NN08201, 2726

STELLINGEN

1. Het grootste effect van ontbossing op bosvogels vond op Java eeuwen geleden plaats.
*Dit proefschrift*

2. De algehele verarming van de vogelstand op het platteland heeft een negatief effect op de vogelsoortenrijkdom in kleine bosreservaten.
*Dit proefschrift*

3. De kolonisatie door vogels van een voordien "vogelvrij" eiland is sprongsgewijs en niet monotoon, maar weerspreekt hiermee de eilandtheorie van MacArthur & Wilson niet.
*MacArthur & Wilson (1967). The theory of island biogeography. Princeton University Press.*
*Dit proefschrift*

4. De beschermde status van de Balispreeuw *Leucopsar rothschildi* heeft nog geen duurzaam positief effect gehad op hun in het wild voorkomende aantallen.
*Dit proefschrift*

5. Als gevolg van de ontsluiting van de tropische regenwouden neemt de diversiteit van actief gesproken talen in Indonesië minstens even snel af als die van de bosvogels.

6. Iemand die tot twee of meer *IUCN Species Specialist Groups* behoort, kan zichzelf geen soortspecialist meer noemen.

7. Het toegeven aan zelfs een bescheiden splitsingsdrang van taxonomen zal een explosieve toename van globaal bedreigde vogelsoorten op Java tot gevolg hebben.

8. Dat de kampongkippen op Java niet van het aldaar voorkomende Bankivahoen afstammen is niet alleen met DNA-hybridisatie studies aantoonbaar.
*cf Fumihito et al.(1996). Proc. Natl. Ac. Sci. U.S.A. 93: 6792-6795*

9. De enorme expansie van de ringmus *Passer montanus* in Indonesië is toe te schrijven aan zijn hoge *Emotional Quotient*.

10. Het verkrijgen van een bedreigde status is voor een aantal vogelsoorten terug te brengen tot het charismatische bezit van een opstaande kuif.

11. De zelfzuchtige Nederlandse koopmansgeest komt tot uiting in het bordje "te koop"; vergelijke dit met soortgelijke aankondigingen, maar met een geheel andere letterlijke vertaling: "*zu verkaufen*", "*for sale*", "*à vendre*", "*se vende*", "*akan dijual*", enzovoort, waarbij het oogmerk dienen is.

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Stellingen behorende bij het proefschrift van Sebastianus (Bas) van Balen: "Birds on fragmented islands: persistence in the forests of Java and Bali".
Wageningen, 13 december 1999.

# Birds on fragmented islands

persistence in the forests of Java and Bali

NN08201, 2726

CORRECTIONS to
"Birds on fragmented islands" by Bas van Balen

p 9 (Table 2.1): no. 23, column 3 and 4 should read: *S *SP; no. 30, column 5 should read: *; no. 32 column 3 should read: *; no. 37 should read: - * R RP *S 5 5 4 1 4 4 4 1; no. 45, column 5 should read: *
p.11 (Table 2.2): no. 18 should read: - RS RS - [RSP RSP] RSP; no. 19, column 5 should read: *; no. 35, column 7 should read: ?RS?P
p.16, l.25: "depleted" should read "depicted".
p.21, l.44: "failing" should read "falling".
p.26, l.23: "one fifth" should read "one third"
p.28, l.29 (*Alcedo meninting*), column 5 should read: 1; l.35 (*Lalage nigra*), column 4 should read: 0
p.142, l.22 insert: A fourth species, the white-breasted babbler *Stachyris grammiceps*, was treated in Chapter 4.
p.146, l.12: "ultimate" should read: "proximate stochastic".
p.167, l.5: "18" should read "19".

Promotor: Dr H.H.T. Prins
Hoogleraar in het Natuurbeheer in de Tropen en de Ecologie van Vertebraten

# Birds on fragmented islands

## persistence in the forests of Java and Bali

Sebastianus van Balen

Proefschrift
ter verkrijging van de graad van doctor
op gezag van de rector magnificus
van Wageningen Universiteit,
Dr. C.M. Karssen
in het openbaar te verdedigen
op maandag 13 december 1999
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Cover photos and drawings: Bas van Balen

*Aan mijn vader*

# Table of contents

## Abstract

S. van Balen (1999). Birds on fragmented islands: persistence in the forests of Java and Bali. Doctoral thesis ISBN 90-5808-150-8. Also published as Tropical Resource Management Papers No 30; ISSN 0926-9495, Wageningen University and Research Centre, The Netherlands.

This study describes, analyses and provides suggestions for the amelioration of the impact of age-long deforestation on the distribution of forest birds on the islands of Java and Bali (Indonesia). The first section deals with colonisation and extinction processes of forest birds in a number of remaining forest patches on Java. In the regenerating forest of the Krakatau Islands colonisation and extinction of land birds appear to follow vegetation succession, and therefore seem to affect the monotonic change as predicted by MacArthur & Wilson's equilibrium theory of island biogeography. Extinction of forest birds in the Bogor botanical gardens appears to mirror closely the condition of bird communities in the surroundings of this isolated woodland patch. Distribution patterns of forest birds across 19 highly scattered forest fragments ranging from six to 50,000 hectares show clearly that the ability of birds to survive in surrounding habitat reflects the ability to survive in these patches. To show this, four ecological groups of forest birds have been distinguished: (1) forest interior birds, (2) forest edge birds, (3) woodland birds and (4) rural/urban birds. Nestedness patterns (in which species are found in all fragments larger than the smallest one in which it occurs) are found to be strongest for species restricted to forest interior and edge, weaker for secondary growth, and weakest for rural and urban bird species. A large number of forest interior species appear to be absent from most patches smaller than 10,000 ha, and most are entirely absent from forest patches smaller than 100 ha. In the second section of this thesis the conservation status of three globally threatened, high-profile birds is analysed. The endemic, endangered Javan hawk-eagle *Spizaetus bartelsi*, traditionally considered amongst the most vulnerable forest dwellers, appears to survive in 137-188 breeding pairs in often small and isolated rainforest patches; its survival is explained by (a) juvenile dispersal capabilities, (b) broader niche widths and (c) rather opportunistic feeding. Partly protected by local taboos on hunting, the vulnerable green peafowl *Pavo muticus* has survived many centuries of human pressure; nowadays at least 1000 birds are scattered across numerous subpopulations. The wild population of the endemic, critically threatened endemic Bali starling *Leucopsar rothschildi* collapsed since its discovery in 1910 to near extinction in 1990, due to habitat loss and popularity amongst bird-keepers world-wide; despite various conservation measures (captive breeding, awareness programmes, etc.) an intricate web of socio-economic factors prevents the species from emerging from this precarious situation.

**Key words**: conservation, threatened bird species, Java, Bali, Krakatau, Indonesia, forest fragmentation, extinction, colonisation, Bali starling, *Leucopsar rothschildi*, Javan hawk-eagle, *Spizaetus bartelsi*, green peafowl, *Pavo muticus*, nestedness, captive breeding.

## Preface

Four days from now it will be exactly 15 years ago that I finalised the first draft proposal entitled: "Forest birds and ecosystem management in West Java (Indonesia)" for the research of which the results I will defend today. Title, objectives, scope, supervisors as well as the intended results, however, have been adjusted in the course of years. Understandably many people have helped me by word and deed with the completion of this dissertation. To express my gratitude without forgetting anybody will be hardly possible, but I will do an attempt.

First of all I would like to thank my promotor Professor Herbert Prins, for his scientific support, unlimited patience and always good humour that never failed to sheer me up when spirits were getting low. Special thanks go also to Professor S. Somadikarta (University of Indonesia), who acted as my direct supervisor in Bogor, and to whom I could come for advice at any time since the very beginning. Both Pak Soma and Professor Frank Berendse (University of Utrecht; presently Wageningen University) supervised my MSc study in 1980-1981 on forest birds in the environs of Bogor. These first years in Indonesia laid the very basis for later work.

During the first preparatory stages of the PhD study a large number of people played an important role. In the first instance I am very grateful to Dr Wim Bongers who suggested me to continue my Bogor bird studies and obtain a PhD degree, and helped me with making contacts, etc. My first two intended promotors Professor C.W. Stortenbeker and the late Professor Dick Thalen, Professor M.E. Mörzer-Bruyns, Professor K.H. Voous, Dr Gerlof Mees, Dr Hans de Iongh, Ir Bas van Helvoort, the late Mr Hans Bartels, Jelle Scharringa, Arnoud van den Bergh and Drs Frank Rozendaal helped in various ways with birdsong identification, advices, letters, literature, etc., for which my sincere thanks. The first years in Bogor were financed by the Dutch Emigration Service ("Praktijk Programma Buitenland") and the Indonesian Ministry of Education and Culture with grants from the Zoologisch Insulindefonds, Stichting Fonds voor Natuuronderzoek ten behoeve van het Natuurbehoud (FONA), van Tienhovenstichting, Wereld Natuurfonds and Greshoff's Rumphius Fonds.

The Indonesian Institute of Sciences, and later the Indonesian Ministry of Forestry (Department of Forest Protection and Nature Conservation: PHPA) allowed me to carry out research and surveys for the forest bird study. My thanks go to Professor Rubini Atmawidjaja, Ir Sutisna Wartaputra, Ir Syafii Manan, Bp Abdul Bari, Drs Effendy Sumardja, Ir Dwiatmo Siswomartono, Bp Sujadi, Bp Ari Sudarsono, Ir Tony R. Suhartono, and Drs Widodo S. Ramono. In the field I was often assisted and guided by PHPA rangers, for which I express my gratitude.

My sincere thanks go to the bird curators of the Nationaal Natuurhistorisch Museum Dr Gerlof Mees and Dr René Dekker who have always been helpful, any time I visited their bird collection and through correspondence.

In Bogor and Jakarta I frequented and received support from a large number of institutes and organisations. My thanks go to the directors of Puslitbang Biologi and Museum Zoologi Bogor: Dr Soenartono Adisoemaro, Dr Soetikno Wirjoatmodjo, Dr Sampoerno Kadarsan and Drs M. Amir, and my colleagues at the bird department of Museum Zoologi Bogor: Drs M. Noerdjito, Dr Dewi Prawiradilaga, Ir Sri Paryanti, Ir Daryono, Dr Asep Adikerana, Drs Wahyu Widodo, Ir Sudaryanti and Ir Endang T. Margawati. I extend my thanks to my colleagues at the Agricultural University of Bogor Dr Hadi Alikodra, Ir Yeni A. Mulyani, and Ir Jarwadi B. Hernowo; at the University of Indonesia: Professor M. Soerjani who invited me to his Center for Environmental Studies; at the Yayasan Indonesia Hijau/PPLH Seloliman: Bp Indrajit, Drh Suryo W. Prawiroatmodjo, Sybout Porte, Rod Sterne, Mbak Zaenab, Alain

Compost and others; at the Wetlands International – Indonesia Programme: former coordinator Drs Marcel Silvius, and his staff; at the School for Environmental Management: Bp Benny Sormin, Dr Herman Rijksen, Drs Fred Smiet, Ir Bas van Helvoort and Theo Rijnberg; at WWF-Indonesia Programme: Dr Russell Betts, Dr Kathy MacKinnon, Dr Charles Santiapillai, Ibu Hilda The and Teh Kusye; at the Indonesian Ornithological Society: Derek Holmes, the late Chuck Darsono, Paul Andrew, Pak Kamil Oesman; and the Indonesian Zoo Association (PKBSI): Gen. D. Ashari, Drs H. Ismu S. Suwelo and Bp Subagyo.

My thanks go to my colleagues and assistants during the Bali Starling Project: Drs I Wayan Dirgayusa, Drs Made Wedana Adiputra, Slamet Suparto and Dr Prabawa B. Nugraha. The following institutes/organisations were involved in the Bali Starling project and I very much appreciated cooperation at Taman Mini Indah with Dr Made Sri Prana, Ir Endang Priyambada, Drs Vivi Astaviane, Drs Widya Brata and Ir Endang Budi Utami; at Taman Safari with Drs Jansen Manansang, Bp Tony Sumampau and Ligaya Tumbelaka; at the Surabaya Zoo with Drs Vincent Harwono Gepak and Ir H. Bambang Sudaryanto; at Bali Barat NP with directors Ir Harry Rohadi, Bp Ubus Wardju Maskar and Ir Ikin Mutaqin, and staff I Made Suta Adi, M. Noor Soetawidjaya, Wawan Suryawan, and many others; and the American Zoo Association with Bob Seibels, Kevin Bell and Dr Don Bruning. The Bali Starling project was sponsored by the American Zoo Association, Art Ortenberg/Liz Claiborne Foundation, Jersey Wildlife Preservation trust and the Swedish Ornithological Society.

My cooperation with the Indonesian ex-students Drs Mochamad (Didi) Indrawan, Drs Yusup Cahyadin, Drs Iwan Setiawan, and Drs Andi Setiadi, and Dutch ex-students Dr Paul Erftemeijer, Drs Vincent Nijman and Drs Resit Sözer produced lasting friendships. Their motivation and enthusiasm has always been a stimulus during my own research.

The peafowl surveys were sponsored by WWF – Indonesia Programme, the Oriental Bird Club and the World Pheasant Association. Special thanks are forwarded to Caroll Inskipp, Melanie Heath, Professor David Jenkins, Dr Philip McGowan, Dr Peter Garson and Keith Howard for their support.

My participation in the Javan Hawk-eagle surveys was supported by grants from the American Federation and Aviculture channelled provided by the World Working Group of Birds of Prey and Owls, through which I was introduced to Professor Bernd Meyburg, Dr Jean-Marc Thiollay and Robin Chancellor, and indirectly to Herman & Hanni Meiss and Hans Kalisch, all of whom have always been helpful with logistics, financial support, and/or advices on raptor identification.

Further thanks go to Professor Ian Thornton and Dr Richard Zann (La Trobe University); Professor J M. Diamond (University of California); to Wally Sander and Dick Watling (New Zealand Dpt of Conservation); to Ir Sjaak Beerens (Kali Konto Project); to Victor Mason (Bali Bird Club); to my companions in the field as far as not mentioned elsewhere: Drs Chairul (Uyung) Saleh, Drs Amir Faisal, Drs Sukianto Lusli, Drs Agus Marhadi, Simon Hedges, Martin Tyson, David Quammen, Phil Hurrell, Dr Richard Noske, and Dr Josep del Hoyo; to Dr Tony Whitten for tape-recording bird choruses for me; and to all birders mentioned in the chapters of this thesis who shared their bird records with me.

Working nine years off and on for BirdLife International – Indonesia Programme in Bogor has produced a lot of good memories: Paul Jepson, Richard Grimmett, Bu Ani Siregar, Drs Ria Saryanthi, Drs Rudyanto, Tomie Dono, Ir Sujatnika, Herly, Dewi, Ir Jeni Shanaz, Drs Willy Rombang, Drs Wahyu Rahardjaningtrah, Drs Yusup Cahyadin, Agus, Pak Nasir and Holik are all thanked for their help and friendship. My special thanks go to Dr Michael

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Surveying even the remotest corners of Java, Madura and Bali was made comfortable because of the proverbial Indonesian hospitality. To all people who accommodated me during my fieldwork on Java, Madura and Bali, I express my sincerest "hatur nuhun", "matur nuwun", "suksma", "mator kasoon" or "trims berat".

Back in the Netherlands office life was made easier through the secretarial help from Gerda Martin, Tanita Goossens and Marjolein den Brabander, and after Dr Han Olff introduced me to Windows 95. Three years later Maarten Smit saved my corrupted computer from being smashed through the window and introduced me to Windows 98. Herman van Oeveren prepared the cover design of my thesis and helped me with numerous other computer matters. Parts of the manuscript have been checked on grammar and spelling of English, Dutch, French and Indonesian texts by Dr John Grimshaw, Dr Pieter Ketner, Dr Sip van Wieren, Clement Ekanga, Dr Arend Brunsting, Dr Ignas Heitkönig and Drs Ria Saryanthi, and others mentioned in the chapters. My fellow PhD's and "partners in stress" at the department: Bart, Claudius, Paul, Margje, Irma, Juul and Fulco are thanked for their advices and mental support.

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Both my "paranymphs" Dr Jan Verhagen en Derk van Balen are thanked for reading the manuscript, and Jan for mental support and transport during the writing-up phase in the Netherlands, and my brother Derk, representing my brothers, sisters and in-laws, for support, and taking care, often assisted by our friend Maddy Roosen, of my little family while I was away on survey.

To me personally being in the field to watch and study birds was amply worth the leech and mosquito bites, ulcers, sore feet, rattan thorns, and other sorts of minor discomfort. But being far away from home is different matter. Therefore I dedicate this dissertation to my family, in the first place my father who would have loved to be here today, but sadly he is not with us anymore; to my mother for her good care but never ceasing worries; to Like for her unlimited patience, understanding and care, and to Leonie and Gerrit who one day may want to read the chapters written in this book.

Chapter 1

# General Introduction

The megadiverse Republic of Indonesia takes the fourth position in the list of the World's richest bird countries, and is first for endemism (Sujatnika *et al.* 1995). Amongst the 24 Endemic Bird Areas (EBAs) of Indonesia, the islands of Java and Bali (respectively the fourth and sixteenth largest islands in the Indonesian archipelago) score relatively highly with 38 restricted range species (breeding ranges of <50,000 $km^2$), and 29 to about 40 endemic species, depending on the taxonomic position taken (Sibley & Monroe 1990; Andrew 1992; Sujatnika *et al.* 1995). Though avian endemism is predominant in the montane fauna, the lowland forests of Java and Bali are intriguing and important from a bird conservation point of view (see Box 1.1). Under pressure of an ever increasing human population only about 2.3% of the original 10 million ha tropical lowland forest remains on Java (see Figure 1.1 and Table 4.1) and this is divided into numerous patches varying from only a few up to 50,000 hectares.

**Box 1.1** Endemic lowland forest birds on Java and Bali

| | |
|---|---|
| Javan honey-buzzard | *Pernis ptilorhyncus* |
| Javan hawk-eagle | *Spizaetus bartelsi* |
| yellow-throated hanging-parrot | *Loriculus pusillus* |
| Javan owlet | *Glaucidium castanopterum* |
| Javan frogmouth | *Batrachostomus javensis* |
| black-banded barbet | *Megalaima javensis* |
| (Javan) greater goldenback | *Chrysocolaptes lucidus* |
| white-breasted babbler | *Stachyris grammiceps* |
| crescent-chested babbler | *Stachyris melanothorax* |
| grey-cheeked tit-babbler | *Macronous flavicollis* |
| olive-backed tailorbird | *Orthotomus sepium* |
| Javan sunbird | *Aethopyga mystacalis* |
| Bali starling | *Leucopsar rothschildi* |

Based on: Sibley & Monroe 1990; Andrew 1992; MacKinnon & Phillips 1993; van Balen 1993; Mees 1996.

Java has traditionally been one of the centres of scientific activity in Southeast Asia, being well explored because of its relatively good infrastructure and accessibility. Consequently, the island has a relatively good historical record and

**Figure 1.1** Forest cover on Java and Bali (after RePPProT 1990; Whitten *et al.* 1996)

the first comprehensive bird list dates from the early 19th century (Horsfield 1821; Kuroda 1936; Junge 1953).

**Box 1.2** Globally (near-)threatened lowland forest bird species on Java and Bali

| | |
|---|---|
| white-winged duck | *Cairina scutulata**(E) |
| grey-headed fish-eagle | *Ichthyophaga ichthyaetus* (NT) |
| Javan hawk-eagle | *Spizaetus bartelsi* (E) |
| green peafowl | *Pavo muticus*** (V) |
| large green pigeon | *Treron capellei* (NT) |
| yellow-throated hanging-parrot | *Loriculus pusillus* (NT) |
| Javan frogmouth | *Batrachostomus javensis*(NT) |
| black-banded barbet | *Megalaima javensis* (NT) |
| straw-headed bulbul | *Pycnonotus zeylanicus**(V) |
| large wren-babbler | *Napothera macrodactyla* (NT) |
| white-breasted babbler | *Stachyris grammiceps* (V) |
| white-bellied fantail | *Rhipidura euryura* (NT) |
| Bali starling | *Leucopsar rothschildi* (C) |

C: Critical, E: Endangered, V: Vulnerable, NT: Near-Threatened
*Almost certainly extinct on Java (Green 1992; van Balen 1997); **Not a forest bird according to Wells (1985), but treated as such in this study.

Java and Bali share 13 resident land bird species that are currently listed as globally threatened or near-threatened (Collar *et al.* 1994; see Box 1.2). The three main causes of declining bird populations are:

(1) Habitat loss through land use conversion. With more than 115 million people on Java and 3 million on Bali in 1995 (Whitten *et al.* 1996), the pressure on the natural ecosystems of these partly (10-18%) mountainous islands is enormous. Deforestation started in the 16th century, but intensified in the 19th century under the colonial "Cultuurstelsel", and had decimated the existing forest by the beginning of this century (Smiet 1990).

(2) Hunting (for food, especially along Java's north coast, with air rifles rampant throughout the country), and excessive trapping for the, mainly local, pet trade.

(3) The use of pesticides: populations of brahminy kites *Haliastur indus*, egrets, and large-billed crow *Corvus macrorhynchos* have declined enormously since the 1960s, which may have been largely caused by excessive use of DDT and other pesticides (van Balen 1984; van Balen *et al.* 1993).

There is no evidence for secondary extinctions, but these are suggested by the decrease of the Asian koel *Eudynamys scolopacea*, a brood-parasite formerly common throughout Java, but now locally distributed, in concurrence with its host, the large-billed crow (van Balen 1984).

**Habitat fragmentation**

Due to a longer history of deforestation and habitat fragmentation, Java has lost species at a faster rate than Sumatra and Borneo, all having once shared the same Sunda shelf bird species pool. Consequently, Java has an extensive system of forest fragments of variable size designated as nature reserves. The discussion as to whether a set of small reserves may be sufficient to contain the same number of species as a large reserve, is the so-called Single Large Or Several Small (SLOSS) reserves debate (Boecklen 1997). The nestedness index, based on the common property of species distributions on real and habitat islands to be distributed in nested subsets, is a useful tool to test this. This implies that, if each bird population has its own requirements for area, then in a perfected nested community a species will occur in all fragments that are larger than the smallest in which it occurs. Unfortunately, most studies on habitat fragmentation and birds have been done in small fragments (<10 ha), that are dominated by edge effects; these small forest areas contain viable populations for none or few sensitive species, and they are rarely the focus for conservation programmes (Zuidema *et al.* 1996).

It is known that species tolerant to habitat fragmentation locate and colonize new habitat much faster than intolerant ones (Villard & Taylor 1994). It may therefore be wrong to consider only species numbers and not species composition when discussing species diversity in remnant areas (Saunders *et al.* 1991), as some communities could be composed of habitat tolerant ("weed") species with low "conservation value". Forest interior and forest edge species are known to exhibit differential responses to habitat modification (e.g., Warburton 1997), but few studies have been made to show a more differentiated classification of qualities that relate to the likelihood of survival in a fragmented landscape.

**Globally threatened species**

In the conservation biology literature a wide range of factors have been suggested to explain extinction proneness of certain bird species. Top predators, habitat specialists, and species near the limits of their range tend to be rare and especially vulnerable (Terborgh & Winter 1980). Particularly vulnerable are the falcons (Falconidae), pheasants (Phasianidae), woodpeckers (Picidae) and babblers (Timaliidae). Some of the more recently recognised categories are: migratory birds, as these face problems in re-locating forest patches (Tracy & George 1992); birds with exaggerated communication and/or sexual systems (Tanaka 1996); and species joining mixed foraging flocks (Jullien & Thiollay 1998).

Brooks *et al.* (1997) and McKinney (1998) use lists of globally threatened species to describe and predict extinction processes along with deforestation. It is, however, questionable whether these lists are exhaustive and how appropriate species numbers are for making predictions. More than half of the thirteen threatened species on Java and Bali are non-forest species. Moreover, excessive trapping, the use of pesticides, and loss of non-forest (mainly wetland) habitat are the main factors that have put their survival in jeopardy.

Box 1.2 shows the six globally threatened lowland forest species found on Java and Bali (Collar *et al.* 1994). Javan hawk-eagle *Spizaetus bartelsi*, green peafowl *Pavo muticus*, and white-breasted babbler *Stachyris grammiceps* are still relatively widespread, surviving in lowland forest throughout Java. The Bali starling *Leucopsar rothschildi* is restricted to a single patch on Bali, whereas the other two species, white-winged duck *Cairina scutulata* and straw-headed bulbul *Pycnonotus zeylanicus*, are considered extinct, with no confirmed records after World War II.

Seven other species are likely to decrease in numbers, for instance due to forest destruction, but do not (yet) meet the IUCN threat criteria (Collar *et al.* 1994). In anticipation of information from field surveys and monitoring these birds have been classified as near-threatened species (Collar *et al.* 1994; see Box 1.2).

**Research hypothesis and questions**

Two approaches exist in conservation biology (Caughley 1994):

1) The practice-lacking small-population paradigm, which endeavours "to determine the effect of smallness on the persistence of a population" and deals with " the risk of extinction inherent in a population". Here environmental stochasticity and catastrophes, demographic stochasticity and genetic deterioration are the factors that cause extinction.

2) The theory-lacking declining-population paradigm, which deals with "the cause of smallness and its cure" and with "processes by which populations become extinct". Here habitat destruction and fragmentation, overkill (and excessive trapping), impact of introduced species, and chains of extinction are the factors causing extinction.

Hedrick *et al.* (1996) warned against this artificial division as being over-simplistic and likely to polarise conservation biologists, with the result that different approaches are pitted against each other. They proposed the "inclusive population viability analysis", in which both ultimate deterministic causes (the declining population paradigm) and proximate stochastic causes (the small population paradigm) are considered. In this thesis both approaches are combined in:

1) the analyses of a number of lowland forest bird communities, in which it is hypothesised that the response of birds to habitat fragmentation, and resulting distribution across remaining forest patches is strongly determined by a species-specific tolerance to habitat disturbance; and 2) three case studies on globally threatened forest birds, namely Javan hawk-eagle, green peafowl, and Bali starling. These are not isolated cases, and from the conservation histories of these birds more can be learned about small populations dwindling towards extinction.

The questions which underlie this thesis and which need to be answered by studying forest fragmentation and bird extinctions (Heywood & Stuart 1992; Bierregaard *et al.* 1997; Corlett & Turner 1997), are:

(1) To what extent are large numbers of species already committed to extinction?

(2) Does species loss continue, or has a new equilibrium been reached?

(3) Which species are most vulnerable over the course of decades (or centuries)?

(4) What size should forest remnants be to preserve significant fractions of the original lowland avifauna, and for how long can they do so?

(5) What are the effects of conservation actions on extinction rates?

In this thesis the field studies on Javan and Balinese lowland forest birds which were carried out between 1979 and 1999 will be described, and the results interpreted and discussed. A chapter on the islands of Krakatau has been included.

**Outline of this thesis**

In Chapter 2 the re-colonisation history of birds along with vegetation succession on the vacant real islands of Krakatau is described and used to test the predictability of an equilibrium of extinction and colonisation.

Chapters 3 and 4 treat extinction processes in a number of Javan forest fragments: (a) one of Java's oldest forest reserves, the 80 ha botanical gardens of Bogor; and (b) 19 different lowland forest fragments all over Java, ranging in size from nine to over 50,000 hectares.

Chapters 5 through 10 describe case studies in which various aspects of the conservation biology of three threatened species on Java and Bali are treated:

(a) Bali starling: conservation measures (Chapter 5); status and distribution (Chapter 6);
(b) Javan green peafowl: status and distribution (Chapter 7);
(c) Javan hawk-eagle: distribution (Chapter 8), status (Chapter 9) and conservation biology (Chapter 10).

The final chapter gives an overall discussion in which the different strands that have been developed are woven into a synthesis. Conservation measures are also briefly discussed.

Chapter 2

# Colonisation of Rakata (Krakatau Islands) by non-migrant land birds from 1883 to 1992 and implications for the value of island equilibrium theory

I.W.B. Thornton, R.A. Zann & S. van Balen 1993
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**Abstract**
Colonisation curves and changes in immigration and extinction rates of non-migrant land birds since the 1883 eruption are provided for the recolonisation of Rakata (Krakatau Islands). including results of surveys made in 1990 and 1992. The contention by Bush & Whittaker (1991) that non-monotonic changes in observed immigration and extinction rates of birds and butterflies cast doubt on the ability of the equilibrium theory of island biogeography (MacArthur & Wilson 1967) to provide the basis for a predictive recolonisation model is examined in the light of our recent data. We conclude that rates of immigration and extinction are highly sensitive to decisions as to immigration status of species, particularly where intersurvey intervals are short and turnover numbers are low. We note that for no group of organisms on the island is there an equilibrium in number of species, most of the observed turnover having been successional. Contrary to Bush & Whittaker (1991), the number of non-migrant land bird species has not declined since 1951 and numbers are still rising, albeit more slowly than in the early decades of this century. The colonisation curve is flattening, and immigration rate is failing towards extinction rate, in general although not precise accord with the model. On comparing the colonisation dynamics of birds with those of plants and butterflies and mindful of the qualifications MacArthur & Wilson (1967) placed on the applicability of their models to cases where succession is important in the early stages of colonisation, we conclude that it is premature to discard their dynamic approach as a theoretical framework for the study of animal colonisation of the Krakataus.

## INTRODUCTION

One conclusion of a recent paper by Bush & Whittaker (1991) on the colonisation of the Krakatau islands since the 1883 eruption was that chances in observed immigration and extinction rates on the island of Rakata (Krakatau's remnant) are non-monotonic and that this casts doubt on the ability of equilibrium theory (MacArthur &

Wilson 1967) to provide the basis for a predictive recolonisation model. Their conclusions were partly based on the data set for resident land birds (excluding owls), including a 1989 survey by Haag & Bush (1990) but excluding data from our surveys in 1984 and 1985 (Thornton *et al.*, 1990b; Zann *et al.* 1990a,b). In a recent short note Bush & Whittaker (1991) observed that the census data provided by Zann *et al.* (1990b) support the non-monotonicity of the rate curves, and thus their argument that the pattern is "therefore contra to MacArthur & Wilson's (1967) model of island colonisation". We have since made surveys in 1990 and 1992 and in this paper we consider the effect of our 1984, 1985, 1990 and 1992 data on Bush & Whittaker's conclusions, specifically concerning the colonisation dynamics of birds and, more generally, concerning the value of the dynamic island biogeographical approach to studies of the colonisation of the Krakataus.

In September 1984 R.A. Zann, A.S. Adikerana, M.V. Walker and G.W. Davison (the last three being ornithologists with considerable experience in the region), and again in August 1985 (Zann), surveyed birds on Rakata at three sites in coastal forest (73 man-hours visual, 28 man-hours spotlighting, 3446 $m^2$ x rain-free hours mist-netting, 2 hours sound recording), at eight sites in *Neonauclea* forest (79, 112, 2584 and 0.3 respectively), at five sites in *Neonauclea-Ficus* moss forest (23 man-hours visual) and at one site in *Schefflera-Leucosyke* summit scrub (10 man-hours visual) (Zann *et al.* 1990b). The 1986 survey did not include Rakata. Further ornithological surveys of the island were made in August-September 1990 by Zann and van Balen (another ornithologist with considerable previous experience in the region), and in July 1992 by van Balen. Rakata was surveyed on 31 August, 1 September and 2 September 1990 and on 6 July 1992. In 1990 observations began at 05h00 each day and totalled over 50 man-hours of visual survey and sound recording; in 1992 there were 10 man-hours of sound and visual survey and 3824 $m^2$ x rain-free hours of mist-netting.

## THE DATA SET

Like Bush & Whittaker (1991), in previous papers on bird colonisation of the Krakataus our group has confined its attention to non-migrant land birds (excluding shore birds). We list and number these species (Tables 2.1 and 2.2) in the same order as in Table 2 of Thornton *et al.* (1990b). Species are counted as absent if they were not recorded from two successive surveys of suitable habitat. A species is therefore assessed as having been present, although not recorded in a survey (indicated by an asterisk in the tables), if it was recorded in the immediately preceding and subsequent surveys, unless there are good reasons, such as conspicuousness by sight or sound of the species concerned, to decide otherwise. The assessment is thus made on the basis of minimum turnover and is more conservative than the unassessed records.

The data from our 1990 and 1992 surveys necessitate modification of our previous species list (Thornton *et al.* 1990b), and the incorporation of these data and those

**Table 2.1.** Resident land birds recorded on the Krakataus in the 1980s and their frequency on individual islands in our surveys of August 1990 and July 1992.
Species listed and numbered in same order as Table 2 of Thornton *et al.* (1990b). Rakata, Sertung, Panjang and Anak Krakatau denoted by initial letters. Rakata in bold where presence not in doubt.

| Species | 1983 | 1984 | 1985 | 1989 | 1990 | | | | 1992 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R | S | P | A | R | S | P | A |
| 4. *Corvus macrorhynchos* | (R)A | A | - | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5. *Centropus bengalensis*[1] | + | SA | A | A | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 |
| 6. *Treron vernans*[2] | * | RS | RSP | RS | 3 | 3 | 0 | 0 | 3 | 0 | 2 | 0 |
| 7. *Caprimulgus affinis* | - | A | (R)(S)<br>(P)A | A | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 3 |
| 8. *Chalcophaps indica* | * | RSP | RSP | *S | *0 | 4 | 4 | 0 | 1 | 2 | 0 | 0 |
| 9. *Aerodramus fuciphagus* | * | RSPA | *PA | * | 3 | 4 | 3 | 3 | *0 | 2 | 3 | 3 |
| 10. *Halcyon chloris* | RSA | RSPA | RSPA | RSPA | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 11. *Pycnonotus goiavier* | *A | RSPA | RSPA | RSPA | 5 | 5 | 5 | 5 | 4 | 5 | 4 | 4 |
| 12. *Oriolus chinensis* | *A | RSPA | RSPA | RSA | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 3 |
| 13. *Artamus leucorhynchus* | * | RSPA | RSPA | RSPA | 3 | 5 | 3 | 4 | 3 | 4 | 3 | 4 |
| 17. *Eudynamys scolopacea* | * | * | * | * | 3 | 3 | 2 | 0 | *0 | 0 | 3 | 1 |
| 18. *Ducula bicolor* | RS | RS | RSP | R | 0 | 4 | ?1 | 0 | 0 | 4 | 3 | 0 |
| 19. *Hirundo tahitica* | * | RSA | RA | *SP | 3 | 3 | 0 | 2 | *0 | 2 | 0 | 1 |
| 20. *Amaurornis phoenicurus* | - | A | A | S | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 2 |
| 21. *Haliastur indus* | - | (R) | - | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22. *Haliaetus leucogaster* | RSP | RSP | RSA | RSPA | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| 23. *Dendrocopus moluccensis* | * | S | SP | RSP | *0 | 4 | 3 | 0 | 3 | 1 | 3 | 0 |
| 24. *Lalage nigra* | * | * | RP | *A | 1 | 3 | 0 | 2 | 3 | 2 | 0 | 3 |
| 25. *Copsychus saularis* | RS | RSPA | *SPA | RSPA | 3 | 4 | 4 | 5 | 4 | 4 | 4 | 4 |
| 26. *Pachycephala grisola* | * | RSPA | RSPA | RSPA | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 5 |
| 27. *Aplonis panayensis* | R | RPA | RSP | RSA | 4 | 5 | 4 | 0 | 3 | 4 | 4 | 0 |
| 28. *Anthreptes malacensis* | R | RSPA | *SP | RSP | 4 | 5 | 4 | 5 | 4 | 4 | 3 | 3 |
| 29. *Nectarinia jugularis* | * | RSPA | *SPA | RSPA | *0 | 3 | 3 | 5 | *0 | 3 | 0 | 5 |
| 30. *Dicaeum trigonostigma* | * | R | R | - | 4 | ? | 3 | 0 | 4 | 0 | 3 | 0 |
| 31. *Macroypygia emiliana* | RS | RS | RSPA | RS | 4 | 4 | 4 | 1 | 4 | 0 | 3 | 0 |
| 32. *Collocalia esculenta* | * | | RP | SA | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 33. *Gerygone sulphurea* | * | RSPA | *SPA | RSPA | *0 | 3 | 4 | 5 | 3 | 3 | 3 | 4 |
| 34. *Cyornis rufigastra* | RS | RSPA | RSPA | RSPA | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 4 |
| 35. *Spilornis cheela* | - | - | ?R | - | ?3 | 2 | ?1 | 0 | 0 | 0 | 0 | 0 |
| 37. *Ptilinopus melanospila* | - | R | RP | *S | 5 | 4 | 1 | 4 | 4 | 4 | 4 | 1 |
| 38. *Aethopyga siparaja** | R | RP | RP | * | 3 | ? | 3 | 0 | 3 | 0 | 0 | 0 |
| 39. *Pycnonotus plumosus* | * | RS | - | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40. *Falco severus* | - | - | - | A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41. *Ictinaetus malayensis* | R | RP | RSP | R | ? | 0 | 2 | 1 | 0 | 0 | 0 | 0 |
| 42, *Ducula aena* | RSP | RP | *P | RSP | 3 | 4 | 4 | 0 | 4 | 2 | 3 | 0 |
| 43. *Tyto alba* | (R)*** | A | SA | - | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 |
| 44. *Apus affinis* | * | RSPA | RSA | RPA | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 3 |
| 45. *Zoothera interpres* | * | R | *(A)[2] | | 3 | 0 | 0 | 0 | *0 | 3 | 0 | 0 |
| 46. *Corvus splendens* | - | - | *(A)[2] | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 47. *Spizaetus cirrhatus* | - | - | - | (A) | 3 | 2 | 1 | 0 | 2 | 0 | 2 | 0 |
| 48. *Pernis ptilorhyncus* | - | - | - | (R) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| **Table 2.1.** Continued | 1983 | 1984 | 1985 | 1989 | 1990 | | | | 1992 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R | S | P | A | R | S | P | A |
| 49. *Falco peregrinus* | - | - | - | - | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 |
| 50. *Zosterops palpebrosus**** | - | - | - | - | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 51. *Pericrocotus cinnamomeus* | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 52. *Lonchura leucogastroides* | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 53. *Lonchura punctulata* | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 54. *Treron griseicauda* | - | - | - | - | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

*Assumed present on Rakata; **previously recorded as *Aethopyga mystacalis;* *** in 1982; ( ) single observation, presumed straggler not accepted as resident on assessment; ? record questionable, requires confirmation, not accepted on assessment; 1976 record on Anak Krakatau (B. King pers. comm.); + assumed present on archipelago; [1] recorded on Panjang in 1982 by Ibkar-Kramadibrata *et al.* (1986); [2]present on Anak Krakatau in 1986. 1990 and 1992 frequencies: 0 absent, 1 rare (1 observation), 2 occasional, 3 frequent, 4 common, 5 very common. 1983 records from Bush & Newsome (1986) and Bush *in litt;* 1984 and 1985 records from Thornton *et al.* (1990a), Zann *et al.* (1990a, b) 1989 records from Haag & Bush (1990).

*Note:*

50-53 are new records not involving Rakata, as follows.

50. Oriental whiteye *Zosterops palpebrosus.* One individual was seen on Anak Krakatau by T. Lund, a Danish birdwatcher, on 29 August 1990. Not counted as resident.
51. Small minivet *Pericrocotus cinnamomeus.* A single female was seen and heard by van Balen in July 1992 on the Sertung spit. This is a rather common species on Java and also is a resident of Panaitan Island. Not counted as resident.
52. Javan white-bellied munia *Lonchura leucogastroides.* One individual was mist-netted in July 1992 on the E Foreland of Anak Krakatau. Not counted as resident.
53. Scaly-breasted munia *Lonchura punctulata.* A small flock was heard by van Balen several times on the E. Foreland of Anak Krakatau in July 1992, and identified from the unmistakable 'tepee' or 'kidee' call. This is the only munia resident on Sebesi Island. Not counted as resident on the Krakataus.

of our 1984 and 1985 surveys requires changes to the list provided by Bush & Whittaker (1991). These changes are detailed below.

**Species recorded as present on Rakata prior to the 1980s that were not so listed by Bush & Whittaker (1991)**

**Crested goshawk** *Accipiter trivirgatus* (15 in Table 2.2). Hoogerwerf (1953b) believed this was probably misidentified by Dammerman's group (Chasen 1937; Dammerman 1948) as the smaller sparrowhawk *Accipiter virgatus.* The sparrowhawk was regarded by Dammerman (1948) and Hoogerwerf (1948, 1953) as comprising two subspecies: *virgatus,* resident on Java, and *gularis,* which is migratory and breeds in NE Asia. King *et al.* (1975) and MacKinnon (1988) recognised these as separate species, the resident besra *A. virgatus* and the Japanese sparrowhawk *A. gularis.* Chasen (1937) and Dammerman (1948) recorded a species of *Accipiter,* which they regarded as probably being the migratory *gularis,* from Rakata in 1919 (and also from Sertung in 1933). Hoogerwerf (1953) noted that the species recorded by Chasen and Dammerman was seen hovering, and flying in circles and believed this behaviour

**Table 2.2**. Resident land birds of the Krakataus, 1883-1992.
For symbols see Table 2.1. Data from Thornton *et al.* (1990b) and Table 2.1. 1983-1992 column pools all the data of Table 2.1. The two preceding columns (in square brackets) show these data as two subsets reflecting the two main periods of sampling.

| | 1908 | 1919-1921 | 1932-1934 | 1951-1952 | [1983-1985 | 1989-1992] | 1983-1992 |
|---|---|---|---|---|---|---|---|
| 1. *Alcedo coerulescens* | R | - | - | - | [- | - | - |
| 2. *Pycnonotus aurigaster* | R | - | - | - | [- | - | - |
| 3. *Lanius schach* | R | RS | - | - | [- | - | - |
| 4. *Corvus macrorhynchos* | RP | RS | RSP | S | [(R)A | - | (R)A |
| 5. *Centropus bengalensis* | R | RS | RS | R | [SP[1]A | A | SPA |
| 6. *Treron vernans* | R | RS | RSP | *S | [RSP | RSP] | RSP |
| 7. *Caprimulgus affinis* | R | RS | RS | A | [(R)(S)(P)A | A] | (R)(S)(P)A |
| 8. *Chalcophaps indicus* | R | RS | RS | R | [RSP | RSP] | RSP |
| 9. *Aerodramus fuciphagus* | RP | RS | RS | R | [RSPA | RSPA] | RSPA |
| 10. *Halcyon chloris* | R | RS | RSP | R | [RSPA | RSPA] | RSPA |
| 11. *Pycnonotus goiavier* | R | RS | RSP | RA | [RSPA | RSPA] | RSPA |
| 12. *Oriolus chinensis* | RSP | RS | RSP | R | [RSPA | RSPA] | RSPA |
| 13. *Artamus leucorhynchus* | RP | RS | RS | R | [RSPA | RSPA] | RSPA |
| 14. *Centropus sinensis* | + | S | - | - | [- | - | - |
| 15. *Accipiter trivirgatus* | * | R | RS | S | [- | - | - |
| 16. *Geopelia striata* | * | R | + | S | [- | - | - |
| 17. *Eudynamys scolopacea* | - | RS | RSP | R | [* | RSPA] | RSPA |
| 18. *Ducula bicolor* | | - | RS | RS | [RSP | RSP] | RSP |
| 19. *Hirundo tahitica* | - | RS | RS | | [RSA | RSPA] | RSPA |
| 20. *Amaurornis phoenicurus* | - | RS | RSP | RS | [A | SA] | SA |
| 21. *Haliastur indus* | - | RS | RS | S | [(R) | -] | (R) |
| 22. *Haliaeetus leucogaster* | - | RS | RSP | RSA | [RSPA | RSPA] | RSPA |
| 23. *Dendrocopus moluccensis* | - | R | RS | R | [*SP | RSP] | RSP |
| 24. *Lalage nigra* | - | RS | RS | R | [RP | RSA] | RSPA |
| 25. *Copsychus saularis* | - | RS | RS | R | [RSPA | RSPA] | RSPA |
| 26. *Pachycephala grisola* | - | RS | RS | R | [RSPA | RSPA] | RSPA |
| 27. *Aplonis panayensis* | - | RS | RSP | R | [RSPA | RSPA] | RSPA |
| 28. *Anthreptes malacensis* | - | RS | RS | R | [RSPA | RSPA] | RSPA |
| 29. *Nectarinia jugularis* | - | RS | RSP | R | [RSPA | RSPA] | RSPA |
| 30. *Dicaeum trigonostigma* | - | RS | RS | R | [R | R?SP] | R?SP |
| 31. *Macropygia emiliana* | - | - | S | R | [RSPA | RSPA | RSPA |
| 32. *Collocalia esculenta* | - | - | R | R | [RP | *SA] | RSPA |
| 33. *Gerygone sulphurea* | - | - | RSP | R | [RSPA | RSPA] | RSPA |
| 34. *Cyornis rufigastra* | - | - | RSP | R | [RSPA | RSPA] | RSPA |
| 35. *Spilornis cheela* | - | - | - | R | [?R | "RS?P] | ?RS?P |
| 36. *Rhaphidura leucopygialis* | - | - | - | R | - | - | - |
| 37. *Ptilinopus melanospila* | - | - | - | R | [RP | RSPA] | RSPA |
| 38. *Aethopyga siparaja*** | - | - | - | RS | [RP | R?SP] | R?SP |
| 39. *Pycnonotus plumosus* | - | - | - | RS | [RS | | RS |
| 40. *Falco severus* | - | - | - | S | [- | A] | A |
| 41. *Ictinaetus malayensis* | - | - | - | - | [RSP | RP(A)] | RSP(A) |
| 42. *Ducula aena* | - | - | - | - | [RSP | RSP] | RSP |

**Table 2.2** Continued

| | 1908 | 1919-1921 | 1932-1934 | 1951-1952 | [1983-1985 | 1989-1992] | 1983-1992 |
|---|---|---|---|---|---|---|---|
| 43. *Tyto alba* | - | - | - | - | [SA | A] | SA |
| 44. *Apus affinis* | - | - | - | - | [RSPA | RPA] | RSPA |
| 45. *Zoothera interpres* | - | - | - | - | [R(A)[2] | RS] | RS(A)[2] |
| 46. *Corvus splendens* | - | - | - | - | [(A)[2] | -] | (A)[2] |
| 47. *Spizaetus cirrhatus* | - | - | - | - | [- | RSP(A)] | RSP(A) |
| 48. *Pernis ptilorhyncus* | - | - | - | - | [- | (R)] | (R) |
| 49. *Falco peregrinus* | - | - | - | - | [- | (R)A] | (R)A |
| 50. *Zosterops palpebrosus* | - | - | - | - | [- | (A)] | (A) |
| 51. *Pericrocrotus cinnamomeus* | - | - | - | - | [- | (S)] | (S) |
| 52. *Lonchura leucogastroides* | - | - | - | - | [- | (A)] | (A) |
| 53. *Lonchura punctulata* | - | - | - | - | [- | (A)] | (A) |
| 54. *Treron griseicauda* | - | - | - | - | [- | (R)] | (R) |

to indicate a misidentification of the larger, resident, crested goshawk *A. trivirgatus*. Hoogerwerf was aware of the differences between these species for in the same paper he recorded a small *Accipiter* from Sertung that he stated was probably the besra. Although there is doubt about the identity of the sightings by Chasen and Dammerman we have opted to accept Hoogerwerf's view and list the goshawk *A. trivirgatus* rather than the Japanese sparrowhawk *A. gularis* as present on Rakata in 1919, on Rakata and Sertung, in 1933 (Dammerman 1948) and on Sertung in 1951 (Hoogerwerf 1953). The species has not been recorded since 1951.

**Asian Koel** *Eudynamys scolopacea* (17 in Tables 2.1 and 2.2). This species was fairly numerous on Rakata and Sertung in 1919, less so in 1933, and was recorded on Rakata in 1951 by Hoogerwerf (1953b), who stated "we possibly heard the species once (on 6 October)", but nevertheless listed the species as present (see also below).

**Brahminy kite** *Haliastur indus* (21). The species was recorded as present on Rakata in 1919 (perhaps one individual) and 1933 (and on Sertung in 1920, 1932 and 1951) (Bartels 1920; Dammerman 1922, 1929, 1948; Chasen 1937; Hoogerwerf 1953b). See also below.

**Serpent eagle** *Spilornis cheela* (35). This eagle was beard frequently and seen on Rakata in 1951 by Hoogerwerf (1953b). See also below.

**Species recorded on Rakata in the 1980s, 1990 or 1992 that were not recorded as present on the island by Bush & Whittaker for the period 1983-1989**

**Large-billed crow** *Corvus macrorhynchos* (4). See also below.

**Pink-necked pigeon** *Treron vernans* (6). Previously fairly common on Rakata, but not found by Hoogerwerf in 1951 (it was present on Sertung in 1952), this pigeon was recorded on Rakata in 1984, 1985, 1989 and 1990 (Thornton *et al.* 1990b; Zann *et al.* 1990b; Haag & Bush 1990; and our 1990 survey). In our 1992 survey it was very vocal and assessed as frequent (Table 2.1). It is counted as present on Rakata. (The species was found on Anak Krakatau during our 1986 expedition).

**Savanna nightjar** *Caprimulgus affinis* (7). Heard on the island (Zwarte Hoek) in 1985 (Zann *et al.* 1990b). See also below.

**Emerald dove** *Chalcophaps indica* (8). Formerly very common on Rakata, and previously recorded as breeding there (Dammerman 1948), several individuals (of both sexes) were netted on the island in 1984 and 1985 (Zann *et al.* 1990b) and one in 1992. Although it was not recorded on Rakata in 1989 or 1990, our 1990 survey did not include mist-netting, in the *Barringtonia* formation, the method of discovery of this secretive bird in 1984, 1985 and 1992. It is counted as present on Rakata.

**Edible-nest swiftlet** *Aerodramus fuciphagus* (9). This species was seen on Rakata in 1984 (Zann *et al.* 1990b) and was assessed as frequent there in 1990 (Table 2.1).

**Asian Koel** *Eudynamys scolopacea* (17). Recorded on Rakata in our 1990 survey and assessed as being frequent on the island, we believe the koel is likely to have been present since 1951 but missed in the 1980s surveys (see above). It was discovered on Anak Krakatau in 1992. The koel's calls are "not heard for months on end" and it is "rarely seen" (Hoogerwerf 1953b) so that, for this bird in particular, absence of evidence is not necessarily evidence of absence.

**Brahminy kite** *Haliastur indus* (21). This species was seen only once in the surveys of the last decade (in 1984), soaring over Rakata's Zwarte Hoek (Zann *et al.* 1990b). We previously believed the species may have been missed in 1985 (Thornton *et al.* 1990b), but it has not been recorded in any subsequent survey (Table 2.1) and its status on the island must be regarded as doubtful. We have not counted it on assessment (see also below).

**Pied triller** *Lalage nigra* (24). Both sexes were twice seen on Rakata in 1985 (Zann *et al.* 1990b) and the species was again seen there in 1990 and 1992. It is counted as present on Rakata.

**White-bellied swiftlet** *Collocalia esculenta* (32). Although we recorded this species on Rakata (and Panjang) in 1985, we found it only on Anak Krakatau in 1990 and did not record it in 1992 (Table 2.1). Bush & Whittaker (1991) recorded it as present on Sertung and Anak Krakatau in 1989. We assess it as absent now from Rakata.

**Crested serpent-eagle** *Spilornis cheela* (35). First recorded, on Rakata, by Hoogerwerf in 1951, the serpent eagle was possibly seen on Rakata in 1985 and may have been heard there and on Panjang in 1990 (but was definitely heard on Sertung in 1990). On a conservative assessment we discovered its presence on Rakata, but it is possible that it has persisted since 1951 (see above).

**Black-naped fruit-dove** *Ptilinopus melanospila* (37). First discovered, feeding on figs on Rakata, in 1951 by Hoogerwerf (1953b). Netted on Rakata in 1984 and seen in 1985 (Zann *et al.* 1990b), the fruit dove was again recorded there (as very common) in 1990 and (as common) in 1992.

**Olive-winged bulbul**, *Pycnonotus plumosus* (39). Seen in coastal vegetation on the island in 1984 by G.H.W. Davison (Zann *et al.* 1990b) this bulbul was then assessed as present but rare (Thornton *et al.* 1990b). The species has not been recorded since, however, and is now assessed as absent from Rakata.

**Oriental hobby** *Falco severus* (40). In November 1952 Hoogerwerf (1953b) saw one individual on Sertung in *Casuarina* heavily damaged by Anak Krakatau's October eruption. One individual was seen around Rakata's summit in 1982 (Alain Compost pers. comm.) but the species has been seen since only on Anak Krakatau (on our 1986 expedition and in 1989 by Haag & Bush). It is now counted as a straggler on Rakata in 1982, and is assessed as not being resident on the island.

**Barn owl** *Tyto alba* (43). See also below.

**Chestnut-capped thrush** *Zoothera interpres* (45). An individual of this furtive species was netted on Rakata in 1984 and one was seen on Anak Krakatau during our 1986 expedition (Zann *et al.* 1990b). The species was heard on Rakata several times in 1990 and classed as frequent. (S. Cook netted four birds on Sertung in 1992).

**Changeable hawk-eagle** *Spizaetus cirrhatus* (47). This species was seen once on Anak Krakatau in 1989 by Haag & Bush (1990), who believed the individual may not have been resident. We saw the hawk-eagle on Sertung and heard it on Panjang and Rakata in 1990. We both saw and heard it on Panjang and Rakata in 1992, and large inactive nests in tall trees, built on the lowest branches, near the trunk, were seen on both islands. The species is known to build more than one nest however, using only one for breeding, so that these may have been nests of a single pair. A recent immigrant to the archipelago, the species is counted as present on Rakata.

**Peregrine falcon** *Falco peregrinus* (49). One individual was seen on 6 July 1992 flying out over coastal vegetation at Owl Bay, Rakata. towards Panjang. Peregrines have otherwise only been recorded from Anak Krakatau. It is, however, likely that their home range includes all four islands, their 'core area' being on Anak Krakatau. In 1990 one was seen and followed with a theodolite telescope, flying from Anak Krakatau over the sea towards Sertung. In the absence of further evidence we do not count the peregrine as resident on Rakata.

**Grey-cheeked green pigeon** *Treron griseicauda* (54). One male, seen on 6 July 1992 on Rakata by van Balen was probably of this species which occurs in Java and southern Sumatra, but may have been *Treron curvirostra;* it is difficult to distinguish between these species in the field. We do not count this single record on assessment; the status of the species may be clarified by future surveys.

**Species listed as present on Rakata 1983-1989 by Bush & Whittaker but not recorded by our group**

**Oriental honey-buzzard** *Pernis ptilorhycus* (48). This species was recorded on Rakata in August 1989 by Haag & Bush (1990), who regarded the individual as possibly being a migrant. MacKinnon (1988) states that the resident form is confined to western Java and a short-crested race visits Java in the winter; this sighting may thus have been of the resident form. For the present we assess the honey buzzard as being absent from Rakata.

**Species assessed as present on Rakata 1984-86 by Thornton *et al.* (1990b), now believed to have been absent or adventive.**

**Large-billed crow** *Corvus macrorhynchos* (4). Hoogerwerf (1953b) failed to find the species on Rakata during 9 days in 1951, but saw several on Sertung. The species was seen on Rakata in 1983, however, by Bush & Newsome (1986) but not on that island since. We earlier regarded the crow as probably having become extinct on the archipelago between 1984 and 1985 (Thomton *et al.* 1990b; Zann *et al.* 1990a,b). It was not recorded in the surveys of 1985, 1986 (which chiefly concerned Anak Krakatau), 1989, 1990 or 1992. We now count this crow as an extinction.

**Savanna nightjar** *Caprimulgtis affinis* (7). The Rakata record of this species since 1932-1934 is of the call of a single individual in the beach area of Zwarte Hoek in 1985. A single individual was also heard in 1985 on each of Panjang. (Bat Cave Beach) and the Sertung spit. Although regularly recorded from Rakata and Sertung from 1908 to 1933, the species was not found on the three older Krakatau islands in the 1951, 1983, 1984, 1989, 1990 or 1992 surveys. Hoogerwerf heard the nightjar in August 1952 along Anak Krakatau's beach, and it was present on that island throughout the 1980s and early 1990s. Until there is confirmation of the species' continued presence on Rakata we regard the individual heard at Zwarte Hoek as having been a stray from Anak Krakatau.

**Brahminy kite** *Haliastur indus* (21). The single individual seen in 1984 is now thought to have been adventive; there have been no other records from Rakata since 1933.

**Silver-rumped swift** *Rhaphidura leucopygialis* (36, Table 2.2). Earlier assessed as having been present on the island but missed in our 1984 and 1985 surveys, the species was not recorded in any of the subsequent surveys and we now believe it to have been absent in the 1980s also.

**Oriental hobby** *Falco severus* (40). The single individual seen in 1982 by A. Compost constitutes the only record from Rakata and the individual is now thought to have been adventive, possibly from Anak Krakatau. We believe it has now been replaced on the archipelago by the peregrine falcon.

**Barn owl** *Tyto alba* (43). We do not exclude owls from our data. They may be seen at night, when they are also vocal, their roosts and nest sites are often indicated by droppings, and they produce characteristic pellets. The barn owl was first seen at Owl Bay, Rakata, in 1982 by Thornton (Zann *et al.* 1990b) and in that year was recorded from Anak Krakatau by Ibkar-Kramadibrata *et al.* (1986), whose survey did not include Rakata. It has now been shown to be breeding on Anak Krakatau (Rawlinson *et al.* 1992). The species was not recorded on Rakata in 1989 by Haag & Bush, nor in our 1990 or 1992 surveys when no night work was done on Rakata. Owl Bay, however, has been a frequent campsite of a number of expeditions since 1982, and no further indication of the owl's presence has been noted. We thus do not count the owl as resident on Rakata.

## COMMENTS

Bush & Whittaker (1991 p. 346) stated, “by 1951 seven of the original thirteen resident land bird species had become extinct”. From our reading of their Table 2 this should have read “six of the original thirteen”. They then noted that three of these were observed to have had declining populations in 1951, and two of the three were not recorded on Rakata between 1951 and 1983. There was no bird survey between 1951 and 1983, but one of the three, *Centropus bengalensis,* has not been recorded on Rakata in the 1983-1992 surveys. They continued “the four remaining species from the 1908 avifauna all exhibit coastal distributions”. It is not clear whether this statement refers to the four still remaining on Rakata in 1983-1989 according to their Table 2 (our data show seven species still on Rakata), or to the four that are left after the three with declining populations have been considered. Either way the following species would be included, which do not have coastal distributions: *Halcyon chloris,* seen and netted in *Neonauclea* forest, where it was common up to 250 m, as well as in *Barringtonia/Terminalia* habitat, and *Pycnonotus goiavier,* recorded in all habitats except the beach, including *Neonauclea-Ficus* forest above 400 m and the *Schefflera* scrub on Rakata's summit at about 770 m. *Oriolus chinensis,* which would be included if the first of the alternatives above is correct, was recorded in *Barringtonia*

*/Terminalia* habitat, *Neonauclea* forest below 400 m, and in *Neonauclea-Ficus* forest up to 640 m.

On page 348 Bush & Whittaker (1991) stated, “other than [extinctions of 1908 species] only three species have gone extinct on Rakata since 1951 (Table 2)”. According to their Table 2, this should read “five species”. They continued, “of the nine bird species recorded since 1934 on Rakata but not found on that island in the 1980s, one was documented from Sertung, and a further five species from Anak Krakatau”. Inspection of their Table 2 shows that the number of species quoted should read eight, one, and three, respectively. Using our data, the figures become four, three, and two respectively.

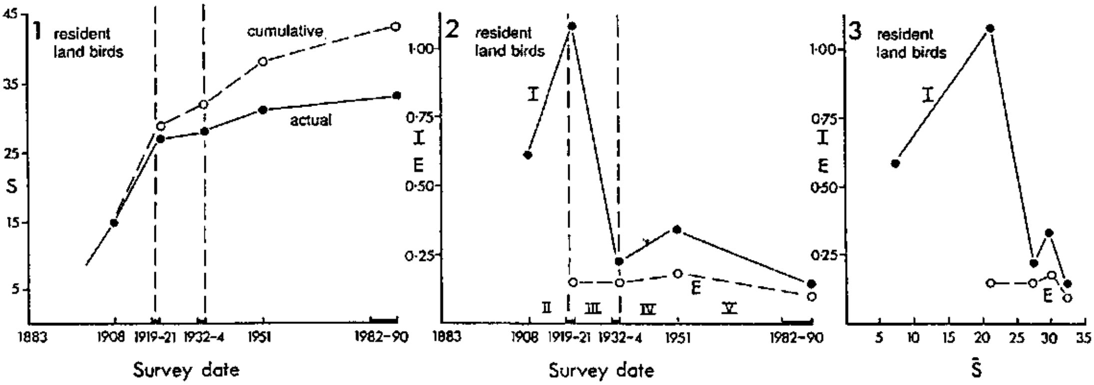
## RESULTS

Thornton *et al.* (1990a) provided a colonisation curve and tables of immigration and extinction rites for Rakata, based on work up to 1986, showing values based on records alone and on an assessment of these. In Table 2.3 and Figure 2.1 we bring our 1986 data for Rakata up to date in the light of the 1989, 1990 and 1992 surveys (see above), grouping the 1983-1992 survey data. In Figure 2.2 we plot the Rakata immigration and extinction rates, (based on minimum turnover) against survey dates for comparison with Bush & Whittaker's Figure 7, and in Figure 2.3 these rates are plotted against average number of species present in the intersurvey intervals.
Species numbers, rather than having fallen by 20% since 1951 (Bush & Whittaker 1991, Table 2, Figure 8), have risen by between 7% and 44%, depending on whether all records are accepted at face value (from twenty-seven to thirty eight species, 44%), or subjected to assessment and the principle of minimum turnover applied (from twenty-nine to thirty-one species, 7%) (our Table 2.2). The colonisation curve (Figure 2.1) does not fall, as depleted by Bush & Whittaker, rather the rate of increase of species numbers has declined markedly since the early 1920s (the time of forest formation) and the curve has flattened considerably.

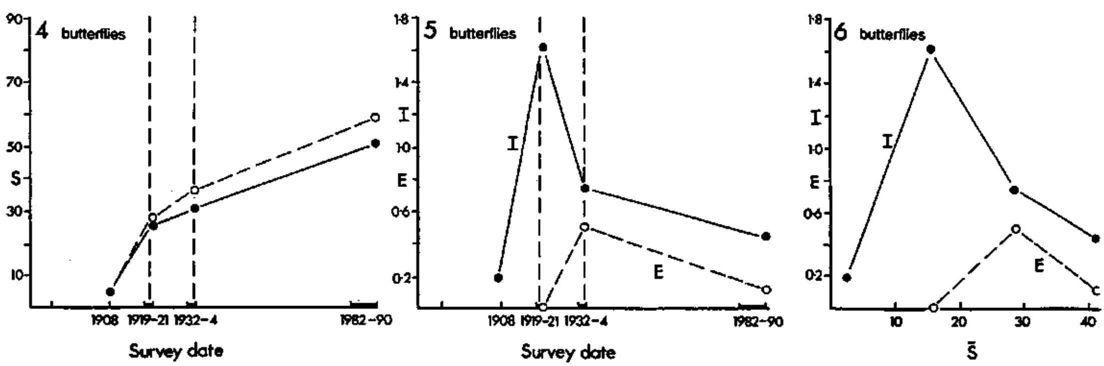
**Table 2.3.** Resident land bird species of Rakata, 1908-1992, based on assessment of records on the basis of minimum turnover. Data from Table 2.2.

| Intersurvey period | I | | II | | III | | IV | | V | |
|---|---|---|---|---|---|---|---|---|---|---|
| Survey dates | | 1908 | | 1919-21 | | 1932-34 | | 1951 | | 1983-93 |
| Intersurvey interval (years) | 25 | | 13 | | 13 | | 17 | | 41 | |
| Actual number of species | | 15 | | 27 | | 28 | | 29 | | 31 |
| Cumulative number of species | | 15 | | 29 | | 32 | | 38 | | 43 |
| Gains | 15 | | 14 | | 3 | | 6 | | 6* | |
| Losses - | - | | 2 | | 2 | | 5 | | 4 | |
| I (immigration rate) | 0.60 | | 1.08 | | 0.23 | | 0.35 | | 0.15 | |
| E (extinction rate) † | - | | 0.15 | | 0.15 | | 0.29 | | 0.10 | |

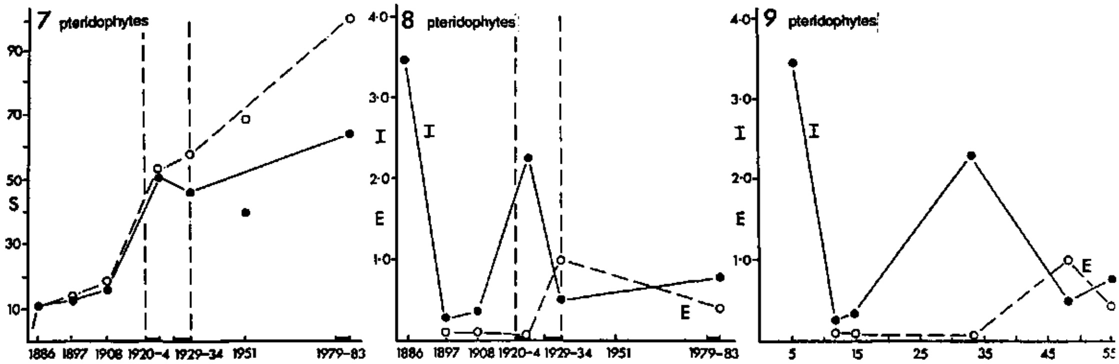
*One immigrant, *Ducula bicolor*, is a well-known 'in-and-out' species that colonies for short periods opportunistically (Hoogerwerf 1953b). †In species per year.



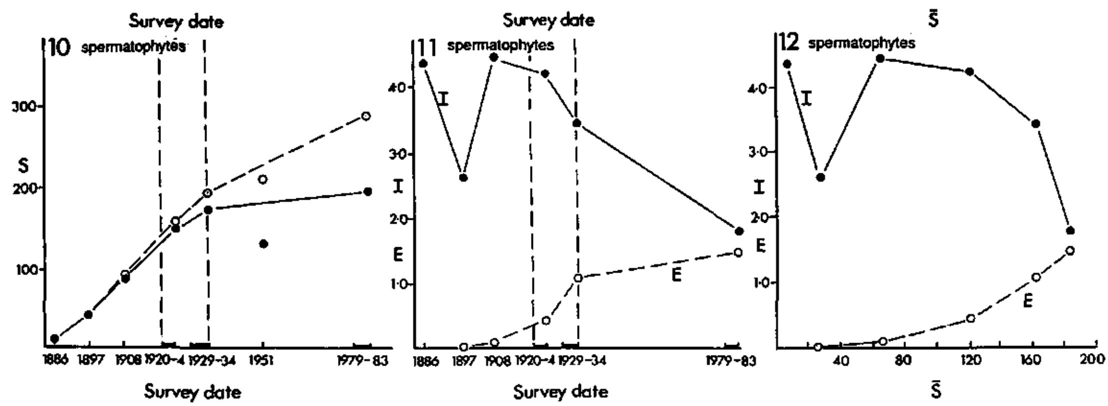

**Figures 2.1 – 2.3**. Resident land birds, Rakata, 1908-1992
Figure 2.1, species (S) accumulation colonisation curves; Fig. 2.2, change with time of immigration (I) and extinction (E) rates, as species per year for intersurvey periods II-V; Figure 2.3, change of I and E with average number of species (S) in intersurvey intervals. Vertical dashed lines represent period of forest formation; dark horizontal bars indicate closely successful surveys that are integrated; open circles in Figure 1 indicate cumulative, closed circles actual, number of species. Data from Table 2.3.



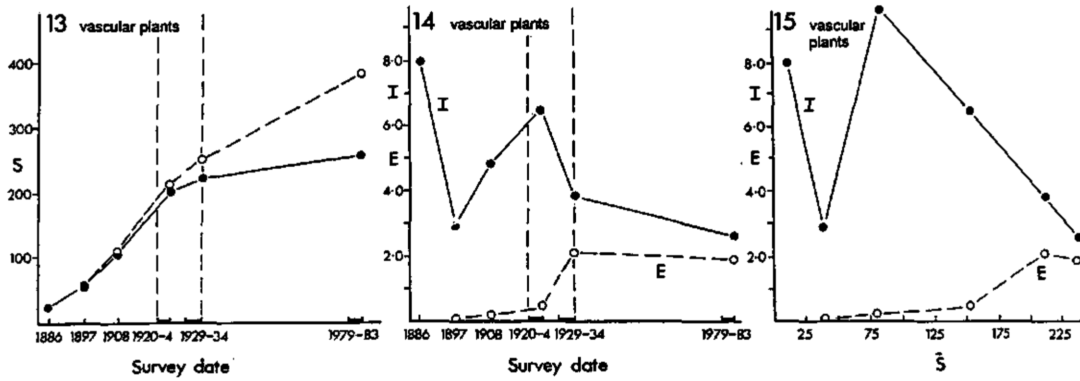

**Figures 2.4 - 2.6**. Butterflies, Rakata, 1908-1990
Figure 2.4, species accumulation curves; Figure 2.5, changes of immigration and extinction rates with time; Figure 2.6, changes of immigration and extinction rates with average number of species present. Symbols and abbreviations as Figs 2.1 – 2.3. Data from Bush & Whittaker (1991) Table 1 (see text).




**Figures 2.7 – 2.9**. Pteridophytes, Rakata, 1886-1983
Figure 2.7, species accumulation curves; Figur 2.8. changes of immigration and extinction rates with time; Figure 9, changes of immigration and extinction rates with average number of species present. Symbols and abbreviations as Figures 2.1 – 2.3. Data from Whittaker *et al.* (1989).




**Figures 2.10 – 2.12**. Spermatophytes, Rakata, 1886-1983
Figure 2.10, species accumulation curves; Figure 2.11, changes of immigration and extinction rates with time; Fig. 12, changes of immigration and extinction rates with average number of species present. Symbols and abbreviations as Figures 2.1 – 2.3. Data from Whittaker *et al.* (1989).




**Figures 2.13 – 2.15.** Vascular plants, Rakata, 1886-1983
Figure 2.13, species accumulation curves, Figure 14, changes of immigration and extinction rates with time; Figure 2.15, changes of immigration and extinction rates with average number of species present. Symbols and abbreviations as Figures 2.1 – 2.3. Data from Whittaker *et al.* (1989).

Immigration rate (Figure 2.2) rose in intersurvey period II, then declined in period III to rise slightly in period IV and then drop to its lowest value in period V. The 1931 survey was made without an ornithologist and immigration rate based on this survey (i.e., in period III) would be underestimated if species had been missed. Extinction rate based on records would be overestimated if species were missed; extinction rate based on minimum turnover would be little affected. The general trend of Figures 2.2 and 2.3 is an initial increase in the immigration rate followed by a decline to a low value approaching the extinction rate; there is little evidence of non-monotonic change apart from the early rise at the time of forest formation (Figure 2.2). Extinction rates are low throughout and substantially the same for each intersurvey period.

## DISCUSSION

Bush & Whittaker, believing that bird numbers had fallen since 1951, and noting that immigration and extinction rate time curves for birds and butterflies were not monotonic, asserted, "The change from grasslands to forest during the 1920s appears to have been accompanied by non-monotonic changes in immigration and extinction rates. *This observation alone* would cast doubt on the ability of equilibrium theory to provide the basis for a predictive model of re-colonisation" (Bush & Whittaker, 1991 p 354) (our stress).

MacArthur & Wilson (1967) suggested that theoretically the curve for island immigration rate (plotted against number of species present) should fall smoothly, and that for extinction rate should rise smoothly, to meet at an equilibrium condition. They acknowledged, however (pp. 50, 51), that "we still know very little about the precise shape of the extinction and immigration curves, so that few predictions can be made". For the plants, birds and butterflies of the Krakataus we now know something of the shape of these curves (Figures 2.1 - 2.15).

The numbers of immigrants and extinctions are low, and thus rates are highly sensitive to decisions as to the true immigrant status or extinction of species, particularly when intersurvey intervals are short (see Table 2.1). These decisions have been made here after careful assessment, but a difference of only one or two species may alter the curves considerably. Several general trends, however, are apparent.

On the basis of minimum turnover, the immigration rate of vascular plants to Rakata (data from Whittaker *et al.* 1989) (Figure 2.14) fell initially (cf. Bush & Whittaker 1991, Figure 3b), as expected by theory, but then rose, to fall again. The initial fall is greater for pteridophytes (Figure 2.8) than for spermatophytes (Figure 2.11 cf. Bush & Whittaker's Figure 3a) and the subsequent rise in the rate of pteridophytes lays behind that of spermatophytes by one survey, occurring not before, but during, forest formation. The shapes of the immigration rate curves suggest that in each we may be seeing the resultant of two curves, that of an early phase of colonisation, in which the pool of potential pioneer colonising species quickly became depleted, and that of a subsequent phase of secondary colonisers, the potential pool of which was depleted more slowly. The species-time curve for pteridophvtes (Figure 2.7) is also of a shape suggesting the combination of two phases of increase in species numbers, one before, one during, forest formation. This is not seen in the curve for spermatophytes (Figure 2.10) nor therefore in the curve for vascular plants (Figure 2.13), perhaps because the spermatophyte phases are actually less distinct. The difference in the time of the peaks of the two immigration rate curves suggests that the second phase was rather later in the case of pteridophytes than spermatophytes; possibly the beginning of forest formation, as a result of spermatophyte succession, with its attendant changes in microclimates, was a prerequisite for the second wave of pteridophytes, which, unlike the first wave, was composed largely of shade species.

The two groups of animals for which there are good data, involving a substantial number of species over time, are resident land birds and butterflies. We use the data of Table 1 of Bush & Whittaker (1991) for butterflies, omitting *Rapala iarbus* and *Anapheis java* as being migrants, and applying minimum turnover assumptions, as for birds and plants. Both birds and butterflies show a somewhat different pattern of changes in immigration and extinction rates (Figures 2.2 and 2.5 respectively) from that of spermatophytes (Figure 2.11) even accounting for the lack of early animal surveys. Immigration rate of birds and butterflies rose to a maximum (Figures 2.2, 2.3, 2.5, 2.6), in contradiction of the basic theory, the rise (as for pteridophytes, Figure 2.8) coinciding with forest formation, followed by the expected decline. There were no early zoological surveys, the first being 25 years after the 1883 event, so that if there had been a 'pioneer' effect, as suggested above for plants, it would not have been monitored. The peaks of butterfly, bird, and pteridophyte immigration rates lag behind that of spermatophytes (Figure 2.11) by one survey, as may be expected in a successional situation, suggesting the influence of changes in spermatophytes on other colonising groups.

Extinction rates, according to theory, should be low initially, then gradually rise to meet falling immigration rates at equilibrium (MacArthur & Wilson 1967). Whilst the extinction rates of plants rose, they did not do so gradually; the rise for both pteridophytes (Figures 2.8, 2.9) and spermatophytes (Figures 2.11, 2.12) was most marked at about the time of forest closure, when they at least doubled. The extinction curve of butterflies (Figure 2.5) is similar to that of pteridophytes (Fig. 8), although there are fewer data points. The extinction rate of birds (Figures 2.2, 2.3) has remained fairly constant at about one species every 7 years; that of butterflies (Figures 2.5, 2.6) ranges from zero to one every 2 years. The butterfly species accumulation curve (Figure 2.4) provides no evidence of an approach to equilibrium by this group.

Thus, on the evidence, there are the following differences from the gradual mutual approach of the immigration rate and extinction rate curves that would be expected from the basic theory. For plants (no equivalent data are available for animals) there is some indication of an early pioneer phase of colonisation followed by a phase of secondary colonisers. Immigration rate of spermatophytes rose to a peak prior to forest formation (Figures 2.11), and that of pteridophytes peaked during this period (Figure 2.8) then fell; there was a marked rise in extinction rate of both groups at about the time of forest canopy closure. The early pioneer phase of colonisation by birds and butterflies, if there was a distinct one, was not monitored, but their immigration rates, which were first measured later than those of plants, rose (Figures 2.2 and 2.5 respectively) with that of pteridophytes, following the spermatophyte immigration rate peak as forest formation began, then declined.

Contrary to the statement of Bush & Whittaker (1991, p. 346) the immigration rate of butterfly species has not risen. Using the data of their Table 1 and applying minimum turnover technique, between the 1919/21 and 1933 surveys eight species immigrated (immigration rate 0.7 spp/y) and between 1933 and 1982/89, twenty-six species (0.5 spp/y). Moreover, their Figure 5 also shows a decline, not an increase, in immigration rate over the last intersurvey period.

Bush & Whittaker use "the present rising rate of immigration" of butterfly species, together with falling extinction rates, as a reason to "deny the proximity of a MacArthur & Wilson-style equilibrium for butterflies". There is certainly no evidence of an approach to such an equilibrium for butterfly species, but a "present rising rate of immigration" cannot be used as support for this assertion. Bush & Whittaker also stated (p 345), "the immigration and extinction curves ... intersect by the end of the 1920s (Figure 5)". They do so on their Figure 5 only if one assumes that the records accurately reflect extinctions; their minimum turnover curves (as our Figure 2.5) do not intersect.

Extinction rates of birds and butterflies have not risen consistently to approach the failing immigration rates (as they have in spermatophytes). Although a peak is seen in the extinction rate curve of butterflies (Figures 2.5, 2.6) which corresponds to about the time of canopy closure, there is no such peak in the case of birds (Figures 2.2, 2.3), possibly reflecting the closer ecological ties between butterflies and plants, and their greater difficulty, therefore, in persisting in a rapidly changing floristic environment.

We see nothing in the data to warrant the general conclusion that the model has been found wanting. We believe it is possible that we are observing the results of a number of superposed, partially overlapping, colonisation series, corresponding to major successional changes in the island's environment (e.g., development of grassland, forest formation, forest canopy closure), changes which may affect the various subsets of the biota differentially. The environment of the target of colonisation, the islands, is constantly changing (partly as a result of colonisation), and thus so are the *effective* available pools of groups (e.g., birds, pteridophytes) of potential colonisers. The changes in these pools will vary in degree between different groups of organisms, and it is not surprising, that the basic theoretical curves are not clearly or easily evident.

MacArthur & Wilson pointed out that succession (forest formations) may be important in the early stages of colonisation by Krakatau birds, and may explain the "more rapid increase [of bird species] between 1908 and 1920 than between 1883 and 1908". They acknowledged that the rate curves may be non-monotonic in situations where succession is important in the early stages of colonisation and involves different trophic levels. They suggested, for example, that the extinction curve may initially decline where the heterogeneity of the area permits earlier colonists to persist although new ones have become established. On the evidence of our data, this does not seem to have occurred on the Krakataus. Rather, extinction rate of birds has not risen, and those of butterflies and plants rose at about the time of forest closure. Immigration rate, however, after an initial pioneer phase had run its course, has fallen; were it to fall to the same level as extinction rate and be maintained there, there would be equilibrium of course, in spite of the lack of a rise in extinction rate.

On neither Rakata nor the Krakataus is an equilibrium of butterfly species numbers evident (Yukawa 1994, New *et al.* 1988, Thornton & New 1988, Thornton *et al.* 1990a). Although the data for birds and plants may be interpreted, if one follows the MacArthur-Wilson model, as indicating that equilibria are being approached (flattening of the species-time curves, approach to proximity of the immigration and extinction rate curves) there is no evidence that this is so for butterflies, whose numbers are still rising fairly steeply. We do not believe, however, that the theory implies that equilibrium would be achieved, or approached, by all segments of a biota simultaneously (e.g., Thornton *et al.* 1990a; Thornton 1991). The dependence on the prior presence of particular species of plants for successful colonisation is probably more rigorous for butterflies than it is for birds, few of which have such strict, specific plant requirements, and, again if one follows the model, butterfly species numbers may therefore be expected to equilibrate (if they do) more slowly than those of birds.

Bush & Whittaker (1991, p. 352) argued that because the majority (actually 59%) of butterfly species first recorded in 1979 utilise food plants which have been present since 1908-1920, "we may reject the hypothesis that the majority of butterfly species have had to await the arrival of food plants". This test, however, which was thought to prove that butterflies were "genuinely rare arrivals", loses much of its force when one considers that between 1933 and 1979 there was no butterfly survey. Species first recorded in 1979 could have become established a decade or so after their food plants and then had to await their discovery some 46 years later to become new records.

Bush & Whittaker (1991) stated, 'simple notions of equilibrium are thus shown to be inadequate in such complex ecosystems'. Certainly the MacArthur-Wilson theory in its basic form cannot fully explain the Krakatau data, but this was acknowledged by its authors. It is unlikely, in its pure form, to fully explain the build-up of a complex biota either where much of the turnover is successional or where there have been local disturbances setting back or deflecting succession. Both of these are relevant to the Krakatau situation as Whittaker and his colleagues have so ably demonstrated for plants, although local disturbances have been least on Rakata. In our previous publications (e.g., Thornton *et al.* 1990a,b) we have used the theoretical model as a framework against which to set the observed data, and have found this approach to have heuristic value, as, we believe, was MacArthur & Wilson's main intention. For example, clear differences from the theoretical curves may be instructive in pointing up departures, from the simple model (which treats all species as interchangeable, such as the suggestion of two overlapping colonisation sequences from the colonisation curve of pteridophytes, and the rise in their immigration rate along with birds and butterflies [and aculeate Hymenoptera (Yamane *et al.* 1992)] at the time of forest formation. Comparison of the curves of different components of the biota may highlight different responses to the changing environment. The near equilibration, alone of the plant dispersal-groups, of the sea-dispersed component (Whittaker *et al.* 1992), for which Bush & Whittaker (1991) have offered an explanation, is one example. Another is the much slower approach to equilibrium by butterfly species numbers than by those of birds, which we have suggested results from the different nature of the ecological links with plants of these animal groups.

The generally accepted "hierarchical" dependences by certain groups for their successful establishment on the presence of other groups of organisms, or on particular physical changes that are concomitants of succession, dependences that were well recognised by Treub (1888), Docters van Leeuwen (1936), Dammerman (1948), and by MacArthur & Wilson (1967), will of course tend to complicate the basic theoretical curves but in our view do not invalidate the model's usefulness.

Although, as Bush & Whittaker suggest, a millenial time scale may well be necessary for any equilibration of the forest tree component of the biota, and, therefore, for that of the total ecosystem, it should not be assumed that all components would equilibrate at the same rate as forest trees. The strengths of community links with forest trees and the degree of congruence between changes in other groups of organisms and those of the forest trees may be expected to vary among the various components of the biota. Some may have close, direct ecological ties with trees; for others there may be a number of intervening links and a much more indirect relationship, resulting in a greater degree of independence from the slow changes in forest tree component species and dominance patterns which Bush & Whittaker predict. At the extremes, a eurytopic scavenger-omnivore such as *Varanus salvator* is unlikely to respond to such changes as faithfully as, for example, stenophagous species of Lepidoptera, or bats which have highly specialised roosting requirements such as species of *Tylonycteris.* As already noted here for birds and butterflies, and elsewhere (Thornton *et al.* 1990a, Thornton 1991) for other groups, the evidence suggests that only some components of the biota are moving towards asymptotes, and these are doing so at different rates. Such a differential pattern is likely to continue as forest succession and maturation slowly proceeds.

Thus, although Bush & Whittaker's criticism of the applicability of the dynamic equilibrium island biogeographic approach to the colonisation of forest trees may be valid, in our view extrapolation to include all biotic components, and extension to all specific localities, all complex forest communities, and even the lowland tropics generally, is not warranted by the evidence so far accrued on the Krakataus.

The MacArthur-Wilson theory regards the constancy of island species numbers as being due to a dynamic balance between immigration and extinction, the identity of some of the species present changing over time, but the total number fluctuating about an equilibrium that is characteristic for a particular island. Bush & Whittaker (1991) advocate a move to the ideas of Lack (1976), by which constant species numbers are maintained about a figure which is determined by the fixed number of available niches on the island, rather than by the resultant of a dynamic equilibrium. On this model potential colonists are excluded by incumbent species and extinctions are few; there is little or no turnover on an island once it has received its complement of species, apart from that of transients, whose status as components of the biota are arguable.

Both Whittaker's group and ours agree that on the Krakataus turnover in plant and animal species has thus far been largely successional, with a considerable core of species, best identified in plants by Bush & Whittaker (e.g., 1991) which has changed little in numbers or identity over a long period. This suggests a pattern similar to that found in the experimental aquatic microcosms of Dickerson & Robinson (1985), but it must be noted that as yet on the Krakataus we have no equilibrium to test; we are still monitoring the process of reassembly. Nevertheless, many of the findings of experimental community ecologists, such as Robinson & Dickerson (1987) and Drake (Drake 1991; Drake *et al.* 1993), could be studied profitably in the context of the Krakatau case. We who study "natural experiments" may learn much from those who assemble, and can thus manipulate, their own microcosms in the laboratory.

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Chapter 3

# Bird survival in an isolated Javan woodland: island or mirror?

J.M. Diamond, K.D. Bishop & S. van Balen 1987
Conservation Biology 1: 132-142

**Abstract**
Differential extinction of forest species following forest fragmentation raises the questions of which populations are most prone to disappear, and why. Hence we studied an 86-bectare woodland in west Java, the Bogor Botanical Garden (BBG), that became isolated when surrounding woodland was destroyed 50 years ago. Out of 62 bird species breeding in the BBG during 1932-1952, 20 had disappeared by 1980-1985, four were close to extinction and five more had declined noticeably. The two main variables that identify extinction-prone populations in the BBG are 1) small initial population size in the BBG and 2) rareness or absence in the surrounding countryside. Although the BBG retained wooded habitat it is evidently too small to retain self-sustaining populations of many woodland bird species. Small populations at high risk of extinction for stochastic reasons are doomed to disappear permanently unless subsidised by recolonisation from the surroundings. Thus, a too-small reserve cannot function as a distributional island but comes to mirror the species composition of its surroundings. More such case studies documenting species losses from small habitat fragments are required to demonstrate to non-biologists the need for reserves large enough to support self-sustaining populations.

## INTRODUCTION

Through deforestation, humans are carving up the world's forests into virtual islands of habitat surrounded by open country. Distributions of species confined to forest are thereby shrinking and becoming fragmented. Since forest species constitute most of the world's terrestrial plant and animal species, deforestation has become one of the major threats to species' survival.

The future of many forest species may depend on their ability to survive in isolated forest fragments. Hence conservationists are concerned by several studies indicating that such fragments do not retain their full original quota of species but instead suffer gradual losses, due to extinctions of isolated small populations. One such study, the Minimum Critical Size project of World Wildlife Fund—U.S. and Instituto Nacional de Pesquisas de Amazonia, is pursuing the problem experimentally by isolating Brazilian forest patches and monitoring their populations (Lovejoy *et al.* 1984). Other studies in Brazil, Ecuador, Panama, New Zealand, and the United States have instead approached the problem observationally, by comparing the species composition of large forest tracts with that of small tracts isolated at a known time in the past, or by comparing modern with historical species records for small tracts (Willis 1974, 1979, 1980; Wilson & Willis 1975; Forman *et al.* 1976; Leck 1979; Terborgh & Winter 1980; Whitcomb *et al.* 1981; Karr 1982a,b; Diamond 1984; Newmark 1986).

All these studies, whether experimental or observational, show that isolated fragments tend to lose species and that certain species are far more extinction-prone than others. These species' loss's exemplify the phenomenon termed faunal relaxation, whereby species diversity shifts from one equilibrium value to another after a change in a controlling variable such as area (cf studies of faunal relaxation on land-bridge islands following severing of the land bridges: Diamond 1972, 1984; Terborgh 1974, 1975; Brown 1978; Wilcox 1978, 1980; Diamond & Gilpin 1983; Patterson 1984; Heaney 1986; Lawlor 1986). For conservation biologists, a goal of such studies is to understand what types of species are most prone to disappear after fragmentation, and why.

This paper reports differential extinction of bird populations in a Javan woodland, the Bogor Botanical Garden (BBG), since its isolation from other woodlands 50 years ago. Because the lowlands of west Java have been largely deforested, the BBG is now one of west Java's few forested islands in a sea of cultivated land. At the time that its last link to other forests was cut, it appeared that the BBG would prove valuable for bird conservation because it supported about 62 breeding bird species and 77 nonbreeders. However, it has now lost one fifth of its breeding species, and several more populations are close to extinction. Our results identify two main determinants of species persistence: initial abundance, and presence in the surrounding countryside. In effect, BBG bird populations are gradually coming to mirror those in the surroundings; the BBG is not a large enough island to retain its avifauna intact.

Our account begins with a brief summary of the west Javan avifauna, the BBG, and our surveys. We then examine which species survived in the BBG, why they survived, and what implications this has for conservation efforts.

**The status of Javan birds**

One often hears the complaint, "There are almost no birds left on Java" (e.g., van Bemmel 1977). While this statement is exaggerated, declines of bird populations have undoubtedly been severe, especially in the lowlands. For example, in recent studies of the Bogor region van Balen (1984) seldom or never saw 30 lowland species that were still common there earlier in this century. Hoogerwerf (1948) reported 56 species confined to elevations below 800 meters; only 11 such species could still be found around Bogor in 1981. At least four factors have contributed to these declines (van Balen 1984):

(1) An obvious factor is habitat destruction. Java is one of the most densely populated areas in the world. Large areas were cleared for irrigated rice cultivation in early times, and for export crops (coffee, tea, sugar, indigo) since Dutch colonisation.

The expanding population today continues to put pressure on surviving patches of vegetation for firewood as well as for agriculture.

(2) Hunting and persecution of birds is intense for three motives: food, supplying a large demand for cage birds, and amusement.

(3) Heavy use of pesticides in agricultural areas may have affected many species, especially those at the tops of food chains, such as raptors, herons, and carrion-eating crows.

(4) Some disappearances resulting from the above three factors caused further disappearances (a "trophic cascade"). For example, the Indian koel *Eudynamys scolopacea*, a cuckoo that is a nest parasite on crows, has disappeared around Bogor along with one of its preferred host crow species.

## STUDY AREA AND METHODS

### The Bogor Botanical Garden

The town of Bogor (formerly known as Buitenzorg) lies in one of the wettest areas of west Java at an elevation of 260 meters, 106°45' east, 6°36' south. Its famous Botanical Garden, established in 1817, occupies 86 hectares along the Ciliwung River. It comprises a fenced, managed, in part heavily wooded area dominated by tall trees (ca 40% native, 60% introduced), with the lower and middle stories dense in some areas, open in others. The BBG also includes a river, streams, a small lake, and lawns.

Until about 1936 the BBG was continuous with other woods to the east. Destruction of those woods then isolated the BBG. Today the nearest possible sources of forest birds are 5 km southwest at Ciburial (a 22-ha water reserve with remnants of forest), 10 km east on Mt. Pancar (a hill with some lowland forest), 10 km southwest on Mt. Salak (a badly disturbed forest), 20 km east at Megamendung, 30 km southeast on Mts. Gede and Pangerango, and 35 km distant on Mt. Halimun. Except for the tiny sites at Ciburial and on Mt. Pancar, these sites are only marginally relevant as potential sources of birds for the BBG, since they lie at or above 1000 m and support montane forest, whose bird species composition is considerably different from that expected at the altitude of Bogor.

### Bird surveys

Some records of birds in the BBG were mentioned by Koningsberger (1901-1909) and Sody (1927). The ornithologist Hoogerwerf (1948, 1949b, 1953a) resided at Bogor for several decades and summarised in a book and two papers the records, breeding or resident status, and abundance of all bird species from about 1932 to 1952. Hoogerwerf described abundances of many species qualitatively, so that column 2 of Table 3.1 presents his abundance estimates for breeding species in three classes: 1 = one or a few pairs, 2 = common, 3 = the most abundant species. Unpublished recent records were obtained by S. Somadikarta during a bird-banding study from 1967 to 1971, and by D. Holmes, who has resided near Bogor since 1974.

**Table 3.1** Changes in BBG bird abundances from 1932–1952 to 1980–1985.
The table lists all 62 bird species found breeding by Hoogerwerf from 1932 to 1952, plus the sole species (black-crowned night heron) that took up residence later (see text for explanation of columns 2–6). * = males, pr = pairs

| | Abundance Ranking 1932–52 | Abundance Ranking 1980–85 | Numbers 1980–85 | Surrounding Abundance Ranking 1980–85 | Capture Frequency Ranking 1980–85 |
|---|---|---|---|---|---|
| Black-crowned night-heron *Nycticorax nycticorax* | 0 | 3 | >100 | 0 | 0 |
| Brahminy kite *Haliastur indus* | 1 | 0 | 0 | 0 | 0 |
| Barred buttonquail *Turnix suscitator* | 1 | 0 | 0 | 1 | 2 |
| White-breasted waterhen *Amaurornis phoenicurus* | 1 | 0 | 0 | 1 | 0 |
| Grey-faced green pigeon *Treron griseicauda* | 2 | 2 | 15 | 1 | 0 |
| Black-naped fruit-dove *Ptilinopus melanospila* | 3 | 2 | 15 | 1 | 0 |
| Peaceful dove *Geopelia striata* | 2 | 0 | 0 | 1 | 4 |
| Spotted dove *Streptopelia chinensis* | 2 | 2 | 20 | 2 | 4 |
| Red-breasted parakeet *Psittacula alexandri* | 1 | 1 | 8 | 1 | 3 |
| Banded bay cuckoo *Cacomantis sonneratii* | 1 | 0 | 0 | 1 | 0 |
| Plaintive cuckoo *Cacomantis merulinus* | 1 | 1 | 4-5* | 2 | 0 |
| Brush cuckoo *Cacomantis sepulcralis* | 1 | 0 | 0 | 0 | 0 |
| Drongo cuckoo *Surniculus lugubris* | 1 | 0 | 0 | 1 | 0 |
| Common koel *Eudynamys scolopacea* | 1 | 0 | 0 | 0 | 0 |
| Collared scopsowl *Otus lempiji* | 1 | 1 | 4 pr | 2 | 1 |
| Edible-nest swiftlet *Aerodramus fuciphagus* | 1 | 2 | 10 | 1 | 0 |
| White-bellied swiftlet *Collocalia linchi* | 3 | 3 | >100 | 3 | 0 |
| Asian palm-swift *Cypsiurus balasiensis* | 1 | 2 | 15 | 2 | 0 |
| Grey-rumped treeswift *Hemiprocne longipennis* | 1 | 0 | 0 | 1 | 0 |
| Collared kingfisher *Halcyon chloris* | 3 | 2 | 6 pr | 2 | 0 |
| Blue-eared kingfisher *Alcedo meninting* | 1 | 1 | 3 pr | 2 | 1 |
| Coppersmith barbet *Megalaima haemacepbala* | 2 | 1 | 1-2 pr | 1 | 0 |
| Fulvous-breasted woodpecker *Dendrocopus macei* | 1 | 1 | 3 pr | 2 | 1 |
| Banded pitta *Pitta guajana* | 2 | 0 | 0 | 0 | 1 |
| Pacific swallow *Hirundo tahitica* | 1 | 1 | <10 | 2 | 0 |
| Red-rumped swallow *Hirundo daurica* | 1 | 1 | <10 | 1 | 0 |
| Black-winged flycatcher-shrike *Hemipus hirundinaceus* | 1 | 1 | 1-2 pr | 0 | 0 |
| Pied triller *Lalage nigra* | 1 | 0 | 1 | 1 | 0 |
| Small minivet *Pericrocotus cinnamomeus* | 1 | 0 | 0 | 1 | 0 |
| White-breasted wood-swallow *Artamus leucorynchus* | 1 | 0 | 0 | 1 | 0 |
| Common iora *Aegithina tiphia* | 2 | 2 | 50 | 2 | 2 |
| Sooty-headed buibul *Pycnonotus aurigaster* | 3 | 3 | >100 | 3 | 4 |
| Grey-cheeked bulbul *Criniger bres* | 2 | 0 | 0 | 1 | 2 |
| Magpie robin *Copsychus saularis* | 2 | 1 | 4-5 pr | 2 | 4 |
| Orange-headed thrush *Zoothera citrina* | 3 | 1 | 1 pr | 1 | 4 |
| Black-capped babbler *Pellorneum capistratum* | 1 | 0 | 0 | 0 | 0 |
| Horsfield's babbler *Trichastoma sepiarium* | 1 | 1 | 4-5 pr | 2 | 1 |
| Bar-winged prinia *Prinia familiaris* | 2 | 2 | >20 | 2 | 1 |
| Brown prinia *Prinia polychroa* | 1 | 0 | 0 | 1 | 0 |
| Common tailorbird *Orthotomus sutorius* | 1 | 1 | 2-3 pr | 2 | 1 |

**Table 3.1** Continued

| | Abundance Ranking | | Numbers | Surrounding Abundance Ranking | Capture Frequency Ranking |
|---|---|---|---|---|---|
| | 1932–52 | 1980–85 | 1980–85 | 1980–85 | 1980–85 |
| Ashy tailorbird *Orthotomus sepium* | 2 | 3 | >25$^{pr}$ | 3 | 0 |
| Pied fantail *Rhipidura javanica* | 2 | 1 | 3-4$^{pr}$ | 1 | 2 |
| Hill blue flycatcher *Cyornis banyumas* | 2 | 1 | 2$^{pr}$ | 1 | 2 |
| Mangrove whistler *Pachycephala grisola* | 2 | 0 | 0 | 0 | 0 |
| Great tit *Parus major* | 1 | 2 | 10$^{pr}$ | 2 | 0 |
| Velvet-fronted nuthatch *Sitta frontalis* | 1 | 0 | 0 | 0 | 0 |
| Plain flowerpecker *Dicaeum concolor* | 1 | 1 | 4-5$^{pr}$ | 0 | 0 |
| Scarlet-headed flowerpecker *Dicaeum trochileum* | 2 | 3 | >25$^{pr}$ | 3 | 0 |
| Brown-throated sunbird *Anthreptes malacensis* | 2 | 2 | 20$^{pr}$ | 2 | 0 |
| Olive-backed sunbird *Nectarinia jugularis* | 2 | 1 | 4-5$^{pr}$ | 2 | 0 |
| Scarlet sunbird *Aethopyga mystacalis* | 1 | 0 | 0 | 0 | 0 |
| Little spiderhunter *Arachnothera longirostra* | 3 | 2 | 25$^{pr}$ | 2 | 0 |
| Oriental white-eye *Zosterops palpebrosus* | 2 | 2 | >20$^{pr}$ | 2 | 2 |
| Philippine glossy starling *Aplonis panayensis* | 2 | 0 | 0 | 1 | 0 |
| Asian pied starling *Sturnus contra* | 2 | 1 | 4-5 | 1 | 4 |
| White-vented myna *Acridotheres javanicus* | 1 | 1 | 4$^{pr}$ | 1 | 4 |
| Eurasian tree-sparrow *Passer montanus* | 2 | 3 | 300 | 2 | 0 |
| Java sparrow *Padda oryzivora* | 2 | 2 | 10 | 1 | 4 |
| Javan munia *Lonchura leucogastroides* | 3 | 2 | 30 | 2 | 3 |
| Scaly-breasted munia *Lonchura punctulata* | 2 | 2 | 50 | 2 | 3 |
| Ashy drongo *Dicrurus leucophaeus* | 3 | 1 | 4-5$^{pr}$ | 1 | 1 |
| Black-naped oriole *Oriolus chinensis* | 3 | 2 | 15$^{pr}$ | 1 | 3 |
| Slender-billed crow *Corvus enca* | 1 | 1 | 6 | 1 | 2 |

Our experience covers the years 1979 to the present. Van Balen (1984; van Balen *et al.* 1986) was resident at Bogor for a total of three years during 1979-81, 1984, and 1985-1986. Bishop began visiting the BBG in 1981 and resided there for 3½ years. Diamond observed during five periods in 1979, 1981, and 1983. Van Balen also observed intensively at seven other sites and occasionally at four other sites, Bishop at several other sites, in the countryside surrounding Bogor. To assess which bird species are captured for sale as cage birds, van Balen regularly visited the bird market in Bogor.

Column 4 of Table 3.1 presents our estimates of numbers of breeding birds in the BBG during 1980-1985. These numbers refer either to the number of pairs or of individuals or (plaintive cuckoo *Cacomantis merulinus*) of singing males, depending on each species' social structure. Column 3 then uses these numbers of column 4 to re-express abundance in three classes similar to those used for presenting Hoogerwerf's estimates, according to the following definitions: 1 = < 10 individuals (< 5 pairs), 2 = 10-50 individuals (5-25 pairs), 3 = > 50 individuals (>25 pairs). Column 5 rates abundance in the surrounding countryside from 0 to 3: 0 = absent (no recent records at all), 1 = rare (several records), 2 = common, 3 = abundant. Column

6 rates the frequency with which caged captives are offered at the Bogor market: 0 = never, 1 = rarely, 2 = occasionally, 3 = commonly, 4 = abundantly.

**Historical changes in bird status in the Bogor Botanical Garden**

Table 3.1 shows that in Hoogerwerf's time the BBG supported 62 breeding species, of which 42 survived to 1980-1985 and 20 disappeared before 1980. The sole possible addition is the black-crowned night heron *Nycticorax nycticorax*, of which a colony bred near the BBG in the 1930s and regularly flew over but rarely alit. This heron now roosts (but apparently does not breed) inside the BBG itself.

Some of the 20 extinctions can be dated approximately. There were apparently extinctions before Hoogerwerf began observing, as Sody (1927) recorded some species that Hoogerwerf did not. The barred buttonquail *Turnix suscitator*, banded pitta *Pitta guajana*, and black-capped babbler *Pellorneum capistratum* must have disappeared by 1967 because Somadikarta found none in the period 1967-1971. Four species, of which two (the coppersmith barbet *Megalaima haemacephala* and orange-headed thrush *Zoothera citrina*) declined noticeably over the period of our own observations, have become reduced to one or two pair and are likely to disappear soon.

Of the 42 species that survived, comparison of the qualitative abundance rankings of columns 2 and 3, taken at face value, suggests that 13 species declined in numbers, 23 did not change noticeably, and six increased. More detailed comparison of Hoogerwerf's field notes with ours indicates that none of the nominal increases (by a single abundance rank) may be significant but that seven of the nominal decreases probably are: those of the coppersmith barbet, magpie robin *Copsychus saularis*, orange-headed thrush, pied fantail *Rhipidura javanica*, hill blue flycatcher *Cyornis banyumas*, Asian pied starling *Sturnus contra*, and ashy drongo *Dicrurus leucophaeus*.

Thus, of Hoogerwerf's 62 species, 20 now are extinct, four are close to extinction, five more have declined noticeably, and barely half (33 species) have maintained their populations. Similarly, between 1968-1971 and 1980-1981 the 22-ha forest fragment at Ciburial suffered four extinctions of resident species (van Balen 1984), one of which (the barred buttonquail) also went extinct and another of which (pied fantail) declined at the BBG.

**Statistical analysis of relations among variables**

The outcome of habitat fragmentation at Bogor is described by a result variable, the 1980-1985 BBG abundance ranking (column 3 of Table 3.1), which might be influenced by three predictor variables: the 1932-1952 BBG abundance ranking, 1980-1985 surrounding abundance ranking, and 1980-1985 capture frequency ranking (columns 2, 5, and 6, respectively, of Table 3.1). (We did not analyse the numerical abundances of column 4, as some values were known only to lie above or below certain limits). We tested for statistically significant relationships in four ways.

First, we examined the effect of each predictor variable separately, by cross-tabulating the result variable against each predictor variable. A Spearman rank test showed the correlations of 1980-85 BBG abundance with 1980-85 surrounding abundance and 1932-1952 BBG abundance both to be highly significant, but the correlation with 1980-1985 capture frequency to be not significant ($p < 0.001$, $p < 0.005$, and $p = 0.10$, respectively). Table 3.2 gives the correlation coefficients between the result variable and each predictor variable, and also among the three predictor variables. Other nonparametric tests of association, including the Somers d test and tau-b test, gave essentially the same results.

**Table 3.2** Spearman rank correlation coefficients.

| | BBG Abundance (1932–1952) | Surrounding Abundance (1980–1985) | Capture Frequency (1980–1985) | BBG Abundance (1980–1985) |
|---|---|---|---|---|
| BBG abundance (1932-1952) | 1 | | | |
| Surrounding abundance (1980-1985) | 0.35 | 1 | | |
| Capture Frequency (1980-1985) | 0.34 | 0.17 | 1 | |
| BBG abundance (1980-1985) | 0.54 | 0.72 | 0.19 | 1 |

Second, we collapsed the 4-valued BBG 1980-1985 abundance ranking to a binary ranking, present or absent, and cross-tabulated this ranking against each of the three predictor variables (Table 3.3). We then tested whether this binary ranking showed any significant linear trend with each of the three predictor variables (Dixon 1983). The trend was highly significant for 1980-1985 surrounding abundance ($p < 0.001$) and 1932-1952 BBG abundance ($p < 0.005$), and also significant ($p = 0.02$) for 1980-1985 capture frequency. (We do not thereby assume that these three relationships are strictly linear; indeed, at least two of the three relationships are curved, as noted in the next paragraph. Instead, we thereby test whether the relationships involve any rising component).

Third, we tested the three predictor variables for their ability to discriminate between 1980-1985 BBG presence and absence by means of a stepwise discriminant analysis. At the first step the predictor variable selected was 1980–1985 surrounding abundance, which had also proved to be the most significant predictor variable by the preceding two tests. The variable selected at the second step was 1980–1985 capture frequency, since it is less closely correlated with 1980–1985 surrounding abundance than is 1932–52 BBG abundance (Table 3.2). Standardised coefficients (Dixon 1983) were -0.92 for 1980–1985 surrounding abundance, -0.20 for 1980-1985 frequency. The resulting function correctly predicts presence or absence for 52 out of the 62 species. This prediction is a significant improvement ($p < 0.01$ by $\chi^2$ test) over the best prediction that one could make solely on the basis of prior possibilities.

**Table 3.3.** Relation between bird survival and three variables.
Abundances in the BBG 1932–1952, in the surrounding countryside 1980–1985, and as cage birds 1980–1985 are taken from columns 2, 5, and 6, respectively, of Table 3.1. Increasing values of these variables (column 2 of this table) indicate increasing abundance. For each abundance value, columns 3 and 4 allocate the breeding species of 1932–1952 into those that were still present and those that were absent in 1980–1985. Column 5 gives column 3 as a percentage of columns 3 plus 4.

| | Value of Variable | Species still Present (1980-1985) | Species Absent (1980-1985) | % of Species Surviving |
|---|---|---|---|---|
| BBG abundance | 1 | 16 | 15 | 52 |
| (1932-1952) | 2 | 17 | 5 | 77 |
| | 3 | 9 | 0 | 100 |
| Surrounding | 0 | 2 | 8 | 20 |
| abundance | 1 | 16 | 12 | 57 |
| (1980-1985) | 2 | 20 | 0 | 100 |
| | 3 | 4 | 0 | 100 |
| Capture | 0 | 19 | 16 | 54 |
| frequency | 1 | 7 | 1 | 87 |
| (1980-1985) | 2 | 5 | 2 | 71 |
| | 3 | 4 | 0 | 100 |
| | 4 | 7 | 1 | 87 |

Finally, inspection of Table 3.3 suggests that most of the predictive effect of 1980–1985 capture frequency lies in the difference between "never captured" (0 in column 6 of Table 3.1 or row 8 of Table 3.3; 54% present in 1980–1985 [right-most column of Table 3.3] ) and "sometimes captured" (1, 2, 3, or 4 in column 6 of Table 3.1 or rows 9-12 of Table 3.3; 71%-100% present in 1980–1985 [right-most column of Table 3.3]). Similarly, Table 3.3 suggests that most of the predictive effect of 1980–1985 surrounding abundance lies in the differences between ranks 0, 1, and 2, since 100 percent of the species at ranks 2 and 3 were present in 1980–1985. That is, 1985–1985 BBG presence/absence is not a strictly linear function of these two predictor variables. Hence we repeated the stepwise discriminant analysis after collapsing 1980-1985 capture abundance to a binary variable (0 vs. 1, 2, 3, 4) and collapsing 1980–1985 surrounding abundance to three values (0 vs. 1 vs. 2, 3). The first step still selected 1980–1985 surrounding abundance; 1980–1985 capture frequency and 1932–1952 BBG abundance were of equal borderline significance; ($p = 0.05$) at the next step; and the resulting function correctly classified 51 species.

Thus, the most significant predictor of bird survival in the BBG following isolation from other woodlands is modern abundance in the surrounding countryside: survival increases with surrounding abundance. While other details vary with the particular analysis, survival also increases with initial (1932–1952) abundance in the BBG and with modern frequency of capture for the cage bird trade.

## CAUSES OF EXTINCTIONS OF BIRD POPULATIONS

At least seven factors merit discussion as possible causes for the declines and losses of species in the BBG.

**Small populations**

For obvious theoretical reasons one expects that the probability-per-unit-time for extinction of an isolated population should decrease steeply with population size (MacArthur & Wilson 1967; Richter-Dyn & Goel 1982; Leigh 1975). Many field studies (summarised by Diamond 1984) have confirmed this prediction. This factor also operated in the BBG: only 52 percent of Hoogerwerf's least abundant species, but 77 percent of his common species and all of his most abundant ones survived (rows 1-3 of Table 3.3). The statistical analysis described in the preceding section showed that abundance in 1932-1952 correlates significantly with presence or abundance in 1980–1985. Note, however, that 1932–1952 abundance in the BBG was irrelevant to the survival of species common or abundant in the surroundings of Bogor (denoted 2 or 3 in column 5 of Table 3.1): all 24 such species survived, including eight that were among the least common species in 1932– 1952 (rows 3, 4, 7, 8, 11, and 12 of Table 3.4). The effect of 1932–1952 abundance is obvious, however, for species rare in the surroundings (denoted 1 in column 5 of Table 3.1): survival increased from 40 to 67 to 100 percent (rows 2, 5, and 9 of Table 3.4) as 1932–1952 abundance increased from rare to common to abundant (ratings 1, 2, and 3 in column 2 of Table 3.1). One would expect 1932-1952 abundance to be even more important for species absent from the surroundings, but there are too few such species (only 10) to make an adequate test.

In short, small population size is a good predictor of extinction for populations that are effectively isolated (by virtue of being rare in the surroundings), but not for populations maintained by nearby sources of colonists.

**Disappearance of surrounding population**

Of the 20 species that vanished from the BBG, all are either now absent (eight species) or rare (12 species) in the area surrounding Bogor. Only 20 percent of the absentees, but 57 percent, 100 percent, and 100 percent of the species rare, common, or abundant in the surroundings, respectively, survived. Surrounding abundance proved to be the variable with the most significant effect on current abundance and survival in all of our statistical analyses.

Most of these absences or low abundances in the surroundings are related to destruction of woodland. Of the 11 species of Table 3.1 that are absent from the surroundings, all except the brush cuckoo *Cacomantis sepulcralis* depend on woods or tall trees for nesting (brahminy kite *Haliastur indus*), roosting (black-crowned night heron), foraging in the crowns (Indian koel, velvet-fronted nuthatch *Sitta frontalis*,

**Table 3.4** Simultaneous effect of initial abundance and present surrounding abundance on bird survival.

Abundances in the BBG 1932–1952 and in the countryside 1980–1985 are taken from columns 2 and 5, respectively, of Table 3.1. Increasing values (columns 1 and 2 of this table) indicate increasing abundance. For each pair of abundance values, columns 3 and 4 allocate the breeding species of 1932–1952 into those that were absent and those that were still present in 1980–1985. Column 5 gives column 4 as a percentage of columns 3 plus 4.

| BBG Abundance (1932-52) | Surrounding Abundance (1980-85) | Species Absent (1980-85) | Species still Present (1980-85) | % of Species Surviving |
|---|---|---|---|---|
| 1 | 0 | 6 | 2 | 25 |
| | 1 | 9 | 6 | 40 |
| | 2 | 0 | 8 | 100 |
| | 3 | 0 | 0 | - |
| 2 | 0 | 2 | 0 | 0 |
| | 1 | 3 | 6 | 67 |
| | 2 | 0 | 9 | 100 |
| | 3 | 0 | 2 | 100 |
| 3 | 0 | 0 | 0 | - |
| | 1 | 0 | 4 | 100 |
| | 2 | 0 | 3 | 100 |
| | 3 | 0 | 2 | 100 |

scarlet sunbird *Aethopyga mystacalis*, plain flowerpecker *Dicaeum concolor*), or foraging in the shaded middle story (black-winged flycatcher-shrike *Hemipus hirundinaceus*, mangrove whistler *Pachycephala grisola*) or in the ground layer (banded pitta, black-capped babbler) beneath the crowns. Similarly, 17 of the 28 species that are rare but not absent in the countryside depend on woods.

The BBG itself continues to provide wooded habitat suitable for these declining species. Thus, one of the most important contributions to bird losses in the BBG is not a factor within the BBG itself, but instead the general decline of west Javan birds. The BBG's area is small, and there are few bird species for which it can support populations numerous enough to be self-sustaining in the long run. Small populations with short life spans depend for their maintenance on sources of colonists to reconstitute the population after an extinction.

When the BBG was surrounded by woodland, extinctions within the BBG must have been brief and temporary. Now, with almost all nearby sources of forest-dwelling colonists destroyed, BBG extinctions tend to be permanent for species rare or absent in the surrounding countryside.

Recolonisation from the surroundings probably underlies a further correlate of proneness to extinction in the BBG. We categorised each species that Hoogerwerf found in the BBG according to diet and body size, and then noted how many species in each such category survived or disappeared. The species that survived were: 20 out of the 33 carnivores, eight of the nine herbivores, 11 of the 16 omnivores, and three of the four nectarivores; and 18 of the 19 small species (weight < 20 g), 11 of the 22 medium-size species (20-49 g), and 13 of the 21 large species (> 50 g). The most significant deviation from independence involves the preferential survival of small species compared to medium and large species ($p < 0.005$ by $\chi^2$ test). Small species are also at disproportionately high abundance in the surroundings: 15 out of 19 small species, but only nine out of 43 medium or large species, are common or abundant in the surroundings ($p < 0.005$ by $\chi^2$ test). (There is no such relation between size and 1932–1952 BBG abundance: $p \sim 0.2$ by $\chi^2$ test). This preferential abundance of small species in the BBG's surroundings may explain their preferential survival in the BBG.

**Habitat changes in the BBG**

War-related neglect of upkeep of the BBG from 1942 to about 1948 led to habitat changes, such as growth of understory, overgrowth of lawns, and drying-out or overgrowth of parts of the lake (Hoogerwerf 1953a). These habitat changes must have had at least temporary effects on birds. One species, the changeable hawk-eagle *Spizaetus cirrhatus,* attempted to breed in the BBG in 1944 but not in earlier or later years; we excluded this species from our analysis. Changes in management of the BBG from the 1930s to the present may also have resulted in some habitat changes.

**Disturbance**

The BBG is now more accessible to the public than formerly. Increased disturbance may be a factor in the declines of some ground-dwelling species (barred buttonquail, banded pitta, orange-headed thrush, black-capped babbler) and perhaps some species characteristic of shaded quiet sites (grey-cheeked bulbul *Criniger bres*, mangrove whistler, scarlet sunbird).

**Trapping**

Trapping of birds as cage pets is a widespread business in Java. Of the 62 species found in the BBG by Hoogerwerf, van Balen (1984) recorded 27 for sale as cage birds in Bogor market. Almost all birds that can be caught and kept alive in a cage for at least several hours are sold at the market. We therefore wondered whether poaching might have contributed to bird declines and might be reflected in a decrease in BBG survival with capture frequency as a cage bird. However, poaching does not seem to be a major factor. We have never observed trapping within the BBG, and it is even less likely to have occurred under the Dutch colonial administration of the 1930s. Most of the cage birds at Bogor market are not trapped near Bogor but are imported from other parts of Java and other islands. In our statistical analyses the probability of a species having survived from Hoogerwerf's time to today increases, rather than decreases, with frequency of capture as a cage bird[1]. Of the 12 species of Table 3.1

[1] The probability that cage birds escape from neigbouring birdmarkets and supplement or recolonise the botanical gardens should not be excluded.

most frequently offered as cage birds at Bogor market, 11 still survive in the BBG. However, these observations do not deny the likelihood that the cage trade has contributed to the general reduction of Javan birds.

**Secondary extinctions (trophic cascades)**

The parasitic brush cuckoo has disappeared not only from the BBG but also from the countryside around Bogor, due probably to declines of its hosts. Both of its likely hosts in the BBG, the pied fantail and hill blue flycatcher, have declined. In contrast, the parasitic plaintive cuckoo survives in the BBG, where its main host, the ashy tailorbird *Orthotomus sepium*, is still abundant (van Balen *et al.* 1986).

**Partly exotic vegetation**

The BBG is not a wholly natural woodland but includes planted non-native trees along with native ones; the non-natives predominate slightly. Might this factor have contributed to the extinctions? Some Javan bird species may depend on native fruits and flowers and may have been unable to establish themselves in the BBG in the first place. However, this is not the question: the question is instead whether partly exotic vegetation contributed to the extinctions of species already established in the BBG by 1932–1952. The BBG was founded in 1817. In the 1920s Sody (1927) recorded 61 of Hoogerwerf's 62 breeding species, and proved breeding for 55 of them and probable breeding for four more. About half of Hoogerwerf's species are territorial residents that probably carried out their whole life cycle within the BBG. Whether the disappearances would have been faster or slower in a purely native woodland is unknown, but it does appear that the extinctions involved populations long established in the BBG by Hoogerwerf's time.

## SUMMARY OF THE CAUSES OF EXTINCTIONS

We conclude that the most important causes of extinctions were the risks inevitable to small populations in a fluctuating environment, combined with the disappearance of sources for potential recolonisation from the surroundings. One parasitic species was eliminated by declines of its hosts. Habitat changes and disturbance may have contributed to some extinctions. It is conceivable that trapping and exotic vegetation had some effect, but we cannot detect supporting evidence.

**Implications for conservation efforts**

At the time when Bogor's woods outside the BBG were destroyed in the 1930s, it seemed that the BBG might prove of considerable value as a refuge for its 62 breeding bird species. Much of that conservation value has been eroded over the past 50 years. Twenty species have already disappeared. Of the 42 survivors, 40 occur in the surrounding countryside anyway. Of the two species absent from the surrounding countryside and completely dependent on the BBG for local survival, both now number less than five pairs and are unlikely to survive for long. Similarly, of the 16 survivors that are rare (entry "1" in column 5 of Table 3.1) in the surroundings, only one has a BBG population exceeding 15 individuals, and only two others exceed 10 individuals. Thus, most of the surviving populations are either likely to disappear soon or else are being subsidised by surrounding populations. Since countryside habitats are being degraded throughout west Java, the prospect for such subsidisation is itself disappearing.

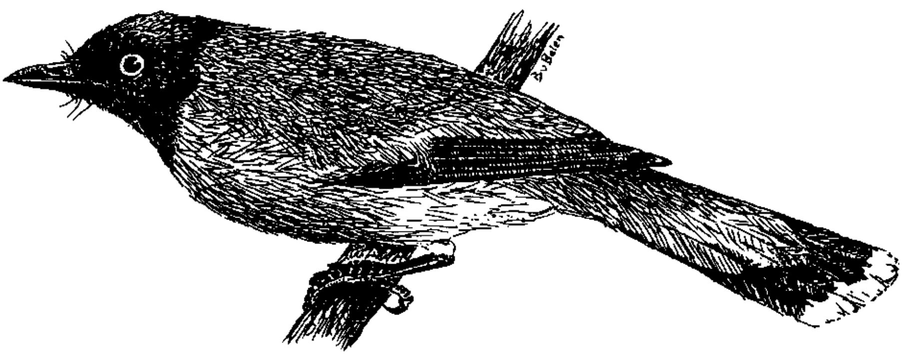
The erosion of the BBG's conservation value for birds is not due to erosion of BBG woodland itself. On the contrary, the BBG has survived much better than might have been anticipated from the problems created by war, change of government, and an expanding human population. Erosion of BBG bird populations is instead mirroring the erosion of surrounding bird populations. At 86 ha, the BBG is simply too small a wooded island to support by itself a secure population of many woodland birds.

These remarks should not be misconstrued to mean that the BBG is devoid of conservation value. It is probably important to many insect and plant species whose populations number many more individuals than do bird populations occupying the same area and are thus more likely to survive unsubsidised. The BBG is also important to certain bird species: especially to the roosting colony of the black-crowned night heron, to some palaearctic migrant visitors that spend the winter in the BBG, and to four breeding species that occur in the surroundings but are much commoner in the BBG: grey-faced green pigeon *Treron griseicauda*, black-naped fruit dove *Ptilinopus melanospila*, Java sparrow *Padda oryzivora*, black-naped oriole *Oriolus chinensis* (van Balen *et al.* 1986).

We see the main message of our analysis for conservation biology as being that of an unintended "demonstration project." What has been happening to woodland birds of west Java is duplicated by declines in innumerable other species of other habitats throughout the world. No biologist will be surprised at our conclusion that a small habitat patch loses species if it is isolated, and that reserves should therefore be large enough to support self-sustaining populations. Biological common sense and any reasonable theory would predict these findings. However, biological common sense and theory are not enough to convince non-biologists (e.g., government officials) who make decisions about establishing reserves. They can instead be convinced only by case studies proving that extinctions actually do occur in small reserves. Furthermore, case studies are needed to provide specific guidelines about reserve areas: how else can one convince a non-biologist, willing to accept the notion of a "large reserve," that 86 ha of Javan woodland does not constitute a large enough reserve?

Regrettably, few case studies of differential extinction in isolated reserves are available to illustrate conservationist reasoning. We hope that more cases like that of the Bogor Botanical Garden can be documented and publicised.

It is a pleasure to record our debt to Mr. Derek Holmes for sharing his bird observations and commenting on a draft of the manuscript, and to Dr. Terry Reedy for statistical help.



Chapter 4

# Differential extinction patterns in Javan forest birds


**Abstract**

The lowland forest of Java is reduced to 2.3% of its original cover. In this study the impact of the forest fragmentation on the distribution of forest birds is investigated. The forest birds of nineteen forest fragments varying from six to 50,000 ha have been surveyed. Species were categorised into Minimal Habitat Requirement classes I (forest interior), II (forest edge), III (woodland) and IV (rural and urban). Nested subset analysis was applied on the four species sets. Nestedness patterns appeared strongest for forest interior species, and weakest for urban species. Incidence rates for the different MHR classes showed that reserves of 200,000 ha or more are needed to contain all forest species. It also shows that woodland species are less affected by forest fragmentation and could partly be supported by management of the countryside surrounding the fragments.


## INTRODUCTION

The island of Java has a long record of forest clearance, which on west Java dates back to 4800 BP (Maloney 1985). The irrigated rice field system was introduced in central and east Java during the Mataram period ($8^{th}$ – $10^{th}$ century) and established towards the $17^{th}$ century (Geertz 1963). Between 1830 and 1870, the "Cultuurstelsel", introduced by the Dutch colonial government created huge areas of monocultures, especially coffee *Coffea* sp. and sugarcane *Saccharum officinarum* (Geertz 1963; Smiet 1990). Nowadays most of Java's natural forest has been converted into agricultural, village and waste-lands. The authenticity of the vast teak forests *Tectona grandis* on Java is unclear and this timber may have been introduced by early Hindus between the $2^{nd}$ and $5^{th}$ century (Whitten *et al.* 1996).

Upland forest is still in good condition in many places, but virtually all lowland forest has been cleared with the exception of isolated patches along the south coast, mainly on south facing slopes (Davis *et al.* 1986). Since the 1960s no continuous forest from shoreline to mountain top survives anywhere in Java. Figure 1.1 and Table 4.1 show the remaining cover of mountain, hill and moist to wet lowland forest in Java, illustrating the disastrous losses of natural areas especially in the lowlands.

MacArthur & Wilson (1967) laid the foundation to the study of the relationship between number of species and area, and its relevance to nature conservation. Their dynamic equilibrium theory does not seem to adequately describe avian community dynamics since different birds have different extinction and immigration rates and thus a different likelihood of being present in a particular isolated site (Opdam *et al.* 1985). Differential extinction probabilities amongst forest birds cause non-random distribution patterns in variably sized fragments, so that species occurring in one given fragment, are expected to occur in all larger fragments; in this way the different bird communities constitute nested subsets (Atmar & Patterson 1993). The study of nestedness in bird communities gives a way to resolving the order of extinction of different constituent species, and to the identification of species populations that are at their minimal sustainable sizes (Atmar & Patterson 1993).

**Table 4.1** Forest cover ($km^2$) in Java and Bali (after MacKinnon *et al.* 1982)

| JAVA | Original | Remaining | Included in reserves |
|---|---|---|---|
| Montane (>1200 m a.s.l.) | 13,180 | 7570 | 870 |
| Hill | 11,190 | 2640 | 500 |
| wet/moist | 10,210 | 2130 | 359 |
| Lowland | 111,360 | 2590 | 1100 |
| wet/moist | 100,110 | 1768 | 626 |
| Swamp | 720 | 50 | 10 |
| Mangrove | 470 | 62 | 10 |
| BALI | | | |
| Montane (>1200m a.s.l.) | 1020 | 695 | 160 |
| Hill | 930 | 420 | 170 |
| Lowland | 3590 | 460 | 420 |
| Mangrove | 20 | 5 | 1 |

Numerous studies have documented and analysed the impact of habitat fragmentation on the distribution of forest birds (see Laurance & Bierregaard 1997). On Java the numerous fragments of lowland forest provide an excellent opportunity to study nestedness of bird communities. These fragments have long histories of isolation, often of more than 50-60 years.

Whereas early studies focussed on species turnover, more recently greater emphasis was given to comparing attributes of persisting and extinct species (Ryan & Siegfried 1994). Natural abundance, presence in corridors and windbreaks, fecundity and preferred habitat most closely fitted bird species' responses to fragmentation (Warburton 1997). Only few studies undertaken to investigate nestedness patterns in the distribution of birds across islands, forest fragments and other isolates have differentiated constituent bird species into forest dependence qualities (Warburton 1997; Wright *et al.* 1998). Blake (1991) showed for a North American bird community that those species requiring forest interior for breeding (and wintering in the tropics) were highly nested as compared to those inhabiting the forest-edge (and are short distance migrants).

Diamond *et al.* (1987) showed that variables such as small initial abundance, and abundance in surrounding countryside identify extinction-prone populations as the so-called "mirror" effect. These variables may be strongly related to habitat tolerance, and they may be reflected in nested subset patterns. These are hypothesised to be stronger for real forest birds, as these are more sensitive to the effects of forest fragmentation, than for species characteristic of forest edge and secondary scrub. Therefore I have split bird communities into different classes of forest dependency, and analysed these separately for nestedness patterns.

The benefits to bird conservation of differentiating species according to forest dependency are obvious: 1) By merely looking at maximised total species richness, "weedy" species are weighted equally with truly endangered species (Diamond 1976; Faaborg 1979). 2) In the debate on SLOSS (Single Large or Several Small) reserves, it is often stated that collections of smaller protected areas have more species than in the larger protected areas (Quinn & Harrison 1988). De Vries (1996) found for ground beetles that larger blocks favoured stenotopic heath land species with low dispersal, whereas small reserves favoured eurytopic species with high powers of dispersal powers. Preserving many small sites instead of a few large ones would protect the latter "weedy" species at the expense of the others.

**Objective of this study**

In this paper I will try to show the impact that forest fragmentation has had and still has on the forest avifauna of Java. The main objective was to show that tolerance to habitat destruction of individual species determines distribution patterns across forest fragments. I will also investigate the effect of initial abundance and colonising abilities on these species.

## METHODS AND STUDY AREAS

**Forest dependence assessment**

Keast (1990) defined forest birds as simply those species that are restricted to forest, dependent on it, or whose centre of distribution is forest. Forest-edge dwellers are thus included. Sody (1956) compiled a comprehensive list of forest birds on Java, but his assumptions about forest bird qualification resulted in a rather indiscriminate enumeration of all birds that have been known to occur in any type of forest on Java. In order to refine Sody's classification in the present study an attempt is made to compile further categories of lowland forest birds. In my analysis I largely make use of Wells' (1985) list of lowland forest birds in western Malesia, with the main exclusion of mangrove specialists and migratory species. Also some of his "lowland" species were discarded by me as being strictly montane on Java and Bali (orange-fronted barbet *Megalaima armillaris*, chestnut-backed scimitar babbler *Pomatorhinus montanus*, eye-browed wren-babbler *Napothera* *epilepidota*, white-bibbed babbler *Stachyris thoracica*, grey-headed flycatcher *Culicicapa ceylonensis*), whereas two of his montane species on Java were treated by me as lowland species (Temminck's babbler *Trichastoma pyrrogenys*, ashy drongo *Dicrurus leucophaeus*). A number of species not considered to be forest birds by Wells, have been included by me as their occurrence in forest suggest a certain degree of affiliation.

To assess more precisely forest dependence of the forest birds under study, notes have been made on their presence in a wide variety of habitats outside the study areas, such as monospecies plantation forests of Darmaga, Gunung Kidul and Gunung Walat, rural habitat in Caringin, Tajur and Madura island, and urban habitats of Jakarta, Bogor and Depok towns. Supporting data were obtained from literature (Koningsberger 1915; Sody 1953, 1956; Wells 1985; van Balen 1987; van Balen *et al.* 1988).

In classifying forest dependence, I identified for each species the most disturbed habitat in which a particular species is known to survive in considerable numbers. Using this Minimal Habitat approach (see van Balen *et al.* 1988), I believe that responses to overall habitat destruction are reflected. I classified all forest species in four Minimal Habitat Requirement (MHR) classes.

(1) *Forest Interior Birds*

Species that live exclusively in natural mixed forest (from evergreen rain to dry deciduous forest).

(2) *Forest-edge Birds*

Species that live mainly along edges of natural mixed forest, but also found in secondary forest fringing primary forest.

(3) *Woodland Birds*

Species that live in natural mixed forest and its edges, but also in purely planted forest, mainly mahogany *Swietenia* sp., kauri *Agathis dammara*, rubber *Hevea brasiliensis*, teak, pine *Pinus merkusii*. Sample areas were Darmaga and Depok university campus areas, and Gunung Walat in west Java (van Balen *et al.* 1986; unpublished data); supporting data are from the region around Bandung (van Helvoort 1981), Manggiri (Buil 1984) and Madura Island (East Java), where no natural forest is extant (van Balen in prep.).

(4). *Rural/Urban Birds*

Species that live in natural mixed forest and its edges, but also in secondary growth in densely populated areas (villages, suburbs and cities). Sample areas were Depok, Bogor (where I lived for more than 15 years), Jakarta, Madura Island and various towns in east Java.

The following birds and bird groups were omitted: nocturnal birds (all Strigiformes, Caprimulgidae and Podargidae), seasonally conspicuous birds (Asian koel *Eudynamys scolopacea*, chestnut-capped thrush *Zoothera interpres*), birds belonging to species of which migratory and resident populations were co-occurring but indistinguishable in the field (Indian cuckoo *Cuculus micropterus*, dollarbird *Eurystomus orientalis*, brown needletail *Hirundapus giganteus*, hooded pitta *Pitta sordida*), and birds that are restricted to particular parts of Java (blue-throated bee-eater *Merops viridis*: western Java; hair-crested drongo *Dicrurus hottentottus*): off-shore islets and deciduous forest in eastern Java) have been omitted. Birds of prey were also excluded from analysis as their large home ranges and (often) vagrant habits make it problematic to assign them to any of the smallest fragments.

**Lowland forest fragments**

During November 1985 - November 1995, 19 lowland forest areas were surveyed. Data collected by the author during earlier surveys in 1980-1981 were also used. The majority of the survey areas were protected and managed by the Indonesian Forestry Service. The forest patches were selected throughout Java at altitudes between sea level and 1000 m a.s.l. Area sizes varied from six to 50,000 ha (Appendix 1 and Figure 4.1).

The natural vegetation cover of the western half part of lowland Java is evergreen and semi-evergreen rain forest (Whitmore 1984; RePPProT 1990; Whitten *et al.* 1996), whereas the natural cover of the eastern half was once dominated by moist deciduous forest, with pockets of rain forest mainly in the southern parts. Rain forest is the richest in plant species of the vegetation types found on Java, between sea level and 1500 m. It is characterised by a high canopy, containing many different strata, and is of a highly mixed nature with few dominant tree species (Backer & Bakhuizen van den Brink 1965). Lowland forest is largely destroyed or degraded in Java, and only scattered patches are left of the original vegetation, totalling to up to 250,000 ha, of which presently less than half is contained in nature reserves (MacKinnon *et al.* 1982), and of which less than 70% belongs to the wet and moist types (Table 4.1). All forest fragments were selected in the wettest parts of Java, with 20-80 rainy days in the 120 day-long wet season, and annual rainfall of 1500-4000 mm (van Steenis 1972; RePPProT 1990).

The forest areas were isolated by tracts of at least several kilometres of non-forest area from other (larger or smaller) forest areas. Isolation was assumed to have occurred before the time of their gazettement as given in MacKinnon *et al.* (1982).

Degree of disturbance in the forest plots under study varied from almost undisturbed with a canopy closure >88%, to slightly disturbed, with a canopy closure down to 80% (following disturbance categories by Smiet *et al.* (1989)). Amongst the surveyed areas some are of particular conservation importance (MacKinnon *et al.* 1982), viz. Ujung Kulon, Pangandaran, and Meru Betiri.

The total forest area surveyed (128,342 ha) represented ca 73% of the total area of wet and moist forest on Java.

**Field survey methods**

The number of visits and time spent per area varied mainly depending on size of the forest, with visits to the larger areas being longer and more frequent. When no or few new species were added to the local bird list, visits were discontinued. For some areas, recent published or unpublished data from fellow ornithologists were used, but only if the time of collection fell within my study period.

The processed distribution data refer to presence/absence of the species only, based on sightings, undisputed voice records and in some cases tracks and moulted feathers. Tape-recordings (Marantz CP430 and Sanyo TRC2300 cassette-recorders) have been made of unknown calls, virtually all of which were identified afterwards. Copies of a number of these are deposited with the British Library of Wildlife Sounds (London).

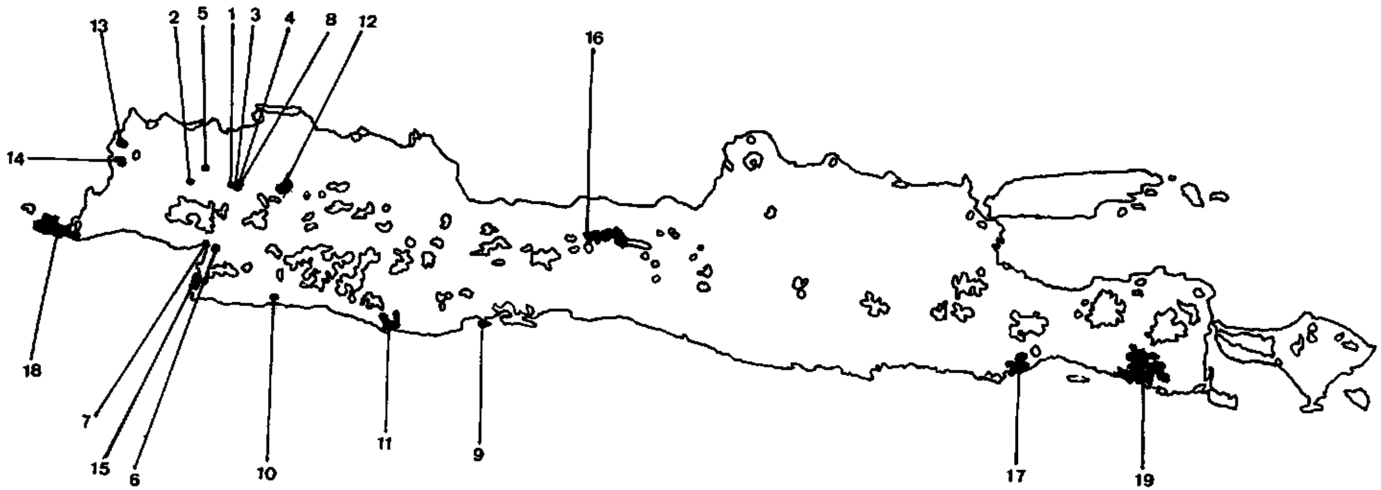



**Figure 4.1** Location of study sites on Java
Remaining forest areas are outlined.
1. Kotabatu; 2. Dungusiwul; 3. Ciburial; 4. Gunung Pancar; 5. Yanlapa; 6. Tangkuban Perahu; 7. Sukawayana; 8. Kebun Raya Bogor; 9 Pangandaran; 10. Ciogong; 11. Leuweung Sancang; 12. Mt Sanggabuana; 13. Ranca Danau/Tukunggede; 14. Mt Aseupan; 15. Cikepuh; 16 Linggoasri; 17. Lebakharjo; 18. Ujung Kulon; 19. Meru Betiri.

**Historical abundance**

A general abundance assessment at the time of isolation has been made based on information in 1895-1935, when mainly M.E.G. Bartels Sr., M. Bartels, E. Bartels and H. Bartels collected birds in the surroundings of the west Javan study plots (Voous 1995). The number of different localities in which a particular species has been collected is used as a measure of abundance. Specimens collected are stored in the Nationaal Natuurhistorisch Museum of Leiden, but for a number of species these skins were lost during World War II, and these species have been discarded from the analysis.

**Colonisation rates**

Thornton *et al.* (1993; see Chapter 2 of this thesis) list all bird species and their time of arrival on the Krakatau Is in Sunda Strait, 42 km off Java. The number of years between the 1883 eruption and first arrival of the species is used by us as a measure of colonisation rate.

**Analysis of nestedness**

The nested subsets concept has appeared in many papers on habitat fragmentation (Patterson & Atmar 1986; Cutler 1991; Atmar & Patterson 1993; Wright *et al.* 1998; and others). Atmar & Patterson (1995) analysed nestedness patterns for a large number of "archipelagos" of real (oceanic, and land bridge) islands, forest fragments etc.

Atmar & Patterson (1993) introduced "temperature" as a measure for nestedness. The calculation of system "temperature" is based on the number of unexpected occupied sites in the matrix sites, the holes and outliers. Local unexpectedness $u_{ij}$ is defined as:

$$u_{ij} = (d_{ij}/D_{ij})^2$$

where $Dij$ is the full line running through the $j$th species on the $i$th island, and $dij$ the specific length along that line. Total unexpectedness $U$ for $m$ islands and $n$ species is:

$$U = 1/(mn) \sum_i \sum_j u_{ij}$$

$U$ is a measure insentitive of matrix shape and size, because of double normalisation of the metric and lies between $u = 0$ (perfectly ordered matrix) and $U_{max} \sim 0.04$. System "temperature" $T$ is defined by:

$$T = kU$$

where $k = 100/U_{max}$. $T$ lies within the range of $0^{\circ}$ to $100^{\circ}$. The so-called extinction threshold line is determined by matrix shape and fill. It is found by choosing point $\varphi D$ ($\varphi$ = percentage fill of the matrix) along the skew diagonal, extending lines from here to the opposite corners, so that two triangles of similar size that equal the desired fill are formed. A line of smoothest transition is drawn from corner to corner, so that the two cut-off parts in the corners equal the two triangles in the centre. Species columns and island rows are packed in such a way that the distances of unexpected presences and absences (outliers and holes) from the calculated extinction threshold line is minimised and that U is at its absolute minimum. The extinction threshold line will be a line of perfect order, not allowing rearrangement of columns and rows that would cause divergence from the lowest *U*.

A computer programme designed by Atmar & Patterson (1995) using the above procedure fits all species in the "coolest" matrix possible. In this the constituent species are arranged from left to right in increasing sensitivity to fragmentation, and the islands from top to bottom in decreasing species richness. Species positions on or below the extinction line fall outside the "safe" zone and are regarded as the first to go extinct. To test the statistical significance of the matrices 100 Monte Carlo simulations (RANDOM1; see Cutler 1991) using the same computer programme were run.

*Species with high degrees of nestedness*

In most cases the distribution of particular species across the matrix diverges from perfect nestedness, and is "hotter" than the average "temperature" of the matrix formulas. This is caused not only by extinction (which cause holes in the matrix), but also by immigration to depauperate areas (Atmar & Patterson 1993). Not only the species that conform with high nestedness values, but also species which fall outside the system cause concern (the "idiosyncratic" species of Atmar & Patterson (1993)). As these are very unpredictable in distribution, and may occupy scattered habitat in declining amounts, they are not necessarily captured in reserves. The following scenarios can be thought of as causing non-conforming distribution patterns:

1. Post-isolation immigration (e.g., small island species; nomadic species)
2. Fundamental disjunction in historical evolution of community structures. On Java this would be of less prevalence in the lowlands, where only few species do not occur throughout.
3. Competitive exclusion ecological/behavioural generalists (small islands)
4. Unique ecogeographic features (e.g., river, bamboo forest)

The individual species nestedness values, the "idiosyncratic" species temperature, $I(j)$ of Atmar & Patterson (1993) is calculated using the following formula:

$$I(j) = k/m \sum_i u_{ij}$$

*Sites with high degrees of nestedness*

Not only species, but also areas may be hotter than the average matrix temperature. With their interpretation we should be careful as it is closely intertwined with distribution of non-conforming species (Atmar & Patterson 1993). Isolation effects may be strongly influenced by surrounding habitat and it makes a great difference whether the matrix consists of (i) Built-over area (villages, settlement area); (ii) Rural area; (iii) Plantation forest (teak, rubber, etc.); or (iv) Regenerating or secondary forest. For nestedness matrices the following assumptions are made by Atmar & Patterson (1993):

(1) The habitat fragments were once a whole and populated by a single common source

biota.

(2) Islands are uniform in habitat heterogeneity and type mix, and remain so.
(3) There exists no clinal (latitudinal) gradient.
(4) Species are equally isolated on all islands.

In my study the three first assumptions have been countered with by choosing fragments as intact as possible in basically the same vegetation type and by omitting species that have a skewed distribution pattern on Java (see above). By categorising bird species into minimal habitat requirement classes the fourth assumption is met.

## RESULTS

### Number of forest birds

Appendix 2 gives the distribution of all forest birds across the 19 forest fragments under study. Certain species (notably woodpeckers) drop out of the increasingly smaller areas, an only the larger reserves contain more complete assemblages. A generally more tolerant group is the cuckoo family, which is quite widespread.

Five resident lowland forest species were not recorded in any of the study plots. These are: buff-rumped woodpecker *Meiglytes tristis*, scaly-breasted bulbul *Pycnonotus squamatus* and yellow-eared spiderhunter *Arachnothera chrysogenys* (all very rare and local on Java, with no or only one recent record); straw-headed bulbul *Pycnonotus zeylanicus* (once common on Java, but wiped out by trapping for the bird trade); and the hairy-crested drongo *Dicrurus hottentottus* (only on small offshore islands in western, and in dry deciduous forest in the eastern part of Java).

### Species-area relationship

The Log N-Log Area relationship for all species all species combined ($z$ = 0.17, $r^2$ = 0.56) is shown in Figure 4.2. These level off going from true forest species (z = 0.34, $r^2$ = 0.80) to the woodland species (z = 0.15, $R^2$ = 0.31; see Table 4.2). No correlation was found between number of rural/urban species (MHR class IV) and area.

The relationship between the proportions of MHR classes I, II and III in each forest fragment against fragment size is shown in Figure 4.3 (I: $R^2$ = 0.79; II: $R^2$ = 0.29; III: $R^2$ = 0.79). Because of their divergent habitat preferences, and their poor representation in the bird communities causing too much variance, class IV birds have been omitted. Classes I and II exhibit similar curves, and their proportions rise sharply with increasing fragment size (class I: $r^2$ = 0.80; class II: $r^2$ = 0.37). In sharp contrast to this stands MHR class III, and the proportion of these woodland birds drops with larger sized fragments (class III: $r^2$ = 0.82). In fragments larger than 20-25,000 hectares the three classes are more or less similarly represented.

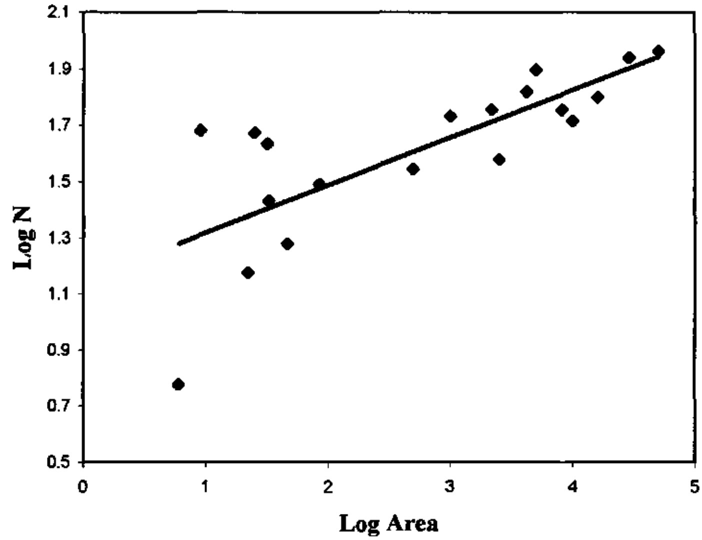



**Figure 4.2** Log relationship Area and Total Species Numbers

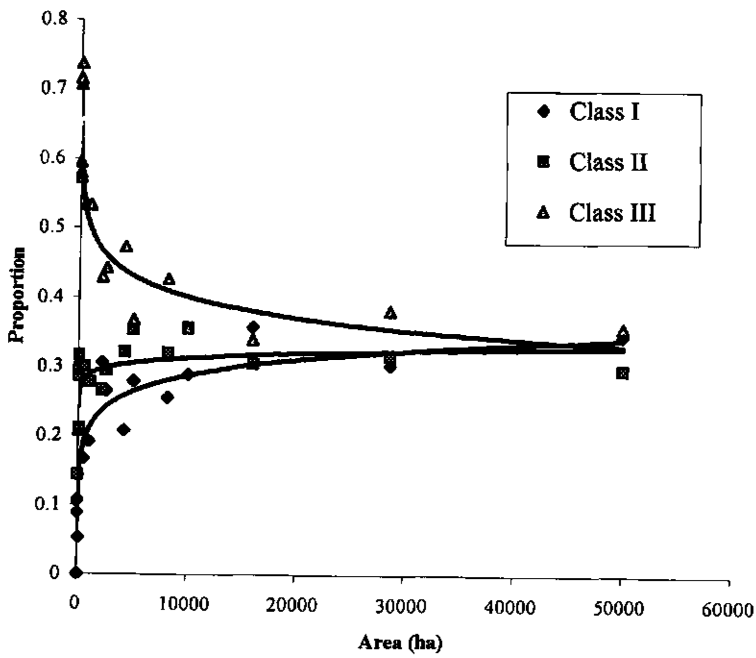



**Figure 4.3** Representation of classes I (forest interior birds), II (forest edge birds) and III (woodland birds) with increasing size of forest stands.

**Table 4.2** Spearman rank correlates, z-values and $r^2$-values for Area, Number of Species and Nested Order relationships (* = p< 0.05, ** = p< 0.01)

| MHR Class | n | Nspecies/Area r | LogN/LogArea z | $r^2$ |
|---|---|---|---|---|
| I | 34 | 0.88** | 0.34 | 0.80 |
| II | 31 | 0.74** | 0.24 | 0.58 |
| III | 33 | 0.51* | 0.15 | 0.31 |
| IV | 14 | 0.30 | 0.02 | 0.04 |
| Total | 112 | 0.75** | 0.17 | 0.56 |

**Nestedness**

The matrix for all 112 species (not illustrated) combined has a nestedness degree of 14.4°. In Appendix 2 the ranking order of the different species in the respective nestedness matrices from high to low occupancy in the matrix is given. This order reflects the degree of vulnerability to fragmentation of the constituent species, and will be used to test the variables 'initial abundance' and 'colonisation rate' which are thought to be of crucial importance in the development of the system. Figures 4.4 a-d show the matrices for the respective bird classes I - IV. With increasing habitat tolerance of the bird communities, the degree of nestedness increases from 9.7° for class I birds to 20.5° for class IV birds, and the extinction threshold curve becomes convex with increasing percentage fill of the matrix from 31 to 57% (see Table 4.3). In Table 4.4 the species of classes I and II with a non-conforming distribution pattern (with nestedness degrees much larger than *T*) are listed.

**Initial rareness and extinction**

Initial rareness is an important factor in the extinction process of a certain species (e.g., Diamond *et al.* 1987). In Appendix 2 the number of historical localities (*ca*

**Table 4.3** Nestedness degrees and other matrix characteristics.

| | nestedness degree (in °) *T* | number of species | matrix fill (%) | probability[1] of randomness *p* |
|---|---|---|---|---|
| I | 9.7° | 34 | 31.1 | $8.42e^{-26}$ |
| II | 13.3° | 31 | 40.8 | $7.83e^{-28}$ |
| III | 17.1° | 33 | 58.7 | $9.34e^{-35}$ |
| IV | 20.5° | 14 | 56.6 | $3.53e^{-9}$ |
| Total | 14.4° | 112 | 42.5 | $4.54e^{-88}$ |

[1] Monte Carlo derived probability that matrix was randomly generated; *p* is the probability that the Monte Carlo simulations find a *T* value lower than found for each class.

1895-1935) are listed. The negative correlation between initial abundance and fragmentation vulnerability as found in the nestedness matrix, is highly significant for Class II birds ($r = 0.69$; $n = 30$; $p < 0.01$), significant for class I ($r = 0.32$; $n = 33$; $p < 0.05$) and class III ($r = 0.38$; $n = 32$; $p < 0.01$), but not significant for class IV birds ($r = 0.12$; $n = 14$).

**Species with non-conforming distribution**

Before calculating the idiosyncratic distribution the forest bird matrix has again been split up into four sub-matrices, one for each MHR class. I will describe the non-conforming ("idiosyncratic") species for true forest and forest edge species, as these classes of nested species are most interesting with respect to extinction processes.

*Class I* Out of the nine species identified as having a non-conforming distribution, four occur in the highest parts of the lowlands, and two are slope specialists (see Table 4.5). Nine out of ten upper lowland species that are found in class I are idiosyncratic.

*Class II* Non-conforming distribution in class II species is less readily explained. In contrast to class I, only two (out of nine) upper lowland species are idiosyncratic. One (out of five) is a coloniser of offshore islands. The white-rumped shama *Copsychus malabaricus* was once common but has been decimated by trapping for the bird trade. Four other species are all of localised occurrence on Java.

**Colonisation rate**

The ability to colonise the Krakatau Islands is not correlated with fragmentation sensitivity whether all 112 constituent species are taken combined ($t = 0.1$; $df = 35$; Student's t-Test) or split into four classes. However, there is a trend visible, if the proportions of colonisers within each class examined: of the I, II, III and IV class birds, 0%, 16%, 17% and 43%, respectively, were found to be good island colonisers.

**Table 4.4 Species with high species "temperatures"** (*: preferring the higher parts of the lowlands; ** hill specialists (Hoogerwerf 1948; Sody 1956; Wells 1985; van Balen pers. obs.); @ island colonizers (Thornton *et al.* 1993).

| Class I | nestedness (in °) | Class II | nestedness (in °) |
|---|---|---|---|
| *Treron capellei* | 11.8 | *Ducula aenea*@ | 23.5 |
| *Celeus brachyurus** | 28.2 | *Ducula badia*** | 22.0 |
| *Picus mentalis** | 14.1 | *Surniculus lugubris* | 67.5 |
| *Reinwardtipicus validus** | 40.8 | *Picus miniaceus* | 18.8 |
| *Coracina fimbriata** | 17.3 | *Copsychus malabaricus* | 51.8 |
| *Chloropsis sonnerati* | 73.8 | *Stachyris grammiceps* | 18.8 |
| *Enicurus velatus*** | 11.8 | *Macronous flavicollis* | 23.5 |
| *Cyrnis unicolor* ** | 18.8 | *Nectarinia sperata* | 31.4 |
| *Trichastoma pyrrogenys** | 29.8 | *Prionochilus percussus* | 26.7 |
| | | *Arachnothera affinis** | 17.3 |

**Table 4.5** Hill specialists on Java

| | Altitudinal Range | |
|---|---|---|
| | Min | Max |
| Javan hawk-eagle *Spizaetus bartelsi* | 350 | 3000 |
| *Mountain imperial pigeon *Ducula badia* | 600 | 2200 |
| Ruddy cuckoo-dove *Macropygia emiliana* | 0 | 1500 |
| **Orange-breasted trogon *Harpactes oreskios* | 0 | 900 |
| Scaly-breasted bulbul *Pycnonotus squamatus* | 0 | 600 |
| Black-crested bulbul *Pycnonotus melanicterus* | 0 | 1000 |
| Lesser forktail *Enicurus velatus* | 0 | 2300 |
| ***Temminck's babbler *Trichastoma pyrrogenys* | 500 | 1300 |
| Crescent-chested babbler *Stachyris melanothorax* | 250 | 1500 |
| White-bibbed babbler *Stachyris thoracica* | 250 | 1600 |
| *White-breasted babbler *Stachyris grammiceps* | 600 | 3000 |
| Yellow-bellied warbler *Abrocopus superciliaris* | 150 | 1800 |
| Pale blue flycatcher *Cyornis unicolor* | 800 | 1150 |
| ***Spotted fantail *Rhipidura euryura* | 800 | 1500 |
| *Grey-headed flycatcher *Culicicapa ceylonensis* | 0 | 1700 |
| *Thick-billed flowerpecker *Dicaeum agile* | 0 | 700 |
| Violet-tailed sunbird *Aethopygia mystacalis* | 0 | 1600 |
| *Oriental white-eye *Zosterops palpebrosa* | 100 | 2500 |

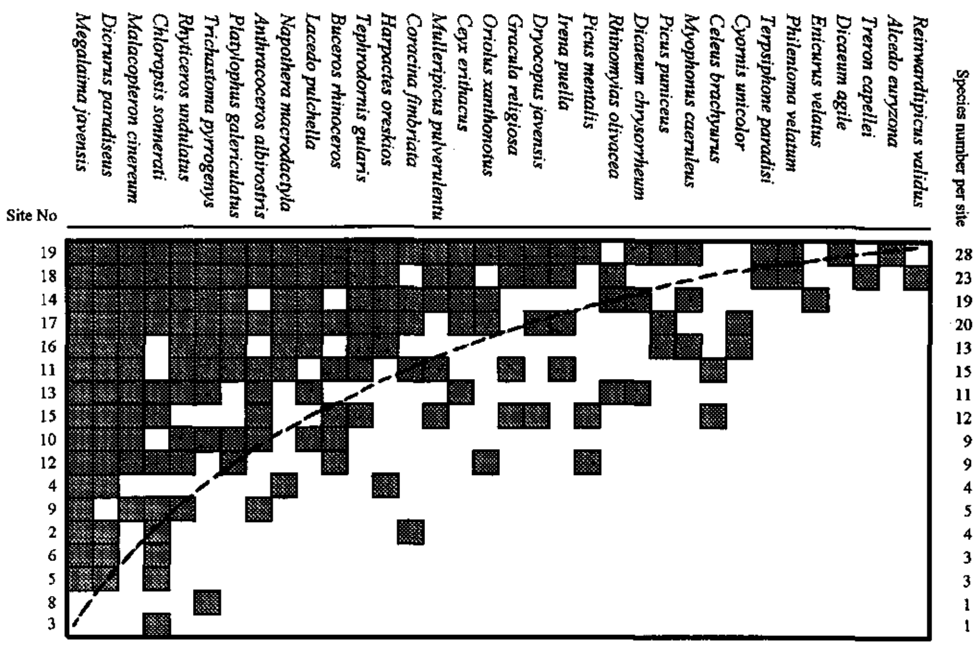



**Figure 4.4a** Nestedness matrix for Javan forest interior birds. Site numbers refer to the numbers in Figure 4.1.

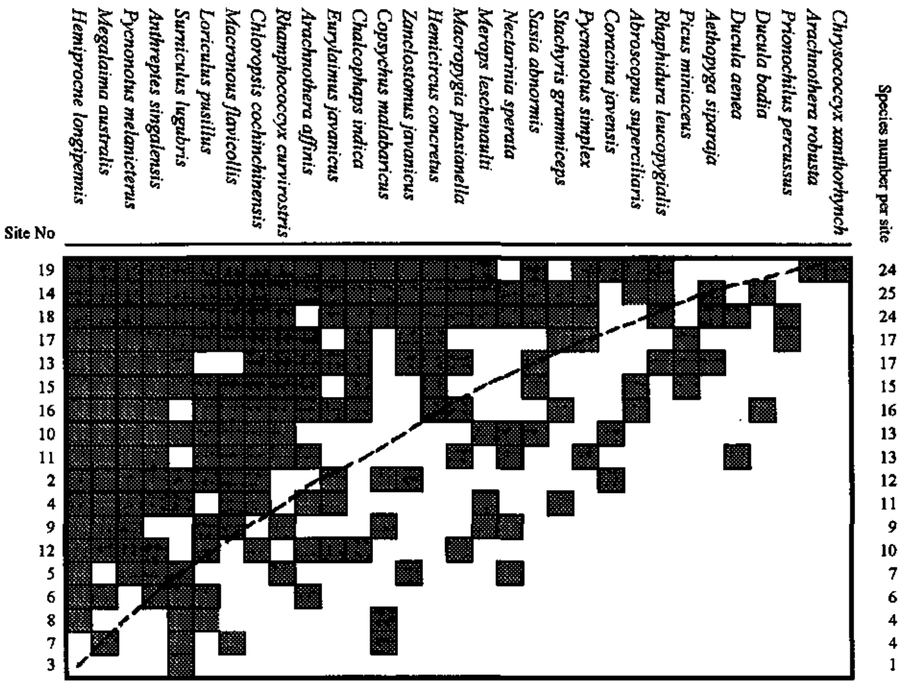



**Figure 4.4b** Nestedness matrix for Javan forest edge birds

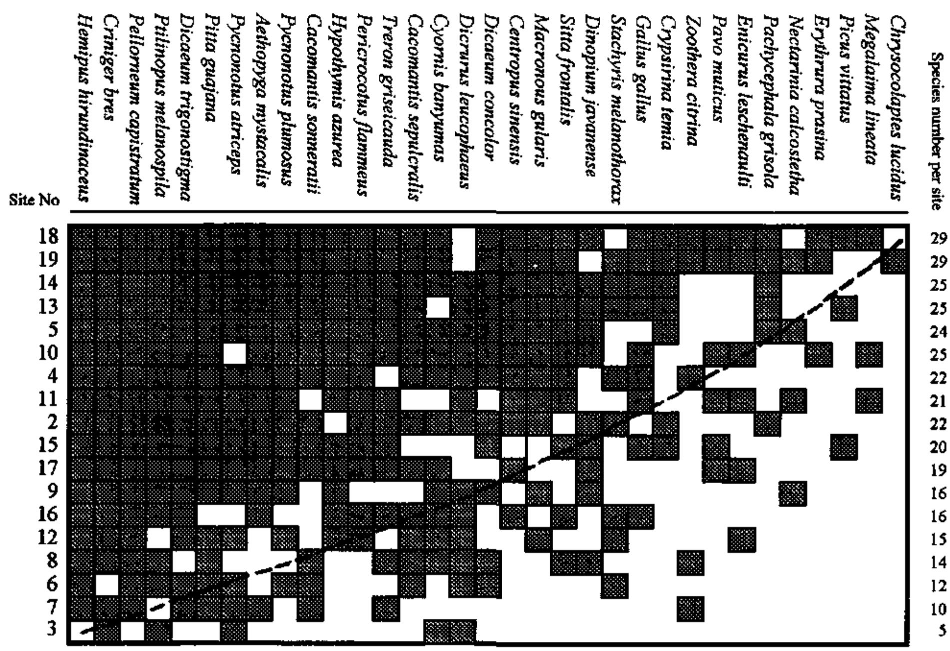



**Figure 4.4c** Nestedness matrix for Javan woodland birds

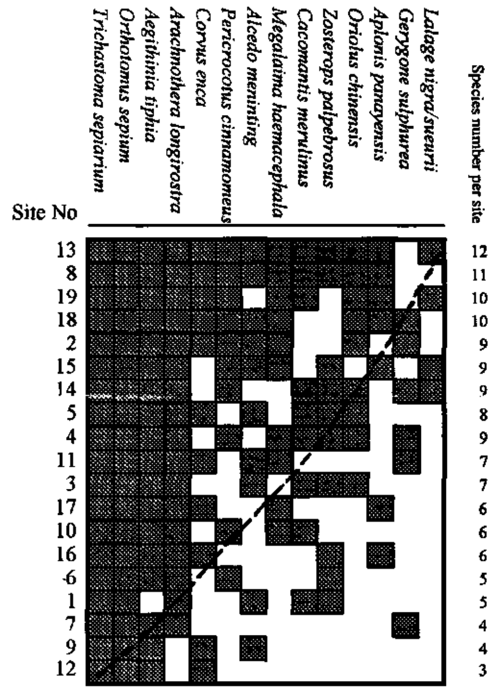



**Figure 4.4d** Nestedness matrix for Javan rural and urban birds.

## DISCUSSION

### Species richness and area

The Log N/log Area regression line for all species combined has a slope of z = 0.17 which stands near the top end of the range for non-isolates (Preston 1962). After splitting into four MHR classes I –IV the respective slopes appear to range between 0.002 for class IV (urban) species to 0.30 for class I (forest interior) species. With $z = 0.17$, class III species conform well to non-isolates. As shown by their high $z$-values the forest classes I and II are apparently effectively isolated by their own habitat restrictions.

The very different shapes of the curves in Figure 4.3 for the woodland birds (class III) on the one hand and the true forest birds (class I) on the other hand is explained by the dominance of the first mentioned in the smaller reserves with relatively more edge habitat. Lovejoy *et al.* (1986) found edge effects up to at least 100m inside the forest, with the result that the smallest reserves are completely affected. In the small fragments, edge species gain over interior species. In the intermediate reserves the true forest interior species become more abundant. The three classes curves are equally represented in forest stands >20-25,000 ha, as these are sufficiently large to support more complete assemblages of all classes.

### Nestedness

Ranking according to size, rather than species richness, is more informative if one is interested in how fragmentation is influencing patterns of species diversity (Cook 1995). In the programme provided by Atmar & Patterson (1993) this ranking order is not necessarily used in the matrix. In our data set, correlation between the two is, however, highly significant in classes I and II ($r = 0.88$, $p < 0.01$, and $r = 0.80$, $p < 0.01$) and significant in class III ($r = 0.44$, $p < 0.05$) and either should be suitable for our analysis of the first three classes. There is no significant correlation between the two in class IV ($r = 0.33$).

Atmar & Patterson (1993) pointed out that species occurrences close to the extinction threshold line and below this, are in "closest danger of extinction". Whilst our matrix data are solely based on the present situation, there are data from long before the present study that may support this. Diamond *et al.* (1987; Chapter 3 of this thesis) listed all birds ever recorded from the Bogor Botanical gardens. A large number of these have become extinct (almost one-third over the past 50 years), generally after extinction or decrease in the surroundings of the gardens. In Appendix 2 these species are shown under *h*. The three I and six II class species amongst these are of most relevance in our analysis. Plotting them in the appropriate nestedness matrices shows that class I species rufous-backed kingfisher *Ceyx rufidorsum*, blue whistling-thrush *Myophonus caeruleus* and hill mynah *Gracula religiosa* would have been positioned in the peripheries of the grey zone on the "dangerous" side of the extinction threshold line, and thus their demises agree well with the predictions deduced from the nestedness matrix. Of class II, however, only crimson sunbird *Aethopyga siparaja* is on the dangerous side, whilst *Chalcophaps indica, Phaenicophaeus curvirostris, Merops leschenaulti, Chloropsis cochinchinensis* and *Anthreptes singalensis* should have been safe. Another forest fragment with some historical records is Dungusiwul (Hildebrand 1939) where the malkoha *Phaenicophaeus curvirostris* and kingfisher *Ceyx erithacus* are recorded as lost. For this area only the kingfisher is (again) positioned below the extinction line.

The nestedness degrees for class I and II species fit well in the range reported by Atmar & Patterson (1995) for, respectively, birds in forest fragments ($x = 11.8^o$; s.d. = 2.5; $n = 9$; one extremely "hot" ($49^o$) and two extremely "cold" ($0.73^o$ and $1.3^o$) temperatures were discarded by me), and birds on land bridge islands ($x = 12.6^o$; s.d. = 4.9; $n = 7$). The class IV matrix fits in the range of those for oceanic islands ($x = 21.7^o$; s.d. = 12.4; $n = 15$). Class I and II species (that is interior forest and forest edge species) apparently conform more or less to relaxing land bridge islands, as could be expected because of their isolation, whereas class IV, and to less extent class III (respectively, rural/urban birds and woodland bird species) conform to oceanic islands characterised by species that can more freely move across.

The high proportion of non-conforming hill species may indicate a scattered distribution pattern in the peripheries of the lowland forest fragments and foothill outliers. No explanation seems readily available for the much lower proportion of non-conforming hill species in class II, but their better dispersal abilities and habitat tolerance may have countered the just mentioned disadvantage.

**Species of special concern**

Forest woodpeckers have seriously suffered from fragmentation on Java and most have only been found in the larger fragments. Woodpeckers have been found to be threatened not only by loss of habitat, but also by altered ecological relations and competition for nest cavities (Harris & Silva-Lopes 1992). Two species especially are now extremely rare on Java (buff-rumped woodpecker *Meiglyptis tristis* and orange-backed woodpecker *Reinwardtipicus validus*). The distribution of woodpeckers over the fragments suggests the existence of a threshold of fragment size above which more complete woodpecker assemblages appear. Fragments smaller than 2,500 ha have only one or two species, while those larger than this have six or more species. Perhaps some unknown interdependent relationships exist, where smaller woodpeckers depend on other, larger species for the excavation of nest holes, which in their turn depend on area size. Faunal cascades occur when areas become too small.

Another cause of an eroded, "hot" matrix is the almost unlimited trapping for the bird trade: straw-headed bulbul *Pycnonotus zeylanicus*, white-rumped shama *Copsychus malabaricus* and hill mynah *Gracula religiosa* are extremely popular cagebirds. Though still common in the first half of this century, now all of them are rare and very local, and the first recently became extinct.

**Nestedness and colonisation rates**

Hanski & Zhang (1993) report that species with intermediate migration rates persist best. Javan lowland forest species that are supposed to be nomadic include: large green pigeon *Treron capellei*, jambu fruit-dove *Ptilinopus jambu*, mountain imperial pigeon *Ducula badia*, chestnut-capped thrush *Zoothera interpres* and pin-tailed parrot-finch *Erythrura prasina*. There are no data on the fruit-dove in the fragments, whereas the thrush was omitted by me from further analyses because of its inconspicuousness. The other three species are very scarcely distributed across the forest fragments. The high rank in the nestedness matrix of these species and nestedness degrees of both pigeons suggest higher extinction proneness of (local) migratory species, rather than persistence because of intermediate migration rates.

No significant correlation was shown between the ability to colonise the Krakatau Islands and fragmentation vulnerability. However, an increasing degree of vagility is indicated by an increasing proportion of potential small island colonisers, in a series progressing from class I to class IV. This may partly explain a decreasing degree of nestedness, as none of the true forest species, only one of the five vagile forest edge species (*Ducula aenea*), none of the woodland, but three out of six rural/urban species (*Lalage nigra, Gerygone sulphurea, Zosterops palpebrosa*) are non-conforming species, with nestedness degrees $>T$.

**Conservation implications**

All reserves smaller than 10,000 ha combined (in total 23,743), that is 18 % of the total surveyed area, account for 127, or 92 % of the forest bird species encountered (see Appendix 2). This is more than in any of the reserves larger than 10,000 ha. This would support Simberloff & Gotelli's (1984) statement that several small reserves contain more species than one large. This would, however, largely pertain to birds belonging to slightly nested communities. Species of classes I and II, which are fully dependent on forest cover, have some of the rarest species amongst them, occurring in only one or two of our largest sites. Here the importance of nestedness is clear, as pointed out by Cook (1995), who showed that some species can be rare regionally, even in species-rich (= largest) sites. The forest edge species and those of the interior need much larger reserves, though even the largest do not even seem to contain all possible lowland species. Speaking in nestedness terms: the colder, and more packed the matrix becomes, the more the "Single Large Or Several Small" debate is in favour of larger reserves: fifteen species (12 class I and 3 class II spp) do not occur in the reserves smaller than 10,000 ha (see Appendix 2). Figure 4.5 shows the accumulative species numbers plotted against accumulative area of the studied fragments. Secondary growth species (class III & IV) are entirely assembled in a combined reserve area smaller than 5000 ha. Only the total combined area is large enough to contain the entire assemblage of true forest species.

These results demonstrate that a system of only small reserves is apparently not adequate to preserve the entire Javan forest avifauna and emphasise the importance of large reserves. Nestedness patterns of the species show that with ongoing relaxation of species numbers in the forest reserves, the number of species not contained in smaller reserves may increase. Nevertheless, the smaller reserves could play an important role as stepping stones and thus ameliorate the consequences of forest fragmentation and isolation for a number of bird species.

The remaining lowland forest is scattered over many much smaller reserves and forest pockets, from which a proportion of forest bird species are destined to drop out sooner or later, as predicted from the matrices. Classes 1 and 2 of true forest birds, constituting a

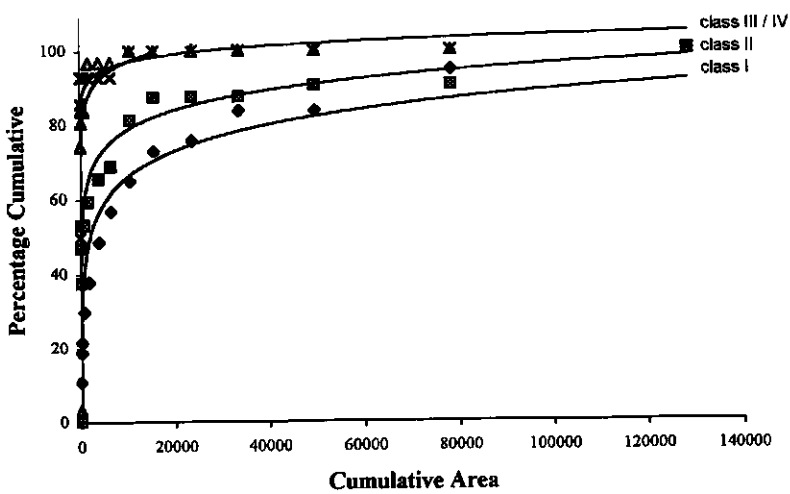



**Figure 4.5** Cumulative percentages of species occupation and cumulative area.

large proportion of the entire avifauna, will be particularly hard hit. It is very important to preserve as much as possible of the remaining lowland forest, of which only 50 % is contained in reserves (Table 4.1). Large areas of secondary forest should be secured to allow development of climax tropical rain forest, such as Gunung Pangasaman lowland forest (34,000 ha) in west Java, or various secondary forest areas along the bay of Pelabuhan Ratu, with its extremely rich avifauna. Although many of these areas are now being considered as nature reserves, they remain directly threatened by illegal wood cutting, poaching and agricultural encroachments. Furthermore, the restoration of various habitats, such as planted forest under the jurisdiction of the Forestry Department, reforestation projects (Gunung Kidul, Gunung Walat) should be encouraged.

## CONCLUSION

Species distributions across the nestedness matrices are not always unanimously explained. Patterson (1990) pointed out for plants that colonising causes nestedness at first, which is then followed by decreased nestedness erosion; therefore in some cases nestedness has been greater in the past than at present. Colonisation and extinction processes are closely intertwined and multiple equilibria make it difficult to predict occurrence of species in fragmented landscape (Hanski *et al.* 1995). As we saw above, colonisation ability can not explain a hot matrix, e.g., caused by the occurrence of outliers, though its effect may be largely compounded by less vagrant, but equally less isolated species as they are capable of dispersal through suitable habitat. On the other hand, a highly nested matrix was partly explained through extinction processes. At least differentiation between different habitat tolerance classes should adequately explain some patterns in nestedness. Birds with good chances of survival outside the forest reserves will persist longer in even the smallest reserves and would be able to survive in plantations, urban forest and other matrix habitat, and are thus of less importance with regard to reserve management.

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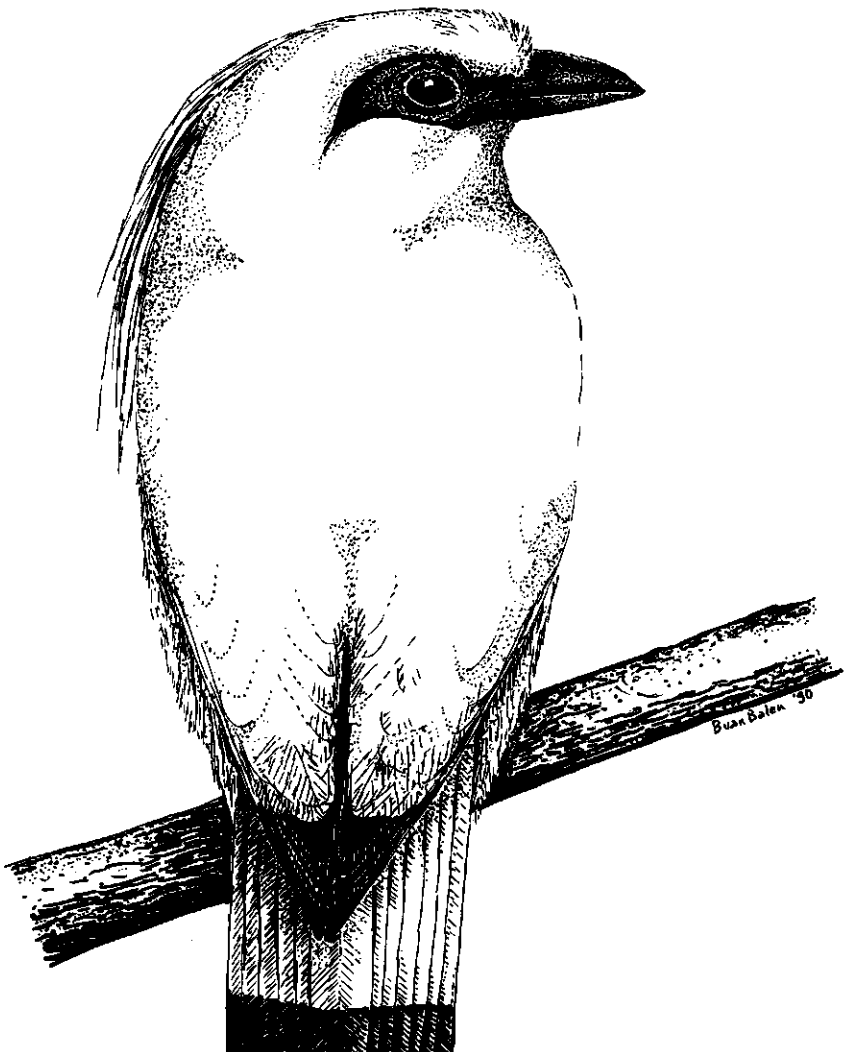

Chapter 5

# Status and distribution of the endemic Bali starling *Leucopsar rothschildi*

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Oryx [accepted]

**Abstract**
The Bali starling *Leucopsar rothschildi* is a passerine endemic to the dry monsoon forest of the island of Bali, Indonesia. Habitat conversion and excessive trapping for the pet trade brought the species to the verge of extinction in the 1980s. The species is critically endangered because of 1) an extremely small population size, 2) restriction to a small area, 3) illegal trapping, and 4) small amount of suitable habitat left within its natural range. An intricate web of factors prevents the Bali Starling from emerging from this precarious situation.

## INTRODUCTION

The Bali starling (Bali or Rothschild's mynah) *Leucopsar rothschildi* represents a monotypic genus which is endemic to the island of Bali (Indonesia). Habitat destruction and capturing for the pet trade brought the species to the verge of extinction. In 1990 and, after a temporary recovery, in 1998 the species was at an all time low number of less than 15 individuals, restricted to the Bali Barat National Park (van Balen & Gepak 1994; I. Z. Mutaqin verbally 1998).

On account of its restricted range, its extremely small numbers in the wild, and pressures on the last free-ranging birds, the Bali starling is considered critically endangered according to the newest IUCN threat categories (Collar *et al.* 1994). In this paper we made a reconstruction of the species' historical distribution and decline. We also report current population trends and evaluate the possible factors that induced the population crash and those that are likely to inhibit recovery of the population.

## METHODS

### Literature study

A number of reports on Bali starling distribution have been consulted (see van Balen 1995a). Figures obtained between 1974 and 1984 on the population size of the Bali starlings have been interpreted with caution, as these refer to partial inventories, i.e., counts of only a restricted number of roosts. For the re-assessment of the population estimates between 1974-1984, the intensity of surveying, coverage, dispersal behaviour of the Bali starling and contemporary weather conditions have been taken into account.

**Population censuses**

In 1984 the Indonesian Department of Forest Protection and Nature Conservation (PHPA), in co-operation with BirdLife International (then ICBP) started monitoring the wild population on a regular basis. The census method was standardised (van Balen 1995b), based on a counting method already in use by the Bali Barat reserve managers (I M.S. Adi verbally). Until 1991 one annual census of the wild population was made at the end of the dry monsoon (September-October), when the birds associate in roosting flocks. During the recovery of the wild population (see below) a second annual post-breeding census was introduced, immediately after the last young birds had fledged (May or June) and coinciding with the first weeks of the dry monsoon. This provided data on population dynamics, in particular the relationship between fledging success and population size. Each census extended over a period of four days. Dusk and dawn counts lasting 2.5 hours each were made by 9-18 teams of two to three experienced park wardens. Each team was posted at a strategic position near roosting sites, or along flight routes to and from these sites. These sites were identified during reconnaissance visits one or two weeks prior to each census. Numbers of in-going and out-going birds and passers-by, flight direction, times of observation and weather conditions, were recorded on standard forms. To monitor dispersion and range expansion, which might occur with increasing population size, we conducted surveys outside the presently known range. These concentrated along the north and south coast of west Bali and preceded the pre-breeding census when the birds were maximally dispersed.

**Interviews**

M. W. Adi Putra took semi-structured interviews with local people living within the historical range of the Bali starling. Fifty respondents of 25 years and older were questioned about the occurrence, numbers and time of extirpation of Bali starlings in their area. Additional information was requested about habitat, seasonality in distribution and roosting sites.

## HISTORICAL SYNOPSIS

**Pre 1935. Early distribution and numbers**

Stresemann (1912, 1913) collected the first Bali starling known to science near Bubunan, from where its range ran in westerly direction (Figure 5.1). Its habitat was described as "dry savannah and shrub woodlands", and "tall and dense forest" in the 1920s (von Plessen 1926; van der Paardt 1926), historically restricted to a narrow belt of dry monsoon climate (Walker *et al.* 1980). Monsoon forests exist where there are

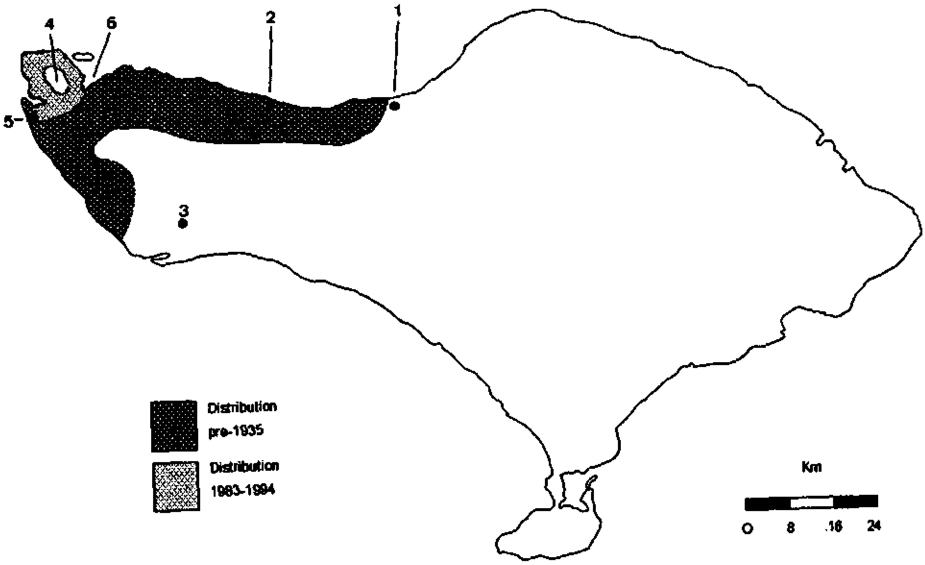


**Figure 5.1** Distribution of Bali starlings, 1911 – 1998 (1: Bubunan; 2: Gerokgak; 3: Negara; 4: Prapat Agung Peninsula; 5: Gilimanuk; 6: Teluk Terima).

several dry months (each with <60 mm rainfall) annually. They are mostly deciduous, although perhaps only briefly, have less climbers and epiphytes, and are less species rich (Whitmore 1984). In the beginning of this century this forest type was largely undisturbed in the unpopulated north-western part of Bali, and only sporadically interspersed with alang-alang *Imperata cylindrica* fields in particular along the north coast (von Plessen 1926). In the 1920s the Dutch colonial government leased out 600 ha for kapok *Ceiba pentandra* and coconut *Cocos nucifera* in the Teluk Terima area, in the center of Bali starling distribution and now National Park territory.

Reports from 1914-1926 mention the low densities of Bali starlings in the northern coastal areas of western Bali in February-July, but large numbers in September-November, towards the end of the dry monsoon, throughout NW Bali, including Gilimanuk on the west coast. Hundreds of Bali starlings visiting an abandoned papaw *Carica papaya* plantation in the Teluk Terima area (von Plessen 1926), and flocks of 30 and more birds were seen throughout the entire northwest of Bali in October-November. They foraged solely on fruiting shrubs of *Lantana camara* (Van der Paardt 1926) which, ironically, is a naturalised pest from tropical America (Backer & Bakhuizen van den Brink 1965). Bali starlings occurred in small numbers in the higher parts of the hills in the interior of west Bali (von Plessen 1926). The north coast of west Bali was the centre of the species' distribution, and numbers declined sharply in easterly and southerly directions. Although he travelled extensively throughout the rest of Bali, von Plessen (1926) failed to see the species anywhere else. These observations were confirmed by reports from local people.

West & Pugh (1986) gave a rough population estimate of 300 to 900 birds for wild Bali starling at the time of the discovery. They based this number on the reduction of the species' range, assuming a density similar to those reported over the last decade. Although the Bali starling appears to have always been scarce, this estimate is likely to be far below the real numbers, considering the starling's range which was larger than was thought before, and the huge numbers of birds that were captured and exported between the 1960s and 1980s (see Table 5.1).

**1940-1974. "The Exodus"**

Forests on Bali and Java continued to shrink rapidly during this period (Smiet 1992; Whitten *et al.* 1996) and settlements started to enter the Bali starling's range. In 1947 the Bali Barat game reserve was established theoretically securing a large part of the species' range. However, the Margasari social forestry project was established in 1970 within the game reserve. No information is available from the wild in this period, which is characterised by a general lack of ornithological activities throughout the Indonesian archipelago (Junge 1953; Jepson 1997). The trade in wild Bali starlings reached its height in the early sixties and seventies when hundreds of birds were put on overseas transports (van Bemmel 1974; Seibels & Bell 1993). Table 5.1 lists a number of important events in Bali starling trade (undoubtedly the "tip of the iceberg"). Many Bali starlings were imported even after the species was put on Appendix 1 of CITES in 1970, and received protected status by Indonesian law in 1971.

**Table 5.1** Selected events in the history of Bali Starling *Leucopsar rothschildi* trade.

| | |
|---|---|
| 1928 | First five Bali Starlings exported to Europe, which bred in captivity three years later (Ezra 1931). |
| 1960-1962 | Large imports appeared in Europe: one single assignment of 50 birds reported from UK (Harrison 1968). |
| 1969 | Birds found in eleven countries throughout the world, e.g., USA, Sri Lanka, Hong Kong, Belgium (Spilsbury 1970). |
| 1969 | Official reports of 55 birds refused, and another shipment entering the USA despite the banned importation after the Endangered Species Act in the same year (King 1974). |
| early 1970s | Hundreds of birds transported into Europe, the majority in hands of malevolent aviculturists (Morrison 1981). Illegal railway transport of 200 Bali Starlings confiscated in Jakarta (Kamil Oesman verbally 1994). |
| 1972 | 30 birds counted in Singapore bird park (Morrison 1981). |
| 1976 | 15 birds in Surabaya bird market for export to Singapore through Jakarta (Suwelo 1976). |
| 1979 | Nine birds in seen in Singapore bird park; never less than 19 encountered in the local shops for sale (Morrison 1981). |
| 1982 | 16 seen together in cages in Denpasar, the property of one man; trappers seen active in one of the main roosts in Bali Barat (Ash 1984) |

**1974-1983. The decline**

Accounts of local people indicate that the conversion of monsoon forest to agricultural land had a negative impact on Bali starlings. Nevertheless, there are reports of Bali starlings occurring in man-made environments and even of Bali starlings breeding in coconut groves (Hayward *et al.* 1980). Bali Barat received the status of national park in 1982.

Fifty years after its discovery the first information on Bali starling numbers became available. Time and budget constraints resulted in estimates that are extrapolations from censuses of known roosts rather than comprehensive censuses. Population estimates were made almost annually and Tables 5.2 and 5.4 give population estimates between 1974-1980. It should be remarked that spring counts were most likely boosted by fledglings, whereas the autumn counts were taken after the dry season, when most of the annual mortality had occurred.

Interestingly Bali starlings were found in fair numbers at places (notably Manistutu) where von Plessen (1926) failed to observe any. The figures also show that on the periphery of distribution, where most of the poaching took place, numbers rapidly shrunk. Interviews with local people made clear that in the 1960s the Bali starling largely disappeared from the southern part of its range and in the 1970s from the northeast.

**1983-1994. Bali Starling Project**

From 1983 to 1994 the species has been the subject of a conservation programme, called the Bali Starling Project (BSP). Its range had shrunk to the fire-induced open shrub and savannah woodland, found below an elevation of 150-175m in the north-eastern part of peninsular Prapat Agung. The open woodlands were dominated by *Acacia leucophloea* trees with an undergrowth of *Lantana camara* and *Eupatorium* shrubs and *Imperata cylindrica* grass, and intersected by moister and more densely forested valleys with dominant trees *Grewia koordesians, Vitex pubescens, Borassus* and *Schoutenia*. This vegetation type might however be sub-optimal habitat for the Bali starling in which it had been "pushed" by poaching pressure. Movements between roosts and foraging sites increased towards the end of the dry season when food resources ran short. Distances of up to 5-6 km were recorded when part of the birds dispersed in groups of 20-30 into the open mixed forest edge and flooded savannah woodland in the southern parts of the Prapat Agung peninsula. Breeding (December-April) was restricted to an area of 500 ha and nest sites were taken in trees in the above-described valleys. Non-breeding and immature birds also roosted in this area, but covered larger distances (up to 2-3 km) to forage. Table 5.3 gives the results of twelve censuses conducted in 1984-1994. Each of these was based on six counts on consecutive days. The original estimates of totals have been revised by taking into account possible movements between roosts and double counts. The censuses show that Bali starlings have disappeared from areas where they occurred only ten years before.

After a crash of the Bali starling population that started in the early 1980s and which almost completed the extinction of the species in the wild, the population recovered in 1991-1992. This was mainly due to improved and effective protection of the park, in addition to favourable weather conditions, which greatly enhanced breeding success (van Balen & Gepak 1994; see Chapter 6 of this thesis). Figure 5.2 shows numbers of the wild population and numbers of birds that fledged. After 1992 breeding was good, but did not result in an increase of the population. Evidence of bird catchers in the park indicated that poaching was the main cause.

**Table 5.2** Distribution and numbers of Bali Starling numbers across west Bali, 1974-1980

| Year | 1974[1] | 1975[2] | 1976[3] | 1977[4] | 1979[5] | 1979[6] | 1980[7] |
|---|---|---|---|---|---|---|---|
| Month | Oct | Feb | Sep | Jan | Mar/Apr | ? | Aug |
| 1. Cekik | - | - | - | - | 2 | 2 | 2 |
| 2. Sumber Batok/Klampok | 40 | 40 | - | x | 4 | - | - |
| 3. Tegal Bunder/Sawo Kecik | 2 | 20 | 35 | x | - | 5 | 10 |
| 4. Teluk Lumpur | - | - | - | - | - | 36 | 25 |
| 5. Prapat Agung | 2 | 18 | 0 | x | 25 | 39 | 43 |
| 6. Batu Licin | - | - | - | - | - | - | - |
| 7. Lampu Merah | 13 | 13 | - | x | 26 | 7 | 16 |
| 8. Teluk Kelor 42 | - | - | x | 9 | 26 | 41 | |
| 9. Batu Gondang | [32] | 36 | 21 | x | 11 | 11 | 10 |
| 10. Teluk Brumbun | - | 12 | - | - | - | 12 | 6 |
| 11. Tanjung Kotal | - | - | - | - | - | 2 | 21 |
| 12. Tanjung Gelap | - | 9 | - | - | - | - | - |
| 13. Teluk Terima | 6 | 7 | 10 | x | - | 7 | 6 |
| 14. Banyuwedang | 13 | 15 | 82 | x | 7 | 18 | 19 |
| 15. Krapeyak | - | - | - | - | - | 2 | - |
| 16. Sumber Batok | - | - | - | x | - | 5 | 8 |
| 17. Sumberrejo | - | - | 5 | - | - | - | - |
| 18. *Munduk Tumpang | - | - | - | - | - | - | - |
| 19. *Pulaki | - | 5 | - | - | - | 7 | - |
| 20. *Grokgak | - | - | - | - | - | 2 | 11 |
| 21. *Tegalunan | - | - | - | - | - | 2 | - |
| 22. *Yeh Embang | - | - | - | - | - | 5 | 9 |
| 23. *Penyaringan | - | - | - | - | - | 28 | 22 |
| 24. *Manistutu | - | - | 25 | - | - | - | - |
| Estimated Totals: | 100 | 100 | 200 | 125 | 110 | 175 | 200 |

Sources: 1. Sungkawa *et al.* 1974; 2. Natawiria *et al.*. 1975; 3. Suwelo 1976, 4. Sieber 1978; 5. de Iongh *et al.* 1979; 6. Hayward *et al.* Oxford Expedition, unpublished data 1980, 7. van Helvoort *et al.* 1985. *outside Bali Barat National Park.

**Table 5.3**. Distribution and mean numbers of Bali Starlings, 1984-1994

| Year | 1984 | 1988 | 1989 | 1990 | 1991 | 1991 | 1992 | 1992 | 1993 | 1993 | 1994 | 1994 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Aug | Oct | Sep | Oct | May | Sep | Jun | Oct | Jun | Oct | Jun | Oct |
| 2 Sumber Batok/Kelampok | - | - | - | 4 | - | - | - | - | - | - | - | - |
| 3 Tegal Bunder/Sawo Kecik | 48 | 5 | 2 | - | - | - | - | - | - | 2 | - | - |
| 5. Prapat Agung | 18 | 7 | - | - | - | 20 | 9 | - | - | - | - | - |
| 6. Batu Licin | 2 | 2 | - | - | - | - | - | - | - | - | - | - |
| 7. Lampu Merah | - | 2 | 3 | - | - | - | - | - | - | - | - | 2 |
| 8. Teluk Kelor | 8 | 12 | 5 | 5 | 4 | 4 | 31 | 19 | 18 | 14 | 8 | 3 |
| 9. Batu Gondang | 6 | - | 13 | 2 | 27 | 10 | 7 | 18 | 4 | 13 | 19 | 10 |
| 10. Teluk Brumbun | - | 3 | - | 3 | 7 | - | 6 | 4 | 19 | 4 | 6 | 2 |
| 11a Tanjung Kotal/Kelompang | 2 | - | - | - | - | - | 2 | 4 | 4 | 2 | 7 | 8 |
| 12. Tanjung Gelap | 2 | - | - | - | - | - | - | - | - | - | - | - |
| Total | 86 | 31 | 23 | 14 | 38 | 34 | 55 | 45 | 45 | 33 | 40 | 25 |
| N valid counts | 6 | 5 | 6 | 5 | 5 | 6 | 5 | 6 | 5 | 5 | 5 | 5 |

Sources: B.E. van Helvoort & M.N. Soetawidjaya, unpubl. data; van Helvoort, 1990; van Balen & Soetawidjaya, 1989-1991; va Balen *et al.* 1990; van Balen & Jepson, 1992; van Balen & Dirgayusa, 1993-1994.

### 1994 to date. Post-BSP

In 1994 the Bali Starling Project was continued by the Bali Barat National Park management as sole executors of the field programme. The dwindling population was monitored closely though the 1994-1995 and 1995-1996 censuses were limited to once a year (Suryawan 1996; PHPA/BirdLife International-IP, 1997). On two occasions in 1998 six birds were released (I.Z. Mutaqin & Samedi verbally 1998).

**Table 5.4** Population estimates of the wild Bali Starlings..

| Year | Month | Population Estimate | | | References |
|---|---|---|---|---|---|
| | | Pre | Breeding | Post | |
| 1974 | Oct | 100 | - | - | Sungkawa *et al.* 1974 |
| 1975 | Feb | - | - | 68-144 | Natawiria 1975 |
| 1976 | Sep | 175 [+ 25] | - | - | Suwelo 1976, |
| | Dec/Jan | - | >127 | - | Sieber 1978 |
| 1977 | Aug/Sep | 110 | - | - | Alikodra 1978 |
| 1979 | Mar/Apr | - | - | 150-200 | de Iongh 1982 |
| 1980 | Aug | >207(+22) | - | - | J.R. Hayward *et al.* (Oxford Expedition unpublished data |
| 1981 | Oct | 254 | - | - | I M. Sutaadi (Bali Barat NP), unpublished data |
| 1983 | Oct | 142 | - | - | J Rustandi (PPA/Denpasar), unpublished data |

## CAUSES OF DECLINE

### Habitat conversion

Conversion into coconut and kapok plantations, and settlements replaced most of the former habitat of the Bali starling. Dry hill and lowland forest shrunk from an original area of 3,550 km2 to 600 km2 (MacKinnon *et al.* 1982). Agricultural lands and a village form enclaves within BBNP and it is estimated that about one third of the ca 10,000 ha of suitable Bali starling habitat in the park has been converted into settlements and plantations (Wind 1991). Also today development projects for tourism and the improvement of Bali's infrastructure pose a threat to BBNP's already affected integrity. Outside the national park, the areas inhabited by people along the north and south coast of west Bali had Bali starlings until as recently as the mid-1980s. Development of these areas is, however, proceeding very rapidly and most of it may be unsuitable already.

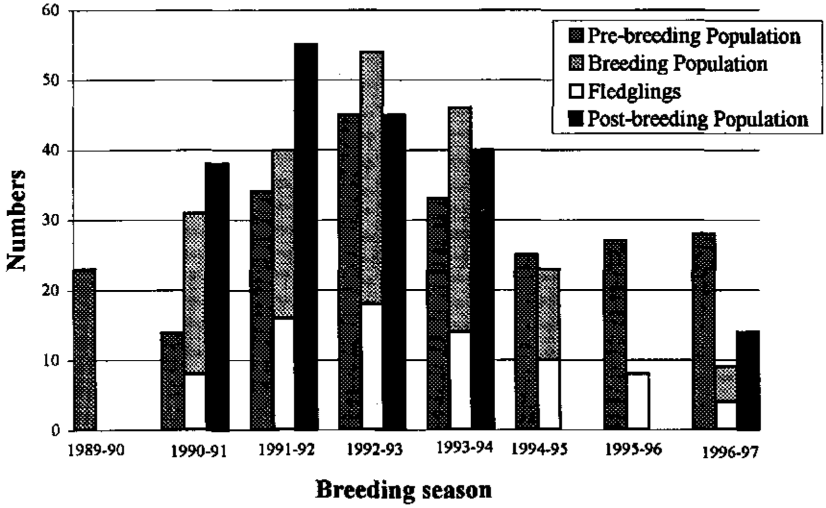


**Figure 5.2** Numbers of wild birds and fledglings in 1989-1997; in 1989-1990, 1994-1995 and 1995-1996 no spring censuses have been conducted (after PHPA/BirdLife 1997).

Early observations of the species' erratic occurrence suggest seasonal movements. Von Plessen (1926) observed Bali starlings in the mountains between May and July, coinciding with the end of the breeding season, before the birds normally disperse from their breeding grounds. This may suggest the occurrence of birds breeding in the hills, as is supported by several nesting pairs of Bali starlings found far inland on foot hills north and east of Negara until the mid-1980s (M.W. Adi Putra this paper). Especially towards the end of the dry season the birds seemed to concentrate in coastal areas, where they had been absent during the wet season (van der Paardt 1926; von Plessen 1926). Since then most of the Bali starling's former habitat has been irreversibly lost to agriculture. This raises the question whether and to what extent the present habitat fragmentation has disrupted the movements between nesting grounds and "wintering" quarters. It may be necessary to restore habitat ranging from the coastal area to the interior hills, and take this into account in reforestation projects that are planned for Bali. A large part of the above-mentioned areas has the status of Protection Forest and has been proposed as an extension of ca 58,000 ha to the national park (MacKinnon *et al.* 1982). At present the unclear legal status has resulted in weak protection and general deterioration of the habitat due to human activities.

### Illegal trapping

The losses resulting from trapping have been severe during the past three decades. Even in the early 1970s trading took place at a large scale despite national and international bans. At present capturing is mainly to meet the demand for wild-caught birds within Indonesia. Capturing the wild starlings was traditionally accomplished with the use of birdlime and decoys. Birds were also taken out of their nest holes, preferably done during the night. However, more recently mistnets are used and the poachers are reportedly well equipped with telescopes and walkie-talkie's. Poachers are known to come from the enclave village and mainland Java. Prices of up to US$ 130 for a live bird in 1982 have been reported (Ash 1984), and nowadays prices of US$ 2000 or more are being paid for the birds on the black market (PHPA/BirdLife IP 1997). Prices as these are strong incentives to catch Bali starlings from the wild that make stopping the illegal trapping and trade extremely difficult.

The importance of efficient protection of the park has been made clear on one hand by the increase of Bali starling numbers as the consequence of a temporary new life blown into the protection and management of Bali Barat in the late 1980s. A second increase in 1991-1992 was also the result of a temporary relief from poaching and favourable weather conditions. On the other hand during the period the zero growth of the population during the otherwise successful breeding seasons of 1992-1993 and 1993-1994 was the result of largely uncontrolled poaching.

## FACTORS LIMITING RECOVERY

### Climate

The rainy season in the north west part of Bali has from December to April, and the dry season from June to October (Sandy 1987). Shifts by several months are known, e.g., in 1991 and 1993, when the rainy season extended until June/July. Figure 5.3 shows the rainfall pattern of this part of Bali. Bali starlings breed only during the wet season. The onset of the rains triggers the development of young leaf sprouts and foliage-consuming caterpillars, items which form the main diet of the nestlings during the first weeks (Cahyadin 1992).

A breeding cycle can be completed in 57 days (van Helvoort *et al.* 1985). This means that in a wet season of 6-8 months three broods can be raised, but fewer in shorter rainy seasons. Whilst poaching and habitat destruction have been the major factors to the Bali starling's decrease in the wild, the unpredictability of the climate in the region present an extra risk factor that has to be taken into account. The long droughts associated with El Niño Southern Oscillations (ENSO) are known to have an especially deleterious impact on the populations of both seabirds and land birds (Schreiber 1994). Indeed, the ENSO of 1982/83 and that of 1986-1987 coincided indeed with 50% collapses in numbers of wild Bali starlings. Prolonged ENSO influenced periods of drought were also prevalent during the years 1989 through 1990, when Bali starling numbers nearly dropped to zero. In these years hardly any breeding took place and only two fledglings were observed in the first quarter of 1989 (van Balen et al. 1990).

Day and night temperatures differ to the extent that dew formation is substantial. It is believed that during the dry season the Bali starlings in the driest areas largely depend on this when no other water resources are available (van Helvoort 1990). Circumstantial evidence shows that the starlings sometimes take brackish seawater in the mangrove bushes along the coast (I M. Suta Adi verbally). Distribution of Bali starlings in the dry season is believed to be influenced by the distribution of available water sources, and attraction to waterholes makes them vulnerable to capturing.

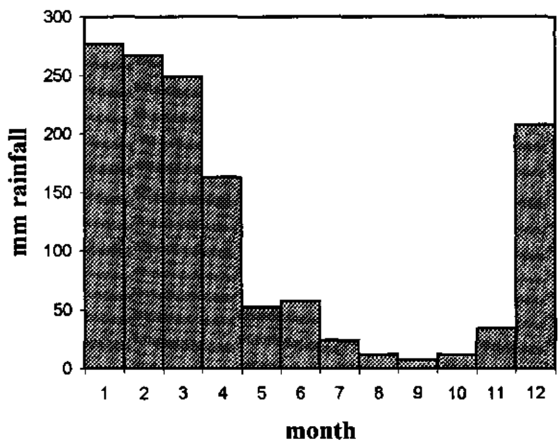


**Figure 5.3** Average rainfall in northwest Bali (data taken from the Gerokgak Weather Station (after Sandy, 1987)).

**Nest hole availability**

Due to a long history of timber collection and local forest fires, there is a limited number of large trees offering suitable nest sites in peninsular Prapat Agung. Therefore, in 1984-1986, 96 nest boxes and excavated logs were installed to offset the presumed shortage of natural nesting sites in the park (van Helvoort *et al.* 1986). However, only black-winged starlings *Sturnus melanopterus*, geckos Gecko sp., ants and wild bees were found to use these (van Balen *et al.* 1990). Further provision of artificial nests has been discontinued until a fuller understanding of the Bali starling nest hole selection process is established. Moreover, numbers of wild starlings are very low now, and nest hole availability may become a limiting factor only when the population recover substantially.

**Inter-specific competition**

The black-winged starling, endemic to Java and Bali and believed to be closely related to the Bali starling, is considered a possible competitor for food resources and nest holes (Sieber 1978; Hartojo & Suwelo 1987). Aggressive behaviour between the two species was observed in the breeding season (Natawiria 1975), but it was black-winged starlings that were chased away by Bali starlings from the latter species' breeding territory (Y. Cahyadin verbally) The black-winged starling is a typical open woodland bird and was reported as being very scarce in west Bali in times when forest cover was still extensive and the Bali starlings numerous (von Plessen 1926). Both species met mainly towards the end of the dry season when mixed flocks were reported foraging on the berries of the Lantana camara shrubs (van der Paardt 1926;

Natawiria 1975). It has been suggested that because of the recent disappearance or increasing scarcity of certain preferred local fruit trees, and the serious disruption of the closed forest habitat, the more arboreal Bali Starling is being crowded out by the black-winged starling in the changed environment (Sontag 1991, 1992). Ironically, the black-winged starling has itself become scarce in the area as a result of excessive illegal trapping for the bird trade, and competition has become irrelevant.

**Small population size**

In a very small population inbreeding is inescapable and, as it generally affects fecundity (Senner 1980) and fitness/adaptability (Allendorf & Leary 1986), it frequently increases a population's vulnerability to a changing environment. Moreover, natural disasters, such as extended drought, wild fires and disease epidemics could easily wipe out a small isolated population in one stroke.

A new technique known as the population viability analysis (PVA) has become a central component of a number of recent recovery efforts (Scott *et al.* 1994). Whilst numbers in the wild were down below 20, calculations at the 1990 Bali Starling PVA Workshop suggested a 100% probability of extinction within a year if no action was undertaken. The (partly) successful release of captive-bred birds (van Balen & Gepak 1994) in April 1990, increased protection of the park, and favourable climatic conditions resulted in a temporary recovery in the following two years.

An effective population size has been suggested of not less than 50 in the short term, and 500 in the long term, below which numbers inbreeding would become unacceptably high (Franklin 1980). An effective population size of 500 birds would require a roughly estimated population of 1000 birds, assuming 50% of the birds are contributing to the breeding pool (Seal 1990). This number, if distributed over several wild sub-populations in secure areas on Bali, is believed to be sufficient to ensure the Bali starling's viability. Natural habitat has become scarce and reforestation as well as effective forest protection throughout its range is needed to provide enough area to support this number (Wind 1991). There are also proposals to establish feral populations of Bali starlings in suitable tourist areas elsewhere on Bali (P.R. Jepson verbally).

**Genetic erosion**

Van de Paardt (1926) reported that Bali starlings "keep shunning people; as soon as village huts appear, the number of birds decline; they are noticeably pushed back by Man". This is in contrast with more recent accounts of birds breeding in coconut groves adjacent to villages (van Helvoort et al. 1985). It may indicate that the Bali starling has been in an assimilation process before it was pushed back by poaching to its present refuge. Adaptive abilities seen in urbanising forest birds in Papua New Guinea (Diamond 1986), or the European blackbird *Turdus merula* in European cities may be genetically determined (Gehlbach 1988). Captive stock in USA and Europe originates largely from birds imported in the early seventies, when Bali starlings were still relatively abundant. Within easy reach of villages and human settlements, they were thus more susceptible to poaching. Would it be possible that more Bali starlings with, than without, genes for a more adaptive character have been caught away from the wild population in the early seventies? And that in the wild a depauperate population remained lacking this adaptability and doomed to being locked up in a still shrinking habitat patch?

**Skewed sex ratio**

Poachers often obtain their birds at night during the breeding season, when females are in the nest holes, and males hold guard in a nearby tree, safe from poachers (Sieber 1983; I.Z. Mutaqin verbally). Indeed, a higher proportion of female than male birds is known to have been exported to the USA in the 1960s (R.E. Seibels verbally). The resulting skewed sex ratio in the wild is suggested by field observations of three released, captive-bred females paired to wild males (M.N. Soetawidjaya verbally 1990; Cahyadin 1992; I.Z. Mutaqin verbally 1998), whereas no reverse cases are known. Moreover, breeding activity had ceased almost entirely in the years prior to the 1990 releases (van Helvoort verbally).

The negative impact of sex-skewed capturing in small populations is clear. Franklin (1980) pointed out that an unequal number of sexes would give a smaller effective population and thus increased genetic drift. This then causes inbreeding depression, random change in phenotypes and a decrease in genetic variance.

**Weak law enforcement**

Protecting the Bali starling from the illegal trade seems straightforward and simple. At the "source" end of the trade chain the birds are found in a very small area. At the "sink" end the situation is far less surveyable, but huge penalties exist (in theory) for possessing protected wildlife (PHPA/BirdLife IP 1997), and these should effectively discourage people from capturing, trading and keeping illegal birds. Reality is different. Rich and powerful people can afford to keep Bali starlings entirely unpunished. In the early 1990s the Indonesian Department of Nature Conservation was charged with a programme aimed at getting hold of captive birds for the breeding and release programme by giving amnesty to illegal keepers of Bali starlings. Implementation was seriously impeded and made ineffectual by an exhibit of power. At the source end the problems are no less complicated. Lack of law enforcement finds its roots in the absence of an effective bonus system for park wardens. Moreover, though only incidentally illegal bird catchers have been caught and punished, to date no single illegal keeper was ever punished. Morale of the park wardens is understandingly low. Failing to address this problem has caused the creation of a perverse incentive, and keeping the population low has actually become advantageous. For park guards it means that their jobs are guaranteed and for the bird catchers that birds make higher prices in the illegal trade.

## FUTURE OF THE BALI STARLING

Habitat degradation and excessive capturing brought the Bali starling to the verge of extinction. The hazardous effects of a small population, the intricacy of the law enforcement system and harsh local climatic conditions, have so far prevented the Bali starling from emerging from this precarious situation. BirdLife International has been involved in the Bali starling conservation programme from 1984 through 1994, in an attempt to strengthen the management of the Bali Barat national park - the key objective of later phases in its field programme. This, and major achievements in captive release techniques (van Balen & Gepak 1994; Collins et al. 1998) have not yet resulted in a continued recovery of the wild population of Bali starlings. The main problem has been with security in the park. However, topics such as field warden discipline, the arresting and prosecution of poachers and traders, and the gazetting of conservation areas are all outside the sphere of responsibility of international agencies. It is therefore encouraging that a Species Recovery Plan has been prepared and adopted in close cooperation with all implementing parties in Indonesia (PHPA/BirdLife International-IP 1997). In this document all aspects of Bali starling conservation: protection in the wild, extension programmes, habitat restoration, law enforcement, are addressed and it will provide the guidelines for continuation of the conservation programme.

The Bali Starling Project was directed by the PHPA (Ministry of Forestry), BirdLife International, and the American Zoo and Aquarium Association (AZA, formerly AAZPA). Sponsors were the Art Ortenberg/Liz Claiborne Foundation, AZA, the Jersey Wildlife Preservation Trust, and the Swedish Ornithological Society. Paul Jepson, Paul Loth, Bob Seibels and an anonymous reviewer gave valuable comments on drafts of the paper.

Chapter 6

# The captive breeding and conservation programme of the Bali starling *Leucopsar rothschildi*

S. van Balen & V.H. Gepak 1994
Pp 420-430 in Creative Conservation: Interactive management of wild and captive animals. P.J.S. Olney, G.M. Mace & A.T.C. Feistner (eds). Chapman & Hall, London.

**Abstract**

The Bali starling *Leucopsar rothschildi* is a passerine endemic to the island of Bali. Habitat loss and illegal trapping caused the decline of numbers in the wild. About a dozen survived in 1990 in the Bali Barat National Park in the north-western tip of Bali. In 1983 a co-operative captive-breeding programme was initiated to re-stock the numbers in the wild. Birds bred in zoological gardens in the United States and Great Britain supplemented a breeding stock kept in the Surabaya Zoo in East Java. In July 1988 and April 1990, three and twelve captive-bred birds were released in the park. The second attempt succeeded in releasing birds that survived longer than six months: one female was observed in October the same year; another female was rediscovered in the subsequent breeding season, paired to a wild bird three young and successfully raising three young.

## INTRODUCTION

The Bali Starling *(Leucopsar rothschildi)* is a strikingly beautiful silky-white bird with black tips to the flight feathers and blue naked skin around the eyes. It was first described and placed in a monotypic genus by Stresemann in 1912, a year after he discovered it in the dry lowland forest along the coast of north-west Bali (Stresemann 1912). Since its discovery the numbers have declined and its distribution has receded. In the 1920s it occupied roughly 30,000 ha of uninhabited land (van der Paardt 1926; von Plessen 1926; van Helvoort 1990), but with the progressive conversion of forest to agricultural land, by the late 1980s its range had shrunk to less than 4000 ha and the population was restricted to a small part of the Bali Barat National Park in the north-west of the island (van Helvoort 1990). In the last 20 years the decline in numbers has been accelerated by trapping for the international pet trade and an increased demand from aviculturists. By 1990 the total wild population was estimated to be as low as 13 (van Balen & Soetawidjaya 1991). The Bali starling has been included in the IUCN Red Data Book since 1966, in the Endangered category, and international trade is prohibited under the Convention on International Trade in Endangered Species (CITES). Since 1970 the species has had absolute protection under Indonesian law.

In 1983 the Indonesian government, represented by the Directorate General of Forest Protection and Nature Conservation (PHPA) formally requested the International Council for Bird Preservation (ICBP)[1] to draw up and put into action a conservation project for the Bali starling. The implementation of this project was preceded by a feasibility and preparation period of 1983-1986 (van Helvoort *et al.* 1986), and by 1987 PHPA, ICBP, the American Association of Zoological Parks and Aquariums (AAZPA) and the Jersey Wildlife Preservation Trust (JWPT) had produced a comprehensive five-year cooperative programme. The agreed overall aim was to restore a viable and self-sustaining population in Bali Barat National Park. The objectives included:

(a) monitoring and protecting the birds in the wild;
(b) establishing a captive breading programme in Indonesia with input from other captive breeding programmes in America, Jersey and elsewhere;
(c) restocking the wild population;
(d) promoting public awareness.

A further three-year plan was agreed in 1992 which continued the original aims and expanded the objectives to include:

(a) stopping the illegal capture of birds;
(b) reducing the demand for wild-caught birds;
(c) establishing new populations within the species' dispersive range from captive stock
(d) continuing to promote an awareness of the cultural and aesthetic value of conserving the Bali starling in the wild;
*(e)* undertaking management-orientated studies of the behaviour and ecology of the species;
(f) developing the capability of the Bali Barat National Park to be self-sufficient in conserving the species.

## CAPTIVE STOCK WORLD-WIDE

Fortunately there has been for some time a relatively large captive population in zoos, bird collections and private collections world-wide. This population has been estimated to be in excess of 700 individuals (van Helvoort 1990), but only recently has there been an attempt to co-operatively manage parts of this scattered population. Poor record-keeping and uncontrolled breeding has made any analyses and management difficult. There are two regional studbooks which do provide usable data. One, the American studbook, which is under the auspices of AAZPA and one of

[1] Since 1993 BirdLife-International

their Species Survival Plans (SSP), recorded as Of July 1992, 381 birds in 68 participating institutions (Seibels 1992). The other, which is under the auspices of the Federation of Zoological Gardens of Great Britain and Ireland, registered as at the end of 1991, 110 birds in 20 institutions (Fisher 1992). In Europe the European Association of Zoos and Aquaria (EAZA) has approved the setting up of a co-ordinated breeding programme (EEP).

## CAPTIVE BREEDING PROGRAMME IN INDONESIA

### Breeding stock

In August-November 1987 the breeding facility already in existence in Surabaya Zoo in east Java was renovated. This facility comprised 29 aviaries with 16 Bali starlings. In November 1987 the captive population was increased with the addition of 37 birds donated by zoos and private collections in the USA and by Jersey Wildlife Preservation Trust. Five of these birds, most of them over 10 years old, died shortly after arrival. In 1992 the breeding stock in Surabaya Zoo consisted of 44 birds, with IS birds (11 male, seven female) born before 1985, 10 birds (four male, six female) born in 1985 or later, and 16 birds (six male, eight female, two unknown) of unknown age, but all born before 1987.

### Husbandry

A number of publications on breeding Bali starlings have appeared in the last two decades (Taynton & Jeggo 1988; Partington *et al.* 1989; see also bibliographies in Seal (1990) and Seibels (1991)). Husbandry used in Surabaya Zoo followed the guidelines given by American zoos (Seibels 1991) and a brief account only is given here.

The breeding aviaries for single pairs were at least 2.5 m high, 2.5 m wide and 4 m deep, well planted with low shrubs and small trees. Breeding results during the first season were disappointing and measures to enhance productivity were taken:

(a) aviaries were screened in order to avoid interaction with starlings in adjoining breeding units;
(b) in 1989 the old nest-boxes were replaced by boxes that followed a design widely used in the USA (Seibels 1991);
(c) disturbance from visitors to the zoo was decreased by closing off the immediate surroundings of the aviaries;
(d) birds with poor breeding performance were re-paired;
(e) in addition to dry food pellets, fresh local fruits (papaw, bananas) and live food (mealworms, ant pupae) were provided.

### Breeding results

Egg hatching during the year was satisfactory. Mortality, however, after hatching remained high and to date an average of only six to nine birds reach maturity each year. The introduction of new nest-boxes in August 1989 resulted in some increase in the number of clutches, but the chick mortality stayed high. To date 39 birds have been successfully raised. Figure 6.1 shows the breeding results for 1988-1992. As three pairs that were amongst the most productive of the breeding stock, were stolen in March 1991, the period April 1991 to July 1992 has been omitted from the graph. The stolen birds were retrieved in the second half of 1992.

**Studbooks**

In order to manage the captive population scientifically, and in particular to minimise inbreeding, carefully maintained studbooks are essential. American and British birds are already registered, and regional studbooks for birds in Indonesia and in Europe are being prepared. Other studbooks should be prepared for birds held in Japan and Singapore.

Taynton & Jeggo (1988) found evidence of increased chick mortality with higher inbreeding levels in Jersey birds, and van Helvoort (1990) reported an inbreeding depression in the American population leading to a reduction in fertility. A recent study (Thohari *et al.* 1991) indicated an extremely low heterozygosity of certain blood protein types in the captive population held in Indonesia, with as yet unknown implications for the species. The introduction of wild-caught Bali starlings, of which a fair number are still in private hands, in Java and Bali would diversify the captive gene pool.

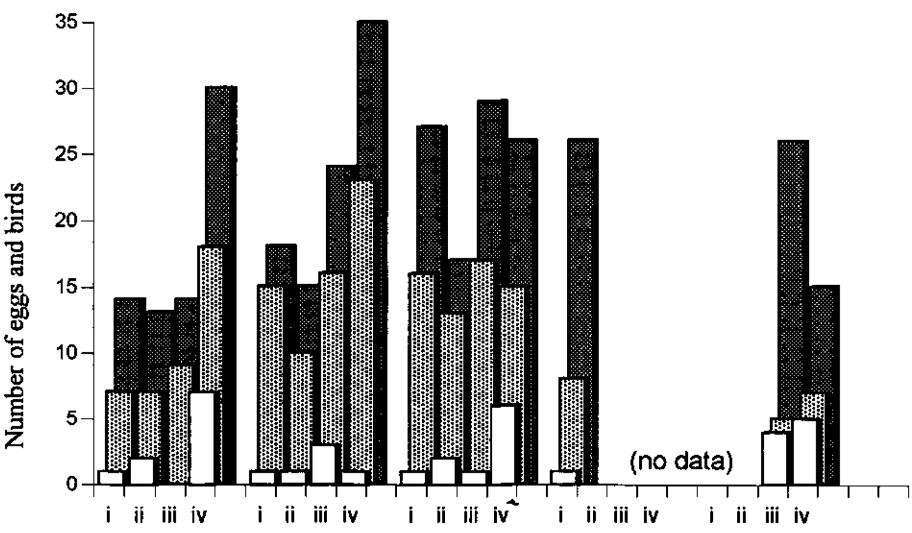


**Figure 6.1** Breeding results of the Bali starling propagation centre at the Surabaya Zoo, 1988-1992; reliable figures for the period April 1991 – June 1992 were not available (I: January – march, II: April – June, III: July – September; IV: october – December; solid bars: number of eggs laid; grey bars: hatchlings; white bars: successfully fledged birds).

**Minimal viable population**

It has been tentatively suggested that for a species' long-term survival a minimum effective population of 500 individuals is needed (Franklin 1980). More specifically a recent population viability analysis (PVA) (Seal 1990) considered that to be viable, 1000 birds in the wild and another 1000 in captivity were desirable, with these two populations being managed as a single meta-population. These numbers are based on little empirical data and their feasibility (especially with regard to the wild population) is doubtful, but it is clear that more birds will decrease the risk of genetic deterioration and extinction. The zoos and private collections in the USA can together house only a restricted number of birds. Those registered in the studbook are closely managed and monitored, as are those in the British studbook, but there are many in the widely scattered world captive population which are outside any managed breeding programme. Co-ordination amongst collections is necessary to increase the effective size and viability of the captive breeding programme.

Of the 44 birds at present in the Surabaya zoo only four are successful breeders. Recombination of the pairs, especially among the groups of different origin, is essential to enhance productivity and increase the effective breeding population. The extension of the Indonesian propagation programme to other sites would increase the size of the Indonesian captive population and the number of birds for release. To this end, birds obtained under a one-time amnesty campaign from local private owners in exchange for captive-bred birds brought over from the USA (in June 1992, 17 birds were brought over for this purpose), and those handed over directly with the help of local PHPA officers, are now being registered. To date more than 80 birds have been registered and fitted with transponders. In 1993 they will be placed in the new additional captive breeding centres, or be released into the wild, if considered appropriate.

**Release programme**

The building of a Pre-release Training Centre (PTC) in the Bali Barat National Park was completed in June 1988. The unit comprises 10 aviaries each 5 x 3 x 2 m and follows the design of the Captive Propagation Centre in Surabaya zoo. The PTC is located in an off-public site, with restricted access for interested visitors. The aviaries are sufficiently isolated to reduce any habituation to humans, including the bird keeper.

In autumn 1987, when less than 50 birds survived in the wild, a release was felt to be justified. In July 1988 the first group of three birds from the Surabaya zoo was accommodated in the PTC. To adjust the birds to their future environment, they received six week's training which focused on developing skills for foraging in the wild, retaining fear of humans, and gradually accustoming the birds to the boxes in which they were to be transported to the release site. In the field, the birds were released in turns during the first week, in order to maintain the birds close to the release site - the caged birds always attracted the ones already released. This attempt resulted in one known casualty and the disappearance of the other two birds. The extremely dry conditions and strong wind at the time of release, the birds' unfamiliarity with the area, and the location of the site distant from any known Bali starling roosting area may have been contributory factors which caused the failure (B. van Helvoort verbally)

During the Bali starling PVA workshop, held in Bogor, Indonesia, and attended by an international group of conservationists, aviculturists, and other experts (see Seal 1990), it was decided that a second attempt to release captive-bred birds into the wild population should be undertaken as soon as possible.

Accordingly, in April 1988, eight captive-bred birds were brought over from Surabaya Zoo to Bali. One bird died shortly afterwards, probably due to stress, and another was considered unfit for release. The birds were given various kinds of wild fruits which were known to have been eaten by Bali starlings. They readily took various arthropods, including scorpions and millipede, and small reptiles, that entered their cages. They showed instinctive reactions towards raptors flying over. In early 1990, two birds confiscated in east Java were added to the PTC group; one of these was considered for release, but the other was assumed to be unfit for release as its malformed bill suggested it had been hand-raised.

In April 1990 another six captive-bred birds were transported from Surabaya Zoo to Bali Barat and housed in the PTC. The second attempt was planned for a location in the far north east edge of the Prapat Agung Peninsula in Bali Barat, a short distance form the Teluk Kelor guard house. Here wild Bali starlings were known to roost regularly. A two-compartment simple cage (2 x 2 x 2.5 m) was built on the site to serve as training accommodation. On the day the birds were transported to the release site, transponders were inserted, and colour rings were attached. Special heavy-duty rings designed for the Bali starling conservation programme were attached to the two confiscated birds, whilst the other birds had their metal zoo rings. In order to tell the released birds from the wild birds during at least the first weeks, the breast feathers of the birds to be released were dyed red with rhodamine B. Two coloured plastic spiral rings were attached to *all* the birds each coded with a unique combination of numbers. On April 15 1990 the first four birds were released from the cage where they had been housed during the previous two days. On April 17, three birds were released, followed by two, two, one and one on each consecutive day. Birds unfit for release stayed in the cage to decoy released birds back to the cage, where food and water were provided during the first weeks. The wild caught confiscated bird that was released with the captive-bred birds, and which was expected to act as a sort of guide was a disappointment: immediately after its reluctant take off, it flew away in a direct line and was never seen again.

Daily monitoring of the starlings by teleșcope (20-60x) from a hide near the release site was maintained during the first weeks, where food pellets, fruits and drinking water were provided. Acceptance of the wild by the released birds went smoothly and soon mixed foraging, communal anting and roosting flocks could be seen. One pair was formed within one week and the wild bird would follow its partner close to the food and drinking water container. The observation of several birds around the site, but not at the drinking place soon after release, suggested that acclimatisation was rapid in some cases.

Reading of the ring codes became increasingly difficult, as the birds became more wary in the process of adaptation, making the success rate hard to assess. This was aggravated by unexpectedly high poaching pressure near the sites. Within one month one of the released birds, detectable by its transponder, was rediscovered in the hands of a local bird dealer, and an unknown number of other birds may have been trapped. In early October 1990, however, six months after the release, a marked bird was identified about 8km from the release site. It was observed copulating with a wild bird (in the kapok tree *Ceiba pentandra* plantation enclave along the main road that cuts through the National Park), but disappeared soon after. In November the same year, another released bird was rediscovered, paired to a wild bird. In January the following year this pair successfully raised three young in a tree hole not far from the release site.

A major decline in numbers of Bali starlings was found during the pre-breeding census of 1990. Even with the 13 released birds, numbers had dropped to some 15 birds largely due to poaching. The following breeding season guarding of the park was increased, but no releases took place, primarily because sufficient were not available from the Surabaya breeding facility. Poaching appeared to be better controlled, though still going on, and the post-breeding censuses completed in June 1991 and June 1992 showed about 35 and 55 birds, respectively (Figure 5.2). Eight occupied nests were located in the Teluk Kelor/Batu Gondang area. Only natural nest holes were used, and again the nest boxes provided a few years ago were ignored. Though a quarantine period in the PTC is common practice before release, and the birds kept in the zoo are examined regularly, there is still a considerable risk of disease transmission. The incidence of atoxoplasmosis in captive Bali starlings in American zoos (Partington *et al.* 1989) is especially worrying. Following a discussion paper prepared by PHPA and ICBP, an AAZPA team came from the USA in August 1992 to examine the birds held in Indonesian zoos and in the PTC in Bali. A medical quarantine protocol for all birds to be released and for birds held in captive breeding centres has since been developed (Appendix 4 of van Balen & Jepson 1992).

To further reduce the risk of disease transmission, release in the future will be in former, but now empty, Bali starling habitat. This reintroduction, as opposed to restocking, will involve rather different and more elaborate release techniques, as no resident guides will be available. An intensive field study is being prepared by ICBP and AAZPA, aimed at collecting data on behaviour and breeding success of released birds (M. Collins verbally). A possible release site has been identified on the island of Menjangan, pending more information on diseases in the captive population and full control of poaching in the area. Furthermore, the use of radio-telemetry is being considered and preliminary tests on captive starlings has had promising results (Elbin *et al.* 1991).

## CONCLUSION

Habitat availability in the present National Park as a limiting factor on the recovery of the Bali starting is currently being investigated by the project. There may not be enough suitable habitat in the national park to support more than a three- or fourfold increase in the present population of 55 Bali starlings. Even if attained, this figure would be far below any number suggested for a viable population. Any continuation of the release programme will have to take this into account and the conversion of the plantation enclaves that exist in the Bali Barat National Park into Bali starling habitat must keep pace with an increasing number of starlings.

Considerable time and effort has been put into the captive-breeding programme, but to date its success in terms of contribution to the conservation of the Bali starling has been limited. The recovery of the wild population following the improvement in protection shows that other techniques can be possibly more immediately efficient. However, the potentially deleterious consequences of inbreeding cannot be discounted and the introduction of new genes is justified. Further releases are planned for 1993 and feasibility studies are now being carried out. To avoid disturbance of the present wild population, sites in Bali starling habitat other than the previous ones will be selected.

The Bali Starling Project Phases 1-3 would not have been possible without the assistance and commitment of a large number of people and institutions. The Project is managed by ICBP and financed by AAZPA and the New York Zoological Society, Liz Claiborne/Art Ortenberg Foundation, and JWPT. The PHPA head offices, the Bali Barat National Park and Surabaya Zoo were the local partners in the implementation of the Project. In particular, M. Noer Soetawidjaja, Slamet Suparto and Made Rasma c.s. were most closely involved in the release programme. Thanks are forwarded to the former Bali Starling Project officer, Bas van Helvoort, for the discussions and support provided during the early stages of the project, and to Paul Jepson and Professor H.H.T. Prins for their valuable comments on an early draft of the paper.

Chapter 7

# The distribution and status of green peafowl *Pavo muticus* in Java

S. van Balen, D.M. Prawiradilaga & M. Indrawan 1995
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**Abstract**
Green peafowl *Pavo muticus* was once widespread throughout East and South-east Asia. Because of habitat destruction and excessive hunting, it has now disappeared from most of its former range. In Java a few national parks in the lowlands form their last refuges, but small groups of birds still survive in vast teak plantations and rugged limestone hills in the central and eastern parts of the island. This paper gives a summary of an extensive survey of extant peafowl populations throughout Java. Recommendations for conservation actions have been made: (1) awareness programmes accompanying improved law enforcement and development of ecotourism; (2) additional surveys to assess the importance of small reserves in peafowl areas; (3) re-introduction of confiscated birds into suitable reserves.

## INTRODUCTION

The historical range of Green Peafowl *Pavo muticus* covers a large area in East and South-east Asia, from Bangladesh to Indo-China and Java. In most of its range, however, it is locally and patchily distributed, and it is probably extinct in some places, i.e., northeast India, Malaysia (Johnsgard 1986). Though protected by law in a number of countries, e.g., Indonesia (Abdullah *et al.* 1978), Thailand, Malaysia (Johnsgard 1986) and Burma (Collar & Andrew 1988), the species has continued to decline, due to excessive hunting for its feathers, meat or chicks (for sale, or to be kept as pets). Because of this, the species was nominated as vulnerable in the revised BirdLife world check-list of threatened birds (Collar *et al.* 1994).

Some confusion exists in literature about its status on Java, where it is reportedly restricted to essentially only a few isolated reserves in the provinces of West and East Java (Collar & Andrew 1988), and with a total population of only 250 birds (Johnsgard 1986). Numerous personal communications, and the evidence in the form of peafowl offered for sale on bird markets in various parts of Java, suggested a more widespread occurrence. It was therefore considered necessary to get better information on the status and the distribution of the species. Data of this study have contributed to the re-assessment of the status of Green Peafowl in Java (Collar *et al.* 1994).

## SURVEYS

In 1990-1991, five 2-3 week surveys were done in areas from where recent verbal reports of peafowl had been received or which were mentioned by various authors (e.g., Sody 1953; Manuputty 1956) as historically supporting peafowl. Also written reports on recent wildlife inventories that were examined by us at local forestry district offices appeared to be very useful sources of up to date information on peafowl populations. These data were added to other surveys that were conducted in a more general forest bird survey conducted by van Balen on Java from 1985 onward.

The presence of peafowl was established through sightings, signs (tracks, feathers, dusting wallows) and calls. Peafowl roosting sites were first located, either from information provided by local villagers and/or through listening for the birds' far carrying pre-roosting calls in the morning and evening (Stewart Cox & Quinell 1989; Indrawan 1992). Because green peafowl generally favour particular trees for a roost, it was often possible to obtain an impression of the distribution of different groups in an area. Their extreme alertness made close encounters very difficult, and only rarely was it possible to estimate group size. Where possible, notes were made of behaviour and social structure of the birds.

The aim of the surveys was to assess the status, habitat and present threats to the survival of the green peafowl in the areas concerned.

## DISTRIBUTION AND STATUS

Figure 7.1 shows the localities where peafowl were recorded in historical times only (open circles) and where they were seen recently (solid circles). Localities for which the absence of peafowl could be established recently are indicated by crosses. Especially in the western part of Java the distribution shows a very scattered pattern, with peafowl occurring mainly in remote coastal areas. In central and eastern Java clusters are formed in the extensive teak *Tectona grandis* forests and rugged hill and mountain areas in the interior.

Table 7.1 lists the areas where peafowl occurred formerly, but from where presence has not been confirmed since 1980. Data on habitat and numbers is given, if available. Some of these localities have been surveyed recently, but no evidence of peafowl occupancy was found. All the other places still have to be re-visited, and the potential presence of peafowl cannot be rejected.

In Table 7.2 all localities, including those visited during the survey, where the presence of peafowl was recently confirmed are listed. More notes on the habitat, conservation value of the area and, if available, numbers of peafowl present are given in the following section. Localities are listed according to the provinces in which they were situated. County names (*kabupaten*) are in brackets.

*West Java*

**Panaitan** (Pandeglang) Kal (1910) and Johnsgard (1986) reported, that Panaitan Island supported peafowl, but this had not been stated by Hoogerwerf (1953c). Surveys in 1985, 1986 and 1988 by the Biological Science Club (Jakarta) and van Balen did not result in peafowl observations on the island.

**Ujung Kulon** (Pandeglang) Hoogerwerf (1947, 1969, 1970) gave comprehensive accounts of the Ujung Kulon reserve area, including detailed information on peafowl. The population in the park was estimated a maximum of 200-250 individuals (Hoogerwerf 1970). The Ujung Kulon peninsula of 30,000 ha was established as a nature reserve in 1921. In 1980 the area was declared a National Park (IUCN 1992) containing offshore Panaitan Island and Mt Honje on the mainland besides the peninsula proper. There are no indications of a recent decline in the park and peafowl are still common in the reserve itself, especially on and around the grazing fields of Cijungkulon and Cigenter. The *ca* 500 ha Peucang Island 500-800 m off the northwest coast of the peninsula is often mentioned as having an isolated population (Johnsgard 1986; Collar & Andrew 1988). However, the varying number of individuals on the island (Hoogerwerf 1970) suggest that these are birds from the main population.

**Tapos** (Bogor) A specimen collected by Macklot at Tapos in August 1828, is in the Bogor Museum. It is not clear whether Tapos near Cibinong, Jasinga or Leuwiliang is meant, but all are near Bogor. The absence of wild peafowl at these localities is confirmed by van Balen and Prawiradilaga who lived in Bogor for many years.

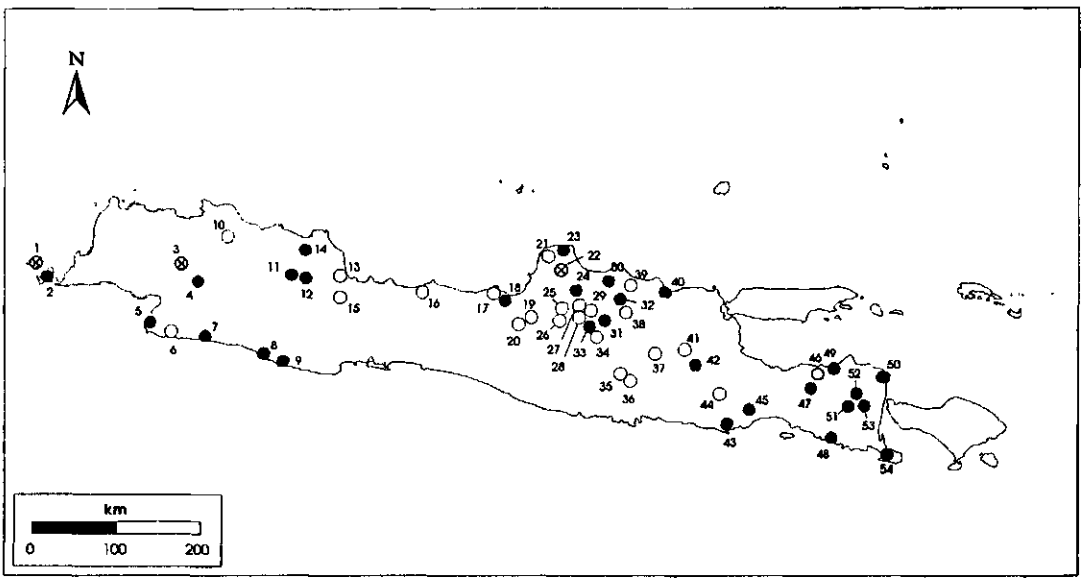


**Figure 7.1.** Localities of green peafowl in Java. O: historical records only; ●: recent records; ⊗: no recent records confirmed. Locality numbers are presented in Tables 7.1 and 7.2.

**Table 7.1** Localities of green peafowl on Java before 1980, without recent observations.

| No. | Locality | Habitat | Year | Numbers of peafowl | References | Coordinates |
|---|---|---|---|---|---|---|
| *West Java* | | | | | | |
| 1. | Panaitan | LW | ? | ? | 2 | 105 13 E; 6 35 S |
| 3. | Tapos | ? | 1828 | ? | 4 | 106 47 E; 6 36 S |
| 6. | Ciseureuh | LW | 1918 | ? | 5 | 106 40 E; 7 25 S |
| 10. | Karawang | ? | 1896 | ? | 5 | 107 18 E; 6 19 S |
| 13. | Cirebon | ? | 1940 | ? | 4 | 108 33 E; 6 43 S |
| 15. | Cilowa | ? | 1901 | ? | 5 | 108 30 E; 6 59 S |
| *Central Java* | | | | | | |
| 16. | Pemalang | TF | 1950s | M[1] | 3 | 109 24 E; 6 54 S |
| 17. | Kendal | TF | pre 1940 | 7 | 7 | 110 12 E; 6 56 S |
| 19. | Penawangan | TF | 1880 | ? | 1 | 110 35 E; 7 12 S |
| 20. | Gedangan | TF | pre 1940 | ? | 5/7 | 110 28 E; 7 16 S |
| 21. | Banjaran | ? | 1936-38 | ? | 9 | 110 46 E; 6 32 S |
| 22. | Colo | TF | pre 1970 | ? | 5/7/9 | 110 54 E; 6 41 S |
| 25. | Purwodadi | ? | 1936-38 | Q | 9 | 110 55 E; 7 06 S |
| 26. | Gundih | TF | 1935-38 | F/Q | 6/7/9 | 110 54 E; 7 12 S |
| 27. | Wirosari | TF | 1880 | Q | 1 | 111 06 E; 7 04 S |
| 28. | Kradenan | TF | 1880 | Q | 1 | 111 06 E; 7 10 S |
| 29. | Ngaringan | ? | 1936-38 | ? | 9 | 111 12 E; 7 08 S |
| *East Java* | | | | | | |
| 34. | Walikukun | ? | 1936-38 | R | 9 | 111 15 E; 7 24 S |
| 35. | Paringan | ? | 1936-38 | ? | 9 | 111 33 E; 7 49 S |
| 36. | Pulung | TF | 1950s | M | 3 | 111 38 E; 7 52 S |
| 37. | Nganjuk | ? | 1936-38 | ? | 9 | 111 56 E; 7 36 S |
| 38. | Padangan | TF | pre 1940 | < | 7 | 111 37 E; 7 09 S |
| 39. | Jatirogo | TF | 1943-45 | ? | 8 | 111 39 E; 6 53 S |
| 41. | Jombang | ? | 1930s | < | 9 | 112 15 E; 7 33 S |
| 44. | Kebonagung | ? | ? | ? | 4 | 112 37 E; 8 02 S |
| 46. | Besuki | ? | 1910 | ? | 5 | 113 41 E; 7 44 S |

**Habitat**: teak forest (TF), lowland woodlands (LW), grassland (G). **Numbers**: rare (R), few (F), quite common (Q), many (M), decreasing (<), not recorded or not possible to infer (?). **References**: 1, Bruinsma (1916); 2, Kal (1910); 3, Manuputty (1956); 4, Museum Zoologi Bogor; 5, Nationaal Natuurhistorisch Museum (Leiden); 6, S. Paryanti (verbally 1991) 7, Sody (1953); 8, Soepraptomo (1953); 9, de Voogd & R.H. Siccama (1939).

[1] In October 1996, 12 peafowl were observed in the Sokawati teak forest block, Pemalang, and more birds were reported by forestry officers from adjacent blocks (Sukandar *et al.* 1996)

**Table 7.2.** Localities of green peafowl on Java with observations after 1980 (see text for references) Habitat: teak forest (TF), lowland woodlands (LW), coffee plantations (C), grassland (G), woodlands at higher altitudes (H); Status of area: national park (NP), strict nature reserve (NR), proposed reserve (P), protection forest (PF), recreation forest (RF).

| No. | Locality | Habitat | Numbers of peafowl | Status of area | Coordinates |
|---|---|---|---|---|---|
| *West Java* | | | | | |
| 2. | Ujung Kulon | LW/G | 200-250NP | | 105 20 E; 6 45 S |
| 4. | Mt Gede/ Pangrango | H | <5 | NP | 106 58 E; 6 48 S |
| 5. | Cikepuh | LW | <10 | NR | 106 25 E; 7 15 S |
| 7. | Ciogong | LW/TF | 5-10 | P | 107 03 E; 7 24 S |
| 8. | Cikelet | ? | ? | - | 107 41 E; 7 38 S |
| 9. | Leuweung Sancang | LW/G | 15-20 | P/NR | 107 52 E; 7 44 S |
| 11. | Buahdua | TF | 25-30 | - | 107 59 E; 6 44 S |
| 12. | Sampora | TF | 23-29 | - | 108 08 E; 6 46 S |
| 14. | Cikawung | TF | 8 | - | 108 08 E; 6 28 S |
| *Central Java* | | | | | |
| 18. | Alas Roban | TF | ? | - | 110 17 E; 6 58 S |
| 23. | Clering | LW | <10 | NR/- | 110 56 E; 6 28 S |
| 24. | South Pati | TF | 10-25 | - | 111 04 E; 6 54 S |
| 30. | Mantingan | TF | 15 | - | 111 24 E; 6 51 S |
| 31. | Randublatung | TF | 70 | - | 111 23 E; 7 14 S |
| 32. | Cepu | TF | 104-167- | | 111 35 E; 7 05 S |
| *East Java* | | | | | |
| 33. | Alas Sengok | TF | 5 | - | 111 12 E; 7 17 S |
| 40. | Tuban | ? | ? | - | 112 03 E; 6 53 s |
| 42. | Wonosalem | C | ? | - | 112 22 E; 7 43 S |
| 43. | Lebakharjo | LW | <10 | PF/P | 112 52 E; 8 23 S |
| 45. | Ranu Darungan | H | <10 | NP | 112 56 E; 8 12 S |
| 47. | Yang Highlands | H/G | 25-50 | NR | 113 36 E; 7 58 S |
| 48. | Meru Betiri | LW/C/G | 25-50 | NP | 112 56 E; 8 12 S |
| 49. | Pasirputih | LW/TF | 75 | RF/P | 113 49 E; 7 43 S |
| 50. | Baluran | LW | 200 | NP | 114 22 E; 7 51 S |
| 51. | Mt Raung | H/G | ? | P | 114 02 E; 8 06 S |
| 52. | Krepekan | H/C | 30 | - | 114 04 E; 8 03 S |
| 53. | Lijen | H/C | 10-20 | - | 114 11 E; 8 08 S |
| 54. | Alas Purwo | LW/TF | 25-50 | NP | 114 24 E; 8 41 S |

**Mt Gede/Pangrango** (Bogor, Cianjur, Sukabumi)

Van Heeckeren tot Waliën (1912) mentioned the occurrence of peafowl in the Mt Gede area. Without records for the period between 1929 and 1992, a peacock was observed on the crater wall of this mountain early 1992 (P. Jepson verbally) and in July 1992 its call was heard on the lower northwestern slopes at 1200 m of its twin volcano Mt Pangrango (I W.A. Dirgayusa verbally). However, these observations most likely refer to stragglers from the local safari garden located 10-15 km to the northwest, where free ranging peafowl are kept.

**Cikepuh** (Sukabumi)
Vorderman (1887) and Bartels (1902) described the plain where the Ciletuh river flows into the sea; the area was also called Zandbaai, and rhinoceroses and many peafowl occurred here. Rather few peafowl were reported by de Voogd & R.H. Siccama (1939) for the Cikepuh area, immediately south of the Ciletuh river. Peafowl was observed in the 1980s in this area (D.S. Hadi verbally). The Cibanteng reserve in the northern part of the area and Cikepuh game reserve (together >8500 ha) were established in 1925 and 1973 (MacKinnon *et al.* 1982; IUCN 1992). The habitat is mostly secondary forest, with patches of primary forest and grassland.

**Ciogong** (Cianjur)
Van Maarseveen (1940) reported peafowl in the Sindangbarang region on the south coast. In February 1987, van Balen surveyed the lowland forest plot of Ciogong in the same region. This 1000 ha forest is bordered to the north and west by teak plantations; inside the area two plots of 8 ha and 20 ha were logged in the late fifties. A few rivulets flow through the forest, which has been proposed as a nature reserve. Peafowl were not seen, but reports by the local warden (Didin verbally) of small numbers were regarded as reliable.

**Cikelet** (Garut)
The presence of peafowl was reported in 1991 by local people for the northern part of the district of Cikelet, west of Pameungpeuk (D. Holmes verbally)

**Leuweung Sancang** (Garut)
Leuweung Sancang contains a 2157 ha lowland nature reserve established in 1978 (IUCN 1992) along the south coast. Lush rain forest and edges to surrounding plantations are the favourite habitat for peafowl. There are plans to extend the reserve area to include 3000 ha of the Cipatujuh area in the east (MacKinnon *et al.* 1982). During a visit on 3-5 June 1987 two birds without trains were seen at the edge of the Leuweung Sancang lowland forest reserve bordering a coconut *Cocos nucifera* plantation. On a follow-up visit in May 1991, we saw 20 peafowl distributed in four sites along the northern border.

**Buahdua** (Sumedang)
Peafowl was reported in 1993 as common but being heavily hunted at Buahdua on the lower northeastern slopes of Mt Tampomas (Sujatnika verbally).

**Sampora** (Sumedang)
In the forestry district of Sampora 23-29 peafowl were seen at seven study plots (Gunawipura 1986).

**Cikawung** (Indramayu)
Van der Vegte & Bartels (1937) gave information on peafowl observed near Losarang. Few peafowl was reported from the Indramayu forestry district by de Voogd & R.H. Siccama (1939). In November 1993, eight peafowl in three forest blocks were observed at Cikawung; the birds were heavily hunted with air rifles, snares and sometimes poisoned; eggs and young were sold (Setiawan & Nurdiana 1993)

*Central Java*

**Alas Roban** (Semarang)
Before World War II, 180 birds were reported by Sody (1953) for the teak forests in Semarang county; a few other old records (Gedangan, Penawangan) are listed in Table 7.1. A record in 1991 of chicks offered for sale at Alas Roban near Semarang town (A. Saksono verbally) suggests that peafowl still occurs in the area.

**Colo** (Jepara)
Paryanti (verbally 1991) reported peafowl in teak forest on the southern slope of Mt Muriah near Colo a decade ago, but local foresters, interviewed on the present survey have not seen peafowl there since 1970.

**Clering** (Jepara)
MacKinnon *et al.* (1982) reported peafowl for the Mt Clering forest reserve; in June 1991, peafowl were seen at Giding near Clering. In the area two reserves, Keling I-III (essentially three patches of forest, totalling 60 ha), and Clering, 1379 ha, were established in, respectively, 1919 and 1973.

**South Pati** (Pati)
Frequent egg collecting was reported for the southern part of Pati county (de Voogd & R.H. Siccama 1939), where peafowl was most common in Kwawur, Guyangan and Selotanah (Manuputty 1956). On the present survey to the area, peafowl were observed at Kedungwesi, Brati and Kalangan in the Kapur Utara hills, and local reports were received of the presence of peafowl at Guyangan and Selotanah.

**Mantingan** (Rembang)
Fifteen birds in three locations were reported by local foresters for the first quarter of 1991 in the Mantingan area, where hunting pressure is high; only one bird was seen at Bedingan (Kali Nanas) in one of the three places visited in June 1991. Two tiny reserves, Gunung Butak (45 ha), and Sumber Semen (17 ha), were established in 1975 (MacKinnon *et al.* 1982) on the Kapur Utara limestone hills.

**Randublatung** (Blora)
Peafowl were reported as "regular" in the Randublatung area (de Voogd & R.H. Siccama 1939); before World War II, 25 and 165 birds were recorded in the northern and southern parts of this teak plantation area by Sody (1953). In June 1991, peafowl was seen here at three sites, Menden, Kedungsambi and Bodoh, where about 70 birds were reported by the local forestry office.

**Cepu** (Blora)
Sody (1953) reported an estimated pre-World War II population of 300 birds in the teak forests at Cepu. On the present survey peafowl was observed at Nglebur and Bleboh in June 1991 and peafowl was reportedly caught by local people in the Nglebur region and Ngasahan; local foresters reported 104-167 birds in the Cepu area in 1990 and 76 birds (in 18 sites) in early 1991.

*East Java*

**Alas Sengok** (Ngawi)
An increasing number of peafowl was reported for Ngawi by De Voogd & R.H. Siccama (1939), with 75 birds before World War II (Sody 1953). In June 1991, five birds were seen in the teak forest at Alas Sengok.

**Tuban** (Tuban)
In 1992 local foresters reported peafowl from the Tuban area (I. Setiawan verbally).

**Wonosalem** (Jombang)
Wallace (1869) recorded peafowl in 1861 near Wonosalem, 350-500 m on the west slope of Mt Arjuno, where coffee plantations, bamboo thickets and coarse grasses dominated the vegetation. Here his assistant collected some peafowls. Vorderman (1899) described a bird, taken as young from the same area. Peafowl was reported from the area in February 1993 (V.H. Gepak verbally).

**Lebakharjo** (Malang)
Baerveldt (1950) saw two peafowl families near Lebakharjo, where the Manjing and Glidik rivers meet. Though not heard or seen by us on 25-28 October 1989, local villagers reported peafowl from the vicinity of the Teluk Lenggasana (or Lebakharjo) protection forest. The 16,000 ha of lowland rainforest, is still largely in good condition, despite being intersected by enclave plantations. It has been proposed as a nature reserve (Bekkering & Kucera 1990).

**Ranu Darungan** (Malang)
A small number of peafowl was reported in 1991 in the Ranu Darungan area at 800-900 m in the southern foothill of Mt Semeru (J. Wind verbally). Whitehead (1893) reported the sighting of green peafowl in 1886 near the top of Mt Bromo. Ranu Darungan is included in the Bromo-Tengger-Semeru National Park (57,606 ha), established in 1982 (IUCN 1992).

**Yang Highlands** (Probolinggo, Bondowoso, Jember)
Formerly reported as very abundant (Sody 1953), peafowl appear to have decreased seriously on the grassy plains of the Yang highlands. Hoogerwerf (1974) thought that this could be partly due to the destruction of eggs and limitation of peafowl food resources (e.g., grass seeds) by fires. The 14,145 ha area became a game reserve in 1962 (IUCN 1992), but heavy poaching decimated the local deer population, and left few peafowls. Van der Zon & Supriadi (1979), however, reported peafowl a very common and groups of 5-10 were often seen. On 1-5 July 1989, only two or three birds were heard and a cock with a long train was seen at *ca* 2300 m a.s.l., an exceptionally high altitude for this species.

**Meru Betiri** (Jember, Banyuwangi)
We visited the Meru Betiri forest reserve on the south coast on 11-17 October 1990. Meru Betiri was declared a Wildlife Reserve in 1972 (MacKinnon *et al.* 1982) and is now a National Park (IUCN 1992). Its lush lowland rainforest alternating with enclave plantations and grazing fields covers 58,000 ha and is good habitat for green peafowl. These were heard mainly near Sumbersari in the central part of the park (where at least two roosts were discovered), and near the 30 ha grazing field of Rajegwesi. Peafowls were also reported by the local wardens at the Sukamade

camping ground.

**Pasirputih** (Panarukan)
On 16 December 1987, three trainless peafowl were observed in mangrove shrubs, at the edge of teak forest along the coast, some km west of Pasirputih (van Balen). In 1991-1992, despite heavy hunting, at least 75 birds were seen southeast of Pasirputih, in the Mt Ringgit area, a small forested hill, with teak forest and village gardens in the valley. Pasirputih is a tourist resort and small nature reserves of 4000 and 2000 ha were proposed by MacKinnon *et al.* (1982) on the nearby Mt Beser (1368m) and Mt Ringgit (1000m).

**Baluran** (Panarukan)
Robinson & Kloss (1924) collected peafowl at Bajulmati, along the east coast, just south of Baluran. Very high numbers were reported from Baluran in 1941, but these were disappointingly low in 1971 (Hoogerwerf 1974). The extensive savanna woodland and monsoon forest of Baluran offers ideal peafowl habitat, attested by the large number of birds that this area supports. Population estimates of up to 200 birds have been made (Johnsgard 1986). It is likely that illegal hunting along the borders suppresses numbers considerably, but overall numbers in the park may still reach 200[2]. In the dry season conditions become harsh at Baluran and part of the peafowl population moves into evergreen kapok tree *Ceiba pentandra* plantations in an area of wells with a permanent river. Baluran was established as a Game Reserve in 1937, and up-graded to a National Park in 1980 (MacKinnon *et al.* 1982; IUCN 1992). It covers 25,000 ha; the kapok tree plantations are outside the protected area boundary.

**Mt Raung** (Banyuwangi, Bondowoso, Jember)
Considerable numbers of peafowl were reported by local campers at Mt Raung in the south part of the mountain complex. We did not visit this area. A 60,000 ha reserve is proposed for Mt Raung (MacKinnon *et al.* 1982).

**Krepekan and Lijen** (Bondowoso, Banyuwangi)
On 24 June - 10 July 1990, we visited the Ijen crater and the lower parts of its foothills where coffee plantations border the eastern (Lijen) and western forest (Krepekan). At least six different roosts were discovered in the Krepekan area and three in Lijen[3] (Indrawan & van Balen 1991). All were in and near coffee plantations and forest edge outside the reserve area, and some were close to villages. The Ijen crater is included in the 2,560 ha Kawah Ijen/Merapi/Ungup-Ungup area, which is a nature reserve since 1920 (MacKinnon *et al.* 1982).

**Alas Purwo** (Banyuwangi)
Sody (1953) reported peafowl as very abundant in the Alas Purwo forest reserve. Alas Purwo, a Game Reserve since 1939 (IUCN 1992) has recently been declared National Park. It consists of limestone forest and areas cleared for grazing. The 41,000 ha park is bordered by teak and mahogany *Swietenia* spp plantations. Between 15-30 May 1990 we located five peafowl sites in the Alas Purwo reserve and saw groups of 3-12 birds with the largest group in the 75 ha Sadengan area.[4] Good shelter is provided here by the surrounding forest. Groups of up to 8 were observed in the teak forest and in the north of the Sagara Anak estuary (H. Prins verbally).

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[2] Indrawan (1995) made a preliminary estimate of 400 - 616 birds based on intensive counts in 1993.
[3] A preliminary estimate of 64 – 88 birds for the total area was made in 1993 (Indrawan 1993).
[4] A preliminary estimate of 168 – 268 was made in 1993 (Indrawan 1993).

## DISCUSSION

### Population numbers and habitat

Sody (1953) attempted to make an estimate of total numbers of Green Peafowl in Java. Sporadic figures from local forestry reports on teak forests led him to a minimum estimate of 2-3000 birds for teak plantations, but no estimate could be made for woodlands as only information such as "scarce" or "rather many", was available to him. The present survey does not allow an accurate count either. The estimated number of 915 - 1149[5] birds observed during the past few years are only a part of the total population of which the size is unknown and therefore only general remarks can be made.

*Forest reserves.* Three national parks, Ujung Kulon, Alas Purwo and Baluran, include substantial areas of peafowl habitat and together they support the major part of the peafowl population within protected areas in Java. In addition, the Yang Highlands nature reserve and Meru Betiri National Park contain small peafowl populations. The two nature reserves, Ciogong and Kawah Ijen, only have peafowl at the edges of their forest. A general feature of areas supporting peafowl is a "parkland" landscape created either naturally by banteng *Bos javanicus* grazing, by park management or by enclaves of plantations. When abandoned either by the wild cattle or by humans, these fields become overgrown with shrubs and trees and become less attractive to peafowl. This was seen in Leuweung Sancang, where the peafowls moved to the planted rubber *Hevea brasiliensis* forest north of the reserve, after the grazing fields inside the reserve became less suitable through natural afforestation.

*Teak forests.* The teak forests which cover a large part of the 1,121,300 ha of plantation forest on Java and Bali (RePPProT 1990) have long been known for their peafowl. Junghuhn (1850-1853) noted that "few birds other than peafowl inhabited these forests". Cordes (1881) pointed to the local abundance of the birds, especially where the teak forest alternates with small patches of alang-alang *Imperata cylindrica* grass fields. Koningsberger (1915) only mentioned peafowl for the remote areas, but stated that secondary woods were actually more suitable than the teak stands, where in the dry season, the birds liked to perch in the bare trees. Quarterly reports by forestry district offices, as well as our survey show that peafowl are still widespread in the teak plantations, despite the hunting pressure throughout the region. However, numbers are generally low and the scattered populations may be under immediate threat of extinction. Even when local people themselves do not hunt the birds because of taboos, the birds are not secure, because hunters often come from elsewhere.

*Open woodlands.* Excellent examples of this habitat are found in some of the reserves mentioned above, e.g., Baluran, Yang Highlands. Outside the protected areas some other woodlands offer suitable habitat to peafowl. This is especially the case in the rugged limestone hill ranges of Kapur Utara and Kendeng, which cross the boundary of Central and East Java, and where pockets of open woodland often interspersed with teak

[5] With more recent information from Baluran, Alas Purwo and in Indrawan (1993) and van Balen (1997) this figure would be 1272 – 1721 (= 39-50% higher). But this is still a underestimate of the total Javan population.

plantations, are found. Other steep, relatively inaccessible hills include Mt Ringgit and the foothills near Krepekan, and it is in these refuges that scattered populations of peafowl survive in the otherwise densely populated lowlands and hills of Java.

Nearby supplies of good and plentiful water were mentioned as indispensable by Johnsgard (1986). However, in Baluran, the rivers are dry for most of the year and only a few peafowl visit wells nearby. The same is true for Alas Purwo. Also the birds may not be as sensitive to cold weather as thought by Johnsgard (1986) because we found peafowl up to 2300m in the Yang Highlands, and there are even reports of peafowl up to almost 3000m asl.

**Conservation**

For centuries perhaps, hunting must have been the most serious threat to peafowl. In the 1930s and 1950s overhunting of the eggs and birds was reported from Pati, Walikukun and Jombang (de Voogd & R.H. Siccama 1939; Manuputty 1953). Early this century, at the high of the worldwide plumage trade, they were killed for their train feathers, of which fashionable hats, fans and cigar cases were made (de Graaff & Stibbe 1918). The feathers were regarded as trophy by the European hunters, but in general as bringing ill fortune to Javan possessors (Hoogerwerf 1970). In some areas, hunting of peafowl, in whatever form, is still taboo, e.g., Leuweung Sancang and Clering. However, in other areas (notably Ponorogo), the popular and traditional *reog* dance requires, amongst other items, feathers from a peacock's train, of which 2-5000 are used in a single dancing outfit (Mujib 1992)[6]. There is an increasing demand on the Indonesian market for the feathers for ornamental purposes, and because single feathers sell for up to US$ 0.50, they are very much sought after. Because of decreasing domestic peafowl numbers, feathers are reportedly imported from Indian peafowl through Jakarta to meet the demand (Mujib 1992). In captivity it was shown that the moult of the 156 train feathers would be completed in less than one month, with an average of six feathers shed per day (Kuroda 1936). Near Mt Ringgit, local villagers search for moulted feathers in September-December during the moult. However, the large number of plumes obtained from a bird in the hand and the higher market value of fresh feathers rather than shed ones, result in peacocks being hunted with snares and guns. Because of the additional meat, seldom is the "goose with the golden eggs" spared. Peafowl eggs, laid in clutches of 3-4, rarely 5, are another source of protein for hunters. They are also often sold to be incubated by domestic fowl, because the chicks are also a highly valued (though illegal) commodity. Peafowl are regularly offered for sale in most local bird markets, and prices of up to US $75-100 for 7-8 month old birds have been recorded (Basuni & Setiyani 1989).

In the teak forest areas in Central and East Java, where the standard of living is very low, hunting pressure is especially high. The meat is consume locally; the feathers, live birds and sometimes eggs, are traded throughout Java.

Another threat may come from the use of pesticides, where peafowl come in close contact with agricultural practices. The incident in the village of Wanabaja (East Java), where one farmer deliberately poisoned with DDT a large number of crop raiding peafowl in the early 1980s (Imamudin verbally), may be not an isolated case.

[6] See also van Balen (1997).

Green peafowl do not always suffer under the extensive habitat alteration by Man. On the contrary, peafowl often take advantage of the "parkland" landscapes created. The frequent fires mentioned by Hoogerwerf (1974) may have suppressed the numbers of peafowl in the Yang Highlands, but at the same time they maintained suitable habitat by the prevention of forest encroachment in the grasslands.

**Conclusions and recommendations**

Table 7.1 shows the localities on Java from where peafowl have or may have disappeared this century. The number of places for which absence could be confirmed is too small to draw conclusions about the relative size and causes of the decline. The situation appears to be more favourable than is suggested by recent publications on the species' status on Java, or the gloomy prediction by Beebe (1931) that "the birds are becoming rarer in Java, and before many years, as the plantations increase, they will become extinct". Nonetheless, the Javan Green Peafowl is correctly considered endangered by the Mace-Lande category of threat, following the CAMP workshop held at Antwerp in February 1993 (Mace & Lande 1991; van Balen & Holmes 1993).

Habitat changes seem to be of minor importance as habitat that is tolerated (or favoured) by peafowl, e.g., teak forest and forest edges along plantations, is still extensive on Java.

Numbers seem to fluctuate considerably (e.g., Baluran, Yang Highlands; see above text), and the species may well tolerate local small population sizes for prolonged periods, as their tolerance towards man-made environments and far-carrying advertising calls facilitate the exchange of birds amongst separate populations.

The gradual disappearing of local taboos on peafowl hunting, and the improved accessibility of remote areas have undoubtedly caused the most important impact on peafowl numbers throughout Java.

Pending more field surveys, the following recommendations are made:

(1) **Awareness**. The instalment by the Indonesian Government of new, much improved environmental laws in 1990 could without doubt ameliorate the present situation, if properly enforced. However, peafowl are mainly distributed in regions with the lowest per capita incomes and the relatively high prices paid for feathers and live specimens continue to be an irresistible temptation. Extension programmes should accompany law enforcement, and in tourist areas such Pasirputih, the birds could be promoted as attractions for tourists (which is already done in Baluran), from whom the local people could take some profit as guides, etc.

(2) **Surveys**. Many of the established as well as proposed nature reserves, national parks, and other forest areas for which there were unconfirmed reports on the occurrence of peafowl have been visited during the present survey. Undoubtedly many more areas support the species, especially in the extensive teak plantations of Grobogan and Ponorogo in Central and East Java, and these areas should therefore be surveyed. Moreover, the role of the smaller reserves of 17-45 ha, of which a number are located in peafowl area, should be studied. They may very well provide refuges in the otherwise much less hospitable teak monocultures.

Indrawan *et al.* (1994) studied the use of roost calling patterns of the males for developing an index for quick population estimates.

(3) **Re-introductions.** Peafowl chicks are regularly confiscated by the Department of Nature Conservation (PHPA) at local bird markets. The zoological gardens where the birds are normally deposited, are presently saturated. Sometimes it is decided to release confiscated birds into areas with peafowl, e.g., Baluran, where more than 20 were released in 1991. However, this may introduce diseases in the wild birds, although it is difficult to assess the associated risk (see Hillgarth *et al.* 1989). An alternative could be the re-introduction of peafowl into areas where the species disappeared in recent times. A possible area for re-introduction would be Mt Muriah (Colo). A 12,000 ha reserve is proposed (MacKinnon *et al.* 1982) for the 1620 m dormant volcano of Mt Muriah (or Muryo), where the species used to occur before 1970s. Alternatively, though no historical accounts of the presence of peafowl could be found, a good place for such translocations would be the Pangandaran nature reserve (West Java), where grazing fields, surrounded by dense forest form suitable habitat. An additional argument for Pangandaran is that it is much visited by tourists.

During the surveys in 1990-1991 the authors were assisted by A. Marakarmah (Leuweung Sancang, Alas Purwo, Meru Betiri), I W.A. Dirgayusa, M.A. Isa (teak forests in Central and East Java), I. Setiawan and A.P. Setiadi (Pasir Putih, Baluran).

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B.van Balen 1990

Chapter 8

# Distribution and conservation of the endemic Javan hawk-eagle *Spizaetus bartelsi*

S. van Balen, V. Nijman & R. Sözer 1999
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**Abstract**
The Javan hawk-eagle Spizaetus bartelsi is endemic to the island of Java. Severe habitat fragmentation and small population size, aggravated by illegal hunting have put this rain forest species on the list of threatened bird species. Intensive searching since 1986 resulted in the discovery of a large number of localities additional to the historic ones. All known locality records of Javan hawk-eagle have been scrutinised and are listed in the present paper. Confirmed post-1980 records are from 24 forest fragments of varying sizes: ten (including 28 discrete localities) in west, seven (including 14 discrete localities) in central and seven (including 20 discrete localities) in east Java. The configuration of available habitat in forest clusters is evaluated. The co-existence with other threatened bird taxa, and the need for further field surveys and studies of the Javan hawk-eagle are discussed.

## INTRODUCTION

The Java hawk-eagle *Spizaetus bartelsi* is a little-known eagle, endemic to the scattered rainforests of Java. Continuing deterioration of Java's forests is bringing this and many other forest birds closer to extinction. On account of loss, degradation and fragmentation of natural forests, and its small population size, the Javan hawk-eagle has been given the IUCN status Endangered (Collar *et al.* 1994).

Java is important for global bird preservation; both in terms of species richness, level of endemism and degree of threat the island scores highly. Indonesia is one of the World's centres of global bird endemism (ICBP 1992). The forests on Java (and Bali) have been recognised as one of two Javan Endemic Bird Areas (EBAs), i.e. an area with two or more restricted-range species occurring in it, the other being the Javan coastal zone (Sujatnika *et al.* 1995). The Java and Bali forest EBA is listed as "critical" in the conservation priority listing of Endemic Bird Areas. It contains 38 restricted-range species, 25 species being confined to it (Sujatnika *et al.* 1995). Java and Bali furthermore harbour 19 threatened bird species, while one, Javan lapwing *Vanellus macropterus* is almost certainly already extinct (Collar *et al.* 1994).

In setting priorities for bird conservation, both the Endemic Bird Area approach and the threatened species approach are in practice through the identification of Important

Bird Areas (IBAs), i.e. sites supporting (a) globally threatened species, (b) restricted-range species, (c) important congregations of seabirds and/or waterfowl, or (d) bird communities characteristic of and restricted to avifaunal zones or biomes which lack EBAs (see Evans 1994). As the top avian predator in the Javan forest ecosystem, Javan hawk-eagles can be used as an indicator species for relatively undisturbed environments. By virtue of its endemicity, its habitat and breeding requirements, and its conservation status, the Javan hawk-eagles is an important species in identifying IBAs.

International attention to the plight of the eagle was more or less instigated by the species nomination as Indonesia's flagship species for rare animals (Widyastuti 1993). Indonesian authorities (Indonesian Institute of Sciences; Ministry of Forestry; Ministry of State for the Environment) and non-governmental organisations have been assisted in separate initiatives in their efforts to save the eagle and conduct co-operative research projects by the Norwegian research institute NINA (N. Røv and J.O. Gjershaug verbally), the Japanese Society for Research of the Golden Eagle (T. Yamazaki verbally), Environment Australia (N. Mooney verbally) and the predominantly North American IUCN/CBSG (Manansang *et al.* 1997). Many local survey reports have appeared, some of which were specialised Javan hawk-eagle surveys, but too often without substantiation of the field sightings. For the conservation of the species management and gazettement of reserves it is of utmost importance that the distribution and ecological range of this eagle is adequately mapped. Therefore this report seeks to make a comprehensive inventory of existing Javan hawk-eagle habitat by assembling and scrutinising all existing reports.

## METHODS

The best method to assess the presence of Javan hawk-eagle is to find vantage points, i.e. on hill tops, along ridges, in forest openings and along forest edges, and search the sky and canopy on days with fine weather. Especially in the late morning, typically between 09h00 and 12h00, birds can be seen soaring and displaying in these places. Calls are another clue to their presence and with some practice they can be recognised with confidence (Nijman & Sözer 1998).

Field observations were made in the framework of a general study on forest birds on Java in 1980 – 1981 and 1984 – 1997 (van Balen); and during specialised surveys in March – September 1994 (Nijman; Sözer), June – July 1995 (Nijman; van Balen), August – September 1997 (Nijman), May-June 1998 (Sözer), and September 1998 – January 1999 (Nijman). Additional data come from museum specimens stored in Leiden (RMNH, The Netherlands), Bogor (MZB, Indonesia) and Washington D.C. (USNM, U.S.A.) museums; and from published as well unpublished field observations of Javan hawk-eagles. Published records from Cirebon (Kuroda 1936) and Baluran NP (C.D. Bishop *in* Robson 1988) have been omitted by us because of inadequate descriptions of the observed birds and/or evident confusion with other raptor species. Highly unlikely observations, such as four pairs on the 528-ha offshore island of Sanghiang (Sunda Strait), or one pair at the artificial lake of Kedungombo (C Java), with no forest in the wide surroundings (Manansang *et al.* 1997), have been discarded. Less doubtful localities were evaluated after descriptions had been solicited from the observers. Especially the possible confusion with resembling crested species such as rufous-bellied eagle *Hieraaetus kieneri* and crested honey-buzzard *Pernis ptilorhynchus* (see van Balen *et al.* 1999) had to be ruled out. In other cases the expertise and reliability of the observer alone was considered sufficient to warrant inclusion.

## DISTRIBUTION

### Localities

In the following paragraphs all localities are listed from where Javan hawk-eagles have been recorded since the beginning of this century. Indicated protection status of the areas follows MacKinnon *et al.* (1982), which is found back on maps produced by RePPProT (1990) and, largely unaltered, adopted by Whitten *et al.* 1996. Figure 8.1 all localities records and mapped; the number of records are indicated by dots of different sizes.

*West Java*

1: **Ujung Kulon National Park**. Despite intensive ornithological surveys, until recently almost exclusively undertaken in the 30,000-ha peninsula comprising this reserve, no Javan hawk-eagles were seen (Hoogerwerf 1948, 1969-1971; van Balen unpublished data 1986-1989). In June 1994 during a brief survey a single adult was seen flying over forest in the northern part of the isthmus that connects the peninsula to the mainland part (Mt Honje) of the park (Sözer). In August-September 1997 N. Røv *et al.* (in Sözer *et al.* 1998) recorded two neighbouring pairs on Mt Honje. Ujung Kulon NP embraces more than 75,000 ha area of old secondary lowland forest, with primary forest in the higher parts. The peninsula and isthmus are relatively secure from logging and encroachment, but the mainland part is threatened by surrounding cultivation.

2. **Mt Aseupan**. A single adult was seen in June 1991 (P. Heath *in litt.* 1992) and a single bird in September 1997 in the lowland forest above the Curug Gendang waterfalls above Carita Beach (Nijman). The area belongs to a 95-ha tourist resort but is adjacent to a larger, heavily disturbed lowland forest of several thousand hectares rising up to 1174 m.

Unconfirmed sightings were made in 1995 in the Rawa Danau Nature Reserve, *ca* 7 km to the north (Manansang *et al.* 1997)

3. **Mt Karang.** Robinson and Kloss (1924) did not collect the species from this area, where they stayed two weeks in April 1920. During a four-day survey in April 1995 a juvenile was seen on the southern slope and an adult on the eastern slope (van Balen). Mt Karang (1778 m) is a protection forest of *ca* 3000 ha managed commercially by the forestry department; rainforest below 1000 m has been converted entirely to mahogany plantations, orchards, paddy fields and village gardens. The area has formed an isolated forest complex since at least the beginning of this century.

4. **Gobang**. G.F. Mees (1946-1949, unpubl. data; *in litt.* 1995) reported repeated observation of a single (most likely the same) juvenile bird in February and August 1948; the bird frequented

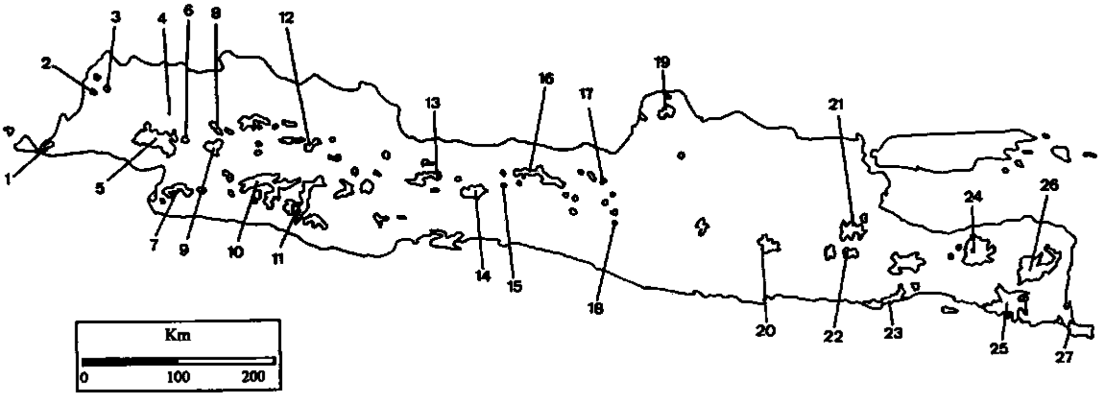


**Figure 8.1** Localities of Javan Hawk-eagle in Java. Numbers refer to those in the text. Remaining forest areas have been outlined.

a ladang and forest edge on Gunung Pengangkang, where presently no extensive rain forest is extant.

5. **Mt Halimun**. Although this area was visited twice by M. Bartels in 1922-1925, first sightings from this area date from as recently as the mid-1980s. Since then Javan hawk-eagles have been seen regularly at various localities, i.e., around the Nirmala tea estate where subadults and adults were seen soaring during various visits between 1986 and 1989 (e.g., Thiollay & Meyburg 1988; van Balen 1991); Cikotok, with sightings in 1994-1995 (D. Liley verbally; van Balen); and six territorial pairs within a linear distance of *ca* 10 km at Ciptarasa in the south-west corner of the mountain (N. Røv *et al.* in Sözer *et al.* 1998). The area covers lowland and hill forest from 500 to 1929 m and is largely enclosed in the 40,000 ha of Mt Halimun NP, although especially in the western part important lowland forests are present outside the park boundaries (Whitten *et al.* 1996). Encroachments from surrounding agriculture and large tea estate enclaves, illicit logging, hunting and illegal gold mining form major threats to the forest (Wind & Soesilo 1978).

6. **Mt Salak**. Javan hawk-eagle was seen once at the Ciomas tea estate on the northern slopes by Hoogerwerf (1948). In the mid-1980s P. Andrew (*in litt.* 1992) saw the eagle on the southern slopes. Hernowo (1997) reported a single adult in March 1996 at Awibengkok on the south-west slope of the mountain. Immatures were seen in April 1981 above Cidahu on the southeast slope, and in October 1986 above Gunung Bunder (Pasirreungit) on the northern slope (van Balen). In September-October 1987 single immatures seen above Sukamantri on the north-east slope (van Balen); at the same general locality breeding was reported in 1997 at Loji where a fledgling was

seen near its nest; Bobojong where an active nest was under observation from July until October; and at Citiis a single bird seen in November 1997 (Hapsoro *et al.* in Sözer *et al.* 1998). Mt Salak is a volcano 2211 m high, well vegetated above 1000 m. Encroachment by agriculture and various projects (geothermal generator, development for tourism) impinge on its integrity. The forest has the status of protection forest.

7. **Jampang**. Four birds were collected in Cibutun, Sukamaju and Jampang Kulon by Bartels in 1927-1928. A single immature was seen perched in a tree overlooking the valley south-east of Pelabuhanratu in April 1983 (P. Andrew *in litt.* 1995). More recent records are from Ciracap, where an old nest was reported in July 1997; and Cigaru where a bird was seen in September 1997 (Hapsoro *et al.* in Sözer *et al.* 1998). Forest in this area has the status of protection forest and is broken into several small blocks and a larger one in a rugged area of this scarcely populated region. In the flat peripheries of this area the Cibanteng Nature Reserve and the adjacent Cikepuh Wildlife Reserve (together little more than 8500 ha) are established; from here no Javan hawk-eagle records are known.

Unconfirmed sightings were made in 1991 in the tiny Sukawayana Nature Reserve on the coast west of Pelabuhanratu (Manansang *et al.* 1997).

8. **Megamendung and Puncak**. During regular surveys in 1981-1998 single birds were observed at Megamendung and Telaga Warna (Ciloto) (van Balen 1988; A. Supriatna unpubl. data 1997-1998). Single juvenile birds were seen in October 1986 and December 1991 on Mt Pancar (Meyburg *et al.* 1989; van Balen). Breeding was noted at Cibulau, both in June-September 1997 and December 1997 (T. Yamazaki, A. Supriatna & I. Setiawan verbally; van Balen; Nijman). The Telaga Warna area forms a 350-ha nature reserve, but the remaining part of the area is greatly threatened by encroachment of tea estates and holiday resorts. Mt Pancar is a somewhat isolated hill, 800 m high, with moderately disturbed forest above 600 m.

9. **Mts Gede and Pangrango**. First record from the area is a female collected on Mt Gede by E. Prillwitz in August 1898 (Amadon 1953). The type locality of the Javan hawk-eagle is found on the south-west slope of the complex, above Pasir Datar, where subsequently another six specimens and one egg were collected by M. Bartels and his sons (specimens in RMNH). Another nest was recorded in the first half of this century, *ca* 25 km east of the mountain complex, near Gunung Masigit (H. Bartels verbally 1995), but no extensive forest survives here nowadays. On the northern slopes a single bird was collected in the Gunung Mas tea estate in 1922 (specimen in MZB). Above Cisarua on the north-western slope a single bird was seen in June 1994 (Sözer *et al.* 1998). From the area above Cibodas on the north-eastern slope Javan hawk-eagles were reported by a large number of visiting birdwatchers (e.g., Delsman 1926; Hoogerwerf 1949a; Andrew 1985); here an active nest was found in 1992 (van Balen *et al.* 1994). Another active nest was under observation in 1994 at Pasir Pogor on the western slope (Nijman *et al.* in press). A pair with their young was seen in July-August 1986 above Selabintana on the southern slope (Meyburg *et al.* 1989). Although virtually the entire area is enclosed with the 15,000-ha Gunung Gede Pangrango National Park, ranging from 500 to 3019 m, encroachment from surrounding agriculture, hunting, and the effects of *ca* 30,000 visitors annually impose continuous threats.

10. **Mts Patuha and Tilu.** Specimens originating from Ciwidey (single juvenile in May 1928; shot on a tennis lawn), Gambung on Mt Tilu (three juveniles in 1908-1931), Lake Pangkalan (single male in 1922) and Pangalengan (single male in 1933) are stored in RMNH and MZB.

Bartels (1931) mentioned the occurrence of two pairs on the southern slopes of Mt Patuha above Koleberes in 1927-1929. Apart from an unconfirmed sighting at Gunung Halu in the west (T. Sibuea verbally), no subsequent observations have been made of the eagle, but its survival is very likely as forest cover is still extensive. A number of nature reserves exist in the area, the most important of which are Mt Tilu (8000 ha) and Mt Simpang (15,000 ha); one nature reserve has been proposed: Mt Masigit (23,000 ha), ranging from 1000 to 2078 m.

11. **Mt Papandayan and Kawah Kamojang.** A juvenile caught under a house at Cikajang (Garut), was erroneously identified by Sody (1920) as changeable hawk-eagle *Spizaetus cirrhatus* (see Becking 1989). Recent observations are of a single bird in the Kawah Kamojang reserve (H. Kobayashi *in litt.* 1992) and two single immatures above Darajat on Mt Papandayan in September 1987 (van Balen). The nature reserves and tourist forests of Mt Papandayan and Kawah Kamojang comprise 844 ha and 8000 ha of mountain forest, respectively; three wildlife reserves have been proposed: Mt Kencana (25,000 ha), Cimapang (1500 ha) and Gunung Limbang (20,000 ha), ranging from 300 to 2182 m.

Unconfirmed sightings were made in 1995 in the Leuweungsancang Nature Reserve along the coast south, and Gunung Sawal Wildlife Reserve, *ca* 35 km to the east (Manansang *et al.* 1997).

12. **Mts Tangkubanperahu and Burangrang**. A single male originating from Gunung Melati (Cikondang) is stored in MZB. P. Andrew (*in litt.* 1992) reported Javan hawk-eagle for Situ Lembang in the mid-1980s. In May 1998 Javan hawk-eagles were observed at Panaruban on the northern slopes of Mt Burangrang (RS). The forests north of Bandung are heavily fragmented, totalling less than 5000 ha included in five reserves and tourist forests ranging from 1400 to 2076 m. Unconfirmed sightings were in 1995 on Mt Tampomas, 10 km to the east (Manansang *et al.* 1997)

*Central Java*

13. **Pembarisan Mountains**. During a two-day visit in July 1994 two Javan hawk-eagles were heard above the village of Gandoang on the southern slopes of one of the taller mountains in the area, locally known as Mt Segara (Sözer & Nijman 1995b). The area is underexplored, but probably substantial tracts of lowland and hill rain forest remain; *ca* 13,000 ha of this is proposed as a nature reserve. To the south the area is bordered by extensive pine *Pinus merkusii* plantations, while extensive teak *Tectona grandis* forests border the area to the east.

14. **Mt Slamet**. Between 1990 and 1998 pairs and juvenile Javan hawk-eagles were reported from the forest of the tourist resort Pancuran Tujuh (above Baturaden) on the southern slope (Seitre & Seitre 1990; M.D. Linsley verbally 1994; Sözer & Nijman 1995b; I. Setiawan verbally 1998). In June 1994 a displaying pair was seen above a teak-covered hill near Karanganyar, in cultivated land along the main road between Tegal and Purwokerto and several kilometres from small scattered patches of natural forest on the western slope of Mt Slamet. On the north-western slopes several Javan hawk-eagles were seen in June 1994 above Pekandangan on the north-western slope of the same mountain (Sözer and Nijman 1995b), and a single bird in March 1994 near Guci (M. Linsley *in litt.* 1997). At 3418 m, Mt Slamet is Java's second highest mountain. On the wetter southern slopes extensive forest remains down to 700 m, while on the north-western slope forest remains above the 1200 m contour. The eastern slope is more cultivated and

forest has disappeared below 1900 m. Currently the forest above 1000 m on Mt Slamet is a proposed nature reserve of 15,000 ha.

15. **Mts Cupu and Simembut**. On the hills of the Cupu and Simembut forest complex, between Mt Slamet and the Dieng Mountains, a single bird was observed in May 1994 in a small fragment of forest (M.D. Linsley *in litt.* 1997). Small fragments of natural forest remain here, at 350-1000 m, surrounded by either open ground or pine plantations.

16. **Dieng Mountains.** Javan hawk-eagles have been recorded throughout the area: a single adult on the eastern slopes of Mt Prahu in August 1994; adults and juveniles near Linggo during three visits between 1994 and 1999; single adult near Lebakbarang in December 1998; a single bird near Mt Kemulan in January 1999 (van Balen; Nijman; Sözer). The mountains north and north-west of the Dieng plateau are still covered with an extensive block of natural forest covering the total range from lowland to montane. On the northern foothills of Mt Lumping above Linggoasri, the forest (partly a former coffee plantation abandoned in the 1930s) extends down to *ca* 300 m, while the eastern slopes of Mt Prahu are forested only above 1500 m. The forest totals 25,500 ha. Currently the area below 1000 m is unprotected forest managed by the Indonesian Forestry Service; the area above 1000 m is protected forest and proposed as a reserve. Main threats to the area are planned logging of the lowland forest near Linggoasri and its conversion to rubber *Hevea brasiliensis*, pine or damar *Agathis dammara* plantations (Nijman & van Balen 1998).

17. **Mt Ungaran**. In April-May 1994 M. Linsley (*in litt.* 1997) observed daily a pair of Javan hawk-eagles above Gonoharjo (Limbangan district) on the north-western slopes of Mt Ungaran. This small isolated volcano near Semarang is covered with good forest only above *ca* 1500 m; a *ca* 5500-ha area is proposed as a nature reserve.

18. **Mts Merapi and Merbabu**. The southern slopes of Mt Merapi, above Kaliurang, were surveyed for four days in June 1994, and in September 1995; single Javan hawk-eagles were heard and seen on Mts Plawangan and Turgo (Nijman). A four-month-old juvenile from the surroundings of Deles on the eastern mountain slopes was kept in a cage at Kaliurang, and Javan hawk-eagle may still occur at Bebeng in the south-east (Rudyanto verbally 1995). Mt Merapi is one of Java's most active volcanoes. At the beginning of 1994 the southern slopes with the 230-ha Plawangan Turgo nature reserve/recreation park, were still well forested above 900. In November 1994 parts of these were devastated by an eruption, whilst most of the forest on the eastern slopes escaped. The northern slopes have long been deforested whereas the western slopes are constrained by a permanent outflow of lava. On the southern slopes of Mt Merbabu there appears to be no natural forest left; *ca* 15,000 ha of forests on these twin volcanoes are proposed as a nature reserve.

19. **Mt Muriah**. The south-eastern and eastern part of this mountain complex, near Colo, was visited for two days in August 1994, and four days in July 1995; during the second visit an adult and a juvenile were seen at 1400 m (VN, SvB). The peaks of this dormant volcano on Java's north coast are covered with mostly secondary forest from 600-1602 m. The lower, central parts of the complex are cultivated. The forests on Mt Muriah are proposed as a nature reserve of 12,000 ha.

*East Java*

20. **Mts Liman and Wilis**. The south-eastern part, north-west of Sendang, was surveyed for two days in September 1994 and a five-day visit was paid to the western (east of Ngebel) and northern parts in July 1995. Calls of Javan hawk-eagle were heard above Sendang on the southern slope of Mt Wilis (Sözer & Nijman 1995a), and in the Gunung Sigogor Nature Reserve (Nijman; van Balen). The mountain complex comprises four summits of which Liman is the highest (2563 m). Forest fires occur regularly and large parts of the area are covered with shrubs and small trees and sparse fire-climax cemara *Casuarina junghuhniana* forest on the upper slopes. The lower south-eastern slopes of Mt Wilis are still well forested, while elsewhere scattered patches of forest remain amidst secondary forest, regrowth, bushes and plantations. The forests on Mt Wilis are a proposed 45,000-ha large game reserve, whilst two small areas, Gunung Sigogor (190 ha) and Picis (28 ha), have long been gazetted nature reserves.

21. **Mt Arjuno.** Wallace (1869) collected in the north-west parts but missed Javan hawk-eagle, whereas in 1927 a single bird was taken by J.J. Menden on Mt Arjuno (specimen in USNM). In April 1993 a single subadult was seen on Mt Dorowati, a southern foothill (van Balen). Six birds – including a pair and immatures – were observed in the Ratu Suryo Grand Forest Park in July 1997 (KSBK Malang; I. Setiawan & N. Mooney in Sözer *et al.* 1998) and in November 1998 (Nijman). A single juvenile was seen at Trawas in December 1992 in a kapok tree *Ceiba pentandra* plantation adjacent to lowland forest on the southern slopes of the Mt Penanggungan, a northern foothill of Mt Arjuno (van Balen). The Arjuno Lalijiwo Nature Reserve covers 5000 ha of mainly montane forest ranging from 1500 to 3339 m. The Mt Penanggungan is a 1653 m high mountain is covered with disturbed forest from *ca* 600 m to its summit.

22. **Mts Kawi and Kelud.** In April 1993 single birds and pairs were seen above Dadapan and Coban Manten on the western and north-eastern slopes, respectively, of Mt Kawi (van Balen). Subsequently an adult was seen in September 1997 above Coban Rondo on the northern slope (Nijman). The Mt Kawi area is presently a mosaic of partly regenerating former coffee plantations and partly degraded lowland, hill and montane forest in varying degrees of disturbance (Smiet 1992). The 50,000 ha Gunung Kawi Kelud, including Mt Arjuno (300-2806 m) area is a proposed nature reserve.

23. **Bantur and Lebakharjo**. No specialised ornithological surveys had been made in these areas until October 1989 when, during a four-day survey, a juvenile was seen in the forest edge near the village of Lebakharjo (van Balen). In September 1997 two adults were observed soaring above the Balekambang Recreation Forest, south of Bantur (Nijman). The Lebakharjo (also known as Teluk Lenggosono) and Bantur forests, respectively covering 13,000 and 5000 ha, have been gazetted as proposed reserves (Bekkering & Kucera 1990; Whitten *et al.* 1996). Only a few hundred hectares of forest near Balekambang receive protection as a recreation forest. Wood-cutting and hunting form major threats (MacKinnon *et al.* 1982), while plans have been put forward for forest plantations and/or rattan estates. The area is separated by plantations, secondary forests and a few roads from the 57,000 ha Bromo Tengger Semeru National Park.

24. **Yang Highland**. Kooiman (1940, 1941) described a mounted juvenile bird in possession of the reserve manager. A possible sighting was made of a single bird near the Taman Hidup lake on the west slope in July 1989 (van Balen). The Yang Highlands are partially enclosed in the 14,145 ha Yang Plateau Wildlife Reserve. Threats to the area include poaching, burning of the

grasslands and use of the area for military exercises (MacKinnon *et al.* 1982). The Yang Highlands, i.e. the wildlife reserve and the surrounding podocarp forest (mostly under the jurisdiction of the Indonesian Forestry Service), have great potential as a national park if especially the higher parts are properly managed (Whitten *et al.* 1996).

25. **Meru Betiri National Park**. Javan hawk-eagle has been recorded regularly from at least four different localities (i.e., Sumbersari, Permisan, Teluk Hijau and Sukamade) in the eastern half of the park since the mid-1970s (H. Bartels verbally 1984; Thiollay and Meyburg 1988; Meyburg *et al.* 1989; van Balen 1991; Tobias & Phelps 1994). In December 1989 an immature was seen above secondary forest west of Kalibaru, between the southern foothills of Mt Raung and the northern boundary of the park (van Balen). The 50,000 ha lowland forest ranging from sea-level to 1223 m has the status of national park; it is the last area in which the Javan tiger *Panthera tigris sondaica* persisted (MacKinnon *et al.* 1982). The former coffee plantation enclave is presently being abandoned, but encroachment in particular from the north keep threatening the integrity of this important area. The national park is separated from the Ijen Highlands by a relatively narrow area of plantations, secondary forest and a road.

26. **Mt Raung and Ijen Highland.** Kooiman (1940) mentions a live bird captured by Mr H. Lucht on the Ijen plateau. In June 1990, a juvenile and an adult were seen above Lijen on the eastern slope. In July 1990, on the south-western foothills of the adjacent Mt Raung, an immature bird was seen in a narrow stretch of hill forest (van Balen). The area is only partly protected by the 2560-ha nature reserve of Kawah Ijen Merapi Ungup-ungup, and by three tiny reserves. More important reserves are proposed for Mt Raung (60,000 ha; north-east of Meru Betiri), and Maelang (70,000 ha; south- west of Baluran National Park).

27. **Alas Purwo National Park**. During an eight-day visit in May 1990 a juvenile and adult bird were seen at Pasirputih (Sembulungan) in the north, and a single bird was heard near Sadengan in the central part (van Balen 1991). During an eight-month period in 1997, M. Grantham *(in litt.* 1998) saw one subadult in the open forest at Sadengan in November. Alas Purwo (also referred to locally as Blambangan, or Banyuwangi Selatan) is a 62,000-ha lowland forest reserve ranging from sea-level to 360 m in the drier part of Java. Wood-cutting forms the major threat to the habitat.

## Forest clusters

Figure 8.1 shows that the distribution of Javan hawk-eagle across Java is mainly concentrated in eight major blocks of forest, each at least covering 20,000 ha. Unhampered dispersal within these blocks is expected on the basis of distance between forest fragments, topography and land use of the area. These forest clusters are:

(i) Mts Halimun and Salak (total: 50,000 ha);
(ii) Mts Gede and Pangrango, Megamendung and Puncak (total: 20,000 ha)
(iii) Mountain range south of Bandung (total: 90,000 ha)
(iv) Mt Slamet through Mts Cupu and Simembut to the Dieng Mountains (total: 40,000 ha)
(v) Mts Liman and Wilis (total: 25,000 ha)
(vi) Mts Arjuno, Kawi and Kelud (total: 50,000 ha)
(vii) Bantur, Lebakharjo and Mt Semeru (total: 38,000 ha)

(viii) Meru Betiri, Ijen highlands, Mt Raung and Maelang (total: 183,000 ha)

These forest clusters are of the utmost importance for the survival of the different populations of Javan hawk-eagle. The observations of adult and immature Javan hawk-eagles between a number of these forest patches suggest that dispersal is possible. They cover large areas over a wide altitudinal range, and are laid out across the entire length of the island.

## DISCUSSION & CONCLUSION

According to Kuroda (1936) the Javan hawk-eagle breeds in the wooded hills of West Java. Also Brown & Amadon (1968) consider the species to be restricted to the wooded hills of West Java, although Kooiman (1940) had reported the species to be present in the Ijen and Yang highlands in the East Javan province. Typical habitat of the Javan hawk-eagle was described by Thiollay & Meyburg (1988) and Meyburg *et al.* (1989) as wet tropical rain forest. Later surveys indicated the occurrence of the eagle and possible breeding pairs in much drier forest types in East Java, e.g. Alas Purwo (van Balen 1991). In total less than 10% of the original natural forest remains: 19% of the original hill forest, 54% of the mountain forest and only 2% of the lowland forest (MacKinnon *et al.* 1982; van Balen 1988). The latter forest type is now almost exclusively found along the southern coast of the island.

During the present study, without exception the eagles were encountered in hilly terrain. Its characterization as a slope specialist (Wells 1985) fits well with its general absence from the largely flat lowlands of Ujung Kulon, Cikepuh and most likely the northern plains (although here very little forest is extant to attest). The only record from the northern plains – Gobang – originates from a formerly forested hill.

Immature, dispersing birds have been seen in a variety of disturbed areas, including a tennis lawn, kapok plantations, forest edges, secondary forests, much in line with what has been seen in the closely related Blyth's hawk-eagle *Spizaetus alboniger* (Medway & Wells 1976). Adults are occasionally seen in disturbed habitats as well, but generally only when more undisturbed natural forest types are in the vicinity.

### Conservation area network

An extensive network of conservation areas has been established, with important forest clusters included in the Mt Halimun, Mts Gede Pangrango and Meru Betiri National Parks. However, not all areas are adequately protected and a number of national parks suffer much from hunting and encroachment along the forest edges.

Protected areas in Indonesia can be divided into 1) sanctuary reserves; 2) nature conservation areas; and 3) protection forest (after MacKinnon 1982; Whitten *et al.* 1996):

(1) *a.* Strict nature reserve (*cagar alam*): generally small undisturbed fragile habitats of high conservation importance, strictly protected and allowed to develop naturally. *b.* Wildlife sanctuary (*suaka margasatwa*): medium or large areas of relatively undisturbed

**Table 8.1** Forest areas containing Javan Hawk-eagles

| | Forest Block | Size[1] ($km^2$) | Status[2] | Survey intensity[3] | Number of recent localities | Altitudinal range of observations | Other threatened Species[4] |
|---|---|---|---|---|---|---|---|
| ***West Java*** | | | | | | | |
| 1 | Ujung Kulon | 125 | NP | xxx | 2 | 10-?300 | 1,2,3,4,7 |
| 2 | Mt Aseupan | 30 | PF | xxx | 1 | 100 | 7 |
| 3 | Mt Karang | 30 | PF | x | 2 | 1,000-1,200 | [8] |
| 5 | Mt Halimun | 400 | NP | xxx | 3 | 900-1,200 | 5,6,7,[8] |
| 6 | Mt Salak | 100 | PF | xxx | 5 | 1,000-1,200 | 5,6,7,[8] |
| 7 | Jampang | 100 | NR/WS | x | 3 | ? | 7,8] |
| 8 | Megamendung & Puncak | 60 | NR/PF | xxx | 4 | 6,00-1,600 | 7,[8] |
| 9. | Mts Gede/Pangrango | 140 | NP | xxx | 4 | 1,100-1,700 | 5,6,7,8 |
| 10 | Mts Patuha/Tilu | 460 | PF | x | ?1 | [600-1000] | 7 |
| 11 | Mt Papandayan & Kawah Kamojang | 550 | PF/NR | xxx | 2 | 2,000 | 7,[8] |
| 12 | Mts Tangkuban Perahu/ Burangrang | 100 | PF/NR | x | 2 | 950 | 5,6,7,[8] |
| ***Central Java*** | | | | | | | |
| 13 | Pembarisan Mts | 130 | PF | x | 1 | 470-600 | - |
| 14 | Mt Slamet | 150 | PF | xx | 4 | 700-2,200 | 6,7 |
| 15 | Mts Cupu/Simembut | ? | PF | x | 1 | 700-1,00- | |
| 16 | Dieng Mts | 250 | PF | xxx | 4 | 600-1,775 | 7 |
| 17 | Mt Ungaran | 50 | PF | x | 1 | 700-1,000 | 7 |
| 18 | Mt Merapi/Merbabu | 80 | PF | xxx | 2 | 1,150-1,300 | - |
| 19 | Mt Muriah | 100 | PF | xx | 1 | 1,400 | [3],[8] |
| ***East Java*** | | | | | | | |
| 20 | Mts Liman/Wilis | 250 | PF | xx | 3 | 1,100-1,300 | - |
| 21 | Mt Arjuno | 250 | PF/GFP/NR | xxx | 3 | 400-1,050 | [3],[8] |
| 22 | Mts Kawi/Kelud | 250 | PF | xxx | 4 | 1,100-2,200 | 3 |
| 23 | Bantur & Lebakharjo | 180 | PF | x | 1 | 100 | 3,7 |
| 24 | Yang Highlands | 140 | PF/WS | xx | ?1 | 2,000 | 3 |
| 25 | Meru Betiri | 500 | NP | xxx | 5 | 0-100 | 3,8 |
| 26 | Mt Raung & Ijen Highland | 700 | PF/NR | xx | 2 | 825-900 | 3, 5,[8] |
| 27 | Alas Purwo | 160 | NP | xxx | 2 | 0-360 | 2,3 |

**Notes to Table 8.1:**
[1]Approximate size of Javan Hawk-eagle habitat;
[2].Status: NP: National Park; GFP: Grand Forest Park; NR: Nature Reserve; WS: Wildlife Sanctuary; PF: Protection Forest;
[3] Survey intensity: x = <5 survey days, xx = 5-10 survey days, xxx = >10 survey days;
[4] Other threatened species: 1. Milky Stork *Mycteria cinerea*; 2. Lesser Adjutant *Leptoptilos javanicus*; 3. Green Peafowl *Pavo muticus*; 4. Sunda Coucal *Centropus nigrorufus*; 5. Javan Scops-owl *Otus angelinae*; 6. Javan Cochoa *Cochoa azurea*; 7. White-breasted Babbler *Stachyris grammiceps*; 8. Java Sparrow *Padda oryzivora*. Sources: van Balen (1997; pers. obs.); van Balen *et al.* 1995; Becking 1994; Hoogerwerf 1948; M. Linsley (pers.comm.); skin collection in Leiden and Bogor musea.
Data in brackets [ ] are before 1980 only.

stable habitats of moderate to high conservation importance, where habitat management may be conducted. *c*. Hunting reserve (*taman buru*): medium or large (semi-)natural habitats with game hunting potential.
(2) *a*. National park (*taman nasional*): large, relatively undisturbed area, with high conservation importance, managed through a zoning system to facilitate research, education, tourism, etc. *b*. Grand forest park (*taman hutan raya*): area intended to provide a variety of indigenous and/or introduced plants and animals for research, education, tourism, etc. *c*. Recreation park (*taman wisata*): small area mainly intended for recreation and tourism purposes.
(3) Protection forest (*hutan lindung*): forested lands on steep, high, erodible lands where forest cover is essential to protect important catchment areas, but where conservation priorities are not so high as to justify reserve status.

Although Java is seriously deforested, the opportunity still exists to create a number of large new forest reserves. On Java a number of forest clusters cover potentially suitable forest areas between 20,000 ha (Mts Gede and Pangrango, and Puncak and Megamendung) and 183,000 ha (Meru Betiri, Ijen Highlands, Mt Raung and Maelang). For the continued existence of Javan hawk-eagle it is therefore crucial to concentrate on the conservation of these forest areas. Some of the forest clusters consist of national parks or nature reserves and are (at least on paper) adequately protected. Other clusters, however, consist mainly of non-conservation areas and are therefore more susceptible to degradation. These are: (1) mountains south of Bandung; (2) Mt Slamet and Dieng Mountains; (3) Mts Kawi - Kelud - Arjuno; (4) Bantur and Lebakharjo; and (5) Ijen Highlands and Mt Raung. All these five forest clusters are proposed as conservation forest (MacKinnon *et al.* 1982; RePPProt 1990) and their gazettement is overdue. Efforts to preserve the species should be concerted to maintain or improve the integrity of these blocks through the consolidation of existing forest corridors, "stepping stones" or extensively used buffer zones, and existing reserves should be safeguarded against further fragmentation.

**Important Bird Areas programme**
BirdLife International in cooperation with the Indonesian Ministry of Forestry has created a network of birdwatching clubs throughout Java. Most of these clubs are engaged in the Important Bird Area programme (IBA), the main aim of which is the assessing and monitoring of areas important for bird conservation. Excluding the old

observations at Gobang, where no forest is extant, Javan hawk-eagles have been recorded in 26 forest areas throughout Java. In only seven areas no other threatened species (see Collar *et al.* 1994) have been recently recorded (Table 8.1). One of these areas (Mts Cupu and Simembut) was not visited by us, and two (Pembarisan Mountains and Mt Karang) were only visited during 2-4 days. In ten of the twenty-six areas supporting populations of Javan hawk-eagles, two to four other threatened bird species have been recorded. Three of the threatened species have habitat requirements similar to the Javan hawk-eagle or overlap almost completely in their range, i.e. the white-breasted babbler *Stachyris grammiceps*, and the strictly sub-montane Javan scops-owl *Otus angelinae* and Javan cochoa *Cochoa azurea.* All other threatened bird species (three of wetland/coastal, and three open woodland/forest edge) occupy very different habitats. However, if we look at the subspecies level, many more threatened taxa are found co-occurring with the eagle, notably those species that are represented by distinct but rare races endemic to the Javan lowland and hill forest (van Balen 1988; Whitten *et al.* 1996).

**Field surveys and studies**

A number of surveys were carried out during 1986-1997, and resulted in the (re)discovery of Javan hawk-eagle at a number of historical and new sites (Thiollay & Meyburg 1988; van Balen 1991; van Balen & Meyburg 1994; Sözer & Nijman 1995a). Figure 8.1 shows the extent of remaining forest with existing records indicated. In some extensive areas with suitable habitat only few (e.g., Mt Raung and Ijen Highlands) or no (e.g., Bromo Tengger Semeru National Park) Javan hawk-eagles have been recorded as they are still seriously under-surveyed (see Table 8.2). Additional areas that need surveys are listed are listed in Table 8.2.

In the framework of the IBA programme priority should be given to the correct identification of eagles and mapping of under-surveyed eagle habitat. Main aims for future in-depth research should be: (1) the assessment of home range sizes; (2) the study of demography and recruitment; (3) the study of dispersal behaviour of both adult and juvenile birds; and (4) further study on habitat requirements for different age classes.

**Table 8.2** Natural areas in Java (>10,000 ha), supposedly with Javan hawk-eagle populations and needing (additional) surveys.

| Localitiy | Gazetted | |
|---|---|---|
| Area (in ha) Status | | |
| *West Java* | | |
| Mt Pangasaman | 34,000 | proposed game reserve |
| Mt Kencana | 25,000 | proposed wildlife sanctuary |
| Mt Limbang | 20,000 | proposed wildlife sanctuary |
| Mt Simpang | 12,000 | strict nature reserve |
| Masigit Karumbi | 12,420 | hunting reserve |
| Waduk Gede/Jati Gede | 10,500 | proposed nature reserve |
| *Central Java* | | |
| Mt Lawu | 21,000 | proposed nature reserve |

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Chapter 9

# Population status of the endemic Javan hawk-eagle *Spizaetus bartelsi*

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Ibis [under review]

**Abstract**

The endemic Javan hawk-eagle *Spizaetus bartelsi* is considered threatened by extinction because of its small population size and fragmentation of its habitat on the densely populated island of Java, Indonesia. Research was carried out from 1980 to 1998 in order to assess the status of this little studied species. Its presence was confirmed by us in 21 forest blocks of 50 km$^2$ and larger, in both wet and dry climatic zones. We estimate that there are 137-188 pairs remaining, which account for a total population of 600-900 birds. Javan hawk-eagles appeared to be less restricted to primary rainforest than previously presumed. Furthermore, some long-time isolated forest areas of less than 100 km$^2$ contained Javan hawk-eagles. Juvenile dispersal through secondary habitat was thought to mitigate the effects of insularisation.

## INTRODUCTION

Six species of *Spizaetus* hawk-eagles occur in Indonesia, including one wide-ranging species: the changeable hawk-eagle *Spizaetus cirrhatus*, found in India and throughout SE Asia; and two single island endemics (Andrew 1992): the Sulawesi hawk-eagle *Spizaetus lanceolatus*, endemic to Sulawesi and satellite islands, and the Javan hawk-eagle *S. bartelsi*, endemic to Java. The last-mentioned is classed as endangered according to IUCN threat categories on account of severe habitat fragmentation and small population size (Collar *et al.* 1994). Recent observations of birds being offered for sale on local markets (despite its protected status in Indonesia) are evidence of an additional threat (Meyburg *et al.* 1989; Sözer & Nijman 1995; Gunawan 1996).

The overall destruction of the original lowland vegetation on Java has turned the habitat of Java's rainforest specialists into a highly fragmented system of numerous forest patches of varying sizes. On Java less than 10% of land cover remains under highly fragmented natural forest. It may therefore be surprising to find the Javan hawk-eagle still largely present throughout its entire historical range. Surveys carried out by the authors from 1987 through 1999 attempted to obtain a picture of the number of Javan hawk-eagles that survive. In this paper we present a new appraisal of status, and current threats to survival of the Javan hawk-eagle.

## MATERIAL AND METHODS

### Study area

Originally, the island of Java was probably completely covered by tropical forest (MacKinnon *et al.* 1982), the first major loss of which may have occurred with the introduction of teak *Tectona grandis* by early Hindus in the 2nd to 4th century (Whitten *et al.* 1996). An estimated total area of 10 million ha of natural forest (lowland, hill and montane) was present in the 17th century (Smiet 1990). About hundred years ago 4 million ha was left of this, but this further decreased to about 1.5 million ha in the first half of the 20th century, further decreasing to about 1 million ha during the past 50 years (Smiet 1992). The original vegetation cover is now largely replaced by cities and villages, roads, agricultural land, cash crop plantations (coffee *Coffea* spp, tea *Thea* spp), forest plantations (teak, pine *Pinus merkusii*, rubber *Hevea brasiliensis*), leaving the natural forest areas as habitat islands. Overall, less than 10% of the original natural forests remain: 54% of the mountain forest, 19% of the original hill forest, and only 2% of the lowland forest (MacKinnon *et al.* 1982; van Balen 1988; Smiet 1990). The latter forest type is now almost exclusively found scattered along the southern coast and in the easternmost part of the island of Java.

The climate on Java differs greatly along the longitudinal axis of the island. The eastern part of Java and the north coast have a pronounced dry season, while in the western half it is weak and nowhere marked. In general, the wettest vegetation types (mixed lowland and hill rainforest and ever-wet montane forest) only occur in areas with at least 30 rainy days during the driest four consecutive months (van Steenis & Schippers-Lammertse 1965), and hence is mostly found in the western and central part of Java. Rain forest is also found throughout the otherwise seasonally dry east in the wet "islands" which arise as a result of cloud stowage on the southern and south-eastern slopes of the higher mountains (van Steenis 1972). In the drier areas moist forest and deciduous forest replace rainforest.

### Field observations

Tropical forest eagles are notoriously difficult to observe. Thiollay (1985) estimated that on average he observed only one raptor per day while walking slowly inside the rainforest.

**Table 9.1** Survey area and survey effort, 1980-1999.

| Province | Remaining forest area (in km$^2$)[1]. | Forest area surveyed (in km$^2$) | Survey effort (in days) |
|---|---|---|---|
| West Java | 3163 | 2435 (77%) | 335 |
| Central Java | 1365 | 1300 (95%) | 142 |
| East Java | 5965 | 4815 (81%) | 155 |
| Total | 10 493 | 8565 (82%) | 632 |

[1]After MacKinnon *et al.* (1982)

The (sub)tropical mountain hawk-eagle *Spizaetus nipalensis*, spends 95% of daytime perched inside the forest, and on 20% of the days observed it does not fly at all (T. Yamazaki pers. comm. 1995). Therefore the presence of the Javan hawk-eagle was assessed by scanning a large area from a vantage point (i.e., hill top, forest edge or opening) and searching the sky and canopy on days with favourable weather between 09.00 and 12.00 hours when the birds are expected to soar and display. Presence could also be assessed by calls heard from both these vantage points and along transects inside the forest.

Observations were made in the framework of a general study on forest birds on Java in 1980-1981 and 1984-1997, and during specialised surveys in March- September 1994, June-August 1995, August-September 1997 and September 1998- January 1999 (van Balen *et al.* in press; Chapter 8 of the present thesis). The presence of the species was assessed in numerous small forest areas (<50 km$^2$) and in 34 sizeable forest blocks (>50 km$^2$) with known historical or expected occurrence of the Javan hawk-eagle. In total the investigated forest areas cover over 8500 km$^2$ (see Table 9.1) or over 80% of all remaining forest on Java. The majority of areas were visited at least twice, while surveys typically lasted several days up to several weeks. In all we spent 632 field days (11 % of which were shared amongst us) throughout Java surveying inside natural forest (see Table 9.1). While travelling (almost exclusively by public transport) to and through forest areas we spent numerous additional hours on the look-out for raptors; in forested areas the roads were often so bad that a relative low speed was maintained, allowing observations to be made. The routes travelled are indicated in Figure 9.1.

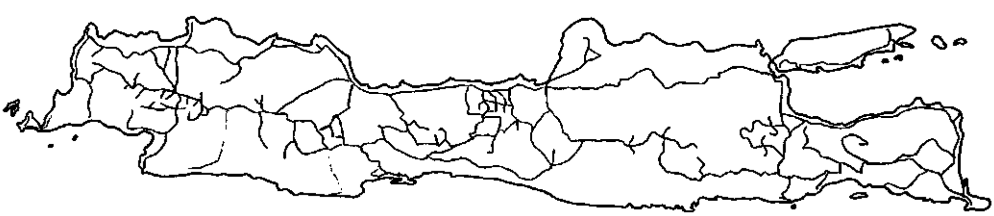

**Figure 9.1** Routes travelled in Java, 1980 - 1999.

**Estimate of population numbers**

The number of breeding pairs per forest area was calculated by extrapolation based on the geographic area inhabited and the density expressed in number of established pairs per area. Thiollay & Meyburg (1988) estimated home ranges of 2-3000 ha for Javan hawk-eagles, but used sizes of 1700-4500 in their population estimates. Home range size for a breeding male under study in West Java was estimated at a minimum of *ca* 1200 ha (Sözer & Nijman 1995), and for another adult in Central Java at *ca* 3600 ha (VN, unpublished data). Bartels (1931) reported a 4 km distance between two breeding pairs, which, assuming most breeding activities had been taking place in the centres of two circle-shaped, contiguous territories, corresponds to the first estimate. More recent records have suggested locally higher densities based on observations of six territorial pairs along a 10 km linear distance, which may extrapolate to about 500 ha for a territory (Røv *et al.* *in* Sözer *et al.* 1998).

Raptor numbers are limited by the availability of nest sites and prey (Newton 1991), which are determined by habitat quality. This in turn is determined by the following parameters:

*Altitude.* The large forest patches often cover wide altitudinal ranges, with possibly varying densities of Javan hawk-eagles. Hill and sub-montane forests are believed to be preferred to forest on the flat plains.

*Climate.* The richest forest types – mixed lowland and hill rainforest and montane everwet forest – only occur in areas with at least 30 rainy days during the four driest consecutive months (van Steenis & Schippers-Lammertse 1965); these types are believed to contain the highest densities of Javan hawk-eagle.

*Ruggedness of the area.* Javan hawk-eagle are characterised as slope specialists (Wells 1985), and tall forest on slopes is believed to be favoured.

*Degree of fragmentation.* Single large circular-shaped is believed to contain more pairs per ha than an irregularly shaped isolated or forest area of the same size (see Figure 9.2).

Habitat quality was determined by giving the same weight to above-mentioned qualities. The size of forest fragments was measured from land use maps provided by RePPProT (1990: scale 1: 250 000). By comparing these figures with figures given in conservation management plans (e.g., MacKinnon *et al.* 1982; Whitten *et al.* 1996) and our own data from the field, we made a qualitative estimate of the available habitat. For areas less than *ca* 50 km$^2$ and supposed to be too small to support more than two pairs of Javan hawk-eagle (i.e., Mts Karang, Aseupan and Ungaran) we did not estimate area or population size because the inherent error would be proportionally larger. For the population estimates the following assumptions were made:

(1) The home range size of an established pair is between 2-3000 in high quality habitat, 3-4000 ha in areas with a medium habitat quality, and 4-5000 ha in low habitat quality areas.
(2) All adult eagles occur in pairs and occupy contiguous breeding territories, whereas juveniles and immatures do not hold territories.
(3) No sizeable Javan hawk-eagle habitat has been omitted in the calculations.
(4) Only mixed tropical evergreen forest contains breeding Javan hawk-eagles.

In order to extrapolate observations to an estimation of the total wild population an assessment of age structure is required. To model this, three principal data sources were used: 1) (un)published observations in the wild; 2) specimens stored in museums (National Museum of Natural History in Leiden, the Netherlands; Museum Zoologicum Bogoriense in Bogor, Indonesia); and 3) live eagles freshly captured from the wild and held in zoological gardens (Taman Mini Indonesia Indah Bird Park, Surabaya Zoo, Taman Safari Indonesia), private collections or encountered on local bird markets. The various life stages in Javan hawk-eagle can be readily recognized by plumage patterns as described in Meyburg *et al.* (1989) and Nijman & Sözer (1998). In this paper Javan hawk-eagles are considered adult when the banding patterns on belly and wings are complete. Eye-colour is an additional clue as it changes from very dark brown, almost black in downy chicks, dark blue bluish-grey in juveniles into light grey and lemon in subadults to golden yellow in full adults. The Javan hawk-eagle is believed to mature at an age of four years (Sözer & Nijman 1995), but most likely starts breeding only in its fifth year, as in other eagle species of comparable size (Newton 1979; Yamazaki pers. comm. 1990).

## RESULTS

### Distribution

We observed Javan hawk-eagles at 49 localities distributed across 21 forest blocks, and during the last two decades other ornithologists have recorded their presence in three additional areas: Jampang, Mts Cupu-Simembut (a small forest fragment between Mt Slamet and Dieng mountains) and Ungaran (Figure 9.2; Table 9.2). Historically (pre-1975) Javan hawk-eagles had been recorded from 18 localities in 11 areas; in two of these areas (one of which has presently no forest left), no recent observations were made of Javan hawk-eagles.

There is a preponderance of birds occurring in areas with highest rainfall (type 1 in Table 9.2), and only occasionally were birds encountered in rather dry types of forest, such as the semi-deciduous forest of Alas Purwo. Adult Javan hawk-eagles held territories in the least accessible, most rugged parts of tropical forest, whereas, juveniles more than adults, were occasionally found in cultivated land. Generally we encountered Javan hawk-eagles in hilly terrain, and rarely in flat plains. If occurring in rather flat regions, e.g., Ujung Kulon and Alas Purwo, the species is generally present only in the relatively most hilly parts. We recorded the species at sea level (e.g., Lebakharjo, Meru Betiri) to about 2500m (Mt Slamet). An equal number of records originated from lowland areas (below 1000-1200 m), as from the (sub)montane forests, namely, 33 and 37, respectively. However, on Java about three and a half times as much forest remains in the hills and mountains as in the lowlands (MacKinnon *et al.* 1982). Though the three Javan provinces have different proportions of remaining lowland / montane forests (0.17 for West Java, 0.10 for Central Java, and 0.45 for East Java), we did not find differences in the proportion of lowland vs mountain records ($\chi 2=3.85$, df=2, $p>0.2$).

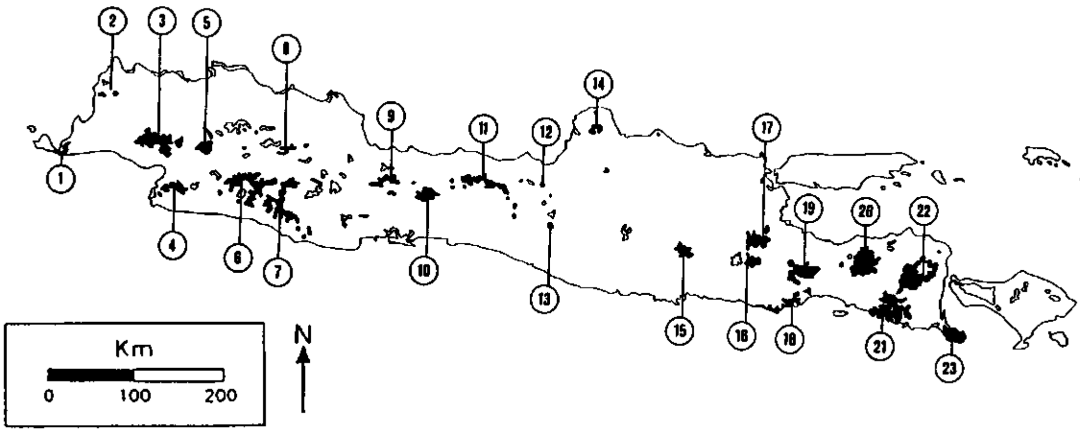


**Figure 9.2** Localities of Javan hawk-eagle on Java mentioned in the text.
Ujung Kulon; 2: Mts Aseupan and Karang; 3. Mts Halimun and Salak; 4. Jampang; 5. Mts Gede and Pangrango; 6. Mts Patuha and Tilu (South Bandung I); 7. Mt Papandayan and Kawah Kamojang (South Bandung II); 8. Mts Tangkubanperahu and Burangrang (North Bandung); 9. Pembarisan Mountains; 10. Mt Slamet; 11. Dieng Mountains; 12. Mt Ungaran; 13. Mts Merapi and Merbabu; 14. Mt Muriah; 15. Mts Liman and Wilis; 16. Mts Kawi and Kelud; 17. Mt Arjuno; 18. Bantur and Lebakharjo; 19. Bromo Tengger Semeru; 20. Yang Highland; 21. Meru Betiri; 22. Mt Raung and Ijen Highland; 23. Alas Purwo.

## Population size

Table 9.2 presents the estimated number of pairs per forest area. The size of each forest block, altitudinal range of the forest, habitat and climatic type are given, and localities within the same forest blocks are grouped. Hitherto, no Javan hawk-eagles have been confirmed for the Bromo / Tengger / Semeru National Park. Ornithologically, the park is under-explored, and we have only surveyed the area briefly (four days in 1991 by van Balen, mainly above 2000 m). However, its close vicinity to Lebakharjo (<10 km), where Javan hawk-eagles were found, and its habitat (*ca* 200 km$^2$ of protected and relatively undisturbed rainforest) make us believe that the Javan hawk-eagle is present in the area. We have included the area in the analysis with a conservative medium habitat quality score. The estimated total breeding population size is 137-188. The adult : immature ratio for direct field observations is 24:28, for museum specimens 10:14 and for live birds observed at bird markets and zoological parks 4:9. These ratios are not significantly different ($\chi^2$ =0.26, df = 4, p>0.5). Giving every observation the same weight, assuming that they are independent, and that chances to record a non-adult or an adult are equal, the adult : non-adult ratio is 1:1.3. This implies a total population estimate of the Javan hawk-eagle of between 600 and 1000 individuals.

## DISCUSSION

The destruction and fragmentation of the once continuous forest on Java is widely considered the major threat to the survival of the Javan hawk-eagle (Thiollay & Meyburg 1988; Collar *et al.* 1994; Sözer *et al.* 1998). The species was believed to be divided in two populations, separated by a 375-670 km wide gap of non-forest area in the central part of Java (Thiollay & Meyburg 1988). Contra to Thiollay & Meyburg (1988), however, we did find substantial areas of remaining forest in the central part of Java, and indeed it is estimated that the Central Javan gap, sustains about 15% of the total population.

**Population status**

The Javan hawk-eagle has always been described as either rare (Hoogerwerf 1949; Brown & Amadon 1968) or very rare (Kuroda 1936). Meyburg (1986) included the species among the thirty birds of prey that are in most urgent need of a survey. The apparent discrepancy between the number of old and new records, which might suggest an increase in present Javan hawk-eagles, may be explained by more directed surveying for Javan hawk-eagles, supported by the use of heavy-power telescopes and light-weight tape-recorders. The increased accessibility to formerly unexplored habitat has also undoubtedly contributed to more birds having been observed. Finally, more sophisticated field identification techniques have contributed to a larger number of positive identifications.

In July-August 1986 Thiollay & Meyburg (1988) visited the island of Java on a three-week raptor survey. In three of the five reserves visited, the presence of Javan hawk-eagles was assessed, and the total number of birds was estimated at not more than 60 breeding pairs (Meyburg *et al.* 1989). Based on the discovery of additional localities this number was adjusted to 67-81 (van Balen & Meyburg 1994) and then 81-108 pairs (Sözer & Nijman 1995). Our new population estimate is again considerably higher, owing to new localities, a more accurate estimation of forest size, and differentiation in habitat quality and density. Despite various assumptions we had to make, we are confident that our new population estimate is the most accurate currently possible. The present study provides a baseline, against which future research and management can be set. At the same time, more recent satellite imageries or aerial photo mapping will allow a more precise estimate of the extent of forest cover on Java and more long-term and focussed field observations will provide a better insight in the density of Javan hawk-eagle. This in turn will allow a better estimate of its numbers. However, it is unlikely that greater precision will change drastically our conclusions or recommendations.

**Table 9.2**. Description of Javan Hawk-eagle localities

| Nr[a] | Block | Altitudinal range m a.s.l.[b] | Total size[c] (x100ha) | Climate type[d] | Status[e] | Ruggedness[f] | Fragmentation[g] | Habitat Quality[h] | Breeding pairs |
|---|---|---|---|---|---|---|---|---|---|
| *West Java* | | | | | | | | | |
| 1. | Ujung Kulon | 0-623 | 125 | 2 | NP | 2 | 2 | 2 | 3-4 |
| 3. | Mts Halimun/Salak | 400-2211 | 500 | 1 | NP/PF | 1 | 1 | 1 | 16-25 |
| 4. | Jampang | 0-700 | 100 | 2 | NR/WR | 1 | 3 | 2 | 2-3 |
| 5. | Mts Gede/Pangrango | 500-3019 | 200 | 1 | NP | 1 | 2 | 1 | 6-10 |
| 6/7. | South Bandung | 300-2622 | 900 | 2 | PF/NR | 1 | 2 | 2 | 23-30 |
| 8. | North Bandung | 1000-2076 | 100 | 1 | PF/NR | 2 | 3 | 2 | 2-3 |
| *Central Java* | | | | | | | | | |
| 9. | Pembarisan Mts | 300-1351 | 130 | 2 | PF | 1 | 2 | 2 | 3-4 |
| 10. | Mt Slamet | 700-3418 | 150 | 2 | PF | 2 | 1 | 2 | 4-5 |
| 11. | Dieng Mts | 250-2565 | 250 | 1-2 | PF | 2 | 2 | 2 | 6-8 |
| 13. | Mts Merapi/Merbabu | 950-2911 | 80 | 1-2 | PF | 2 | 3 | 2 | 2-3 |
| 14. | Mt Muriah | 600-1602 | 90 | 2 | PF | 2 | 2 | 2 | 2-3 |
| *East Java* | | | | | | | | | |
| 15. | Mts Liman/Wilis | 600-2565 | 250 | 1-2 | PF | 2 | 3 | 2 | 6-8 |
| 16/17. | Mts Kawi/Arjuno | 300-2886 | 500 | 2 | PF/GFP | 1 | 2 | 2 | 13-17 |
| 18. | Bantur/Lebakharjo | 0-250 | 180 | 2 | PF | 1 | 2 | 2 | 5-6 |
| 19. | Bromo/Tengger/ Semeru | 800-3676 | 200 | 1-2 | NP | 2 | 2 | 2 | 5-7 |
| 20. | Yang Highlands | 1600-3088 | 100 | 1-2 | PF/WR | 3 | 2 | 2 | 2-3 |
| 21. | Meru Betiri | 0-1223 | 500 | 2 | NP | 1 | 2 | 2 | 13-17 |
| 22. | Ijen/Raung/Maelang | 0-3332 | 830 | 1-2 | PF/NR | 2 | 2 | 2 | 21-28 |
| 23. | Alas Purwo | 0-360 | 160 | 2-3 | NP | 3 | 2 | 3 | 3-4 |
| | | | | | | | | | Total: 137-188 |

**Notes to Table 9.2**:
a. Block numbers correspond with those in Figure 9.2;
b. Altitudinal range: figures in italics represent approximate lower limits of forest (after MacKinnon *et al*. 1982; SvB, VN & RS, pers. obs.); forest is not always continuous over the entire altitudinal range.
c. Size of available habitat estimated after RePPProT (1990: scale 1: 250,000), MacKinnon *et al.* (1982) and our own data; see text for details.
d. Climate type: 1: 40-80 rainy days during the four driest consecutive months, 2: 20-40 rainy days, 3: 0-20 rainy days (after van Steenis 1972).
e. Status: NP: national park (*taman nasional*), GFP: grand forest park (*taman hutan raya*), NR: strict nature reserve (*cagar alam*), WS: wildlife reserve (*suaka margasatwa*), PF: watershed protection forest (*hutan lindung*). Tiny nature reserves in larger forest areas not included.
f. Ruggedness: 1 = almost entirely covered with tall forest on slopes; 2 = partially covered with tall forest on slopes; 3 = scarcely or not covered with tall forest on slopes.
g. Fragmentation: 1 = one large, compact area; 2 = several medium-sized, interconnected forest areas; 3 = several small to intermediate forest areas, with or without adjacent smaller areas.
h. Habitat quality: See text for details.

## CONCLUSION

In the present survey the Javan hawk-eagle was found present in almost all but the smallest natural forest areas. A broader niche width than previously thought may account for less dependence on primary forest and the dispersal of juvenile through secondary habitat apparently mitigated the effects of habitat loss and fragmentation. However, its small population size, the ever-decreasing area of natural forest and habitat deterioration due to high population pressure, and the possible effects of hunting and poaching pose increasing threats for the Javan hawk-eagle and make it one of the most endangered birds of prey on the World.

We thank the Indonesian Institute for Sciences (LIPI) and the Directorate General of Forest Protection and Nature Conservation (PHPA), for permission to conduct field research. BirdLife International - Indonesia Programme is thanked for logistic support and the use of their facilities. Grants were received from the Van Tienhovenstichting, Wereld Natuurfonds, Zoologisch Insulinde Fonds, Gresshoff's Rumphiusfonds, FONA, World Working Group of Birds of Prey and Owls, the American Federation of Aviculture and the Fauna & Flora Preservation Society, the Oriental Bird Club, the J.C. van der Hucht Fonds, P.A. Hens Memorial Fund and the Martina de Beukelaar Stichting. The bird curators of the National Museum of Natural History in Leiden (Dr G.F. Mees, Dr R. Dekker) and the Museum Zoologicum Bogoriense (especially Ir Sudaryanti, Ir Daryono, Dr Asep Adikerana, Dr D. Prawiradilaga) provided access to the specimens of their collections. Prof. dr. K.H. Voous, Prof. dr. S. Somadikarta, Dr J. Wattel, Dr P.J.H. van Bree, Mr P. Jepson, Dr.B.-U. Meyburg, and the late Mr H. Bartels provided valuable advice throughout the project. Prof. dr. H.H.T. Prins, Dr A.Ø. Mooers, P. Jepson and Prof. dr. S.B.J. Menken commented on earlier drafts of the paper.

Chapter 10

# The Javan hawk-eagle: misconceptions about rareness and threat

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Biological Conservation: accepted (awaiting revised version)

**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 137 - 188 pairs with confirmed presence at discrete 24 localities throughout Java. Surprisingly, 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.

## INTRODUCTION

In 1992 the Javan hawk-eagle *Spizaetus bartelsi* was declared Indonesia's national mascot of "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 suddenly 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). 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, 1931). Until a decade ago virtually nothing was known about its biology. 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, he did not record a single specimen in the nearby Gede-Pangrango NP, and in most of the other forest areas in Java (Hoogerwerf 1948). In the same period the Bartels' family gathered a large series of museum skins in the same locality. During our studies we have recorded the species in numerous localities throughout Gede-Pangrango NP, and indeed throughout Java (van Balen *et al.* in press).

Java has known a long history of cultivation and deforestation that already started about 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 early 1960s virtually all forest fragments that contain Javan hawk-eagles 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; van Balen 1988; Smiet 1992; Figure 1.1). The latter forest type is now almost exclusively found scattered along the southern coast of the island.

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 deteriorated forest fragments. Sometimes substantive chunks of valuable habitat are cleared at once, as was witnessed during our surveys on the south west slopes of Mt Ijen, the north-western 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 & Meyburg 1988; Collar *et al.* 1994; Sözer *et al.* 1998).

Recent surveys by the authors have added numerous new locality records (see Sözer *et al.* 1998; van Balen *et al.* in press). The species was even found in the central part of the island where there was believed to be a wide gap of largely non-forest area between the two sub-populations of west and east Java (Thiollay & Meyburg 1988). Despite this the species should still be considered as one of the world's least known raptors (van Balen & Meyburg 1994). 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 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.

**Table 10.1** Areas surveyed for Javan hawk-eagle (based on data from van Balen *et al.*, in press)

| Blocks containing Javan hawk-eagles | Forest Area ($km^2$)[2] | Forest Type[1] | Estimated distance (km) to nearest JHE block (> 150 $km^2$) | Altitudinal range 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 | c 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 | |
| 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[3] | 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 $km^2$) *W Java* Kotabatu, Dungusiwul, Ciburial, Yanlapa, Tangkuban Perahu, Sukawayana, Bogor Botanical Gardens, Pangandaran, Mt Pulosari
(16-50 $km^2$) *W Java* Ciogong[4], Leuweungsancang, Mt Tukung Gede/Ranca Danau; *E Java* Mt Lawu, Mt Ringgit, Baluran
(50-160 $km^2$) *W Java* Cikepuh; Segara Anakan[5], Leuweungsancang[6]
(160-500 $km^2$) *W Java* Ujung Kulon peninsula

[1] Forest types (from Whitten *et al.* 1996): RF: rainforest; DF: deciduous forest; MF: montane forest (>1000m); E: evergreen; SE: semi-evergreen; M: moist; D: dry; A: aseasonal; S: seasonal
[2] Estimated area of good forest does not necessarily equal the size of the reserve.
[3] This area was surveyed only briefly, but assumed to contain Javan hawk-eagles.
[4] Widely varying estimates exist; here the mapped forest area (Whitten *et al.* 1996) is given.
[5] The adjacent island of Nusa Kembangan was not visited by us, but may contain Javan hawk-eagle.
[6] Includes the adjacent proposed reserve Cipatujuh.

## 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 1980-81 and 1984-1997 (SvB) and 1994-1999 (VN) totalling 632 man-days surveying inside natural forest areas. Details can be found in van Balen (1991), van Balen & Meyburg (1994), Sözer & Nijman (1995), Nijman *et al.* (in press), and van Balen *et al.* (in press).

Table 10.1 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 *et al.* under review), which excludes a few small areas, namely Mts Aseupan, Karang and Ungaran, that 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.

In none of nine isolated forest areas smaller than 1600 ha surveyed (van Balen 1988; SvB unpublished data) did we record resident pairs of the eagle. This increased to three out of nine forest areas ranging between 1600 and 5000 ha (33%); seven out of ten forest areas between 5000 – 16 000 ha (70%); five out of six forest areas between 16 000 – 50 000 ha (83%); and present in all of the five forest areas larger than 50 000 ha (100%). The relationship between the size of the forest area (log transformed) and frequency of occurrence (arcsin transformed) is significant ($r^2$ adj. = 0.968; $p < 0.0005$) (Figure 10.1).

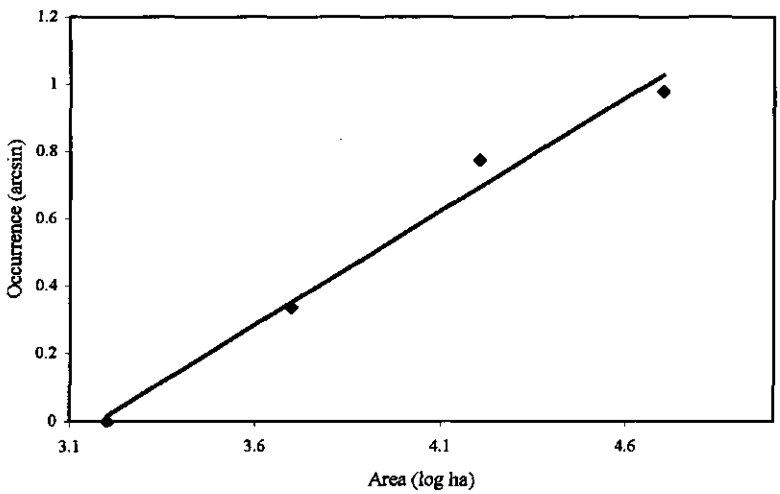



**Figure 10.1** Relationship between forest patch size (log transformed) and frequency of occurrence (arcsin transformed).


**Figure 10.2** Generalised land use cover of Java , Madura and Bali (after Whitten *et al.* 1996)

Figure 10.2 shows the 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 less than 10 to 102 km, and averages 33 km. Four forest areas, i.e., Ujung Kulon, Mt Aseupan, Mts Merapi-Merbabu and Mt. Muriah, are isolated from other sizeable forest patches by distances > 50 km (Table 10.1), and have been so since at least since the end of the 19th century (Koorders 1912 in Whitten *et al.* 1996; Anonymous 1926).

## DISCUSSION

### Habitat requirements

The Javan hawk-eagle is largely restricted to rugged, hilly terrain, and generally we encountered the birds in 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.* in press). Hitherto the eagle has not been recorded from the northern plains, although at present very little forest remains in that area (Smiet 1992). 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 (see Janes 1985). Hunting above flat lands demands adaptations different from hunting above slopes, which may result in subtle morphological differences (see Janes 1985; 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 & 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.* 1999), disappeared with the almost complete deforestation of the flat lowlands in the northern half of Java already sometime during the 19th century.

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 1991). 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 & Craig 1991).

Tolerance to habitat disturbance is also found in the closely related Blyth's hawk-eagle. On mainland Sumatra it is reported to be strictly dependent on mature forest (Thiollay 1996a). The continued survival of this eagle on the small island of Nias, which it shares with two other hawk-eagle species (Thiollay 1996b) and where heavy deforestation had left little good forest already a century ago (Stibbe 1919), indicates a plastic response to small area 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 & Meyburg 1988) of the latter should be re-evaluated.

**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 & Meyburg (1988) suggest that the rufous-bellied eagle *Hieraaetus kieneri* may be a competitor, which would explain the lower numbers of Javan hawk-eagles in south-eastern Java in the presence of that species. However, we found no evidence of lower or higher numbers of either species in eastern Java as compared to central or west Java. Both species overlap largely in range and habitat, but most likely differ in diet, with the aerial hunting rufous-bellied eagle showing a preponderance for birds (Becking 1989; del Hoyo *et al.* 1994), while a large proportion of the diet of Javan hawk-eagle consists of mammals and reptiles (Røv *et al.* 1997; Nijman *et al.* in press). 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; van Balen and Nijman pers. obs.).

**Habitat fragmentation**

Four important conservation tenets (see Verner 1992) are considered by us 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 & 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 & Nijman 1995; VN unpublished data). However, Thiollay & 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 reached on the continent or in continuous habitat. 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 also explain why we found surviving populations in a number of small patches: the smallest area in which we recorded the species comprised of *ca* 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 (Soemarwoto & Conway 1991). Their forest-like structure more or less mimic natural forest (Soemarwoto 1987; Whitten *et al.* 1996). Although Thiollay (1996a) did not attach much value to the traditional agroforests (in Sumatra) as adequate habitat for forest raptors, 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, is remarkable. As Rosenzweig (1995) explained ubiquity as reflecting a wide tolerance of habitat differences, this might indeed suggest a role of surrounding secondary habitat, plantation forest and farmland that could increase 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.* in press). They may even take profit from higher biomass production in edge habitat. Tenet 2 is also not supported.

3. "Blocks of suitable habitat that are close together are better than blocks 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 & Allendorf 1996). The presence therefore of both juveniles and adults, in singles and pairs, in at least five long-term isolated forest patches < 100 $km^2$ in size, suggests that the species has good dispersal abilities that mitigate the effects of insularisation in even the most distant blocks. There appears to be no support 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.* in press). In Central Java the vast teak plantations may increase connectivity and explain the persistence of the eagle on the isolated Mt Muriah. Tenet 4 is therefore not rejected.

**Small population**

Collar *et al.* (1994) considered the Javan hawk-eagle to be endangered on account of its small declining population of < 2500 birds, with no single sub-population larger than 250 mature birds; consequently an extinction possibility of > 20% within five years was calculated. A Vortex simulation programme was used in a recent Population Viability Analysis (Manansang *et al.* 1997). Chances for long-term survival appeared bleak with high (human-induced) mortality for each of the three postulated sub-populations. A case was made for a captive breeding programme.

The presence of the eagle in the smallest and most distant of surveyed forest fragments (< 10,000 ha) suggests that these are not strictly isolated and that there could be dispersal between all fragments. The postulated sub-populations 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 (presently estimated at < 1000 birds, which includes breeding pairs and unpaired immatures (van Balen *et al.* under review; Chapter 9 of this thesis), 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 in 15-20 pairs (Walter 1990), and on Nias Island (562,500 ha) for at least the last hundred years three hawk-eagle species have persisted in some small forest patches (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 in understanding extinction processes (Ryan & Siegfried, 1994), but Thomas (1990) proposed a Minimal Viable Population (MVP) 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 was reduced to (maximally) about one tenth of its original (AD 1600) size by the 1930s.

Although raptors are known to survive at low population levels (e.g., Walter 1990), rather unstable circumstances on Java (volcanoes, susceptibility to droughts, etc.) seem not very favourable for long-term survival. It may therefore be that, although Java has been isolated since 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 & 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 & 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, unreliably though, reported as having been captured on west Java] which subsequently escaped into the Javan forest, may actually have been a more natural propagule than we initially thought.

**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 & 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.

MVP sizes would be underestimated if in population viability analyses the risk of catastrophes are not incorporated; even with large populations under the absolute best circumstances extinctions should be expected (Mangel & Tier 1994; Rosenzweig 1995). In fact, the concept of MVP appears to become irrelevant for this type of risk. Designing the configuration of conservation areas in which more than one reserves is spaced apart so that catastrophes occur independently at different reserves are considered more effective (Mangel & Tier 1994).

## IMPLICATIONS FOR CONSERVATION

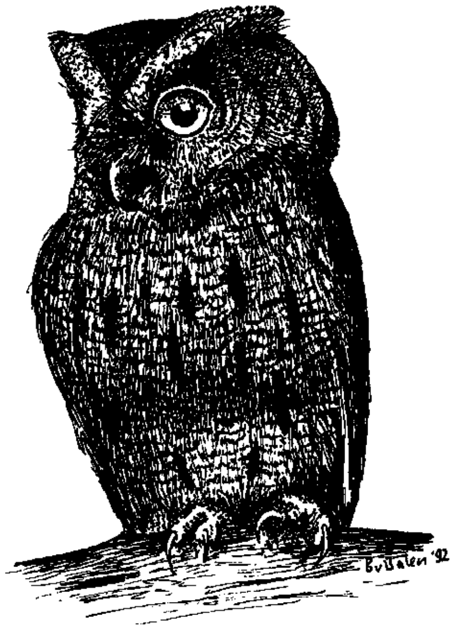
The Javan hawk-eagle is generally *a priori* regarded as endangered because of its being a large raptor, and the fragmentation of its habitat on over-populated Java (Thiollay & Meyburg 1988; Collar *et al.* 1994). Indeed, a recent Population Viability Assessment (PVA) predicted a bleak future with little room for optimism for this endemic eagle (Manansang *et al.* 1997) and seemed to justify a captive breeding programme. 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 (van Balen *et al.* in press) and provided the baseline data for the present review, we have found evidence of a less gloomy situation, partly in conflict with current precepts in conservation biology. 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 the presence in relatively small and isolated forest fragments. The size of fragments rather than distance to neighbouring blocks determines the occupancy of forest areas. Short term persistence is enhanced by the existence of the eagle as an apparently effective metapopulation. Long term persistence may even involve genetic input from outside this metapopulation (by allo-species such as the Blyth's hawk-eagle). The widespread distribution across Java's rainforest, which is due to a wide altitudinal range and a relatively high plasticity to habitat disturbance, in combination with good dispersal abilities, indicate that the eagle has largely overcome the insularisation 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;
(c) rather opportunistic feeding behaviour

Since its inauguration as a national mascot, the Javan Hawk-eagle's image, until recently unknown to almost anybody, has been exposed in billboards, postal stamps, telephone directories, etc. As rare birds, and in particular 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 has been happening with the extremely rare Bali starling *Leucopsar rothschildi* during the past two decades (see Ash 1984; PHPA/Birdlife International-IP 1997). Therefore, strict law enforcement to prevent more eagles being extracted from the wild, not the setting up of an expensive captive breeding programme, and effective management of natural areas are urgent. 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 is a self-contradiction (Simberloff 1998). But it would be ironic if in an attempt to save and manage the Javan rainforest, one of its most exquisite flagships would be threatened by its own qualifications and get into urgent need for management.

The authors wish to thank the Indonesian authorities, and especially the Indonesian Institute for Sciences (LIPI) and the Directorate General of Forest Protection and Nature Conservation (PHPA), for granting permission to do research on Java. We furthermore thank Resit Sözer for his work during the 1994 surveys. We are grateful to BirdLife International - Indonesia Programme for organizational support and the use of their facilities. We also wish to thank the Van Tienhovenstichting, Wereld Natuurfonds, Zoologisch Insulinde fonds, Gresshoff's Rumphiusfonds, FONA, World Working Group of Birds of Prey and Owls (esp. Dr.B.-U. Meyburg, Mr R. Chancellor) with grants by the American Federation of Aviculture and the Fauna & Flora Preservation Society, the Oriental Bird Club, the J.C. van der Hucht Fonds, P.A. Hens Memorial Fund, and the Martina de Beukelaar Stichting for financial support. Furthermore the bird curators of the Nationaal Museum van Natuurlijke Historie in Leiden (Dr G.F. Mees, Dr R. Dekker), and the Museum Zoologicum Bogoriense (especially Ms Sudaryanti, Ir Daryono, Dr Asep Adikerana, Dr D. Prawiradilaga) provided access to the specimens of their collections. Prof. K.H. Voous, Dr W. Bongers, Dr G.F. Mees, Prof. S. Somadikarta, Dr J. Wattel, Mr P. Jepson and the late Mr H. Bartels, provided valuable advice throughout the project. A large number of people, all mentioned in the text, generously shared their field notes, for which the authors are grateful. Paul Jepson, Dr A. Ø. Mooers and an anonymous reviewer commented on drafts of the paper.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Chapter 11

# Synthesis: survival on overpopulated islands

The effect of habitat fragmentation on the occurrence and abundance of forest birds has been the topic of a large number of studies (see Bierregaard *et al.* 1997). In particular the effects on extinction processes have been disputed, as theoretical models predicting extinction rates often appeared to disagree with numbers found in the field (Heywood *et al.* 1994; Balmford 1996; Brooks *et al.* 1997). Data on extinction and colonisation processes in entire bird communities have been presented in the foregoing Chapters 2-4, and data on single species in Chapters 5-10. In this discussion I will feed the debate by showing how extinction processes are determined by differential extinction traits of forest bird species, and how these processes sometimes are shrouded in pre-science mysteries. Conservation measures to reverse extinction processes are briefly discussed.

## HABITAT FRAGMENTATION

### Species/area relationships and extinction

Before their separation from the Asian mainland following the last glacial period, 18,000 years ago, Java and Bali shared a species pool with Sumatra, Borneo and peninsular Malaysia. Relict populations on small land bridge islands in the Java Sea, such as those of the green–billed malkoha *Rhopodytes tristis*, Sunda frogmouth *Batrachostomus cornutus* on Kangean Island, red-eyed bulbul *Pycnonotus brunneus* on the Matasiri Islands, and Abbott's babbler *Trichastoma abbotti* on Bawean and the Matasiri Islands (none of which occur on mainland Java and its other satellite islands, but which are widespread in Sumatra and Borneo), attest this former land connection.

The relationship between number of species and island size predicts a smaller number of bird species for smaller islands with the establishment of a new equilibrium. Figure 11.1 shows the species/area regression line for lowland forest bird species on the islands of Sumatra, Borneo, Java and Bali. Java lies well below this line and has apparently lost proportionately many more species than the other three islands. This is understandable as deforestation has taken place on Java since the 16$^{th}$ century, long before it started to take a toll on the other islands. The maximum rate was reached in the 19$^{th}$ century "Cultuurstelsel", and presently about 2.3% of all original lowland forest remains (Figure 1.1; Smiet 1990). The lowland forest birds

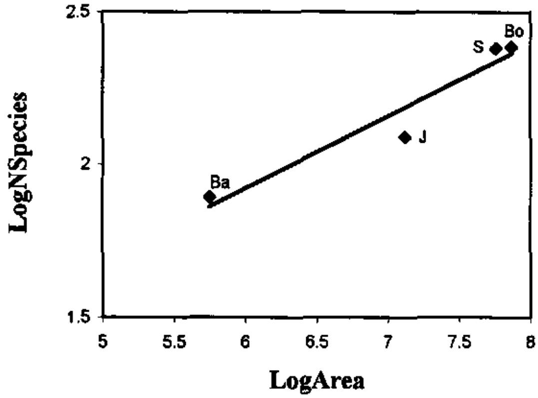


**Figure 11.1** Relationship between number of bird species[1] and island size.
Ba: Bali; J: Java; S: Sumatra; Bo: Borneo.

were particularly affected, as shown in Figure 11.2 in which the low species numbers in lowland Java relative to those in the Sumatran and Bornean lowlands are compared.

According to Brooks *et al.* (1997) the following formula can be applied to predict the numbers of species that survive from an original pool $S_o$ after reduction in island area, and a second reduction in lowland forest area, respectively, based on the species-area relationship $S = cA^z$. The formula for the first reduction would be:

$$\log S_{n1} = \log S_{o1} + z(\log A_n - \log A_o)$$
$$S_{n1} = S_{o1}(A_n/A_o)^z,$$

in which the exponent z = slope of the regression line (Figure 11.1), $S_{o1}$ = original species pool, $S_{n1}$ = present species number, $A_o$ = original lowland forest area of the Sunda shelf, $A_n$ = present forest cover, and c = a constant. Neither of the two original figures can be estimated due to a lack of historical data. What we have are the (resulting) current species numbers. The second reduction is fitted to the formula:

$$S_{n2} = S_{o2}(F_n/F_o)^z$$

[1]Species lists are based on Wells (1985), including all raptors and nightbirds, but excluding his "lowland species" *Megalaima armillaris, Pomatorhinus montanus* and *Napothera epilepidota,* which I believe are better treated as montane.

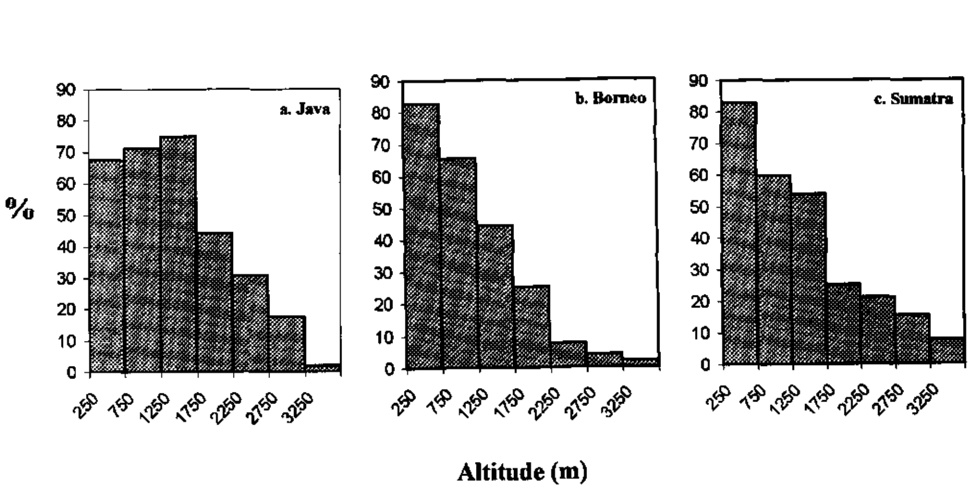


**Figure 11.2** Proportions of bird species along the altitudinal gradient in the Greater Sundas. Adopted from MacKinnon & Phillipps 1994.

in which the exponent z = slope of regression line[2], $S_{o2}$ = number of expected lowland forest species for Java as derived from the species/area curve of Figure 11.1 (y = 0.24x + 0.49); $S_{n2}$ = number of predicted lowland forest species on Java; $F_o$ = original lowland forest cover; $F_n$ = present lowland forest cover. This yields a value:

$$S_{n2} = 166\,(5{,}230/123{,}270)^{0.24} = 76$$

This predicted figure would mean a loss of 90 (= 166 – 76) species since Java's separation, because of the species/area effect (which after relaxation has resulted in an extrapolated loss of 43 (= 166 – 123) species, and as the result of deforestation. The final number of 76 is still 47 species (38 % lower than the present species number of 123 for Javan lowland forest birds (according to Wells 1985). Various authors (e.g., Brooks *et al.* 1997) have assumed that the species listed by Collar *et al.* (1994) as globally threatened species are committed to extinction, and the first to go during relaxation processes. Java's official number of six globally threatened lowland forest birds (see Box 1.2) is far from enough to account for this difference of 47 species.

Conservation statistics show that bird species endemic to single islands appear to be particularly vulnerable (Brooks *et al.* 1997). Balmford (1996) attributed the overestimation

[2]This value closely approaches the "real island" value of 0.25 as recommended for habitat fragments by Rosenzweig (1995); Brooks *et al.* (1997).

of species loss as predicted by deforestation rate (which overrates the number of threatened endemics) to the incompleteness of the red data bird list for Java. He also pointed to *Homo sapiens* as an extinction filter, in a process where vulnerable species have long been purged by early human settlement, which is suggested by the impoverished avifauna along the 300-1500m altitudinal gradient (Figure 11.2; van Balen 1994). Brooks *et al.* (1997) suggested as possible explanations for the underestimated number of threatened Javan endemics that species became extinct before they were described, and that there are more montane than lowland endemics on Java, the mountains being relatively secure.

Heywood & Stuart (1992) state that there is danger in the backward extrapolation of the formula $S = cA^z$. The overestimation of threatened species appears less realistic than stated above, if the calculation of predicted species number is carried out in the opposite direction. From Figure 11.3 it can be extrapolated that an increase of only 32% from 435,000 to 575,440 hectares of lowland and hill forest ($y = 0.21x + 0.86$; $R^2 = 0.98$; $n = 123$) would theoretically accommodate all extant lowland species. This only means that in terms of species per remaining forest area Java is not worse off than the other islands. It should be remembered however that Java's deforestation process is several centuries "ahead" of the other islands, and that lowland forest is extremely fragmented in Java The calculations are implicitly made for a continuous forest stand; further collapse of the avifauna is to be expected.

The present study proved that forest birds are not equally responsive to habitat fragmentation (Chapters 3 and 4). By subdividing all Javan forest birds according to their Minimal Habitat Requirements, I showed that true forest (interior and edge) birds are more prone to disappear from shrinking habitats than secondary-growth (woodland and urban) species. Of the birds that have disappeared from the smaller fragments, a disproportionately large fraction consisted of true forest species.

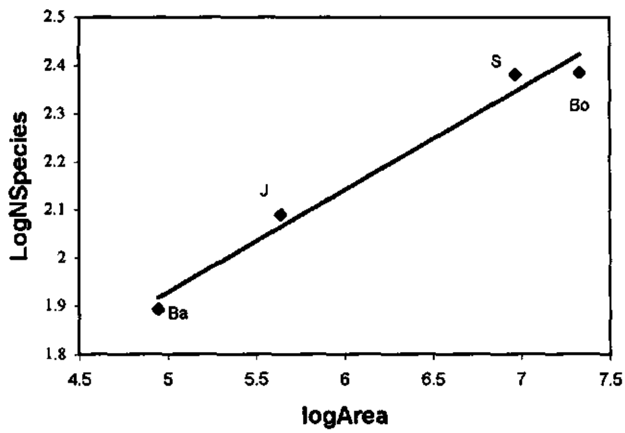


**Figure 11.3** Relationship between number of bird species and lowland forest area
See Figure 11.1 for legends and footnote.

Dial (1994) suggests that species/area curves do predict accurately (with z = 0.17 for non-isolates) the extinction of North American bird species caused by habitat loss, but suggests that z-values are taxon-specific when dealing with continental biota. Differentiating forest birds in four Minimal Habitat Requirement (MHR) classes I – IV (see Chapter 4; Figure 11.4), refines the predicted species number (with z-values: $z_I = 0.34$, $z_{II} = 0.24$, $z_{III} = 0.15$, $z_{IV} = 0.02$), but does not take the discrepancy away. Theory and practice apparently do not converge at this point, but incorrectly formulated theories, misleading data and wrong time scales may be the cause of this (Heywood & Stuart 1992). Species–area relationships do not predict immediate disappearance but eventual loss, and therefore the list of threatened species appears too short. Heywood *et al.* (1994) suggested that the discrepancy between the theoretically, and empirically derived number of species predicted to become extinct is due to a time lag, which disappears when stages involved in "becoming" extinct are made clear. A number of species are thus declining at different speeds towards eventual extinction.

An inter-island comparison shows that the Java lacks "only" 32% of Sumatra's edge and woodland species, but 52% of true forest species (see van Marle & Voous (1988) and Thiollay (1995) for Sumatran data). In Singapore 50% of forest dependent bird species became extinct, even in well protected areas (Corlett & Turner 1997). Most lowland forest species disappeared from Bali: only four (25 %) of Class I and seven (39%) of Class II, but most (74%) of Class III and all of Class IV survive on the island (Mason & Jarvis 1989; MacKinnon *et al.* 1998). Apparently, some species are more vulnerable to extinction than others and they, more-or-less by definition, are the first to disappear. Where deforestation and forest fragmentation play a role, the most vulnerable species are those that depend on these forests. This may appear to be self-evident, but the present study is the first to show that extinction patterns should take into account the ecological profile of the species concerned.

**Colonisation**

The colonisation curve of resident land birds of the Krakataus did not precisely fit the island biogeography model of MacArthur & Wilson's (1967) equilibrium theory (Chapter 2). It did, however, show that succession has an impact on the colonisation by birds. This may imply, that in mainland situations successional processes may be impeded by fragmentation Simberloff 1992). More relevant to this thesis is, however, the realisation that the indiscriminate analysis of entire bird communities by including pioneer bird species that enter the first successional stages, but disappear later, could easily corrupt the assessment of the equilibrium theory. This is a warning against fragmentation studies using archipelagos composed of many too small forest fragments that are dominated by species favoured by secondary growth.

The differentiation in sensitivity towards the effects of fragmentation of the four Minimal Habitat Requirement classes greatly influences the distribution patterns found in Javan forest birds. Java's woodland and urban species resemble supertramp species (see Diamond 1975), found everywhere in the "sea" of rural areas; they are adapted to disperse from (formerly) small fragments of disturbed forest and clearings

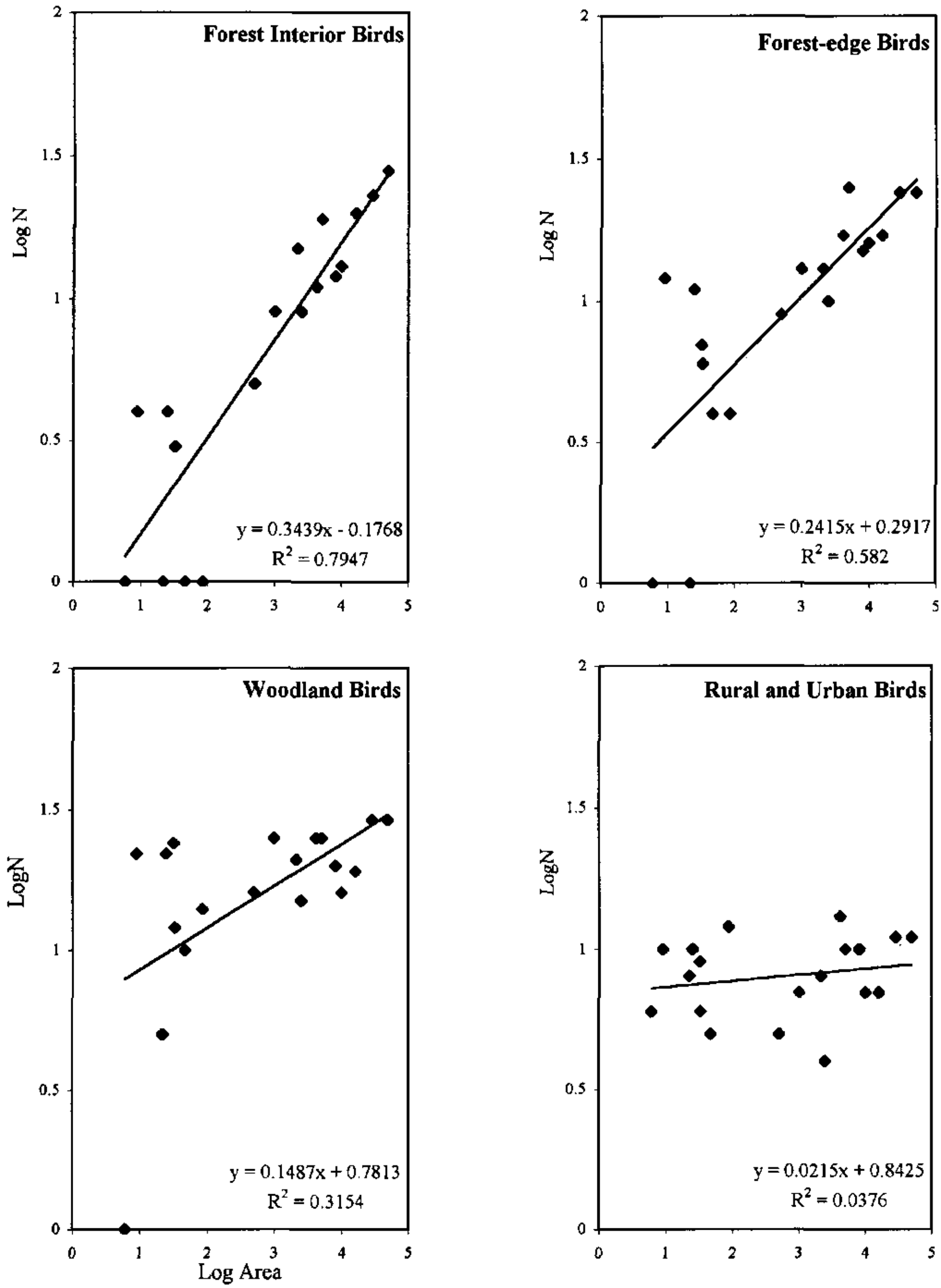


**Figure 11.4** Relationship area and species numbers and different forest dependency classes I (forest interior), II (forest edge), III (secondary growth) and IV (urban).

(in response to volcanism, landslides, riverine areas; shifting cultivation), and most of them were also able to colonise small islands off the coast of Java. At present the roles are reversed, and now true forest birds are the island birds. Most species are not adapted to "overseas" dispersal and are locked up in their forest, but some seem to have made some first steps to colonise more open landscapes.

**Nested subsets**

We have seen the mirror effect in the avifauna of the Bogor gardens, a woodland amidst non-forest habitat (Chapter 3). As a result of differential extinction which partly depends on the persistence of bird species in the non-forest matrix, the Bogor gardens' bird community resembles the surrounding avifauna more and more. Through the analysis of bird communities of a larger number of forest reserves (Chapter 4) I showed that differential extinction is determined by the degree of forest dependence (or tolerance to habitat disturbance) of the bird species. In particular, the potential of these fragments to constitute nested subsets proved suitable to show this different response to forest fragmentation. The perfectness of forming nested subsets (nestedness) depends on how sensitive bird species are to isolation, area and habitat disturbance in the surrounding matrix. The strong nestedness patterns for true forest birds prove that this group is most affected by fragmentation. In general, species belonging to this group do not occur in the smallest reserves. Nestedness becomes stronger with a steeper species/area curve, from forest interior, through forest edge to woodland species. No correlation between species number and reserve size was found in the urban species, and thus a nestedness of 25.8° corresponds with an absence of differential extinction for this group of birds.

Boecklen (1997) expressed his scepticism about the value of assessing nested distributions as a conservation tool. He argued that nestedness is generally a poor predictor for the SLOSS (Single Large Or Several Small) debate, because much variation in nestedness among species distribution exists, and even in strongly nested archipelagos several small islands contain more species than do single islands.

That reserves should be as large as possible, even if certain species forest species survive in smaller fragments, is, however, clearly emphasised by studies in temperate forest birds showing that limitations on habitat selection in fragmented habitat (with lower connectivity) can result in a lower population density than in contiguous habitat; a wider range of habitat is accepted, but lower densities are found per area unit (van Langevelde 1999). This phenomenon is thus the reverse of the insularity syndrome, in which bird populations attain higher densities on isolated (habitat) islands (see Chapter 9), but may be species-specific. Another disadvantage to having only small reserves, as shown by the nested matrices, is that the smaller the reserves, the fewer true forest species they contain. For instance there are indications that the woodpecker species group "collapses" in areas below 2500 hectares (Chapter 4). The system of only small reserves is at the expense of the more vulnerable, true forest species, whereas large reserves would support all forest and woodland birds.

Within Class I and II a special position is taken by the group of species, which are less nested than the other species. Their non-conformity ("idiosyncrasy") reflects a more scattered distribution, and the larger part of them can be classified as hill specialists, or as occurring in the more elevated parts of the lowlands. They occur either in inland parts of the larger lowland reserves and more inland isolated smaller reserves, or in the often scattered foothill forest of Java's mountain range. Figure 11.2a suggests that Java's hills (1000-1500m) are more species-rich than both the lowlands and mountains. They may even have served as refuges during large-scale development of the lowlands. Ongoing encroachment on the hill forests, however, will have disastrous consequences for a number of hill-restricted species, as the upper lowland fringe to mountains is narrowing, and the suitable forest patches in the lowlands are becoming more isolated.

**Persistence**

Simberloff (1992) noted that habitat fragmentation, especially in the tropics, may threaten the persistence of certain species independently of the species/area relationship. The first effect of fragmentation may be to filter out habitat specialists by the early destruction of their habitat (Meffe & Carroll 1994). The almost complete clearance of Javan swamp forest has certainly wiped out the white-winged duck *Cairina scutulata,* which was last observed in 1932. The following options exist for species to persist in a fragmented landscape (Meffe & Carroll 1994):

(1) Survive and thrive in the surrounding matrix (habitat tolerant species, i.e., woodland and urban species)
(2) Maintain viable populations in the fragments (species with small home ranges)
(3) Disperse as "island hoppers" or via corridors (highly mobile species, such as the colonisers of the Krakataus)

For real island and habitat island birds, the so-called insularity syndrome is described (see Wright 1980) and niche expansion is suggested to explain higher densities of the Javan hawk-eagle (Chapter 10; Thiollay & Meyburg 1988). Brooks & Balmford (1996) pointed to the high numbers of forest bird species still surviving in small habitat fragments in the South American Atlantic forest. Here certain lowland forest species are found surviving in secondary forest (Brown & Brown 1992). Any reason for optimism, however, was taken away by the fact that the "surplus" species were in fact all globally threatened species. On Java habitat expansion for other forest birds is strongly suggested because of the occurrence in secondary habitat of a number of species, not normally found in such habitats elsewhere in the Greater Sundas (see Box 11.1).

**Box 11.1** Forest birds with habitat expansions on Java.

| | |
|---|---|
| blue-eared kingfisher | *Alcedo meninting* [1] |
| grey-cheeked bulbul | *Criniger bres* [1] |
| Horsfield's babbler | *Trichastoma sepiarium* [1] |
| fly-eater | *Gerygone sulphurea* [2] |
| mangrove whistler | *Pachycephala grisola* [2] |
| copper-throated sunbird | *Nectarinia calcostetha* [2,3] |
| jungle crow | *Corvus enca* [1] |

[1]primary forest species in Sumatra and Borneo; [2]mangrove forest species; [3]very local on Java

Another category is formed by species that have shifted from secondary habitats to the forest interior, most clearly seen in birds that have become true forest birds on well forested offshore islands, e.g., brown-throated sunbird *Anthreptes malacensis*, yellow-vented bulbul *Pycnonotus goiavier*, black-naped oriole *Oriolus chinensis*, and fly-eater *Gerygone sulphurea*. In my study it was found that the smallest reserves would contain secondary growth species only, amongst which were often species not normally found in the interior forest (Chapter 10). These forest birds would inflate species/area relationships and nestedness patterns if no differentiation is made between the four MHR classes.

Another type of habitat expansion is exhibited by some forest specialists found only in the extreme lowlands of Sumatra and Borneo, but which have a wider (altitudinal) distribution on Java (Hoogerwerf 1948; Wells 1985; van Balen personal observations; see Box 11.2). Yet another instance of altitudinal expansion is given by the slope specialists on Sumatra and Borneo which have become more widespread on Java (see Box 11.2). The expansion of slope specialist species can be explained by diminished competition after Java, Sumatra and Kalimantan became separated and species numbers adjusted to the smaller areas. Java has one lowland forest trogon versus five on Sumatra and Kalimantan; two versus six/seven pittas; five versus 19 bulbuls; and five versus ten shared flycatchers. No such examples exist for lowland specialist species, and their altitudinal shift may solely have to do with the gradual deforestation on Java that forced these species out of the extreme lowlands.

**Box 11.2** Forest birds with altitudinal expansions on Java

| | |
|---|---|
| small minivet | *Pericrocotus cinnamomeus* (E) |
| purple-throated sunbird | *Nectarinia sperata* (E) |
| greater racquet-tailed drongo | *Dicrurus paradiseus* (E) |
| hill myna | *Gracula religiosa* (E) |
| orange-bellied trogon | *Harpactes oreskios* (S) |
| banded pitta | *Pitta guajana* (S) |
| black-crested bulbul | *Pycnonotus melanicterus* (S) |
| hill blue flycatcher | *Cyornis banyumas*(S) |
| ashy drongo | *Dicrurus leucophaeus* (S) |

E: Extreme lowland specialist, and S: Slope specialist on Sumatra and Borneo

It is interesting to note that a number of forest bird species which are widespread in the lowlands of Java have withdrawn into the hilly central parts of Bali (Box 11.3). All of these (except the little cuckoo-shrike *Coracina fimbriata* and grey-breasted spiderhunter *Arachnothera affinis*) are woodland, rural and even urban species on Java, but apparently far less adaptive on Bali.

The presence of true forest species in secondary growth could give the impression that they are not dependent on old growth, but they may eventually fail to reproduce in the lower quality matrix (Meffe & Carroll 1994). However, on Java the non-primary forest matrix may be of sufficient age to have purged such "displaced" species. The matrix

**Box 11.3** Lowland forest birds with restricted distribution on Bali

| | |
|---|---|
| cuckoo-dove | *Macropygia emiliana* |
| little cuckoo-shrike | *Coracina fimbriata* |
| orange-headed thrush | *Zoothera citrina* |
| grey-breasted spiderhunter | *Arachnothera affinis* |
| little spiderhunter | *Arachnothera longirostra* |
| oriental white-eye | *Zosterops palpebrosus* |

could thus have acted as a filter rather than a barrier (Meffe & Carroll 1994). More importantly, only species that had been found in secondary growth effectively isolated from primary forest[3] were treated in this study as woodland and rural/urban species.

Bird trapping is undoubtedly a major factor in the general decline of many bird species on Java (van Helvoort 1981; van Balen 1984, etc.). It could obscure the effects of fragmentation especially in the smaller forest fragments from which entire populations could be eradicated by efficient bird catchers. However, the effect of bird trapping on the general persistence of birds in the Bogor gardens has not been shown (Diamond *et al.* 1987; Chapter 3 of this thesis). General declines on Java have been shown for very popular cage bird species (straw-headed bulbul; ground thrushes *Zoothera* spec, leafbirds *Chloropsis* sp., pin-tailed parrotfinch *Erythrura prasina*, hill myna *Gracula religiosa*), and the number of potential pet species is increasing[4].

## THE THREAT OF EXTINCTION

### Java's lost birds

World-wide very few well-documented extinctions of birds exist. Those documented are from the temperate regions and are seldom caused by habitat destruction (Heywood & Stuart 1992). Locally long droughts, forest fires, and volcanism may also have taken a toll, though they have mainly afflicted dry deciduous, hill and montane forest. Although no single extinction of forest birds by habitat loss has been documented (on Java straw-headed bulbul was wiped out through the pet trade), the distribution and abundance of bird populations, in particular those typical of the true forest have been dramatically affected by widespread forest clearance (Chapters 3 and 4).

Fragmentation was most prominent during the implementation of the 19$^{th}$ Century "Cultuurstelsel". It is very likely that a number of species (including endemics), as

[3] Such control conditions were found on Madura Island which has been entirely deforested since at least the past hundred years.
[4] In recent years tailorbirds *Orthotomus sepium* has become an extremely popular cage bird.

Figures 11.1 and 11.3 and further calculations have already suggested, have been eliminated since the $17^{th}$ century. It is interesting to know that a number of lowland forest birds, reported by Vorderman (1901) as having been collected before the end of the Cultuurstelsel, have never been found again on Java (Box 11.4). The Javan origin of these skins was regarded as erronuous due to mislabelling (see Bartels & Stresemann 1929). It should be noted that earlier this century a number of widespread forest birds were discovered on Java (e.g., rufous piculet *Sasia abnormis*[5], thick-billed flowerpecker *Dicaeum agile*, orange-bellied flowerpecker *Dicaeum trigonostigma*[6], Malay goldfinch *Serinus estherae*, and it could well be possible that a number of rare species disappeared unnoticed. All these "disappeared" species (listed in Box 11.4) are true forest species and resident on Sumatra and Borneo (Smythies 1981; van Marle & Voous 1988), and more or less fit in with the general scenario of extinctions on Java. DNA research and measurements of the skins (so far as these ancient specimens are still extant in museum collections) might clarify their origins.

**Box 11.4** Resident lowland forest bird species of unconfirmed Javan provenance

| | |
|---|---|
| ferruginous partridge | *Caloperdix oculea* |
| Sunda frogmouth | *Batrachostomus stellatus* |
| olive-backed woodpecker | *Dinopium rafflesii* |
| buff-vented bulbul | *Hypsipetes charlottae* |
| puff-backed bulbul | *Pycnonotus eutilosus* |
| grey-headed babbler | *Stachyris poliocephalus* |
| white-necked babbler | *Stachyris leucotis* |
| chestnut-winged babbler | *Stachyris erythoptera* |
| fluffy-backed tit-babbler | *Macronous ptilosus* |
| sooty-capped babbler | *Malacopteron affine* |

After Vorderman 1901; Stresemann & Bartels 1929

**Globally threatened species**

A number of forest birds are very rare, but only a few have not been recorded in recent decades (Box 11.5). Of these, the straw-headed bulbul *Pycnonotus zeylanicus* made the most dramatic collapse. This famous songbird was once common on Java, but excessive trapping for the pet trade made the species rare during the first half of this century; the last Javan records known to me are from 1946 near Jakarta (Hoogerwerf 1948) and the neighbourhood of Bandung in 1951 (van Balen 1997b).

A number of lowland species that are in acute danger (Collar *et al.* 1994) are from wetlands, not mixed rain forest: milky stork *Mycteria cinerea*, lesser adjutant *Leptoptilos*

[5] Reported in 1825, but listed as questionable by Vorderman (1901)

[6] First collected in the $19^{th}$ century, but listed as questionable by Vorderman (1901)

*javanicus*, Javan wattled lapwing *Hoplopterus macropterus* (probably already extinct); or mangroves: Sunda coucal *Centropus nigrorufus;* and open agricultural lands: Java

**Box 11.5** Resident lowland forest birds on Java without records over the past 50 years

| | |
|---|---|
| white-winged duck | *Cairina scutulata* |
| little green pigeon | *Treron olax** |
| moustached hawk-cuckoo | *Cuculus vagans** |
| Hodgson's hawk-cuckoo | *Cuculus fugax** |
| reddish scops-owl | *Otus rufescens* |
| straw-headed bulbul | *Pycnonotus zeylanicus* |
| yellow-cheeked Spiderhunter | *Arachnothera chrysogenys* |
| white-bellied munia | *Lonchura leucogastra*** |

None of these non-endemic species is known from Bali; *resident status doubtful (Hellebrekers & Hoogerwerf 1967); **known from only one specimen (Hoogerwerf 1949)

sparrow *Padda oryzivora* and black-winged starling *Sturnus melanopterus.* Fortunately, most endemic species on Java and Bali are montane, living in the comparative safety of the rugged interior of Java.

Six lowland forest species on Java and Bali have a globally threatened status (Collar *et al.* 1994). The three species that I selected for a closer look were green peafowl *Pavo muticus* (Chapter 5), Bali starling *Leucopsar rothschildi* (Chapter 6 and 7), Javan hawk-eagle *Spizaetus bartelsi* (Chapters 8, 9 and 10). Although the accuracy of censuses varies strongly with their range and numbers, each case stresses the utmost importance of proper monitoring the wild population in order to take adequate management measures. The three Javan species seem to have withstood the fragmentation effects, and found reasonably widespread, and as such they are not typical of the rare, dwindling forest species. The four not only represent four different bird families, but also three different Minimal Habitat Requirement classes. The hawk-eagle is a true forest bird, but good dispersal abilities ameliorate the effects of fragmentation of its habitat. The peafowl is a woodland species for which a very large area of suitable habitat (but largely unexplored as such) is available in the Javan teak plantations. The babbler is a forest-edge species and seems to tolerate certain degrees of habitat disturbance. The Bali starling appears well adapted to harsh conditions, and its less stringent habitat demands should thus give hope for the utilisation of woodland for reintroduction.

Java has always been prone to natural catastrophes: long droughts, forest fires, volcanism, and tsunamis (see Whitten *et al.* 1996). An extended drought and associated forest fire, or perhaps even a tsunami could easily wipe out the remaining tiny population of wild Bali starling; and volcanism is a continuous threat to some upland populations of Javan hawk-eagle. A more real, man-made threat, currently taking place, is loss of anonymity. The Javan hawk-eagle has survived widespread in a relatively large number of forest reserves, but its election as national symbol instigated a hitherto non-existing demand for captive birds, the consequences of which are yet difficult to foresee. Another threat is the gradual loss of local hunting taboos as modernisation proceeds. These taboos may form an important asset to species conservation (Colding & Folke 1997), and very likely have so far prevented the extinction of the Javan green peafowl. Revival of the traditional *reog* dances (often to the satisfaction of the tourist industry), which use huge amounts of peacock feathers, immensely increased the demand for these and caused an upsurge of hunting (van Balen 1997c).

**Endemic taxa**

Brooks *et al.* (1997) showed that single island endemics are more at risk of extinction than are widespread species. On Java 80 of 145 species (55 %) of the forest avifauna is endemic to at least the subspecies level. With more research and better understanding of the taxonomy of Oriental birds, the number of full endemic species, and thus globally threatened species could considerably increase (Brooks *et al.* 1997). Such upgrading has most recently happened with Javan Plover *Charadrius javanicus* (C. Roselaar in Cramp & Simmons 1983), volcano swift *Aerodramus volcanorum* (S. Somadikarta in Andrew (1985); Andrew 1992), Javan cochoa *Cochoa azurea* (Collar & Andrew 1987) and Javan sunbird *Aethopyga mystacalis* (Mees 1986). None of these species enters the category of globally threatened species, but there are some potential candidates amongst the Javan endemic subspecies which have very restricted distributions (see Box 11.6). Whilst the usefulness of species as a biodiversity measure may be queried, the loss of genetic variation that goes along with the eventual demise of these endemic taxa (upgraded to a full-species or not), causes concern.

**Box 11.6** Endemic subspecies of lowland forest birds of Java with very restricted distributional range

| | |
|---|---|
| mountain imperial pigeon | *Ducula badia capistrata* |
| brown wood-owl | *Strix leptogrammica bartelsi* |
| brown hawk-owl | *Ninox scutulata javanensis** |
| blue-banded kingfisher | *Alcedo e. euryzona* |
| rufous woodpecker | *Celeus b. brachyurus* |
| banded woodpecker | *Picus m. miniaceus* |
| orange-backed woodpecker | *Reinwardtipicus v. validus* |
| buff-rumped woodpecker | *Meiglyptis t. tristis* |
| fairy bluebird | *Irena puella turcosa* |
| scaly-breasted bulbul | *Pycnonotus s. squamatus* |
| blue whistling thrush | *Myophonus caeruleus flavirostris* |
| maroon-breasted philentoma | *Philentoma v. velatum* |
| thick-billed flowerpecker | *Dicaeum agile finschi** |
| crested jay | *Platylopuhus g. galericulatus* |

*also occurring on Bali, but subspecific status unclear

**Population Viability Assessments**

Ludwig (1999) warned against unduly optimistic viability assessments due to the disregarding of observation errors or possible catastrophes, and the failure to compute confidence intervals. In the present study no attempt was undertaken to a Population Viability Assessment for any of the three species[7], but it is made clear that unexpected catastrophes (such as an increasing demand for the pet trade, loss of traditional values), as wll as more postive factors (such as the improved census method for the Javan hawk-eagle, and the much higher breeding rates in the Bali starling (see Chapter 6), can drastically change a PVA's outcome.

## CONSERVATION ACTION

Heywood *et al.* (1994) noted that species that are "committed to extinction" would inevitably become extinct if no action is undertaken to reverse current trends. Two distinct recovery goals play a role in species conservation action: the short-term interim goal, which considers the socio-economics *en route* to attaining viability, and the long-term biological goal, which estimates viability (Scott *et al.* 1995). In discussing the diagnosis of declines in bird populations, Green (1994) remarked that "actions aimed to reverse the changes in external conditions which caused the decline need not be the most effective in initiating recovery." Amongst my three study cases the Bali starling exemplifies this, as "reversing changes in external conditions" (i.e., habitat conversion) has not the slightest effect, if the primary threat (i.e., illegal capturing) is not eliminated to allow an initial recovery.

The following conservation actions are considered most relevant to this thesis.

**Habitat restoration**

Theoretically a 32% increase of the existing lowland and hill forest area (see above) would keep Java's avifauna in line with the other Sunda islands. Franklin (1993) considered that manipulating the landscape matrix is as important to reserve issues as are habitat reserve systems. Indeed, Java's non-primary forest area is partly suitable for a number of forest bird species, while adaptive species (most likely to be found in MHR classes III and IV) may profit from surrogate forest such as home garden systems and plantation forests.

However, to preserve all presently extant lowland forest bird species, including the more vulnerable classes I and II, the seriously fragmented condition of Java's lowland forest has to be considered. The nestedness analysis in this thesis (Chapter 4) showed the disastrous effects of fragmentation on occurrence for a number of interior forest species. A large part of Java's remaining lowland and hill forest areas are smaller than 2500 ha, the apparent threshold size for woodpecker assemblages, and Javan hawk-eagle populations. Deforestation in the lowlands of Bali has been very much in line with Java. Almost the

[7] For the Bali starling and Javan hawk-eagle PVA's have been conducted (Seal *et al.* 1990; Manansang *et al.* 1997)

entire Balinese lowland forest avifauna is present in the Bali Barat National Park (see Appendix 2). The park's lowland forest, however, is of a seasonal type, and a number of lowland forest bird species are now restricted to the mountainous and more humid central part of the island (Box 11.4). Habitat restoration by re-afforestation to link up the forests in the dry lowlands with those in the wetter interior may be essential for the survival of the specialist Bali starling (Chapters 5-6). The preservation of existing forest blocks might be sufficient to guarantee the survival of green peafowl (Chapter 7) and Javan hawk-eagle (Chapters 8-10). The white-breasted babbler, and most near-threatened species seem to thrive in a large number of fragments along a wide size range, and appear to be relatively secure at present.

Traditionally managed agroforests are a valuable compromise between conservation of tropical forest biodiversity and sustainable use of natural resources (Thiollay 1995), and analogies can be found in the shaded coffee plantations (Perfecto *et al.* 1996), or home garden systems in Java's rural areas (Michon & Mary 1990). However, in the latter the "traditional features of diversity, complexity, multiple use and stratification are now being gradually lost" with ongoing modernisation (Whitten *et al.* 1996), and an increasingly large proportion of the avifauna will consist of woodland and urban species.

**Captive breeding**

Captive breeding programmes probably saved the last wild population of Bali starling. Ironically, the building up of at least part of the captive breeding stock was supported by the same illegal capturing that contributed to the starling's collapse in the wild.

Sarrazin & Barbault (1996) point to the unique opportunities for experimental studies on ecological processes offered by re-introductions. Adaptability of the Bali starling appeared to be much higher than was believed, and also the study of breeding rates in the wild was indirectly enhanced by the captive release project. Both findings indicate a less gloomy future for the Bali starling.

Captive breeding programmes are too often instigated by inaccurate field surveys (Collar 1997). The surveys as described in the foregoing chapters (Chapters 8, 10) indicate that breeding programmes are not warranted for the Javan hawk-eagle, and an extremely carefully planned one may be considered for the green peafowl (Chapter 7). The captive release of the starling was, however, very timely. Straw-headed bulbul is a very strong and valuable candidate for re-introduction, as its numbers in captivity would be sufficiently large to build up a healthy captive stock without extraction from the wild. White-winged duck is another candidate, but its presumed vagile character could make monitoring, and re-introduction in Java's relatively small nature reserves (which are imbedded in a heavily populated rural matrix), extremely strenuous. Yet the logistics, management and political and judicial support need to be much better before other captive breeding programmes are started. Further captive breeding should always be supportive to in-situ protection.

## FUTURE PERSPECTIVE

It is clear from the above that Java's population growth and inherent pressure on lowland habitat area and integrity do not give much reason for optimism about the future of Java and Bali's forest birds. As we have to deal with a *fait accompli* due to the extremely advanced state of forest loss and fragmentation, every single piece, large or small that is left of lowland rainforest should be preserved and every effort should be taken to link up reserves and forest patches into major forest blocks, as suggested for the Javan hawk-eagle (Chapter 8).

The globally threatened forest bird species that have been treated in this thesis demand different approaches with regard to monitoring in the wild, captive breeding issues and causes of decline and/or rareness in relation to habitat fragmentation. Only for the Bali starling, and perhaps white-winged duck and straw-headed bulbul is the study of ultimate causes relevant, and re-introduction is also clearly an option, though deterministic causes (overcapturing and loss of habitat) are at least as important. For the other threatened species (Javan hawk-eagle, green peafowl, white-breasted babbler) and near-threatened forest bird species, as yet the study and cure of deterministic causes are most relevant. To stop the deleterious effects of habitat fragmentation, and overcapturing on bird numbers in the wild, improvement of the existing nature conservation system and law enforcement measures should be resorted to. In this process, the following circumstances give particular cause for hope:

The growing interest in the study of local wildlife, and birds in particular, is unprecedented and many Indonesian students and birdwatchers are involved in Javan hawk-eagle field studies, general bird surveys etc. Various foreign sponsors and organisations (BirdLife International, WWF, American Zoo Association, Norwegian Research Institute NINA, the Japanese Society for Research of the Golden Eagle) are willing to support projects to preserve threatened species, in particular the Bali starling and Javan hawk-eagle.

The case studies on the three forest birds as described in Chapters 5-10 have contributed to the design of three recently published species conservation action plans: PHPA/BirdLife-IP (1997) for Bali starling; Sözer *et al.* (1998) for Javan hawk-eagle and McGowan *et al.* (1999) for green peafowl.

The Bali starling appears to be far more adaptive and resilient than was believed previous to re-introduction projects. Relief from capturing pressure, and favourable weather condition can trigger an explosive growth rate in this species.

The Javan hawk-eagle is far more widespread than the previous scanty information suggested, and extensive surveys found the species in many forest fragments, seemingly little affected by isolation.

Some Javan forest birds appear to be dynamic in their distribution and abilities to adjust to changing conditions. It should be borne in mind that this has happened for only a small number of species and over an unknown, but presumably long period of time. No such optimism may yet be justified for the same species on the other islands, including where deforestation in the lowlands is of less ancient date.

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# Summary

Large-scale deforestation of the islands of Java and Bali commenced in the 16th Century and approached its maximum extent towards the end of the 19th century after four decades of intensified cultivation under the rule of the so called "Cultuurstelsel". The vegetation cover of Java, consisting largely of rich rain forest types, was by then decimated, and nowadays an estimated 2.3% or less of the original lowland forest cover remains. Pressure from the fast growing human population has its effects on both the distribution and abundance of forest birds. Through extrapolation Java is shown to have a disproportionately low number of lowland forest bird species as compared to the larger neighbouring islands of Sumatra and Borneo, but also the smaller island of Bali. This is the result of a long history of intensive land use several centuries "ahead" of the other islands. Six lowland forest bird species occurring on Java and Bali are nominated as globally threatened by the newest IUCN threat classes, and another seven forest bird species are near-threatened, although this needs confirmation upon the results of extensive monitoring. Amongst these 13 species seven are endemic to Java and Bali. In this thesis the impact of deforestation and other factors (notably excessive trapping and hunting) is investigated for nearly entire lowland forest bird communities, as well as for a number of these globally threatened species, namely the green peafowl *Pavo muticus*, Javan hawk-eagle *Spizaetus bartelsi* and Bali starling *Leucopsar rothschildi*.

In Chapter 2 the effect of afforestation (the reverse of deforestation) on the distribution of birds is investigated for real islands. The natural history of colonisation by land birds is described for the four Krakatau islands since the major eruption in 1883. The colonisation and extinction rates of birds show non-monotonic changes that are believed by some workers to be in discord with the equilibrium in MacArthur & Wilson's theory of island biogeography. Recent data, which were subjected to a more critical assessment of immigration status or extinction of the resident bird species, showed the successional character of species turnover and suggested that in general the equilibrium model can indeed predict recolonisation. The Krakatau study has given insight into how important succession is in colonisation processes, and to what extent species numbers can depend on the various "qualities" of the constituent bird species with respect to their place in the succession. These may also play a role in mainland situations. The Krakatau data also permitted an assessment of the colonisation abilities of a number of forest bird species (of importance in later chapters of this thesis).

In Chapter 3 it is shown for Bogor botanical gardens that initial abundance in this 86-hectare woodland, together with abundance of bird species in the surroundings of the forest fragment, more than other factors such as trapping, determined the colonisation and extinction processes. Certain forest bird species cannot occur in fragments that are too small, and these small fragments then increasingly come to contain a community identical to that of the surrounding countryside. In Chapter 4 this

is shown for 19 Javan lowland forest fragments (<1000m above sea level), mostly nature reserves, varying in size from six to 50,000 hectares. The ability of each species to survive in the surrounding habitat is believed to reflect the likelihood of survival in the fragments. Therefore forest birds inhabiting the forest stands have been subdivided into four Minimal Habitat Requirement (MHR) classes: I) true (interior) forest; II) forest edge; III) woodland; and IV) rural/urban species. Various analyses of the bird communities inhabiting these fragments consistently showed a clear trend in diminished incidence with decreasing fragment size, from MHR class I through class IV. Species numbers were positively correlated with fragment size (Chapter 4). Most interestingly, the woodland species had a $z$-value (which describes the slope of the log/log regression line) of 0.15 which is in perfect accord with those found in conservation literature for non-isolates (samples). The true forest species had $z = 0.34$, in accord with isolates.

Nestedness analysis, which uses the property of sets of real or habitat islands to form nested subsets (species sets in small fragments always re-occur in larger fragments) provided insight into distribution patterns amongst forest fragments. Nestedness attained values of 9.8° for true forest birds to 20.5° for rural and urban species (the more nested, the lower this degree). Such strong nestedness patterns clearly have consequences for decisions to be made about the sizes of bird reserves (the so-called single large or several small (SLOSS) reserves debate), designed to contain complete species assemblages. Only the largest reserves were large enough to conserve the majority of species, but this is only valid for true forest species, and to a lesser extent to forest edge species. Urban species are practically indifferent of fragment size, and woodland species are in an intermediate position. The nestedness analysis indicated a special situation for the woodpeckers, of which assemblages appeared to collapse in fragments smaller than 2500 hectares, suggesting the possibility of secondary extinctions.

The second part of the thesis describes case studies of three globally threatened species.

The Bali starling is a passerine endemic to the dry lowland woodlands of northwestern Bali. Habitat conversion and excessive trapping for the bird trade brought the species down less than a dozen birds in 1990 (Chapter 5). Captive breeding and re-introduction as a tool to restore numbers in the wild proved in theory to work well (Chapter 6). However, continued poaching for the pet trade prevents the species from recovering. The Bali starling is most likely a bird of the MHR class III, suggested by adaptability shown after release into secondary woodland habitat. Its resilience is astonishing: in 1991-1993 the population recovered during a temporary relief from poaching from a dozen to about 60 birds.

The green peafowl was formerly widespread over the mainland of Southeast Asia, and Java. Nowadays it is very much scattered, and rare. During the present survey throughout Java about 30 sub-populations of several to up to several hundred birds were found, totalling more than 1000 individuals, but considerably more peafowl are expected to be found in the largely unsurveyed visited, but extensive teak forests of Central and East Java (Chapter 7). As a MHR class III species, it is comparatively insensitive to forest destruction, and even seeks man-made habitat such a teak forest, coffee plantations etc. This species is an example of how hunting taboos have temporarily secured refuges for localised small populations. The loss of these taboos had a disastrous impact on the wild population.

The Javan hawk-eagle is endemic to Java, and has been subject to extensive surveys between 1980 and 1997. This MHR class I species was found throughout Java in 24 localities of 2500 hectares and larger, sometimes at considerable distances apart (Chapter 8). The population is estimated at less than 1000 birds (Chapter 9). The relatively large number of localities, some small and isolated, is surprising for this large inhabitant of primary forest, but can only be explained by its good dispersal abilities (especially during the immature phase), adaptability to edge habitats and rather opportunistic feeding behaviour (Chapter 10).

The deforestation of Java and Bali has had disastrous effects on the lowland forest avifauna. As estimated from comparison with the islands of Sumatra and Borneo, 43 species of forest birds are believed to have disappeared (independent of the insularisation process of the Sunda shelf, and thus under probable influence of recent forest fragmentation), amongst which are an unknown number of endemic species (Chapter 11). A disproportionate number of true forest species have been purged from the indigenous species pool, and extrapolation of the number of species predicted to remain in Java's available forest patches suggests an additional number of species likely to become extinct there. However, different MHR classes give different predictions about the future effects of forest fragmentation and for MHR classes III and IV agroforests and home gardens may be good alternative increasing their effective area. For class I and II large forest reserves of 10,000 and more hectares are needed. A number of lowland species have considerably expanded their altitudinal range, from being extreme lowland (three species), and hill slope specialists (five), which could not always be attributed to relief from competition. Other species have expanded their forest habitat and colonised woodland areas, though some of these species have done so on Java, but not on Bali.

# Samenvatting

De ontbossing van de Indonesische eilanden Java en Bali is in de 16ᵉ eeuw begonnen en bereikte zijn grootste omvang tegen het einde van de 19ᵉ eeuw, na vier decennia van intensieve landontginning onder het coloniale Cultuurstelsel. De vegetatie van Java, die ooit vooral uit soortenrijk regenwoud bestond, was toen reeds gedecimeerd, en tegenwoordig wordt de resterende bedekking van het oorspronkelijke laaglandbos op niet meer dan 2.3% geschat. De druk van de snel groeiende menselijke bevolking heeft zijn invloed op zowel verspreiding als de getalssterkte van laaglandbosvogels. Door middel van extrapolatie is aan te tonen dat Java een onevenredig klein aantal bosvogels bezit in vergelijking met de naburige eilanden Sumatra en Borneo, maar ook het kleinere eiland Bali. Dit is het gevolg van intensief landgebruik op Java, enkele eeuwen voordat dat op de andere eilanden was begonnen. Zes van de bosvogelsoorten in de laaglanden van Java en Bali worden volgens de nieuwste bedreigingsklassen van het IUCN als wereldwijd bedreigd beschouwd. Daarbij komen zeven andere bosvogelsoorten, die als bijna-bedreigd zijn geclassificeerd, alhoewel de laatste categorie door veldwerk nog bevestiging behoeft. Onder deze 13 soorten zijn er zeven endemisch voor Java en Bali. In dit proefschrift wordt de invloed van ontbossing en andere factoren (vooral overmatig vangen en overbejagen) op nagenoeg volledige laagland bosvogelgemeenschappen onderzocht, alsook voor een drietal wereldwijd bedreigde soorten, namelijk de groene pauw *Pavo muticus*, de Javaanse kuifarend *Spizaetus bartelsi* en de Balispreeuw *Leucopsar rothschildi*.

In Hoofdstuk 2 wordt de invloed van natuurlijke herbebossing (het omgekeerde van ontbossing) op de vogels van echte eilanden behandeld. De natuurlijke historie van de colonisatie door landvogels op de vier Krakatau eilanden, met name het eiland Rakata, sinds de grote eruptie in 1883, wordt beschreven. De colonisatie- en uitstervingssnelheden laten niet-monotonische veranderingen zien, die volgens sommige onderzoekers niet in overeenstemming zouden zijn met het voorspelde evenwicht van MacArthur & Wilson's theorie van eilandenbiogeografie. Recente gegevens die onderworpen werden aan een meer kritische bepaling van de status van vestiging of uitsterven van broedvogels, laten zien dat de soorten *turnover* van successionele aard is, en doen veronderstellen dat het evenwichtsmodel inderdaad vestiging door landvogels kan voorspellen. De studies op de Krakatau eilanden hebben aangetoond dat vegetatie successie belangrijk kan zijn voor vestigingsprocessen, maar ook dat het soortenaantal kan afhangen van de verschillende eigenschappen van de samenstellende vogelsoorten met betrekking tot hun plaats in de successie. Deze zouden ook een rol kunnen spelen in vasteland situaties. Met de Krakatau gegevens kan verder voor een aantal bosvogelsoorten het colonisatievermogen worden bepaald (dit komt terug in latere hoofdstukken van dit proefschrift).

In Hoofdstuk 3 wordt voor 's Lands Plantentuin te Bogor (Kebun Raya Indonesia) aangetoond dat vestigings- en uitstervingsprocessen worden beïnvloed door de talrijkheid van vogelsoorten bij aanvang van isolatie in dit 86 hectare grote beboste stadspark, en hun talrijkheid in de omgeving van dit bosfragment, meer dan door andere factoren, zoals het vangen voor de vogelhandel. Bepaalde bosvogelsoorten kunnen zich niet in te kleine fragmenten handhaven, en de vogelgemeenschappen van deze fragmenten gaan dan geleidelijk steeds meer lijken op de die van het omringende terrein. In Hoofdstuk 4 wordt dit aangetoond voor 18 fragmenten (< 1000m boven zeeniveau), veelal natuurreservaten, in grootte varierend van zes to 50,000 hectares. Daar aangenomen wordt dat de kans op overleven in de fragmenten zijn weerspiegeling vindt in het vermogen van iedere soort te kunnen overleven in omringend habitat, zijn de bosvogels die de bosgebieden bevolken onderverdeeld in vier Minimale Habitat Vereisten (MHV) klassen: I) echte bos vogels; II) bosrandvogels; III) parklandvogels; en IV) stad- en dorpvogels. Verschillende analyses van de vogelgemeenschappen die de fragmenten bevolkten laten, gaande van klas I naar klas IV, consistent een duidelijke trend zien van verminderd voorkomen in kleiner wordende fragmenten. Soortenaantal is positief gecorreleerd aan fragment grootte. Zeer interessant is dat de parklandvogels een *z*-waarde (die de helling van de log/log regressielijn beschrijft) van 0,15 hadden, wat goed in overeenstemming is met de waarden gevonden in de natuurbeheersliteratuur voor niet-geïsoleerde gebieden (*samples*). De echte bosvogels hebben een *z*-waarde van 0,34 hetgeen overeenkomt met de waarde voor geïsoleerde fragmenten.

De analyse naar genesteldheid geeft inzicht in de patronen van verspreiding over de bosfragmenten. Hierbij wordt gebruik gemaakt van de eigenschap van echte eilandgroepen of habitateiland groepen om genestelde ondergroepen te vormen (d.w.z. soorten die in kleine fragmenten voorkomen komen ook voor in grotere fragmenten), Genesteldheid had waarden van 9,8° voor echte bosvogels, tot 20,5° voor stad- en dorpvogels (hoe meer genesteld, des te lager ("kouder") deze waarde). Zulke uitgesproken patronen van genesteldheid hebben gevolgen voor beslissingen die er gemaakt moeten worden over de groottes van vogelreservaten (de zogenaamde *Single Large or Several Small (SLOSS) reserves* discussie), die ingericht worden voor het omvatten van zo volledig mogelijke soortengroepen. Slechts de allergrootste reservaten blijken groot genoeg om de meerderheid van soorten te omvatten, maar dit geldt slechts voor de echte bosvogels, en in mindere mate voor de bosrandvogels. Stad- en dorpvogels blijken nagenoeg geheel ongevoelig voor fragmentgrootte, terwijl de parklandvogels een middenpositie innemen. De genesteldheidanalyse toont een speciale situatie voor de spechten, waarvan soortgroepen uiteenvallen, wanneer deze in fragmenten kleiner dan 2500 hectares voorkomen. Dit kan duiden op secundaire uitstervingen.

Het tweede deel van dit proefschrift beschrijft de speciale studies aan drie wereldwijd bedreigde soorten.

De Balispreeuw is een endeem voorkomend in de moessonbossen op Bali. Het in cultuur brengen van zijn biotoop en vangen voor de vogelhandel hebben het aantal in het wild levende vogels teruggebracht tot niet meer dan een dozijn in 1990 (Hoofdstuk 5). Het kweken in gevangenschap en uitzetten in het wild als een middel om de wilde populatie te herstellen, blijken in theorie wel te werken (Hoofdstuk 6). Echter illegale vogelvangst heeft tot dusverre het herstel van deze soort onmogelijk gemaakt. Aanpassing na uitzetting in secundair bos doet vermoeden dat de Balispreeuw hoogstwaarschijnlijk een MHV klas III soort is. Het herstellingsvermogen van deze soort is verrassend. Zo herstelde de populatie zich in 1990-1992 na een tijdelijk stopzetten van de vogelvangst en groeide tot ongeveer 60 vogels.

De groene pauw kwam ooit wijdverpreid voor in Zuidoost Azië, en Java. Tijdens de in dit proefschrift beschreven survey die over geheel Java plaatsvond, werden zo'n 30 kleine subpopulaties gevonden, bestaande uit enkele tot een paar honderd vogels. In totaal werden meer dan 1000 vogels waargenomen, maar een aanzienlijk aantal is nog te verwachten in de onvolledig bezochte, uitgestrekte teakbossen van Midden en Oost Java (Hoofdstuk 7). Als een parklandvogel (MHV klasse III) is de pauw betrekkelijk ongevoelig voor de aantasting van het bos, en zoekt zelfs kunstmatige habitats op, zoals teakaanplant, koffietuinen, etc. Deze soort is een voorbeeld van hoe jachttaboes tijdelijke veilige heenkomens verschaft hebben aan plaatselijke kleine populaties. Het verdwijnen van dergelijke taboes hebben rampzalige gevolgen voor de wilde populatie.

De Javaanse kuifarend is het onderwerp geweest van uitgebreid veldonderzoek tussen 1980 en 1997. Deze echte bosvogel (MHV klasse I) soort wordt verspreid over geheel Java gevonden in 24 boslocaties van 2500 ha en meer, die soms op grote afstanden van elkaar gescheiden lagen (Hoofdstuk 8). De totale populatie wordt thans geschat op bijna 1000 vogels (Hoofdstuk 9). Om zo'n grote bewoner van het regenwoud te vinden in een groot aantal locaties, waarvan sommige betrekkelijk klein en geïsoleerd, is verrassend. Het kan slechts verklaard worden door het grote verspreidingsvermogen (vooral gedurende de onvolwassen fase), aanpassing aan marginaal habitat en tamelijk opportunistisch fourageergedrag (Hoofdstuk 10).

De ontbossing van Java en Bali heeft ingrijpende gevolgen gehad voor de avifauna van het laaglandbos. Door vergelijking met de eilanden Sumatra en Borneo wordt het aantal bosvogelsoorten dat onder invloed van bosfragmentatie (dus onafhankelijk van het insularisatieproces van het Sundaplat) geschat op 43, waaronder een onbekend aantal endemische soorten (Hoofdstuk 11). Een onevenredig groot aantal bosvogels is dus reeds uit de inheemse avifauna gezeefd en extrapolatie van het aantal soorten dat volgens voorspelling zich in Java's bosfragmenten zal kunnen handhaven, doet vermoeden dat er nog meer soorten zullen uitsterven. De verschillende MHV klassen geven verschillende voorspellingen voor de gevolgen van bosversnippering in de toekomst. Voor de klassen III en IV kunnen de traditionele weelderig begroeide woonerven en volkstuinen een goed alternatief vormen om hun verspreiding effectief te handhaven of vergroten. Voor klasse I en II zijn daarentegen grote bosreservaten van minstens 10.000 hectare nodig. Een aantal laaglandvogels, te weten drie extreme laaglandsoorten en vijf hellingspecialisten hebben hun hoogteverspreiding uitgebreid. Deze uitbreidingen konden niet altijd aan het wegvallen van concurrentie toegeschreven worden. Andere bossoorten hebben hun habitatsgrenzen verlegd en hebben zich nu gevestigd in parklandbossen, alhoewel enkele onder deze dit wel op Java, maar niet op Bali hebben gedaan.

# Ringkasan

Penebangan hutan secara besar-besaran di Pulau Jawa dan Pulau Bali telah dimulai pada abad ke-16. Puncaknya tercapai pada akhir abad ke-19 setelah pengelolaan yang intensif berlangsung selama empat dasawarsa di bawah *Cultuurstelsel* (sistem tanaman paksa di zaman penjajahan Belanda). Waktu itu penutupan vegetasi di Jawa, yang terutama terdiri dari hutan hujan yang kaya, telah sangat dikurangi. Saat ini penutupan hutan pamah asli diperkirakan mencapai 2,3% atau kurang. Dampak negatif dari populasi manusia yang bertambah cepat mempengaruhi baik persebaran maupun kelimpahan burung hutan. Melalui ekstrapolasi dapat diketahui bahwa Jawa memiliki jumlah burung hutan pamah yang secara relatif rendah dibandngkan dengan Pulau Sumatera dan Pulau Kalimantan, yang besar tetapi juga dengan Pulau Bali yang lebih kecil. Hal ini adalah hasil sejarah panjang tata guna lahan intensif di Jawa, yang dimulai beberapa abad sebelumnya dari ketiga pulau yang lain. Enam jenis burung hutan pamah yang terdapat di Jawa dan Bali telah ditetapkan sebagai burung yang secara global terancam punah. Tujuh jenis burung hutan lainnya adalah mendekati terancam punah, tetapi masih perlu dipastikan melalui pemantauan secara luas di lapangan. Di antara ke-13 jenis ini tujuh jenis merupakan endemik Jawa dan Bali. Dalam disertasi ini diteliti dampak penebangan hutan dan faktor-faktor lain (terutama penangkapan dan perburuan secara berlebihan) maupun terhadap komunitas burung hutan pamah, begitu juga terhadap sejumlah jenis burung hutan yang terancam punah, yaitu burung Merak hijau *Pavo muticus*, Elang jawa *Spizaetus bartelsi* dan Jalak (Curik) bali *Leucopsar rothschildi*.

Di Bab 2 pengaruh dari proses penghutanan alami (kebalikan dari proses penebangan hutan) diteliti untuk beberapa pulau dalam arti sebenarnya. Sejarah proses kolonosasi oleh burung terestrial diuraikan untuk keempat pulau Krakatau sesudah letusan dasyat pada tahun 1883. Laju pemukiman dan kepunahan dari burung tersebut menunjukkan perubahan yang tidak-monotonik. Menurut beberapa peneliti lain hal ini tidak sesuai dengan keseimbangan yang diajari oleh teori geografi pulau dari MacArthur & Wilson. Akan tetapi sesudah status imigrasi atau kepunahan dinilai secara lebih kritis, data terbaru menunjukkan sifat suksesional dari pergantian jenis. Model kesimbangan memang dianggap dapat memprediksi proses pengkolonisasian kembali secara umum. Penelitian Krakatau memberikan kejelasan mengenai pentingnya suksesi dalam proses-proses kolonisasi, dan sampai di mana jumlah jenis dapat tergantung pada berbagai kualitas dari jenis-jenis burung bersangkutan jika dilihat posisinya dalam proses suksesi. Sifat-sifat ini dapat berperan di daratan juga. Data Krakatau juga memberikan kajian menengai kemampuan kolonisasi sejumlah jenis burung hutan (yang merupakan bagian penting di beberapa bab berikutnya dalam disertasi ini)

Di Bab 3 ditunjukkan bahwa untuk Kebun Raya Bogor, kelimpahan jenis awal dari burung di dalam hutan seluas 86 hektar ini, beserta kelimpahan sekitarnys, lebih dipengaruhi proses-proses kolonisasi dan kepunahan dibandingkan faktor-faktor lain (seperti penangkapan liar). Beberapa jenis burung tidak mampu bertahan di kantung

hutan yang terlalu kecil. Kantung ini makin lama makin didiami komunitas burung yang menyerupai komunitas yang ada di pedesaan di sekitarnya. Di Bab 4 ditunjukkan untuk 19 kantung hutan pamah (< 1000m d.p.l.), umumnya cagar alam dan luasnya berkisar antara enam sampai 50.000 hektar. Kemampuan burung untuk bertahan di habitat (bukan hutan) sekitarnya diduga kuat mencerminkan kemungkinan untuk bertahan di kantung hutan. Karena itu burung hutan digolongkan dalam empat kelompok Syarat Habitat Minimal (SHM): I) burung hutan sejati; II) burung pinggir hutan; III) burung taman; dan IV) burung pedesaan/perkotaan. Beberapa analisa terhadap komunitas burung yang menempati kantung hutan tersebut menunjukkan secara tetap bahwa ada kecenderungan nyata di mana keberadaan di kantung-kantung tertentu menurun sejalan dengan penurunan ukuran kantung-kantung hutan, dari kelompok I sampai ke kelompok IV.

Jumlah jenis memiliki korelasi positif dengan ukuran kantung hutan (Bab 4). Hal menarik adalah nilai $z$ (yang merupakan lereng garis regresi log/log) yang mencapai 0,15, yaitu sesuai dengan nilai yang terdapat di kepustakaan konservasi untuk kawasan yang tak terisolasi (sampel), sedangkan nilai $z$ untuk burung hutan sejati mencapai 0,34, sesuai dengan kawasan terisolasi.

Analisa kebersarangan memberikan pengertian mengenai pola persebaran di antara kantung-kantung hutan tersebut. Analisa ini menggunakan sifat dari kumpulan pulau atau pulau habitat untuk membentuk subgolongan yang "bersarangan" (dengan kata lain: kumpulan jenis di kantung kecil secara utuh terdapat di kantung yang lebih besar) Nilai kebersarangan mencapai 9,8° untuk burung hutan sejati, sampai 20,5° untuk burung pedesaan dan perkotaan (N.B. Makin bersarangan, makin rendah ("dingin") derajatnya). Pola kebersarangan yang nyata seperti ini jelas mempengaruhi keputusan mengenai ukuran suaka burung (yang disebut pembahasan cagar alam Single Large or Several Small (SLOSS)), yang dirancang agar dapat memuat kumpulan jenis sebanyak-banyaknya. Hanya cagar alam terbesar mampu melestarikan mayoritas jenis burung, tetapi ini hanya berlaku untuk burung hutan sejati (Kelompok SHM I) saja. Persebaran burung pedesaan dan perkotaan (Kelompok SHM IV) boleh dikatakan tidak terpengaruh sama sekali oleh ukuran kantung hutan. Burung taman (Kelompok SHM III) menempati posisi tengah. Analisa kebersarangan menunjukkan keadaan istimewa untuk jenis-jenis pelatuk, di mana kelompok jenis hilang di kantung hutan < 2.500 hektar. Hal ini menunjukkan kemungkinan kepunahan sekunder.

Bagian kedua di disertasi ini menguraikan beberapa studi khusus mengenai tiga jenis burung yang secara global terancam punah.

Penangkaran dan penglepasan ke habitat asli untuk memulihkan jumlah populasi liar ternyata secara teoritis dapat dilaksanakan untuk Jalak bali. Akan tetapi sejauh ini penangkapan liar, dan pengrusakan habitat (yang belum jelas sekali pengaruhnya) telah mempersulit jenis ini untuk pulih kembali. Tetapi daya pulih (*resilience*) jenis ini mengejutkan dunia konservasi: pada tahun 1990 di mana hanya tersisa selusin burung di habitat asli, populasi bertambah sampai 60 burung dalam waktu beberapa tahun saja. selama penangkapan liar dapat dihentikan. Jalak bali kemungkinan besar termasuk Kelompok SHM III, karena daya adaptasi setelah dilepaskan ke dalam habitat hutan sekunder.

Merak Hijau pernah tersebar luas di daratan Asia Tenggara, tetapi persebarannya saat ini terpecah-pecah. Di Jawa jenis ini ditemukan dalam kurang lebih 30 subpopulasi yang terdiri dari beberapa ekor, jumlah total lebih dari 1000 ekor (Bab 7). Sebagai jenis Kelompok SHM III, Merak hijau tidak terlalu dipengaruhi pengrusakan hutan, malah sering dapat ditemukan di habitat buatan seperti hutan jati, kebun kopis dan sebagainya. Jenis ini merupakan contoh bagaimana pantangan berburu dapat mengamankan populasi-populasi kecil yang terpisah. Menghilangnya pantangan tersebut berdampak buruk terhadap populasi liar.

Elang jawa adalah jenis burung pemangsa endemik di Jawa. Selama survai di seluruh Jawa jenis yang termasuk Kelompok SHM I ini ditemukan di 24 lokasi hutan berukuran >2.500 hektar, kadang-kadang berjarak jauh (Bab 8). Populasinya diperkirakan berjumlah kurang dari 1000 ekor (Bab 9). Jumlah lokasi, di antaranya beberapa yang kecil and terisolasi, merupakan hal yang agak mengherankan, tetapi dapat dimengerti mengingat daya penyebaran yang tinggi (khususnya selama periode remaja), daya adaptasi terhadap habitat pinggiran dan perilaku pakan yang agak oportunis (Bab 10).

Pengrusakan hutan di Jawa dan Bali telah berdampak buruk terhadap avifauna hutan pamah. Jika dibandingkan dengan Pulau Sumatra dan Pulau Kalimantan, 43 jenis burung hutan diduga menghilang (yang lepas dari akibat proses terpecah-pecahnya Dangkalan Sunda menjadi pulau-pulau, dan sebagai akibat pengrusakan hutan baru-baru ini). Di antara jenis ini terdapat sejumlah jenis endemik yang tak dikenali (Bab 11). Sejumlah burung hutan sejati yang tak proporsionel telah disingkirkan dari kumpulan jenis asli. Lagipula ekstrapolasi dari jumlah jenis yang diprediksi akan bertahan di kantung-kantung hutan yang masih ada di Jawa, menunjukkan bahwa jumlah yang akan punah dapat bertambah lagi. Prediksi tentang besarnya dampak selanjutnya dari pemecahan hutan untuk masing-masing kelompok SMH berbeda jauh. Untuk Kelompok III dan IV, sistem pekarangan kemungkinan besar merupakan alternatif yang baik untuk memperbesar wilayah efektifnya. Untuk Kelompok SMH I dan II hanya cagar alam yang lebih besar dari 10.000 hektar dapat memadai.Sejumlah jenis burung dataran rendah telah memperluas wilayah altitudinal, yaitu tiga jenis spesialis dataran rendah ekstrem, dan lima jenis spesialis lereng bukit. Perluasan wilayah ini tidak selalu dapat dijelaskan dengan menghilangnya jenis burung pesaing. Tujuh jenis lainnya telah memperluas habitat hutan mereka dan menempati daerah taman, walaupun hanya di Jawa, dan tidak di Bali.


B. v. Balen 1989

**Appendix 1** Description of the 19 lowland forest study localities. General and more detailed information can be found in MacKinnon *et al.* (1982), Whitten *et al.* (1996).

1. Kotabatu. Size: 6 ha. Altitude: 345m. Status: municipal freshwater reservoir. Description: tap water supply for Bogor and therefore protected; evergreen rainforest patch entirely surrounded by suburban area.

2. Dungusiwul. Size: 9 ha. Altitude: 175m. Status: strict nature reserve established in 1931. Description: remnant of evergreen rainforest surrounded by young rubber plantation and village lands. See Hildebrand (1939).

3. Ciburial. Size: 22 ha. Altitude: 274m. Status: municipal freshwater reservoir. Description: secondary evergreen rainforest patch with rich undergrowth; tap water supply for Jakarta and as such protected; entirely surrounded by village lands. See S. Somadikarta (unpublished data stored in Museum Zoologicum Bogoriense).

4. Gunung Pancar. Size: *ca* 25 ha. Altitude: 652m (summit). Status: protection forest. Description: evergreen rainforest on hill top and effectively protected because of the presence of several sacred graves.

5. Yanlapa. Size: 32 ha. Altitude: ca 100m. Status: strict nature reserve, established in 1956. Description: evergreen rainforest. Relatively well preserved flat lowland forest surrounded by sparsely populated area.

6. Tangkuban Perahu. Size: 33 ha. Altitude: 100m. Status: strict nature reserve established in 1919. Patch of disturbed lowland evergreen rainforest along the main road to Pelabuhanratu surrounded by village land and plantation forests.

7. Sukawayana. Size: 46.5 ha. Altitude: sea level. Status: strict nature reserve, established in 1919. Description: semi-evergreen rain forest, heavily disturbed along the borders, straddling both sides of the road west of Pelabuhanratu along beach and on slope; few tall trees, but good undergrowth.

8. Bogor Botanic Gardens (Kebun Raya Bogor). Size: 85 ha. Altitude: 260m. Status: botanical garden established in 1817. Forest patches, with and without dense undergrowth in park landscape. Situated in the centre of Bogor town and since late 1930s entirely isolated from neighbouring forested village grounds. See Hoogerwerf (1950, 1953); Diamond *et al.* (1987); van Balen *et al.* (1988); Rijnberg (1992).

9. Pangandaran. Size: 500 ha. Altitude: 0 – 50m. Status: strict nature reserve established in 1934. Description: evergreen rainforest on peninsula. See Whitten *et al.* (1996).

10. Ciogong[1]. Size: 1000 ha. Altitude: 50 – 200m. Status: protection forest. Description: semi-evergreen rainforest, surrounded by teak forest and rural area; secondary forest enclaves.

11. Leuweung Sancang. Size: 2157 ha. Altitude:0 – 180m. Status: strict nature reserve since 1978.

[1] Contrary to what is reported by MacKinnon *et al.* 1982, the reserve still comprises some relatively good forest.

Description: reasonably well preserved evergreen rainforest, beach forest and some mangroves; adjacent to b village land, rubber plantations etc. in the west, east, and north

12. Mt Sanggabuana. Size: *ca* 2500 ha. Altitude: 150 – 1291m. Status: proposed recreation forest. Description: evergreen rainforest on hill above the artificial lake of Jatiluhur.

13. Ranca Danau/Tukunggede. Size: 4200 ha. Altitude: 100 – 500m. Status: strict nature reserve established in 1921. Description: semi-evergreen rainforest on hill and adjacent to freshwater lake.

14. Mt Aseupan. Size: *ca* 5000 ha. Altitude: 100 – 1174m. Status: protection forest. Description: evergreen rainforest on slopes of low hill (1174m) above the 95 ha Pantai Carita Recreation Forest (established in 1978).

15. Cikepuh. Size: 8127 ha. Altitude: 0 – 235m. Status: strict nature reserve established in 1925. Description: mostly secondary semi-evergreen rainforest with patches of primary forest.

16. Linggoasri. Size: 10,000. Altitude: 300 - 1200m. Status: protection forest. Description: evergreen rainforest on the foothills of the Mt Prahu (2565m). See Nijman & van Balen (1998); V. Nijman (verbally 1999).

17. Lebakharjo . Size: 16,000 ha. Altitude: 0 - 750. Status: protection forest. Description: evergreen rainforest in good condtion. See van Balen (1989); Bekkering & Kucera (1990).

18. Ujung Kulon peninsula[2]. Size: 28,600 ha. Altitude: 0 – 140m. Status: national park, protected since 1921. Description: semi-evergreen rainforest in different stages of succession, but cores of primary forest. See Hoogerwerf (1969-71).

19. Meru Betiri. Size: 50,000 ha. Altitude: 0 – 1223 ha. Status: national park, reserve since 1972. Description: semi-evergreen rainforest, with large enclaves of plantation forest and settlements. See Seidensticker & Suyono (1976).

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[2] Panaitan Island and the Mt Honje extension are excluded from the study area.

**Appendix 2** Distribution of forest birds across the study localities
Nomenclature follows Andrew 1992.

Initials: **ad**: J. Adamson *in litt.* 1989; **c**: L. Conole 1997; **d**: Pak Didin (PHPA) verbally 1990; *h*: Hoogerwerf 1953a, 1974; **he**: P. Heath 1991; *hi*: Hildebrandt 1939; **lo**: local informants; **lu**: T. Luijendijk *in litt.* 1996; **m**: R. Melish unpublished data; **s**: Seidensticker & Suyono 1980; **t**: Tobias & Phelps 1994; **w**: P. Whittington *in litt.* 1993.

appendix 2

| | | | Kotabatu | Dungusiwul | Ciburial | Gunung Pancar | Yanlapa | Tangkuban Perahu | Sukawayana | Kebun Raya Bogor | Pangandaran | Ciogong | Leuweung Sancang | Mt Sanggabuana | Ranca Danau/Tukunggede | Mt Aseupan | Cikepuh | Linggoasri | Lebakharjo | Ujung Kulon | Meru Betiri | Madura | Bali Barat | Initial Abundance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | M | BB | IA |
| | **PHASIANIDAE (Pheasants and allies)** | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | *Gallus gallus* | **red junglefowl** | - | - | - | x | - | - | - | - | - | x | x | - | x | x | x | x | - | x | x | - | x | 15 |
| 2 | *Pavo muticus* | **green peafowl** | - | - | - | - | - | - | - | - | - | x | x | - | - | - | x | - | x | x | x | - | - | 7 |
| | **COLUMBIDAE (Pigeons and doves)** | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | *Treron capellei* | **large green pigeon** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | - | - | - | [3] |
| 4 | *Treron griseicauda* | **grey-cheeked green pigeon** | - | x | - | - | x | - | x | x | - | x | x | - | x | x | x | x | x | x | x | - | x | 23 |
| 5 | *Ptilinopus melanospila* | **black-naped fruit-dove** | - | x | x | x | x | x | - | x | x | x | x | - | x | x | x | x | x | x | x | - | x | 28 |
| 6 | *Ducula aenea* | **green imperial pigeon** | - | - | - | - | - | - | - | - | - | - | x | - | - | - | - | - | - | x | - | - | x | 5 |
| 7 | *Ducula badia* | **mountain imperial pigeon** | - | - | - | - | - | - | - | - | - | - | - | - | - | x | - | x | - | - | - | - | - | 5 |
| 8 | *Macropygia phasianella* | **ruddy cuckoo-dove** | - | - | - | - | - | - | - | - | - | - | x | x | x | x | - | x | - | x | x | - | x | 27 |
| 9 | *Chalcophaps indica* | **emerald dove** | - | - | - | - | - | - | - | *h* | - | - | - | x | x | x | x | x | x | x | x | - | x | 15 |
| | **PSITTACIDAE (Parrots)** | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | *Loriculus pusillus* | **yellow-throated hanging-parrot** | - | x | - | - | - | x | - | x | w | x | x | x | - | x | x | x | x | x | x | - | ? | 16 |
| | **CUCULIDAE (Cuckoos)** | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | *Cacomantis sonneratii* | **banded bay cuckoo** | - | x | - | x | x | x | x | x | - | x | - | - | x | x | x | - | x | x | x | - | x | 18 |
| 12 | *Cacomantis merulinus* | **plaintive cuckoo** | x | - | x | x | x | - | - | x | - | x | - | - | x | x | - | - | - | - | x | x | x | ? |
| 13 | *Cacomantis sepulcralis* | **rusty-breasted cuckoo** | - | x | - | x | x | x | - | x | - | x | - | x | x | x | - | x | x | x | x | x | x | 32 |
| 14 | *Chrysococcyx xanthorhynchus* | **violet cuckoo** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | - | - | 6 |
| 15 | *Surniculus lugubris* | **drongo cuckoo** | - | x | x | x | x | x | x | x | - | x | - | - | x | x | x | - | x | x | x | - | ? | 25 |
| 16 | *Zanclostomus javanicus* | **red-billed malkoha** | - | x | - | - | x | - | - | - | - | - | - | - | x | t | - | - | x | x | x | - | - | 18 |
| 17 | *Rhamphococcyx curvirostris* | **chestnut-breasted malkoha** | - | *hi* | - | - | x | - | - | *h* | x | x | x | - | x | x | x | x | x | x | x | - | x | 30 |
| 18 | *Centropus sinensis* | **greater coucal** | - | x | - | x | x | - | - | - | - | x | x | - | x | x | - | x | x | x | x | x | x | 16 |
| | **APODIDAE (Swifts)** | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | *Rhaphidura leucopygialis* | **silver-rumped swift** | - | - | - | - | - | - | - | - | - | - | - | - | x | x | - | - | - | x | x | - | ? | 1 |
| | **HEMIPROCNIDAE (Tree-swifts)** | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | *Hemiprocne longipennis* | **grey-rumped tree-swift** | - | x | - | x | x | x | - | he | lu | x | x | x | x | x | x | x | x | x | x | - | x | 31 |
| | **TROGONIDAE (Trogons)** | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | *Harpactes oreskios* | **orange-breasted trogon** | - | - | - | x | - | - | - | - | - | - | - | - | - | x | - | x | x | x | x | - | - | 12 |
| | **ALCEDINIDAE (Kingfishers)** | | | | | | | | | | | | | | | | | | | | | | | |
| 22 | *Alcedo meninting* | **blue-eared kingfisher** | x | x | x | - | x | - | - | x | x | - | x | - | x | - | x | - | - | x | - | - | x | 30 |
| 23 | *Alcedo euryzona* | **blue-banded kingfisher** | - | - | - | - | - | - | - | ? | - | - | - | - | - | - | - | - | - | - | s | - | - | 8 |

Appendix 2 Continued

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | M | BB | IA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 *Ceyx erithacus* | **Oriental dwarf kingfisher** | - | *hi* | - | - | - | - | - | *h* | - | - | - | - | x | x | - | - | x | x | x | - | x | 18 |
| 25 *Lacedo pulchella* | **banded kingfisher** | - | - | - | - | - | - | - | - | - | x | - | - | x | x | - | x | x | x | x | - | ? | 13 |
| **MEROPIDAE (Bee-eaters)** | | | | | | | | | | | | | | | | | | | | | | | |
| 26 *Merops leschenaulti* | **chestnut-headed bee-eater** | - | - | - | x | - | - | - | *h* | x | x | - | - | - | x | - | - | - | x | x | lo | x | 21 |
| **BUCEROTIDAE (Hornbills)** | | | | | | | | | | | | | | | | | | | | | | | |
| 27 *Rhyticeros undulatus* | **wreathed hornbill** | - | - | - | - | - | - | - | - | x | d | x | x | x | x | - | x | x | x | x | - | x | 10 |
| 28 *Anthracoceros albirostris* | **Asian pied hornbill** | - | - | - | - | - | - | - | - | x | d | x | - | x | - | x | - | x | x | x | - | x | 12 |
| 29 *Buceros rhinoceros* | **rhinoceros hornbill** | - | - | - | - | - | - | - | - | - | d | x | x | - | - | x | - | x | x | x | - | ? | 8 |
| **CAPITONIDAE (Barbets)** | | | | | | | | | | | | | | | | | | | | | | | |
| 30 *Megalaima lineata* | **lineated barbet** | - | - | - | - | - | - | - | - | - | x | x | - | - | - | - | - | - | x | - | - | x | 27 |
| 31 *Megalaima javensis* | **black-banded barbet** | - | x | - | x | x | x | - | - | x | x | x | x | x | x | x | x | x | x | x | - | - | 27 |
| 32 *Megalaima australis* | **blue-eared barbet** | - | x | - | x | - | x | x | - | x | x | x | x | x | x | x | x | x | x | x | - | x | 23 |
| 33 *Megalaima haemacephala* | **coppersmith barbet** | - | x | - | x | - | - | - | x | - | x | x | - | x | - | x | - | x | x | x | - | x | 33 |
| **PICIDAE (Woodpeckers)** | | | | | | | | | | | | | | | | | | | | | | | |
| 34 *Sasia abnormis* | **rufous piculet** | - | - | - | - | - | - | - | - | - | x | - | - | x | x | x | - | - | x | x | - | - | 6 |
| 35 *Celeus brachyurus* | **rufous woodpecker** | - | - | - | - | - | - | - | - | - | - | x | - | - | - | x | - | - | - | - | - | - | 17 |
| 36 *Picus mentalis* | **checker-throated yellownape** | - | - | - | - | - | - | - | - | - | - | - | x | - | - | x | - | - | - | x | - | - | 16 |
| 37 *Picus puniceus* | **crimson-winged yellownape** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | x | - | x | - | ? | 23 |
| 38 *Picus vittatus* | **laced woodpecker** | - | - | - | - | - | - | - | - | - | - | - | - | x | - | x | - | - | x | - | - | x | 22 |
| 39 *Picus miniaceus* | **banded woodpecker** | - | - | - | - | - | - | - | - | - | - | - | - | x | ? | x | - | x | - | - | - | - | 12 |
| 40 *Dinopium javanense* | **common goldenback** | - | x | - | - | x | - | - | x | x | x | - | - | x | x | x | - | x | x | - | - | x | 36 |
| 41 *Meiglyptes tristis* | **buff-rumped woodpecker** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 7 |
| 42 *Mulleripicus pulverulentus* | **great slaty woodpecker** | - | - | - | - | - | - | - | - | - | - | x | - | - | x | x | - | - | x | x | - | - | 7 |
| 43 *Dryocopus javensis* | **white-bellied woodpecker** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | - | x | x | x | - | x | 10 |
| 44 *Hemicircus concretus* | **grey-and-buff woodpecker** | - | ? | - | - | - | - | - | - | - | - | - | - | x | x | x | x | x | x | x | - | - | 13 |
| 45 *Reinwardtipicus validus* | **orange-backed woodpecker** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | - | - | - | 9 |
| 46 *Chrysocolaptes lucidus* | **greater goldenback** | - | - | - | - | ? | - | - | - | - | - | - | - | - | - | - | - | - | - | x | - | x | 14 |
| **EURYLAIMIDAE (Broadbills)** | | | | | | | | | | | | | | | | | | | | | | | |
| 47 *Eurylaimus javanicus* | **banded broadbill** | - | x | - | x | ? | - | - | - | - | - | - | x | x | x | - | x | - | x | x | - | - | 18 |
| **PITTIDAE (Pittas)** | | | | | | | | | | | | | | | | | | | | | | | |
| 48 *Pitta guajana* | **banded pitta** | - | x | - | x | x | x | x | x | x | x | x | x | x | x | x | - | x | x | x | - | x | 21 |
| **CAMPEPHAGIDAE (Cuckoo-shrikes)** | | | | | | | | | | | | | | | | | | | | | | | |
| 49 *Tephrodornis gularis* | **large woodshrike** | - | - | - | - | - | - | - | - | - | - | x | - | - | x | x | x | x | x | x | - | ? | 15 |
| 50 *Coracina javensis* | **Malaysian cuckoo-shrike** | - | x | - | - | - | - | - | - | - | x | - | - | - | - | - | - | - | - | x | x | x | 22 |
| 51 *Coracina fimbriata* | **lesser cuckoo-shrike** | - | x | - | - | - | - | - | - | - | - | x | - | - | x | - | - | x | ? | x | - | - | 21 |
| 52 *Lalage nigra/sueurii* | **pied/white-shouldered triller** | - | - | - | - | - | - | - | - | - | - | - | - | x | x | x | - | - | - | x | x | x | 38 |
| 53 *Pericrocotus cinnamomeus* | **small minivet** | - | x | - | x | - | x | - | x | - | x | - | - | x | x | x | - | - | x | x | x | x | 36 |
| 54 *Pericrocotus flammeus* | **scarlet minivet** | - | x | - | x | x | - | - | - | - | x | x | x | x | x | x | x | x | x | x | - | x | 31 |
| 55 *Hemipus hirundinaceus* | **black-winged hemipus** | - | x | - | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | 31 |
| **PYCNONOTIDAE (Bulbuls)** | | | | | | | | | | | | | | | | | | | | | | | |
| 56 *Pycnonotus zeylanicus* | **straw-headed bulbul** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | ? | - | - | 13 |
| 57 *Pycnonotus atriceps* | **black-headed bulbul** | - | x | x | x | x | x | x | - | x | - | x | x | x | x | x | - | x | x | x | x | x | 30 |

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | M | BB | IA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 58 *Pycnonotus melanicterus* | black-crested bulbul | - | x | - | x | x | - | - | - | x | x | x | x | x | x | x | x | x | x | x | - | x | 18 |
| 59 *Pycnonotus squamatus* | scaly-breasted bulbul | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| 60 *Pycnonotus plumosus* | olive-winged bulbul | - | x | - | x | x | x | - | - | x | x | x | x | x | x | x | - | x | x | x | x | - | 20 |
| 61 *Pycnonotus simplex* | cream-vented bulbul | - | - | - | - | - | - | ? | - | - | ? | x | - | - | x | - | - | x | x | x | - | - | 20 |
| 62 *Criniger bres* | grey-cheeked bulbul | - | x | x | x | x | - | x | x | x | x | x | x | x | x | x | x | x | x | x | - | x | 29 |
| **IRENIDAE (Leafbirds)** | | | | | | | | | | | | | | | | | | | | | | | |
| 63 *Aegithinia tiphia* | common iora | - | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | 36 |
| 64 *Chloropsis sonnerati* | greater green leafbird | - | x | x | - | x | x | - | - | x | - | - | x | x | x | x | - | x | x | x | - | - | 24 |
| 65 *Chloropsis cochinchinensis* | blue-winged leafbird | - | x | - | x | - | - | - | *h* | - | x | x | x | x | x | x | x | x | x | x | - | ? | 38 |
| 66 *Irena puella* | Asian fairy bluebird | - | - | - | - | - | - | - | - | - | - | - | - | - | he | - | - | x | x | x | - | - | 13 |
| **TURDIDAE (Thrushes and chats)** | | | | | | | | | | | | | | | | | | | | | | | |
| 67 *Copsychus malabaricus* | white-rumped shama | - | x | - | - | - | - | x | x | x | - | - | - | - | x | - | - | - | x | x | - | - | 17 |
| 68 *Enicurus velatus* | lesser forktail | - | - | - | - | - | - | - | - | - | - | - | - | - | x | - | - | - | - | - | - | - | 8 |
| 69 *Enicurus leschenaulti* | white-crowned forktail | - | - | - | - | - | - | - | - | - | x | x | x | - | - | - | - | x | x | x | - | x | 12 |
| 70 *Myophonus caeruleus* | blue whistling-thrush | - | - | - | - | - | - | - | *h* | - | - | - | - | - | x | - | x | - | - | x | - | - | 8 |
| 71 *Zoothera citrina* | orange-headed thrush | - | - | - | x | - | - | x | x | - | - | - | - | - | - | - | - | - | x | x | - | ? | 40 |
| **TIMALIIDAE (Babblers)** | | | | | | | | | | | | | | | | | | | | | | | |
| 72 *Pellorneum capistratum* | black-capped babbler | - | x | - | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | - | - | 24 |
| 73 *Trichastoma pyrrogenys* | Temminck's babbler | - | ? | - | - | - | - | - | x | - | x | x | - | x | x | - | x | x | x | x | - | - | 7 |
| 74 *Trichastoma sepiarium* | Horsfield's babbler | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | 28 |
| 75 *Malacopteron cinereum* | scaly-crowned babbler | - | - | - | - | - | - | - | - | x | x | x | x | x | x | x | x | x | x | x | - | - | 4 |
| 76 *Napothera macrodactyla* | large wren-babbler | - | ? | - | x | - | - | - | - | - | - | x | - | - | x | - | x | x | x | x | - | - | 10 |
| 77 *Stachyris grammiceps* | white-breasted babbler | - | - | - | x | - | - | - | - | - | - | - | - | - | x | - | x | x | x | - | - | - | 13 |
| 78 *Stachyris melanothorax* | crescent-chested babbler | - | x | - | x | - | x | - | *h* | - | - | - | x | x | x | - | x | - | - | x | x | x | 19 |
| 79 *Macronous flavicollis* | grey-cheeked tit-babbler | - | x | - | x | - | - | x | - | x | x | x | - | - | x | x | x | x | x | x | - | - | 17 |
| 80 *Macronous gularis* | striped tit-babbler | - | x | - | x | x | - | - | - | x | x | x | x | x | x | - | - | - | x | x | - | - | ? |
| **SYLVIIDAE (Old World warblers)** | | | | | | | | | | | | | | | | | | | | | | | |
| 81 *Orthotomus sepium* | olive-back tailorbird | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | 40 |
| 82 *Abroscopus superciliaris* | yellow-bellied warbler | - | - | - | - | - | - | - | - | - | - | - | - | - | x | x | x | - | - | x | - | ? | 7 |
| **MUSCICAPIDAE (Flycatchers)** | | | | | | | | | | | | | | | | | | | | | | | |
| 83 *Rhinomyias olivacea* | fulvous-chested rhinomyias | - | - | - | - | - | - | - | - | - | - | - | - | x | x | - | - | - | x | ? | - | x | 4 |
| 84 *Cyornis unicolor* | pale blue flycatcher | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | x | - | - | - | - | 4 |
| 85 *Cyornis banyumas* | hill blue flycatcher | - | x | x | x | x | - | - | x | x | x | - | x | - | x | - | x | x | x | x | x | - | 27 |
| **ACANTHIZIDAE (Thornbills)** | | | | | | | | | | | | | | | | | | | | | | | |
| 86 *Gerygone sulphurea* | flyeater | - | x | - | x | - | - | x | - | - | - | x | - | - | x | - | - | - | x | - | x | x | 2 |
| **MONARCHIDAE (Monarchs)** | | | | | | | | | | | | | | | | | | | | | | | |
| 87 *Philentoma velatum* | maroon-breasted philentoma | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | s | - | - | 9 |
| 88 *Hypothymis azurea* | black-naped monarch | - | - | - | x | x | - | - | - | x | x | x | x | x | x | x | x | x | x | s | ? | x | 24 |
| 89 *Terpsiphone paradisi* | Asian paradise-flycatcher | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | x | - | ? | 4 |
| 90 *Rhipidura euryura* | white-bellied fantail | - | - | - | - | - | - | - | - | - | - | - | x | - | - | - | x | x | - | - | - | - | 11 |

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | M | BB | IA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PACHYCEPHALIDAE (Whistlers)** | | | | | | | | | | | | | | | | | | | | | | | |
| 91 *Pachycephala grisola* | **mangrove whistler** | - | x | - | - | x | - | - | - | - | - | - | - | x | x | - | - | - | x | x | - | x | 23 |
| **SITTIDAE (Nuthatches)** | | | | | | | | | | | | | | | | | | | | | | | |
| 92 *Sitta frontalis* | **velvet-fronted nuthatch** | - | - | - | x | x | - | - | x | - | x | x | - | x | x | x | x | - | x | x | - | - | 29 |
| **DICAEIDAE (Flowerpeckers)** | | | | | | | | | | | | | | | | | | | | | - | - | |
| 93 *Prionochilus percussus* | **crimson-breasted flowerpecker** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | x | - | - | - | 11 |
| 94 *Dicaeum agile* | **thick-billed flowerpecker** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | t | - | x | 3 |
| 95 *Dicaeum chrysorrheum* | **yellow-vented flowerpecker** | - | - | - | - | - | - | - | - | - | - | - | - | x | w | - | - | - | - | s | - | x | 9 |
| 96 *Dicaeum trigonostigma* | **orange-bellied flowerpecker** | - | x | - | x | x | x | x | - | x | x | x | x | x | x | x | x | x | x | x | - | ? | 20 |
| 97 *Dicaeum concolor* | **plain flowerpecker** | - | x | - | x | x | x | - | x | x | x | - | - | x | x | x | - | - | x | ad | - | - | 13 |
| **NECTARINIIDAE (Sunbirds)** | | | | | | | | | | | | | | | | | | | | | | | |
| 98 *Anthreptes singalensis* | **ruby-cheeked sunbird** | - | x | - | x | x | x | - | *h* | - | x | x | x | x | x | x | x | x | x | x | - | - | 18 |
| 99 *Nectarinia sperata* | **purple-throated sunbird** | - | - | - | - | x | - | - | - | c | x | x | - | - | x | - | - | - | x | - | - | - | ? |
| 100 *Nectarinia calcostetha* | **copper-throated sunbird** | - | - | - | - | x | - | - | - | c | - | x | - | - | - | - | - | - | - | ad | - | - | 9 |
| 101 *Aethopyga siparaja* | **crimson sunbird** | - | - | - | - | - | - | - | *h* | - | - | - | - | x | x | - | - | - | x | ? | - | - | 11 |
| 102 *Aethopyga mystacalis* | **violet-tailed (or Javan) sunbird** | - | x | - | x | x | - | x | *h* | x | x | x | - | x | x | x | x | x | x | x | - | - | 23 |
| 103 *Arachnothera longirostra* | **little spiderhunter** | x | x | x | x | x | x | x | x | - | x | x | - | x | x | x | x | x | x | x | - | x | 20 |
| 104 *Arachnothera robusta* | **long-billed spiderhunter** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | - | - | 10 |
| 105 *Arachnothera affinis* | **grey-breasted spiderhunter** | - | - | - | x | - | x | - | - | - | - | x | x | x | x | x | x | x | - | x | - | ? | 26 |
| **ZOSTEROPIDAE (White-eyes)** | | | | | | | | | | | | | | | | | | | | | | | |
| 106 *Zosterops palpebrosus* | **Oriental white-eye** | x | - | x | x | x | x | - | x | - | - | - | - | m | | x | x | - | - | - | - | ? | 36 |
| **ESTRILDIDAE (Estrildine finches)** | | | | | | | | | | | | | | | | | | | | | | | |
| 107 *Erythrura prasina* | **pin-tailed parrot-finch** | - | - | - | - | - | - | - | *h* | - | x | - | - | - | - | - | - | - | x | x | - | - | 13 |
| **STURNIDAE (Starlings)** | | | | | | | | | | | | | | | | | | | | | | | |
| 108 *Aplonis panayensis* | **Asian glossy starling** | - | - | - | - | - | - | - | x | - | - | - | - | x | - | x | x | x | x | x | - | ? | ? |
| 109 *Leucopsar rothschildi* | **Bali starling** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | x | |
| 110 *Gracula religiosa* | **hill myna** | - | - | - | - | - | - | - | *h* | - | - | x | - | - | - | x | - | - | x | x | - | x | 14 |
| **ORIOLIDAE (Orioles)** | | | | | | | | | | | | | | | | | | | | | | | |
| 111 *Oriolus xanthonotus* | **dark-throated oriole** | - | - | - | - | - | - | - | - | - | - | - | x | - | x | - | - | x | - | x | - | - | 14 |
| 112 *Oriolus chinensis* | **black-naped oriole** | - | x | x | x | x | - | - | x | - | - | - | - | x | x | - | - | - | x | x | x | x | 49 |
| **DICRURIDAE (Drongos)** | | | | | | | | | | | | | | | | | | | | | | | |
| 113 *Dicrurus leucophaeus* | **ashy drongo** | - | x | x | x | x | x | - | x | x | x | x | x | x | x | - | x | - | - | - | - | x | 28 |
| 114 *Dicrurus paradiseus* | **greater raquet-tailed drongo** | - | x | - | x | x | x | - | - | - | x | x | x | x | x | x | x | x | x | x | - | x | 25 |
| **CORVIDAE (Crows)** | | | | | | | | | | | | | | | | | | | | | | | |
| 115 *Crypsirina temia* | **racquet-tailed treepie** | - | x | - | - | x | - | - | - | - | - | - | - | x | x | x | - | - | x | x | ? | x | 17 |
| 116 *Platylophus galericulatus* | **crested jay** | - | - | - | - | - | - | - | - | - | d | x | x | - | x | - | x | x | x | x | - | - | 5 |
| 117 *Corvus enca* | **slender-billed crow** | - | x | - | - | x | - | - | x | x | - | x | x | x | - | - | x | x | x | x | - | x | 18 |