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Raptor migration in east Bali, Indonesia: observations from a bottleneck watch site

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A migration bottleneck site for raptors was located near the easternmost point of Bali, on the eastern slopes of the Seraya Range. On 16 days during 24 October to 19 November 2004, a total of 7,169 raptors of four species was observed crossing the Lombok Strait in an eastward direction. The four species were, in decreasing order of abundance, Chinese Sparrowhawk *Accipiter soloensis*, Oriental Honey-buzzard *Pernis ptilorhyncus*, Japanese Sparrowhawk *A. gularis* and Booted Eagle *Hieraaetus pennatus*. Chinese Sparrowhawk, contrary to conclusions from previous studies and reviews, was the commonest migrant sparrowhawk in Bali. Booted Eagle was recorded for the first time in Wallacea. In order to locate the migration routes and other possible crossing points, an additional 19 days were spent in October–November at nine other locations in the eastern half of Bali, where another 1,263 migrating raptors were counted. Another three days were spent on the island of Nusa Penida, which provides a shorter water crossing route between Bali and Lombok, but no raptors were observed.

INTRODUCTION

Indonesia is an important wintering area for several species of birds breeding in the eastern Palearctic. The migration of raptors in the East Asian Flyway from north-east to south-east Asia is still, however, poorly understood (McClure 1998, Zalles and Bildstein 2000, DeCandido *et al*. 2004), and for Indonesia in particular there are very few data for the eastern and northern part of the archipelago. Hence the routes taken by migrating raptors in Wallacea are still largely unknown (White and Bruce 1986, MacKinnon and Philipps 1993, del Hoyo *et al.* 1994, Coates and Bishop 1997, Ferguson-Lees and Christie 2001).

After the discovery in October 1982 of large numbers of raptors migrating from Java to Bali (Ash 1982, 1984, Ash *et al*. 1987), the first structured study on this migration was carried out in Bali Barat (West

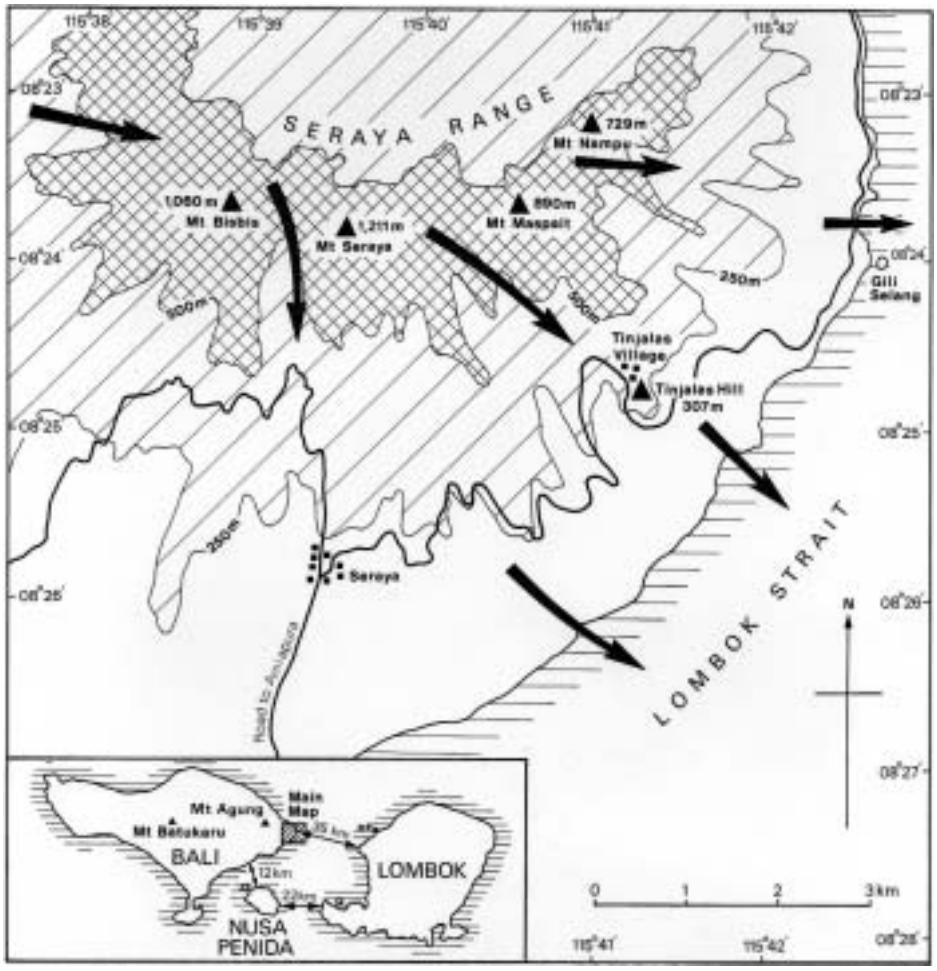

Figure 1. Map of the Seraya Range, east Bali, with the arrows showing direction of flight and crossing points for migrating raptors.

Bali) National Park in 1990 (Ash 1993), followed by a brief survey in 1994 (Mason 1994, 1995). Subsequent work was undertaken in Java at Puncak Pass and Dieng Mountains, in 1998, 1999 and 2001 by Nijman (2001a,b, 2003, in press), and additional irregular counts have been carried out subsequently by organisations such as Yayasan Kokokan Bali (a local NGO) and Himbio Udayana University (V. Nijman and W. Sukmantoro *in litt*. 2004).

During 3 October–25 November 2004, a survey was carried out in eastern Bali, with the aim to locate the main migration routes and crossing points to the Lombok Strait, and to undertake the first counts of raptors migrating from Bali to the Wallacean subregion.

STUDY SITE

The study was conducted at several sites in the eastern half of Bali, mainly in the eastern part of the Seraya Range in Karangasem district (Fig. 1). The Seraya Range runs in a west-east direction, and is formed by four forested peaks: Mt Bisbis, Mt Seraya, Mt Maspait and Mt Nampu. Mt Seraya, at 1,211 m, is the highest peak. The eastern part of the range slopes steeply toward the Lombok Strait. With the exception of the highest mountain slopes, which are covered in remnants of mixed deciduous and evergreen primary and secondary forest, the slopes of the range are terrace-cultivated with maize *Zea* sp., kapok *Ceiba* sp. and palms *Borassus* sp. and *Cocos* sp.

Eastern Bali is one of the driest parts of the island, with less than 1,500 mm rainfall and 5–8 dry months each year (Whitten *et al*. 1996). During the 16 days counting at Seraya, the cumulus cloud cover never exceeded c.40–50%, mainly concentrating above the Seraya Range and above the coastal slopes. No rain was recorded during the observation days. The average daily temperature in October–November is 27–29°C. The wind direction was constantly from S–SE.

After reconnaissance, a watch site was located on the top of a prominent hill 200 m south of the settlement of Tinjalas, in the administrative county of Seraya Timur, at 08°24′S 115°41′E, hereafter referred to as Tinjalas. The hill is 307 m high, 2 km from the range crest and 1 km from the coast, with a flat open top, and maize-terraced cultivations on its flanks. A full 360° view is achievable from the top, spanning from the Seraya Range to the north-west, to the Lombok Strait (here 35 km wide, at its narrowest) in the east, and the island of Nusa Penida to the south-west. The islands of Lombok and Nusa Penida are visible on clear days.

METHODS

To determine the main migration routes, 14 days were spent along the east coast of Bali (Nusa Dua, Tanjungbenoa, Serangan island, Nusa Penida island, East Seraya, Tulamben), and eight days in the central-eastern mountain spine (Mt Batukaru, Lake Tamblingan, Kubusalia, Mt Agung, Tirtagangga, West Seraya) (Table 1). After initial data suggested that the main route in eastern Bali is from the central mountain spine into the Seraya Range, a 16-day sampling count was carried out at Tinjalas between 24 October and 19 November 2004, totalling 85 hours of observation.

From Tinjalas, raptors were observed crossing the strait on a 4 km long front of coastline. A pair of 10×42 binoculars and a compass were used. V. Mason joined and helped counting on some days; on others days P. Asmara', a villager from Tinjalas, helped in spotting the passing raptors. Counting started at around 06h30, roughly 30 minutes after sunrise, until 12h30. On some days, observations continued until 16h30, with a two-hour break at midday to mitigate observer fatigue. The sky above the Seraya Range was constantly scanned using binoculars. White cumulus clouds, when present, facilitated the detection of migrants. Raptors were followed until they disappeared from view in the Lombok Strait, into the clouds or at high altitude.

RESULTS

In 16 sampling days at Tinjalas, a total of 7,169 migrating raptors were counted, most of them directly observed crossing the Lombok Strait in the direction of Lombok (Figs. 2–3). Four species were identified: Chinese Sparrowhawk *Accipiter soloensis* (2,713 individuals, 38% of the total), Japanese Sparrowhawk *A. gularis* (324 individuals, 5%), Oriental Honey-buzzard *Pernis ptilorhyncus* (1,608 individuals, 22%) and Booted Eagle *Hieraaetus pennatus* (five individuals, 0.07%). An additional 2,519 unidentified *Accipiter* spp. individuals were counted, representing 35% of the total and 45% of sparrowhawks. In the early morning hours, when low flying allowed easier sparrowhawk identification, Chinese Sparrowhawk was always the most common species (89% of identified sparrowhawks), suggesting the majority of the unidentified birds were also of this species. This is in contrast with Ash's findings for Bali Barat (1993), but in accordance with subsequent studies in Bali and Java (Mason 1994, 1995, Nijman 2001a,b, in press). Resident raptor species observed regularly at Tinjalas were Changeable Hawk-eagle *Spizaetus cirrhatus* (singles on five October–November dates), Black Eagle *Ictinaetus malayensis* (a pair and one juvenile on seven October–November dates), Crested Serpent Eagle *Spilornis cheela* (2–3 individuals observed on most

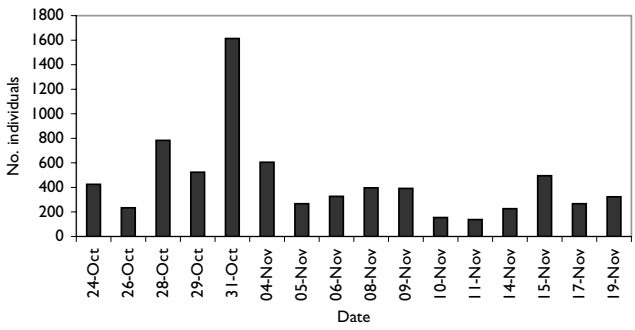

Figure 2. Daily totals of passing raptors at Tinjalas, east Bali, October–November 2004.

days), and Spotted Kestrel *Falco moluccensis* (2–4 individuals observed daily).

The first raptors (both sparrowhawks and honey-buzzards) were observed crossing the strait as early as 06h40, and the last were at 16h20. The main visible passage occurred in between 09h00 and 11h00, but was also noted to be significant in the late afternoon, especially for Oriental Honey-buzzard, which appeared to be more capable than sparrowhawks of crossing when thermal activity was weak. The midday hours were less productive, when the passage appeared to be at its lowest, or birds were simply flying too high to be detected by a ground observer. Sparrowhawks and Oriental Honey-buzzard flew very high by midday, and were difficult to locate even with binoculars. Large flocks of sparrowhawks often appeared in the sky above the Seraya Range at c.1,500 m, and gained altitude by gliding from one thermal to another before crossing the sea. Such high flying behaviour occurred mainly from 10h00 onward, correlated with the increase of thermal activity, and decreased in the afternoon, when passage was reduced anyway. Observations of large flocks disappearing at high altitude or in clouds after 10h00 suggest that a *large* proportion of raptors were undetectable by midday. By 16h00, two hours before dusk, the passage apparently decreased, with only a few birds seen crossing.

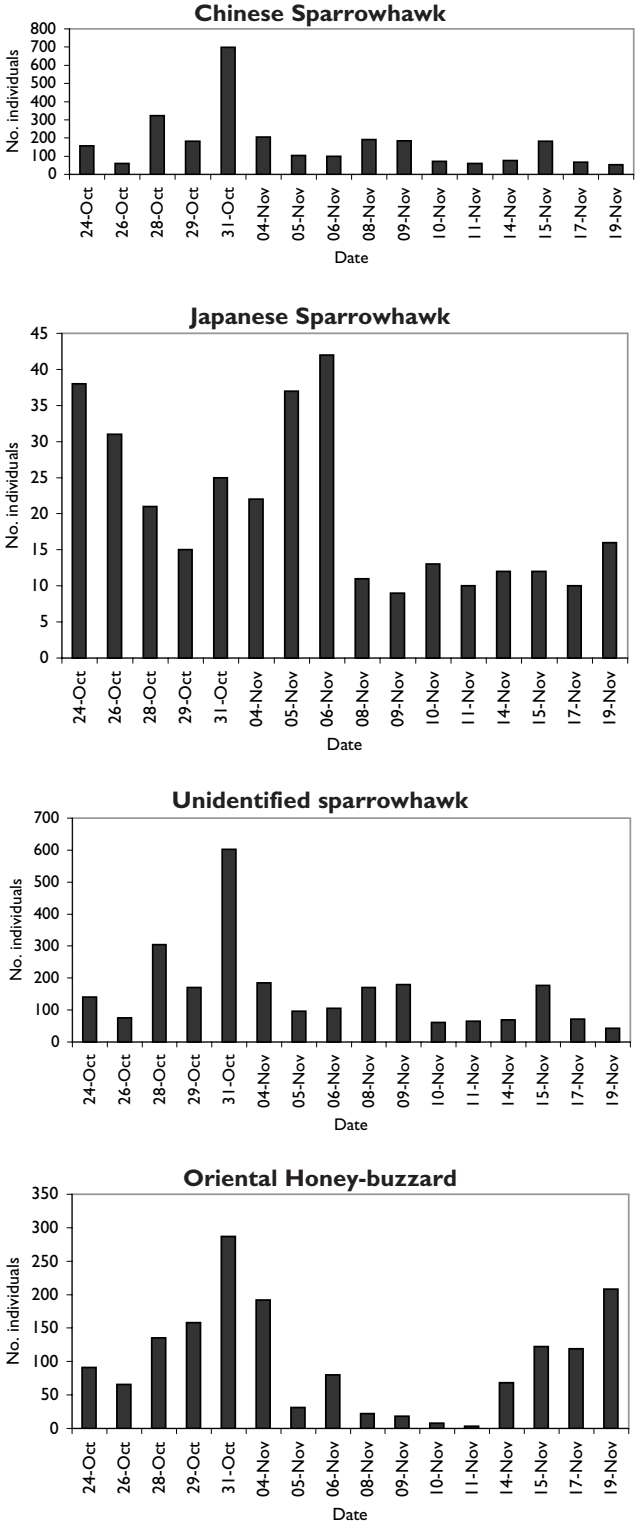

Figure 3. Daily totals of Chinese Sparrowhawks, Japanese Sparrowhawks, unidentified sparrowhawks and Oriental Honey-buzzards at Tinjalas, east Bali, October–November 2004.

On days of strong S–SE wind, raptors were observed soaring longer than usual near the crossing points, and finally crossing at an angle to compensate for the wind direction. Oriental Honey-buzzards often engaged in flapping-flight while crossing at low altitude, especially early morning and afternoon, when thermal activity was weak. The two sparrowhawk species apparently showed more reluctance in crossing the water, soaring longer above the coastal slopes, and at greater heights in thermals before undertaking the crossing. On occasions, single individuals or small flocks of sparrowhawks and honey-buzzards were seen turning back from the strait and landing on the coastal slopes. Multi- and single-species flocks occurred daily, formed mainly in soaring conditions, but also during gliding between thermals. The two sparrowhawk species often flocked together or with honey-buzzards. The largest monospecific flocks of each species were 170 Chinese Sparrowhawks on 31 October, seven Japanese Sparrowhawks on 24 October and 15 Oriental Honey-buzzards on 24 October. Two of the five Booted Eagles were seen together in a flock of seven honey-buzzards on 15 November. The two sparrowhawks and Oriental Honey-buzzard were often observed flying above forest on the Seraya Range shortly after sunrise, indicating that it is used as a roosting site.

No movements of raptors were recorded on Nusa Penida during three observation days (13, 20, and 30 October, Table 1), although intervening and subsequent days at Tinjalas proved to yield a large passage. Movements of raptors were also recorded on the central mountain spine (south of Mt Batukaru, south of Mt Agung, Table 1), where 1,263 migrating raptors were counted. This finding, combined with very few sightings during three days of observation on the northern side of the mountains (at Kubusalia and Lake Tamblingan), reinforced the hypothesis that the southern side of the mountains is used as a 'leading line' (Mason 1995). However, the relatively small number of raptors counted at peak migration might be because of low cloud cover over mountain areas, reducing the visibility of flying birds. No significant raptor movements were recorded in the south-east of Bali nor on the north-east coast.

DISCUSSION

The observations and counts at different sites in eastern Bali indicate that the Seraya Range is an internationally significant bottleneck for migrating raptors (Zalles and Bildstein 2000). Most of the raptors migrating from western to eastern Indonesia during the northern autumn can be monitored from Tinjalas, and the numbers counted indicate that Wallacea is an important wintering area for raptors of eastern Palearctic origin. Further investigation in eastern Indonesia is required to determine their final destination. Very few records of the three main species observed crossing the Lombok Strait are known for the western Lesser Sundas, and none has been previously recorded in Lombok (White and Bruce 1986, Andrew 1992, Coates and Bishop 1997, van Balen 1998), denoting the currently poor knowledge of migrating raptors' distribution in the region.

Previous studies in Bali and Java have recorded totals of 11,000 raptors in 32 days (9 October–9 November 1990) in Bali Barat (Ash 1993), 5,255 in 3 days (16–18 October 1994) in Bali Barat (Mason 1994) and 3,700 in 66 days (autumns 1998, 1999 and 2001) in Dieng Mountains, Java (Nijman in press). Nijman (in press) estimated that 29,000 migrant raptors pass the Dieng Mountains annually. In East Bali, the 7,200 raptors observed at Tinjalas in 16 days during the second half of the season suggest that total numbers may be higher than the 29,000 extrapolated by Nijman. Moreover, migrants were still passing during the last observation day (19 November), suggesting that the migration continued into late November. The count period at Tinjalas was late in the migration season compared with previous studies and therefore provides insights into the latter stages of the migration period. Oriental Honey-buzzard passage showed a marked second peak after mid-November. For Chinese Sparrowhawk, numbers indicate that the passage was ending towards the second half of November, while this pattern was less marked for Japanese Sparrowhawk.

The observation of five Booted Eagles crossing the Lombok Strait in mid-November (three on 15 November and two on 19 November, all dark morphs) indicates that this species winters in Wallacea, despite the lack of previous records (White and Bruce 1986, Andrew 1992, van Balen 1994, Coates and Bishop 1997). Single individuals are reported rarely in Bali and Java (Ash 1982, 1984, MacKinnon and Phillipps 1993, Nijman 2001b, 2003).

The large proportion of unidentified sparrowhawks is similar to previous figures reported in other studies in the region (Nijman 2001a,b, in press). During a survey in west Bali, Mason (1994: 6) stated that 'practically all birds flew over at a great height, barely, if at all, visible to the naked eye…they were probably flying too high and fast to enable detection against a brilliant blue sky and uncomfortably close to the sun'. Kerlinger (1989) compared results from simultaneous radar and visual observations in New Jersey, and showed that at more than 1,500 m distance, most raptors could not be identified visually, even using binoculars or a spotting scope.

Differences in maximum flight altitudes recorded in tropical and temperate latitudes (Smith 1980,

Table 1. Migrating raptors counted at sites in east Bali in October–November 2004.

Site	Dates	Chinese Sparrowhawk	Japanese Sparrowhawk	Unidentified sparrowhawk	Oriental Honey-buzzard	Booted Eagle	Total
Tinjalas 08°24′S 115°41′E	24, 26, 28, 29, 31 Oct; 4, 5, 6, 8, 9, 10, 11, 14, 15, 17, 19 Nov	2,713	324	2,519	1,608	5	7,169
Mt Agung 08°22′S 115°31′E	19 Oct	318	46	395	271	0	1,030
Mt Batukaru 08°22′S 115°06′E	10 Oct, 16 Nov	49	10	73	87	0	219
Kubusalia 08°11′S 115°20′E	7 Nov	0	0	1	0	0	1
Lake Tamblingan 08°16′S 115°06′E	18, 21 Nov	1	0	0	0	0	1
Serangan island 08°44′S 115°14′E	3 Oct, 12 13, 23, 25 Nov	2	0	0	0	0	2
Nusa Dua 08°50′S 115°13′E	22 Oct, 20 Nov	2	0	0	0	0	2
Tanjungbenoa 08°47′S 115°13′E	09, 25 Oct	0	1	0	0	0	1
Ubud 08°31′S 115°15′E	11, 26 Oct, 1, 7, 25 Nov	7	0	0	0	0	7
Nusa Penida island 08°45′S 115°37′E	13, 20, 30 Oct	0	0	0	0	0	0
Tulamben 08°17′S 115°36′E	18 Oct	0	0	0	0	0	0

Kerlinger 1989) suggest that thermal lift may be much stronger in warmer climates, and flight altitude consequently higher compared to temperate climates. It is extremely unlikely that no passage occurred at the time of day with the strongest thermal activity and hence the best soaring conditions. Observation at Tinjalas suggests that large numbers of individuals were still crossing by midday, but too high to be detected. Smith (1980, 1985) cited reports by pilots in Panama that migrating raptors often attained heights of 3,600–4,000m between 11h00 and 13h30 on days of favourable thermal activity, and suggested these as possible explanations for the so-called 'noon-day lull'. For these reasons, the count results are subject to an important quantitative bias, because the figures reflect only the *visible* migration, which represents an unknown proportion of the real passage. Thus no attempt has been made to estimate numbers in this study, and only counts of observed individuals are reported.

There is an interesting discrepancy between authors regarding the proportion and numbers of Japanese to Chinese Sparrowhawks. Ash (1993) reported a ratio of Japanese to Chinese Sparrowhawks of 8.4:1. However, Nijman (2001b) in Java found Chinese Sparrowhawk to be ten times more common than Japanese Sparrowhawk. I found a very similar ratio in east Bali, where Chinese Sparrowhawk represented 89% of identified sparrowhawks. Ash's results may be because of the apparently unfavourable watching conditions at Teluk Terima, the watch site used in Bali Barat National Park. At this site, which is on a beach at sea level, many passing raptors are observed at very high altitude or in the distance (personal observations 2004), and hence identification is extremely difficult. During a survey at this site, Mason (1994: 6) stated that 'it was impossible to distinguish the accipiters at such distance, and it seemed futile to make the attempt'. The issue is discussed in detail elsewhere (Nijman *et al.* in prep.). In mainland South-East Asia, the data are also contradictory. Wells (1999) reported Japanese Sparrowhawk to be far more common than Chinese Sparrowhawk in peninsular Malaysia, but with significant fluctuations during recent decades, whilst DeCandido *et al.* (2004) counted 57,667 Chinese Sparrowhawks but only 5,811 Japanese Sparrowhawks in a recent study in southern Thailand. These data match the ratio found in Java and Bali (Nijman *et al.* in prep.).

Assuming that the birds crossing at Tinjalas followed the Malacca–Sumatra–Java–Bali route, the Lombok Strait is the fourth water crossing encountered after leaving mainland South-East Asia, and the longest after Tanjung Tuan in Malaysia. In a straight line, the crossing from East Seraya to Lombok involves a flight of 35 km above water at its narrowest point. Nusa Penida provides potentially the shortest water crossing route between Bali and Lombok, with only 22 km of water to cross. The position of the island, interposed in between Bali and Lombok in the strait, makes it an apparently ideal 'stepping stone' for migrating birds.

The scarcity of winter records for the four species might be a consequence of the lack of observers, and it is extremely likely that some individuals winter on Bali. Indeed, there have been recent irregular sightings of both sparrowhawks and Oriental Honey-buzzards in the Ubud area of Bali throughout the boreal winter (V. Mason *in litt.* 2005).

Threats and recommendations

The forested areas on the higher slopes of the Seraya Range are used for roosting by migrating raptors. Current logging activity will reduce suitable roosting sites in the foreseeable future. Local villagers complain about predation by raptors on domestic poultry through the year, although this probably involves resident species. No evidence of direct persecution in the area was found, and no information is currently available on possible trapping activity for the widespread cagebird trade in Indonesia.

Bildstein and Zalles (1995) suggested that raptor migration watch sites remain a largely untapped but potentially substantial source of ecotourism revenue. With this in mind, the migrating raptors concentrating in Seraya are potentially a valuable asset for the local economy, and offer an opportunity for developing ecotourism activities. Bali, which is by far the most popular tourist destination in Indonesia, already receives over two million visitors a year (Whitten *et al.* 1996). The creation of a protected area covering raptor roost sites in Seraya might provide a new sustainable resource to the local economy. Well-known success stories in raptor migration tourism, like the Hawk Mountain Sanctuary in Pennsylvania or the International Birding and Research Center in Eilat, Israel, show that this can be successful.

Additional monitoring work is required at Tinjalas and further east in Wallacea, as in western Indonesia. Traditional count methods combined with motorised glider and radar counts are recommended in order to obtain more reliable and complete data. Radiotelemetry should be used to answer questions on migration pathways, flight strategies, habitat usage and distribution, among others. International researchers and Indonesian NGOs should join efforts in order to coordinate future work more effectively.

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