Mass northbound migration of Blue-tailed *Merops philippinus* and Blue-throated *M. viridis* Bee-eaters in southern Thailand, spring 2007–2008

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Counts of migrating Blue-tailed Bee-eaters *Merops philippinus* and Blue-throated Bee-eaters *M. viridis* were made from late February through early April 2007 and again in spring 2008 in southern Thailand at Promsri Hill, just west of the city of Chumphon. A total of 20,916 bee-eaters were counted, averaging 24.1.birds/hour in 2007 and 31.9.birds/hour in 2008, the highest totals for any migrating *Merops* spp. to date. *M. philippinus* composed 95.5% (18,079) of the bee-eaters identified in migration. *M. viridis* was much less common, composing only 4.5% (854) of identified migrants. There were also 1,983 unidentified *Merops* migrants, 9.5% of the total flight. In 2007 and 2008, the first migrant flocks of both species were seen by late February-early March. The seasonal peak of the *M. philippinus* flight was in mid- to late March. The peak of the *M. viridis* flight occurred in late March through early April. Significantly more bee-eaters were counted when winds had an easterly component sea-breeze (NE, E, SE) from the nearby Gulf of Thailand, than when winds were from other directions. The daily peak of bee-eater migration occurred in the early afternoon from 12h00 to 14h00, with increasing easterly winds, one to two hours earlier than the peak of raptor migration. Because of the significant year-to-year variation in numbers of migrants counted at our watch site, we recommend (a) additional counts be made from early February through late May to determine the extent of spring bird migration through this area of South-East Asia; (b) initiate a satellite telemetry tracking program for migratory *Merops* spp. to determine where in the Oriental region these two species are returning to breed; (c) establish a network of migration watch sites in Thailand, and when practicable, neighbouring countries, in order to map diurnal landbird migration routes and important stopover areas, similar to the Asian Waterbird Census; and (d) develop educational materials, such as coloring books for children and on-line information flyers with color photographs for adults, to make everyone aware of this spring migration phenomenon in southern Thailand.

INTRODUCTION

During the last half-century, biologists have begun to map broad patterns of bird migration on continental South-East Asia via satellite telemetry, bird banding and point count observations (McClure 1974, Lane & Parish 1991, McClure 1998, Tordoff 2002, DeCandido *et al.* 2004b, Higuchi *et al.* 2005, DeCandido *et al.* 2006, Shiu *et al.* 2006, Yamaguchi *et al.* 2008). Two of the most distinctive non-passerine species that migrate by day through the Thai-Malay peninsula are the Blue-tailed Bee-eater *Merops philippinus* and Blue-throated Bee-eater *M. viridis* (DeCandido *et al.* 2004a, Wells 1999, Burt 2002, Marks *et al.* 2007, Round 2008). During spring migration, *M. philippinus* are returning to breed as far north as 27°N from south-west China east to Kinmen Island (Taiwan), possibly with a small population at 30°N, while *M. viridis* are returning to breed in southern China to around 33°N (Cheng 1987, Fry *et al.* 1992, Duckworth *et al.* 1999, Carey *et al.* 2001, Liu & Lei 2005–2008, Liu *et al.* 2008, Round 2008, Wang *et al.* 2009, Wu *et al.* 2009). Bee-eaters use a combination of thermal soaring/gliding as well as active flapping flight during migration (Fry *et al.* 1992, Sapir 2009). However, little is known about the magnitude, timing, seasonal duration or daily pattern of migration of any bee-eater species in spring (February–April) or autumn (August–December) on continental eastern Asia.

As part of our research on raptor migration in Thailand (see DeCandido & Nualsri 2009), we also monitored northbound *Merops* migration near the city of Chumphon. Our study site, Promsri Hill (elevation 144 m), afforded an opportunity to study the migration of these birds passing over the open countryside of southern Thailand on the Isthmus of Kra. Specific research questions were: (1) what is the relative proportion of *M. philippinus* vs *M. viridis* during northbound migration; (2) what is the degree of year-to-year variation in the number of *Merops* counted in migration at this watch site; (3) is there a difference in the seasonal timing of migration between the two species; (4) how do wind speed and direction affect bee-eater migration (see Liechti 2006); and (5) how does the pattern of bee-eater migration compare to raptor migration in southern Thailand? By addressing such questions, we hoped to provide information to biologists, conservationists and birdwatchers interested in understanding a crucial time in the life history of these two bee-eater species. From a broader perspective, documenting spring *Merops* migration phenology provides baseline data to those interested in understanding the relationship between climate change and large-scale animal migrations. Several recent studies have reported shifts in the timing of known bird migrations during the last decade (Shi *et al.* 2006, Gordo 2007), and we wanted to stimulate interest in this possibility in South-East Asia by studying some of the region's migratory birds.

METHODS

Chumphon (10°28′N 99°13′E, sea-level) is a small town near the east coast of south-central Thailand, c.475 km south-west of Bangkok. The city is located on the Isthmus of Kra, the narrowest portion of Thailand. From late February to early April 2007 and again in 2008, we made daily counts of bee-eaters, migrating raptors and other land birds from a site 15 km west of Chumphon City known locally as Promsri Hill or Khao Klai. The watch site (10°30′N 99°04′E) afforded an unobstructed 360° view of northbound migrants, and sits on the crest of a hill, c.5 km west of the main N–S highway (Phetkasem Road, Highway 4). The hill is the southern terminus of a low N–S ridge on military land, and is accessible by permit only. Much of this ridge comprises seasonal grasses, scrub

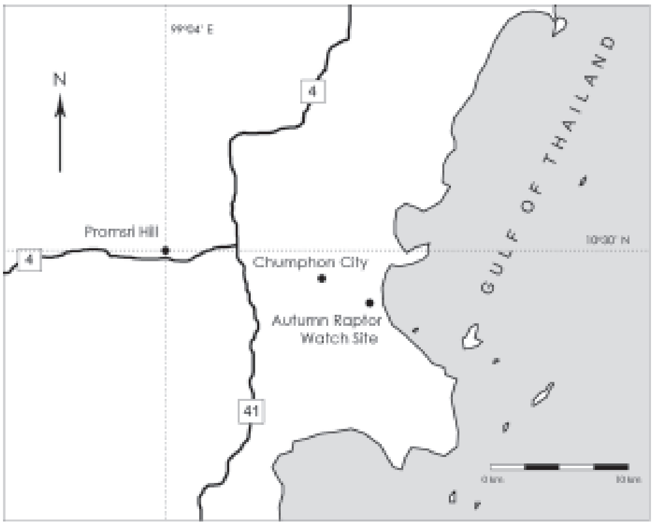

Figure 1. Detailed map of south-central Thailand showing the Promsri Hill migration watch site in relation to Chumphon City, the main road (Route 4), and the autumn raptor watch site used since 2000.

and second growth, on average less than 2 m in height. Most of the surrounding area and nearby hills have been developed for pasture and agriculture (banana, oil palm), with second-growth forest occupying perhaps the upper 10% of these hills. On clear days it was possible to see east c.25 km to the Gulf of Thailand; south c.5 km to a tall hill (Khao Thai Dang); west c.10 km to a hill (Khao Nam Lod) that is part of a N–S ridge; and north c.3 km.

Two species of bee-eater, *Merops philippinus* and *M. viridis*, were counted on migration by RDC and CN using 8× and 10× binoculars. We often had help from others who visited the site on a daily basis, usually after 13h00, and called migrant flocks to our attention that might otherwise been overlooked. We made daily counts during the course of two spring seasons: in 2007, from 28 February to 3 April (35 days; 388 hours of observation); and in 2008, from 28 February to 31 March (32 days; 343 hours of observation). Observations usually began by 07h00 local time, and ended by 18h30 each day. In 2009, CN made observations on migrating bee-eaters and raptors up to three days per week from 1 April to 10 May. During inclement weather such as thunderstorms, we remained in the area of the watch site looking for migrants. For one day in 2008 when rain prevailed all day (10 March), no count was made. Since Wells (1999) mentioned that a few flocks of *M. viridis* were heard migrating at night in Malaysia, we listened for calls of migrant individuals (flocks) for 2–3 hours up to four evenings per week beginning at around 19h00 from the terrace of our residence in the adjacent valley, c.300 m from the watch site.

In both years, wind speed and direction, temperature, humidity and barometric pressure were measured hourly with a hand-held weather station (Kestrel 4000, Nielsen-Kellerman corporation, USA). Wind direction was determined with a compass. Weather conditions typically were hazy and humid with little wind in the morning until 09h00, then becoming clear with scattered cumulus clouds. Until c.09h00 to as late as c.11h00 each day, light west (less than 10 km/hr) winds prevailed, then these switched to easterly due to the interaction of the north-east low-pressure monsoon (Guo *et al.* 2002) combined with a sea-breeze from the nearby Gulf of Thailand (Khedari *et al.* 2002). However, the exact timing of the wind switch varied greatly in 2007 compared with 2008, as did the intensity of the easterly winds.

To locate migrating flocks of bee-eaters, observers scanned primarily to the south and south-east, the direction from which almost all migrants approached the watch site. Many bee-eaters were first heard calling as part of a flock before being seen, and with experience it was possible to locate and distinguish flocks of the two species from these calls. Bee-eaters were considered migrants if they passed south to north across an imaginary east to west line at the watch site, and continued north and out of sight. We did not attempt to age or sex migrants. In order best to evaluate the daily and seasonal pattern of bee-eater migration, we pooled the 2007–2008 data of all individuals we counted at the site, including those *Merops* individuals we could not identify to species. To determine the seasonal peak migration period for *M. philippinus* in 2007 and 2008, we used the highest ten-day average in each year. Since we saw many fewer *M. viridis* individuals, we used the highest five-day average in both years to determine their seasonal peak of migration through southern Thailand. We also calculated a median date of peak passage (the date at which 50% of the migrants had

Figure 2. Map of the Far East showing the two primary continental spring bee-eater migration count sites: (1) Promsri Hill (Thailand) and (2) Tanjung Tuan (West Malaysia). *Merops philippinus* return to breed as far north as 27°N from south-west China east to Kinmen Island (Taiwan), while *M. viridis* return to breed in China to approx. 33°N.

been counted) for each bee-eater species, by pooling 2007–2008 data.

We hypothesised that more bee-eaters would pass the watch site when winds had an easterly component (NE to SE) than when winds were from other directions, primarily west to south. Data from prior studies (DeCandido *et al.* 2004, DeCandido & Nualsri 2009) indicated that during migration in this part of Thailand, many birds including raptors 'drift' to the east (spring) or west (autumn) with the prevailing winds. Our initial observation of migrant *Merops* flocks in February 2007 indicated this was also the case with bee-eaters at our watch site. We used a Chi-square test with one degree of freedom (Preacher 2001) to analyse the effect of wind direction on the number of bee-eaters passing the watch site.

We also counted individuals of several raptor species on migration by hour during spring 2007–2008, most commonly: Black Baza *Avecida leuphotes*, Chinese Goshawk *Accipiter soloensis*, Grey-faced Buzzard *Butastur indicus*, Japanese Sparrowhawk *Accipiter gularis* and Oriental Honey-buzzard *Pernis ptilorhynchus orientalis* (details in DeCandido & Nualsri 2009). We compared the hourly raptor migration counts to the hourly bee-eater migration counts in both years to examine the effects of weather (primarily wind speed and direction) on migrant flocks of bee-eaters and raptors. We also noted other migrant species including small numbers of Ashy Minivet *Pericrocotus divaricatus* travelling in flocks; small numbers of Ashy Woodswallow *Artamus fuscus* and Black Drongo *Dicrurus macrocercus* migrating as singles; Oriental Pratincole *Glareola maldivarum*; Sand Martin *Riparia riparia*, Red-rumped Swallow *Hirundo daurica*, Striated Swallow *Hirundo striolata* and many Barn Swallow *Hirundo rustica*. Certain species were recorded only as seasonal or year-round residents in the area: Brown-backed Needletail *Hirundapus giganteus*, White-throated Needletail *Hirundapus caudacutus*, Fork-tailed Swift (both *Apus p. pacificus* and *A. p. cooki*), House Swift *Apus affinis*, Germain's Swiftlet *Collocalia germani* and Asian Palm Swift *Cypsiurus balasiensis*. To identify migrants, we consulted Lekagul & Round (1991), Wells (1999) and Robson (2002). Scientific names follow Inskipp *et al.* (1996).

RESULTS

Most bee-eaters were observed migrating south to north within 100 m of the watch site, and were only observed travelling in flocks. Beyond c.125–150 m, it was very difficult to detect and identify a small flock of birds even with 10× binoculars. Only single species flocks were observed: individuals of *M. philippinus* were never observed in *M. viridis* flocks or vice versa. Rarely, flocks of the two species migrated within c.25 m of each other.

In 2007–2008, a total of 20,916 bee-eaters were counted, averaging 24.1.birds/hour in 2007 and 31.9.birds/hour in 2008. Two-year totals were 18,079 *M. philippinus* (95.5% of all *Merops* we identified to species), 854 *M. viridis* (4.5%) and 1,983 unidentified *Merops* individuals (9.5% of the total flight). In spring 2008, we counted 2,220 (23.7%) more migrant *Merops* than spring 2007. Figure 3 shows the hourly count of all bee-eater migrants for 2007–2008. Most bee-eaters were seen from 11h00–16h00 (66.7%) with 13h00–15h00 being the peak time for migrants (30.0% of all bee-eaters

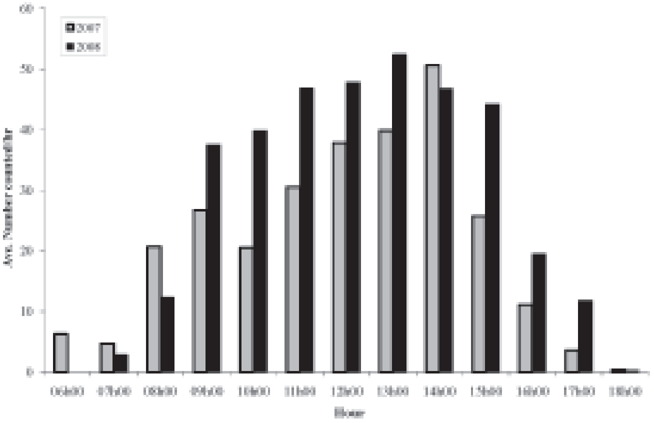

Figure 3. Average number of bee-eaters counted by hour in spring 2007–2008 at Promsri Hill, Thailand.

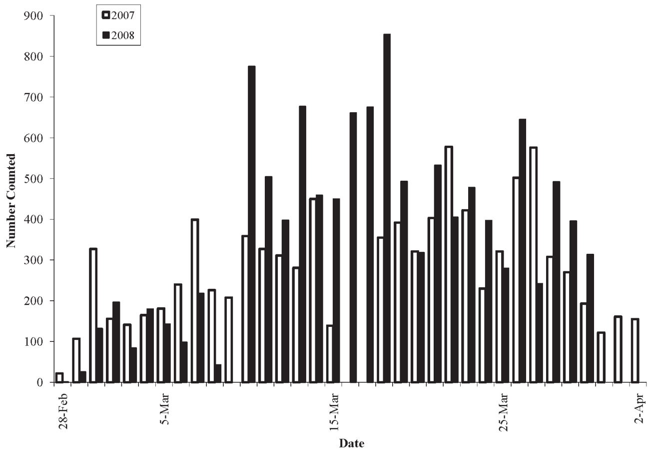

Figure 4. Number of bee-eaters counted per day in spring 2007–2008 at Promsri Hill, Thailand.

counted). However, the single peak hour of migration in 2007 (14h00–15h00) was an hour later compared with 2008 (13h00–14h00). The highest hourly total occurred from 15h00–16h00 on 11 March 2008 when 243 bee-eaters passed the watch site.

Figure 4 shows daily totals of bee-eater migrants in both spring seasons. In 2007, the peak 10-day time-frame of the migration occurred from 18 March to 27 March inclusive, averaging 410 migrants/day. In 2008, the peak time-frame occurred from 11 to 20 March, averaging 595 migrants/day. The highest single-day count of migrating bee-eaters in this study was 854 on 19 March 2008. In spring 2007–2008 the median date of peak passage for all bee-eaters in southern Thailand was 19 March.

The first flock of migrating *M. philippinus* was seen on 28 February 2007, and on 1 March in 2008. The first flock of migrating *M. viridis* was seen on 3 March 2007 as well as 3 March 2008. The two species were observed on migration until the last day of the study in both years. In 2009, CN observed flocks of both species until 5 May.

Figure 5 shows the 2007–2008 average number of *M. philippinus* vs *M. viridis* seen per day at the Promsri Hill watch site. Our data indicate that the seasonal peak of *M. viridis* occurs in late March to early April, several days later than the peak of *M. philippinus*. The two-year median date of peak passage for *M. philippinus* was 20 March and for *M. viridis* 28 March.

In 2007, for the ten-day peak time-frame (19–28 March) for *M. philippinus*, the mean flock (N= 349 flocks) size was 9.2 birds (Standard Deviation [S. D.] = 9.6). On 28 March 2007, the mean flock size for *M. philippinus* (N = 496; 54 flocks) was 9.2 (S.D. = 5.2). The largest flock of migrant *M. philippinus* was 107, passing the watch site between 14h00–15h00 on 23 March 2007. For *M. viridis* in 2007, for the five-day peak time-frame of migration (27–31 March), the mean flock size (N = 23 flocks) was 7.9 (S.D. = 5.1). In 2007, the largest flock of migrant *M. viridis* was 18, passing the watch site between 11h00–12h00 on 27 March.

In 2008, for the ten-day peak time-frame (11–20 March) for *M. philippinus* migration, the mean flock size (N = 458 flocks) was 10.9 (S.D. = 10.0). On 19 March 2008, the mean flock size for *M. philippinus* (N = 831; 78 flocks) was 10.7 (S.D. = 8.5). In 2008, the largest flock of migrant *M. philippinus* was 63, passing the watch site between 11h00–12h00 on 12 March. For *M. viridis* in 2008, for the five-day peak time-frame of migration (27–31 March), the mean flock size (N = 51 flocks) was 6.1 (S.D. = 5.8). In 2008, the largest flock of migrant *M. viridis* was 27, passing the watch site between 09h00–10h00 on 27 March.

In both years, significantly greater numbers of bee-eaters passed the watch site when winds had an easterly (NE, E or SE) component than when winds were from other directions ($\chi^2 = 17.2$, $p < 0.05$). Bee-eaters approaching the watch site used flapping flight interspersed with glides, occasionally soaring upwards on thermals combined with deflection currents on the east side of the observation ridge. Most flocks were migrating less than 20 m above observers' heads, and frequently the flocks came up the hillside at eye-level to feed on insects just above the surrounding vegetation. Occasionally, especially during spring 2007 before 09h00, flocks would stop to feed for up to 10 minutes c.25 m beyond the watch site, using bare tree branches as hunting perches.

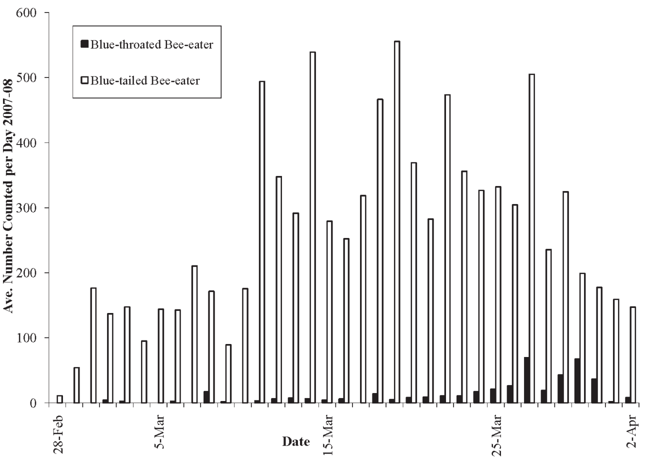

Figure 5. Average number of Blue-throated *vs* Blue-tailed Bee-eaters counted per day in spring 2007–2008 at Promsri Hill, Thailand.

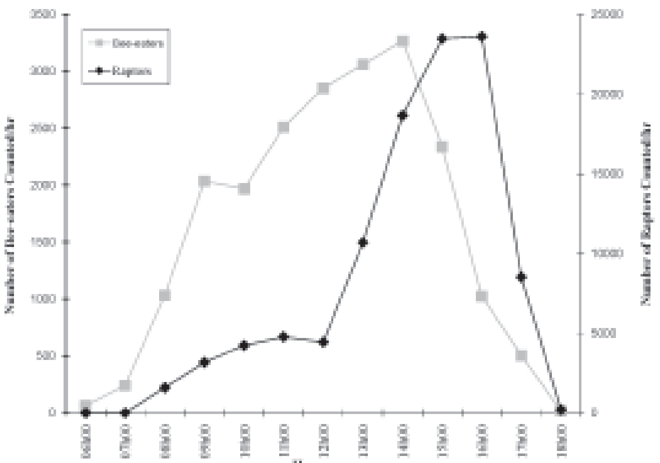

Figure 6. Total number of bee-eaters *vs* raptors counted by hour in spring 2007–2008 at Promsri Hill, Thailand.

Figure 6 shows the hourly pattern of bee-eater vs raptor migration in spring 2007–2008. In the morning, migration activity began on average at about 07h30 (bee-eaters) and 08h00 (raptors). Flocks of bee-eaters began to pass the watch site while individuals of three raptor species, Black Baza, Chinese Sparrowhawk and Grey-faced Buzzard, began to coalesce into flocks and slowly soar up on strengthening thermals mostly to the east (50 m to 5 km) of the watch site. Migrant bee-eater numbers began to increase markedly by 08h00 but levelled off between 09h00 and 10h00 at the watch site. During the morning, raptor migration increased slowly until 11h00 and then levelled off. However, from late morning to early afternoon, bee-eater migrants were seen in increasing number until 14h00. By comparison, although raptor migration also increased markedly in the afternoon, it peaked one to two hours later than the peak passage of bee-eaters (Fig. 6). Bee-eater migration usually ended by c.17h45 while raptors, particularly Black Bazas, Chinese Sparrowhawks, Grey-faced Buzzards and Oriental Honey-buzzards, continued their migration.

DISCUSSION

Southern Thailand, particularly the area near the city of Chumphon on the Isthmus of Kra (Figs. 1 & 2), is a spring and autumn hotspot for many birds that migrate by day, including bee-eaters, Black Drongos (DeCandido *et al*. 2004c) and raptors (DeCandido *et al*. 2004b, DeCandido & Nualsri 2009). Bee-eaters are colourful and gregarious birds, yet little is known about their migration route(s) and ultimate destination(s) in the region during either north- or southbound migration. Historically in Indochina, only a handful of bee-eater migration reports have presented empirical data, often from only single days of observation (see David-Beaulieu 1944, 1949-1950, Melville & Fletcher 1982, Tizard 1996, Evans 2001). The only long-term study of migrant bee-eaters in eastern Asia comes from Hong Kong (Carey *et al*. 2001), where a mean of 22.0 *M. philippinus* were counted each spring during the 1990s.

Our observations at Promsri Hill confirm a significant northbound migration of two bee-eater species, *M. philippinus* and *M. viridis*, through Thailand each spring (Fig. 4). The number of migrants reported in this study are the highest totals for any location in Asia: 18,079 *M. philippinus* (95.5% of identified individuals), 854 *M. viridis* (4.5%) and 1,983 unidentified *Merops* individuals (9.5% of the total flight). Average flock size was greater for *M. philippinus* than for *M. viridis*, and the largest flocks of *M. philippinus* were two to three times larger than *M. viridis* flocks. Overall, our spring counts averaged 28.6 bee-eaters/hr in 2007–2008 with the highest hourly count (287) on 23 March 2007. By comparison in spring 2000–2001 at a location on coastal West Malaysia (Tanjung Tuan), bee-eaters averaged 12.9 migrants/hr with a peak hourly total of 101 on 21 March 2001 (DeCandido *et al.* 2004a). Other published accounts including Wells (1999) and DeCandido *et al.* (2004d) also reported many fewer migrant *M. viridis* in Malaysia during spring. However in Laos, migrant *M. viridis* are considered to be much more common than migrant *M. philippinus*, but the latter is the only year-round resident *Merops* breeding there (David-Beaulieu 1949–1950, Evans 2001, Dersu & Associates 2008, W. Duckworth *in litt.* 2009).

Prior bee-eater research in South-East Asia on coastal west Malaysia revealed that the spring migration of bee-eaters begins in earnest in early March (DeCandido *et al.* 2004a,d). Our data show that the peak of the *M. philippinus* migration in southern Thailand is from mid- to late March (Fig. 5), with 20 March being the median date of peak passage. This is slightly earlier than Wells (1999), who reported peak passage in Malaysia from late March through early April. After mid-April, no *M. philippinus* were seen migrating in Singapore, while the migration in Malaysia was mostly complete by early May (Wells 1999). Observations made by CN at Promsri Hill in April to mid-May 2009 are in agreement with these reports: up to 100 *M. philippinus* were seen in migration per day through late April, declining to ≤ 30/day by early May.

Our 2007–2008 data suggest that the *M. viridis* migration peaks in late March to early April in southern Thailand (Fig. 3), with 28 March being the median date of peak passage, more than a week later than *M. philippinus*. The first flock of *M. viridis* was seen on 3 March 2007, a few days after the first flocks of *M. philippinus* had passed our watch site. Observations by CN in spring 2009 show that up to 20/day *M. viridis* migrate through southern Thailand through late April, declining to ≤ 10/day in early May. However, because we were only able to do part-time counts in spring 2009, it might be that later arriving *M. viridis* were overlooked, leading us to miss the true migration peak for this species in southern Thailand. Round (2008) suggested that *M. viridis* migration peaks 2–4 weeks later than *M. philippinus*, with 'a discernible return passage in southern Thailand noted in late April'. In Laos (Savannakhet province) on 12 April 2007, a flock of 20 was observed (Dersu & Associates 2008). In Hong Kong, seven *M. viridis* were seen at Shuen Wan on 24 April 2008 (G. Welch *in litt.* 2009). In Malaysia, Wells (1999) reported the peak of the spring *M. viridis* migration from March through early April. Wells (1999) also suggested that the *M. viridis* migration begins earlier in the season than *M. philippinus* migration, with the earliest migrant *M. viridis* seen in Singapore on 23 and 25 January; on the west coast of Malaysia on 11 February; and scattered migrant flocks in central Thailand by mid-February. In southern Thailand, further full-time observations are needed in April to determine the extent and peak migration time for *M. viridis*.

Wind direction was the most important factor in the number of bee-eaters we counted in migration in spring 2007 and 2008. Significantly more bee-eaters were seen when winds had an easterly component than when winds were from other directions. Figure 4 shows the effect of this east wind (sea-breeze), from the Gulf of Thailand c.25 km to the west of the watch site. In both years, the easterly sea-breeze increased throughout the day as thermal strength developed, and combined with winds from the north-east low-pressure monsoon (Simpson 1994, Guo *et al.* 2002, Khedari *et al.* 2002). Migrating bee-eaters and raptors 'drifted' inland toward the watch site because of this prevailing late morning through afternoon easterly wind (Fig. 6; see also DeCandido & Nualsri 2009). Greatest number of migrants were observed on afternoons with these conditions, particularly in spring 2008, when east winds generally began earlier and were a few km/hr stronger than in 2007 (Fig. 64). We recorded a 23.7% increase in the number of bee-eaters counted in migration in 2008, as well as an earlier hourly peak in the flight (Fig. 3). On the other hand in autumn 2003, during a southbound raptor migration study at a watch site east of the city of Chumphon (Fig. 1), we counted most migrants before 12h00 when winds were from the north-west (DeCandido *et al.* 2004). During the southbound migration season in southern Thailand, particularly before 12h00, westerly winds predominate, because of the presence of the south-west high pressure monsoonal weather system centred over the Bay of Bengal–Andaman Sea (Singhrattna *et al.* 2005, Hoyos & Webster 2007).

At Promsri Hill, the earlier arrival of bee-eaters than raptors in the morning was due to several factors including: the greater proportion of bee-eaters that began migration earlier than raptors; the greater degree to which bee-eaters used active flight, and the lesser dependence on thermals than broad-winged raptors; and finally, the greater likelihood that bee-eaters would drift inland and pass the watch site on light (< 5 km/hr) easterly winds beginning by c.08h00 (Fig. 6). Typically, at Promsri Hill, bee-eater migration was underway by 07h30 each morning with flocks stopping to feed in the area of the watch site for up to 15 min before resuming migration. In 2007–2008, the nearby lowlands were often foggy in the early morning, while the watch site atop Promsri Hill and surrounding highlands were clear, with insect activity. As easterly winds (and thermal activity) increased by 09h00, flocks of bee-eaters passed the watch site, and the first strong movement of raptors began (Fig. 6). During the day, single-species flocks of bee-eaters frequently came up the hill at or just above eye-level, with individuals pursuing and catching insects on the wing. Members of the flock migrated across a 10–30 m front, and it might be 1 min before all migrants in a large flock passed the watch site. Bee-eaters were very vocal on migration, and with some experience the two species could be distinguished by their calls. From c.13h00 until 16h00, many *Merops* flocks soared 50–75 m above the watch site utilising thermals and deflection currents from the ridge, but after 16h00 bee-eaters were almost always again passing at eye-level. By 18h00, when bee-eater migration had ceased, flocks did not roost in trees near the watch site. Although Wells (1999) reported nocturnal migration of *M. philippinus* in Malaysia, we did not detect bee-eaters passing over our residence in the nearby valley at night.

In the future, we hope that biologists address several questions about bee-eater migration in Thailand: is the peak of *M. viridis* migration in late March/early April as our data suggest, or later in April? Do the first bee-eater flocks pass the Promsri Hill watch site in the first half of February, or as early as January? Is the spring migration of bee-eaters concluded by early May, or do some flocks continue to pass through southern Thailand into June? How extensive is the migration to the west and east of Promsri Hill? Data from 1 April 2004 show that at least

100 *M. philippinus* migrated north in 90 minutes of observation at a site c.18 km to the west of Promsri Hill (S. F. Bailey *in litt.* 2009). This suggests that the total number of *Merops* migrating through southern Thailand each spring could be in the order of 50,000–100,000 birds. Perhaps the most important question to answer is: where are these north-bound bee-eaters returning to nest in Asia? Our *Merops* migration data recorded in 2007–2008 at Promsri Hill, combined with our previous study in Malaysia (DeCandido *et al.* 2004a), suggest that some of these migrants are the same ones observed in Hong Kong where the peak of spring migrant sightings is 24 April to 17 May (see Carey *et al.* 2001). At Kinmen Island (Taiwan) *M. philippinus* return each year in April to breed (Yuan *et al.* 2006). Early arrival dates from 2005–2009 range from 9 to 12 April, with the majority of the migrants arriving several days later (H.-W. Yuan *in litt.* 2009). It is not known if these *M. philippinus* primarily utilised a continental (overland) route to reach Tinmen, or made long-distance over-water crossings from the Philippines and Borneo similar to the route used by migrant Chinese Sparrowhawks and Grey-faced Buzzards each spring (see Germi 2009). By comparison, in southern China the first *M. philippinus* arrive from 26 March each year, and begin nesting in mid-April (Wu *et al.* 2009).

'Both *M. philippinus* and *M. viridis* breed over a wide latitudinal range, in different climates and habitats. It is likely there are differences in timing of breeding at different latitudes, and migration timing would therefore also be expected to differ between populations of both species. *Merops philippinus* is already nesting by February in Indochina, and it is unlikely that migrants observed in March–April at Promsri Hill are from populations that return to breed in central and northern Thailand, Laos, Cambodia, Vietnam and environs (see Duckworth *et al.* 1999, Evans 2001). Rather, it is likely that the *Merops* we observed in migration are returning to nest in southern China east to Kinmen Island, Taiwan.

Further bee-eater migration surveys are needed in South-East Asia to determine the precise timing and migration phenology of different populations of these two species. We recommend that a coordinated network of 3–4 migration study sites be established across Thailand and Malaysia, and, when feasible, in the rest of South-East Asia similar to the regional approach taken by the Asian Waterbird Census to monitor migrants and protect critical habitats along that flyway. Satellite telemetry tracking of several bee-eater migrants in spring would quickly elucidate migration route(s), critical stopover areas and ultimate destinations (see Higuchi *et al.* 2005). Finally, we recommend that educational materials for children including on-line resources such as drawings of the local birds, as well as colouring books, be made freely available. For adults, on-line information flyers about bee-eaters and other migrants in South-East Asia (see van de Kam *et al.* 2008) written in Thai be developed, and these should include requests for information about *Merops* sightings during migration seasons.

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