Raptors in South-east Asia

Nature Society (Singapore) Bird Group and **Southeast Asian Biodiversity Society**

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Front cover photo: Black baza by Lee Tiah Khee.

Table of Contents

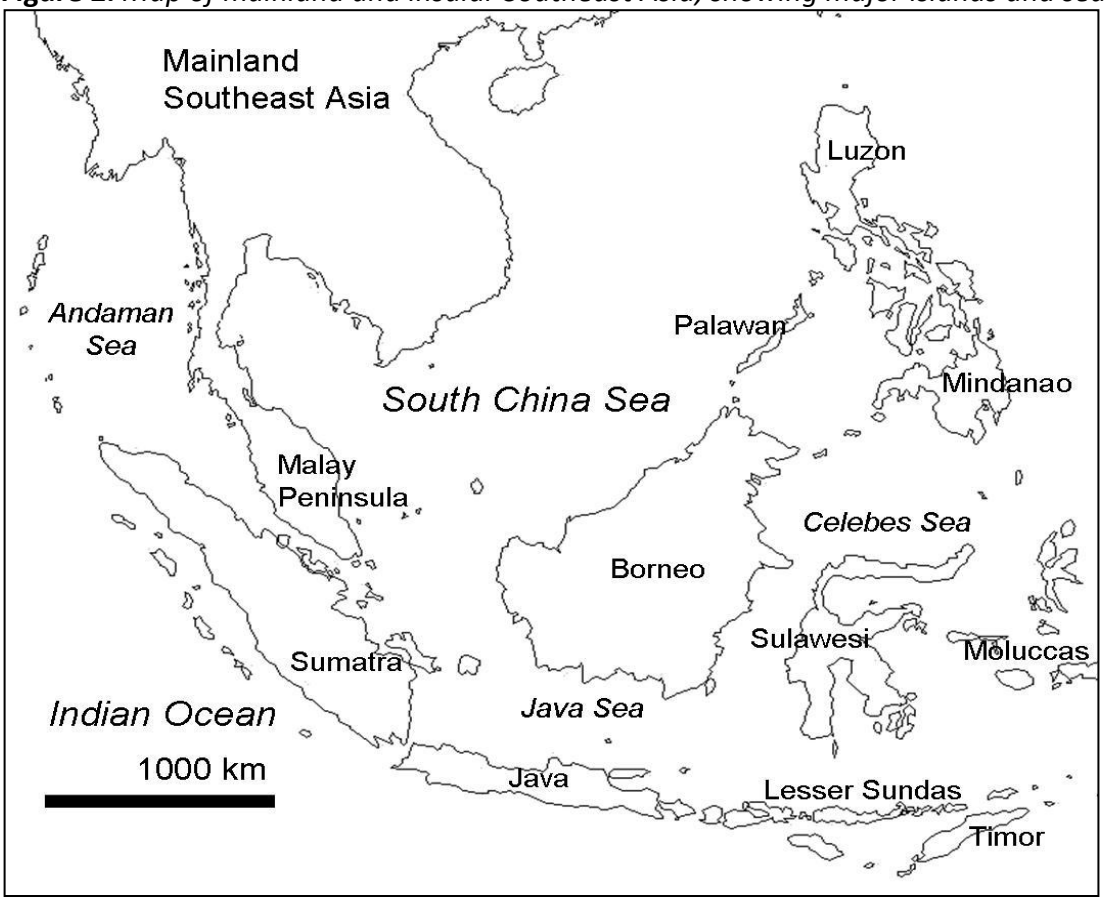
I. Introduction

South-east Asia, a region that falls entirely within the tropics is one of the great repositories of biodiversity globally. This is exemplified by the fact that almost every area of it falls under a biodiversity hotspot defined in Mittermeier *et al*. (2000). Birds, a dominant biotic feature of the South-east Asian landscape are represented by over 2000 species, an estimated 21% of global bird diversity. Raptors, member of the avian order Accipitriformes which is represented by nearly 80 species in South-east Asia, form a little more than 5% of the region's bird fauna, but are disproportionately more conspicuous and well-known than most of the region's other birdlife. One reason for this is that raptors are large, conspicuous and charismatic, making them easily identifiable by the resident populace. Unsurprisingly, raptors feature in national symbols of two South-east Asian countries, Indonesia and the Philippines, clearly highlighting their close cultural connections with the peoples of the region.

Figure 1. *A brief sampling of South-east Asian raptors. (Top left) common (eastern) buzzard (Con Foley), (Top central) crested serpent eagle (Ingo Waschkies), (Top right) rufous-bellied eagle (Ingo Waschkies), (Bottom left) black-thighed falconet (Con Foley), (Bottom right) black baza (Ingo Waschkies)*

In this review, rather than treat South-east Asia as multiple political entities consisting of the countries of mainland South-east Asia, (e.g. Robson 2002) which is biogeographically incomplete, I have also included the islands of the Sunda Shelf (e.g. Sumatra, Borneo, Java, Bali), the Philippine Archipelago and the many islands of Wallacea (e.g. Sulawesi, Moluccas, Lesser Sundas) as there are considerable shared faunal elements, especially in terms of their raptor assemblages and diversity. South-east Asia exhibits diverse vegetation types, and whilst significant areas are covered in tropical evergreen forests, there are also significant areas of mixed deciduous, mangrove (e.g. parts of Sumatra, Borneo), peat swamp (e.g. Borneo) and coniferous forests (e.g. Dalat Plateau, Vietnam) as well as small areas of xerophytic scrub (e.g. central Myanmar). A striking feature of Southeast Asia's physiography is that much of it is mountainous, rising to an elevation of over 5,880 m at Hkakabo Razi in northernmost Myanmar. Other major peaks include Kinabalu (4,095m) in Borneo, Kerinci (3,800m) in Sumatra, Apo (2,954m) in Mindanao and Rinjani (3,727m) in Lombok.

Figure 2. *Map of mainland and insular Southeast Asia, showing major islands and seas.*



With such varied geography and vegetation zones, it is not surprising that South-east Asia is also home to nearly 30% of global raptor diversity, including the world's largest (cinereous vulture, an increasingly regular migrant) and smallest raptors (white-fronted falconet, endemic to north Borneo), as well as a mind-boggling list of endemic raptors on many of the region's islands, the most spectacular being the Philippine eagle of Mindanao, Samar and Luzon.

Furthermore, it is worth nothing that the region falls along a number of important migratory flyways for raptors breeding in east and north-east Asia. Each autumn, flocks of hundreds of thousands of *Accipiter* sparrowhawks, crested honey buzzards and other raptors would funnel through narrowest 'neck' of the Thai-Malay peninsula into insular South-east Asia to spend winter. This spectacle of nature has certainly stimulated newfound interest in raptor watching and now draws thousands of keen birdwatchers into the field to witness the phenomenon.

This review focuses on field identification of raptors and key raptor habitats in the region. It also briefly touches on raptor taxonomy, foraging ecology, breeding ecology, migration and conservation of South-east Asian raptors. Although the forty pages of text would not do justice to the region's magnificent raptor fauna, it is hoped that readers would be given a fairly comprehensive, yet broad overview of the diversity and biology of the numerous hawks and falcons that inhabit Southeast Asia.

II. What is a raptor?

The term 'raptor' has a Latin origin, which means 'to seize' and is also loosely applied to a number of other predatory animals, especially owls which are sometimes described as 'nocturnal raptors' and some group of carnivorous dinosaurs. It is also used to define members of the avian order, the Accipitriformes, which includes three families, notably hawks and eagles (Accipitridae), falcons (Falconidae) and the monotypic osprey (Pandionidae), although the term 'bird of prey' can be also applied. A number of other predatory birds (e.g. New World vultures, secretary bird) share a number of behavioral and morphological features but have been found to belong to a different lineage, based on genetic studies and thus are not considered as raptors *sensu stricto*.

Figure 3. *Two typical raptors that occur in South-east Asia: (Left) crested honey-buzzard is partially migratory, but is also known in to be resident in the region for a few subspecies, (Right) the resident grey-headed fish eagle.*

All members of the accipitriformes share a number of morphological features. However not all are entirely carnivorous as many assume. The classic exception is the palm-nut vulture, a west African hawk that almost exclusively feed fruits of the oil Palm. In general, raptors show typically hooked beaked (to varying extents depending on diet), long wings and sharp talons, all morphological adaptations to carnivory. Many raptors exhibit reversed sexual dimorphism where the females are larger than the males, and this has been postulated by some researchers to be driven by food specialisation. Raptors are generally good fliers and many species are migratory, performing annual migrations covering thousands of kilometers. This explains the relatively large wing area (and hence wing-loading) of many species though this varies, depending on the raptor's specific ecology. Large to medium-sized hawks like the many *Aquila* eagles and *Circus* harriers that hunt in open grassy plains has long broad wings that are important for soaring for long periods over open areas during hunting. Hawks in a dense forest setting on the other hand have shorter, but generally broader wings that allow them to maneuver easily under canopy and some examples include the Philippine eagle *Pithecophaga jefferyi* and the hawk eagles (*Nisaetus* sp.)

Sitting at the other hand of the Accipitriformes are the falcons; powerful hunters with generally long, pointed wings and sleek bodies that allow for fast flight. The most well-known falcon, the nearly cosmopolitan peregrine falcon *Falco peregrinus* which occurs in South-east Asia as a resident and migrant, can reach speeds of nearly 300km/h when diving and this would not be possible if not for its wing-shape and overall build.

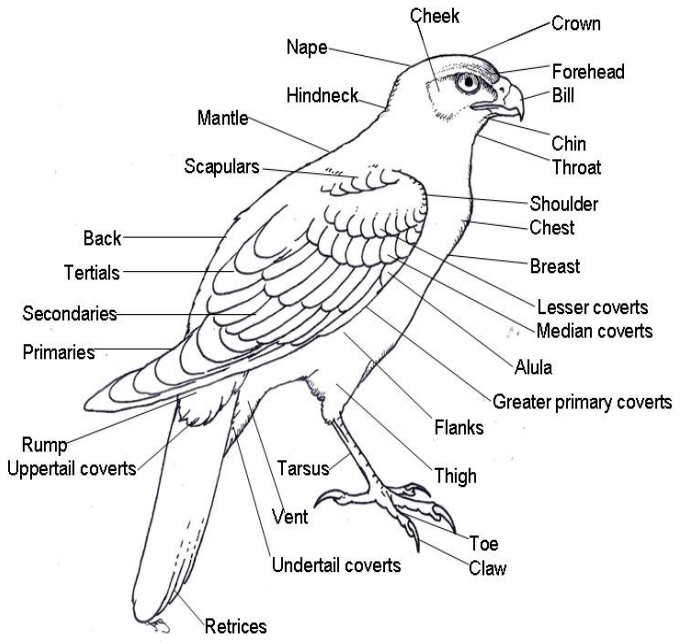
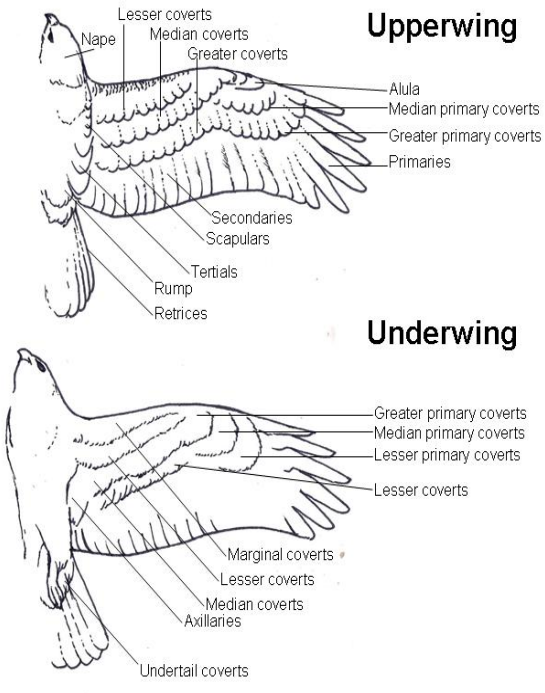


Figure 4a. (Above) *Generalised topography of a perched raptor seen from a profile view.*

Figure 4b. *(Below) Wing topography of a stylized raptor in flight, showing the general structure of the upperwing and the underwing.*



III. Diversity of raptors in South-east Asia

Over 60 species of hawks (accipitridae) and falcons (falconidae) breed in South-east Asia, making it arguably one of the richest areas for raptor diversity in the world. This number is augmented during the boreal winter by nearly 20 species of migratory raptors from temperate central and northern Asia, including both overwinterers and passage migrants.

Figure 5. *Habitats of some eastern Palearctic migratory raptors. (Left) Mixed taiga and steppe in northern Mongolia, home of Amur falcons, black kites and steppe eagle. (Right) Deciduous woodland in north-eastern China, home of Japanese sparrowhawk and crested honey-buzzard.*

South-east Asia is home to a number of raptor genera that are nearly entirely endemic to the region. The only endemic genus is *Pithecophaga*, which is exclusive to the Philippine archipelago. Genera with most, if not all of their representatives occurring in South-east Asia include *Spilornis* (serpent eagles), *Nisaetus* (Asian hawk eagles), *Ichthyophaga* (fish eagles), *Ictinaetus* (black eagle) and *Microhierax* (falconets). One species each of *Spilornis* and *Nisaetus* has ranges that extent into the Japanese archipelago (Ryukyu serpent eagle and mountain hawk eagle).

When considered at the species level, there are 22 raptors endemic to the countries of South-east Asia (see Table 1), with a few species shared by two or three countries (note that this is dependant on taxonomy applied). Indonesia is noted for her high raptor endemism, thanks to the isolation of many islands in Wallacea and thus allows for allopatric speciation. For example, Sulawesi and her satellite islands alone support six endemic raptors, including four sparrowhawks, one serpent eagle and a hawk eagle. Another important area for raptor endemism within Indonesia is the Moluccan islands, which host two to three species of endemic sparrowhawks. Other islands like Java and Flores each support one endemic hawk eagle. In the Philippines, there are four endemic raptors, including one serpent and hawk eagle respectively, and all occur on two or more islands. Borneo hosts the endemic mountain serpent eagle which replaces crested serpent eagle in the highlands, and the white-fronted falconet. A few widespread species like the Wallace's, Blyth's hawk eagle and barred honey-buzzard are found in more than one country, but their global ranges are still restricted to South-east Asia.

South-east Asia shares many of its resident raptors with the Indian subcontinent, southern China and for a handful of species, Australasia. Examples of these wide-ranging species include the white-rumped vulture, crested serpent eagle, the two *Butastur* hawks, changeable hawk eagle, crested goshawk, shikra, besra sparrowhawk and variable goshawk. Not surprisingly, a number of these raptors are morphologically geographically variable, and are represented by a number of distinct subspecies although specific/subspecific level delineation is still not fully resolved and subject to revisions. Many of these raptors are also adaptable and can occur in multiple vegetation types. The widespread changeable hawk eagle is perhaps the region's most adaptable raptors, occurring in forests of varying stature, scrubland and agricultural area, and has a vast range that spans the Indian subcontinent and insular South-east Asia.

Figure 6. *Forest habitats of endemic raptors across insular South-east Asia. (Top left) Mount Kinabalu, Borneo: mountain serpent eagle, (Top right) Lore Lindu National Park, Sulawesi: Sulawesi goshawk, small sparrowhawk, Sulawesi hawk eagle, spot-tailed goshawk, (Bottom left) Sierra Madre mountains, Luzon: Philippine eagle, Philippine hawk eagle, (Bottom right) Kali Batu Putih, Halmahera: Moluccan goshawk.*

The last group of raptors are those that are widespread throughout the Palearctic region (Eurasia, North Africa), notable examples being the Bonelli's eagle and Peregrine falcon. Most raptors within this category occur as passage migrants or overwinter in South-east Asia during

the boreal winter. Many migratory raptors are adaptable and occur in a variety of habitats from lowland evergreen forests to open scrub, agricultural land and even parks. Interestingly, a few widespread Palearctic raptors have isolated resident subspecies that are restricted to the region. The Bonelli's and short-toed snake eagle also breed in Southeast Asia, but probably represent relict populations that were formerly more widespread. Both are now largely confined to isolated pockets of drier habitats in the Lesser Sundas, Indonesia.

To further highlight the region's rich raptor fauna, Singapore, a political unit of no more than 700 km^2, much of which has already been anthropogenically modified in the past 150 years, supports a fairly diverse assemblage of resident and migrant raptors. Singapore is home to six resident raptors and at least a further 10 more species occurring as regular migrants. This does not include the long list of raptors recorded as vagrants.

Table 1. *List of country endemics and near-endemics in South-east Asia. If the raptor listed is also an island or island group endemic (e.g. Lesser Sunda islands), the island group is indicated in parenthesis. (NT–near-threatened, VU–vulnerable, EN–endangered, CR–critically endangered). Threat status follows Stattersfield & Capper (2000).*

Common name	Species	Threat	Country/region
Mountain serpent eagle	*Spilornis kinabaluensis*	NT	Malaysia, Indonesia (Borneo)
White-fronted falconet	*Microhierax latifrons*	NT	Malaysia, Indonesia (Borneo)
Philippine eagle	*Pithecophaga jeffreyi*	CR	Philippines
Philippine hawk eagle*	*Nisaetus philippensis*	VU	Philippines
Philippine serpent eagle	*Spizaetus holospilus*	LC	Philippines
Philippine falconet	*Microhierax erythrogenys*	LC	Philippines
Javan hawk eagle	*Nisaetus bartelsi*	EN	Indonesia (Java)
Sulawesi hawk eagle	*Nisaetus lanceolatus*	LC	Indonesia (Sulawesi)
Flores hawk eagle**	*Nisaetus floris*	CR	Indonesia (Lesser Sundas)
Barred honey-buzzard***	*Pernis celebensis*	LC	Philippines, Indonesia
Sulawesi serpent eagle	*Spilornis rufipectus*	LC	Indonesia (Sulawesi)
Sulawesi goshawk	*Accipiter griseiceps*	LC	Indonesia (Sulawesi)
Spot-tailed sparrowhawk	*Accipiter trinotatus*	LC	Indonesia (Sulawesi)
Small sparrowhawk	*Accipiter nanus*	NT	Indonesia (Sulawesi)
Vinous-breasted sparrowhawk	*Accipiter rhodogaster*	LC	Indonesia (Sulawesi)
Moluccan goshawk	*Accipiter henicogrammus*	LC	Indonesia (Halmahera)
Moluccan sparrohawk	*Accipiter erythrauchen*	LC	Indonesia
Grey-throated goshawk	*Accipiter griseogularis*	LC	Indonesia
Blyth's hawk eagle	*Spizaetus alboniger*	LC	Malay Pen., Sumatra, Borneo
Wallace's hawk eagle	*Spizaetus nanus*	VU	Malay Pen., Sumatra, Borneo
Black-thighed falconet	*Microhierax fringillarius*	LC	Malay Pen., Greater Sundas
White-rumped falcon	*Polihierax insignis*	NT	Mainland South-east Asia

* Philippine hawk eagle is now split into two species, *N. pinskeri* and *N. philippensis* (Haring *et al*. 2007)

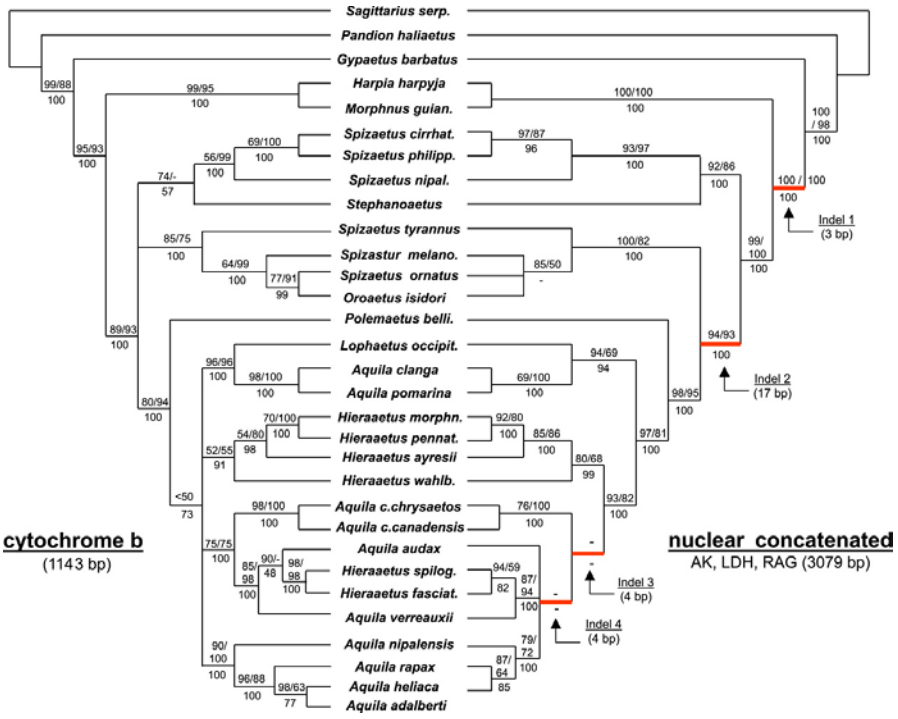
**Considered a valid species by Gjershaug *et al*. (2004)

***Barred honey buzzard is sometimes split by authors into two species, *P. celebensis* of Sulawesi and *P. steerei* of the Philippines (Gamauf & Haring 2005)

IV. Taxonomy and nomenclature

Bird taxonomy is currently undergoing a molecular revolution as advancement in molecular techniques makes phylogeny-based studies easier to carry out. Traditionally, taxonomic relationships of birds were studied by comparing anatomical and morphological characters based alone on museum specimens. The use of DNA-DNA hybridization by Sibley & Ahlquist (1991) was also the first large-scale molecular attempt to evaluate evolutionary relationships in all 9000 over species of birds known then. Sibley & Ahlquist's (1991) study offered more objectivity and scientific rigour than previous morphology-based studies which not only overlooked convergent evolution and cryptic diversity, but wrongly classified many species with what they 'most resembled' and these mistakes are starting to show up in recent studies (e.g. Moyle *et al*. 2011). One major implication of Sibley & Ahlquist (1991) for global bird taxonomy is that it led to numerous revamps at higher taxonomic level for the first time. Tribe Corvini for instance became massively inflated when previously seemingly unrelated monarchs, vangas and cuckooshrikes were discovered to be in fact closely related to crows.

Figure 7. *Dendrogram used to construct phylogeny using the cytochrome B gene (1143 base pairs) from mitochondrial DNA and nuclear DNA concatenated data set. Note paraphyly of the* Aquila*,* Hieraeetus *and* Spizaetus *eagles. Reproduced from Helbig* et al. *(2005).*



Modern bird phylogeny studies have since left behind the DNA-DNA hybridization technique, and have been overtaken by more powerful molecular techniques and bioinformatics tools available. Current molecular techniques can now identify and analyse specific base sequences of mitochondrial or nuclear genes. Heuristic analyses of mitochondrial genes, and implementing

parsimony, maximum likelihood and Bayesian models by means of analytical software (e.g. PAUP*, MrBayes) has revolutionalised our understanding of raptor taxonomy by shedding invaluable insights onto phylogeny, and has provided strong support for some rather drastic revisions of raptor taxonomy. Thanks to these techniques, the New World vultures (e.g. California condor, turkey vulture) are now no longer classified with other members of the Accipitriformes, and have been re-assigned a family of their own within the Ciconiformes.

Many species of South-east Asian raptors have not escaped the molecular revolution that has taken global bird taxonomy by storm. Already, there are numerous revisions and more can be expected. The formerly pantropical hawk eagle genus *Spizaetus*, with its seven to 15 member species, are found not to be as closely related as popularly thought. Asian hawk eagles were reassigned to their original and now re-erected genus, *Nisaetus* after these were found to be merely distant relatives of the Neotropical hawk eagles, as was previously thought (see Helbig *et al*. 2005). Recent molecular studies of the Asian hawk eagles (e.g. changeable hawk eagle, Philippine hawk eagle) have found considerable intraspecific variation and polyphyly that it is now necessary to elevate some well-marked subspecies (e.g. race *pinskeri* of Philippine hawk eagle) to species level (Haring *et al*. 2007). Meanwhile, molecular-based taxonomic reviews of the buteonine buzzards, honey-buzzards, booted eagles and fish eagles have all yielded interesting, sometimes startling results, and should lead to major revisions in raptor nomenclature in the coming years. Here I present merely a brief overview of the great strides in raptor taxonomy in the past decade. Interested readers are encouraged to read the publications that are recommended below.

Further reading

Gamauf, A., Gjershaug, J-O., Røv, N., Kvaløy, K. and Haring, E. (2005). Species of subspecies? The dilemma of taxonomic ranking of some South-East Asian Hawk-Eagles (genus *Spizaetus*). *Bird Conservation International* 15: 99 – 117.

Haring E., Kvaløy, K., Gjershaug, J.-O., Røv, N. and Gamauf A. (2007): Convergent evolution and paraphyly of the hawk-eagles of the genus *Spizaetus* (Aves, Accipitridae) - phylogenetic analyses based on mitochondrial markers. *Journal of Zoological Systematics and Evolutionary Research* 45: 353 – 365.

Helbig, A.J., Kocum, A., Seibold, I. and Braun, M.J. (2005). A multi-gene phylogeny of aquiline eagles (Aves: Accipitriformes) reveals extensive paraphyly at the genus level. *Molecular Genetics and Evolution* 35: 147 – 165.

Lerner, H.R.L. and Mindell, D.P. (2005). Phylogeny of eagles, Old World vultures, and other Accipitridae based on nuclear and mitochondrial DNA. *Molecular Phylogenetics and Evolution* 37: 327 – 346.

V. Identification of raptors in the field

5.1. Overview

Accurate identification of species is the foundation of all biological field studies at the organismal level and is crucial as it allows many other aspects of biology to be appropriately inferred and investigated. Raptor identification presents a daunting challenge to ornithologists and students because many raptors are so morphologically variable that it is no longer easy to readily identify them visually. Variation within the species due to geographical factors is further complicated by the fact that plumage can also vary greatly with age. Such age-dependant plumage variations are so great that the juvenile of certain species (e.g. changeable hawk eagle, Sulawesi hawk eagle) appears radically different from the adults.

Despite challenges, accurate identifications can be made by observing and systematically comparing aspects of habits, size (perched and in flight), shape (body and wing) and plumage patterns (wing, tail). To anyone that observes raptors, it sooner or later becomes apparent that different species tend towards different proportions, build and body shapes, whether perched or flying. For convenience sake, I have grouped all South-east Asian raptors into 18 groups, each with their respective distinctive body shapes and sizes. Being able to fit an observed raptor into any of these groups can help considerably in species-level identification.

1. **Osprey (*Pandion haliaetus*)** – Medium-sized raptor, with long, narrow wings and relatively small head. Short crest may be visible. Has a superficial gull-like appearance.
2. **Vultures (*Gyps*, *Sarcogyps*, *Aegypius*)** – Easily the largest of raptors in build and wingspans. Very large and bulky. Long broad wings in flight and relatively small head due to bald appearance in many species. (5 sp.)
3. ***Aquila* eagles and black eagle (*Aquila*, *Ictinaetus*)** – Generally large to medium-bodied eagles, robust looking, usually with dark plumage. In flight, shows long broad wings. (7-8 sp.)
4. **Philippine eagle (*Pithecophaga jefferyi*)** – Massive, with large head and broad wings. (1 sp.)
5. **Goshawks and Sparrowhawks (*Accipiter*)** – Small to medium-sized, compact-looking raptors with fairly short, broad wings. (15-16 sp.)
6. ***Buteo* buzzards** – Medium-sized, robust looking raptors with relatively large heads. Usually fairly broad wings. (2-3 sp.)
7. ***Butastar* buzzards** – Small to medium-sized, robust-looking raptors with relatively short broad wings. (3 sp.)
8. ***Milvus* and *Haliastur* Kites** – Small to medium-sized raptors with long, broad wings. (3 sp.)
9. **Serpent eagles (*Spilornis*)** – Medium-sized, robust-looking raptors with relatively short, broad wings and large heads. All species also possess a short crest. (4 sp.)
10. **Short-toed snake eagle (*Circaetus gallicus*)** – Medium-sized, pale looking raptor with long wings. Very ‘owl-like’ face.

11. **'Hawk eagles' (*Nisaetus, Hieraeetus*)** – Medium-sized to large, compact-looking raptors with comparatively short, broad wings. Highly variable plumage, often with extensive barring and streaking. All *Nisaetus* eagles possess a crest of varying lengths. (9-10 sp.)
12. **Fish eagles (*Haliaeetus*, *Ichthyophaga*)** – Large-sized and small-headed, with long and relatively narrow wings. Associated with water bodies. (4-5 sp.)
13. **Harriers (*Circus*)** – Medium-sized, slender-looking appearance, with long, relatively narrow wings and long unfeathered legs. Many species have an 'owl-like' face. (5-6 sp.)
14. **Honey-buzzards (*Pernis*)** – Medium-sized raptors with long, broad wings and relatively small heads. Rounded tail, often fanned out. (2-3 sp.)
15. **Bazas (*Aviceda*)** – Small-sized raptors, with short broad wings. All species possess a short pointed crest. (3 sp.)
16. **Bat hawk (*Macheiramphus alcinus*)** – A distinctive medium-sized raptor with long pointed wings and largely dark plumage. Very similar to the falcons in overall build.
17. **Falcons (*Falco*)** – Large range of sizes, from small to medium-bodied. Most have long, pointed wings and prominent facial skin around the eye. (8-9 sp.)
18. **Small falcons (*Polihierax*, *Microhierax*)** – Smallest of raptors in the region. Most are bulbul-sized and marked with extensive black and white. (6 sp.)

Figure 8. *Body shapes and proportions of six raptors seen in flight, with silhouette of a house crow for comparison. Notably, raptors have different wing proportions, with some species having long narrow wings (white-bellied fish eagle) while others (crested goshawk) short broad wings. Examples used here are species resident in Singapore.*

(More information on body shapes keys can be found in Appendix I, page 41)

5.2 Identification of perched raptors

While identification of raptors using field guides seems straightforward, field conditions makes this exercise far from optimal. Furthermore, observation time is extremely limited, especially

when the raptor in question is soaring quickly through. As seen in previous sections, familiarization with body shapes and proportions of flying raptors can help narrow the observed raptor to a few possible species, followed by further comparisons of plumage patterns and simple elimination. Occasionally when the raptor descends to perch, a different set of identification pointers is now necessary, since certain parts of its anatomy visible in flight may now no longer be visible and vice versa. Eventually, some of these raptors perch long enough for extensive notes to be taken. A thorough examination of a combination of features usually should lead to positive identification.

Some identification pointers to take note of for perched raptors includes

1. Overall shape and proportion of body, especially the head in relation to the torso – Large or small bodied? Is the head large or small in relation to the body?
2. Presence of crest and its shape – Is crest long and pointed, or short?
3. Bill shape and depth of gape – Is bill 'heavy' looking and hooked? How deep is the gape?
4. Legs – are legs feathered or exposed? How extensive is the feathering along the tarsus?
5. Position of folded wings in relation to tail tip – long-winged raptors usually have wings that extend to near or beyond the tail.
6. Plumage – What is the dominant colour? Are there extensive patterning like streaks, barrings or botchings on body?
7. Length and shape of tail – Is the tail square, wedge or round shaped?

Figure 9. *Raptors in flight can be extremely difficult to identify. (Left) crested honey buzzard soaring over Changi, Singapore (Con Foley), (Right) Bonelli's eagle over central Flores, Indonesia (Ingo Waschkies)*

5.3 Identification of flying raptors

Perched raptors present a set of challenges for identification because not all features are visible to the observer, especially the extensive patterning on the underwings. On the other hand,

more often than not, raptors are observed flying and with more features exposed; this may in fact prove easier for identification.

Some identification pointers to look for in flying raptors include:

1. Wing shape and proportion – Are the wings pointed or rounded? What is the proportion of the wing length in relation to breadth?
2. Proportion of the wings in relation to the body – This will give a clearer gauge of whether the wings are broad. Vultures, for example will appear very 'large-winged'
3. Wing position when soaring or gliding – This is obvious when a raptor is observed head-on. Are the wings held flat, or a shallow V shape?
4. Underwing pattern – Is there barring on the outer flight feathers? Are they any carpal patches?
5. Tail shapes – Is the tail square-shaped, wedge-shaped or rounded?
6. Tail pattern – Are there bands on the tail? How many bands are there?
7. Size of head in relation to body – Large or small-headed appearance?
8. Body patterns – Are there barring, streaking or botching on the breast, belly and vent?
9. Markings on the head – Are there visible brows, throat patches, moustache?

5.4 Identification using voice

The vocalizations of raptors are also useful guides in identification, though often underused. While most vultures and *Aquila* eagles hardly ever vocalize, many serpent and hawk eagles are often extremely vocal and so are fish eagles; knowledge of their calls could thus come in handy for identification. Fish eagles especially utter a variety of strange shrieks, yelps and honks, while the calls of hawk eagles tend to be shrill, high-pitched and often repetitive whistles. Serpent eagle calls are superficially similar to that of hawk eagles, but tends to be shorter in duration and less frequently uttered. Sonograms can be sometimes useful in visualizing the characteristics of a species' vocalizations and can help in identification. For a more comprehensive description of raptor calls in the region, Robson (2002), Ferguson-Lees & Christie (1999) and Wells (1999) are all relevant and useful. An online database (URL: www.xeno-canto-org) contains a large repository of freely accessible bird calls (covers more than 75% of the world's bird species) and can be used for making comparisons with calls heard in the field as an identification aid.

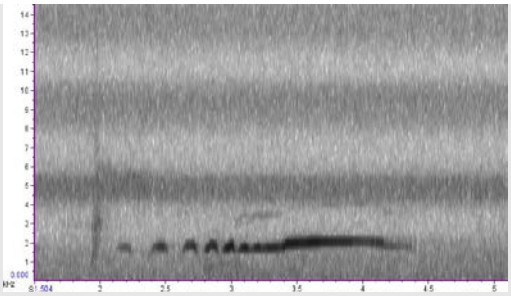


Figure 10. *Sonogram of Mountain serpent eagle call, Mount Kinabalu, Borneo. (Frank Lambert, XC58818. Accessible at www. xeno-canto. org/58818.)*

Other aspects of raptor plumage

5.5 Intraspecific Polymorphism

Besides plumage variation that occur due to age, sex and geography, some raptors exhibit remarkably distinct plumage variations within the species, sometimes with more than one form

occurring together. Commonly encountered in South-east Asia are melanistic forms, often described in field guides as 'dark morphs'. Biologically, melanism arises due to over-production of the pigment, melanin in the plumage of these raptors, resulting in a dark-brown to black appearance. A classic example is the changeable hawk eagle, which often occur as 'dark morphs' in many parts of Southeast Asia, particularly in the subspecies *limnaeetus*.

Another raptor with highly variable plumage is the crested honey buzzard, undoubtedly one of the region's most confusing raptors to identify in the field. In South-east Asia, the resident race *torquatus* of the crested honey-buzzard, barred honey-buzzard and Jerdon's baza are all morphologically similar to sympatric resident *Nisaetus* hawk eagles and are excellent examples of Batesian mimicry. In this case, the more powerful hawk eagles are being mimicked by the honey buzzards and bazas for protection against predators. The level of mimicry is so fine that there are two distinguishable forms of the crested honey buzzard, one which resembles the Wallace's hawk eagle, and the other which resembles the Blyth's hawk eagle (see Phillipps & Phillipps 2011).

5.6 Moulting

Moulting involves change and replacement of body and wing feathers and occurs at periodic intervals, usually at times when plumage usage is least intense and is thus timed at a periods in a raptor's life where the demands of migration, breeding and feeding are minimal (Ferguson-Lees & Christie 1999). Moult does not occur as one single event, but is usually temporally partitioned into body moult which precedes quill moult (i.e. moulting of wing feathers). Knowledge of moult can be useful in assessing the age and sex of a raptor. Moulting raptors tend to exhibit variable plumage depending on the stage and extent, so much so that some species appears 'oddly plumaged' and cannot be easily matched to images in field guides, posing difficulty for identification. For more details on moulting, both Ferguson-Lees & Christie (1999) and Thiollay (1994) have furnished a more comprehensive overview.

Further reading

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VI. Raptor habitats in South-east Asia

6.1 Overview

Raptors are among the most successful of land birds, occurring in almost all continents and habitats. Part of the reason for South-east Asia's raptor diversity and richness can be attributed to its diverse vegetation cover, which ranges from mangroves and peat swamps to snow-capped peaks in the Indo-Burmese Himalayas. Given that the dominant vegetation types in South-east Asia are tropical and subtropical forests, it is not surprising to find a large proportion of raptors in the region being forest specialists, with a large number of endemics. Some of these forest raptors are more adaptable and are able to make use of disturbed areas, especially the changeable hawk eagle. This section reviews the variety of habitats in the region as well as their resident communities of raptors.

6.2 Tropical and subtropical forests

South-east Asia's tropical and subtropical (mixed/evergreen) forests are home to its most species-rich raptor communities, harboring a many as eight species at a single locale, depending on forest type and elevation. A typical lowland forest raptor community in peninsular Malaysia contains about six to eight raptor species, including crested serpent eagle, Wallace's (an extreme lowland specialist) and changeable hawk eagles, crested goshawk, rufous-bellied eagle, crested honey-buzzard, Jerdon's baza, bat hawk and the minute black-thighed falconet. In forested areas with large rivers or lakes, both grey-headed fish eagle and lesser fish eagle can be expected to occur, sometimes even sympatrically (Taman Negara, peninsular Malaysia). Very similar raptor assemblages can also found in lowland forests in Sumatra, Siberut, Borneo, peninsular Thailand and Myanmar.

Forests at higher elevations usually support the black eagle, mountain hawk eagle and Blyth's hawk eagle. Although the Blyth's hawk eagle is primarily a raptor of hilly terrain to montane elevations, it ranges down to lowland forest in some parts of peninsular Malaysia (e.g. Panti). Likewise, the mountain hawk eagle occurs mainly in montane forests above 900 m across South-east Asia, but ranges down to as low as 600 m on Langkawi island. In Java, hill and montane forest sites (e.g. Mount Gede, Mount Halimun) support the endemic Javan hawk eagle, the widespread Black eagle, and occasionally changeable hawk eagle.

Compared to sites on mainland South-east Asia, raptor communities on islands are tend to be less species rich. A typical raptor community at a lowland forest site on Luzon, Philippines (e.g. Subic Bay forest) would support four to five species, including Philippine hawk eagle, Philippine serpent eagle, barred honey-buzzard, rufous-bellied eagle and Philippine falconet. In remote mountain ranges on Luzon and Mindanao (e.g. Mount Kitanglad), the Philippine eagle is the most distinctive raptor and co-occurs with two to three other raptor species (e.g. Philippine hawk eagle, Philippine serpent eagle). Raptor communities are relatively similar in Sulawesi, where a lowland forest site usually supports Sulawesi serpent eagle, Sulawesi hawk eagle, barred honey-buzzard, Jerdon's baza and one to two of its four endemic *Accipiter* sparrowhawk quartet. In the forests of the Moluccas, there are no serpent or hawk eagles. Instead, their

niches are replaced by the Gurney's eagle, Pacific baza and one to two species of sparrohawks (e.g. Moluccan sparrowhawk), again depending on geographic location.

Figure 10. *Three typical forest raptors in South-east Asia. (Left) crested goshawk, Palawan, Philippines (Con Foley). (Middle) Blyth's hawk eagle, Fraser's Hill, Peninsular Malaysia (Con Foley). (Right) Sulawesi hawk eagle, Tangkoko DuaSaudara National Park, Sulawesi, Indonesia (Ingo Waschkies).*

During the boreal winter, a number of migrant raptors (e.g. crested honey-buzzard, Chinese goshawk, Japanese sparrowhawk, black baza) can occur in forests but none are specifically forest-dependent and can utilize a variety of man-made habitats as well

6.3 Mixed deciduous forests

In parts of Southeast Asia where there are distinct dry and wet seasons, mixed deciduous forests become the dominant forest type. Although these forests are structurally less complex than tropical evergreen forests, they support a richer plant community than the next group of forests. Extensive stands of mixed deciduous forests occur in many parts of mainland South-east Asia, particularly in wetter parts of Cambodia, Myanmar, Thailand and Laos. In these areas, their raptor communities are very similar to tropical forests, supporting up to eight raptor species. Typical raptors include changeable hawk eagle, crested serpent eagle and crested goshawk.

Some wetter parts of the Lesser Sundas islands in Indonesia also support mixed deciduous forests, particularly in Flores, Sumba, Timor and the Tanimbar islands. A detailed description of forests here is provided in Coates & Bishop (1997). Here, raptor communities are relatively simple, with up to five species present and includes Bonelli's eagle, short-toed snake eagle, Pacific baza, variable goshawk, spotted kestrel and Flores hawk eagle, the last which is endemic to the Lesser Sundas.

Figure 11. *Raptors of dry dipterocarp forests on mainland South-east Asia. (Left) red-headed and white-rumped vulture (Lim Kim Chuah), (Centre) white-eyed buzzard, (Right) white-rumped falcon, seen here with lizard prey (James Eaton)*.

6.4 Dry dipterocarp forests

Large expanses of northern and eastern Thailand, as are parts of Laos, Myanmar and Cambodia are covered with dry dipterocarp forests. Dry dipterocarp forests are typified by low tree density, with its trees dominated by a few dipterocarp species, and an open shrubby understorey. Unlike tropical and mixed deciduous forests, their raptor communities are comparatively poorer, supporting four to five raptors including Shikra, changeable hawk eagle, rufous-winged buzzard, the endemic white-rumped falcon and in parts of the Myanmar, white-eyed buzzard. Dry dipterocarp forest, which is usually interspersed with savannah in Myanmar and Cambodia's northern plains, however are of exceptional conservation importance as they support South-east Asia's last remaining colonies of red-headed, slender-billed and white-rumped vulture. These vultures benefit from human assistance by regular food provisions in 'vulture restaurants'.

6.5 Mangroves and the coasts

Mangroves used to fringe the coastline of much of South-east Asia, particularly along sheltered coasts although much has now been lost to human activities. Four raptor species occur regularly in mangroves, the wide-ranging white-bellied sea eagle, crested serpent eagle, brahminy kite and the osprey which is a non-breeding visitor to many parts of South-east Asia. From time to time, migrant raptors like sparrowhawks may also use mangroves for foraging.

6.6 Open country

Open country habitats typically include grasslands, marshland and paddy fields. While such habitats support few resident raptors, the black-winged kite, changeable hawk eagle and spotted kestrel (eastern Indonesia) being notable exceptions, raptor communities in open

country habitat are augmented every winter by numerous Palearctic migrants, including up to three harrier species, *Aquila* eagles, black kite, common kestrel and peregrine falcon. The Amur falcon, a passage migrant is South-east Asia on its way to winter in southern Africa also regularly turns up in open country habitats in Thailand, and possibly Myanmar.

Figure 12. *Three migratory raptors to Southeast Asia. (Left) greater spotted eagle seen in a typical wintering habitat, dry paddy fields in Peninsular Malaysia (Con Foley). (Middle) The Chinese goshawk occur in a variety of habitats as a winterer, ranging from open country and scrub to forests (Con Foley). (Right) common kestrel winters in open grassy areas (Ingo Waschkies)*

6.7 Human-modified habitats

Much of Southeast Asia's natural vegetation is now steadily being destroyed and replaced by expanses of monoculture of a few commercially valuable crops, particularly oil palm, rubber and coconut. Less extensive are *Acacia* and *Tectonia* plantations, the latter which is still widespread in parts of Java. Quite a few species of raptors are able to persist in human-modified habitats, and those that have adapted include black-winged kite, changeable hawk eagle and crested goshawk. Some forest raptors like Wallace's hawk eagle may sporadically occur in plantations, but only when they wander beyond the forest edge to forage. Migratory raptors also regularly utilize such habitats, where small prey like lizards, rodents and insects can be locally abundant.

Further reading

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Thiollay, J-M. and Meyburg, B. (1988). Forest fragmentation and the conservation of raptors: A survey on the island of Java. *Biological Conservation* 44: 229 – 250.

Thiollay, J-M. and Rakhman, Z. (2002). The raptor community of central Sulawesi: habitat selection and conservation status. *Biological Conservation* 107: 111 – 122.

VII. Raptor behavioral ecology

7.1 Overview

Raptors exhibit diverse behavior across many aspects of their life histories and so it is difficult to draw broad generalizations. Even seemingly closely related species may exhibit many differences in their foraging behavior and general ecology. The behavioral ecologies of some eastern Palearctic raptors (e.g. grey-faced buzzard, Japanese sparrowhawk) are relatively well-known thanks to extensive studies conducted in their breeding or passage locales (e.g. Japan, Taiwan). This unfortunately is not the case for many of the raptors that inhabit tropical forests in insular South-east Asia and many aspects of their breeding and life history remain to be discovered, including even basic knowledge on their feeding or nesting habits. For some, even the nests are yet to be described (e.g. vinous-breasted sparrowhawk, Moluccan goshawk) or are only recently discovered (e.g. subspecies *renschi* Bonelli's eagle). This section on behavioral ecology describes the key events in a raptor's life, and draw reference to some of the better-known examples from South-east Asia where there has been published literature.

7.2 Foraging and diet

Figure 13. (Left) *White-bellied fish eagle catching fish from near the water surface, Langkawi Island, peninsular Malaysia (Ingo Waschkies). (Right) Juvenile pied harrier quartering low over open grassland for terrestrial prey in Changi, Singapore (Con Foley).*

Raptor diet is varied and undoubtedly, the type of prey taken determine the hunting strategy used. Most raptors are predators of small mammals, birds and reptiles, and some may opportunistically take carrion. One typical generalist predator is the changeable hawk eagle. While it diet is dominated by small prey like rodents and lizards captured using still-hunting, changeable hawk eagles may even take prey as large as small monkeys, francolins and hares. On the other hand, many more species of raptors have relatively specialised diets, taking only a

narrow range of prey items. *Spilornis* serpent eagles are good examples and all species seem to feed exclusively on snakes and lizards. The aptly named bat hawk is a specialist bat predator and where they occur, actively hunts just before dusk when large numbers of bats leave their cave roosts. Likewise, the aptly named honey-buzzards of which two species occur in the region are specialists on bee larvae, combs and wasp larvae though they also opportunistically take small animals.

Foraging behavior is equally diverse and can be variable depending on the type of prey being captured and the environment. Still-hunting (or perch-hunting), whereby the raptor makes short flights to capture the prey from a usually hidden vantage is employed by many raptors, especially forest and piscivorous species, and is optimal not only due to the nature of the environment where thick vegetation provides concealment for predator and prey alike, but is also energy efficient as it does not require prolonged periods of flight. Raptors in open country like harriers, kites and buzzards also use such strategies though the open nature of the environment means that slow soaring and hovering not only covers a large area, but also increases chances of successfully finding terrestrial prey like rodents, lizards and ground birds. Some species like the white-bellied fish eagle practice kleptoparasitism, stealing food items from conspecifics and smaller raptors (e.g. osprey, brahminy Kite) whenever the opportunity arises to supplement their diets.

Figure 14. *Changeable hawk eagle with leaf monkey prey, peninsular Malaysia caught by still-hunting.*

Depending on the type of prey hunted, raptors are active at different hours of the day. Forest-dwelling raptors tend to be active earlier, possibly to coincide with the hours that their mammalian or bird preys are active. As many of these raptors use flapping flight during hunting, there is little need for thermals, unlike raptors which use soaring flight to search for prey. Large vultures like the two *Gyps* species resident in the region (e.g. slender-billed vulture, white-rumped vulture) tend to be inactive until the middle to late morning when birds start soaring, to take advantage of thermals to look out for food items. Given that flight is extremely energy costly, many raptors spend much of the day resting, in-between and after periods of hunting.

Current knowledge on the diet of Asian raptors is based on the few instances of field observations, as well as inferences made from the observations elsewhere, especially in India. Some of the raptors species with the most comprehensive knowledge on diet and foraging behavior are also the region's most threatened species (e.g. Philippine eagle, Javan hawk eagle) and have been the focus of intensive studies. Studies on the Javan hawk eagle for instance have documented at least eight mammal species and a further six unidentified mammalian taxa

based on pellets found in nests, besides five known bird prey (Prawiradilaga 2006). Likewise, the Philippine eagle has been consistently studied for nearly four decades. Such has yielded fairly comprehensive data on their diets: we now know the diet of Philippine eagles to include many large mammals like long-tailed macaques, common palm civet, Philippine colugo and tarictic hornbills (Thiollay 1994) and despite its name, feeds primarily on colugos.

Table 2. *Prey items documented in the diet of various South-east Asian raptors*

Prey class	Examples of prey taxa	Raptor species
Large mammals (> 5.0kg)	Long-tailed macaque, Philippine colugo	Philippine eagle, mountain hawk eagle
Medium-sized mammals (1.0 – 5.0kg)	Plaintain squirrel, Common palm civet, various flying squirrels, Malay stink badger	Philippine eagle, mountain hawk eagle, black eagle, all *Aquila* eagles
Small mammals (<1.0kg)	Rats, treeshrews, *Callosciurus* squirrels *Sundascurius* squirrels	Hawk eagles, all *Aquila* eagle, *Butastur* buzzards, *Circus* harriers, black-winged kite, crested goshawk, black kite, brahminy kite, various falcons
Lizards	Monitors, agamids, skinks	*Spizaetus* eagles, *Butastur* buzzards black baza, common buzzard
Snakes	Oriental whip snake, various Colubrid tree snakes, puff-faced water snake	Crested serpent eagle, grey-headed fish eagle, Jerdon's baza
Large birds (> 3.0kg)	Red junglefowl (& domestic fowl), rufous hornbill, herons, ducks	Philippine eagle, mountain hawk eagle, black eagle, peregrine falcon
Medium-sized birds (0.2 – 3.0kg)	Green pigeons, owls, *Penelopides* hornbills	Philippine eagle, rufous-bellied eagle, crested goshawk, black eagle
Small birds (< 0.2kg)	Various sparrows, tits, bulbuls, warblers, starlings, babblers	*Accipiter* sparrowhawks, peregrine falcon, oriental hobby
Frogs	Various *Rana* and *Ferjevarya* frogs	Chinese goshawk, grey-faced buzzard. *Circus* harriers
Fish	Various carp, catfish, snakeheads and introduced cichlids	Osprey, grey-headed and lesser fish eagle, white-bellied fish eagle
Insects	Dragonflies, orthopterans, large lepidopterans, bees and wasp larvae	*Microhierax* and *Polihierax* falconets, bazas, crested honey buzzard
Carrion	Various dead mammals (wild and domestic) and birds	All *Gyps* and *Sarcogyps* vultures, brahminy kite, *Aquila* eagles

7.3 Territoriality and breeding

Many birds, including raptors keep breeding territories, which are actively defended from conspecifics. Territories are important as they present exclusive foraging opportunities to their owners, thus allowing for a constant supply of food even during non-breeding periods. Various displays and threat advertisements are employed by their owners to repel intruders from straying into defended territory. Interestingly, this is not as apparent for non-breeding or immature conspecifics. Territorial behavior between breeding pairs play a major role in determining spatial distribution, and thus directly influence breeding densities, on top of three

other key factors. Besides territoriality, the availability of potential nest sites, prey abundance and habitat are other important factors though these have not been investigated in detail for many South-east Asian raptors. With increasing conversion or modification of habitats, habitat availability nowadays increasingly limits breeding densities of raptors throughout many parts of South-east Asia.

Most raptors are monogamous and at least from a South-east Asian context, there is little evidence for other breeding strategies like polygyny or cooperative breeding. Breeding occurs when sexual maturity is reached; age to sexual maturity however varies greatly between species, depending on size. Small-bodied species like sparrowhawks may first breed at one to two years of age. At the other end of the spectrum, the large fish eagles first breed only when they are four to five years of age. Breeding is heavily influenced by seasonality and raptors living in areas with pronounced dry seasons usually breed early in the dry season so that the fledging of young coincides with the arrival of the monsoon rains where prey is more abundant. In areas where seasonality is less pronounced or non-existent, raptors may breed throughout the year. In Singapore, the grey-headed fish eagle usually breeds between December and March but attempted nesting has been documented in other months (Yong *et al*., in prep).

Figure 15. *A five month (or approximately 120 days) old Philippine eagle Chick at a regular nest site at Mount Kitanglad, Mindanao, Philippines. The nest is a large structure almost 2 m across, built about 30 m above the ground in a forested ravine, and apparently has been re-used for over multiple breeding seasons. Generally, the largest tropical forest raptors have the longest incubation periods and chicks also take the longest time to fledge. The normal clutch size for this species is one egg. (Richard Thomas).*

All raptors species in the region are known to build a nest platform, largely constituted from sticks, and leaves, with the exception of the *Microhierax* and *Polihierax* falconets which are primarily hole-nesters. Many South-east Asian raptors build their nests on tall dead or living trees, and there is some evidence to show that some species like the White-bellied fish eagle reuse their nests over multiple years by adding more material to an existing nest structure. Others like the grey-headed fish eagle are seldom known to reuse their nests (Yong *et al*. in prep), building new structures every breeding season. Some like the resident subspecies *ernesti* of the Peregrine falcon and the white-rumped vulture are known to nest on cliff ledges on limestone hills in peninsular Malaysia (see Wells 1999), the latter in small colonies.

When nesting, raptors engage in a diverse behaviors ranging from courtship feeding and display flights to affirm territory or strengthen pair-bonding. Nests are also aggressively defended from intruders, including conspecifics. Mated pairs can be seen engaged in spectacular display flights, which include repeated diving and rising again, cartwheeling or for some species like the *Nisaetus* hawk eagles, simply just soaring and calling (Ferguson-Lees & Christie 1999).

Clutch size refers to the number of eggs laid and can range from one to two for the largest forest raptors and fish eagles, to three to four in the kites and smaller hawks. Incubation periods are variable between species and while it may take up to a month for sparrowhawks (e.g. Crested goshawk), may last up to two month for the Philippine eagle. Incubation duties are usually held by the female although the male may relieve her occasionally for some species. For many of the larger raptors (e.g. *Aquila* eagles), one of the chicks usually kill its sibling, and is popularly described by ornithologists as Cainism, a behavioral response to increase chances of survival by monopolizing all food resources

The nestling period is defined by the point the chick hatches to the time it takes its first flight. In the case of the many *Accipiter* species in the region, this may take barely a month to slightly beyond a month (e.g. 32 days for crested goshawk). Naturally, the Philippine eagle which is the largest raptor in the region, can take up to over three months (23 – 24 weeks) before the chick makes any attempt to leave the nest and fly.

7.4 Migration

Migration is perhaps one of the most well-studied aspects of raptor behavioral ecology although much of what is known, until recently is drawn solely from studies in North America, Europe and the Middle East. South-east Asia has increasingly received more attention from researchers and in the last ten years, raptor migration censuses at multiple field sites across South-east Asia has yielded significant knowledge of the movement patterns and numbers of migratory raptors passing through. Three of the most well known sites for raptor migration are Khao Dinsor and Radar hill in peninsular Thailand and Tanjong Tuan on the west coast of peninsular Malaysia. More recently, Germi *et al*. (2009) has documented previous unknown, large scale passage of over 100,000 Chinese goshawks over Sangihe island north of Sulawesi, including a significant number of individuals overwintering on that island.

7.4.1 Why migrate?

Migration is one of the greatest spectacles of nature and the large numbers of animals on the move have astounded even our pre-civilisation ancestors. Despite the seeming complexity of animal migration, there are three key reasons to explain migratory behavior and in the context of many birds including raptors, this can be summarized as:

a. Avoiding the cold boreal winter and the harsh conditions it presents
b. Exploiting more easily available food resources (in the tropics)
c. Establish new foraging (and for a few species, breeding) territories

7.4.2 Major migration sites in South-east Asia

Currently, the most well-watched raptor migration sites in South-east Asia are in southern Thailand, particularly Radar hill in Prachaup Khiri Khan and Chumphon provinces where there have been regular attempts to document migrating raptors. In the autumn of 2003, counts conducted in Chumphon for example documented over 170,000 raptors of 15 species over a period of 43 days based on daily counts (DeCandido *et al*. 2004), highlighting the importance of the site as a migratory bottleneck for raptors. The large numbers of migrating raptors using the site means that it is also presently the most important known site for migrating raptors in South-east Asia until more other similar sites are found. Sangihe island, directly north of the Sulawesi was virtually unknown as a migration site until recent studies confirmed that significant number of Chinese goshawks were passing through, and this clearly is another key raptor migration site in the region.

Figure 16. *Key raptor migration sites in East and South-east Asia, based on current knowledge. Reproduced from DeCandido* et al. *(2004).*

1. Tanjung Tuan, Malaysia
2. Selangor Plains, Malaysia
3. Chumphon, Thailand
4. Sa Pa, Vietnam
5. Beidaihe, China
6. Uchiyama-toge, Nagasaki, Japan
7. Kohyamacho, Kagoshima, Japan
8. Miyako Islands (Ryukyus) and Okinawa, Japan
9. Kenting National Park, Taiwan
10. Bali Barat National Park, Indonesia
11. Sangihe Island, Indonesia (not shown in map)

7.4.3 Phenology and geography of raptor migration

Raptor migration phenology is no different from that of other migratory birds. Autumn migration involves the movement of large numbers of migratory raptors from their breeding grounds in temperate and for a few species, subtropical areas of northeast and east Asia, into tropical South-east Asia. This usually occurs over late August and early November. The journey into South-east Asia may take at least one to two months, from the time they depart their breeding grounds in say, Japan. This passage is reversed in Spring migration where raptors, as are many other waders, wildfowl and passerines move back to their breeding grounds in east and northeast Asia over the months of March to May, mostly in smaller numbers. Courtship and breeding then occurs over the intervening few months until autumn of the same year.

There are two major routes used by raptors migrating into South-east Asia and the Pacific islands. Both are part of the larger East Asian flyway. The continental route originates from Japan and the Korean Peninsula, follows the coast of China southwards into continental South-east Asia and finally funneling into the Malay Peninsula from where several major island hops follow, first into Sumatra, then Java and Bali. This is a major route for crested honey-buzzard, Japanese Sparrowhawk and black baza, as evidenced by field data. The oceanic route follows southern Japan and involves a number of major sea crossings, firstly from Japan into the Ryukyu Islands, then into Taiwan, followed by the Philippines and finally into Sulawesi, its

Figure 17. *(Left) Migratory path taken by a tracked crested honey-buzzard following the continental route on the East Asian flyway. Reproduced from Agostini & Mellone (2007). (Right) Flocks of Oriental honey-buzzards migrating over central Peninsular Malaysia. Reproduced from Lim & Lim (2010)*

satellites (e.g. Sula, Banggai islands) and the Moluccan islands. This route is known to be especially important for grey-faced buzzard and Chinese goshawk (Germi *et al*. 2009). Although some species occur along both routes, they are dominant in either one of them. The grey-faced buzzard for example occurs mainly along the oceanic route, but is also recorded in relatively low numbers on the continental route. Four environmental factors are known to influence raptor migration movements: wing loading, general weather conditions, presence of thermals (important for soaring while minimizing energy consumption) and the tendency to avoid sea-crossings where possible. Making sea crossings is especially energetically draining since the weaker thermals makes it necessary for more flapping flight, making it perilous for exhausted individuals. Where major sea crossings need to be undertaken, migrating raptors like Japanese sparrowhawk will try to rest where possible, including roosting and foraging on ships (Ellis *et al*. 1990).

Table 3. *List of widespread Palearctic species that regularly winter in South-east Asia. See Ferguson-Lees & Christie (1999) for a more detailed description of breeding ranges. Threat status follows Stattersfield & Capper (2000).*

Common name	Species	Threat	Breeding range
Accipitridae			
Oriental honey-buzzard	*Pernis ptilorhyncha*	LC	North, Northeast, East Asia
Black kite	*Milvus migrans*	LC	North, Northeast, East Asia
Booted eagle	*Hieraeetus pennatus*	LC	North, Northeast Asia
Eastern marsh harrier	*Circus spilonotus*	LC	North, Northeast Asia
Pied harrier	*Circus melanoleucos*	LC	North, Northeast Asia
Chinese sparrowhawk	*Accipiter soloensis*	LC	East, Northeast, East Asia
Japanese sparrowhawk	*Accipiter gularis*	LC	East, Northeast, East Asia
Black baza	*Aviceda leuphotes*	LC	East Asia
Grey-faced buzzard	*Butastur indicus*	LC	North, Northeast Asia
Common buzzard*	*Buteo buteo*	LC	North, Northeast, East Asia
Greater spotted eagle	*Aquila clanga*	VU	Europe, North, Central Asia
Steppe eagle	*Aquila nipalensis*	LC	North, Central Asia
Imperial eagle	*Aquila heliaca*	VU	North, Central Asia
Falconidae			
Peregrine falcon	*Falco peregrinus*	LC	North, Northeast, East Asia
Common kestrel	*Falco tinnunculus*	LC	North, Northeast Asia

*Common buzzard is sometimes treated as a separate species, eastern buzzard *Buteo japonicus*

Figure 18. (Left) *The steppe eagle regularly migrates to mainland South-east Asia in small numbers. Most birds winter in the coastal plains, especially in cultivation in parts of Cambodia and Thailand (Ingo Waschkies). (Below) The Jerdon's baza is a partial migrant in South-east Asia. Although most populations are sedentary, small numbers have been seen on migration (Con Foley).*

7.4.4 Raptor migration in Singapore

Recent studies show that 14 species of migratory raptors occur in Singapore either on passage or as winter visitors, with three to four species present in relatively large numbers (e.g. Oriental honey-buzzard, Black baza, Japanese sparrowhawk). Considerable raptor passage has been documented at a few key sites though this fluctuates greatly with time. The highest count documented locally involved over 1500 Oriental honey-buzzard on passage into Sumatra from Tuas in Singapore's extreme west coast in November 2008. The fact that such numbers were undocumented in subsequent years suggests that movements of raptors through Singapore is sensitive to weather conditions.

Of the many species recorded, less than 10 overwinter in Singapore. The bulk of migrating sparrowhawks and honey-buzzards recorded locally are passage migrants enroute to Sumatra and other parts of western Indonesia (e.g. Riau islands). Small numbers of Chinese goshawk and common buzzard, as are crested honey-buzzard, Japanese sparrowhawks, black baza and eastern marsh harrier are the main species overwintering here. Some, like the osprey and peregrine which is observed all year round may occur here both as migrants and residents though there is no breeding evidence to date.

A number of migratory raptors occur in Singapore as extreme vagrants, examples being the imperial eagle, Amur falcon and the lesser kestrel. All either do not overwinter in South-east Asia or only do so in small numbers. The Himalayan griffon, formerly thought to be sedentary is now sporadically recorded in the South-east Asia in midwinter, including Singapore (Yong & Kasorndorkbua 2008). The proximal causes of this 'migration' are still not understood although climate change has been suggested as a possible driver.

Figure 19. *Variation in diversity of 12 species of migratory raptors in Singapore over a 32 month period, from October 2007 to May 2010. The high richness of raptors consistently detected over November suggests that this is the peak month for raptor passage in Singapore.*

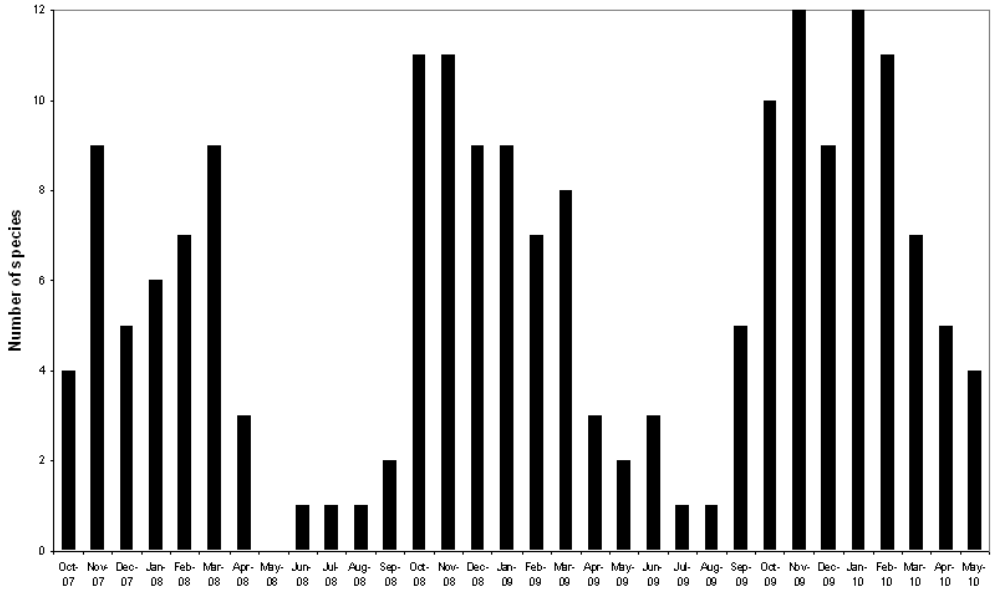

Figure 20. *Key raptor passage sites in Singapore. From west to east, sites are: Tuas West, Bukit Timah hill, Kent Ridge park, Mount Faber Park, Changi east.*

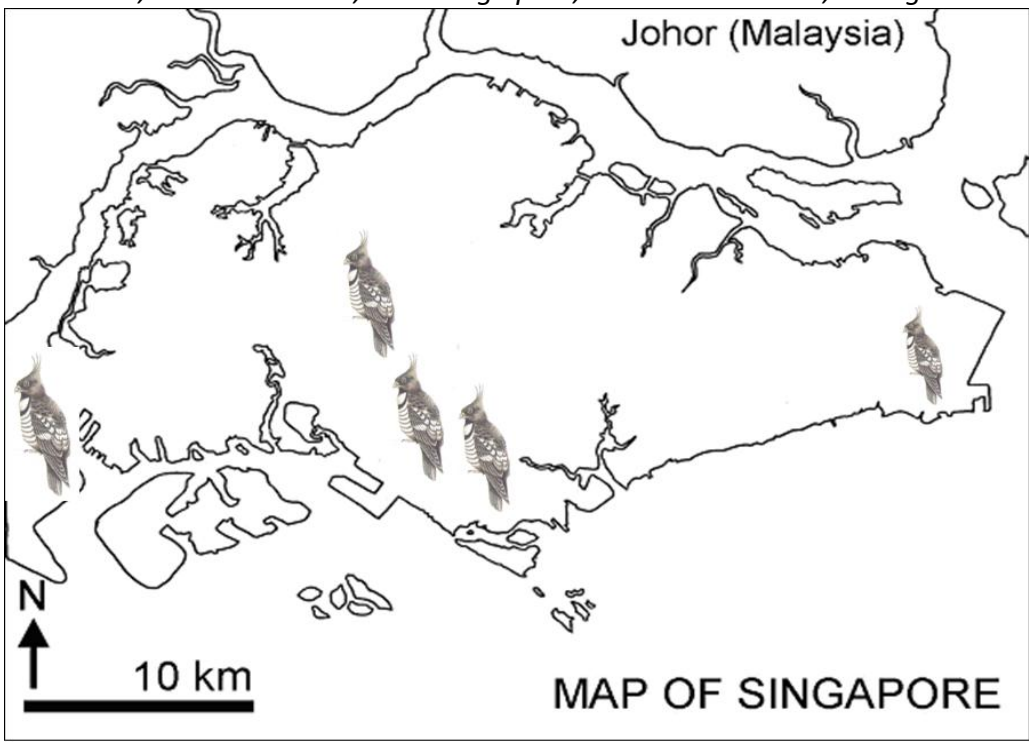

Table 4. *Abundance of migratory raptors recorded in Singapore over a 17 month period (2009 – 2010). The crested honey buzzard is clearly the most abundant raptor on passage.*

Common Name	Months (2009 – 2010)																
	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10
Oriental Honey Buzzard	19	17	429	0	0	1	1	0	2	42	430	22	27	20	16	2	2
Common Buzzard	0	0	1	0	0	0	0	0	1	1	4	0	3	2	0	0	0
Grey-faced Buzzard	0	0	0	0	0	0	0	0	0	2	5	0	0	0	0	0	0
Japanese Sparrowhawk	3	2	4	1	0	0	0	0	5	15	71	3	6	3	3	37	2
Chinese Goshawk	2	0	1	0	0	0	0	0	0	1	10	3	3	1	3	0	0
Black Baza	45	70	43	0	0	0	0	0	0	4	224	27	130	91	41	1	0
Black Kite	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Booted Eagle	2	0	0	0	0	0	0	0	0	0	1	1	3	2	0	0	0
Rufous-bellied Eagle	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Greater Spotted Eagle	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Eastern Marsh Harrier	3	1	2	0	0	0	0	0	0	1	9	5	6	4	3	0	0
Hen Harrier	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pied Harrier	0	0	0	0	1	0	0	0	0	0	2	0	1	0	0	0	0
Peregrine Falcon	5	5	8	1	0	1	0	0	1	5	11	1	6	4	8	3	1
Common Kestrel	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Osprey	5	4	5	2	1	1	0	1	1	8	10	1	7	11	4	1	0
Total abundance	85	100	493	4	2	3	1	1	10	81	778	64	194	140	78	44	5
Total diversity	9	7	8	3	2	3	1	1	5	10	12	9	12	11	7	5	4

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Figure 21. *Grey-faced buzzard on migration over peninsular Thailand (Con Foley). More than 17,000 individuals have been observed at some count sites (e.g. Promsri hill), forming nearly 40% of all raptors counted. Where the bulk overwinter is still largely a matter of speculation as grey-faced buzzards appear to be relatively rare in peninsular Malaysia and Singapore.*

VIII. Conservation of raptors in South-east Asia

8.1 Overview

Almost a quarter of all species of raptors recorded in South-east Asia are now currently listed as near-threatened or threatened by Birdlife International (Stattersfield & Capper 2000). Although some species like the white-bellied fish eagle are still widespread and relatively common in its range (with 10 pairs estimated for Singapore alone), others like the Philippine eagle and Javan hawk eagle have highly restricted distributions and have global populations of less than 200 pairs. Others, while still common in many areas have shown marked local declines, as exemplified by the brahminy kite in Java. This section reviews the need for raptor conservation and the key threats faced by raptors in South-east Asia.

Figure 22. *Two of South-east Asia's highly threatened raptors. (Left) The critically endangered Philippine eagle. (Right) The vulnerable Wallace's hawk eagle has lost most of its lowland rainforest habitat.*

8.2 Why conserve raptors?

A primary aim of the science of ecology is to examine the biotic interactions between organisms. The key rationales for conserving raptors are a largely ecological. Raptors are predators, which mean that all species are found high up or at the apex of food chains. As pointed out in Sergio *et al.* (2008), top predators are able to directly influence ecological dynamics at various spatial and time scales by initiating trophic cascades by directly impacting organisms at lower trophic levels. A decline in an apex predator's population may allow for herbivores that were being predated, or mid-level predators, to be released from predation pressures they were previously subjected to. Release of predation pressure allows these

species to increase their populations drastically which in turn may affect other species in the ecosystem. In exceptional cases, this may even lead to changes at a landscape level. While there is no evidence for this happening in South-east Asia, studies in North America and Europe have documented declines of predators, including raptors, which in turn triggered increases in rodent populations with predictable consequences on the plants these feed on. Raptors, being top predators are also good indicators of environmental health and can thus be used as 'sentinels'. The fact that raptors have large area requirements for territories (and hence low population densities), and low fecundity means that undetected environmental pollution may first surface in the declines of raptor populations. Studies in North America and Europe have demonstrated bioaccumulation of pesticides in raptors, classic examples including the Peregrine falcon and bald eagle, leading to long term population declines. Pesticides like DDTs are eaten by prey organisms, which in turn are consumed by raptors and become accumulated in their tissues with pathogenic implications, leading to failed nesting in the long term.

Raptors are also umbrella and flagship species in conservation. That they are easily recognizable by people and are able to evoke interest and emotion in the populace means that a number of raptors are used as the subject of conservation campaigns in the region, again the best example being the Philippine eagle. The fact that many raptors have large home ranges means that attempts to conserve them will benefit other species occurring in the same habitat, and the local ecosystem at large. This inevitably extends an 'umbrella' of protection for other species as well.

8.3 Threats to raptors

Although threats faced by raptors globally are varied, most South-east Asian are threatened by habitat loss and degradation (especially forest fragmentation), given the large area of forest habitats they need. South-east Asia's landscape has gone through large-scale modification by humans in the last three decades and much of its natural landscapes are now lost. This is even more acute for primary forests, given the fact that tropical forests are more rapidly lost here than in any other tropical regions (Sodhi *et al*. 2004). Lowland

Figure 23. *Two near-threatened raptor species affected by rapid deforestation in South-east Asia. (Left) small sparrowhawk is endemic to Sulawesi's lowland and montane forests (Ingo Waschkies). (Right) white-fronted falconet is confined to north Borneo's lowland forests (Michelle and Peter Wong).*

evergreen forests have been largely lost due to logging and agriculture in Sulawesi, Sumatra, Borneo, most of the Philippine islands, as are many areas in continental South-east Asia. Deforestation now increasingly threatens forests on hill slopes and mountains and is particularly increasingly apparent in parts of upland Sumatra, Luzon and Mindanao.

The Philippine eagle, Javan and Flores hawk eagle are now restricted to remaining fragments of mostly montane forests on Mindanao, Luzon, Java and Flores respectively, where deforestation is low. Wallace's hawk eagle is confined to lowland forests in the Thai-Malay Peninsula, Sumatra and Borneo and has lost most of its core habitat; it is now classified as globally vulnerable. Less is even known about the status of raptors in the Lesser Sundas and the Moluccas, but predictably the same story applies, forest raptors are likely due to most threatened given extensive habitat loss in their ranges (van Balen 1998).

While many raptors have declined due to direct habitat loss, others declined with the corresponding loss of their prey base. All three resident species of vultures in mainland South-east Asia are clear examples. The decline of the region's large mammals due to habitat loss and hunting meant a significant reduction of food resources for scavengers. This is made worst by changes in animal husbandry practices. The last hundred years have seen a dramatic range contraction of three vulture species in South-east Asia, with total extirpation in the Malay Peninsula. The red-headed vulture, formerly resident in Thailand's western forest corridor became extinct there in the 1990s, the last individuals being killed by poison baits in set by hunters. Vulture populations now persist only in northern Myanmar (e.g. Kachin state) and Cambodia's northern plains, and even so only under intensive conservation measures.

Figure 24. *South-east Asia's last remaining vulture populations are in Cambodia's northern plains, a large area of dry dipterocarp forests and wooded savannahs bordering southern Laos, which is protected in a number of key conservation sites (e.g. Kulen-Promtep wildlife sanctuary, Preah Vihear protected forest).*

Hunting of raptors for various reasons (e.g. sport, falconry), though not a major threat in South-east Asia is especially detrimental to certain species. The best example is the Javan hawk eagle which is often poached for the pet trade to be kept as household status symbols by wealthy people in Indonesia (van Balen *et al*. 2000). The recent declaration of this species as a nationally 'rare animal' has worsened the situation, as suggested by recent evidence from the illegal wildlife trade. Others raptors are accidentally or deliberately shot by hunters, either because individuals were seen predating livestock, or simply for food and sport. The recent loss of a juvenile Philippine eagle to the guns of hunters in Mindanao, and a similar fate of that of a rehabilitated and released Cinereous vulture 'Anakin Skywalker' in Myanmar exemplify this fact (See Anon 2008, Casey 2007).

In short, raptors in South-east Asia currently face four key threats:

1. Direct loss of natural habitat (e.g. lowland forest) to human activities
2. Degradation and fragmentation of existing natural habitat
3. Loss of prey base (especially large wild mammals)
4. Hunting (e.g. for sport, food, falconry)

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IX. Studying and surveying raptors

9.1. Overview

Many methods have been or are in the process of being devised to study raptors in the wild. The easiest methods involve simple visual surveys; for migratory species, this may involve positioning oneself along major migration bottlenecks and counting the raptors as they fly over. Increasingly, researchers are resorting to radio or satellite telemetry to document movement and survival of raptors. Raptors are caught, either from their nests, mist-nets or by baiting and are then fixed with transmitting units, allowing spatial data on the raptor's location to be systematically collected. The advent of satellite telemetry (e.g. ARGOS, GSM technology) means that tracking of raptor movement can now be executed with considerable precision, though the technology for conducting such studies is not easily accessible to many researchers based in the tropics. On the other hand, these studies have revealed many exciting new findings: for instance, transmitters attached to migrating Amur falcons have recently continuously tracked their movement into southern Africa from Northeast Asia, one of the longest migrations amongst birds in general.

9.2 Surveying diurnal migratory raptors

As pointed out in Bibby *et al*. (2000), estimating populations of migratory raptors can be done by conducting counts at fixed migration sites, which often are geographic locales preferred by migrating raptors. Areas with good vantage points like hills are important for an unobstructed view of most migrating raptors. Methodically scanning of the skies is important and repeated moving of the binoculars from left to right or vice versa along a single field of view ensures that most of the gliding birds are counted (see Sutherland 1996). Teams of counters spread out along a front would be necessary especially when birds fly in along a broad front and there exists a danger of double counting. Care must thus be taken to define fields of views to minimise this. Especially when large flocks of raptors are passing over, these can be counted in groups of tens, as opposed to individual counting which is slow and often inaccurate. All in all, as much as 90% of the birds passing through can be documented over a two to three week window.

9.3 Surveying resident raptors

9.3.1 Simple 'look-see' counts for single species

A good knowledge of the habitat preference of the species of research interest is important for 'look-see' counts to be effective. For raptors, the counting unit is the 'breeding territory', as recommended by Bibby *et al*. (2000), each whose occupancy is indicated by the presence of a breeding pair. Evidence for breeding includes direct observations of raptor pairs, active nests that contain eggs or young. Other signs that can be taken to indicate breeding occupancy are observations of adults carrying food back to a nest, and finding newly moulted feathers. Data collected can then be mapped using geographic information systems (ArcGIS) software and subsequently used to estimate the density of breeding pairs in the area studied. For better

accuracy, Bibby *et al*. (2000) recommends that all observations of birds and nesting activity be counted within a single breeding season to minimize double-counting of mated pairs.

9.3.2 Roadside surveys of soaring raptors

This method allows large open habitats to be surveyed in a short time. An observer drives slowly on a clear day and count all soaring raptors seen on either side of the road within a specified distance of up to 1.6 km (Bibby *et al*. 2000). While easy to carry out, the variability in detecting raptors and its limitation to times of the day when the weather is warm (for soaring raptors) are two considerations that must be taken into account. Also, forest habitats cannot be effectively surveyed this way for raptors. Estimates of relative abundance and number of breeding pairs over defined 'transects' however can be easily obtained this way.

9.3.3 Raptor tracking

Due to their large territories and distances covered by raptors, especially migratory species, satellite telemetry is often employed to study raptors. Tracking a raptor using a transmitting unit attached to its body allows for various scientific questions, including many that cannot be addressed by simple observational studies, to be answered. Examples includes questions on behavioral ecology, especially those addressing migratory behavior (e.g. routes taken, presence of rest stops, timing, site fidelity, hunting and ranging behavior in wintering sites), post-fledging dispersal, annual mortality and general survival. An excellent summary of this is provided in Meyburg & Meyburg (2002). Currently, transmitting units as small as 20g are available and this can be fitted on the smallest of raptors, as opposed to the larger and more conventional units that can weight almost 100g. While battery operated transmitters can work for a few months, solar-powered models can function for as many as five years.

Transmitters fitted on a raptor allow the location, in terms of coordinates to be continuously monitored with some transmitters being able to deliver up to 1000 locations in a single year (Meyburg & Meyburg 2002). Data transmission can be done using the Global positioning system (GPS) or ARGOS, the latter which can be extremely costly. One of the main problems of raptor tracking is that the raptor has to be caught first and this can be quite labour and skill intensive. A common method used by researchers in Europe to capture raptors involves setting up a decoy owl, to provoke an aggressive response, and a nearby net, in which the raptor flies into and becomes trapped. Other methods involve catching raptors when they are least mobile, and these can be done by baiting raptors with food, or capturing them in the nests.

9.4 The raptor literature

Being highly charismatic species, there is comparatively more research on raptors than many other groups of birds. Two peer-reviewed journals are dedicated solely to raptor research, namely the *Journal of Raptor Research*, which is published by the Raptor Research Foundation, and *Vulture News* which is published by Vulture Study Group. The *Asian Raptor Bulletin* which is published by the Asian Raptor Research and Conservation Network (ARRCN) is another leading source of information on South-east Asian raptors. Other journals which features occasional papers on raptor ecology and biology includes, *The Auk*, *Condor*, *Emu*, *Ibis*, *Forktail*, *Japanese*

Journal of Ornithology, *Journal of Field Ornithology*, *Wilson Bulletin* and *Journal of Avian Biology*. *Biological Conservation*, *Biodiversity and Conservation*, and *Animal Conservation* occasionally feature articles on raptors, with a conservation perspective. The Global Raptor Information Network (GRIN) (URL: http://www.globalraptors.org/grin/indexAlt.asp) is supported by the Peregrine Fund and is not only a key source of raptor information, but also provides extensive networking opportunities with raptor researchers globally.

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X. Glossary of terms

Allopatric speciation: a process where two or more populations of an organism, separated by geographical barriers, evolve separately to form new species.

Apex predator: a predator that is not preyed upon by any other predator, occurring at the top of food chains

Batesian mimicry: a form of mimicry where a harmless organism mimics the appearance of a more dangerous organism to evade predators, gaining protection in the process.

Bioaccumulation: Accumulation of toxic substances in an organism's tissue due to its inability to degrade or excrete these substances.

Cartwheeling: a common display gesture in raptors whereby two individuals engage talons in mid-air, after which both birds 'rotate' about on an axis and falls earthwards.

Clutch size: the number of eggs laid by a bird.

Conspecifics: members of the same species.

Convergent evolution: evolution of structural features with similar functions, but in unrelated organisms, due to similarities in environmental conditions.

Cooperative breeding: A social system in animals, especially birds and mammals, where individuals help care for young that are not their own, at the expense of their own reproduction.

DNA-DNA hybridization: a molecular technique commonly used in the study of taxonomic relationships between organisms where the extent of genetic similarity is compared between two DNA sequences from respective organisms studied. The more the similarity, the more closely related two organisms are.

Endemic: a term used to highlight the restricted distribution of an organism, within a small geographical area.

Fecundity: reproductive potential of an organism.

Kleptoparasitism: a form of feeding in some animals species whereby food is stolen from the organism that has originally caught it.

Melanism: a condition caused by the over-production of the black pigment, melanin.

Monophyly: a taxonomic term to define a group that contains an ancestral species and all its descendant species.

Moulting: the process of losing the outer covering (e.g. feathers, fur), to be replaced by a newer set of covering. This often occur at specific points in an organism's life.

Palearctic: a vast zoogeographic region containing Europe, most of temperate Asia, the Middle East and North Africa.

Polygyny: a mating system where a male have several female mates.

Phylogeny: the evolutionary relationships between a group of related organisms.

Sexual dimorphism: a condition where males and females of the same species have different external characteristics.

Site fidelity: a behavioral trait where an organism returns to the same place over time.

Telemetry: a method where measured quantities from a remote site can be transmitted to a data collection point for recording and processing.

Trophic cascade: a chain reaction of alterations in the lower levels of a food web or food chain when the upper levels (e.g. predators) are removed.

Wing loading: the ratio of an organisms' weight to its wing area. Lower wing loading allows for slower flight without stalling.

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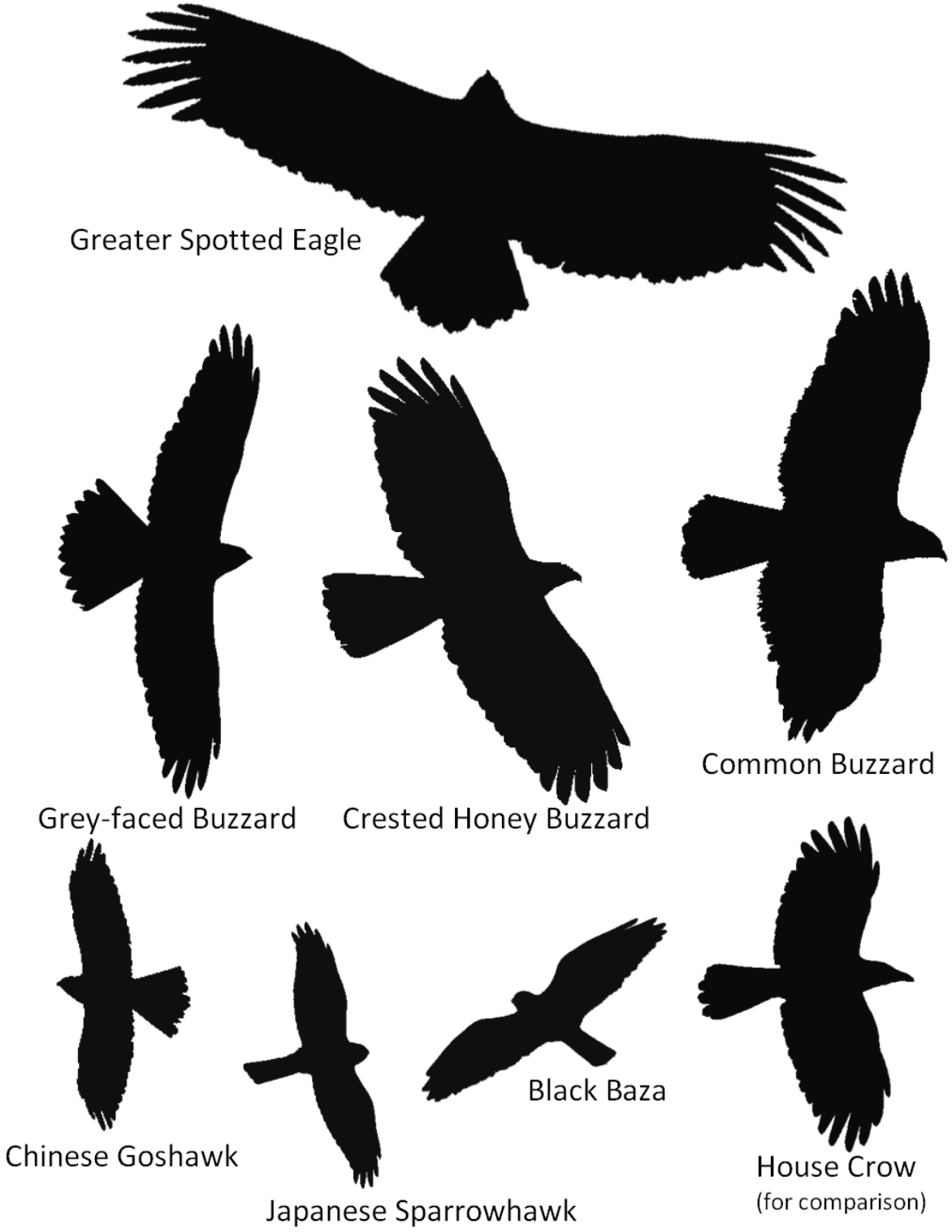
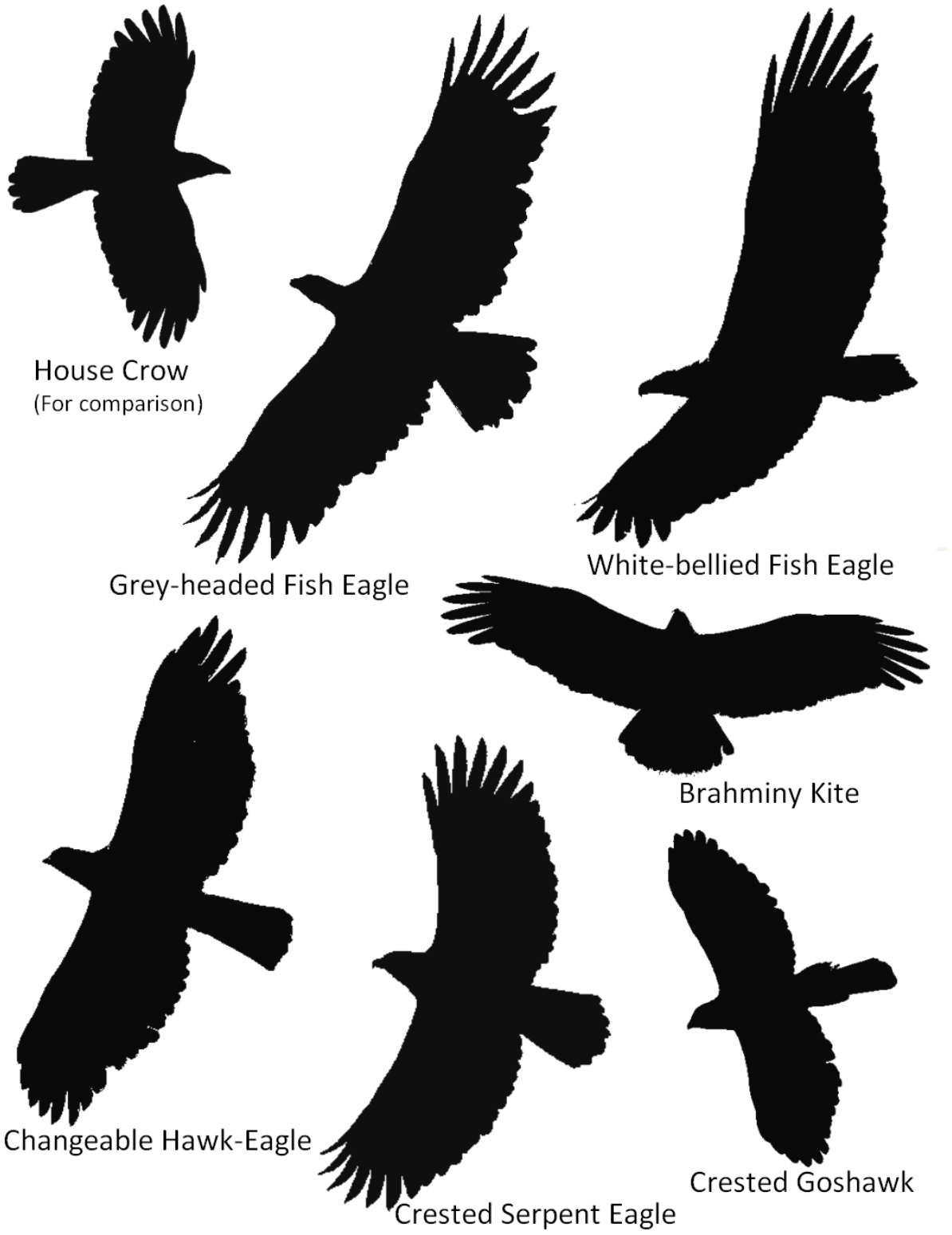
XI. Appendix I: Raptor flight charts

Migratory raptors in Singapore



Resident raptors in Singapore



Often confused raptor species pairs