MAGNITUDE AND TIMING OF MIGRANT RAPTORS IN CENTRAL JAVA, INDONESIA

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A study of visible migration of raptors through the Dieng Mountains, Central Java, Indonesia, was based on six sites perpendicular to the axis of migration. At least 30 000 raptors migrated through the area annually over an 8-week period in Sep-Nov. The migration mainly comprised Japanese Sparrowhawks *Accipiter gularis* (estimated total of 3500 individuals annually), Chinese Sparrowhawks *A. soloensis* (23 000), and Oriental Honey-buzzards *Pernis ptilorhyncus* (2500). For these three species, the central 75% of the population passed during a 2-4 week period (Japanese Sparrowhawk: 18d; Chinese Sparrowhawk: 14d; Oriental Honey-buzzard: 29d). The Dieng Mountains are one of less than ten sites in SE Asia where >10 000 raptors pass annually. Monitoring raptors at other sites along the Australasian migratory pathway would increase information about migration timing, species composition, and species-, age- and sex-specific patterns of East Asian raptors.

Key-words: *Accipiter gularis - Accipiter soloensis - Pernis ptilorhyncus* - migration - monitoring

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INTRODUCTION

Every year millions of birds of hundreds of species from Eastern Asia migrate south to Indochina, Indonesia and Australia (Lane & Parish 1991). Yet, in comparison with other bird migration systems, the Asian-Australasian flyway remains relatively little studied. As Nisbet (1976) noted, in East Asia the area suitable for insectivorous birds in midwinter is limited because, under the cold winds of the northeast monsoon, the 10°C isotherm moves in January to the Tropic of Cancer. The area of land further south (excluding New Guinea and Australia where few migrants winter) is less than 4 million km^2 and supports the birds breeding in a region 5-6 times larger. Moreover, these winter quarters are fragmented into a complex pattern of islands and peninsulas, forcing birds to make sea crossings (Nisbet 1976). Within the wintering area, the number of migratory raptors gradually decreases towards the south and southeast. Hitherto, 20-22 migratory raptor species are known from Thailand and Peninsular Malaysia (Lekagul & Round 1991; Bijlsma 1996; Wells 1998), 14-16 from Sumatra and Borneo (van Marle & Voous 1988; MacKinnon *et al.* 1998), but only 8-10 from Java and Bali (Ash 1984, 1993; Nijman 2001b) excluding two species that originate from the southeast.

Recently a number of initiatives has been launched to monitor the movements of raptors in western Indonesia (Nuraeni & Suparman 2000) and West Malaysia (Chong 2000). Until this study, however, no data were available to assess the timing and magnitude of migration. In the northern autumns of 1998, 1999 and 2001, data were collected on the migration of raptors through the Dieng Mountains, Central Java, Indonesia. The aim of this study was to (1) determine the numbers of diurnal raptors migrating through the Dieng Mountains, (2) document the timing of raptor passage, (3) compare phenology between species, and (4) compare the above with data from other raptor watch sites in SE Asia.

METHODS

Study area and data acquisition

The study was conducted in the western part of the Dieng Mountains in the province of Central Java. The Dieng Mountains are made up of a number of largely contiguous and dormant volcanoes surrounded by their foothills and adjoining plains. The main orientation of the mountain range is east-west, following the longitudinal axis of the island. The area is still extensively covered with forest ranging from *c*. 300 m a.s.l. in the north-western part to 2565 m a.s.l. in its south-eastern part. The study site is amongst the wettest areas of Java, with between 6000-7000 mm annual rainfall (RePPProT 1990). It rains almost daily during Oct-Apr, mostly in the afternoon (for a more complete description of the study site: Nijman & van Balen 1998). Observation sites were located on ridges, small hills and in open areas with unrestricted views especially to the west. The main study site was near the village of Linggo, with additional data collected at five sites along a latitudinal axis perpendicular to the migration front. Overall, the study covered an area of 21 km, from Kajen in the north to Kalibening in the south (Fig. 1). The study site at Linggo effectively covered *c*. 4 km of the latitudinal axis.

The study was conducted in Sep-Oct 1998, Sep-Oct 1999 and Nov 2001. I was present in the study area for several weeks before and after the first and last migrants were observed, and conducted the majority of the observations; other researchers assisted occasionally. Observations

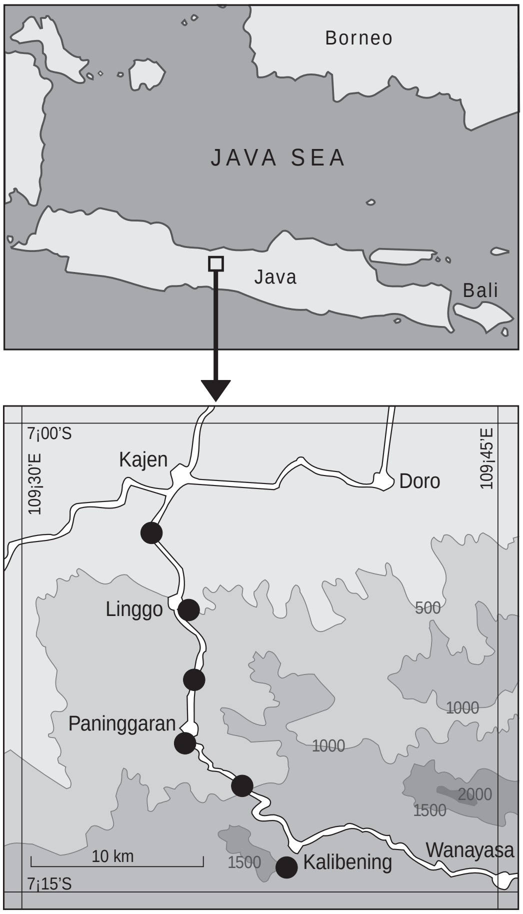

Fig. 1. The island of Java (top) and the study area in the Dieng Mountains (bottom); study sites are indicated by filled circles.

were made during all daylight hours but only during spells of favourable weather, with a total effort of 66 days. Raptors were spotted following methods recommended in Bildstein & Zalles (1995). To reduce bias due to observer fatigue, observation bouts lasted a maximum of four hours, with typically one to two observation bouts per day. Because of low clouds and birds flying in clouds, it was not possible to identify all raptors that passed. Occasionally whole flocks of raptors 'disappeared' into the clouds. The two species of migrant accipiter (Japanse Sparrowhawk *Accipiter gularis* and Chinese Sparrowhawk *A. soloensis*) were difficult to distinguish, and counting was difficult when mixed flocks were involved. No attempt was made to determine the relative contribution of male and female, or adult and immature birds.

Analysis

Ideally raptor migration should have been recorded at all hours of the day at all sites simultaneously from the moment the first raptors arrived until the last have passed (Titus *et al*. 1989). Because of logistical constraints a sampling regime was chosen with observations spread out over three years. Only rarely were observations conducted at more than one site at a time. Data from the three years were combined to provide a general overview of timing and magnitude of migration.

For each week the ratio of identified Japanese and Chinese Sparrowhawks was calculated based on running three-week means. For the first and the last week of migration, the mean of a two-week period was taken. Following Ash (1993), it was assumed that the unidentified accipiters comprised both species in the same proportion as those identified. For analysis, the day was divided in four equal time intervals: (I): 06:01-09:00 h, (II): 09:01-12:00 h, (III): 12:01-15:00 h, and (IV): 15:01-18:00 h. Numbers of raptors passing during time interval II were generally higher that at any other time interval (Ash 1993; Nijman 2001 a) and the data were most complete for this time interval. For each interval and week, the number of migrants was calculated as the proportion ϕ of those passing at interval II. As with identification of accipiters, this was based on a three-week running mean.

The total number of migrants passing through the main study site was calculated using the weekly passage rates. Let for any given species *x* for given week pr_{II} be the average hourly passage rate for time interval II (09:01-12:00 h, i.e. a three hours period), then 3 pr_{II} equals the total number of migrants for time interval II. Let furthermore ϕ_I be the ratio of migrants of species *x* passing at interval I to those passing at time interval II, ϕ_{III} be the ratio of migrants of species *x* passing at interval III to those passing at time interval II, etc. (By definition, ϕ_{II} equals 1). Then summation of $\phi_{I\text{-}IV}$ (3 pr_{II}) equals the total number of migrants of species *x* passing per day. This figure multiplied by 7 gives the total number of migrants of species *x* passing per week. Summation of these weekly totals over a *n*-week migration period then gives the total number of migrants for species *x* passing through the study area:

$$\sum_{i=1}^{n} S_x = 7 \bullet \sum \phi_{I-IV} \bullet (3pr_{II}) \qquad \text{equation 1}$$

For each of the study sites along the latitudinal axis, passage rates were compared with those at the main study site (Linggo) for that week. If these rates did not differ significantly (Mann-Whitney *U*-test), it was assumed that the migration involved similar numbers as at Linggo. Cases where passage rates were significantly greater than at Linggo did not occur. The total width of the migration front was assessed as the latitudinal distance between the northern and southernmost sites where migration was observed. Given that the observation at Linggo covered *c*. 4 km of this distance, the total number of migrants in the Dieng Mountains was calculated as the total width of the migration front (in km) divided by 4 km and multiplied by the total number observed at Linggo.

For those weeks and those years where data were available, annual variation of migration was assessed by comparing passage rates at Linggo with Mann-Whitney *U* tests. Likewise, Mann-Whitney *U*-tests were used to assess spatial variation in migration between Linggo and other study sites by comparing passage rates for those weeks that data were available. Temporal variation in passage rates, both within and among species was assessed with Friedman two-way analysis of variance (Siegel 1956). Annual variation of the direction of migration was assessed with Friedman two-way analysis of variance with 1998, 1999 and 2001 as samples and percentage of individuals grouped in eight 45° segments (N, NW, W, etc.) as cases. Temporal variation in migration direction was assessed by comparing the direction of migration for the first four weeks with those of the last four weeks. Values are reported as means ± SD and significance was assumed when $P < 0.05$.

RESULTS

Migration direction and species composition
Migration was generally in an eastern direction. Data from 1998 reveal that some 70% of the individuals (n = 540) arrived from a WSW-SW direction (200-235°) and 72% of the individuals (n = 756) flew off in an E-ESE direction (83-113°). Direction of arrival was not evenly distributed ($\chi^2_1 = 149$, $P < 0.001$) and significantly more individuals arrived from a WSW direction than any of the other 7 directions combined ($\chi^2_1 = 115$, $P < 0.001$). This prevalence of migrants arriving from a WSW-direction did not differ between the first and the second half of the migration period ($\chi^2_1 = 1.3$, $P > 0.20$). Data from the observation sites perpendicular to the migration front suggest that migration was concentrated along the northern foothills of the central mountain chain. No migration was observed in the alluvial plains north of Linggo, nor on a plateau at the southern end.

Six species of raptor migrate through the Dieng Mountains, with no apparent difference in relative abundance (Friedman's one way analysis of variance, $\chi^2_{r\,3} = 12.5$, $P < 0.001$). For Common Buzzard *Buteo buteo*, Booted Eagle *Hieraaetus pennatus* and Eurasian Marsh Harrier *Circus aeruginosus* only single individuals were observed (Nijman 2003), whereas hundreds of Japanese Sparrowhawks and Oriental Honey-buzzards *Pernis ptilorhyncus* and thousands of Chinese Sparrowhawks were recorded. All further analyses concern only the latter three species. Migration was observed over an eight-week period from 26 September until 17 November. First and last dates of occurrence were similar for all species; i.e. 26 September-12 November for Japanese Sparrowhawk, 26 September-13 November for Chinese Sparrowhawk, and 28 September-17 November for Oriental Honey-buzzard.

A total of 3512 accipiters were observed, of which 2280 were identified to species (2048 Chinese Sparrowhawks and 232 Japanese Sparrowhawks). The proportion of unidentified accipiters remained similar over the years, ranging from 30% in 1998 to 42% in 2001. These unidentified accipiters were mostly Chinese and Japanese sparrowhawks, but may have included small numbers of the two resident accipiters, Crested Goshawks *A. trivirgatus* and Besras *A. virgatus*, or other migratory species such as Shikras *A. badius* or Eurasian Sparrowhawks *A. nisus*. Note, however, that the latter two species have not yet been recorded for Java (MacKinnon *et al*. 1998) and that the former two species are uncommon in the study area during the non-migration period (Nijman 2001a).

The weekly ratio of Japanese: Chinese Sparrowhawks averaged 1: 5.3, with a range of 1: 1.3 during the second week of migration and 1: 9.5 during the fifth week. Especially in the first three weeks, relatively high numbers of Japanese Sparrowhawks were identified (ratio 1: 2.3), whereas during the 4-7th weeks many more Chinese Sparrowhawk were tallied (ratio 1: 8.1). In the following analysis, the numbers of unidentified accipiters are included as either Japanese or Chinese Sparrowhawks according to these ratios.

Passage rates, timing and magnitude
Passage rates at time interval II differed significantly between the three species (Friedman $\chi^2_{r\,2} = 12.3$, $P < 0.001$; Fig. 2). Passage of Japanese Sparrowhawks peaked in the fifth week with passage rates of 3.3 ± 3.7 birds hr^{-1} (range 0.5-11.7, $n = 14$). Passage rates differed significantly between the four time intervals ($\chi^2_{r\,3} = 15.0$, $P < 0.004$). The proportion ϕ for early morning (time interval I) was 0.2 ± 0.1 ($n = 8$); i.e., passage rates in the early morning were only a fifth of those during late morning (time interval II). For early and late afternoon (time intervals III and IV) these proportions were 0.3 ± 0.2 ($n = 7$) and 0.1 ± 0.1 ($n = 6$), respectively. Like Japanese Sparrowhawks, passage of Chinese Sparrowhawks peaked in the fifth week, with passage rates of 18.2 ± 22.1 birds hr^{-1} (range 0.9-58.0, $n = 14$). Passage

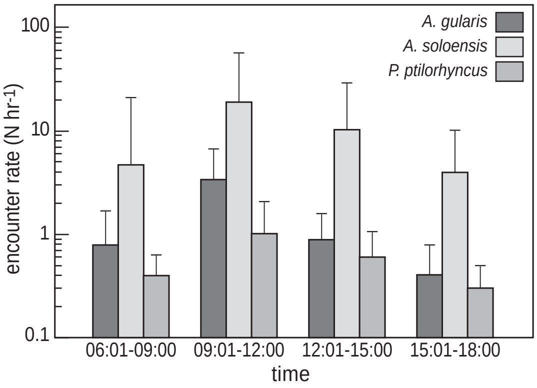

Fig. 2. Diurnal variation in passage rates (average number of individuals passing per hour + SD) in the 5th week (18 - 24 October) of three migratory raptors in the Dieng Mountains, Central Java, Indonesia.

rates differed significantly between the four time intervals ($\chi_{r\,2}^{2}$ = 12.5, $P < 0.001$). Intensity of passage was lowest during early morning ($\phi = 0.2 \pm 0.2$, $n = 8$) and late afternoon ($\phi = 0.2 \pm 0.1$, $n = 7$) and greatly reduced during early afternoon ($\phi = 0.4 \pm 0.3$, $n = 8$). Thus, early morning and late afternoon passage rates were about a fifth of those observed during late morning and the early afternoon passage rate was about 60% lower than in late morning. Passage rates of Oriental Honey-buzzards differed significantly between the four time intervals ($\chi_{r\,3}^{2}$ = 11.8, $P < 0.003$). Like the accipiters, it was very much reduced during the early morning ($\phi = 0.2 \pm 0.1$ $n = 7$) and late afternoon ($\phi = 0.1 \pm 0.2$, $n = 8$) and less so during the early afternoon ($\phi = 0.3 \pm 0.3$, $n = 6$). The passage of Oriental Honey-buzzards was more equitable over the migration period, and variations in passage rates between weeks did not differ as much as they did in the accipiters. Passage peaked later, at the 6th week with 1.4 ± 0.9 birds hr^{-1} (range 0-3.1, $n = 9$).

The central 75% of the Japanese Sparrowhawk migration transpired within a period of *c*. 18 days, and the central 90% passed within *c*. 31 days (Fig. 3a). Peak numbers of Chinese Sparrowhawks transpired over a slightly shorter period; i.e., the central 75% passed in a *c*. 14 days-period, and the central 90% passed within

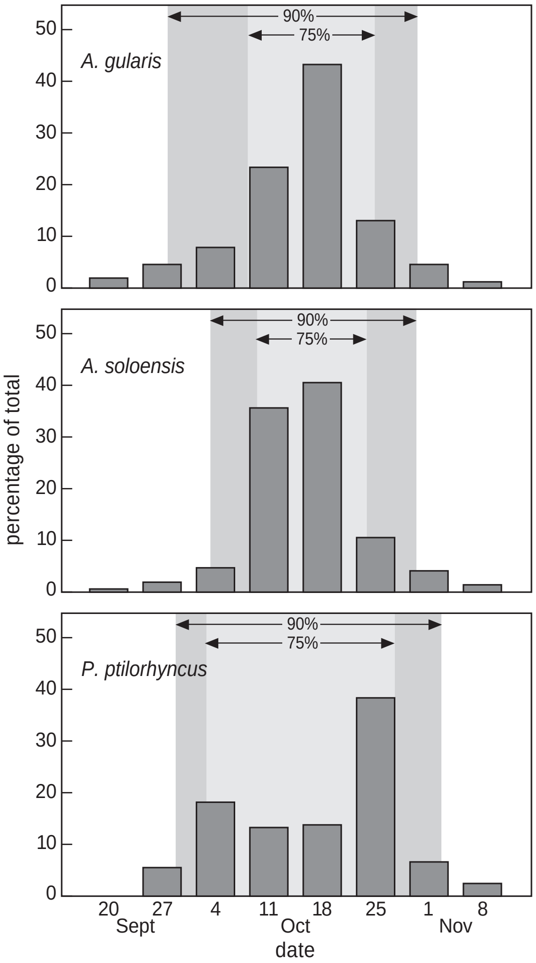

Fig. 3. Timing of passage Chinese Sparrowhawk, Japanese Sparrowhawk and Oriental Honey-buzzard through the Dieng Mountains, Central Java, Indonesia (data from 1998, 1999, and 2001).

c. 27 days (Fig. 3b). Oriental Honey-buzzards showed less of a peak than the two accipiters, and migration was observed over a 51-day period. The central 75% and 90% occurred over 29 and 34-day periods, respectively (Fig. 3c).

The weekly migration totals calculated for Japanese Sparrowhawks using Equation 1 ranged from 18 in the first week to 396 in the fifth week, with a total of 915 birds. For Chinese Sparrowhawks the calculated weekly totals ranged from 25 in the first week to 2518 in the fifth week, totalling 6190 birds. No Oriental Honey-buzzards were observed in the first week, and the calculated weekly totals for this species ranged from 18 in the eighth week to 257 in the sixth week. The estimated total number of Oriental Honey-buzzards passing at Linggo was 662 individuals.

For those weeks that data were available for more than one year, passage rates at Linggo did not differ significantly across years (1998 vs. 1999: Mann Whitney U, all $P > 0.05$; 1999 vs 2001, all $P > 0.10$). Migration was observed at the central four monitoring sites. At none of these sites did the passage rates differ from those observed at Linggo for the same week (Mann-Whitney U, all $P > 0.05$). The shortest distance between the northern and southernmost site where migration was observed was *c*. 15 km. Extrapolating from the calculated number of migrants passing at Linggo (a 4 km broad front) some 3500 Japanese Sparrowhawks, 23 000 Chinese Sparrowhawks, and 2500 Oriental Honey-buzzards migrate through the Dieng Mountains annually. Of these estimated 29 000 raptors 3700 (13%) were actually observed.

DISCUSSION

This is the first comprehensive study of raptor migration in Indonesia, and the Dieng Mountains is the only location in the country where raptor migration has been monitored and where counts of thousands of raptors have been made. Ground observers miss an unknown proportion of the migrants, particularly high fliers and small birds (Kerlinger 1989), and indeed, Sattler & Bart (1986) showed that ground observers see and count some 70% (range <50% - >90% depending on the species) of the actual numbers of birds flying above them. In Israel, Leshem (1994) found strong agreement between five different methods of counting raptors, including counts by ground observers. Hence, it seems that studies from stationary sites may underestimate the magnitude of migration but still adequately detect relative patterns. In the present study, a significant number of migrants likely remained undetected as they passed at high elevations or remained within the cloud cover. Raptor migration studies based on visual migration from stationary positions in tropical rain forest environments, where during the migration period large amounts of rainfall or dense cloud cover impairs visibility, probably are more likely to suffer from underestimation of numbers than comparable studies in temperate regions.

The Asian-Australasian bird migration system is one of the least studied flyways in the world, and only fragmentary information is available on the timing and migration routes of northern migrant raptors (Lane & Parish 1991; van Balen 1998). Recently, Zalles & Bildstein (2000) identified almost 400 migration watch sites worldwide along corridors used by migratory raptors. Most of these watch sites are situated in Europe, the Middle East, and North America with relatively few situated in East and Southeast Asia. Of the 103 Asian raptor watch sites listed, only 31 report >10 000 migrants annually. Six of these sites report passage of at least 100 000 migrants annually, all of them in the Middle East, although recent data from Japan indicate that >400 000 raptors migrate through Uchiyama-toge annually (Nitani 2000; pers. comm.) and >170 000 raptors were counted recently at Chumphon, Thailand (DeCandido *et al*. 2004). For South and Southeast Asia only eight sites are known where counts exceeded 10 000 migrants annually (Zalles & Bildstein 2000). From Southeast Asia detailed information on autumn migration is available from only four sites: Cape Rachado in Peninsular Malaysia (Wells 1990, 1998; Chong 2000), the Puncak Pass in West Java (Nuraeni & Suparman 2000; Nijman 2001b), the Dieng Mountains in Central Java (this study), and Teluk Terima in West Bali (Ash 1993). At all four sites, principally the same species are present, as are the patterns of migrations, albeit in different proportions (Nijman 2001a). However, the timing and magnitude of each migration differs considerably. In Peninsular Malaysia, raptor migration is observed from the second week of September to the end of December (Wells 1990). The data suggest that, as in Central Java, passage of Oriental Honey-buzzards is recorded over the longest time interval (*c*. 4 months) and Chinese Sparrowhawks over the shortest (*c*. 3 months), with Japanese Sparrowhawks in an intermediate position (Wells 1990). The relative long interval for the Oriental Honey-buzzards (and possibly the bimodal distribution: Fig. 3) may be due to age-related differences in timing of migration, with an early peak consisting of adults and a later peak of juveniles (as in European Honey-buzzard *Pernis apivorus*; Schmid 2000). In West Java, raptor passage seems to commence about a week earlier than in Central Java and lasts about a week longer (Nuraeni & Suparman 2000; Nijman 2001b; U. Suparman pers. comm.). Ash's (1993) study covered only the central migration period over West Bali, yet patterns of migration were similar to those in Central Java. The central 75% of the population of Japanese and Chinese Sparrowhawks passed within 10 and 12 days, respectively, and the central 75% of the Oriental Honey-buzzard migration passed within a 24-day period (Ash 1993). These peak passage periods are shorter than in Central Java, which may be related to a reduction of the migration stream or simply is an artefact of Ash's incomplete coverage of the migration period.

Medway & Wells (1979: 39) assessed that in Selangor, West Peninsular Malaysia, migration was concentrated along a *c*. 16-km broad front and estimated that at least 180 000 Oriental Honey-buzzards and as many accipiters (mostly Japanese Sparrowhawks) pass every year. Numbers of migrant raptors passing through the Puncak Pass in West Java are not readily available, but preliminary data suggest that they are in the same proportion and order of magnitude as those observed in the Dieng Mountains (Nuraeni & Suparman 2000; Nijman 2001b; U. Suparman pers. comm.). Ash (1993) counted some 11 000 raptors over a 30-day period in West Bali, but since many birds were missed and the migration period lasted longer than Ash's study, total numbers must be (considerably) higher.

In conclusion, raptor migration in Central Java comprises six species in considerable numbers and because of this study is now one of few Southeast Asian watch sites for which data on the timing and magnitude of migration are available. Given that data from more than one year are available for few sites in the region, and that recent data are lacking from most such sites, setting up a long-term raptor migration monitoring program in the Dieng Mountains, and indeed other sites, would appear worthwhile. This would also provide an opportunity to study age- and sex-specific patterns in migration. Public awareness about the state of populations of raptors in Indonesia is in dire need of promotion (van Balen *et al*. 2001). Many of the country's threatened raptors are secretive rain forest birds making it difficult to create public awareness for their protection. Especially on the densely populated island of Java opportunities to observe raptors, threatened or not, are very much limited. Watch sites as those in the Dieng Mountains, offer such an opportunity, and furthermore clearly demonstrate that biological boundaries extend far beyond political boundaries.

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SAMENVATTING

Elk najaar migreren grote aantallen vogels van Oost-Azië naar hun winterkwartieren in Indochina en Indonesië, maar er is slechts weinig bekend over de timing en kwantiteit van (roofvogel)trek langs deze migratieroute. Tussen 1998 en 2001 is de najaarstrek van roofvogels door het Dienggebergte in Midden-Java bestudeerd. Tellingen vonden plaats op zes telstations loodrecht op het migratiefront. Jaarlijks, over een periode van acht weken tussen eind september en midden november, migreerden minstens 30 000 roofvogels door het Dienggebergte, hoofdzakelijk Chinese Sperwers *Accipiter soloensis* (jaarlijks ongeveer 23 000 individuen), Kleine Sperwers *A. gularis* (3500) en Aziatische Wespendieven *Pernis ptilorhyncus* (2500). De migratiepiek, gedurende welke 75% van de migranten passeerde, nam een periode van twee tot vier weken in beslag (Chinese Sperwer: 14 d; Kleine Sperwer: 18 d; Aziatische Wespendief: 29 d). Het Dienggebergte is één van minder dan tien locaties in Zuidoost-Azië waarvan we weten dat er meer dan 10 000 roofvogels per jaar passeren. Het monitoren van roofvogels op andere plekken langs de Australaziatische migratieroute is nodig om een beter inzicht te krijgen in de doorkomst, soortensamenstelling en soorts-, leeftijds- en seksespecifieke migratiepatronen van Oost-Aziatische roofvogels.

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A COMPARISON OF SPRING MIGRATION PHENOLOGY OF BEE-EATERS AND ORIENTAL HONEY-BUZZARDS *PERNIS PTILORHYNCUS* AT TANJUNG TUAN, MALAYSIA, 2000-01

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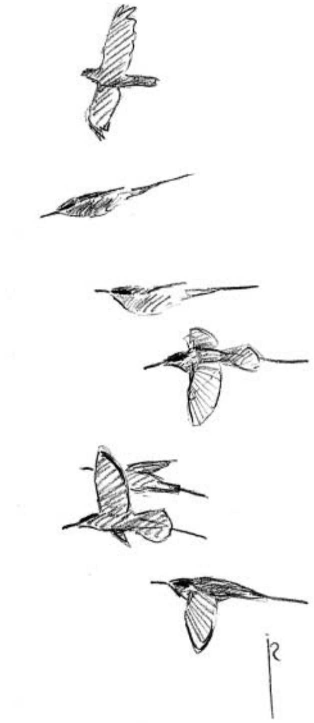

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Counts of migrating Blue-tailed Bee-eaters *Merops philippinus* and Blue-throated Bee-eaters *M. viridis*, as well as five raptor species were made in March 2000 and March 2001 at Tanjung Tuan, a coastal migration watch-site in western Malaysia. Totals of 2226 bee-eaters (12.9 bee-eaters h^{-1}) and 11 441 raptors (66.5 raptors h^{-1}) were counted. The Blue-tailed Bee-eater comprised 60.8% of *Merops* individuals (1353 birds) that could be identified. The Blue-throated Bee-eater was much less common, comprising 10.0% of the flight (222 counted). Oriental Honey-buzzards *Pernis ptilorhyncus* comprised 93.1% (10 648 individuals) of the raptor flight. Bee-eater and Honey-buzzard migration peaked during 11:00-16:00h, and both generally preferred westerly winds to make landfall at Tanjung Tuan.

Key Words: *Merops philippinus* - *M. viridi* - *Pernis ptilorhyncus* -migration - Malaysia - East Asian Flyway

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INTRODUCTION

Since the 1950s, Oriental Honey-buzzards *Pernis ptilorhyncus* have been known to migrate northeast from Sumatra across the Straits of Malacca to the west coast of Malaysia each spring (Oakeley 1955; White 1961; Medway & Nisbet 1965; Medway & Wells 1976; Wells 1990). Recently it was discovered that significant numbers of Blue-tailed Bee-eaters *Merops philippinus* and Blue-throated Bee-eaters *M. viridis* also use the same route each year (Medway & Wells 1976; Fry *et al*. 1992; Wells 1999). However, information regarding routes, timing and destinations of diurnal migrants on this East Asian Flyway in both spring and fall are not well known (see McClure 1974; McClure 1998; DeCandido *et al*. 2004). In Southeast Asia, migrating bee-eaters and Honey-buzzards travel in flocks, interspersing flapping-flight with soaring in thermals whenever possible. In this paper we analyze the diurnal rhythm of migrating bee-eaters and Honey-buzzards where both make landfall on the Asian mainland after an overwater crossing of at least 38 km.

Port Dickson (2°24'N, 101°51'E, sea-level) is a small town on the west coast of Malaysia situated on the Straits of Malacca, approximately 94 km southwest from Kuala Lumpur (Fig. 1-2). It is

Fig. 1. Location of Tanjung Tuan in relation to Sumatra

Fig. 2. Location of Tanjung Tuan, Malaysia (1) relative to other important raptor migration watch sites in East Asia: Selangor Plains, Malaysia (2); Chumphon, Thailand (3); SaPa, Vietnam (4); Beidaihe, China (5); Uchiyama-toge, Nagasaki, Japan (7); Miyako Islands (Ryukyus), Okinawa, Japan (8); and Bali Barat National Park, Indonesia (9). See DeCandido *et al.* (2004) for information about these watch sites.

located at the southern end of a south to north range of mountains that presumably funnels spring migrants north along the western lowlands of the Malay Peninsula (Medway & Nisbet 1965; Wells 1999). The watchsite, known locally as Tanjung Tuan, is situated on the deck of a lighthouse, south of Port Dickson at km 16, approximately 3 km west of the coastal highway. The lighthouse, built by the Dutch in the 18th century, sits atop a rocky peninsula providing a 180-degree view to the west, south and north; it is surrounded by coastal evergreen rainforest in a small**,** forest reserve. On clear days it is possible to see Sumatra approximately 38 km across the Straits of Malacca to the southwest. This is the shortest overwater distance along the Straits from Tanjung Medang on the island of Pulau Rupat of northwestern Sumatra (Zalles & Bildstein 2000).

METHODS

Migrants were counted during 8-22 March 2000 (104 observation h) and 2-12 March 2001 (68 h) by DA and RDC using 8.5x and 10x binoculars**.** Observations typically began at 09:00-10:00 h local time and usually ended by 17:00 h. DeCandido identified, counted, and recorded the numbers of bee-eaters and raptors seen, while Allen photographed the migration. Most bee-eaters (75.9%) and almost all raptors (> 99%) were identified to species level. Weather conditions typically were hazy-cloudy with little wind in the morning till 10:00 h, then becoming clear but humid. On many days at approximately 10:45 h, a 3-12 km h^{-1} sea breeze from the west/northwest would begin. On certain days the wind direction and speed changed significantly in subsequent hours. Wind direction was measured by recording the reading shown on the weather vane mounted atop the lighthouse and a handheld compass.

We scanned mainly to the west across the Straits of Malacca in the direction of Sumatra from the patio of the lighthouse. Bee-eaters and raptors were considered migrants if they passed west-to-east across an imaginary north-south line and continued west and out of sight past the lighthouse and nearby hills. Occasionally, migrants did not pass the immediate area of the watchsite but continued on a northeastern course over the Straits of Malacca, presumably making landfall north of the lighthouse towards Port Dickson**.** We pooled the number counted of both *Merops*-species along with all bee-eaters we could not identify to species level**.**

RESULTS

In 2000-01, a total of 2226 bee-eaters of two species (12.9 birds h^{-1}) were counted during 26 observation days. These included 1353 Blue-tailed Bee-eaters (60.8%), 222 Blue-throated Bee-eaters (10.0%) and 651 unidentified individuals (29.2%). Also, a total of 11 442 raptors (66.5 birds h^{-1}), were counted in migration. Oriental Honey-buzzard was the most common raptor, making up 93% (10 648 total; 61.9 birds h^{-1}) of the flight in 2000-01. Black Bazas *Aviceda leuphotes* comprised 5.3% (608 total), and Chinese Goshawk *Accipiter soloensis* (62), Grey-faced Buzzard *Butastur indicus* (48) and Japanese Sparrowhawk *A. gularis* (12), accounted for 1.1% (4.6 birds h^{-1}); 64 raptors could not be identified. The majority of bee-eaters (84.0%) were seen from 11:00-16:00 h (Fig. 3). The highest hourly total occurred between 13:00-14:00 h on 21 March 2000 when 101 Blue-tailed Bee-eaters were counted**.** Once the first flock of bee-eaters

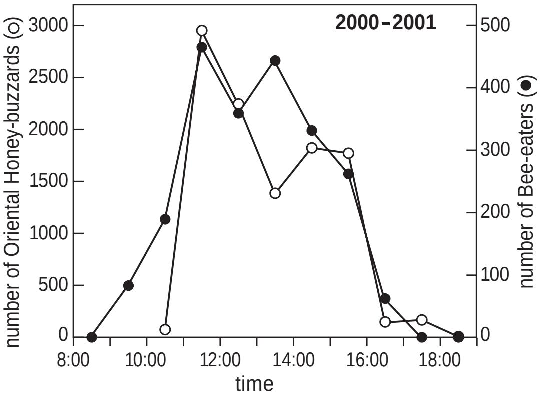

Fig. 3. Number of bee-eaters and Oriental Honey-buzzards counted in migration by hour of the day at Tanjung Tuan, Malaysia, in March 2000-2001

arrived at the Cape, scattered flocks would follow for 4-6 h each day on most days, especially after 10 March. Exceptionally, bee-eater migration would last for seven (17 March 2000) to eight (21 March 2000) consecutive hours on a given day. On peak flight days, the arrival of bee-eaters began in the 09:00-10:00 h (17, 20 and 21 March 2000). Flocks were not usually seen after 16:00 h, and no bee-eaters were recorded migrating after 17:00 h. High daily counts of bee-eaters occurred after 15 March 2000, frequently when winds with a westerly component were moderate to strong (> 15 km h^{-1}) as on 16 March 2000 (169 counted), 17 March 2000 (254) and 19 March 2000 (248). Overall, 30.1% of the bee-eater flight in 2000-01 was counted on these three days of moderate to strong winds. However, the highest day counts in both years occurred on days with light (< 10 km h^{-1}) winds: 11 March 2000 (139 counted) and 21 March 2001 (326).

Most (95.0%) migrating Oriental Honey-buzzards were seen from 11:00-16:00 h, with a decided peak between 11:00-12:00 h, and a second, smaller**,** peak between 14:00-15:00 h and small flocks up until 18:30 h only on days of high counts (2 and 12 March 2001). The highest hourly count in 2000-01 was 841 individuals from 11:00-12:00 h on 9 March 2001**.** The majority (96.7%) of Honey-buzzards made landfall at the Cape with light to moderate (< 15 km h^{-1} and usually

< 10 km h^{-1}) winds. Generally, light winds with a westerly component produced the best Oriental Honey-buzzard flights. However, in 2001, of the four days with > 1000 Honey-buzzards counted, three had light winds from the NE to E, and the fourth had light northwestern winds.

DISCUSSION

Since the 1950s in Malaysia there has been known a significant migration of raptors that are returning each spring from Sumatra to the Asian mainland in the area of Tanjung Tuan. However, only a few published accounts provided information about the daily and seasonal raptor migration phenology at the site (Oakeley 1955; White 1961; Medway and Nisbet 1965; Wells 1990; 1999). Even fewer data exist for the number of individuals of the two *Merops* species that utilize this same route each spring (see Medway & Wells 1976; Wells 1999). In Southeast Asia, the handful of bee-eater migration reports present data from single days of observation (see David-Beaulieu 1944; David-Beaulieu 1949-50; Melville and Fletcher 1982; Tizard 1996; Evans 2001). The only long-term study of migrating bee-eaters comes from Hong Kong (Carey *et al*. 2001). Even there, data are based upon a small sample: a maximum 30-year aggregate of 30-40 individuals total, counted by week in spring.

At Tanjung Tuan, Oriental Honey-buzzards and bee-eaters showed a diurnal migration pattern typical of soaring birds (Kerlinger 1989), with a late morning peak, an indication of a noon lull and steeply declining passage in the late afternoon. Both species (groups) use thermal soaring and active flight during migration, and readily cross large bodies of open water. In the closely related European Honey-buzzard *Pernis apivorus* and European Bee-eater *Merops apiaster* flying speeds were very similar between both species groups (Bruderer & Boldt 2001), but Honey-buzzards showed a wide variation in gliding and flap-gliding speeds depending on environmental conditions (Bruderer *et al*. 1994). The – on average – earlier arrival of bee-eaters at Tanjung Tuan may have been caused by employment of active flight to a greater degree, a lesser dependence on thermals than broad-winged raptors and/or taking advantage of favourable weather conditions in Sumatra (thermals) and Malaysia (onset of sea-breeze from the W and NW at about 10:45 h) earlier than Honey-buzzards. Both bee-eaters and Honey-buzzards declined rapidly as migrants after 15:00 h, but why only Honey-buzzards were seen in migration after 17:00 h remains to be determined.

Bee-eaters were more likely then Oriental Honey-buzzards to make landfall at Tanjung Tuan when winds were moderate to strong (> 15 km h^{-1}) from the NW-W (DeCandido *et al.* 2004). Several high daily bee-eater counts occurred on moderate to strong wind days, when simultaneously no Oriental Honey-buzzards were counted in migration. All Honey-buzzard flights at the Cape were correlated with light winds (< 15 km h^{-1}, usually < 10 km h^{-1}). It seems likely that varying numbers of bee-eaters and Honey-buzzards are migrating in all wind speeds and wind directions along a fairly broad front as they approach Tanjung Tuan. Moderate to strong westerly winds concentrated the bee-eater flight at the Cape probably because it was the closest site to make landfall. What factor(s) influence Honey-buzzards to choose Tanjung Tuan to make landfall in large numbers on certain days but not others remain to be determined. Light winds, sometimes with a westerly component, produced the best Honey-buzzard flights, but on other days with the same conditions, few Honey-buzzards appeared. Also, large flights of Honey-buzzards occurred on days with NE-E winds. The influence of wind direction and speed upon migrants at Tanjung Tuan warrants additional investigation, as do the factors that initiate movements of particularly large numbers of bee-eaters and raptors. In any event, conditions in Sumatra probably play the most important role in determining the extent and timing of bee-eater and Honey-buzzard migration at the Cape on any given day.

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SAMENVATTING

De laatste jaren zijn in Zuidoost-Azië diverse bergketens en zee-engtes ontdekt waar thermiekgevoelige vogels zich tijdens de trek concentreren. Een van deze plekken ligt vlakbij Port Dickson in Maleisië aan de Straat van Malakka. Tijdens de voorjaarstrek bereiken roofvogels en bijeneters hier land na een oversteek van minimaal 38 km open water vanaf het eiland Pulau Rupat voor de kust van Sumatra, Indonesië. Tijdens tellingen in maart 2000 en 2001 werden 11 442 roofvogels in vijf soorten (vooral Aziatische Wespendief *Pernis ptilorhyncus*) en 2226 bijeneters in twee soorten geteld. Deze passeerden vooral tussen 10:00u en 16:00u lokale tijd, waarbij de bijeneters iets eerder begonnen en de wespendieven wat langer doorgingen (vooral op dagen met sterke trek). De bijeneters werden vaker gezien tijdens windsterktes van 15-30 km u^{-1}, de wespendieven bij <15 km u^{-1}. Alle passanten maakten gebruik van thermiek, maar wisselden dat af met vliegen indien noodzakelijk. Dat laatste werd wat vaker door bijeneters toegepast, mogelijk de verklaring waarom ze al vóór 11:00u begonnen binnen te druppelen. (RGB)

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