An Introduction to the Raptors of Southeast Asia

Status, Identification, Biology and Conservation

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Table of Contents

1. Introduction

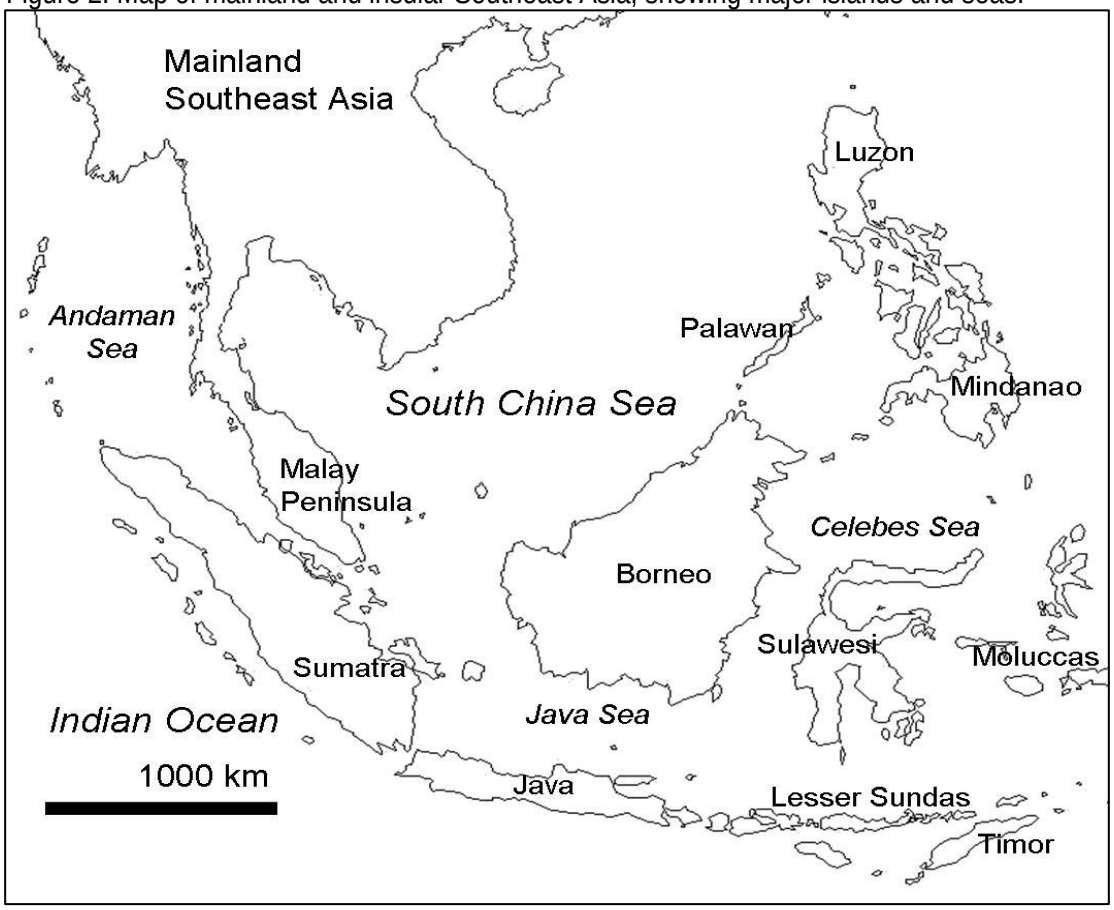
Southeast Asia, a region that falls entirely within the tropics is one of the greatest repositories of biodiversity in the world. This is exemplified by the fact that almost every area of it falls under a hotspot of biodiversity, as defined in Mittermeier *et al*. (2004). Birds, a dominant feature of the larger Southeast Asian landscape are represented by over 2000 species, or some 20% of the world's birdlife. 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 bird species. One of the reasons for this is that raptors are large, conspicuous, charismatic and powerful-looking, making them easily identified by the resident populace. Not surprisingly, raptors feature in the national symbols of two Southeast Asian countries, Indonesia and the Philippines, clearly highlighting their close cultural connections with the peoples of the region.

Figure 1. A brief sampling of Southeast Asian raptors. (Top left) Common 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, on top of the frequently used treatment of Southeast Asia as including only countries on mainland Southeast Asia (e.g. Robson 2002) which is incomplete, I have also

included the islands of the Greater Sundas (e.g. Sumatra, Borneo, Java, Bali), the Philippine islands and the many islands of Wallacea (e.g. Sulawesi, Lesser Sunda islands) as there are too much faunal elements in common, particularly raptor diversity which is largely shared between these areas. The region defined here as Southeast Asia has highly varied vegetation, and whilst large areas of it are covered with evergreen tropical forests, there are also significant areas of other vegetation types like deciduous, mangrove (e.g. parts of east Sumatra, south Borneo), peat swamp (e.g. Borneo) and coniferous forests (e.g. north Thailand, southern Vietnam), as well as small areas of thorn scrub (e.g. central Myanmar). A striking feature of the landscape in Southeast Asia is that much of it is rugged and mountainous, rising to a maximum elevation of 5,880 m at Hkakabo Razi in northernmost Myanmar. Other major peaks include Kinabalu (4,095m) in the Crocker range in Borneo, and Kerinci (3,800m) in the Barisan range of Sumatra.

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 the region holds nearly 30% of the world's raptor species, 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 raptor species on many of the region's forested islands, the most spectacular being the Philippine eagle of Mindanao, Luzon and intervening islands. Furthermore, it is also worth nothing that the region falls along a number of major fly-ways for raptors migrating between Northeast Asia and Southeast Asia in the boreal winter. For example, every autumn, tens of thousands of sparrowhawks and honey-buzzards

would pass through a number of sites along the Thai-Malay peninsula, Sumatra and Java as they migrate south into the region's many tropical islands.

The pages of this review cover a number of areas on raptor biology, with the primary focus on identification, status and behavioral ecology of Southeast Asian raptors, as well as some supplementary material on how to conduct simple surveys of raptors. Although the thirty or so pages of text would definitely 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.

2. What is a raptor?

The term 'raptor' has a Latin origin, meaning 'to seize' and has been loosely applied to a number of other predatory birds, especially owls which are sometimes described as 'nocturnal raptors' as well as some groups of dinosaurs. In strict sense, it is used to define members of the avian order Accipitriformes, which includes three families, the largest being the hawks and eagles (Accipitridae), falcons (Falconidae) and lastly, the monotypic osprey (Pandionidae). A number of other carnivorous birds (e.g. American vultures, secretary bird), whilst sharing some similar behavioral and morphological features have been found to be genetically distinct and are thus no longer considered as true raptors.

Figure 3. Two typical raptors that occur in Southeast Asia: (Left) Oriental honey-buzzard is migratory, but also breeds in the region, (Right) the resident Grey-headed fish eagle.

All members of the Accipitriformes share a number of general morphological features though not all are entirely carnivorous as popularly thought. The classic exception is the Palm-nut vulture, a West African species that has a diet largely constituted of the fruits of the Oil Palm. In general, raptors show the typical hooked beaked (to varying extents depending on diet) and sharp claws, all morphological adaptations to carnivory. Many raptors exhibit reversed sexual dimorphism where the females are larger than the males, and this has been postulated to be influenced by food specialisation. Raptors are generally good fliers, and a significant number 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 again is variable, and is subjected to the raptor's habits and 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 their search for prey. Hawks that occur in forests on the other hand have shorter, but generally broader wings that allow them to maneuver easily under the canopy and one good example is the Philippine eagle *Pithecophaga jefferyi*.

Sitting at the other hand of the spectrum are the falcons, powerful hunters with generally long, pointed wings and sleek bodies that allow for rapid, spectacular dives during hunting. The most well-known of the falcons, the nearly cosmopolitan Peregrine falcon *Falco peregrinus* which occurs in Southeast Asia as a resident and migrant, can reach speeds of nearly 300km/h when diving and this feat would not be possible if not for its wing-shape and overall streamlined build.

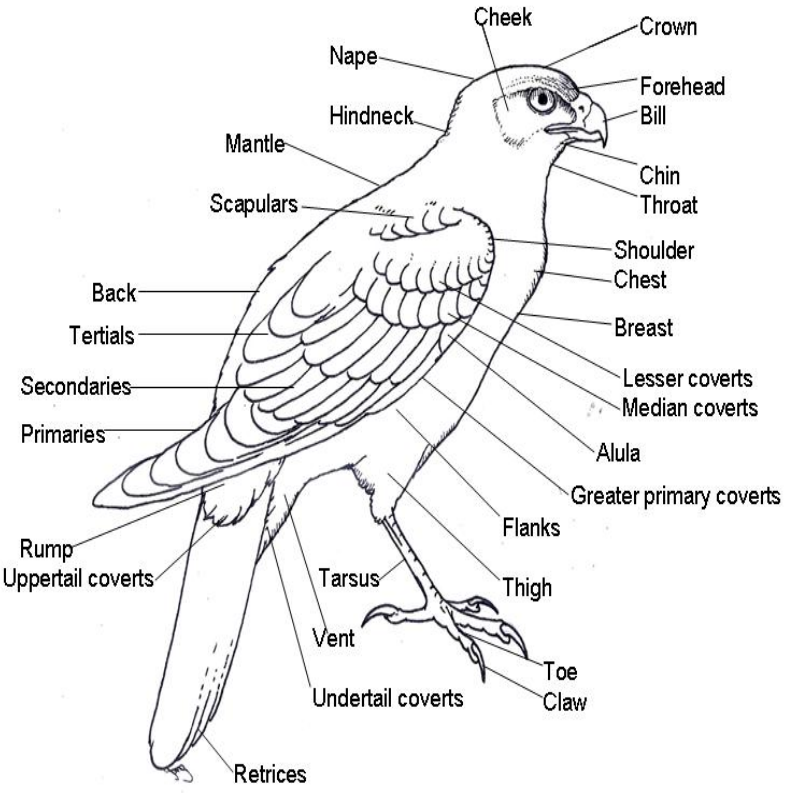
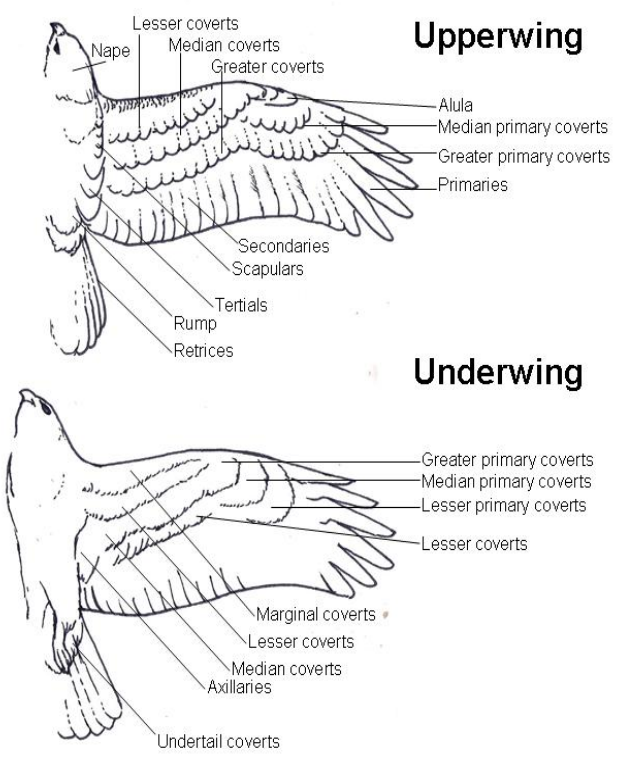


Figure 4a. (Above) Generalised topography of a perched raptor from a profile view.

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



3. Diversity of raptors in South-east Asia

Over sixty species of hawks and falcons breed in Southeast Asia, making it one of the richest areas for raptor diversity in the world. This is augmented every winter by nearly 20 species of migratory raptors from temperate central and northern Asia, many which fly south in large spectacular flocks in excess of tens of thousands of birds along the major migratory fly-ways.

Figure 5. Habitats of some eastern Palearctic migratory raptors. (Left) 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 Oriental honey-buzzard.

Southeast Asia is home to a number of raptor genera that are either partially or entirely confined to within its boundaries. The only endemic genus is *Pithecophaga*, which is exclusive to the Philippine archipelago. Genera with majority of their representatives occurring in Southeast Asia include *Spilornis* (Serpent eagles), *Spizaetus* (Asian hawk eagles), *Ichthyophaga* (Fish eagles), *Ictinaetus* (Black eagle) and *Microhierax* (Falconets).

When considered at species level, there are 22 raptors, depending on the taxonomy followed (see Table 1) that are endemic to the countries of South-east Asia, with a few species shared by two or three countries in the region. Indonesia is notable for high raptor endemism, due primarily to her many oceanic islands in Wallacea and hence allowing for allopatric speciation. For example, Sulawesi and her satellite islands alone harbour six endemic raptors, including four sparrowhawks, one serpent eagle and hawk eagle respectively. Another major area of raptor endemism within Indonesia is the Moluccan islands, which host two to three species of sparrowhawks with narrow insular distributions. Flores and Java each hosts one endemic hawk eagle, both severely endangered. 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 and the lowland White-fronted falconet. A few widespread raptors like the Wallace's, Blyth's hawk eagle and Barred honey-buzzard are found in two or more countries, but their global ranges are still entirely within Southeast Asia.

Southeast Asia shares many of its resident raptors with the Indian subcontinent, southern China and for some species, Australasia; which means that many of these raptors are widespread within the Oriental region. Examples of these include the White-rumped vulture, Crested serpent eagle,

two *Butastur* hawks, Changeable hawk eagle, Crested goshawk, Shikra and Besra Sparrowhawks. Not surprisingly, a number of these raptors are morphologically, geographically variable, being represented by a number of distinct races although lines of specific/subspecific level delineation are still not entirely resolved. Many of these raptors are also ecologically variable and can occur in different vegetation types. The Changeable hawk eagle is one of the most adaptable examples, occurring in secondary forests, scrubland and agricultural area and with a vast range extending throughout the Indian subcontinent to much of Southeast Asia.

Figure 6. Forest habitats of endemic raptors in various parts of Southeast 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 refers to those that are widespread throughout the Old World (Eurasia, Africa), for instance the Bonelli's eagle and Peregrine falcon. Most raptors that fall within this category occur as migrants during the boreal winter. Ecologically, many of these 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 raptors like the endemic race *renschi* of the Bonelli's eagle and the 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 vegetation 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, is an excellent example. The island alone supports six resident raptors and at least ten 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 Southeast Asia. If a raptor is also an island endemic, the island group is indicated in brackets. (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	*Spizaetus philippensis*	VU	Philippines
Philippine serpent eagle	*Spizaetus holospilus*	LC	Philippines
Philippine falconet	*Microhierax erythrogenys*	LC	Philippines
Javan hawk eagle	*Spizaetus bartelsi*	EN	Indonesia (Java)
Sulawesi hawk eagle	*Spizaetus lanceolatus*	LC	Indonesia (Sulawesi)
Flores hawk eagle	*Spizaetus floris*	CR	Indonesia (Flores)
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 Southeast Asia

Table 2. List of widespread Palearctic species that regularly winter in Southeast Asia. See Ferguson-Lees & Christie (1999) for a more detailed description of its breeding range.

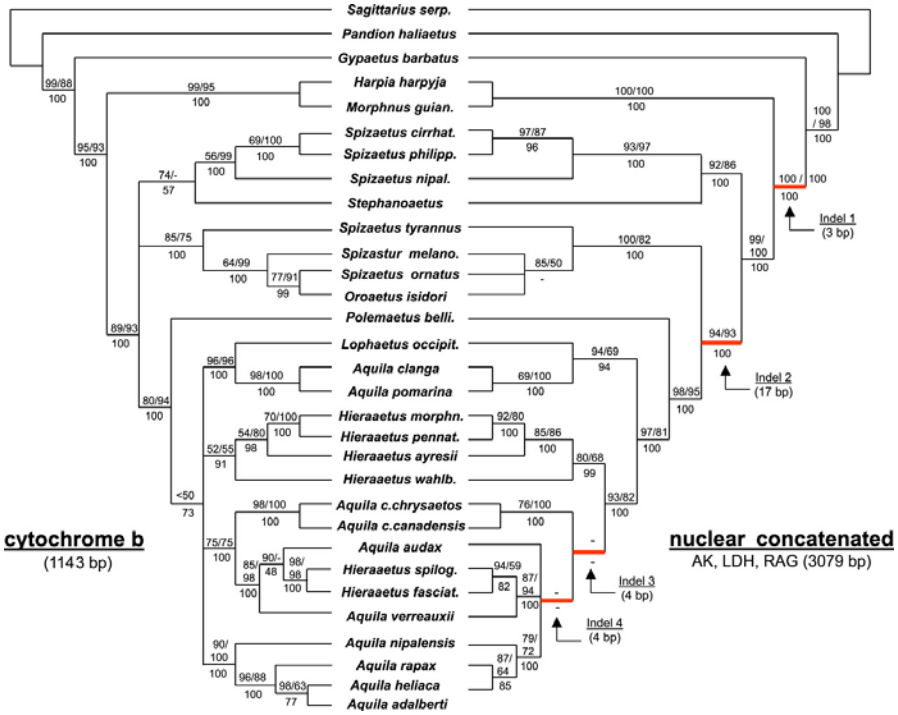
Common name	Species	Threat	Breeding range
Accipitridae			
Oriental honey-buzzard	*Pernis ptilorhyncha*	LC	North, Northeast, East Asia
Black kite	*Milvus migrans*	LC	North, Northeast, East Asia
Booted eagle	*Hieraeetus pennatus*	LC	North, Northeast Asia
Eastern marsh harrier	*Circus spilonotus*	LC	North, 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

4. Taxonomy and nomenclature

Bird taxonomy is currently undergoing a molecular overhaul, as advanced molecular methods become more easily available for phylogeny-based studies. The first major attempt to review the taxonomy of the world's birds using what is now an antiquated method, DNA-DNA hybridization, by Sibley & Ahlquist (1991) provided probably the first large-scale, objective attempt to examine taxonomic relationships in all the world's 9000 over species of birds. At the time of study, it was probably more objective and rigorous than previous traditional, morphology-based studies which needless to say, overlook critical aspects of convergent evolution and cryptic diversity. The work of Sibley & Ahlquist (1991) ultimately led to major revamps at higher taxonomic level, for instance Tribe Corvini was significantly inflated when previously unrelated monarchs and cuckooshrikes were discovered to be closely related to crows.

Present studies have discarded DNA-DNA hybridization, to be replaced by more powerful molecular techniques and bioinformatics tools available, which now allow specific base sequences of mitochondrial or nuclear genes to be identified and analysed. Analyses by comparisons of genes common to all species (e.g. Cytochrome B), and implementing parsimony, maximum likelihood and Bayesian models using various analytical software (e.g. PAUP*, MrBayes) has since revolutionalised raptor taxonomy by shedding invaluable insights on phylogeny, and has provided strong scientific support for some rather drastic revisions of raptor classification. For example, thanks to these techniques, 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.

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



Many species of Southeast Asian raptors have not escaped the taxonomic revolution that has overtaken classical morphology-based taxonomy. The formerly pantropical genus *Spizaetus*, with its seven to 15 member species depending on authors, are found to be not closely related, and had its Asian members reassigned to their original genus, *Nisaetus*, after these were found to be distantly related to the Neotropical hawk eagles, as was previously thought (see Helbig *et al*. 2005). Recent studies of the Asian hawk eagles (e.g. Changeable hawk eagle, Philippine hawk eagle) have found considerable intraspecific variation and polyphyly that it may be more meaningful to raise some subspecies (e.g. race *pinskeri* of Philippine hawk eagle) to species level (Gamauf *et al*. 2004). 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.

5. Identification of raptor species

5.1. Overview

Accurate identification of species is the foundation of reliable field studies and is crucial as it allows many other aspects of biology to be appropriately inferred or studied. Raptor identification presents a particularly daunting challenge to researchers and students alike, mainly because of the highly variable plumages of many species. Within-species variation due to geography is complicated by the fact that plumage can also vary 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 adult forms. Likewise, even within species, sexual dimorphisms can make accurate identification a particularly challenging task.

Identification of raptors starts from shape and build and this means familiarity with the topography is especially important. For convenience sake, I have grouped all the raptors occurring in Southeast Asia into sixteen major groups, each with fairly distinctive body shapes and sizes. Being able to allocate a raptor observed into any of these groups would help considerably in species-level identification. These groups broadly include:

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.
3. *Aquila* eagles and Black eagle – Generally large to medium-bodied eagles, robust looking, usually with dark brownish plumage. In flight, shows long broad wings.
4. Goshawks and Sparrowhawks (*Accipiter*) – Small to medium-sized, compact-looking raptors with fairly short, broad wings.
5. *Buteo* buzzards – Medium-sized, robust looking raptors with relatively large heads. Usually fairly broad wings.
6. *Butastar* buzzards – Small to medium-sized, robust-looking raptors with relatively short broad wings.
7. *Milvus* and *Haliastur* Kites – Small to medium-sized raptors with long, broad wings.
8. Serpent eagles (*Spilornis*) – Medium-sized, robust-looking raptors with relatively short, broad wings and large heads. All species also possess a short crest.
9. Hawk eagles (*Spizaetus, Hieraeetus*) – Medium-sized to large, compact-looking raptors with relatively short, broad wings. Highly variable plumage, often with extensive barring and streaking. All *Spizaetus* eagles possess a crest of varying lengths.
10. Fish eagles (*Haliaeetus, Ichthyophaga*) – Large-sized and small headed, with long and relatively narrow wings. Associated with water bodies.
11. Harriers (*Circus*) – Medium-sized, slender-looking appearance, with long, relatively narrow wings and long unfeathered legs. Many species have an ‘owl-like’ face.
12. Honey-buzzards (*Pernis*) – Medium-sized raptors with long, broad wings and relatively small heads. Rounded tail, often fanned out.
13. Bazas (*Aviceda*) – Small-sized raptors, with short broad wings. All species possess a short pointed crest.
14. Bat hawk (*Macheiramphus alcinus*) – A distinctive medium-sized raptor with long pointed wings and largely dark plumage. Very similar to a falcon in overall build.
15. Falcons (*Falco*) – Large range of sizes, from small to medium-bodied. Most have long, pointed wings.
16. Falconets (*Polihierax, Microhierax*) – Smallest of raptors in the region. Most are bulbul-sized and marked with extensive black and white.

5.2 Identification of perched raptors

While identification of raptors using field guides seem relatively straightforward, field conditions makes this exercise far from optimal and very often, observation time is extremely limited, especially when the raptor in question is flying past. Occasionally when resting, some of these raptors perch long enough for extensive noted to be taken and this is when the whole process is

made easier. 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?

5.3 Identification of flying raptors

Perching raptors present a set of challenges for identification because not all features are apparent to the observer, for instance, 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 although the length of time the raptor is seen is usually limited to a few seconds to not more than one or two minutes.

Figure 8. Raptors in flight can be extremely difficult to identify. (Left) Oriental honey-buzzard soaring over Changi, Singapore (Con Foley), (Right) Bonelli's eagle over central Flores, Indonesia (Ingo Waschkies)

Some identification pointers to look at for flying raptors included –

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

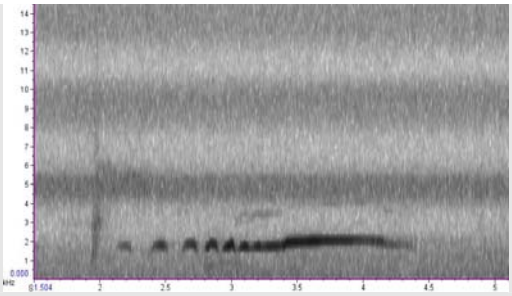


Figure 9. Sonogram of Mountain serpent eagle call, Mount Kinabalu, Borneo. (Frank Lambert, XC58818. Accessible at www. xeno-canto. org/58818.)

Besides physical appearance, calls of raptors are also useful guides in identification. 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 would thus come in handy for identification. Fish eagles 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' calls 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 particularly useful. An online database (URL: www.xeno-canto-org) contains a large repository of freely accessible raptor calls and can be very useful for making comparisons and identifying raptor calls.

Other aspects of raptor plumage

5.5 Polymorphism

On top of plumage variation due to age, sex and geography, some raptors can exhibit remarkably distinct plumage types within species, with more than one form occurring together in the same geographic locality. Commonly encountered in Southeast Asia are melanistic morphs, often described in field guides as 'dark morphs' and arises due to over-production of the pigment melanin in the plumages of these raptors, causing them to take on a darkish brown to black appearance. A typical example is the Changeable hawk eagle, which often occur as 'dark morphs' in parts of Southeast Asia, particularly in the race *limnaeetus*. Another raptor with highly variable plumage is the Oriental honey-buzzard, which no doubt is one of the most confusing raptors to identify. In Southeast Asia, the 'Tweeddale' morphs and resident race *torquatus* of the Oriental honey-buzzard, Barred honey-buzzard and Jerdon's baza are very similar to sympatric resident *Spizaetus* hawk eagles and are often cited as examples of Batesian mimicry, where more powerful species are being mimicked for protection against predators.

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 often timed at a time in a raptor's life where demands of migration, breeding and feeding is not too severe (Ferguson-Lees & Christie 1999). Knowledge of moult can be useful in assessing the age and in some cases, the sex. As a result of moulting, the external appearances of many raptors can be quite variable, so much so that some species appears odd and unlike what is typically described in field guides. Moult does not occur as one single event throughout, but usually partitioned in time into body moult which precedes quill moult (moulting of wing feathers). For more details on moulting, both Ferguson-Lees & Christie (1999) and Thiollay (1994) have furnished a more comprehensive overview.

Further reading

Ferguson-Lees, J. and Christie, D.A. (1999). *Raptors of the World*. U.K.: Academic Press.

Thiollay, J-M. (1994). Family Accipitridae (Hawks and Eagles). Pp. 52–205 in del Hoyo, J., Elliott, A. and Sargatal, J., eds. *Handbook of the Birds of the World*, Vol. 4. Barcelona: Lynx Edicions.

6. Raptor habitats in Southeast Asia

Raptors are among the most successful of land birds, occurring in almost all continents (except Antarctica) and habitats. Part of the reason for Southeast Asia's raptor diversity and richness can be attributed to its varied habitat types, which ranges from mangroves along sheltered coastlines, to snow-capped peaks in the Indo-Burmese Himalayas. As the dominant climax vegetation in Southeast Asia is tropical and subtropical evergreen forests, it is not surprising to note that a large proportion of resident raptors in the region are forest specialists, though some of these are able to utilise disturbed or cultivated areas. A number of raptor species are widespread in forested habitats throughout Southeast Asia, notable examples being the Crested serpent eagle, Changeable hawk eagle and Black eagle. This section reviews the variety of habitats and the communities of raptors associated with each.

6.1 Tropical subtropical evergreen forests

Southeast Asia's evergreen forests are home to its most species-rich raptor communities, harboring a many as eight species at a single site, depending on the forest type and elevation. A typical lowland forest raptor community in peninsular Malaysia would contain about six to eight members, including Crested serpent eagle, Wallace's and Changeable hawk eagles (an extreme lowland specialist), Crested goshawk, Rufous-bellied eagle, Oriental honey-buzzard, Jerdon's baza, Bat hawk and Black-thighed falconet. In forested areas with large rivers, both Grey-headed fish eagle and Lesser fish eagle can be expected to occur. Very similar communities are also found in lowland forests in Sumatra, Borneo, peninsular Thailand and Myanmar.

Forests at higher elevations support the Black eagle, Mountain hawk eagle and Blyth's hawk eagle. The Blyth's hawk eagle is usually a raptor of hilly country to high mountains, but may range down to forest at plains level, especially in parts of peninsular Malaysia. Likewise, the

Mountain hawk eagle occurs mainly in montane forests above 900m, but on Langkawi island off peninsular Malaysia, ranges down to as low as 600m on the island's highest peak, Mount Raya. In Java, hill and montane forest sites (e.g. Mount Gede, Halimun) support the endemic Javan hawk eagle, the widespread Black eagle, and occasionally Changeable hawk eagle.

Compared to the mainland, raptor communities on islands are generally less species rich. A typical raptor community at a similar lowland forest site in Luzon, Philippines (e.g. Subic Bay) would support about 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 similar in Sulawesi, where a lowland forest site could support Sulawesi serpent eagle, Sulawesi hawk eagle, Barred honey-buzzard, Jerdon's baza and one to two species of the endemic *Accipiter* sparrowhawk quartet, depending on locale. In the forests of the Moluccas, no serpent or hawk eagle occurs. Instead, their niches are replaced by the Gurney's eagle, Pacific baza and one to two species of *Accipiter* sp (e.g. Moluccan sparrowhawk, Variable goshawk), depending on geographic location.

Figure 10. Three typical evergreen forest raptors in Southeast 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).

In winter, a number of migrant raptors (e.g. Oriental honey-buzzard, Chinese goshawk, Japanese sparrowhawk, Black baza) occur here as well but none are specifically dependant on evergreen forests and can exploit a variety of man-made habitats as well

6.2 Mixed deciduous forests

Especially in parts of Southeast Asia where there are distinct dry and wet seasons, mixed deciduous forests are the dominant forest type. These forests are less complex than evergreen forests, but support a more diverse plant community than the next group of forests. Extensive

stands of this habitat occur in many parts of mainland Southeast Asia, particularly Cambodia Myanmar, Thailand and Laos. In these regions, their raptor communities are very similar to that of adjacent evergreen forests, supporting six to eight raptor species. Typical raptors include Changeable hawk eagle, Crested serpent eagle and Crested goshawk.

Some parts of the Lesser Sundas islands in Indonesia also support mixed deciduous forests, particularly Flores, Sumba, Timor and the Tanimbar islands. Here, raptor communities are relatively simple, with four to five species present and may include Bonelli's eagle, Short-toed snake eagle, Pacific baza, Variable goshawk and Spotted kestrel.

Figure 11. Raptors of dry dipterocarp forests in mainland Southeast Asia. (Left) Red-headed vulture (Lim Kim Chuah), (Centre) White-eyed buzzard, (Right) White-rumped falcon, seen here with lizard prey (James Eaton)

6.3 Dry dipterocarp forests

Large expanses of northern to north-eastern Thailand, as well as parts of Laos, Myanmar and Cambodia are covered with dry dipterocarp forests, which are typified by relatively low tree density consisting of a few dipterocarp species and an open shrubby understorey. Compared to evergreen forests, their raptor communities are significantly poorer, supporting four to five raptors including Shikra, Changeable hawk eagle, Rufous-winged buzzard, the endemic White-rumped falcon and the White-eye buzzard in parts of Myanmar. Dry dipterocarp forest and savannah in Myanmar and Cambodia's northern plains, however are of exceptional conservation importance as Southeast Asia's last remaining colonies of Red-headed, Slender-billed and White-rumped vulture continue to persists, and benefit from human assistance by regular food provisions in 'vulture restaurants'.

6.4 Mangroves

Mangroves used to fringe the coastline of much of Southeast Asia, particularly sheltered coasts although much of this has now been lost to human activities. Three raptor species occur regularly in this habitat, the wide-ranging White-bellied sea eagle, Brahminy kite and the Osprey which is a non-breeding visitor to many parts of Southeast Asia.

Figure 12. Two migratory raptors to Southeast Asia. (Left) Greater spotted eagle seen in a typical wintering habitat, dry paddy fields in Peninsular Malaysia (Con Foley). (Right) The Chinese goshawk can occur in a variety of habitats, ranging from open country to forest (Con Foley).

6.5 Open country

Open country habitats described here includes 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, resident raptor populations are augmented in winter by numerous Palearctic migrant raptors, including up to three harrier species, *Aquila* eagles, Common kestrel and Peregrine falcon.

6.6 Human-modified habitats

Much of Southeast Asia's original vegetation is now steadily being replaced by agricultural estates, particularly oil palm, rubber and coconut monocultures. Less extensive are teak and *Acacia* plantations. Quite a number of raptors are able to persist in such habitats, and those that have adapted include Black-winged kite, Changeable hawk eagle and Crested goshawk. Other forest raptors like Wallace's hawk eagle may occur, but only sporadically when they wander beyond the forest edges. Migratory raptors also regularly occur in such habitats, supported by numerous small prey like lizards, rodents and insects.

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7. Raptor behavioral ecology

7.1 Overview

Raptors, with their diversity, exhibit varied behavior in all aspects of their lives and so it is difficult to draw broad behavioral generalizations besides the fact that the vast majority are predators. Even seemingly closely related species may exhibit extensive differences in behavior and ecology. The behavioral ecology of some eastern Palearctic raptors (e.g. Grey-faced buzzard, Japanese sparrowhawk), many which winter in Southeast Asia, is relatively well-known thanks to extensive studies. This unfortunately is not the case for many of the tropical forest raptors in Southeast Asia and much remains to be discovered, including even basic aspects of feeding and nesting behavior. For some species, even the nests are yet to be described (e.g. Vinous-breasted sparrowhawk, Moluccan goshawk). This section addresses some of the key events in a raptor's life, and draw reference to specific better-known examples from Southeast Asia.

7.2 Hunting and feeding

Figure 13. (Left) White-bellied sea 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 kind of prey taken would determine the hunting strategies used. Most raptors are predators of small mammals, birds and reptiles, and may opportunistically take carrion as well. A typical generalist predator among raptors is the Changeable hawk eagle, which although is more often seen catching small prey like rodents and lizards using still-hunting, may even capture prey as large as small monkeys and hares. On the other hand, many more species of raptors have relatively specialised diets, taking only a small range of prey items. The *Spilornis* serpent eagles are good examples and most species feed almost exclusively on snakes and lizards. The aptly named Bat hawk is a specialist on bats and where they occur, coincide their foraging time with the period large numbers of bats vacate their

cave roosts in the evening. Likewise, the aptly named honey-buzzards, of which two species occur in the region, are specialists on bee larvae, combs and wasp larvae.

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 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 good cover for predator and prey alike, but also energy efficient as it does not require prolonged periods of flight. Raptors occurring in open areas like harriers, kites and buzzards also practice such techniques though the nature of the environment means that slow soaring and hovering over the habitat not only allow a greater area of the habitat to be covered, but increases chances of successfully finding terrestrial prey like rodents and quails. A few species like the White-bellied sea eagle also practice kleptoparasitism, stealing food items from conspecifics and smaller raptors (e.g. Osprey, Brahminy Kite) whenever the opportunity arises.

Table 3. Prey items known in the diet of various Southeast 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, *Aquila* eagles
Small mammals (<1.0kg)	Rats, treeshrews, *Calloscuirus* squirrels *Sundascurius* squirrels	Hawk eagles, *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	Philippine eagle, Mountain hawk eagle, Black eagle
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, 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 sea eagle
Insects	Dragonflies, orthopterans, large lepidopterans, bees and wasp larvae	*Microhierax* and *Polihierax* falconets, Black Baza, Oriental Honey Buzzard
Carrion	Various dead mammals (wild and domestic) and birds	All *Gyps* and *Sarcogyps* vultures, Brahminy kite, *Aquila* eagles

Depending on the type and amount of prey taken, raptors are active at different hours of the day. Forest-dwelling raptors tend to be active earlier, partly to coincide with the hours that their mammalian or bird prey are active. As many of these raptors use flapping flight, there is little need for thermals, as opposed to 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, when thermals build up to look out for food items. Not surprisingly, and due to the fact that flight is extremely energy costly, many raptors spend much of the day resting, in-between and after periods of hunting.

Currently, much knowledge we have about the diet of Asian raptors are based on the few instances of observations, as well as inferences made from the observations of raptors from elsewhere, particularly in India. The raptors where there are now most comprehensive details on diets are also the region's most threatened raptors (e.g. Philippine eagle, Javan hawk eagle) and thus 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, on top of five bird species (Prawiradilaga 2006). Philippine eagles have been constantly studied for nearly four decades and again, these have provided relatively detailed description of prey items, which we now know to include large mammals like long-tailed macaques, common palm civet, Philippine colugo and various large birds (Thiollay 1994).

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 when breeding. Various displays and threat advertisements may be employed by their owners to repel intruders into a defended territory though 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 Southeast Asian raptors. With increasing conversion or modification of habitats, habitat availability nowadays increasingly limits breeding densities of raptors throughout many parts of Southeast Asia.

Most raptors are monogamous breeders and at least from a Southeast Asian context, there is little evidence for other breeding strategies like polygyny or cooperative breeding. Breeding occurs when sexual maturity is reached and this is highly variable among raptors, depending on size. Smaller species like sparrowhawks may first breed at one to two years of age while at the other end of the spectrum, the large fish eagles first breed at four to five years of age. Breeding is influenced by seasonality and raptors living in parts where pronounced dry seasons exist, may only breed early on the dry season, so that the young can fledge when the monsoon rains set in. Nearer the equator where seasonality is less pronounced, raptors may breed throughout the year. For example, in Singapore, the Grey-headed fish eagle mostly breeds from January to March but attempted nesting has been documented in August – September (Yong, in prep).

All raptors species in the region are known to build a nest platform, largely consisting of sticks, and in some cases, leaves, with the exception of the *Microhierax* and *Polihierax* falconets which are hole-nesters. Given the fact that the dominant vegetation type in the region is forest, many Southeast Asian raptors build their nests on tall trees, whether dead or living, and there is some evidence to show that some species like the White-bellied sea eagle reuse their nests over

multiple years by adding more material to an existing nest structure. Some like the resident Peregrine falcon and formerly, the White-rumped vulture have been 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 variety of behavior ranging from nest defense, courtship feeding, and display flights to affirm territory or strengthen pair-bonding. Pairs of raptors can been seen engaging in spectacular display flights, including repeated diving and rising again, cartwheeling or simply just soaring and calling, as is the case for the *Spizaetus* hawk eagles.

Figure 14. 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).

Clutch size, which refers to the number of eggs laid, can range from one to two for the largest forest raptors to three to four in the kites. Incubation periods are variable as well, 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. Either the female incubates alone, or the male may relieve her occasionally for some species. Finally, the nestling period, which is defined by the period from the point the chick hatches to the time it takes it first flights, can also vary a great deal. In the case of the region's many *Accipiter* species, this may take just barely a month to slightly over a month month (e.g. 32 days for Crested goshawk). Naturally, the largest forest raptor in the region, the Philippine eagle can take up to over three months (23 – 24 weeks) before the chick makes any attempt to 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 primarily from studies in North America, Europe and the Middle East. Southeast Asia has increasingly received more attention from ornithologists and the last ten years, raptor migration counts at a number of field sites throughout Southeast Asia has yielded significant knowledge of the movement patterns and numbers of migratory raptors passing through. Three of the most well known sites in this respect are Chumphon 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 goshawk over oceanic Sangihe island north of Sulawesi, including many wintering individuals on that island.

7.4.1 Why migrate?

Migration is one of the greatest spectacles of nature and the large number of animals passing through has astounded even our pre-civilisation ancestors. Despite the seeming complexity of animal migration, there are few key reasons to explain this behavior and in the context of many birds, including raptors, this can simply 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 Southeast Asia

Currently, the most well-watched raptor migration sites in Southeast 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 Southeast 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 15. Key raptor migration sites in East and Southeast 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

The phenology of raptor migration is no different from that of most other boreal migratory birds. Autumn migration involves the movement of large numbers of migratory raptors from their breeding grounds in the temperate areas of northeast and east Asia for tropical Southeast Asia which stretches from between late August to early November. The journey to Southeast Asia may take at least one to two months from the time they depart their breeding grounds. This passage is then reversed in Spring migration where raptors, as well as many other waders, wildfowl and passerines move back to their breeding grounds in east and northeast Asia over the months of March to May. Courtship and breeding then occurs over the intervening few months until Autumn of the same year.

There are two major routes taken by migratory raptors into Southeast Asia, both part of the East Asian flyway. The continental route originates from Japan and the Korean Peninsula, follows the coast of China southwards towards continental Southeast 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 Oriental honey-buzzard 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

Figure 16. (Left) Migratory path taken by a tracked Oriental 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)

finally into Sulawesi, its satellites (e.g. Sula, Banggai islands) and the islands of the Moluccas. This route is known to be especially important for Grey-faced buzzard and Chinese goshawk. Although some raptors can utilize both routes, many species are dominant in either one of them. The Grey-faced buzzard for example occurs mainly along the oceanic route, but is recorded in relatively low numbers on the mainland. Four main factors are known to influence raptor migration and these includes wing loading, general weather conditions, presence of thermals (important for soaring while minimizing energy consumption) and the tendency to avoid sea-

crossings. Where major sea crossings are involved, migrating raptors like Japanese sparrowhawk will try to rest where possible, including roosting and foraging on ships (Ellis *et al*. 1990).

Figure 17. (Left) The Steppe eagle regularly migrates to Southeast mainland 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 Southeast Asia. Although most populations are sedentary, small numbers have been seen on migration as well (Con Foley).

7.4.4 Raptor migration in Singapore

Despite the fact that observations on raptor migration have been gradually accumulating, little is known about patterns and magnitude of raptor migration in Singapore. Fortunately, in the advent of annual counts conducted in the last three years, we now have a better understanding of key raptor migration sites and peak passage periods in Singapore than before.

Recent counts show that 14 species of migratory raptors occur in Singapore either on passage or as winter visitors, with three to four species 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 can fluctuate with time. The highest count involved in excess of 1500 Oriental honey-buzzard on passage into Sumatra from Tuas in Singapore's extreme west coast in November 2008. The fact that this was not documented in subsequent years implies that movements of raptors over Singapore can be sensitive to variable weather conditions.

A number of migratory raptors occur in Singapore as extreme vagrants, examples being the Imperial eagle, Amur falcon and the Lesser kestrel. The Himalayan griffon, which is now sporadically recorded in the region, has increasingly strayed into the region in the last decade, including Singapore (Yong & Kasorndorkbua 2008) but the proximal causes of this movement are still not understood although climate change has been suggested as a possible reason.

Figure 18. Variations 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.

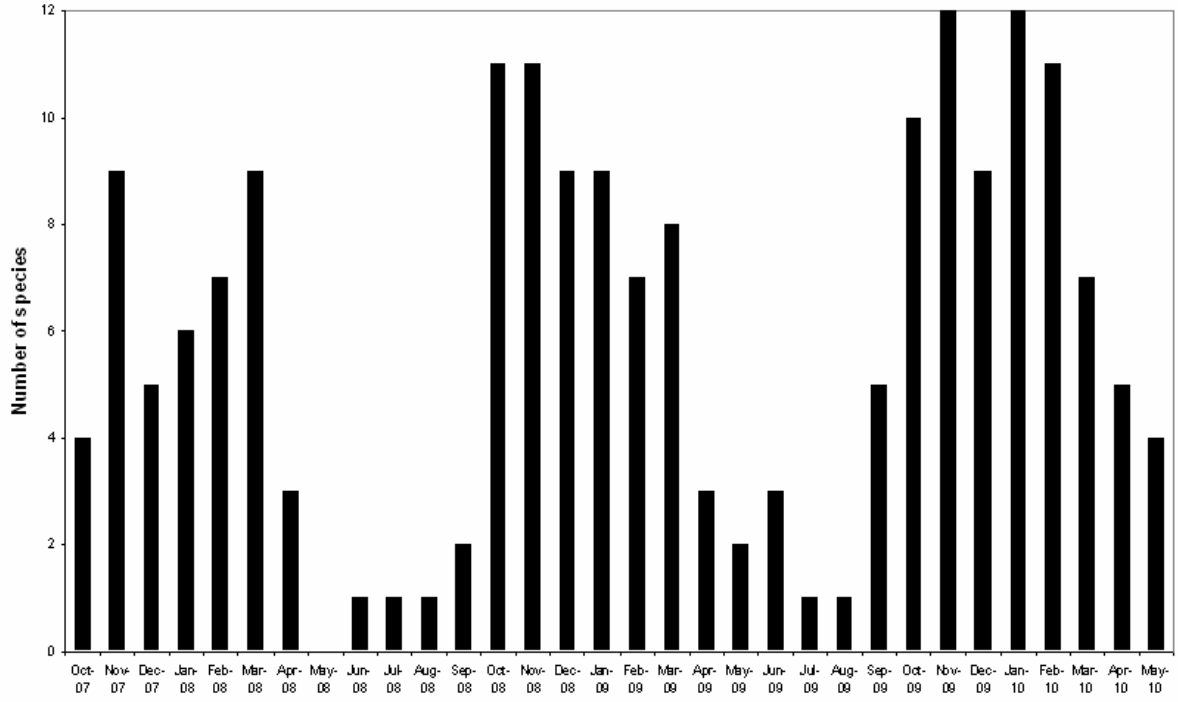

Figure 19. Key raptor passage sites in Singapore. From west to east, sites are: Tuas West, Bukit Timah hill, Kent Ridge park, Mount Faber Park, Changi east.

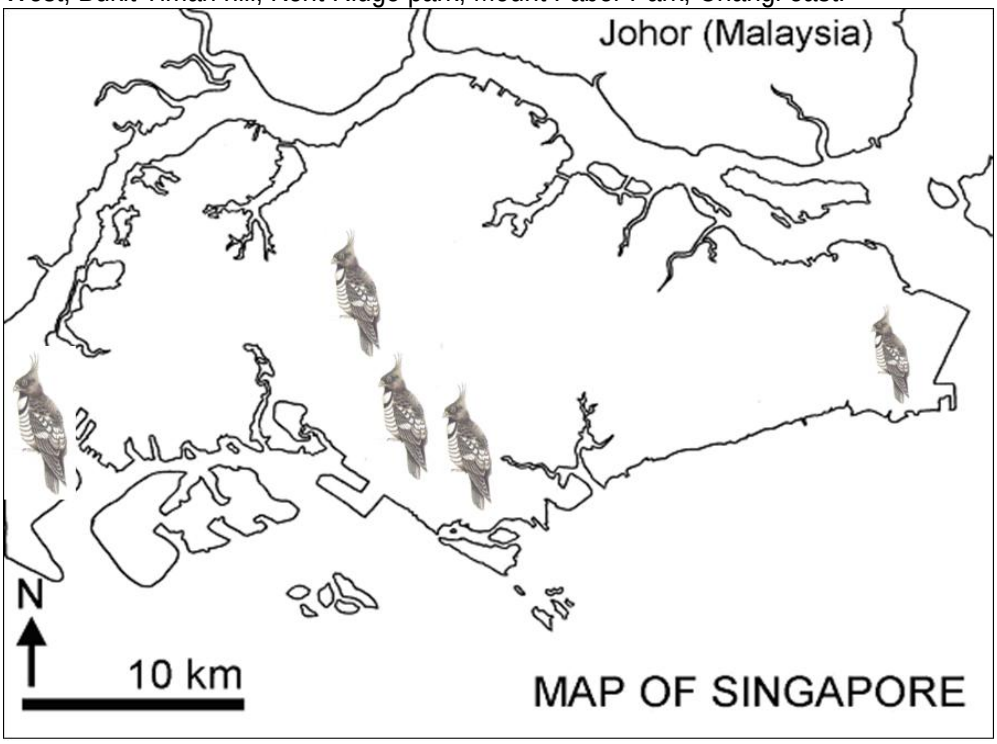

Table 4. Migratory raptors recorded in Singapore over a 17 month period (2009 – 2010).

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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8. Conservation of raptors in Southeast Asia

8.1 Overview

Almost a quarter of all species of raptors recorded in Southeast Asia are now currently listed as near-threatened or threatened by Birdlife International (Stattersfield & Capper 2000). Although some species like the White-bellied sea eagle are still widespread and common throughout its range, others like the Philippine eagle and Javan hawk eagle have highly limited distributions and have global populations of less than 200 pairs. Others, while still common in some 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 Southeast Asia.

Figure 20. Two of Southeast 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 ecology is to examine the biotic interactions between organisms. The key rationale for the conservation of raptors is a purely ecological one. 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 spatiotemporal scales, by initiating trophic cascades through directly influencing organisms at lower trophic levels. A decline in an apex predator's population may allow for herbivores that were being predated upon, or meso-predators, to be released from predation pressures they were previously subjected to, hence allowing these to increase their populations drastically and thereby influencing associated species. In exceptional cases, this may even lead to landscape changes. While there is still no evidence for this in Southeast 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 home ranges (and hence low population densities), and low fecundity means that environmental changes may first surface in declines of raptor populations. Studies in North America and Europe have demonstrated bioaccumulation of pesticides on raptors, the best examples being the Peregrine falcon and Bald eagle, leading to significant population declines. Pesticides like DDTs are consumed by prey organisms, which are then consumed by raptors and become accumulated in their tissues as these cannot be broken down, leading in the long term to failed nesting.

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 worldwide are varied, most Southeast Asian raptors face primarily one common threat and that is habitat loss and degradation (especially by fragmentation), given their large area requirements. Southeast Asia's landscape has gone through unprecedented modification by humans in the last few decades and much of the original habitat is now lost. This is even more acute for primary forests, considering the fact that forests are more rapidly lost here in percentage terms than any other tropical regions (Sodhi *et al*. 2004). Lowland evergreen forests have been largely lost due to logging and agriculture in Sulawesi, Sumatra, Borneo, most of the Philippine islands, as is many areas of continental Southeast Asia. Deforestation is now increasingly threatening forests on hill slopes and mountains and is particularly increasingly apparent in many parts of upland Sumatra, Luzon and Mindanao.

Figure 21. Two near-threatened raptor species affected by rapid deforestation in Southeast Asia. (Left) Small sparrowhawk of Sulawesi's lowland and montane forests (Ingo Waschkies). (Right) White-fronted falconet of north Borneo's lowland rainforests (Michelle and Peter Wong).

The Philippine eagle, Javan and Flores hawk eagle are now restricted to remaining fragments of forests on Mindanao, Luzon, Java and Flores respectively, confined mostly to remote mountainous areas where deforestation has not yet reached. Wallace's hawk eagle, a species that

occurs only in lowland forests in the Malay Peninsula, Sumatra and Borneo have seen most parts of its habitat removed and is now classified as globally vulnerable. Much less is even known about the status of raptors in the Lesser Sundas and the Moluccas, but predictably, studies will show that many of the endemic forest raptors occurring there will be threatened by habitat loss in their ranges as well (van Balen 1998).

While many raptors have declined as a direct result of habitat loss, others have declined with the corresponding loss of their prey. All three resident species of vultures in mainland Southeast Asia are clear examples of this. The loss of the region's large mammalian fauna, due to habitat loss and hunting meant a significant reduction of available food resources for scavenging vultures. This is made worst by changes in animal husbandry practices in the region. The last hundred years have seen a dramatic range contraction of all three resident vulture species in Southeast Asia, with total extirpation in the Malay Peninsula. Significant population of vultures now persist only in northern Myanmar (e.g. Kachin state) and Cambodia's northern plains, and even so only with intensive conservation measures. The Red-headed vulture, formerly resident in Thailand's western forest corridor became extinct in the country in the 1990s, the last individuals being killed by poison baits in Huai Kha Khaeng wildlife sanctuary.

Figure 22. Southeast 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, and is protected in a number of large conservation sites (e.g. Kulen-Promtep Wildlife Sanctuary).

Hunting of raptors for various reasons, though not a major threat in this region has been especially detrimental to certain species. The best example is the Javan hawk eagle which is often captured for the pet trade, to be kept as status symbols 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. Others raptors are either 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 in Mindanao to the guns of hunters and a similar

fate of that of a rehabilitated and released Cinereous vulture in Myanmar continues to exemplify this fact (See Anon 2008, Casey 2007).

In summary, raptors are threatened by:

1. Direct loss of habitat to human activities
2. Degradation and fragmentation of existing habitat
3. Loss of prey base (mostly mammalian)
4. Hunting (e.g. for sport, food, falconry)

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9. Studying and surveying raptors

9.1. Overview

Many methods have been or are being devised to survey raptors in the wild. The simplest 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, or by baiting and are then fixed with transmitting units, allowing data on the location of a raptor to be periodically 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 costs of carrying out such studies is still not accessible to many researchers in the tropics. However, these studies have

revealed many exciting new findings, and transmitters attached to migrating Amur falcons have recently continuously tracked its movement into 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. Indicators of this would be visual observations of raptor pairs, or finding active nests that contains 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. This can then be mapped using geographic information systems (GIS) software and subsequently used to estimate the density of breeding pairs in the habitat area being studied. For better accuracy, all observations of birds and nesting activity should 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 range sizes, 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 of raptors, especially those with a focus on migratory behavior (e.g. routes

taken, presence of rest stops, phenology, site fidelity, 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 exclusively 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*, published by the Asian Raptor Research and Conservation Network (ARRCN) is another leading source of information on Southeast Asian raptors. Other journals which features occasional articles on raptor 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), which is supported by the Peregrine Fund is not only a key source of raptor information, but also provides extensive networking opportunities with raptor researchers globally.

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10. 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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