

STRUCTURE AND COMPOSITION OF MIXED-SPECIES INSECTIVOROUS BIRD FLOCKS IN KHAO YAI NATIONAL PARK

Somchai Nimnuan¹, Philip D. Round¹, and George A. Gale²

ABSTRACT

The types and organization of mixed-species bird flocks were studied in semi-evergreen forest on the Mo-Singto Long Term Biodiversity Research Plot, Khao Yai National Park. A total of 58 species of birds was observed in 75 mixed-species flocks during May–October 2002 (average 12.8 individuals per flock, 5.9 species per flock and 2.2 individuals per species). Cluster analysis helped distinguish one well-defined flock association consisting mostly of White-crested Laughingthrushes (*Garrulax leucolophus*), White-browed Scimitar Babblers (*Pomatorhinus schisticeps*) and Red-headed Trogons (*Harpactes erythrocephalus*), and other medium-sized birds which foraged in the understorey and on the ground. Up to 16 species of small birds were also found inhabiting mixed flocks in the middle storey and canopy. Further study is needed to understand more detailed aspects of these flocks, including whether discrete flocks are maintained year-round, whether recognizable “home ranges” exist for flocks, the extent to which territory-holders participate in flocks, and to determine more precisely the costs and benefits of these mixed-species associations.

Key words: Khao Yai, bird-wave, cluster analysis, mixed-species flock.

INTRODUCTION

Mixed-species flocks or “bird-waves” are defined as aggregations of two or more species moving in a coordinated fashion for a prolonged period (HUTTO 1987). Mixed-species feeding flocks of mainly insectivorous birds are a frequent phenomenon in both tropical lowland and montane forest. Birds form flocks, both single-species flocks and mixed-species flocks, either for improved protection from predators (THIOLLAY & JULLIEN 1998), or possibly because feeding benefits may accrue to flock members (HUTTO 1988). The term is not usually applied to passive aggregations of primarily frugivorous birds around stationary food-sources such as fruiting trees. There have been relatively few studies of mixed-species flocks in Southeast Asia. Mixed-species flocks in Khao Yai were said by MCCLURE (1974) to include mainly Campephagidae, Aegithinidae, Zosteropidae, Sylviidae and Nectariniidae. More recently, KING & RAPPOLE (2001a) studied mixed-species flocks in dry dipterocarp forest (Myanmar) and indicated that there were three principal types of flocks consisting of laughingthrush flocks, warbler flocks and woodshrike flocks.

¹Department of Biology, Faculty of Science, Mahidol University, Rama 6 Road, Bangkok 10400, Thailand.

²King Mongkut's University of Technology Thonburi, School of Bioresources & Technology, 83 Moo. 8 Thakham, Bangkhunien, Bangkok 10150, Thailand.

Received 4 August 2003; accepted 10 July 2004.

We focused our attention on the types and organization of mixed-species flocks found in tropical evergreen forest in Khao Yai National Park. Specifically we wished to determine (1) which species associated in mixed-species feeding flocks; and (2) whether any particular associations among species could be identified.

STUDY AREA

The study was conducted on the Mo-singto Long Term Biodiversity Research Plot, Khao Yai National Park ($14^{\circ}26'N$, $101^{\circ}22'E$). The plot covers an area of 30 ha in the contiguous ca. 2000 km^2 forest area in the park, and has been surveyed and mapped on a 20-m grid. The locations of all trees greater than 10 cm dbh have been plotted (BROCKELMAN 1998). The plot is dominated by series of ridges and valleys with an elevation range of 723–817 m above sea level. The vegetation is mainly mature evergreen forest with small areas of regenerating secondary forest. Precipitation is 2000–3000 mm/year (Royal Forest Department data), most of which falls during May to October.

METHODS

Data were collected during May to October 2002. One three-to-four-day visit was made per month during June to September, with approximately 10 days being allocated for fieldwork during May and October. Observations were made by one observer (SN) walking established trails through the forest, listening for vocalizations (mobbing, alarm calls, contact calls) and watching for movement. All species of birds encountered were identified, using LEKAGUL & ROUND (1991) and counted, and recorded as either associating with a mixed-species flock, moving singly, or in single-species flocks. When a flock was located, it was followed for as long as possible, and the position of the flock was noted using the established grid. The number of individuals per species, for all species in each flock, was counted and this process was repeated every 15 minutes. Between counts selected individuals of as many species as possible were categorized as to feeding stratum (height above ground).

Each species was scored for percentage occurrence in total number of flocks observed, and mean number of individuals per flock. Associations between species were scored as either (1) present or (0) absent and a cluster analysis was performed on those species occurring in more than 5% of the flocks using unweighted pair-group amalgamation (linkage) rules, with the Pearson r correlation coefficient as the distance measure. Statistica 5.5 was used to perform this analysis. Species taxonomy and nomenclature throughout this account follows ROUND (2000). Scientific names of all flock-participating species are given in Table 2.

RESULTS

A total of 63 species of birds was encountered throughout the study period. Of these, 58 species were recorded apparently participating in associations of two or more species and thus considered to be in mixed-species flocks (Table 2). The five species recorded

that did not participate were Mountain Imperial Pigeon (*Ducula badia*), Blue Pitta (*Pitta cyannea*), Hill Myna (*Gracula religiosa*), Black-crested Bulbul (*Pycnonotus melanicterus*) and Stripe-throated Bulbul (*P. finlaysoni*).

A total of 75 mixed-species foraging flocks was encountered during 16 days of observation. The average flock size was 12.8 individuals per flock. On average there were 5.9 species per flock and 2.2 individuals per species (Table 1).

Nineteen species of birds occurred in more than 10% of the flocks, and 37 species in more than 5%. White-bellied Yuhina and warblers, *Phylloscopus* spp., were the most frequent participants in mixed flocks, each found at a frequency of 41%. However, the *Phylloscopus* warbler total was probably contributed by at least two species, Two-barred Warbler (*P. plumbeitarsus*) and Yellow-browed Warbler (*P. inornatus*), which the observer could not reliably distinguish. The other most frequent species found in mixed-species flocks were Greater Racket-tailed Drongo (39%), Black-naped Monarch (37%), White-crested Laughingthrush (35%), White-browed Scimitar Babbler (28%), Red-headed Tropic (24%), Large Scimitar Babbler and Striped Tit Babbler (each 20%; Table 2).

Rosy Minivet predominated in terms of the number of individuals per flock (4.75 individuals). The strongest species associations were between White-crested Laughingthrush and White-browed Scimitar Babbler (Pearson correlation $r = 0.77$, $P < 0.001$); and between Lesser Necklaced Laughingthrush and Green Magpie ($r = 0.74$), White-browed Scimitar Babbler and Red-headed Tropic ($r = 0.73$), White-crested Laughingthrush and Large Scimitar Babbler ($r = 0.67$), White-crested Laughingthrush and Green Magpie ($r = 0.66$), White-crested Laughingthrush and Lesser Necklaced Laughingthrush ($r = 0.60$). All these correlations were significant ($P < 0.001$). These six species, together with a seventh species, Laced Woodpecker, formed a moderately distinct and identifiable cluster (Fig. 1). All these species were medium to large inhabitants of middle storey and understorey, with the laughingthrushes feeding mainly on the ground.

The cluster analysis showed a dichotomy between 14 species of medium to large birds, including those mentioned above, and 23 species of smaller birds, most of which inhabited middle and upper storey and canopy. Possibly as many as 16 species of these smaller birds showed a tendency to cluster together, while within these a number of species-pairs showed apparent association (e.g., Scarlet Minivet with Bar-winged Flycatcher-shrike, $r = 0.73$, $P < 0.001$; Greenish Warbler with Sultan Tit, $r = 0.58$, $P < 0.001$, and White-bellied Yuhina with Black-naped Monarch, $r = 0.57$, $P < 0.001$; Fig. 2). There was a tendency for the flycatcher-shrike, minivets, Sultan Tit and leaf warblers to frequent the canopy, while the yuhinas and Black-naped Monarch frequented the upper-middle storey. However, there are probably too few observations at this stage to draw any detailed conclusions about the composition of small-bird flocks.

A third, rather poorly defined cluster included Ashy Drongo, Plain-tailed Warbler, Puff-throated and Grey-eyed Bulbuls, Hill Blue Flycatcher, Dark-necked Tailorbird and Striped Tit Babbler and may merely represent species that do not otherwise fit into any clear grouping. The bulbuls were both frugivorous and insectivorous, and sometimes occurred in single-species flocks and sometimes apparently joined mixed flocks. This is consistent with the observations of the other studies in the tropics (MCCLURE 1967, HUTTO 1987) in terms of passive aggregations of mixed-species foraging flocks. The insectivorous Hill Blue Flycatchers were strongly territorial and this may restrict their participation in flocks should their territory boundaries not coincide with the foraging range of the flock.

Table 1. Flock-sizes and species diversity at Mo-Singto study area (n = 75)

Variable	Average	Range
Number of individuals	12.8	2-45
Number of species	5.9	2-15
Number of individuals per species	2.2	1-10

Table 2. List of birds that occurred in flocks listed in order of frequency of encounters.

Species	Occurrence in flocks		Total individuals	Abbreviation
	Frequency	Average number of individuals		
White-bellied Yuhina (<i>Yuhina zantholeuca</i>)	0.41	2.23	69	YUH
Leaf Warbler spp. (<i>Phylloscopus plumbeitarsus</i> , <i>P. inornatus</i>)	0.41	4.39	136	GWA
Greater Racket-tailed Drongo (<i>Dicrurus paradiseus</i>)	0.39	1.31	38	GDR
Black-naped Monarch (<i>Hypothymis azurea</i>)	0.37	1.89	53	MON
White-crested Laughingthrush (<i>Garrulax leucolophus</i>)	0.35	4.62	120	WLG
White-browed Scimitar Babbler (<i>Pomatorhinus schisticeps</i>)	0.28	2.00	42	WSB
Red-headed Trogan (<i>Harpactes erythrocephalus</i>)	0.24	1.33	24	RHT
Large Scimitar Babbler (<i>Pomatorhinus hypoleucus</i>)	0.20	1.80	27	LSB
Striped Tit Babbler (<i>Macronous gularis</i>)	0.20	2.80	42	STB
Plain-tailed Warbler (<i>Seicercus soror</i>)	0.17	1.77	23	PWA
Green Magpie (<i>Cissa chinensis</i>)	0.16	1.67	20	GMG
Blue-winged Leafbird (<i>Chloropsis cochinchinensis</i>)	0.16	1.75	21	BWL
Lesser Necklaced Laughingthrush (<i>Garrulax monileger</i>)	0.15	1.55	17	NLG
Green-billed Malkoha (<i>Phaenicophaeus tristis</i>)	0.15	1.00	11	GBM
Asian Paradise-flycatcher (<i>Terpsiphone paradisi</i>)	0.13	1.00	10	APF
Orange-breasted Trogan (<i>Harpactes oreskios</i>)	0.12	1.22	11	OBT
Black-winged Cuckooshrike (<i>Coracina melaschistos</i>)	0.12	1.89	17	BCS
Greater Flameback (<i>Chrysocolaptes lucidus</i>)	0.11	1.63	13	GFB
Laced Woodpecker (<i>Picus vittatus</i>)	0.11	1.50	12	LWO
Ashy Drongo (<i>Dicrurus leucophaeus</i>)	0.09	1.29	9	ADR
Grey-headed Flycatcher (<i>Culicicapa ceylonensis</i>)	0.09	1.57	11	GFY
Emerald Dove (<i>Chalcophaps indica</i>)	0.08	1.17	7	EMD
Scarlet Minivet (<i>Pericrocotus flammeus</i>)	0.08	2.50	15	SCM
Bar-winged Flycatcher-shrike (<i>Hemipus picatus</i>)	0.08	3.17	19	BFS
Greater Yellownape (<i>Picus flavinucha</i>)	0.07	1.60	8	GYN
Green-eared Barbet (<i>Megalaima faiostricta</i>)	0.07	1.80	9	GBR
Black-naped Oriole (<i>Oriolus chinensis</i>)	0.07	1.20	6	BNO
Sultan Tit (<i>Melanochlora sultanea</i>)	0.07	4.20	21	SUT
Lesser Racket-tailed Drongo (<i>Dicrurus remifer</i>)	0.07	1.00	5	LDR
Asian Fairy Bluebird (<i>Irena puella</i>)	0.05	2.25	9	AFB
Dark-nacked Tailorbird (<i>Orthotomus atrogularis</i>)	0.05	1.75	7	DNT
Grey-eyed Bulbul (<i>Iole propinqua</i>)	0.05	2.00	8	GBU
Puff-throated Bulbul (<i>Allophoixus pallidus</i>)	0.05	2.75	11	PBU
Hill Blue Flycatcher (<i>Cyornis banyumas</i>)	0.05	1.25	5	HFY
Sulphur-breasted Warbler (<i>Phylloscopus ricketti</i>)	0.05	1.50	6	SWA
Rosy Minivet (<i>Pericrocotus roseus</i>)	0.05	4.75	19	ROM
Black-throated Sunbird (<i>Aethopyga saturata</i>)	0.05	2.00	4	BSU

Table 2. (continued).

Species	Occurrence in flocks		Total individuals	Abbreviation
	Frequency	Average number of individuals		
Little Spiderhunter (<i>Arachnothera longirostra</i>)	0.04	1.33	4	LSP
Blyth's Leaf Warbler (<i>Phylloscopus reguloides</i>)	0.04	1.67	5	BWA
Red Junglefowl (<i>Gallus gallus</i>)	0.04	1.33	4	RJF
Pale-legged Leaf Warbler (<i>Phylloscopus tenellipes</i>)	0.04	2.00	6	PLW
Black-throated Laughingthrush (<i>Garrulax chinensis</i>)	0.03	1.00	2	BLG
Black-and-buff Woodpecker (<i>Meiglyptes jugularis</i>)	0.03	1.00	2	BWO
Moustached Barbet (<i>Megalaima incognita</i>)	0.03	2.00	4	MBR
Abbott's Babbler (<i>Trichastoma abbotti</i>)	0.03	2.00	4	ABB
Great Iora (<i>Aegithina lafresnayei</i>)	0.03	2.00	4	IOR
Brown-rumped Minivet (<i>Pericrocotus cantonensis</i>)	0.03	2.00	4	BRM
White-rumped Shama (<i>Copsychus malabaricus</i>)	0.03	1.00	2	WSH
Ashy Bulbul (<i>Hypsipetes flava</i>)	0.03	2.00	4	ABU
Silver-breasted Broadbill (<i>Serilophus lunatus</i>)	0.03	2.50	5	SBB
Long-tailed Broadbill (<i>Psarisomus dalhousiae</i>)	0.03	4.00	8	LBB
Banded Kingfisher (<i>Lacedo pulchella</i>)	0.01	1.00	1	BKF
Blue-eared Barbet (<i>Megalaima australis</i>)	0.01	4.00	4	BBR
Puff-throated Babbler (<i>Pellorneum ruficeps</i>)	0.01	1.00	1	PTB
Radde's Warbler (<i>Phylloscopus schwarzi</i>)	0.01	1.00	1	RWA
Banded Broadbill (<i>Eurylaimus javanicus</i>)	0.01	2.00	2	BBB
Silver Pheasant (<i>Arachnothera longirostra</i>)	0.01	1.00	1	SPH
Oriental Pied Hornbill (<i>Anthracoceros albirostris</i>)	0.01	3.00	3	OHO

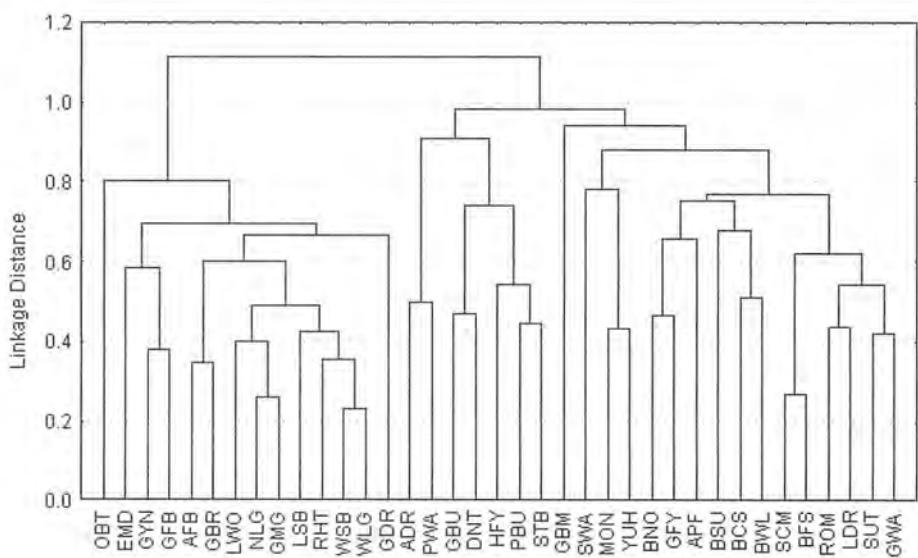


Figure 1. Cluster diagram for 37 species (those present in $\geq 5\%$ of the flocks) using unweighted pair-group averaging amalgamation (linkage) rules and Pearson r correlation coefficient as distance measure; y-axis is $1-r$.

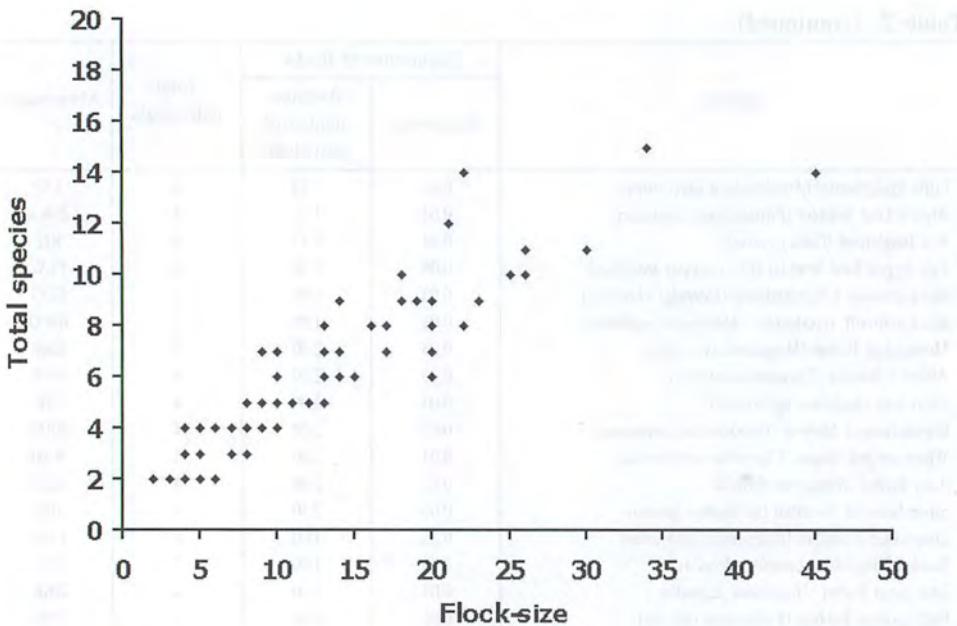


Figure 2. Correlation between total number of species and flock-size (total number of individuals) found in flocks ($r = 0.63$, $P < 0.001$).

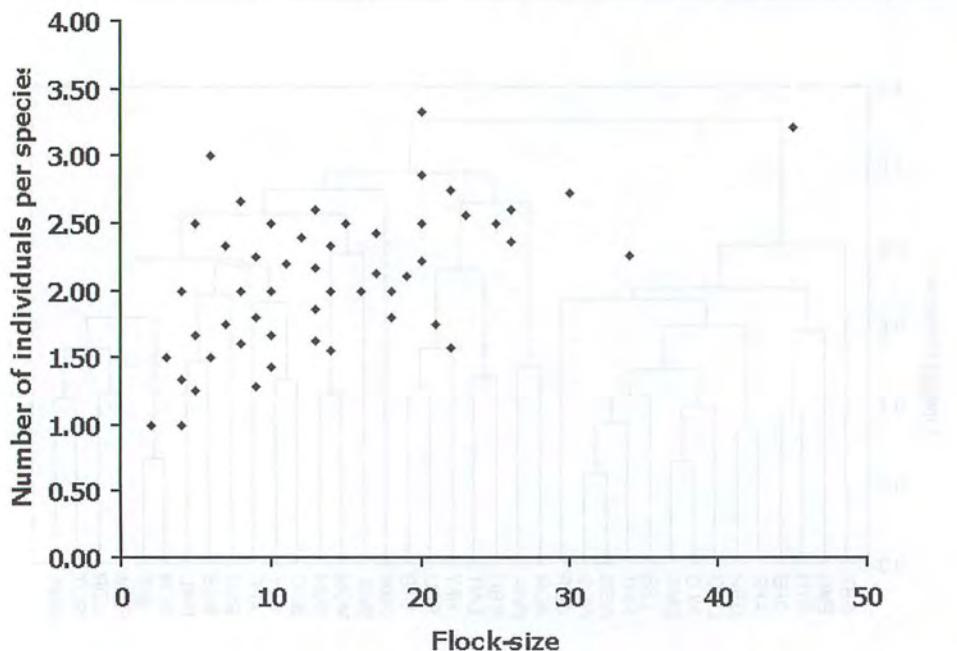


Figure 3. Correlation between number of individuals per species and flock-size (total number of individuals) found in flocks ($r = 0.54$, $P < 0.001$).

There was a significant correlation between the number of individuals and number of species in mixed-species flocks ($r = 0.63$, $P < 0.001$, Fig. 2) such that large flocks usually contained more species of birds than smaller flocks. There was also a less marked, but still significant, correlation between the number of individuals per species and flock-size ($r = 0.54$, $P < 0.001$, Fig. 3). There was no significant correlation between total flock-size and the number of two of the core flock species, White-crested Laughingthrushes ($r = 0.36$, $P = 0.07$) and White-bellied Yuhinas ($r = 0.01$, $P = 0.96$) although there was a significant correlation between total flock-size and the number of *Phylloscopus* warblers participating ($r = 0.84$, $P < 0.001$).

There were seven species recorded with flocks for which the frequency of occurrence was very low (1%) and the associations with the flocks unproven or accidental. These were Banded Kingfisher, Blue-eared Barbet, Puff-throated Babbler, Radde's Warbler, Banded Broadbill, Silver Pheasant and Oriental Pied Hornbill.

DISCUSSION

The compositions of mixed-species flocks in Khao Yai were somewhat similar to those in a very different forest type, dry dipterocarp forest, in Myanmar (KING & RAPPOLE 2001a). There, three principal types of flocks were detected: one consisting mostly of Common Woodshrike (*Tephrodornis pondicerianus*), Small Minivet (*Pericrocotus cinnamomeus*) and White-browed Fantail (*Rhipidura aureola*); a second type consisting mainly of small birds such as Arctic Warbler (*Phylloscopus borealis*), Dusky Warbler (*P. fuscatus*) and Radde's Warbler (*P. schwarzi*); and a third type which was generally centered around Greater Necklaced Laughingthrush (*Garrulax pectoralis*) and Lesser Necklaced Laughingthrush (*G. monileger*).

The relatively small number of individuals per species found during the present study suggests that most were represented in flocks by single individuals, pairs, or family groups. This was similar to the findings of POWELL (1979) and KING & RAPPOLE (2001a). The relation between total flock-size and number of species was stronger than the relation between flock size and average number of individuals per species. Flocks grew more by adding further species than by adding further individuals per species. Studies elsewhere (e.g., POWELL, 1979; MUNN & TERBORGH, 1979) have shown that territory holders join flocks; usually remaining with the flock for only as long as it remains within their territory. This would limit the number of individuals of any one species participating at any one time. In Khao Yai, for example Hill Blue Flycatchers, which are strongly territorial, would be restricted in this manner. Additionally, if a flock already contains several individuals of one species, then other, conspecific, individuals might do better to avoid the flock, and forage elsewhere in order to avoid close competition.

The flocks in Khao Yai were distributed in different foraging strata, which is consistent with the findings of other studies (MCCLURE, 1967). MCCLURE (1967) also found that there were more flocks in August, when there would be many fledged young, and fewer flocks between January and July when a majority of the birds are breeding. However the present study was of too short a duration to examine the effects of seasonality on flocking behaviour.

Some apparent flock and species-pair associations (e.g., Plain-tailed Warbler with Ashy Drongo; Grey-eyed Bulbul with Dark-necked Tailorbird) may be spurious. First, there may be too few observations to provide statistically valid associations about them. Secondly some species may not truly associate, but merely use the same microhabitat, such as White-rumped Shama and Abbott's Babbler, which both appeared to be associated with rattan clumps. In addition there is the problem of statistical type 2 errors: with a 37 x 37 correlation matrix some apparent associations might be expected to be spurious (DEVORE & PECK, 1990).

The association of Greater Racket-tailed Drongo, which was frequently associated with mixed-species flocks of laughingthrushes, invites special questions, since the drongo may be a kleptoparasite which steals food flushed by the laughingthrushes (KING & RAPPOLE, 2001b.) This was the subject of a separate study (DHANASARNPAIBOON & ROUND, 2004)

This study raises several other interesting questions for further research. For example, both residents and migrants join flocks. However most observations were made outside the migratory season (May to October), and it is possible that *Phylloscopus* warblers and other migrants might be even more frequent if observations were made throughout the winter. Further study is also needed to understand the mechanism of flock formation: whether discrete flocks are maintained year-round, and whether recognizable home-ranges or territories exist for flocks. For example, four different White-crested Laughingthrush flocks were thought to inhabit the Mo-Singto plot, each of which tended to be found in the same areas on successive days. However, at the time of this study, colour-marking, to enable individuals to be recognized and their movements tracked, had not yet commenced. Finally, further research is needed on the associations of small mammals with mixed-species bird flocks. At least three species of squirrels (Burmese Striped Tree Squirrel *Tamiasciurus macrurus*, Variable Squirrel *Callosciurus finlaysoni*, and Grey-bellied Squirrel *C. caniceps*) appeared to keep up with the birds, especially flocks of laughingthrushes, as they moved through the forest. This might indicate that they benefit from flocking behaviour in the same way as do the birds, as previously suggested by MCCLURE (1967).

ACKNOWLEDGMENTS

We thank Dr. Warren Y. Brockelman and the staff of the Khao Yai gibbon project for allowing temporary use of their accommodation, and for their help and suggestions in fieldwork. Mr. Andrew J. Pierce also gave much advice. We thank Mr Prawat Wohandee, Superintendent of Khao Yai National Park, and the Department of National Parks, Wildlife and Plant Conservation for permitting us to collect observations in Khao Yai National Park. SN would like to thank Wuttipat Raksakorn and Supatcharee Dhanasarnpaiboon for their help and encouragement in fieldwork, and his family for the encouragement and support. This work was carried out as a senior project submitted in partial fulfillment of the requirements for B.Sc. (Biology), Faculty of Science, Mahidol University.

REFERENCES

- BROCKELMAN, W. Y. 1998. Long term ecological research plot for the study of animal diets in Khao Yai National Park. Pages 307–310 in P. Poonswad (ed.), *The Asian Hornbills: Ecology and Conservation*. Thai Studies in Biodiversity, No. 2.
- DEVORE, J AND R. PECK. 1990. *Introductory Statistics*. West Publishing Company, USA.
- DHANASARNPAIBOON, S. AND P. D. ROUND. 2004. Foraging of Greater Racket-tailed Drongo (*Dicrurus paradiseus*) and Lesser Racket-tailed Drongo (*D. remifer*) in mixed species bird flocks at Khao Yai National Park. *Nat. Hist. Bull. Siam Soc.* 52: 59–67.
- HUTTO, R. L. 1987. A description of mixed-species insectivorous bird flocks in Western Mexico. *Condor* 89: 282–292.
- HUTTO, R. L. 1988. Foraging behavior patterns suggest a possible cost associated with participation in mixed-species bird flocks. *Oikos* 51: 79–83.
- KING, D. I. AND J. H. RAPPOLE. 2001a. Mixed-species bird flocks in dipterocarp forest of north-central Burma (Myanmar). *Ibis* 143: 380–390.
- KING, D. I. AND J. H. RAPPOLE. 2001b. Kleptoparasitism of Laughingthrushes *Garrulax* by Greater Racket-tailed Drongos *Dicrurus paradiseus* in Myanmar. *Forktail* 17: 121–122.
- LEKAGUL, B. AND P. D. ROUND. 1991. *A guide to the Birds of Thailand*. Saha Karn Bhaet, Bangkok. 457 pp.
- MCCCLURE, H. E. 1967. The composition of mixed species flocks in lowland and sub-montane forest of Malaya. *Wilson Bull.* 79: 131–154.
- MCCCLURE, H. E. 1974. Some bionomics of the birds of Khao Yai. *Natural History Bulletin of the Siam Society*. 25: 99–194.
- MUNN, C. A. AND TERBORGH, J. W. 1979. Multi-species territoriality in Neotropical foraging flocks. *Condor*. 81: 338–347.
- POWELL, G. V. N. 1979. Structure and dynamics of interspecific flocks in a Neotropical mid-elevation forest. *Auk*. 96: 375–390.
- ROUND, P. D. 2000. *Field Check-List of Thai Birds*. Bird Conservation Society of Thailand, Bangkok. 116 pp.
- THIOLLAY, J. M. AND JULLIEN, M. 1998. Flocking behaviour of foraging birds in a neotropical rainforest and the antipredator defence hypothesis. *Ibis*. 140: 382–394.

