest) appeared of little importance. Only the sunbirds appeared to be associated with secondary or disturbed forest, favouring dense ground cover and trees with low DBH and a low point of inversion (POI below halfway up the stem). There was no correlation between nectar-eating birds (such as sunbirds) and flowering trees, probably because the majority of flowering trees recorded (67 of 103 trees; 65.05%) were pines *Pinus kesiya*, which are wind-pollinated. The occurrence of the insectivorous Large Cuckooshrike *Coracina macei* was closely correlated to the presence of pine trees. This may be due to increased insect activity in the flowering trees, or simply because of greater visibility (and audibility) of the species in the canopy of pines.

Population sizes

Bird density estimates at Chu Yang Sin varied widely between species (Table 7). Highest densities were those for Lesser Racket-tailed Drongo (3.29 per ha), Mountain Fulvetta (3.26 per ha) and White-cheeked Laughingthrush (3.13 per

Table 7. Density estimates for birds of Chu Yang Sin Nature Reserve, Dak Lak province, Vietnam from point count data collected in 1995, in descending order of density

Species	Density \pm 1 SE	nC	Max. area	Popn	SE
<i>Dicrurus remifer</i>	3.29 \pm 0.63	40	10,880	35,790	6,800
<i>Alcippe peracensis</i>	3.26 \pm 0.87	30	8,640	28,190	7,520
<i>Garrulax vassali</i>	3.13 \pm 1.72	13	10,880	34,010	18,740
<i>Seicercus affinis</i>	1.22 \pm 0.37	17	8,220	10,020	3,070
<i>Aethopyga gouldiae</i>	0.99 \pm 0.58	12	8,640	8,570	4,970
<i>Alophoixus ochraceus</i>	0.79 \pm 0.18	21	10,880	8,570	1,910
<i>Megalaima oorti</i>	0.75 \pm 0.15	30	10,880	8,140	1,580
<i>Garrulax milleti</i>	0.70 \pm 0.18	16	10,880	7,690	1,960
<i>Oriolus traillii</i>	0.63 \pm 0.12	27	10,880	6,820	1,330
<i>Megalaima franklinii</i>	0.61 \pm 0.13	28	8,640	5,240	1,080
<i>Niltava grandis</i>	0.61 \pm 0.22	12	10,880	6,590	2,400
<i>Irena puella</i>	0.51 \pm 0.11	23	10,880	5,490	1,160
<i>Hypsipetes leucocephalus</i>	0.47 \pm 0.15	13	8,640	4,020	1,300
<i>Culicicapa ceylonensis</i>	0.44 \pm 0.10	20	10,880	4,840	1,070
<i>Hemixos flavala</i>	0.42 \pm 0.12	12	10,880	4,610	1,350
<i>Psarisomus dalhousiae</i>	0.34 \pm 0.11	12	10,880	3,740	1,160
<i>Heterophasia melanoleuca</i>	0.32 \pm 0.09	14	8,220	2,640	720
<i>Arborophila brunneopectus</i>	0.28 \pm 0.10	10	10,880	3,080	1,110
<i>Blythipicus pyrrhotis</i>	0.28 \pm 0.08	13	10,880	3,080	860
<i>Ducula badia</i>	0.24 \pm 0.07	11	10,880	2,640	800
<i>Pteruthius flaviscapis</i>	0.22 \pm 0.07	10	19,510	4,330	1,400
<i>Arachnothera magna</i>	–	10	10,880	–	–
<i>Cyornis rubeculoides</i>	–	10	10,880	–	–

Density, density estimate (individuals per hectare); nC, number of contacts; Max. area, maximum area of suitable habitat (hectares of forest in altitude range of species); Popn, population estimate; –, population estimate could not be calculated (number of individuals low).

ha). Two of these (the drongo and laughingthrush) are conspicuous species, more likely to be recorded than small, solitary birds. White-browed Shrike Babbler had the lowest density calculated (0.22 birds per ha). Less frequently recorded birds would probably occur at lower densities than this, but, where there are few records, DISTANCE cannot calculate detection functions for a species (this was the case for two species with 10 contacts; see Table 7).

It should be stressed that these population sizes calculated are broad estimates, owing to the assumptions of the methodology (see Discussion) and the limited resolution of the altitude/habitat data available. For most species, the total potential area of habitat given in Table 7 exceeds the real amount (as the altitude ranges utilized by birds do not fit those for which forest data is available). In addition, habitat data were obtained in 1994 and it is possible that the extent of forest types has altered over the intervening period, although the area remains extensively forested.

Endemic and threatened species

Seven species recorded in the current survey are endemic to the Da Lat Plateau EBA, occur in a restricted range including the Da Lat Plateau, and/or are listed as globally threatened (Collar *et al.* 1994). These are described individually below.

Germain's Peacock Pheasant Polyplectron germaini

This species is endemic to southern Vietnam, from Quang Tri (Delacour 1925) south to Dong Nai (Robson *et al.* 1993). At Chu Yang Sin, it was heard calling in March and April 1995.

Blyth's Kingfisher Alcedo hercules

This species was recorded at one station in Krong Bong (altitude 950–960 m). Although widespread (occurring from eastern Nepal to Vietnam and Thailand), Blyth's Kingfisher appears to be rare over much of its range (Collar *et al.* 1994). In Vietnam, its range is described as "Tonkin" (northern Vietnam) by King *et al.* (1975), although it has since been recorded in the north Annam region of north-central Vietnam (Robson *et al.* 1993; Dymond 1998), and central Annam (Eames and Robson 1992). This is the southernmost record of the species within Vietnam, extending the known Vietnamese range of the bird considerably.

Black-hooded Laughingthrush Garrulax milleti

This species was recorded on 16 occasions (each contact at a different station) over a fairly wide altitudinal range (from 900 to 1,460 m), although most records were made in the lower part of this range. Nine contacts were heard-only, and seven groups (from one to three individuals; mean group size = 2.19) were seen. Given the shy nature of this species, this probably represents an underestimate of flock size. This species appears to utilize all layers of the forest, being recorded on the forest floor, shrub and lower canopy layers, and the canopy. The population estimate for this species is fairly high in comparison with other large birds (over 8,000 birds in the 34,000 ha Reserve); however, because most records were heard-only (and it is difficult to judge distances to heard-only contacts), this may be an overestimate. There is also a high degree of error associated with this estimate (SE = 25% of estimate).

This species, previously thought to be restricted to the Da Lat Plateau EBA (Stattersfield *et al.* 1998) has also been recorded at several sites in Laos (Thewlis *et al.* 1998).

White-cheeked Laughingthrush Garrulax vassali

For this species 13 contacts were made in 11 different stations. Compared with the other *Garrulax* species, this species occurs at lower elevations, from 900 to 1,070 m in altitude (mean = 952 m), although at another site (Nui Ba mountain) it has been recorded at 1,900 m (Robson *et al.* 1993). Most records were sightings (12 of 13 contacts). Group size varied from one to 10 individuals, but most groups were small (mean group size = 3.31 birds). As for *G. milleti*, birds were recorded at all layers in the forest, although there appeared to be some preference for the lower canopy (1.5–4 m). The estimate of population density for this species was extremely high at 34,000; however, the degree of error associated with this estimate was also very high (SE = 55% of estimate).

Collared Laughingthrush Garrulax yersini

Four contacts at four different stations were made for this species. The species was recorded only in the higher-altitude stations (between 1,400 and 1,900 m). Two records were heard-only. Three contacts appeared to be with lone birds, on

one occasion three individuals were seen in a group. In contrast to the other *Garrulax* species above, all records were of birds on, or very close to, the ground, and none were recorded in the forest canopy. In addition to Chu Yang Sin, the species is present in Thuong Da Nhim Nature Reserve (Eames 1995).

Short-tailed Scimitar Babbler *Jabouilleia danjoui*

Three contacts were made with this species (two heard-only, one seen), all of lone individuals, at altitudes of 900 to 1,290 m. All were recorded on the ground. Although the species also occurs in the Annamese Lowlands EBA to the north, the subspecies *J. d. danjoui* is endemic to the Da Lat Plateau (Eames 1995).

Grey-crowned Crocias *Crocias langbianis*

This species was observed at only one census station, at 1,020 m in the Krong Bong sector of the Reserve. However 13 incidental observations of the species were made over the period of the survey (outside the VCP stations), and these observations are detailed by Eames *et al.* (1995). The birds were observed in groups of one to five (mean group size = 1.85 birds), usually in multiple-species flocks, feeding on insects in the forest canopy at altitudes of *c.* 910–1,130 m (mean = 975 m). The species is listed as Critical by Collar *et al.* (1994).

Discussion

Bird–habitat associations

Problems in the use of Discriminant Function Analysis to identify bird–habitat associations have been discussed by Jones *et al.* (1995) and Marsden *et al.* (1997). However, in both of these studies, the success rate of DFA in separating sites as positive or negative for bird species was considerably higher than in the present study. This may have been a consequence of all but one station in the present study being visited on only one occasion. Repeated visits to stations, as carried out by Jones *et al.* (1995), would have reduced the possibility of erroneously recording a species as absent (a false negative). In addition, the range of habitat types selected, the variables recorded, and the degree of resolution at which variables are recorded may all influence the outcome of DFA. In the survey at Chu Yang Sin, all stations selected were in the same broad forest type. Given the mobility of the birds studied, it is likely that a greater number of stations, each visited several times, would have been needed to investigate thoroughly habitat associations. For any such analysis, the choice of habitat variables measured and methods of measurement are fundamental. For small birds in particular, it is possible that microhabitat variables are at least as important as the larger-scale variables measured in the Chu Yang Sin study.

DFA assumes that birds occur at their maximum possible density, distributed in every station where habitat conditions are suitable. However, this assumption is unlikely to be met in a real bird community (Capen *et al.* 1986). Factors such as daily and seasonal migration could lead to bias in results (false positive stations where birds are moving through unsuitable habitat, and false negatives because birds are not found at every suitable station).

For those species that were successfully classified by DFA, by far the most important factor separating positive and negative stations was altitude. While

altitude in turn affects both the biotic and abiotic environment, it appears that most bird species were not significantly affected by variables measuring forest quality or composition, over the range represented at the study sites. Only Large Cuckooshrike was associated with coniferous trees, the possible reasons for which have been discussed earlier. Of six forest bird species identified as occurring predominantly in pine forests on the Da Lat Plateau by Eames (1995), only Green-backed Tit *Parus monticolus* was recorded in Chu Yang Sin Nature Reserve in the present survey, at only three survey stations. Most of the survey stations in the current study were in broadleaved evergreen forest (reflecting habitat composition of the nature reserve), and the pine areas studied were smaller and isolated. Species heavily dependent on conifers might only be expected in the few pine-dominated areas included in the survey.

Population sizes

DISTANCE sampling involves several assumptions about bird detection in the field relevant to this study. It assumes that all birds on the survey point (i.e. at 0 m) are recorded; that individual birds are not recorded more than once (re-entering the same plot, or flying between plots as the survey is carried out); that group size and distance are accurately measured; and that the presence of observers does not influence the detectability of birds. In order to minimize inaccuracies caused by bird movement, birds overflying the plots were recorded but these records were excluded from the calculations. Estimation of group size is more difficult in the case of heard-only records (Jones *et al.* 1995), the likelihood being that group size is underestimated in heard-only contacts, producing underestimates of population densities. This effect will be greatest in smaller, less conspicuous birds (as these are less likely to be detected visually to confirm flock size). Observer effects are also likely to lead to underestimates of population densities for shy, particularly ground-dwelling species (e.g. pheasants and pittas).

In the calculation of population size from density estimates, the low resolution of habitat information available for Chu Yang Sin is an important factor that may introduce inaccuracies (variable between bird species). It has been assumed that none of the species studied occur in plantations or cleared areas. Since no stations were sited in forest-edge or cleared areas, no data are available to test the extent to which the birds of Chu Yang Sin use degraded or non-forest habitats within the boundaries of the Reserve. Although most are predominantly forest birds, data from the few pine-dominated stations studied suggest that, provided a mosaic of habitat types including primary forest remains, and areas of monoculture or clearance are not extensive, many "forest" bird species may survive in apparently suboptimal habitats. Thus estimates of total population size may be too small for generalist species which can utilize altered habitats. However, large or shy species, or those favoured by hunters, may be absent from otherwise suitable habitat that lies close to human habitation. Because of these factors, population densities and total populations given for Chu Yang Sin should be regarded as broad estimates.

Two of the restricted-range species of the Da Lat Plateau EBA (Germain's Peacock Pheasant and Vietnamese Greenfinch) have not been recorded in the Chu Yang Sin Nature Reserve. The latter species usually occurs in pine forest

(Stattersfield *et al.* 1998), so extensive suitable habitat would appear to remain within the EBA, outside protected areas. However, Crested Argus is a bird of broadleaved forest (up to 1,500 m) and may be threatened by the expansion of coniferous forest in the Da Lat Plateau EBA. This species also occurs in the Annamese Lowlands EBA in central Vietnam and Laos, and (as a different subspecies) in peninsular Malaysia (Stattersfield *et al.* 1998).

Conservation implications and priorities

The natural vegetation of much of the Da Lat Plateau was originally characterized by high-altitude moist forest formations. However, human intervention has led to the replacement of much of this forest by a fire-climax forest dominated by *Pinus kesiya*, bamboo forest, and scrub (Eames 1995). At Chu Yang Sin Nature Reserve, only small areas of pine forest occur (mainly on ridgetops), with apparently little influence on the species composition of the reserve. However, the wholesale replacement of the natural moist forest that has occurred over large areas of the Da Lat Plateau (and continues to occur today) has created conditions very different from those at Chu Yang Sin, and it is impossible to extrapolate results from the protected area to the wider region. On such a scale, the reduced structural diversity and tree species richness of pine forests, together with higher order effects (for example, reduced invertebrate species diversity) are likely to have a major detrimental influence on the bird communities of the Da Lat Plateau (Eames 1995).

The Chu Yang Sin Nature Reserve supports substantial populations of a range of bird species, including three of the four endemic birds of the Da Lat Plateau. One of these (Grey-crowned Crocias) is currently known from only one other site (Dymond 1998). The results of DFA suggest that, to maintain biodiversity at the site, it is important to maintain natural forest over a wide range of altitudes. Forest at lower altitudes is particularly threatened by human encroachment, which may have led to the exclusion of the lowland restricted-range species Crested Argus.

In addition to its importance for biodiversity conservation, the forest of Chu Yang Sin has a role in watershed protection (Eames 1995). However, there are several threats to the integrity of forest in the area. Although the Reserve has no permanent human settlements, the population of Krong Bong District has increased due to inward migration (both planned and unofficial), leading to increased exploitation of natural resources (particularly firewood) outside the Reserve. As available resources are exhausted, it is likely that local people will turn to the Reserve to supply them (Eames 1995).

Acknowledgements

The authors would like to thank the following people for providing assistance during the field survey and data analysis. In Dak Lak Province: Mr Y Ly Nie Kdam, Vice-Chairman of Dak Lak Provincial People's Committee; Mr Nguyen Cong Ba (Director) and Mr Ha Cong Tuan (Vice-Director) of the provincial Agriculture and Forestry Department; Mr Ngo Quang Quy, Vice-Director of the provincial Forest Inventory and Planning Office; the People's Committee of Krong

Bong District. In addition to three of the authors of this paper (LTT, JCE, NC), the project team consisted of Le Van Cham (Forest Inventory and Planning Institute), Tran Van Khoa (Dak Lak Forest Protection Department) and Nguyen Sinh Vat (National Centre for Natural Science and Technology). In Hanoi, thanks are due to Ha Quy Quynh for producing the map for this paper. Thanks also to Martin Jones, Stuart Marsden, Frank Lambert and Nick Brickle for providing useful comments on an early draft of this paper. Fieldwork comprised a component of the joint BirdLife International and FIPI (Ministry of Agriculture and Rural Development) project entitled "Conservation of Biodiversity in the Annamese Lowlands and Da Lat Plateau, Vietnam". Contract B7-5041/93/11, funded by the Commission of the European Communities (DG1).

Appendix 1. Bird species list for Chu Yang Sin Nature Reserve, Dak Lak province, Vietnam.

No. of Stations = Number of VCP stations at which the species was observed, by site.

CCP, Chua Pan Pham; KB, Krong Bong district.

T, Listed as Threatened in Collar *et al.* (1994).

N, Listed as Near-threatened in Collar *et al.* (1994).

E, Species endemic to the Da Lat Plateau EBA (Stattersfield *et al.* 1998).

RR, Restricted-range species also found outside the Da Lat Plateau EBA.

ess, Subspecies endemic to the Da Lat Plateau EBA (Eames 1995).

rss, restricted-range subspecies also found outside the Da Lat Plateau EBA (Eames 1995).

* Observed in Jan.–Feb. 1994 (Eames and Nguyen Cu 1994 unpubl.).

(*) Observed in 1994: identification uncertain.

Species	No. of stations in		Notes
	CCP	KB	
<i>Francolinus pinteadius</i> Chinese Francolin			
<i>Arborophila rufogularis</i> Rufous-throated Partridge	1	0	* ess
<i>Arborophila brunneopectus</i> Bar-backed Partridge	4	6	* ess
<i>Arborophila chloropus</i> Scaly-breasted Partridge	0	1	T
<i>Gallus gallus</i> Red Junglefowl	1	0	*
<i>Lophura nycthemera</i> Silver Pheasant			rss
<i>Polyplectron germaini</i> Germain's Peacock Pheasant			T RR
<i>Picumus innominatus</i> Speckled Piculet	1	0	*
<i>Dendrocopos canicapillus</i> Grey-capped Pygmy Woodpecker			
<i>Dryocopus javensis</i> White-bellied Woodpecker			
<i>Picus chlorolophus</i> Lesser Yellownappe			* rss
<i>P. flavinucha</i> Greater Yellownappe	0	1	*
<i>Dinopium javanense</i> Common Flameback			
<i>Blythipicus pyrrhotis</i> Bay Woodpecker	5	8	* rss
<i>Hemicircus canente</i> Heart-spotted Woodpecker			*
<i>Megalaima lagrandieri</i> Red-vented Barbet			*
<i>M. faiostricta</i> Green-eared Barbet			*
<i>M. franklinii</i> Golden-throated Barbet	17	11	* rss
<i>M. oorti</i> Black-browed Barbet	24	6	* rss
<i>Buceros bicornis</i> Great Hornbill			
<i>Harpactes erythrocephalus</i> Red-headed Trogon	4	0	* rss
<i>Eurystomus orientalis</i> Dollarbird			
<i>Alcedo hercules</i> Blyth's Kingfisher	0	1	* T
<i>A. atthis</i> Common Kingfisher			
<i>Lacedo pulcella</i> Banded Kingfisher	2	0	

Appendix 1 continued

Species	No. of stations in		Notes
	CCP	KB	
<i>Halcyon smyrnensis</i> White-throated Kingfisher			*
<i>Megaceryle lugubris</i> Crested Kingfisher			*
<i>Nyctyornis athertoni</i> Blue-bearded Bee-eater	1	0	*
<i>Merops leschenaulti</i> Chestnut Headed Bee-eater	1	0	
<i>Clamator coromandus</i> Chestnut-winged Cuckoo			
<i>Hierococcyx sparverioides</i> Large Hawk Cuckoo			
<i>Cuculus micropterus</i> Indian Cuckoo			
<i>C. poliocephalus</i> Lesser Cuckoo			
<i>Cacomantis sonneratii</i> Banded Bay Cuckoo			
<i>Surniculus lugubris</i> Drongo Cuckoo			
<i>Phaenicophaeus tristis</i> Green-billed Malkoha	2	0	*
<i>Centropus sinensis</i> Greater Coucal			*
<i>C. bengalensis</i> Lesser Coucal			*
<i>Loriculus vernalis</i> Vernal Hanging Parrot			*
<i>Psittacula alexandri</i> Red-breasted Parakeet			*
<i>Apus affinis</i> House Swift			*
<i>Otus spilocephalus</i> Mountain Scops Owl			*
<i>O. sunia</i> Oriental Scops Owl			
<i>O. bakkamoena</i> Collared Scops Owl			
<i>Strix leptogrammica</i> Brown Wood Owl			
<i>Glaucidium brodiei</i> Collared Owllet	1	0	*
<i>Caprimulgus indicus</i> Grey Nightjar			*
<i>C. macrurus</i> Large-tailed Nightjar			
<i>Streptopelia chinensis</i> Spotted Dove			*
<i>Macropygia unchall</i> Barred Cuckoo Dove	1	0	
<i>Chalcophaps indica</i> Emerald Dove			
<i>Treron curvirostra</i> Thick-billed Green Pigeon	1	1	
<i>T. phoenicoptera</i> Yellow-footed Green Pigeon			
<i>Ducula badia</i> Mountain Imperial Pigeon	6	5	
<i>Spilornis cheela</i> Crested Serpent Eagle			*
<i>Accipiter trivirgatus</i> Crested Goshawk			*
<i>A. badius</i> Shikra			
<i>A. virgatus</i> Besra			
<i>Ictinaetus malayensis</i> Black Eagle			*
<i>Spizaetus cirrhatus</i> Changeable Hawk Eagle			*
<i>Ardeola bacchus</i> Chinese Pond Heron			
<i>Butorides striatus</i> Little Heron			
<i>Pitta oatesi</i> Rusty-naped Pitta	1	0	* rss
<i>P. cyanea</i> Blue Pitta	0	7	*
<i>Serilophus lunatus</i> Silver-breasted Broadbill			
<i>Psarisomus dalhousiae</i> Long-tailed Broadbill	1	11	
<i>Irena puella</i> Asian Fairy Bluebird	5	18	*
<i>Chloropsis cochinchinensis</i> Blue-winged Leafbird	3	0	
<i>C. hardwickii</i> Orange-bellied Leafbird	1	1	
<i>Lanius collurioides</i> Burmese Shrike			(*)
<i>Garrulus glandarius</i> Eurasian Jay			
<i>Cissa chinensis</i> Common Green Magpie	1	2	* ess
<i>C. hypoleuca</i> Indochinese Green Magpie			N
<i>C. thalassina</i> Short-tailed Green Magpie	0	1	N
<i>Oriolus chinensis</i> Black-naped Oriole			rss
<i>O. traillii</i> Maroon Oriole	8	19	* rss
<i>Coracina macei</i> Large Cuckooshrike	6	0	
<i>C. polioptera</i> Indochinese Cuckooshrike			

Appendix 1 continued

Species	No. of stations in		Notes
	CCP	KB	
<i>C. melaschistos</i> Black-winged Cuckooshrike	0	2	
<i>Pericrocotus solaris</i> Grey-chinned Minivet			* rss
<i>P. ethologus</i> Long-tailed Minivet	1	2	* rss
<i>P. flammeus</i> Scarlet Minivet			*
<i>Hemipus picatus</i> Bar-winged Flycatcher-shrike			
<i>Rhiphidura albicollis</i> White-throated Fantail	6	1	* rss
<i>Dicrurus leucophaeus</i> Ashy Drongo	1	0	*
<i>D. aeneus</i> Bronzed Drongo	0	2	*
<i>D. remifer</i> Lesser Racket-tailed Drongo	18	22	*
<i>D. paradiseus</i> Greater Racket-tailed Drongo			*
<i>Hypothymis azurea</i> Black-naped Monarch			*
<i>Terpsiphone paradisi</i> Asian Paradise-flycatcher			*
<i>Aegithina tiphia</i> Common Iora			*
<i>A. lafresnayi</i> Great Iora			*
<i>Tephrodornis gularis</i> Large Woodshrike	1	1	
<i>Monticola solitarius</i> Blue Rock Thrush			
<i>Myophonus caeruleus</i> Blue Whistling Thrush	1	1	*
<i>Zoothera citrina</i> Orange-headed Thrush			*
<i>Z. sibirica</i> Siberian Thrush			
<i>Z. dauma</i> Scaly Thrush			*
<i>Z. marginata</i> Dark-sided Thrush	1	0	*
<i>Brachypteryx leucophrys</i> Lesser Shortwing	2	0	* rss
<i>B. montana</i> White-browed Shortwing			*
<i>Muscicapa dauurica</i> Asian Brown Flycatcher			(*)
<i>Ficedula mugimaki</i> Mugimaki Flycatcher	1	0	
<i>F. hodgsonii</i> Slaty-backed Flycatcher	2	0	
<i>F. strophiatea</i> Rufous-gorgeted Flycatcher			*
<i>F. parva</i> Red-throated Flycatcher			*
<i>F. solitaria</i> Rufous-browed Flycatcher			* rss
<i>F. hyperythra</i> Snowy-browed Flycatcher			* rss
<i>F. westermanni</i> Little Pied Flycatcher	1	0	* rss
<i>Eumyias thalassina</i> Verditer Flycatcher			
<i>Niltava grandis</i> Large Niltava	3	9	*
<i>Cyornis hainanus</i> Hainan Blue Flycatcher	0	1	
<i>C. rubeculoides</i> Blue-throated Flycatcher	8	2	*
<i>Culicicapa ceylonensis</i> Grey-headed Canary Flycatcher	8	12	*
<i>Luscinia cyane</i> Siberian Blue Robin			*
<i>Copsychus saularis</i> Oriental Magpie Robin			*
<i>C. malabaricus</i> White-rumped Shama			*
<i>Myiomela leucura</i> White-tailed Robin	2	0	*
<i>Enicurus schistaceus</i> Slaty-backed Forktail	1	2	*
<i>E. leschenaulti</i> White-crowned Forktail			*
<i>E. maculatus</i> Spotted Forktail	5	2	* ess
<i>Cochoa viridis</i> Green Cochoa	0	1	N
<i>Saxicola ferrea</i> Grey Bushchat			*
<i>Sturnus nigricollis</i> Black-collared Starling			*
<i>S. burmannicus</i> Vinous-breasted Starling			
<i>Gracula religiosa</i> Hill Myna			
<i>Sitta nagaensis</i> Chestnut-vented Nuthatch			*
<i>S. frontalis</i> Velvet-fronted Nuthatch			
<i>S. solangiae</i> Yellow-billed Nuthatch			* T RR rss
<i>Certhia discolor</i> Brown-throated Treecreeper	1	0	* ess
<i>Parus monticolus</i> Green-backed Tit	3	0	ess

Appendix 1 continued

Species	No. of stations in		Notes
	CCP	KB	
<i>P. spilonotus</i> Yellow-cheeked Tit	1	0	*
<i>Sylviparus modestus</i> Yellow-browed Tit	2	0	* ess
<i>Aegithalos concinnus</i> Black-throated Tit	1	1	* rss
<i>Hirundo rustica</i> Barn Swallow			*
<i>H. striolata</i> Striated Swallow			*
<i>Delichon dasypus</i> Asian House Martin			*
<i>Pycnonotus melanicterus</i> Black-crested Bulbul			*
<i>P. jocosus</i> Red-whiskered Bulbul			*
<i>P. aurigaster</i> Sooty-headed Bulbul			*
<i>P. flavescens</i> Flavescent Bulbul			rss
<i>Alophoixus ochraceus</i> Ochraceous Bulbul	6	15	*
<i>Hemixos flava</i> Ashy Bulbul	12	0	*
<i>Hypsipetes mclellandii</i> Mountain Bulbul	9	0	* ess
<i>H. leucocephalus</i> Black Bulbul	11	2	*
<i>Prinia atrogularis</i> Hill Prinia			*
<i>P. rufescens</i> Rufescent Prinia			
<i>P. flaviventris</i> Yellow-bellied Prinia			(*)
<i>P. inornata</i> Plain Prinia			*
<i>Tesia oliven</i> Slaty-bellied Tesia	1	0	
<i>T. cyaniventer</i> Grey-bellied Tesia			*
<i>Urosphena squameiceps</i> Asian Stubtail			*
<i>Orthotomus cuculatus</i> Mountain Tailorbird			*
<i>O. atrogularis</i> Dark-necked Tailorbird	3	0	*
<i>Phylloscopus maculipennis</i> Ashy-throated Warbler			*
<i>P. inornatus</i> Inornate Warbler	4	0	*
<i>P. borealis</i> Arctic Warbler			*
<i>P. trochiloides</i> Greenish Warbler	0	1	
<i>P. reguloides</i> Blyth's Leaf Warbler			* ess
<i>P. davisoni</i> White-tailed Leaf Warbler	5	1	* ess
<i>Seicercus burkii</i> Golden-spectacled Warbler	1	0	
<i>S. affinis</i> White-spectacled Warbler	17	0	*
<i>S. castaneiceps</i> Chestnut-crowned Warbler	1	0	* ess
<i>Abroscopus superciliaris</i> Yellow-bellied Warbler	4	0	
<i>Garrulax leucolophus</i> White-crested Laughingthrush	1	0	
<i>G. milleti</i> Black-hooded Laughingthrush	5	11	* T RR
<i>G. chinensis</i> Black-throated Laughingthrush			
<i>G. vassali</i> White-cheeked Laughingthrush	2	11	* RR
<i>G. merulinus</i> Spot-breasted Laughingthrush	0	1	* N ess
<i>G. yersini</i> Collared Laughingthrush	3	0	* T E
<i>Pelloroneum tickelli</i> Buff-breasted Babbler	0	1	*
<i>Malacopteron cinereum</i> Scaly-crowned Babbler			*
<i>Pomatorhinus hypoleucos</i> Large Scimitar Babbler			* rss
<i>P. schisticeps</i> White-browed Scimitar Babbler	2	3	* rss
<i>P. ochraceiceps</i> Red-billed Scimitar Babbler	1	0	* rss
<i>Jabouilleia danjoui</i> Short-tailed Scimitar Babbler	0	3	* T RR ess
<i>Napothera brevicaudata</i> Streaked Wren Babbler	2	0	* rss
<i>N. epilepidota</i> Eyebrowed Wren Babbler	1	0	* rss
<i>Pnoepyga pusilla</i> Pygmy wren Babbler			* rss
<i>Stachyris ruficeps</i> Rufous-capped Babbler	1	1	* ess
<i>S. nigriceps</i> Grey-throated Babbler			* rss
<i>Macronous kelleyi</i> Grey-faced Tit Babbler			N
<i>Leiothrix argentauris</i> Silver-eared Mesia			rss
<i>Cutia nipalensis</i> Cutia	1	0	* ess

Appendix 1 continued

Species	No. of stations in		Notes
	CCP	KB	
<i>Pteruthius flaviscapis</i> White-browed Shrike Babbler	4	6	* rss
<i>P. aenobarbus</i> Chestnut-fronted Shrike Babbler	3	1	* ess
<i>Minla cyanouroptera</i> Blue-winged Minla	2	1	* ess
<i>Alcippe castaneiceps</i> Rufous-winged Fulvetta			* ess
<i>A. ruficapilla</i> Spectacled Fulvetta			N ess
<i>A. peracensis</i> Mountain Fulvetta	22	7	* rss
<i>Crocias langbianis</i> Grey-crowned Crocias	0	1	* T E
<i>Heterophasia annectans</i> Rufous-backed Sibia			* ess
<i>H. melanoleuca</i> Black-headed Sibia	14	0	* ess
<i>Yuhina nigrimenta</i> Black-chinned Yuhina			*
<i>Y. zantholeuca</i> White-bellied Yuhina	5	4	*
<i>Paradoxornis gularis</i> Grey-headed Parrotbill	0	5	* ess
<i>Dicaeum agile</i> Thick-billed Flowerpecker	1	0	
<i>D. chrysorrheum</i> Yellow-vented Flowerpecker			*
<i>D. ignipectus</i> Fire-breasted Flowerpecker	9	0	*
<i>Aethopyga gouldiae</i> Mrs Gould's Sunbird	9	3	* rss
<i>A. nipalensis</i> Green-tailed Sunbird	2	1	* rss
<i>A. christinae</i> Fork-tailed Sunbird			
<i>A. siparaja</i> Crimson Sunbird	1	1	(*)
<i>Arachnothera longirostra</i> Little Spiderhunter			*
<i>A. magna</i> Streaked Spiderhunter	3	7	* rss
<i>Passer montanus</i> Eurasian Tree Sparrow			*
<i>Motacilla cinerea</i> Grey Wagtail			
<i>Lonchura striata</i> White-rumped Munia			*
<i>L. punctulata</i> Scaly-breasted Munia			(*)

Appendix 2. Endemic/restricted-range subspecies observed in the current study.

Taxon	Species		Subspecies	
	E	RR	E	RR
<i>Arborophila rufogularis annamensis</i>			*	
<i>A. brunneopectus albigula</i>			*	
<i>Blythipicus pyrrhotis annamensis</i>				*
<i>Megalaima franklinii auricularis</i>				*
<i>M. oorti annamensis</i>				*
<i>Harpactes erythrocephalus annamensis</i>				*
<i>Pitta oatesi bolovenensis</i>				*
<i>Cissa chinensis margaritae</i>			*	
<i>Oriolus traillii robinsoni</i>				*
<i>Pericrocotus ethologus annamensis</i>				*
<i>Rhiphidura albicollis cinerascens</i>				*
<i>Brachypteryx leucophrys langbianensis</i>				*
<i>Ficedula westermanni langbianus</i>				*
<i>Enicurus maculatus robinsoni</i>			*	
<i>Certhia discolor meridionalis</i>			*	
<i>Parus monticolus legendrei</i>			*	
<i>Sylviparus modestus klossi</i>			*	
<i>Aegithalos concinnus annamensis</i>				*
<i>Hypsipetes mccllellandii griseiventer</i>			*	
<i>Phylloscopus davisoni klossi</i>			*	
<i>Seicercus castaneiceps annamensis</i>			*	
<i>Garrulax milleti</i>	*			
<i>G. vassali</i>		*		
<i>G. merulinus annamensis</i>			*	
<i>G. yersini</i>	*			
<i>Pomatorhinus schisticeps annamensis</i>				*
<i>P. ochraceiceps alius</i>				*
<i>Jabouilleia danjoui danjoui</i>			*	
<i>Napothera brevicaudata rufiventer</i>				*
<i>N. epilepidota clara</i>				*
<i>Stachyris ruficeps pagana</i>			*	
<i>Cutia nipalensis legalleni</i>			*	
<i>Pteruthius flaviscapis annamensis</i>				*
<i>P. aenobarbus indochinensis</i>			*	
<i>Minla cyanouroptera orientalis</i>			*	
<i>Alcippe peracensis annamensis</i>				*
<i>Crocias langbianis</i>	*			
<i>Heterophasia melanoleuca robinsoni</i>			*	
<i>Paradoxornis gularis margaritae</i>			*	
<i>Aethopyga gouldiae annamensis</i>				*
<i>A. nipalensis ezrai</i>				*
<i>Arachnothera magna remota</i>				*

E, endemic; RR, restricted-range.

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MIKE HILL

BirdLife Seychelles, PO Box 1310, Victoria, Mahé, Seychelles

JONATHAN C. EAMES, LE TRONG TRAI and NGUYEN CU

BirdLife Vietnam, 293B Tay Son, Hanoi, Vietnam