

# Woodpeckers benefit from participation in mixed-species flocks in lowland deciduous forest, Huai Kha Khaeng Wildlife Sanctuary, Thailand

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## INTRODUCTION

Mixed-species foraging bird flocks, consisting of two or more species traveling together as they feed, are a common phenomenon in terrestrial habitats worldwide (Moynihan 1962, Terborgh 1990, Greenberg 2000, Sridhar *et al.* 2009). Two principal reasons for species to participate in mixed-species foraging flocks have been postulated: anti-predator vigilance and increased foraging efficiency. In general, birds participate in flocks mainly to reduce their own predation risk through detection and dilution effects (Dehn 1990).

The dilution effect occurs as the predation risk is spread among flock members; hence the risk to the individual is reduced. Predator detection is enhanced by more pairs of eyes, and individual vigilance among mixed-species flock participants is augmented or replaced through corporate vigilance (Robert 1995, Thiollay 1999, Goodale & Kotagama 2008). Nevertheless, relatively few studies have quantifiably demonstrated a relationship between vigilance and flock size. This is likely due to difficulties and ambiguity in distinguishing anti-predator vigilance from other behaviours, as many species scan for arthropod prey and predators concurrently. Vigilance behaviours may be more easily discernible and measurable in foliage-gleaning and bark-gleaning species such as woodpeckers that spend a longer time at each foraging station. For example, the frequency of vigilance behaviours (head-cocks and sideways head movements) in the North American Downy Woodpecker *Dryobates pubescens* was negatively correlated with both flock size and foraging rates (Sullivan 1984b).

Previous studies in South-East Asia have described some aspects of behaviour of species foraging in flocks (McClure 1967, Croxall 1976, King & Rappole 2001, Styring & Ickes 2001, Dhanasarnpaiboon & Round 2004), although species-specific benefits have not yet been quantified. This paper reports on observations of mixed-species foraging flocks in a heavily threatened habitat—lowland deciduous forest (Hoekstra *et al.* 2005).

The main purpose of this study was to determine the relationship between vigilance rates and participation in mixed-species flocks in woodpecker species.

## STUDY SITE

The study site was located in Huai Kha Khaeng Wildlife Sanctuary, Uthai Thani province, western Thailand. Together with the adjacent Thungyai Naresuan Wildlife Sanctuary, Huai Kha Khaeng constitutes Thailand's first UNESCO World Heritage Site in the natural heritage category and a major portion (over 60,000 ha) of Thailand's Western Forest Complex, the largest contiguous protected area in mainland South-East Asia (UNESCO 2014). Field observations and data collection were carried out near the Sub Fa Pha Ranger Station of the sanctuary (15.5383°N 99.3000°E) at elevations of 210–300 m above sea level. The habitat was a mosaic of secondary dry dipterocarp and mixed deciduous forest. In addition, bamboo forest also made up part of the habitats covered.

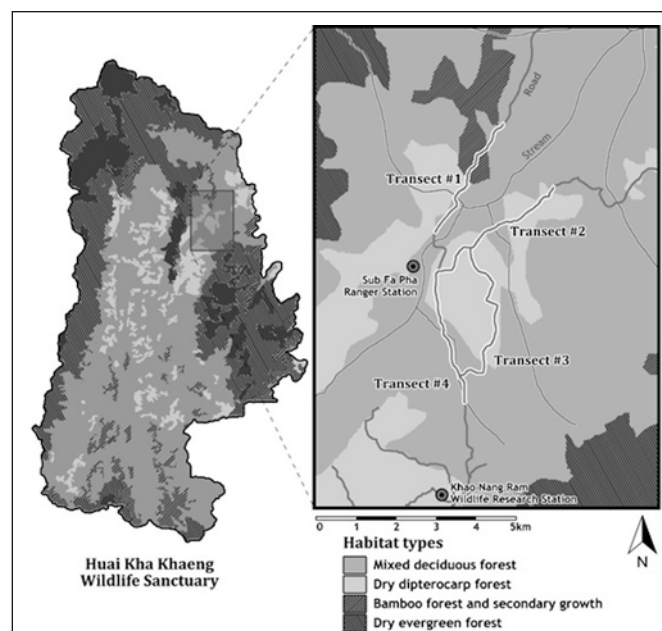
## METHODS

Observations were made while we walked slowly along laterite roads through the forest during the first and last four hours of daylight. A total of four transects, each c. 5.0 km long (Figure 1), were alternately walked during each morning and afternoon session (two transects per day). The main advantage of collecting data while walking on clear paths instead of through dense vegetation was for ease of observation and to minimise disturbance. Data were collected for at least 12 days monthly during January to December 2012.

During every encounter with any potential mixed flocking species on a transect line, we identified the species involved and number of individuals per species. A mixed flock was defined as any association of at least two species foraging within 10 m of one another that stayed together for more than five minutes (Morse 1977). Moreover, at least half of the birds in the flock must move 10 m in the same direction in order to qualify (Bell 1982, Berner & Grubb 1985). The flocking propensity of a species was defined as the number of occasions on which it was encountered in mixed-species flocks relative to the total number of encounters with that species.

Any foraging woodpecker encountered was identified and followed to collect data on vigilance, which comprised behaviours such as head-cocking, head-turning and looking-up in the midst of tapping or probing for prey in wood. Data on flock size and species of flockmates, if any, were also collected. This study followed methods used by Sullivan (1984a,b) to determine the relationship between the vigilance rate (frequency of vigilance behaviours per minute), flock size and context (inside or outside mixed-species flocks). The difference between vigilance rates of woodpecker species inside and outside mixed-species flocks was analysed statistically by incorporating the non-parametric Wilcoxon Rank Sum Test using software RStudio (RStudio Team).

**Figure 1.** Transects and habitat types in the study site.



## RESULTS

A total of 657 mixed-species foraging flocks were recorded and 117 species were considered potentially regular flock members. We obtained at least eight samples of vigilance rates both outside and inside mixed-species flocks for four species: Greater Yellowname *Chrysophlegma flavinucha* (flocking propensity 0.85;  $n = 117$ ), Lesser Yellowname *Picus chlorolophus* (0.69;  $n = 49$ ), Black-headed Woodpecker *P. erythropygus* (0.69;  $n = 254$ ) and Common Flameback *Dinopium javanense* (0.72;  $n = 219$ ). All four woodpeckers were found to be associated mainly with flocks comprising medium-sized insectivores, of which the most important for flock formation were the Lesser Necklaced Laughingthrush *Garrulax monileger*, White-crested Laughingthrush *G. leucolophus* and the Greater Racquet-tailed Drongo *Dicrurus paradiseus*. Although vigilance rates of all four woodpeckers inside and outside mixed-species flocks were highly variable (Figure 2), they were significantly lower inside mixed flocks (Wilcoxon rank-sum test  $p$ -values: Greater Yellowname 0.002, Lesser Yellowname 0.003, Black-headed Woodpecker 0.001 and Common Flameback <0.001). The species with the most data, Common Flameback, demonstrated a reduction in the mean ( $x \pm SE$ ) vigilance rate (vigilance behaviours per minute) from  $6.1 \pm 0.6$  ( $n = 17$ ) outside mixed-species flocks to  $2.2 \pm 0.5$  ( $n = 27$ ) while foraging with flocks. Similar patterns were also observed in other species:  $6.3 \pm 0.7$  ( $n = 17$ ) outside mixed-species flocks vs.  $2.5 \pm 0.5$  ( $n = 23$ ) with flocks in Greater Yellowname,  $8.0 \pm 1.0$  ( $n = 9$ ) vs.  $4.1 \pm 0.6$  ( $n = 14$ ) in Lesser Yellowname and  $8.2 \pm 0.9$  ( $n = 17$ ) vs.  $4.2 \pm 0.5$  ( $n = 19$ ) in Black-headed Woodpecker.

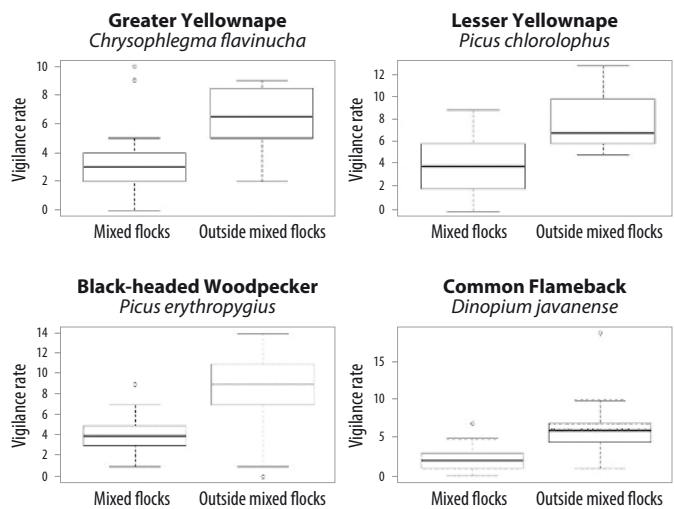
Vigilance rates significantly declined as flock size increased for all four species (Figure 3;  $p$ -values of linear models: Greater Yellowname <0.001, Lesser Yellowname 0.042, Black-headed Woodpecker 0.001 and Common Flameback 0.011).

## DISCUSSION

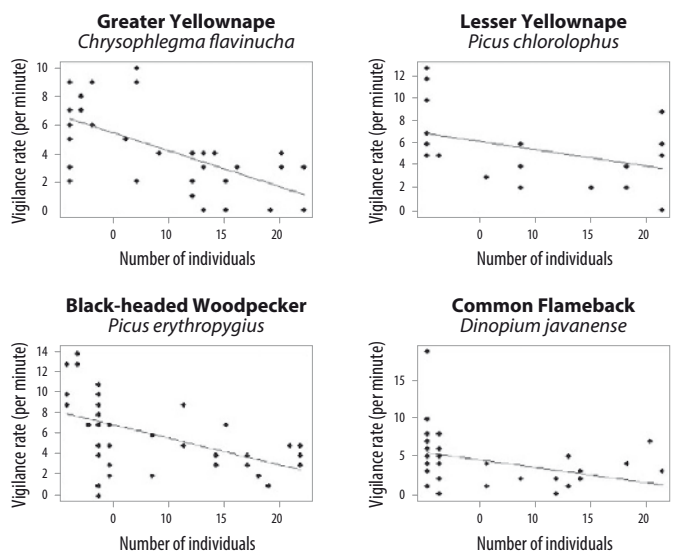
Vigilance rates and flock size were negatively correlated in woodpeckers (Figure 3). This implied that woodpeckers could afford to be less wary as flock size increased and could therefore allocate more time to foraging. The frequency of woodpecker vigilance behaviours outside mixed-species flocks was significantly higher than inside mixed-species flocks (Figure 2) and the collective vigilance benefit of mixed-species flock association was confirmed in all four woodpecker species most frequently recorded in mixed-species flocks. Other woodpecker species and, indeed, most mixed-flocking birds might also be expected to lower their vigilance while foraging in mixed-species flocks. A non-avian flockmate in the same site, Western Striped Squirrel *Tamiops mcclllandii*, was proven to play an important role in the flock as an early anti-predator alarm-caller (Limparungpatthanakij *et al.* 2017).

In support of the idea of reduced predation rates in flocks, survival rates of regular mixed-species flock members were elsewhere found to be significantly higher when foraging with mixed-species flocks than when foraging solitarily or in pairs (Jullien & Clobert 2000). All four woodpecker species in this study regularly associated with mixed-species flocks led by the Lesser Necklaced and White-crested Laughingthrushes (Limparungpatthanakij *et al.* 2014), which forage mainly on or close to the forest floor. The Black-headed Woodpecker, confined to deciduous forest of low elevations, also similarly travels in flocks and frequently forages in understorey (Winkler & Christie 2019). In the Neotropics, it was found that mature and secondary forests were particularly important for understorey flock members (Colorado Zuluaga & Rodewald 2015). Maldonado-Coelho & Marini (2004) suggested that conservation plans should focus on species important for flock formation and their preferred habitats as they found that flock structure collapsed in forest fragments where a nuclear species, Red-crowned Ant Tanager *Habia rubica*, was absent.

**Figure 2.** Vigilance rates per minute of woodpeckers (inside vs. outside mixed-species flocks).



**Figure 3.** Vigilance rate versus flock size. Leftmost column of dots represents solitary individuals. The straight line is the best fitted linear relationship of vigilance rate and flock size.



Elsewhere in tropical Asia, detections of mixed-species flocks were reduced in smaller forest fragments in which a nuclear species, Brown-cheeked Fulvetta *Alcippe poioicephala*, was less abundant (Sridhar & Sankar 2008). The extent to which habitat modification and forest fragmentation may adversely impact the abundance and survival of flock participants is a matter of conservation concern.

In order to better understand the benefits and costs to each participant in mixed-species flocks, the behaviours of individuals of the various species might be studied more thoroughly both inside and outside mixed-species flocks, such as through individual marking and perhaps telemetry. This might better elucidate the causal stimuli behind different types of heterospecific associations and interactions among flockmates.

## CONCLUSIONS

Four woodpecker species—Greater Yellowname, Lesser Yellowname, Black-headed Woodpecker and Common Flameback—showed significantly lower vigilance rates when feeding in mixed-species

flocks than when outside such flocks. Their vigilance rates also declined as flock size increased. This implies that they benefitted from joining mixed-species flocks through corporate vigilance. This finding accords with that of Sullivan (1984b) for the North American Downy Woodpecker.

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