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The Javan hawk-eagle: misconceptions about rareness and threat

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Abstract

The Javan hawk-eagle (*Spizaetus bartelsi*) is a threatened raptor endemic to the densely populated island of Java. Historically very little is known about its biology. Recent surveys showed that the population size has been underestimated in the past. The breeding population is estimated to be 137–188 pairs with a total of 600–900 birds and confirmed presence in 22 discrete forest blocks throughout Java. The eagles were present in isolated forest fragments as small as 3000 ha. Good dispersal abilities in juveniles, a niche width in habitat, which is broader than previously assumed, and rather opportunistic feeding behaviour are believed to mitigate the effects of habitat fragmentation. The appointment of the eagle as a flagship species involves serious risks, as it appears to have put the species on the list of rare birds that are in great demand with malevolent aviculturists.

Keywords: Javan hawk-eagle; *Spizaetus bartelsi*; Conservation; Java; Indonesia

1. Introduction

In 1992, the Javan hawk-eagle (*Spizaetus bartelsi*) was declared Indonesia's national "rare animal" by the then president M. Suharto. A major reason to choose mascots has been to increase public awareness of the need to preserve natural resources and the environment (Widyastuti, 1993). Helped by its likeness to the mythological bird Garuda, the national emblem of the Republic of Indonesia, this poorly known bird became the charismatic focus for bird conservation on Java.

Finsch (1908) was the first to recognise the Javan hawk-eagle as a crested form of *Spizaetus* other than *Spizaetus cirrhatus limnaetus*, and it took another 50 years before it was recognised as a separate species (Amadon, 1953). For the first 75 years or so after its discovery, the species remained a mystery. It seems that over this entire period only its discoverers, the Bartels family, collected some data on the species' natural history (Bartels, 1924). It was largely overlooked, and few ornithologists had actually observed the species. Illustrative are the findings of the zoologist A. Hoogerwerf who, between 1931 and 1971, published copiously on Javan birds, including the Javan hawk-eagle (Hoogerwerf, 1946). Residing in Bogor (West Java), he did not record a single specimen in the nearby Gede-Pangrango National Park (NP), nor in most of the other forest areas in Java [Hoogerwerf (1948) and later publications]. In the same period the Bartels family gathered a large series of museum skins in the Gede-Pangrango area, and recorded the species in a number of additional sites (Bartels, 1924; Sözer and Nijman, 1995). During our studies we have recorded the species in numerous localities throughout Gede-Pangrango NP, and indeed throughout Java (van Balen et al., 1999b).

Java has known a long history of cultivation and deforestation that had already started c. 1000 AD, but really took off in 1830 when the Dutch administration imposed the 'Cultuurstelsel'. To support this agro-economic system, farmers were forced to grow export crops on communal ground, which was often forest (Smiet, 1992; Whitten et al., 1996). By the end of the last century the natural forest area was severely fragmented, while by the beginning of the last century

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virtually all forest fragments that contain Javan hawk-eagles at present were isolated from one another. Less than 10% of the original natural forest now remains: 54% of the mountain forest, 19% of the original hill forest and only 2.3% of the lowland forest (MacKinnon et al., 1982; Smiet, 1992). The latter forest type is now almost exclusively found scattered along the southern coast of the island (Fig. 1).

Nowadays, Java is Indonesia's most densely populated island (Whitten et al., 1996) and pressure on the remaining forests is still high. Agricultural encroachment on slopes along the edges of forest blocks, although slow, is the primary threat to the already deteriorating forest fragments. Sometimes substantive chunks of valuable habitat are cleared simultaneously, as we witnessed during our surveys on the southwest slopes of Mt Ijen, the northwestern part of the Dieng Mts, and along the enclaves in Mt Halimun National Park. This destruction and fragmentation is widely considered to be the major threat to the survival of the Javan hawk-eagle (e.g. Thiollay and Meyburg, 1988; Collar et al., 1994; Sözer et al., 1998).

Recent surveys by the authors have added numerous new locality records (van Balen et al., 1999b). The species was even found in the central part of the island where there was believed to be a wide gap of largely non-forested area between the two sub-populations of west and east Java (Thiollay and Meyburg, 1988). Despite this, the species should still be considered as one of the world's least known raptors. General knowledge is rather circumstantial with information available on the species' biology being largely derived from historical notes, anecdotal records and studies of museum specimens. Status assessment, especially of poorly known birds in the tropics, is important for a comprehensive conservation strategy (McGowan et al., 1998), as resources (manpower, funds) become limited with the ever-increasing number of threatened species. Collar (1997) pointed to the danger of exaggerating and misinterpreting the threatened status of a charismatic species such as the Philippine eagle (*Pithecophaga jefferyi*), as this was used to justify a captive breeding programme and averted attention from urgent in situ conservation. Local and international commitment to conservation of the Javan hawk-eagle is attested by the increasing number of overseas scientists that have visited Java over the past few years to study the eagle in co-operative programs with the Indonesian government. A thorough evaluation of its conservation status and survival prospects, based on available published baseline data, is therefore timely.

2. The data set

The data set to which we refer in the following discussion is mainly based on original research conducted by the authors in 1980–1981 and 1984–1997 (S.v.B.) and 1994–1999 (V.N.) totalling 632 man-days surveying inside natural forest areas. Details can be found in Sözer and Nijman (1995), Nijman et al. (2000) and van Balen et al. (1999b).

Table 1 summarises the information on all localities where Javan Hawk-eagles were found during the surveys in 1980–1999. The total number of breeding pairs was estimated at 137–188 (van Balen, 1999), which excludes a few small areas, namely Mt Aseupan, Mt Karang and Mt Ungaran, which would account for another 4–7 pairs. This was extrapolated to 600–900 individuals for the total population including immature birds, distributed across 22 forest blocks of 30 km^2 and larger.

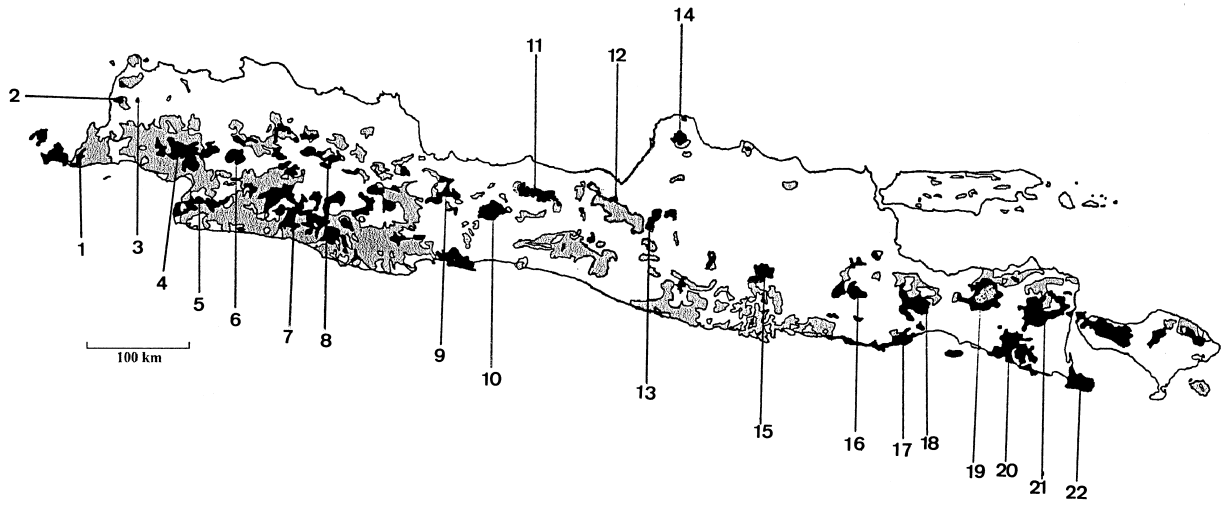

Fig. 1. Generalised land use cover of Java and Bali (after Whitten et al., 1996). Black, forested areas; grey, lowland cultivation, regrowth, grassland, unvegetated; white, land used mainly for settled cultivation of gardens, arable, or tree crops. site numbers as in Table 1.

Table 1
Areas surveyed for Javan hawk-eagle[a]

Blocks containing Javan hawk-eagles	Forest area (km^2)[b]	Forest type[c]	Estimated distance (km) to nearest block (>150 km^2) holding JHE	Altitudinal range of forest cover	Number of pairs
West Java					
1. Mt Honje (Ujung Kulon NP)	125	S/E-RF	65	0–623	3–4
2. Mt Aseupan	30	E-RF	50	100–1174	1–2
3. Mt Karang	30	E-RF	45	1000–1778	1–2
4. Mts Halimun/Salak	500	E-RF	15	400–2211	16–25
5. Jampang	100	S/E-RF	9	100–500	2–3
6. Gede/Pangrango	200	A-MF	15	500–3019	6–10
7. South Bandung	900	A-MF	32	300–2821	23–30
8. North Bandung	100	A-MF	30	1000–2076	2–3
Central Java					
9. Pembarisan Mts	130	E-RF	40	300–1351	3–4
10. Mt Slamet	150	A-MF	45	700–3418	4–5
11. Dieng Mts	250	E-RF/A-MF	45	250–2565	6–8
12. Mt Ungaran	75	A-MF	37	1000–2050	2–3
13. Mts Merapi/Merbabu	80	A-MF	50	950–3142	2–3
14. Mt Muriah	90	S-RF	102	600–1602	2–3
East Java					
15. Mts Liman/Wilis	250	S-RF; S/A-MF	38	600–2563	6–8
16. Mts Kawi/Arjuno	500	S-RF; S/A-MF	20	300–2886	13–17
17. Bantur/Lebakharjo	180	S/E-RF	12	0–250	5–6
18. Bromo/Tengger/Semeru[d]	200	S/A-MF; E-RF	20	800–3676	5–7
19. Yang Highlands	100	E-RF; S/A-MF	22	1125–3088	2–3
20. Meru Betiri	500	S-RF	2	0–1223	13–17
21. Ijen/Raung/Maelang	830	S/A-MF; E-RF	2	100–3332	21–28
22. Alas Purwo	160	M-DF	35	0–360	3–4

Forest areas visited without Javan hawk-eagles
(<16 km^2) *West Java*: Kotabatu, Dungusiwul, Ciburial, Yanlapa, Tangkuban Perahu, Sukawayana, Bogor Botanical Gardens, Pangandaran, Mt Pulosari.
(16–50 km^2) West Java: Ciogong[e], Mt Sawal, Mt Tukung Gede/Ranca Danau; East Java: Mt Lawu, Mt Ringgit, Baluran.
(50–160 km^2) West Java: Cikepuh; Segara Anakan[f], Leuweungsancang[g].
(160–500 km^2) West Java: Ujung Kulon peninsula.

[a] Based on data from van Balen et al., 1999b; see Fig. 1.
[b] Estimated area of good forest does not necessarily equal the size of the reserve.
[c] Forest types (from Whitten et al., 1996): RF: rainforest; DF: deciduous forest; MF: montane forest (>1000 m); E: evergreen; SE: semi-evergreen; M: moist; D: dry; A: aseasonal; S: seasonal.
[d] A recent survey confirmed the presence of Javan hawk-eagles in this area (R. Nursaid, pers. comm., 1999).
[e] Widely varying estimates exist; here the mapped forest area (Whitten et al., 1996) is given.
[f] The adjacent island of Nusa Kembangan was not visited by us, but may contain Javan hawk-eagle.
[g] Includes the adjacent proposed reserve Cipatujuh.

We recorded no resident pairs of the eagle in nine isolated forest areas smaller than 1600 ha surveyed, but they were found with increasing frequency in larger forest areas: in three out of nine forests of 1600 and 5000 ha (33%), seven out of 10 forest areas between 5000 and 16 000 ha (70%), five out of six forest areas between 16 000 and 50 000 ha (83%), and present in all five areas >50 000 ha (Table 1). The relationship between the size of the forest area (log transformed) and frequency of occurrence (arcsin transformed) is significant (r^2 adj. = 0.968; $P < 0.0005$) (Fig. 2).

Fig. 1 shows the 22 surveyed area and generalised land cover of Java. The shortest distance from one forest patch containing the species to another sizeable forest patch (>150 km^2) ranges from < 10 to 102 km, and averages 33 km. Four forest areas, namely Ujung Kulon, Mt Aseupan, Mts Merapi-Merbabu and Mt. Muriah, are isolated from other sizeable forest patches by distances >50 km (Table 1), and have been so since at least the end of the 19th century [Koorders (1912) cited in Whitten et al., 1996].

3. Discussion

3.1. Habitat requirements

The Javan hawk-eagle is largely restricted to rugged, hilly terrain, and generally we encountered the birds in

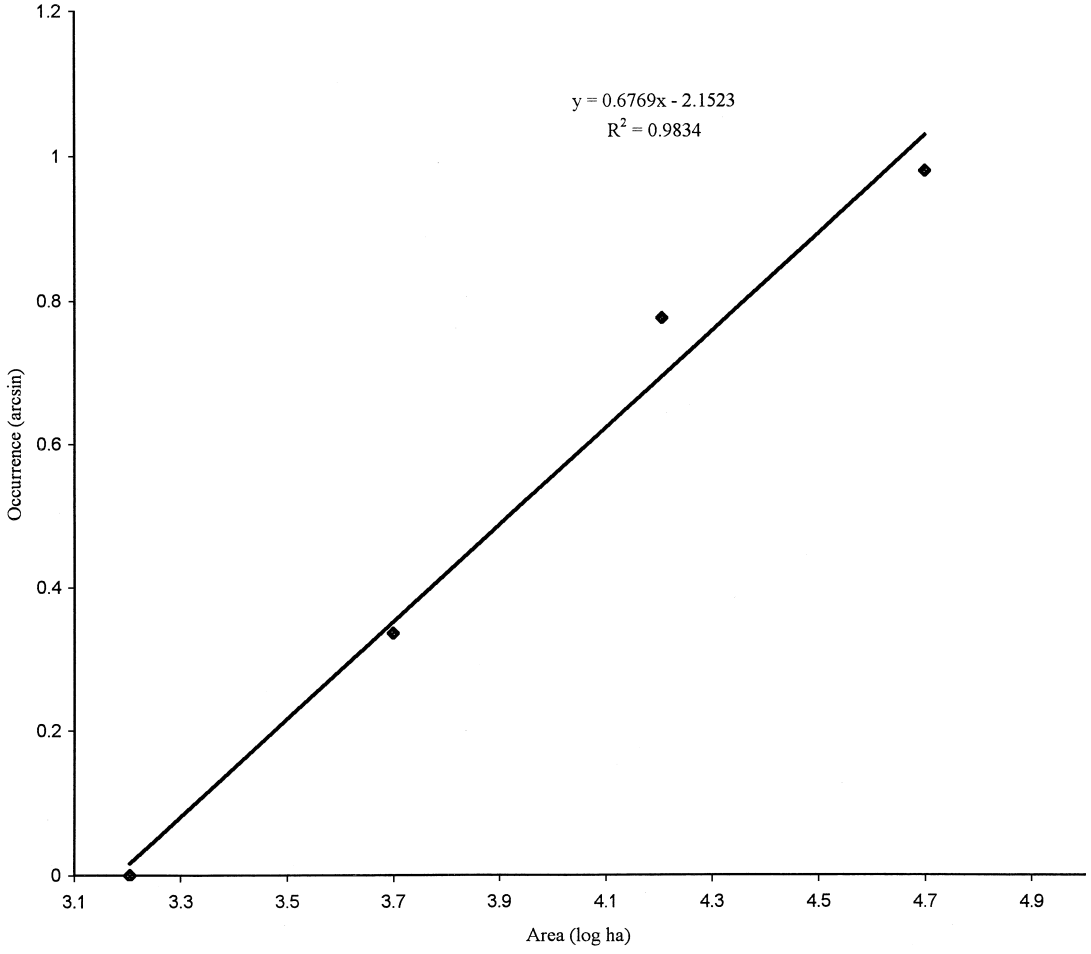

Fig. 2. Relationship between forest patch size (log transformed) and frequency of occurrence (arcsin transformed).

undulating, hilly or mountainous terrain. In rather flat forest areas, e.g. Ujung Kulon and Alas Purwo, the species was only recorded in the most rugged parts (van Balen et al., 1999b). Hitherto the eagle has not been recorded from the northern plains, but at present very little forest remains in that area (Whitten et al., 1996). Indeed, Wells (1985) considered this species a slope specialist and the eagle may be a genuine slope species with special demands as to topographic relief. Hunting over flat lands demands adaptations different from hunting over slopes, which may result in subtle morphological differences (Gamauf et al., 1998) found amongst the different Indonesian hawk-eagles. Interestingly, the closely related and morphologically very similar Blyth's hawk-eagle (*Spizaetus alboniger*) (Hoogerwerf, 1946) appears to be largely replaced in the flat lowlands (including swamp forest) by the extreme lowland specialist and morphologically different Wallace's hawk-eagle (*Spizaetus nanus*) in other parts of Indo-Malaysia (Medway and Wells, 1976). A scenario may be thought of in which Wallace's hawk-eagle, or perhaps even another hawk-eagle species (see van Balen et al., 1999a), disappeared sometime during the 19th century with the almost complete deforestation of the flat lowlands in the northern half of Java.

Traditionally, adult Javan hawk-eagles were believed to be confined to the interior of relative large forest areas, with only immatures occasionally venturing out to forest edge, secondary forests or plantations (Bartels, 1924). Recent observations, however, indicate less dependence on primary wet rainforest for the species, and apart from secondary habitat, dry forest types were also found to be suitable (van Balen et al., 1999b). It has even been suggested that the relatively sterile plantations of Sumatran pine (*Pinus merkusii*) in the hills might serve as (marginal) breeding habitat, (Sözer et al., 1998). Apparently for many species, habitat requirements are often less fixed than most researchers assume (see Gray and Craig, 1991).

Tolerance to habitat disturbance is also found in the closely related Blyth's hawk-eagle. On mainland Sumatra this species is reported to be strictly dependent on mature forest (Thiollay, 1996a). Its continued survival on the small island of Nias, which it shares with two other hawk-eagle species (Thiollay, 1996b) and where heavy deforestation had already left little good forest a

century ago (Stibbe, 1919), indicates a plastic response to small areas and habitat disturbance. Although comparison between Blyth's and Javan hawk-eagles may not be warranted, it suggests that the presumed total dependence on primary rainforest (Thiollay and Meyburg, 1988) of the Javan hawk-eagle should be re-evaluated.

3.2. Interspecific competition

If forest fragmentation results in compression in numbers, increased competition is expected amongst different members of the guild of large raptors; when few species have survived, competition can be normal again, or even reduced. Thiollay and Meyburg (1988) suggest that the rufous-bellied eagle (*Hieraaetus kienerii*) may be a competitor, which would explain the lower numbers of Javan hawk-eagles in southeastern Java in the presence of that species. However, we found no evidence of lower numbers of either species in eastern Java as compared to central or west Java. Both species overlap largely in range and habitat, but probably differ in diet, with the aerial hunting rufous-bellied eagle showing a preponderance for birds (del Hoyo et al., 1994), whilst a large proportion of the diet of Javan hawk-eagle consists of mammals and reptiles (Røv et al., 1997; Nijman et al., 2000). The changeable hawk-eagle (*Spizaetus cirrhatus*) may be another possible competitor (K.H. Voous in litt., 1990). Although largely overlapping in diet, interference must be negligible, as *S. cirrhatus* is much more a species of open woodlands, and therefore only co-occurs marginally with *S. bartelsi* in semi-deciduous forest, disturbed forest and forest edge (Bartels, 1924; S.v.B. and V.N., pers. obs.).

3.3. Habitat fragmentation

The occurrence in isolated forest patches often large enough only to contain half a dozen pairs at most suggests more adaptability to fragmentation than might be expected from this vulnerable forest raptor. We consider four important conservation tenets, proposed by Verner (1992), in relation to the conservation biology of the Javan hawk-eagle.

1. "Large blocks of habitat capable of supporting sub-populations of many breeding pairs are better than smaller blocks capable of supporting only one to a few breeding pairs".

Javan hawk-eagles have relatively large home range sizes and need large stretches of forest. Based on displaying pairs, Thiollay and Meyburg (1988) estimated home ranges of 2–3000 ha per pair. By mapping all locations where two individually recognisable birds were recorded, home range sizes were estimated at 1200 and 3600 ha (Sözer and Nijman, 1995; VN, unpubl. data). However, Thiollay and Meyburg (1988) found indications of the syndrome of insularity (sensu Wright, 1980) in Javan raptors. This is characterised by a higher density and a larger niche breadth in small (habitat) islands than is reached on the Asian continent. Indeed, Røv et al. (1997) found local high densities of Javan hawk-eagles in the Mt Halimun NP, with possibly territories as small as 500 ha. The syndrome may explain why we found surviving populations in a number of small patches: the smallest area in which we recorded the species consisted of *c*. 3000 ha forest (Mt Karang). Tenet 1 is thus not supported by our data.

2. "Unfragmented blocks of relatively homogeneous habitat suitable for a species are generally better than loose aggregations of smaller blocks of suitable habitat".

The effective habitat size of forest fragments can be increased by a buffering function of intervening matrix if this has a low degree of habitat difference (Harris, 1984; Widén, 1994). Aggregations of smaller blocks may therefore not appear as archipelagos, but might be considered as composites cemented by mature plantation forest etc. On Java, 17% of the agricultural land consists of home gardens, whose forest-like structure more or less mimic natural forest (Whitten et al., 1996). Thiollay (1996a) did not attach much value to the traditional agroforests (in Sumatra) as adequate habitat for forest raptors, but the presence of Javan hawk-eagle in small isolated forest patches (e.g. Mt Karang and Mt Aseupan), which on their own may be not large enough to support a viable eagle population, might indeed suggest a beneficial role of surrounding secondary habitat, plantation forest and farmland increasing the effective size of such small areas. The birds appear to be opportunistic feeders and their diet is known to include items obtained from outside its primary habitat, e.g. skinks (*Mabuya* spp) and house fowl (Røv et al., 1997; Nijman et al., 2000). They may even benefit from higher biomass production in edge habitats. Thus, tenet 2 is also not fully supported.

3. "Blocks of suitable habitat that are close together are better than blocks [far] apart".

The forest areas where Javan hawk-eagles have been recorded are found scattered over the island of Java. It seems unlikely for very small populations to persist a long time without the occasional input from outside areas (Mills and Allendorf, 1996). The presence, therefore, of both juveniles and adults, in singles and pairs, on Mts Aseupan, Karang, Muriah, Ungaran and Merapi/Merbabu, each < 100 km^2 in size and isolated >100 years at distances of >37 km from the nearest 150 km^2 forest patch (Table 1), suggests that the species has good dispersal abilities that mitigate the effects of insularisation in even the most distant blocks. Therefore, there appears to be no support as yet for tenet 3.

4. "Habitat separating blocks of suitable breeding habitat should allow dispersal by members of the species in question, and especially by juveniles".

Taylor (1993) pointed to the importance of landscape connectivity, which is "the degree to which the landscape facilitates or impedes movement among resource patches". Javan hawk-eagles, mostly immatures, have occasionally been found in "atypical" (suboptimal) habitat, such as plantation forest (Bartels, 1924; van Balen et al. 1999b). In Central Java the vast teak plantations may increase connectivity and explain the persistence of the eagle in the isolated forest around Mt Muriah. Tenet (4) is therefore not rejected.

3.4. Small population

The presence of the eagle in some very small (< 5000 ha) and distant forest fragments suggests that these are not strictly isolated and that there must be dispersal between all fragments. The postulated sub-populations thus appear to constitute a single metapopulation (sensu Hanski, 1991), which considerably enhances the chances for persistence of the entire population. Although the total population is indeed very small, various examples suggest that small populations can survive on even smaller areas than Java. Birds of prey especially seem to survive with extremely small populations. For instance on the island of Soccoro (14 000 ha) an endemic race of the rufous-tailed hawk (*Buteo jamaicensis*) survives with only 15–20 pairs (Walter, 1990), and on Nias Island (562 500 ha) three hawk-eagle species have persisted in some small forest patches for at least the last 100 years (Thiollay, 1996b).

These examples refer to relatively short-term persistence of raptor populations. A tentative effective population of 500 individuals, i.e. 250 breeding pairs, has been suggested for long-term survival of a population of animals (Franklin, 1980). Not much advance has been made since then in understanding extinction processes (Ryan and Siegfried, 1994), but Thomas (1990) proposed a Minimal Viable Population size of several thousand to 10 000 individuals in a single population without active management. The Javan hawk-eagle population has persisted at low population levels (< 5000 birds) during at least the past 100–140 years (and perhaps much longer), and, along with the shrinking of the forest, must have been reduced to (maximally) about one tenth of its original (AD 1600) size by the 1930s.

Although raptors are thus known to survive at low population levels, rather unstable circumstances on Java (volcanoes, susceptibility to droughts, etc.) seem unfavourable for long-term survival. It may therefore be that, although Java has been isolated for the past 10 000 years from Sumatra and Kalimantan, the Javan hawk-eagle receives genetic input from the neighbouring sibling "species", i.e. Blyth's hawk-eagle. This so-called introgression (Grant and Grant, 1992) would increase a species' evolutionary potential and persistence. The occurrence of Blyth's hawk-eagle (not subspecifically differentiated from the mainland birds) on Nias and other islands off west Sumatra (van Marle and Voous, 1988) would be evidence of its dispersal capabilities. Java, less distant from south Sumatra than Nias is from west Sumatra, could thus receive straggling birds from Sumatra. An immature Blyth's hawk-eagle shown in 1994 to the authors (and said to have been captured on west Java), which subsequently escaped into the Javan forest, may actually have been a more natural propagule than we initially thought.

3.5. Natural disasters

Stochastic fluctuations of the environmental type are of a greater problem for population persistence than those of the demographic type (Dennis et al., 1991) and "catastrophes are likely to make local extinctions far more common than short-term studies of environmental variability would lead us to believe" (Mangel and Tier, 1994). Java has suffered 33 major volcanic eruptions since 1600 (Whitten et al., 1996), an average of one every 12 years. Seven of the eight major forest clusters where Javan hawk-eagles are surviving include active volcanoes, and during our relatively short survey period we have already witnessed the loss of invaluable habitat due to an eruption of Mt Merapi. Tsunamis, long droughts and forest fires are added threats that are frequently occurring on Java.

Minimum viable population (MVP) sizes would be underestimated in population viability analyses if the risks of catastrophes are not incorporated; even with large populations under ideal circumstances extinctions should be expected (Mangel and Tier, 1994). In fact, the concept of MVP appears to become irrelevant for this type of risk. Mangel and Tier (1994) consider it more effective to have several reserves spaced well apart so that catastrophes do not affect all at the same time.

4. Implications for conservation

The Javan hawk-eagle population of no more than 900 birds is substantially less than the critical number of 2500 birds (with no single sub-population larger than 250 mature birds) for endangered species, as proposed by Collar et al. (1994). A Vortex simulation programme in a recent Population Viability Analysis by Manansang et al. (1997) gave an extinction probability of > 20% within 5 years. The chance for long-term survival appeared bleak with high (human-induced) mortality of three postulated sub-populations. A case was made for a captive breeding programme. However, the PVA exercises were based on incomplete data sets without adequate ground truthing and too many unsubstantiated assumptions. In the surveys, which attempted to cover all forest areas on Java and provided the baseline data for

the present review (van Balen et al., 1999b), we have found evidence of a less gloomy situation. Java's forests, although fragmented, apparently still constitute an adequate reserve system for the eagle, especially with the recently discovered presence in a long-thought gap covering the central part of Java, and its presence in relatively small and isolated forest fragments.

The widespread distribution of the eagle across Java's rainforest, which is due to its wide altitudinal range and a relatively high plasticity to habitat disturbance in combination with good dispersal abilities, indicate that it does not show deleterious effects caused by habitat fragmentation. Mitigating effects are thought to come in particular from the following qualities of the eagle: (a) juvenile dispersal through atypical habitat; (b) niche width in habitat broader than previously assumed; and (c) rather opportunistic feeding behaviour.

Since its inauguration as a national mascot, the Javan hawk-eagle's image, until recently unknown to local people, has been exposed in billboards, postal stamps, telephone directories, etc. As rare birds, and particularly birds of prey, are in increasing demand amongst malevolent (or ignorant) aviculturists in Indonesia (van Balen, 1998), the eagle's new status could easily initiate a spiral of increasing prices paid for captive specimens, as with the extremely rare Bali starling (*Leucopsar rothschildi*) during the past two decades (PHPA/Birdlife International-IP, 1997). Therefore, strict law enforcement to prevent more eagles being extracted from the wild and effective management of natural areas are urgent, rather than the setting up of an expensive captive breeding programme. The existing Species Recovery Plan for the Javan hawk-eagle (Sözer et al., 1998) offers an action programme in which the importance is emphasised of (1) co-ordination of inter-agency action, and (2) obtaining key information on its ecology.

Single species management as opposed to ecosystem management is under debate and intensive management of an indicator species is a self-contradiction (Simberloff, 1998). It would be ironic if, in an attempt to save the Javan rainforest biotope, the survival of the "flagship species" in the wild should itself be threatened.

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