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Emu



Volume 100, 2000
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Breeding Biology of Javan Hawk-eagle *Spizaetus bartelsi* in West Java, Indonesia

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Summary: The Javan Hawk-eagle *Spizaetus bartelsi* is one of the rarest and least known birds of prey, regarded as globally endangered and confined to the last remnants of forests left on the densely populated island of Java, Indonesia. Its biology is little-known and only a few cases of breeding have been reported. Systematic observations in 1992 and 1994 of two breeding pairs in the rainforest of the Gede-Pangrango National Park, West Java, are described in this paper. In total over 100 h of observation were made and cov-

ered different stages of the breeding cycle. Clutches consisted of one egg, incubated for 47 ± 1 days predominantly by the female, to whom the male brought prey. After the egg hatched the female joined the male in hunting. The male was rarely seen on the nest as copulation and prey transfer took place mainly on nearby trees. After fledging the eaglet stayed near the nest for at least two months. A prolonged post-fledging period followed, the juvenile remaining with its parents for more than one year.

The Javan Hawk-eagle *Spizaetus bartelsi* is one of the least known raptors in the world (Meyburg et al. 1989). The species is confined to the last remnants of forest on the densely populated island of Java, Indonesia. Due to the ever-decreasing area of natural forest left on Java, and more recently due to an increase in trade of birds, the species is considered globally endangered (Collar et al. 1994).

Since 1986 a number of surveys have been conducted on the distribution and population status of the Javan Hawk-eagle including some identifying management priorities (e.g. Mooney 1997) and now the species is known from more localities than ever. The current population is estimated at a maximum of c. 200 breeding pairs (SvB, VN & RS unpubl. data). The species occurs in the ever-wet rainforest, which is largely restricted to the western half of the island, to the south and south-eastern slopes of the higher volcanoes more to the east, and in some deciduous forest, which is more common to the eastern part of the island. As in many tropical rainforest raptors, information on demography and breeding biology is almost completely lacking (Thiollay 1985, 1994; Clark 1994). Burton (1989) commented: 'with no information concerning the nest, eggs or habits of the bird currently available, it is difficult to envisage how any sort of conservation strategy can be developed, and at least for the present, the bird's future must remain precarious'. Recently this biological information was essential to establish a framework for a recovery

plan to protect the Javan Hawk-eagle from further decline (Sözer et al. 1998).

Until now few cases of breeding by Javan Hawk-eagles were recorded (Bartels 1924; Bartels 1931; van Balen et al. 1994; Sözer & Nijman 1995a; Røv et al. 1997). The nest and egg have been described (Bartels 1924; Hellebrekers & Hoogerwerf 1967; Meyburg et al. 1989; Røv et al. 1997) and some details on different stages of the breeding cycle have been reported (van Balen et al. 1994; Sözer & Nijman 1995a). Currently a number of other projects are in progress (N. Røv & J.O. Gjershaug pers. comm.; T. Yamasaki pers. comm.; D.M. Prawiradilaga pers. comm.).

This paper describes aspects of the breeding biology and breeding requirements of the Javan Hawk-eagle in West Java.

Methods

Study area

Two nests were studied on the twin volcanoes Mt. Gede (2958 m) and Mt. Pangrango (3019 m), West Java, i.e. at Cibodas on the north-east slope (September 1992), and at Pasir Pogor on the west slope (February–June 1994). The nests were situated inside or near the borders of the Gede-Pangrango National Park. Some additional data were collected on a nest currently under observation by a team led by T. Yamasaki, at Cibulau near

the Telaga Warna Nature Reserve (June–September 1997). The park consists mainly of montane forests and includes the well-known botanical gardens of Cibodas. It covers an area of *c.* 15 000 ha, and an additional few thousand hectares of degraded forest is situated outside the park borders. The nearby Telaga Warna Nature Reserve surrounds a small lake and the reserve proper covers an area of 350 ha. The forests in the entire study area cover over 20 000 ha.

The climate in the study area is perhumid, average rainfall exceeds 3000 mm to up to more than 7000 mm annually (RePPPProT 1990). There is little seasonal variation with only a slight decrease in rainfall from May to August. However, the warm phase of the El Niño event (last experienced in 1991 and 1997) results in extended and more pronounced dry seasons, lasting until November. Temperature varies more between night and day

than between months and years, and ranges between *c.* 23–30°C in the lowlands, while above *c.* 2000 m asl, frost can occur at night (van Steenis 1972).

Data collection

Systematic observations on the activities of the birds at and near the nest were carried out with 8–12× binoculars and a 20–60× telescope at distances of *c.* 50 m (Cibodas) and 200–300 m (Pasir Pogor). Data at the nests were continuously recorded, and additional data on the behaviour of adult birds were collected when they were in the vicinity. Generally the sexes could be distinguished by size (Nijman & Sözer 1996), and individuals differed in their plumage and/or moulting pattern. Data on the habitat and local land use were collected.

Nests were observed during different stages of the breeding cycle, and information is combined to provide a general overview. In all, 117 h of observation were made at or near nests, i.e. 16 h over 5 days in September 1992; 88 h (19 days) in February–June 1994, and 13 h (4 days) in June–September 1997. The Pasir Pogor nest covered pre-incubation, incubation and hatching periods up to six weeks when the juvenile disappeared from the nest. Both the Cibodas nest and Cibulau nests covered parts of the hatching and fledging periods.

Descriptions on the development of the juveniles were derived from observations in the field and from a number of birds on display in the Taman Safari Zoo, Cisarua, and the bird park of Taman Mini Indonesia Indah, Jakarta. We collected additional data on the behaviour of Javan Hawk-eagles during a number of surveys throughout the island from 1986–97 (SvB), and intermittently from 1994 to 1997 (VN and RS). Where relevant, these data are included in the results.

Results

Breeding habitat

The nests were located in sub-montane forest. The Cibodas nest was situated at 1410 m asl, 150 m from the forest boundary with the Cibodas botanical gardens and about 50 m from a jungle trail. The nest tree was at the edge of a gap in a disturbed part of the forest. The gap was overgrown with low shrubs, herbs and some bamboo, and lined by tall *Rasamala Altingia excelsa* trees. The Pasir Pogor nest was at 1085 m asl halfway up a steep north-west slope, on the boundary of the National Park. The surroundings consisted of partially disturbed forest, *c.* 500 m from a dairy farm. The Cibulau nest

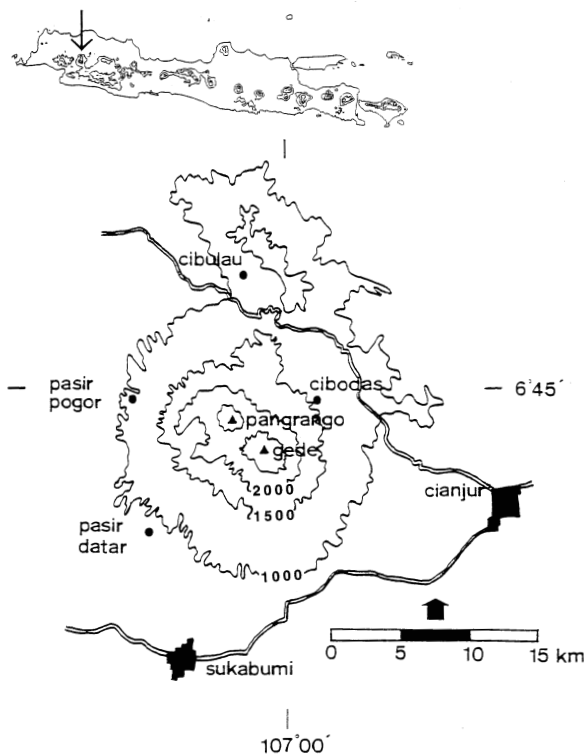


Figure 1 Map of Mt. Gede-Pangrango, West Java, Indonesia, with the locations of the nests studied, and Pasir Datar, the location from where the Bartels reported Javan Hawk-eagles breeding in the 1920s. The insert depicts the island of Java, the arrow points at the location of the study area.

was situated in a small isolated patch of forest surrounded by tea gardens and near a small village adjacent to the Telaga Warna Nature Reserve. This remnant patch of forest (c. 5 ha) was in a small valley, at 1340 m asl and was isolated by a c. 300 m wide stretch of tea gardens from the forests of the reserve.

Nest and nest tree

The nest at Cibodas was on a large branch at c. 25 m in a 35-40 tall Rasamala tree. It was c. 1.0 m wide and c. 35 cm deep, and consisted of sticks and dry branches lined with green fresh branches and leaves. The nest at Pasir Pogor was in the trifurcation of the main stem, halfway up in a tall (c. 30-35 m) Rasamala tree. The dimensions of that nest were difficult to assess but it was at least 1.0 m in diameter. At Cibulau the nest was in a trifurcation halfway up the main stem of a Pasang *Quercus* sp. tree, at c. 15-20 m above ground level. Again the dimensions of the nest were difficult to assess but its estimated diameter was c. 1.25 m. Another nest has been found in a tall Puspa *Schima wallichii* tree (Hapsoro pers. comm.). The nest tree species Rasamala, Pasang and Puspa are among the dominant canopy trees on the west Javan rainforest and are nowadays found mostly in the sub-montane and montane vegetation zones.

According to villagers near the Cibulau nest, that particular nest had been used before, and the pair was observed breeding both in May–June and December of 1997 (I. Setiawan & A. Supriatna pers. comm.). Also the findings of the Bartels' family make it plausible that nests are used for a number of years (Rozenaal 1981). The Cibodas nest was visited again in April 1994 but the branch that supported the nest had broken off; on that and later occasions Javan Hawk-eagles were observed near the former nest site. Invariably the nest trees were amongst the taller trees in the area, and being positioned in prominent positions may serve an important signal function advertising the nesting territory (Newton 1979; Mooney 1997). Table 1 summarises all documented cases of breeding in Javan Hawk-eagles and were all found within a radius of less than 30 km.

Behaviour of the adults

In West Java, courtship displays were observed from March–September; these included advertisement and mutual displays (cf. Brown & Amadon 1968). Single birds were observed calling at intervals from perches as well as in flight, either when soaring or when cruising. Aerial displays in which single birds, after gaining

height first, dived straight down for 10-20 m were performed less frequently. Spectacular mutual displays, consisting of calling, alternating calling, mutual soaring, undulating flying, and talon grasping, were observed in a number of pairs.

Copulation was observed twice, both by the Pasir Pogor pair, involving an adult female and a c. 4-year old subadult; the first was on 13 February 1994, in the pre-incubation stage, while the second was on 22 April 1994, well into the incubation period. The second copulation was preceded by a prey-transfer from the male to the female, and continuous calling by both birds over a two hours period. Incubation was almost exclusively by the female (Table 2). While on the nest, she regularly rearranged nest material and rolled the egg. During the first half of the incubation period (day 1-24) the egg was rolled significantly more (19 times during 25 hours) than in the latter half (six times in 36 hours) ($\chi^2 = 8.7$, $d.f. = 1$, $P < 0.05$). During the incubation period the female left the nest occasionally to feed or to collect fresh branches to line the nest. The male provided the food; prey transfer took place in nearby trees. While the female was feeding, the male generally visited the nest, during which he rearranged the nest and occasionally incubated the egg. The male provided some nest material, but mostly this was done by the female (Binomial test, 1:8, $P < 0.05$). Only once were both male and female observed on the nest. The incubation period lasted 47 ± 1 days. When the young hatched the female joined in hunting, and the time spent off the nest by the female (median 55 min) increased compared to the incubation period (median 21 min) (Mann–Whitney U -test, $n_1 = 17$, $n_2 = 8$, $P < 0.01$). Altogether, the female spent a considerable time on the nest with the eaglet or watched the nest from a perch nearby. During rain the adult eagles generally perched in trees not far from the nest.

Javan Hawk-eagles hunt from concealed perches in the forest or by soaring low over the canopy from where they stoop into the foliage (Bartels 1931; Sözer & Nijman 1995a). The species has a diverse diet including rodents, squirrels (*Ratufa bicolor*, *Callosciurus nigrovittatus* and *C. notatus*), Malay Badger *Mydaus javanensis*, fruitbats *Cynopterus* spp., (juvenile) Ebony Leaf Monkey *Trachypithecus auratus*, Jungle Fowl *Gallus* spp. and Chestnut-bellied Partridge *Arborophila javanica*, lizards and snakes (Bartels 1924; Becking 1989; Prawiradilaga et al. unpubl. data; P. Hurrell in litt.; M. Linsley pers. comm.; J.O. Gjershaug pers. comm.; Hapsoro pers. comm.; this study). Seven times

Table 1 Known cases of breeding by Javan Hawk-eagle *Spizaetus bartelsi* in West Java, Indonesia 1921–97.

Locality site (county)	Breeding season			Species	Nest tree		Status ³	Habitat Altitude (m asl)	Distance to cultivation	Reference
	Observation period	Phase ¹	Egg laid ²		Height tree	Height nest				
Pasir Datar (Sukabumi)	Apr. 1927	i	Apr.	Rasamala <i>Altingia excelsa</i>	c. 60	45-50	NP	c. 1000	6 km	Hellebrekers & Hoogerwerf 1967; Bartels 1924
Pasir Datar (Sukabumi)	Oct. 1921	iii	May	(Hamamelidaceae)	—	—	NP	c. 1000	6 km	Bartels 1924
Mt. Masegit (Cianjur)	Jan. 1928	i-ii	—	(Hamamelidaceae)	—	—	Unp.	—	—	H. Bartels pers. comm. 1994
Kole Beres (Bandung) ⁴	1927–30	—	—	—	—	—	Unp.	—	600-1000	Bartels 1931
Cibodas (Cianjur)	Sep. 1992	iii	June	Rasamala <i>A. excelsa</i>	35-40	25	NP	1410	150 m	This study
Pasir Pogor (Bogor)	Apr.–June 1994	i-iii	Mar.	Rasamala <i>A. excelsa</i>	30-35	25	NP	1085	500 m	This study
Bojong Galing (Sukabumi) ⁵	May 1994	ii	Jan.	—	—	—	—	—	—	Sözer & Nijman 1995a
Cibulau (Bogor)	June–Oct. 1997	i-iv	Mar.	Pasang <i>Quercus</i> sp. (Fagaceae)	30-40	15-20	Unp.	1340	50 m	This study
Cibulau (Bogor)	Dec. 1997	i	Dec.	idem	—	idem	idem	idem	idem	A.A. Supriatna & I. Setiawan pers. comm. 1998
Mt Salak (Bogor)	July–Oct. 1997	i-iii	Jul.	Puspa <i>Schima wallichii</i> (Theaceae)	—	—	Unp.	1150	2 km	Hapsoro pers. comm. 1997

¹ i = incubating, ii = hatching, iii = fledging, iv = post-fledging; ² estimated mostly by deduction from other breeding phases; ³ NP = National Park; Unp. = unprotected; ⁴ Bartels (1931) reported nesting at two sites near the Kole Beres estate, the mating season would be in July and August; ⁵ two confiscated eaglets (estimated age 10 and 11 weeks, respectively), most likely to have originated from the region south of Mt. Gede Pangrango.

Table 2 Percentage of each daylight hour spent near (within 100 m: pre-incubation period only) or at the nest by Javan Hawk-eagle *Spizaetus bartelsi*.

Hour	6-8	8-10	10-12	12-14	14-16	16-18
Pre-incubation period						
Male	n.a.	35	16	0	n.a.	n.a.
Female	n.a.	51	29	0	n.a.	n.a.
Incubation period						
Male	0	2	1	5	5	0
Female	99	88	85	91	89	100
Hatching period						
Male	0	1	1	0	n.a.	n.a.
Female	73	46	38	26	n.a.	n.a.

n.a. = no information available. Based on 104 h of observation (5, 70 and 29 h for pre-incubation, incubation, and hatching period, respectively).

a food transfer by the male to the female was observed, or by one of the adults to the eaglet. Javan Hawk-eagles become more active in the mid or late morning, and can mostly be seen in flight until midday (Meyburg et al. 1989). This is when food has been observed to be transferred — seven transfers between 0800–1300 h during 64 h of observation vs. nil observed transfers during 37 h of observation at other times of the day (G -test: 5.88, $d.f. = 1$, $P < 0.05$).

The young

At three weeks old the nestling was the size of a pigeon and completely covered with white down. The area around the eyes, lores and the bill was dark grey to black. At six weeks the wings were lined with short black tips of the developing primaries; face and bill were still black, and a crest began to appear; the approximately 30 cm large bird was capable of moving around in the nest, and defaecating from the edge. When alone on the nest the young was active, preened itself, moved around, and manipulated nest material. Upon sighting the adult, it adopted a begging gesture with the wings spread and a crouching posture. At an estimated age of nine weeks the eaglet had rich cinnamon brown plumage, with a short white-tipped crest. In size it approached that of the adults and it started flapping its wings. Although it could now eat unaided, the eaglet would beg for food if the adult bird happened to be on the nest while it was feeding. It would then take the food directly from the parent bird's beak or pick it up from the nest floor. Loud and unfamiliar sounds disturbed the young bird and its screaming would attract the adult bird to the nest. Like the adult birds, the eaglet was more active in the morning than in the afternoon. The eaglet spent much time sun bathing, preening, and flapping its wings whilst jumping or walking slowly in the nest. At an estimated age of 10 weeks the eaglet was first seen outside the nest *c.* 1 m from the edge. At 11–12 weeks it was seen flying a short distance.

After fledging the juvenile stayed within *c.* 100 m of the nest, for at least two months. A prolonged post-fledging period followed, and observations on an additional pair studied on Mt. Slamet (7°19'S, 109°13'E) in Central Java indicated that the juvenile may stay with its parents for a year or longer (Sözer & Nijman 1995a).

A description of the various age phases in Javan Hawk-eagle, which are readily recognised by plumage features, is given by Meyburg et al. (1989) and Nijman & Sözer (1998). The eye-colour changes from very dark brown in downy young, dark grayish blue in fledglings,

light grey in first year birds, lemon in subadults to golden yellow in full adults. The Javan Hawk-eagle is believed to be sexually mature when four years old (Sözer & Nijman 1995a).

Local status

Indonesian law (No 421/Kpts./Um/8/8/1970) protects all diurnal birds of prey, whereas rare and endangered species receive extra protection under article 21(2) of the Act R.I. No. 5 of 1990, and there is a ban on the use of firearms and air rifles. Fines and subsidiary confinements can be imposed on law breakers but law enforcement is weak. Finding a Javan Hawk-eagle for sale in a Javan bird market is not unusual.

All nests recently found were near or within the boundaries of protected areas. The Cibodas nest was near the head quarters of the National Park and the botanical gardens and received some protection. The Pasir Pogor nest was on the western slope of Mt. Pangrango, far from any guard post, and did not receive any physical protection. During the study period a number of people were seen entering the valley carrying powerful air rifles, and the collection of firewood was frequent. The pair did not succeed in raising their young successfully; the last observations of the eaglet were made at the end of June when it was about six weeks old. From then on the adults were absent from the valley, but were present again in January 1995 (P. Jepson pers. comm.). The Cibulau nest probably received the best protection currently possible. It was 'adopted' by a nearby small village; hunting and collection of firewood in the forest patch was temporarily prohibited. A representative of the village patrolled the forest patch twice a day and it would have been hard to enter the area unnoticed.

Over the last 15 years more observations on Javan Hawk-eagles have been made in the Gede-Pangrango area than in any other area on Java. It is arguably the best area to study Javan birds, and one of the few areas where there has been a tradition of conducting scientific research. A visit to the Gede-Pangrango National Park is a must for every birder visiting Java (Jepson & Ounsted 1997). It also harbours one of the few larger populations of Javan Hawk-eagle left on Java. The total world population of the species is currently estimated at a maximum of *c.* 200 pairs, with possibly an equal number of juveniles and immatures (SvB, VN & RS unpubl. data). The estimated population of Javan Hawk-eagles in our study area, and the nearby Mt Halimun and Mt. Salak area, totals *c.* 22–35 pairs, making

it one of the few populations for which a substantial part of its habitat is protected.

Discussion

Breeding habitat

It was suggested (Kuroda 1936; Brown & Amadon 1968) that the Javan Hawk-eagle showed a preference for montane forest. Although most nests currently known have been found in submontane forests there is no reason to assume a preference for this forest type. Recent studies (van Balen 1991; van Balen & Meyburg 1994; Nijman & Sözer 1995a, b) have indicated that this is largely an artifact of the relative small area of lowland forest left on Java. In fact Javan Hawk-eagles occur from sea level to above 2000 m asl and have been recorded as high as *c.* 3000 m asl. In West Java only 3-4% of lowland forests remain; almost twice as much forest remains above the 1000 m line as below (MacKinnon et al. 1982). The only large lowland forest areas left are those in Ujung Kulon, where the Javan Hawk-eagle has been observed but which probably offers only partially suitable habitats and the forest along the inaccessible and under-explored south coast.

Bartels (1924, 1931) stated that the species breeds deep in undisturbed forest, but the present study indicates that the birds do not always choose nesting sites far from human activities.

Breeding cycle

Breeding in raptors is generally determined by food supply (Newton 1979, 1991), which in turn is influenced by climate. The study area is one of the wettest areas on Java, with mean annual rainfall ranging between 3-7 m per year (RePPPProT 1990) and in many parts even during the driest four consecutive months of the year on average 40-80 or more rainy days are recorded (van Steenis 1972).

The few data from the first half of this century in the study area in West Java suggest that the dry (or less wet) season may offer a window during which breeding is favourable. More recent information suggests that breeding can occur at almost any time of the year (Røv et al. 1997; this study), which may however also reflect poaching pressure over the past two decades that may have thrown the normal breeding season into disorder. Newton (1979) reports that climatic factors including between year variations in rainfall might explain regional differences between breeding seasons in the

tropics. It is therefore also possible that the influence of El Niño events on the rainfall might contribute to breeding season variation in our study area.

Breeding biology: an intrageneric comparison

Our findings are in general agreement with studies of other Asiatic members of the genus *Spizaetus*. However, most of these are even less known than the Javan Hawk-eagle, with the possible exceptions of Changeable Hawk-eagle *S. cirrhatous* and Mountain Hawk-eagle *S. nipalensis*. Like the Javan Hawk-eagle, other members of the genus have spectacular aerial courtship displays and intensive calling, nest in the tallest forest trees which may be used in subsequent years, usually lay a single egg, have strongly differentiated parental roles, incubate their egg for over 40 days, have a nestling period of about 12 weeks, and a prolonged period of post-fledging dependence of at least a year (Hoogerwerf 1949a, b; Smythies 1960; Brown & Amadon 1968; Medway & Wells 1976; Ali & Ripley 1978; Naoroji 1985; Roberts 1991; Morimoto & Iida 1992; Wells 1998).

Until recently, the observations made by the Bartels (Bartels 1924; 1931; Rozendaal 1981; H. Bartels, pers. comm.), and our own findings made us believe that Javan Hawk-eagles probably follow a biannual breeding cycle (Sözer & Nijman 1995a, b). However, recent observations at the Cibulau nest and (possibly) those from the nest at Mt. Salak (J.O. Gjershaug, pers. comm. 1997; Røv et al. 1997), indicate that the species may breed in shorter intervals, possibly under influence of climate and/or loss of dependent juveniles. Shorter intervals were also reported for the Japanese Mountain Hawk-eagle, which often breeds every year in Japan (T. Yamazaki, pers. comm. 1995).

In many birds of prey, females in particular may sometimes start breeding in sub-adult plumages as a consequence of especially good conditions (i.e. abundant food) or depletion of populations by human persecution (Newton 1979). Mountain Hawk-eagle females may start to breed at an age of only three years (T. Yamazaki pers. comm. 1995), while Changeable Hawk-eagles are also known to breed in subadult plumage (Brown & Amadon 1968). During our study there was probably an abundant food supply (dry seasons on Java were unusually mild in 1993 and 1994) and severe human persecution (e.g., more captive Javan Hawk-eagles than ever were seen in recent years), and one of the breeding males was in sub-adult plumage.

Suggestions for further studies

The current study is the most complete report on breeding Javan Hawk-eagles to date. We have gathered data from a number of nests in different stages of the breeding cycle which have been combined as to create an overall picture. Ideally the complete cycle in one, or preferably more, nest(s) should have been followed. The breeding requirements in the eastern part of the species' range might be somewhat different than those in our study area as Voous (1950) showed a more sharply defined general period of breeding activity in areas with a more pronounced dry season. We therefore encourage other students to focus (parts of) their research efforts in the drier forest types.

Of the South-east Asian congeners of the Javan Hawk-eagle, only the widely distributed Changeable and Mountain Hawk-eagles have been studied in some detail. Of the species with a much more restricted range, i.e. Wallace's Hawk-eagle *S. nanus* and Blyth's Hawk-eagle *S. alboniger* (peninsular Malaysia, Sumatra and Borneo), Sulawesi Hawk-eagle *S. lanceolatus* (Sulawesi and Sula Islands), and Philippine Hawk-eagle *S. philippensis* (Phillipines), virtually no information on reproductive biology is available (cf. Clark 1994). Their conservation status remains unclear, but currently only the Sulawesi Hawk-eagle is considered in no immediate danger (Meyburg & van Balen 1994; van Balen 1994). In order to be able to understand the requirements of these species a focussed research on the breeding biology of a number of the above mentioned species is needed. However, opportunities to study rainforest raptors on these islands are less compared to Java, as the forests in these areas are not easily surveyed due to poor access and rugged terrain. Recently initiated research projects (NINA-NIKU; JME-project) on the Javan Hawk-eagle can tell us more about the biology of this species and, given the great similarities to the Asiatic Hawk-eagles, by extension, about its Asiatic congeners.

Acknowledgements

This study was supported by the Indonesian Institute of Sciences (LIPI) and would not have been possible without the cooperation of the Directorate General of Forest Protection and Nature Conservation (PHPA). Over the years financial support was received from the Oriental Bird Club, J.C. van der Hucht Fund, Martina de Beukelaar Foundation, WWF-Netherlands, Greshoff's Rumphius Fonds, Van Tienhoven-

stichting, FONA and Zoologisch Insulindefonds. The directors and staff of Taman Safari Zoo, Cisarua, and the bird-park of Taman Mini Indonesia Indah, Jakarta, are thanked for their co-operation, as is the PHPA/BirdLife International Indonesia Programme, officers and the former head of the Gede-Pangrango National Park and staff of Museum Zoologi Bogor and the National Museum for Natural History, Leiden. R. Beckwith, D. Dewi (Padjadjaran University Bandung), P. Jepson (formerly BirdLife International IP), Hap-soro (TELAPAK), D.M. Prawiradilaga (FFI / LIPI), A. Prima Setiadi (YPAL), I. Setiawan (BirdLife International-IP) and A.A. Supriatna (CIBA) kindly shared information on breeding data. The late H. Bartels, P.J.H. van Bree (ISP/ZMA), C.J. Hazevoet (Museu de História Natural, Lisboa), P. Jepson, and J. Wattel (ISP/ZMA) provided valuable advice throughout the project. We thank M.G. Brooker, D. Baker-Gabb and N. Mooney for comments on the manuscript.

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