Leucopsar rothschildi

Population Viability Assessment

BALI STARLING

Leucopsar rothschildi

VIABILITY ANALYSIS

AND

SPECIES SURVIVAL PLAN

WORKSHOP REPORT

Prepared by U. S. Seal and Workshop Participants

(Based on a viability analysis and species survival plan
workshop held 22-24 March, 1990 in
Bogor, Indonesia)

Collaborating Organizations

FOREST PROTECTION & NATURE PROTECTION (PHPA)

INTERNATIONAL COUNCIL FOR BIRD PRESERVATION (ICBP)

AMERICAN ASSOCIATION OF ZOOLOGICAL PARKS & AQUARIUMS (AAZPA)

JERSEY WILDLIFE PRESERVATION TRUST (JWPT)

CAPTIVE BREEDING SPECIALIST GROUP (CBSG/SSC/IUCN)
SPECIES SURVIVAL COMMISSION IUCN

A contribution of the IUCN/SSC Captive Breeding Specialist Group in collaboration with The Indonesian Forest Protection & Nature Protection (PHPA), The International Council For Bird Preservation (ICBP), The American Association of Zoological Parks & Aquariums (AAZPA), and The Jersey Wildlife Preservation Trust (JWPT).

Photo Credit: Bali Starling (Leucopsar rothschildi) provided by Phillip Coffey, Jersey Wildlife Preservation Trust.

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King Khalid Wildlife Research Center
Lee Richardson Zoo
Natal Parks Board
Oglebay's Good Children's Zoo
Speedwell Bird Sanctuary

3 March 1995

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THE DIRECTOR GENERAL

FOREST PROTECTION AND NATURE CONSERVATION

Opening speech by the Director General at the occasion of the Workshop on the Population Viability Assessment and Conservation Plan of the Bali Mynah.

March 22, 1990

Distinguished Guests, Ladies and Gentlemen,

It is a great pleasure to welcome all on this occasion to discuss the Population Viability of and the Conservation Plan for the Bali Starling.

As I am sure you are all aware, these past few years have seen a tremendous increase in the attention the world is paying to forests, wildlife and other natural resources of the tropics, and to the nations who are fortunate enough to be responsible for their wise use, conservation and sustainable development.

I want you to know that Indonesia is very conscious of its obligation to balance use and conservation for the benefit of its own people and the benefit of the world community of nations in which we belong.

As a part of the obligation the Government of Indonesia is committed to improving its legal and institutional capability to establish and maintain a representative and meaningful system of conservation areas. Such a system will provide protection, not only to individual species of flora and fauna but to whole habitats and ecosystems and their general diversity, while at the same time providing opportunities for scientific research, recreation and education of our own citizens and visitors from other nations. We are also committed to developing effective means of protecting and conserving wildlife outside the reserves and parks, increasing our ability to control illegal trade in flora and fauna, and strengthening zoos and arboretums for the education and enjoyment of those who cannot easily visit the protected areas in person.

The protection of individual species is of course an important element in the spectrum of conservation requirements of the nation, and here we come to the particular interest of this Workshop on the Population Viability of the Conservation Plan for the Bali Starling.

I think that we are all aware that the ideal way to provide long term protection for this species would be to protect large areas of its natural habitat. I am sure you know that this is a difficult undertaking which will require not only good will and cooperation among all of us - public and private sectors - but also quite a lot of money. It is very expensive to establish effective systems of guarding and monitoring the birds in the wild, and there will have to be investment of capital funds to set up the educational and tourism infrastructure which will make the wild Bali Starling better appreciated by and more easily accessible to our citizens and visitors from overseas. PHPA is already actively managing the National Park where this species occurs and we are constantly looking for ways to improve our skills as well as to better utilize offers of assistance from international sources. But our resources are limited and for that reason I take this opportunity to show your generosity in providing donations to this task.

Among the options available to Indonesia to protect this Starling is a captive propagation program in cooperation with domestic and foreign zoos, particularly in the difficult task of getting the founder stock to successfully propagate the species in captivity. Here once more PHPA has taken the initiative to start an international cooperation with the International Council for Bird Preservation (ICBP), the American Association of Zoological Parks and Aquariums (AAZPA), and the Jersey Wildlife Preservation Trust (JWPT). In 1987 a Memorandum of Understanding was signed between the four parties to start the Bali Starling Project in Indonesia.

The Surabaya Zoo was chosen as the location of the Bali Starling Captive Propagation Center and on 16 November 1987, 40 birds arrived from the United States of America and the United Kingdom of England for use as founder stock. Since then, three captive bred Bali Starlings were reintroduced in the Bali Barat National Park, although unfortunately all have died in the attempt to restock the last and only wild population. Another 13 young birds are now waiting to be released into the wild, this time however with more precaution.

No more than 30 Bali Starlings survive in such a small population may cause some unforeseen genetic problems. Conservation is very much a form of crisis intervention and more often than not decisions must be taken on the basis of scant information and study before conditions deteriorate even further. We hope that this Workshop will provide the material for a sound foundation to management decisions here in Indonesia.

Yet all the efforts put in propagating and reintroducing the species will be ineffective if we have not yet eliminated the problems in the wild, such as poaching and habitat destruction. Therefore, the cooperation between the Bali Starling Project an the management of Bali Barat National Park should be strengthened soonest.

Our concerted effort to protect and preserve the Bali Starling in Indonesia also can be a welcome advertisement of the generosity and spirit of conservation which I believe is a part of our national character, as well as a demonstration of the seriousness with which both government and private sector view our responsibility to the world community and to future generations of our own children.

I wish the Workshop every success in its difficult but admirable task, and thank you all for coming here today as a demonstration of your commitment to our common goal of protecting the Bali Starling.

BALI STARLING

Leucopsar rothschildi

VIABILITY ANALYSIS

AND

SPECIES SURVIVAL PLAN

PROBLEM STATEMENT AND AGENDA

Captive Breeding Specialist Group

Species Survival Commission
IUCN -- The World Conservation Union
U. S. Seal, CBSG Chairman

BALI MYNAH

Leucopsar rothschildi

VIABILITY ASSESSMENT AND CONSERVATION PLAN WORKSHOP

February 15, 1990

Problem:

The Bali mynah or starling (Leucopsar rothschildi) is endangered and numbers about 20-35 birds in the only wild population in Bali Barat National Park. Continuing decline of the population with losses of birds to collectors in addition to natural causes, the primary restriction of the population to a single reserve, and chance environmental events put the population at critical risk of demographic extinction. The small population will rapidly lose genetic variation even if sustained at current levels. These conditions favor early extinction in the wild from random environmental events, continued loss of genetic diversity, and eventual loss of habitat for the species. The species meets all of the criteria to be designated 'Critically Endangered' (new category proposed for use by SSC/IUCN).

Goals:

(1) Prepare a Population Viability Assessment for the Bali Mynah.

(2) Formulate a quantitative strategy with risk assessments to prevent extinction.

(3) Prepare a Conservation Plan including schedules, priorities, and cost estimates with the objective of preventing extinction in the wild and developing viable, self-sustaining wild populations of the Bali mynah.

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Objectives:

(1) Determine numbers of Bali mynahs and subpopulations required for various probabilities of survival and preservation of genetic diversity for specified periods of time (i.e. 25, 50, 100, 200 years).

(2) Consider how possible interventions in the wild population and its habitat might increase the population's rate of growth and decrease its loss of genetic diversity.

(3) Project the potential expansion or decline of Bali mynah wild population numbers under various management regimes.

(4) Outline metapopulation structure needed to establish viable population. Include new wild populations and captive populations in the structure and indicate management structure consequences of this approach.

(5) Formulate and evaluate role of captive propagation in Indonesia and elsewhere as a component of the strategy. In particular, consider how captive propagation could (a) accelerate expansion of population, (b) enhance preservation of genetic diversity, (c) protect population gene pool against fluctuations due to environmental vicissitudes in wild, and (d) provide animals for reinforcement of wild populations or establishment of new populations.

(6) Evaluate role of private aviculturists in Indonesia and abroad as a source of new genetic material, as participants in the metapopulation, and as supporters for the restoration of the species in wild habitat.

(7) Evaluate scenarios for managing birds in captivity (including size, location, and staffing of aviaries in Indonesia), protecting birds in the wild, and reintroducing birds to the wild and evaluate their effects on the viability of the wild population and the viability of the Bali mynah gene pool.

(8) Evaluate scenarios utilizing a release program as a tool to restore the wild population and to establish additional populations.

(9) Identify problems and issues that need continuing analysis and research.

(10) Recommend a course of action.

(11) Produce a document presenting the results of the workshop.

BALI MYNAH

Leucopsar rothschildi

Population Viability Assessment Workshop

(22-24 March 1990)

Bogor , Indonesia

AGENDA

15 February 1990

THURSDAY - 22 MARCH 1990

9:00-10:00 Introductions and arrangements.

PHPA (Sutisna, Effendy)

ICBP (Grimmett)

AAZPA (Seibels)

10:00-10:30 Goals, Workplan, and Assignments for Workshop. (Seal).

10:30-10:45 Break

10:45-12:45 Overview of PVA (Sutisna, Chair):

1. Demographic, environmental, and catastrophic effects on persistence of small populations. (CBSG)

2. Genetics and persistence of small populations. (CBSG)

3. Species survival planning and collaborative management approaches for small populations. (CBSG)

4. Life history characteristics of wild and captive Bali mynah (and other similar mynahs) useful for viability assessment and population models. Clutch size, fertility rates, hatching rates, fledging rates, age of first reproduction, sex and age specific mortality and fertility, seasonality,

generation time, social structure, and dispersal (sex and age effects) distance estimates. (ALL)

12:45-14:00 Lunch

14:00-18:00 Bali Mynah Biology (Effendy, Chair):

1. Life history characteristics of wild Bali mynahs. Reproduction, demography of mortality, food and habitat requirements, social structure, dispersers and dispersal distances. (van Balen)

2. History of Bali mynah populations - numbers and distribution. Taxonomy, genetic analyses, heterozygosity, population substructure. (van Helvoort, van Balen)

3. Current status of Bali mynahs in wild. Sex and age structure, distribution, reproduction, habitat availability. Demography of mortality during past 10 years. Review of recovery and research plans that has guided work of past 5 years and their results. (van Balen)

4. Bali Mynah in Captivity.

   Studbooks. (Seibels, van Helvoort)

   SSP masterplan. (Seibels)

   UK, EEP. (Seibels)

   Indonesia. (Harwono)

   Role and contribution of aviculturists. (Bruning)

   Recruitment of additional founder stock from private holders, i.e. the white-wash program. (Effendy, Grimmett)

   Number, distribution, and sizes of facilities needed to provide stock for release vs security of species gene pool. Support and expertise needed. (Seal, Bruning)

5. Reproductive biology of the Bali mynah and need for enhancement through habitat management and manipulation of captive management. Potential need for enhancement through reproductive technology. Capabilities. (Bell)

6. Husbandry. (Seibels, Harwono, Bruning, Bell)

7. Reintroduction and release program.
Details of current plans and results of studies to date. Sources and numbers of birds needed. Goals. Research needed. (van Balen, Grimmett)

8. Interactions of people with wild population and impact on habitat, carrying capacity, genetics and demography. Current and planned land use patterns and impact on subpopulation structure, population sizes, and mortality. (Bali Barat National Park representatives)

9. Educational Programs. (Effendy)
Public education concerning Bali mynah conservation. Technical training of Indonesian curatorial, keeper, and field biologists.

FRIDAY - 23 MARCH 1990

9:00-12:00 Models and Strategies for the Bali Mynah (Bruning, Chair):

1. Models of persistence times for the current wild population. (CBSG)

2. Genetic and population goals to establish and maintain a viable population. Numbers of founders, effective population sizes, and rates of loss of diversity. Numbers and distribution of populations. Metapopulation approach to a viable population. Time span? (CBSG)

3. Alternative strategies to achieve a viable population. Role of captive populations. Rapid expansion of founder populations. Individual locale recommendations for suggested strategies. (CBSG)

12:00-14:00 Lunch

14:00-17:00 Working sessions to draft report of results and masterplan for further development of program. (Grimmett, Chair)

SATURDAY - 24 MARCH 1990

9:00-13:00 Iterative review and revision of draft meeting report and species masterplan to arrive at consensus agreement of workshop participants; Specifically, review of preferred scenarios. (Seal, Chair)

13:00-14:30 Lunch

14:30-16:00 Conclusion and Closure of Workshop

BALI STARLING

Leucopsar rothschildi

VIABILITY ANALYSIS

AND

SPECIES SURVIVAL PLAN

AGREEMENTS AND RECOMMENDATIONS

PELESTARIAN <u>LEUCOPSAR ROTHSCHILDI</u>

(CURIK BALI) DI INDONESIA

PHPA/ICBP/AAZPA/JWPT/CBSG

24 Maret 1990

POKOK-POKOK PERSETUJUAN SERTA USULAN

MASALAH

Curik Bali (Jalak Bali, Bali Mynah atau Bali Starling) (**<u>Leucopsar rothschildi</u>**) telah terancam punah dan sekarang ini tinggal 24-31 ekor pada sensus terakhir dari populasi liar yang satu-satunya di Taman Nasional Bali Barat. Penurunan terusmenerus populasi akibat penangkapan liar di samping penyebab-penyebab alami, keterbatasan populasi pada satu agar alam, serta kejadian lingkungan yang acak semua mengancam populasi dan burung tersebut segera akan punah secara demografis. Populasi kecil itu akan cepat kehilangan sekalipun bilamana ditahan pada jumlah sekarang. Keadaan itu menguntungkan kepunahan dini di alam bebas. Jenis itu memenuhi semua ketentuan untuk dinyatakan "***Critically Endangered***" ("Nyaris Punah", kategori baru yang diusulkan kepada SSC/IUCN).

POKOK-POKOK PERSETUJUAN

1. Usaha menyelamatkan Curik Bali (Bali Starling) sampai tingkat yang menjamin kelanjutan keberadaannya sebagai jenis liar untuk jangka panjang adalah prioritas pelestarian yang tinggi di Indonesia dan prioritas paling tinggi bagi Propinsi Bali.

2. Pertanggunganjawab untuk menyelamatkan jenis ini dan habitat alaminya berada pada otoritas dan rakyat Indonesia. Tetapi, kelangsungan Curik Bali juga penting dan berguna untuk seluruh dunia, maka masyarakat antarbangsa seharusnya menyumbang kepada usaha melestarikan Curik Bali dan habitat alaminya termasuk Taman Nasional Bali Barat.[PB]

3. Tujuannya adalah untuk segera :

    a. Mencegah penurunan dan kepunahan dari populasi alami Curik Bali yang terakhir di Taman Nasional Bali Barat dan mendukung perkembangannya sampai paling sedikit 200 ekor di Taman Nasional secepat mungkin.

    b. Meningkatkan sistem keamanan dan patroli, sebagai tindakan segera dan jangkau pendek, untuk memberi sumbangan paling besar kepada pencegahan terjadinya kepunahan populasi alami.

c. Mendapat kembali sebanyak mungkin burung terkurung yang masih berasal dari alam asli guna langsung dilepaskan ke alam bebas sebagai prioritas atau untuk penangkaran. Burung-burung itu dibutuhkan untuk menyediakan variasi genetis bagi populasi alami untuk mendukung kelangsungan keberadaan pada jangka panjang.

d. Pelepasan kembali ke dalam populasi alami dari burung yang masih berasal dari alam asli adalah prioritas tertinggi. Burung-burung bersangkutan bukan yang dibesarkan dengan bantuan manusia dan berada dalam tangkapan sebagai burung dewasa selama kurang dari 12 bulan.

e. Memperluas dan membina program penangkaran guna menyediakan burung-burung bagi program pelepasan untuk melestarikan Curik Bali di alam bebas.

4. Tujuan jangka panjang adalah mengembangkan populasi-populasi alami Curik Bali dalam jumlah burung yang cukup untuk menjamin kelangsungan kehidupannya sebagai suatu jenis yang dapat hidup biologis di daerah penyebaran aslinya, yaitu Pulau Bali saja sejauh diketahui sekarang ini. Hal ini menyangkut mendirikan suata populasi dengan jumlah setidaknya 1000 ekor yang tersebar pada sub-populasi sub-populasi alami di daerah yang aman, serta 1000 ekor lagi dalam populasi-populasi terkurung yang dikelola. Semua populasi ini hendaknya dikelola sebagai satu metapopulasi.

5. Seyogyanya dilakukan usaha untuk menyelamatkan sebanyak mungkin burung dari kalangan pribadi di Indonesia yaitu burung-burung yang masih berasal dari alam asli, melalui suatu Kampanye Pemutihan. Persediaan genetis itu adalah penting untuk menyediakan variasi genetis tambahan guna menyelamatkan jenis itu di alam asli.

6. Perlu didirikan pusat-pusat penangkaran tambahan di Indonesia untuk memperbaiki keamanan populasi terkurung di Indonesia, serta untuk berfungsi sebagai sumber burung untuk dilepaskan di alam asli. Burung-burung untuk keperluan itu akan disediakan dari populasi-populasi terkurung di negeri-negeri lain dan dari Kampanye Pemutihan di Indonesia.

7. Semua usaha pelestarian Curik Bali seharusnya diserta dengan pemantauan dan penelitian, termasuk pemantauan populasi alami dan burung yang telah dilepaskan. Pedomannya diberikan di bawah ini.

8. Seluruh proyek pelestarian Curik Bali seharusnya meliputi unsur latihan, terutama latihan petugas keamanan dan petugas penangkaran.

9. Semua proyek pelestarian Curik Bali seharusnya meliputi unsur yang kuat dan tetap melaksanakan penyuluhan dan penerangan umum baik di Bali maupun di seluruh Indonesia. Termasuk proyek-proyek yang dibuat untuk menigkat partisipasi masyarakat di sekitar Taman Nasional.

10. Penduduk yang menetap di enklave di dalam Taman Nasional seharusnya ditransmigrasikan secepat mungkin ke luar enklave. Perkebunan seharusnya dihutankan kembali sesudah penghuni ditransmigrasikan di saat Hak Guna Usaha habis temponya.

11. Bagi pengunjung yang tidak sempat mengamati Curik Bali di alam asli seharusnya dibangunkan fasilitas untuk dapat melihat Curik Bali di suatu tempat yang tepat di Taman Nasional Bali Barat; fasilitas ini dikhususkan untuk parawisatawan masal dan akan berfungsi sebagai usaha penerangan dan pendidikan.

12. Burung-burung di populasi alami seharusnya jangan ditangkap, ditangani atau diganggu guna tujuan apapun.

13. Semua Curik Bali di Indonesia secara hukum adalah milik Pemerintah Indonesia dan harus ada ijin untuk menangkap, memindahkan, menangkarkan atau memeliharanya.

14. Per didirikan suatu dewan penasehat pengelolaan dan penangkaran untuk memberi nasehat kepada Pemerintah Indonesia mengenai standar keperluan, pola dan pendirian pusat-pusat penangkaran, pendirian sangkar tontonan, pemilihan burung bagi program pelepasan dan mengenai pemindahan burung.

ANJURAN

I. <u>Anjuran bagi Pengelolaan Taman Nasional Bali Barat</u>

1. Mempertahankan dan, bilamana perlu, menambah sistem patroli di Semenanjung Prapat Agung melalui latihan staf, motivasi dan kepepimpinan.

2. Meningkatkan pos jaga dan kesejahteraan para petugas lapangan.

a. Penyediaan perabotan rumah tangga dasar

1) Penampungan air minum yang lebih besar

2) Alat-alat dapur dan masak

3) Tempat tidur dan lain-lain

b. Menyediakan alat-alat lapangan, termasuk alat-alat komunikasi, sepeda motor, teropong, dan kompas.

c. Perbaikan pelayanan perahu.

3. Meningkatkan kemampuan dan motivasi para petugas lapangan.

a. Miningkatkan disiplin dan pembelaan diri melalui koordinasi dengan Polisi setempat.

b. Pertanggunganjawab tugas, kesadaran dan metoda.

c. Mengangkat para petugas lapangan sebagai Pegawai Negeri. (Tiada konsensus pada masalah ini, oleh sebab kekhawatiran bahwa status Pegawai Negeri mempunyai pengaruh buruk terhadap motivasi dan bahwa imbalan jasa barangkali lebih effektif sebagai motivasi).

d. Seharusnya diadakan kursus ketrampilan bagi para petugas lapangan. Kursus ini hendaknya termasuk pemakaian kompas, cara patroli, determinasi binatang dan tumbuhan dan konsep dasar pelestarian alam.

4. Administrasi dan koordinasi.

a. Penyediaan perhubungan radio dengan para petugas di lapangan.

b. Penyediaan anggaran ulangan khusus berupa tunjangan logistik dan bagi para petugas lapangan yang pertanggunganjawaban atas patroli lapangan telah ditingkatkan.[PB]

c. Mendorong kerjasamaan erat antara staf Taman Nasional dan staf proyek penelitian.

5. Penghapusan enklave.

a. Mentransmigrasi semua penghuni.

b. Mencabut secepat mungkin (atau tidak memperbarui) Hak Guna Usaha PT Margaran (yang akan habis waktunya tahun 1993) dan PT Dharma Jati Utama (2004).

6. Menyelesaikan masalah status Taman Nasional guna memungkinkan menyatukan kembali habitat asli dari Curik Bali termasuk kawasan yang sekarang berupa hutan tanaman.

7. Dianjurkan menyediakan senjata api pada petugas lapangan[1].

II. **Program Lapangan**

Ada dua tingkat : pemantauan dasar dan penelitian ekologi yang mendetil.

1. Pemantauan dasar dari populasi alami untuk memastikan yang berikut dibawah ini :

a. Populasi total saat sebelum musim kawin mulai (achir musim kemarau). Adakan sensus-sensus lengkap memakai metoda Proyek Jalak Bali.

b. Populasi total sesudah musim kawin (achir musim hujan). Lihat (a).

c. Gerakan Curik Bali dan pengunaan habitat. Pengamatan teratur dari rombongan pemakan dibutuhkan. Peta habitat/vegetasi dianjurkan diteliti ulang.

d. Jumlah pasangan yang bersarang melalui mencari lobang sarang.

e. Penambahan burung muda dari populasi alami melalui pengamatan seksama guna menetukan jumlah burung muda kelahiran tahun ini.

2. Pemantauan dasar dari populasi yang telah dilepaskan untuk memastikan yang berikut dibawah ini :

a. Penyebaran dan gerakan saat sesudah pelepasan.

b. Penyesuaian terhadap keadaan di alam bebas (kemampuan mencari makan dan minum) sesudah pelepasan.

c. Pemantauan jangka panjang seperti dibawah A1a sampai/dengan A1e.

d. Interaksi dengan populasi alami.

3. Populasi lepasan seharusnya dipantau dengan cincin warna dan pemberian tanda serta pemantauan erat di lapangan; bilamana cara-cara itu tidak menghasilkan data yang dibutuhkan, telemetri-radio seharusnya dipakai.

4. Penelitian mendetil dari populasi alami dan populasi yang telah dilepaskan bilamana program telah berhasil.

a. Kebutuhan makanan dan habitat, misalnya pemakaian hutan produksi.

b. Biologi perkembangbiakan dan hasilnya (luas teritori, kapan dan berapa lama musim kawin, jumlah telur per sarang, masa pengeraman, penetasan, jumlah anak yang sampai keluar dari sarang, satu/dua sarang per tahun?).

c. Dampak terhadap populasi alami dari pengunjung Taman Nasional, penelitian lapangan, patroli dan perkembangan fasilitas Taman Nasional (pos jaga, dll.).

III. <u>Kampanye Pemutihan</u>

Karena pentingnya memperoleh sebanyak mungkin burung tangkapan alam yang masa kini dipelihara di sangkar pribadi/swasta, untuk dimasukkan ke dalam rangka penangkaran dan pelepasan, sebagai sumber genetis tambahan, kami mendesak supaya langkah-langkah sebagai berikut dikampanyekan dan akan dimulai sesegera mungkin:

1. Kampanye penyuluhan kepada masyarakat akan dimulai supaya menjamin bahwa partisipasi di dalam upaya ini akan dianggap serta diakui sebagai hormat dan privilese, sekaligus sumbangan penting kepada pelestarian dari burung Indonesia yang unik ini. Sepucuk surat khusus yang menyatakan penhargaan perlu dikirim kepada semua orang yang menyokong kampanye ini.

2. Burung Curik Bali tangkapan alam yang diserahkan kepada PHPA perlu diterima dengan baik serta dilepas dengan segera ke alam atau diikutsertakan ke dalam program penangkaran sejauh ada sangkar penangkaran yang memadai. Lagipula PHPA perlu berusaha mendapatkan semua burung tangkapan alam segera sesudah ada ruangan sangkar yang memadai dan sesudah tersedia burung hasil penangkaran sebagai pertukaran.

3. Pertukaran burung hasil penangkaran dengan burung tangkapan alam seharusnya dimulai segera sesudah tersedia burung hasil penangkaran dan ruangan penangkaran yang memadai. Pada permulaan, Burung hasil penangkaran untuk pertukaran ini akan berasal dari [Kebun Binatang] Surabaya atau dari luar negeri. Burung Surabaya yang tidak produktif atau kelebihan dapat digunakan untuk tujuan ini hingga saatnya tersedia burung lain yang datang dari luar negeri.

4. Semua burung pertukaran seharusnya perlu diberi tanda pengenal secara permanen dengan gelang kaki dan transponder di dalam tubuh.

5. Semua burung tangkapan alam seharusnya diidentifikasi secara permanen dan dimasukkan kedalam buku silsilah [Indonesia].

6. Penempatan burung tangkapan alam ke dalam sarana penangkaran hanya dilakukan kalau tidak ada bukti bahwa burung bersangkutan itu belum lama ditangkap dari alam. Bilamana burung itu dipelihara sebagai burung dewasa selama jangka waktu yang pendek sekali (kurang dari 12 bulan), perlu dipertimbangkan pelepasan ke alam sesegera mungkin melalui Pusat Perlatihan Prapelepasan jika mungkin dan bilamana burung ini mempunyai stamina yang baik serta kemungkinan besar akan berhasil.

7. Mengadakan proses latihan bagi dokter hewan Indonesia agar mereka bisa menentukan jenis kelamin curik lewat laproskopi. Hal ini bisa dikoordinasikan oleh Perhimpunan Kebun Binatang Se-Indonesia serta para dokter hewannya bekerjasama dengan badan-badan Pemerintah yang bersangkutan. Ini barangkali memerlukan kursus latihan yang dibimbing oleh dokter hewan kompeten dari AS atau Inggris melalui kerjasamaan dengan AAZPA atau CBSG.

8. Bilamana ada pemelihara burung tangkapan alam yang mempunyai beberapa ekor curik dan menginginkan kesempatan untuk mengembangbiakkan burung itu sebagai salah satu bagian dari upaya penangkaran, kami mendesak supaya burung tangkapan alam ini bagaimanapun diserahkan kepada PHPA dan diganti dengan burung hasil penangkaran yang mampu berkembangbiak. Kalau seseorang berhasil mengembangbiakkan burung hasil penangkaran di dalam sarana penangkaran yang memadai serta memenuhi syarat-syrat pemeliharaan dan

pendaftaran di dalam buku silsilah [Indonesia], maka orang itu dapat didorong untuk berfungsi sebagai pusat penangkaran Curik Balitambahan.

9. Semua burung tangkapan alam yang telah diperoleh PHPA seharusnya ditempatkan di sarana dimana mereka bisa dipelihara dan dikembangbiakkan sesuai dengan patokan-patokan pemeliharaan dan pendaftaran buku silsilah yang telah ditetapkan sebagai diuraikan dalam laporan ini.

10. Mendesak supaya memperoleh keterangan tentang umur, asal dan jangka waktu pemeliharaan dari setiap orang yang menawarkan burung tangkapan alam kepada PHPA.

11. Mendesak supaya penjagaan, pemantauan dan penerapan hukum ditingkatkan selama Kampanye Pemutihan berlaangsung, supaya dalam kurung waktu ini tidak akan disalahgunakan sebagai dorongan untuk mengambil burung dari alam asli. Pengampunan seharusnya tidak diberikan jikalau ternyata bahwa burung bersangkutan diperoleh dari alam sesudah Kampanye Pemutihan diumumkan.

12. Mendesak agar, dengan penegakan hukum yang ada atau melalui penetapan undang-undang atau peraturan-peraturan baru, maka memperoleh, mengangkut serta menawarkan Curik Bali untuk dijual adalah tindakan pelanggaran hukum yang sanksinya adalah denda yang berarti atau hukuman kurungan.

IV. <u>**Sarana baru bagi Pusat Penagkarang**</u>

1. Rapat ini menganjurkan agar fasilitas baru di Indonesia akan ditunjuk sebagai pusat-pusat penangkaran Curik Bali. Taman Burung di Taman Mini Indonesia Indah dan Kebun Binatang Ragunan adalah pilihan jelas, sebab kedua fasilitas ini tepat dan mereka sangat ditarik. Semua calon penangkaran harus memenuhui patokan yang tepat untuk ditunjuk sebagai Pusat Penangkaran. Taman Nasional Bali Barat adalah tempat yang baik sebagai calon pusat penangkaran.

2. Beberapa syarat seharusnya dipenuhi untuk ditunjuk sebagai Pusat Penangkaran:

   a. Pengunjung harus dibatasi.

   b. Burung-burung seharusnya dimasukkan dalam Buku Silsilah Indonesia dan dikelola sebaik mungkin untuk program pelestarian jenis ini.

c. Para pemelihara dan pengelola seharusnya dilatih tehnik pemeliharaan modern.

d. Harus ada pelayanan dari suatu badan kesehatan hewan guna menjamin kesehatan burung-burung yang dipelihara di suatu Pusat Penangkarang.

e. Semua Pusat Penangkaran seharusnya menerapkan petunjuk pemeliharaan seperti tercantum dalam berkas ini.

3. Anjuran bagi Pusat Penangkaran di Kebun Binatang Surabaya.

Rapat ini menganjurkan bahwa langkah-langkah dibawah ini dilaksanakan atau terus dilaksanakan oleh Kebun Binatang Surabaya guna meningkatkan hasil penangkaran.

a. Menutup bagian selatan dan timur Pusat Penangkaran untuk pengunjung guna menyediakan ketenangan bagi Curik Bali yang sedang berkembangbiak.

b. Meneruskan penelitian ulang terhadap kotoran dari semua burung.

c. Memasang pemisah antara sangkar-sangkar guna menghindarkan kontak visual antara pasangan yang sedang berkembangbiak.

d. Memasang alat untuk menghindarkan gangguan burung oleh kucing di atap sangkar.

e. Mengawetkan semua burung mati dan anak burung yang mati guna penelitian "post mortem".

f. Meneruskan program latihan bagi pemelihara dan staf kesehatan hewan.

4. Anjuran terhadap 2 ekor Curik Bali di Taman Nasional Bali Barat, yang mungkin adalah pendiri.

Kami menganjurkan agar kedua ekor Curik Bali yang sekarang ini sedang dipelihara di sangkar pertunjukan di Taman Nasional Bali Barat, dipindahkan untuk penangkaran dan diganti dengan burung yang tadak dapat dimanfaatkan selain pertunjukan. Burung yang satu, yang kelihatan sedang sehat, seharusnya dipindahkan ke Pusat Pra-Pelepasan; burung kedua, yang paruhnya cacat, tidak baik untuk dilepaskan dan seharusnya dipindahkan di Pusat Penangkaran di Kebun Binatang Surabaya. Sebagai pengantiannya, 2 burung yang tidak pernah berkembangbiak dapat dikirim ke Taman Nasional Bali Barat untuk dipertunjukkan bagi umum. Anjuran lain adalah untuk meneliti kemungkingan suatu bentuk yang baru dan lebih alami bagi sangkar tontonan di Taman Nasional Bali Barat.

5. Sarana pertunjukan seharusnya diberikan hanya burung yang tidak baik untuk penangkaran atau pelepasan atau kebutuhan lain dari program pelestarian.

V. **Pemanduan Pemeliharaan**

Keterangan Umum

1. Ciri-ciri Sangkar:

a. Ukuran seharusnya setidak-tidaknya 2.5 meter tinggi * 2.5 meter lebar * 4 meter panjang bagi 1 pasangan.

b. Harus ada tumbuhan.

c. Tanah di lantai sangkar cukup baik.

d. Pemisahan visual dari sangkar-sangkar sebelah-menyebelah adalah sangat penting, terutama bilamana dihuni burung sejenis.

e. Seharusnya disediakan tempat bertengger horisontal (alami atau buatan) yang mamadai.

f. Guna menghindarkan gangguan tikus, kawat sangkar seharusnya ada berlobang yang lebih kecil dari 1.1 cm dan seharusnya dipasang diatas slop beton.

g. Semut dapat dicegah dengan menempatkan tempat makanan di dalam piring air yang sedikit lebih besar.

h. Pengelolaan burung muda -- pindahkan sesudah mandiri sebab induknya akan membunuh burung muda bilamana bersarang lagi. Sangkar yang besar agar tidak mendapat gangguan manusia guna membantu burung yang akan dilepaskan menyiapkan diri.

2. Kecocokan dengan jenis lain: Tidak mustahil untuk memelihara dan mengembangbiakkan Curik Bali di dalam sangkar berisi berbagai jenis, akan tetapi, ini membawa sejumlah masalah penangkaran dan adalah persepakatan panitia ini bahwa sarana-sarana Pusat Penangkaran Curik Bali hanya menyediakan tempat untuk Curik Bali.

3. Makanan: Buah-buahan setempat yang tersedia (papaya, pisang); makanan hidup (ulat hongkong, kroto) seharusnya selalu disediakan. Khususnya makanan hidup adalah amat penting selama ada anak. Untuk mencegah sembelit, ulat-ulat tersebut perlu lembek, baru berganti kulit atau dipotong-potong kecil. Dianjurkan obat multivitamin sebagai tambahan.

4. Pengasuhan anak curik dengan menyapi tidak dianjurkan karena burung ini akan tidak cocok untuk pelepasan atau penangkaran di kemudian hari.

5. Tata Buku Silsilah: segenap burung seharusnya diberikan gelang kaki dari logam sebagai tanda pengenal tetap. Anakan seharusnya ditangkap dan diberi gelang kaki sesegera mungkin sesudah ke luar dari sarangnya guna mencegah kekeliruan identifikasi. Kartu-kartu 'perseburungan' harus dikelola bagi semua burung serta keturunannya kelak. Keterangan seharusnya meliputi nomor buku silsilah [Indonesia], tanggal perolehannya, asal-susl dan tanggal pengeluaran.

6. Bersarang: Seharusnya disediakan lebih dari satu peti sarang bagi setiap pasangan, baik gowok alami maupun kotak buatan. Ukuran dijelaskan dalam gambar terlampir [tidak terlampir]. Ukuran-ukuran dalamnya tidak terlalu penting, akan tetapi garis tengah dari lobang masuk seharusnya 7-9 sentimeter. Peletakan bisa horisontal ataupun vertikal. Rumput, daun-daunan dan sebagainya harus disediakan guna dipakai oleh burung itu untuk alas sarang.

VI. **Pencatatan dan Tata Buku Silsilah**

Pencatatan adalah hal utama untuk keberhasilan penangkaran dan teramat penting guna mengikuti dan mengawasi nasib semua burung penangkaran. Pencatatan itu seharusnya memenuhi usulan-usulan tersebut dibawah pokok V.5 diatas ini.

1. Sebuah Buku Silsilah Se-Indonesia yang resmi seharusnya dikembangkan secepat mungkin. Buku Silsilah Indonesia seharusnya disiapkan dalam kerjasama dengan Buku Silsilah Amerika Serikat serta Inggris. Kami mendesak agar Buku Silsilah secepat mungkin ditetapkan. Mendirikan Buku Silsilah Antarbangsa sesegera mungkin. Meneliti kemungkinan adanya Curik Bali di Jepang, Meksiko dan Singapur dan memasukkan mereka dalam Buku Silsilah Antarbangsa.

2. Semua pemegang Curik Bali di Indonesia seharusnya menandatangani sepucuk Memorandum Pengikutsertsaan khusus yang menuntut pemeliharaan memadai, pencatatan dan pengikutsertaan kerjasama.

3. Mengunakan program penangkaran serta pelepasan Curik Bali sebagai pola untuk mendirikan sebuah program kerjasama pelestarian jenis satwa serta penangkaran di Indonesia serupa program SSP di Amerika Serikat dan EEP di Eropah.

4. Kami mendesak supaya Pemerintah Indonesia akan memberlakukan semacam pajak atau iuran sebagai tanggungan pemegang Curik Bali yang tidak digunakan sebagai burung penangkaran.

VII. **Program Penerangan Curik Bali**

1. Tujuan:

   a. Menyadarkan masyarakat mengenai nilai dari Taman Nasional Bali Barat. Menekankan Curik Bali sebagai jenis satwa endemik satusatunya di pulau Bali[2].

   b. Mempromosikan Curik Bali sebagai satwa liar identitas daerah Bali[3].

2. Tempat:

   a. Wisma Pendidikan di Kantor Pusat Taman Nasional Bali Barat.

   b. Sekolah-sekolah, dikunjungi satuan mobil.

3. Kelompok sasaran:

   a. Semua lapisan masyarakat di sekitar Taman Nasional Bali Barat.

4. Metoda:

a. Pembuatan selebaran yang menjelaskan Proyek Jalak Bali dan menyebarluaskannya di Taman Nasional diantara para pengunjung, usaha jasa umum, hotel, dsb.

b. Sebuah perpustakaan kecil khususnya dengan buku-buku, majalah-majalah serta berkas-berkas lain tentang pelestarian alam serta alam hayat di Kantor Pusat Taman Nasional, terbuka khususnya bagi mahasiswa dan murid sekolah.

c. Mengadakan pertunjukan secara teratur tentang pelestarian alam, alam hayati di Taman Nasional Bali Barat, terutama Curik Bali.

d. Kunjungan wisata alam yang pendek ke wilayah Taman Nasional dan sekitarnya diselenggarakan secara teratur bagi murid sekolah, kelompok pramuka, dsb. Tur wisata alam ini tidak boleh menganggu populasi alami [Curik Bali].

e. Tulisan-tulisan berulang di suratkabar tentang alam hayati khususnya mengenai Taman Nasional [Bali Barat].

f. Ceramah-ceramah berulang mengenai keanekaragamaan hayati setempat malalui radio dan TV.

g. Pameran tetap di tiap-tiap Pusat Penangkaran (BunBin Surabaya, TNBB, bunbin lain) yang menjelaskan Proyek Jalak Bali.

h. Peristiwa penting dalam rangka Proyek Jalak Bali [seyogyanya] diumumkan secara luas kepada masyarakat (misalnya pelepasan curik, rehabilitasi habitat).

i. Mengerjakan orang setempat sebagai pemandu wisata.

j. Mengadakan kerjasama dengan pusat penerangan wisata setempat.

k. Mendirikan perkumpulan-perkumpulan pencinta alam.

l. Memfungsikan sangkar pameran berisi Curik Bali yang tidak berkembangbiak.

m. Mendirikan "Perhimpunan Mitra Kukila Curik Bali" dengan otoritas tertinggi di Bali (Bapak Gubernur) sebagai pelindung.

5. Personil:

a. Staf Taman Nasional Bali Barat.

b. Staf Proyek Jalak Bali.

NOTES:

1. 'Mind that there should be explicit and clear provisions for the use of (fire)arms, most particularly the responsibilities of the guards when victims fall ! Guards may not be held responsible, unless they are clearly wrong. [Footnote translators]

2. Disamping itu, Curik Bali adalah jenis satwa liar yang paling NYARIS TERANCAM PUNAH di Indonesia [catatan kaki dari penerjemah]

3. Hanya Curik Bali adalah satwa khas Bali yang satu-satunya membedakan dunia satwa Bali dari dunia satwa pulau-pulau lain di Indonesia. [catatan kaki dari penerjemah]

THE CONSERVATION OF LEUCOPSAR ROTHSCHILDI

(CURIK BALI) IN INDONESIA

PHPA/ICBP/AAZPA/JWPT/CBSG

24 March 1990

POINTS OF AGREEMENT AND RECOMMENDATIONS

PROBLEM

The Curik Bali (Jalak Bali, Bali mynah or Bali starling) (Leucopsar rothschildi) is endangered and numbered 24-31 birds during the last census of the only wild population in Bali Barat National Park. Continuing decline of the population with losses of birds to poachers in addition to natural causes, the primary restriction of the population to a single reserve, and chance environmental events put the population at critical risk of immediate demographic extinction. The small population will rapidly lose genetic variation even if sustained at current levels. These conditions favor early extinction in the wild. The species meets all of the criteria to be designated 'Critically Endangered' (which is a new category proposed for use by SSC/IUCN).

POINTS OF AGREEMENT

1. The recovery of the Curik Bali (Bali starling) to levels that ensures its long term survival as a wild species is a high conservation priority in Indonesia and is of the highest priority for the province of Bali.

2. The responsibility for saving this species and its natural environment rests with the authorities and people of Indonesia. However, the survival of the Bali starling is of importance and interest to the whole world and hence the international community should also contribute to the conservation of the Bali starling and its habitat including Bali Barat National Park (BBNT) or Taman National Bali Barat (TNBB).

3. The immediate goals are to:

   a. Prevent the further decline and extinction of the last remaining wild Bali starling population in Bali Barat National Park and to assist its recovery to at least 200 birds in the park as rapidly as possible.

b. Upgrade the guarding and patrolling system, as the highest priority immediate and short term measure, to provide the greatest contribution to prevention of the extinction of the wild population.

c. Recover as many wild caught birds held in captivity as feasible for immediate release into the wild as a priority or for the recovery and captive propagation program. These birds are needed to provide genetic variability for the wild population to assist its long term survival.

d. Release of appropriate wild caught birds back into the wild population is the highest priority. These birds should not have been hand reared and should have been captured as adults during the past 12 months.

e. Expand and improve the captive propagation program to provide stock for the release and reintroduction programs to restore the Bali starling in the wild.

4. The long term goal is to restore the Bali starling in wild populations in sufficient numbers to assure its survival as a biologically viable species in its original habitat so far as known in Bali only. This will entail establishment of a total population of at least 1000 birds distributed in wild populations in secure areas and an additional 1000 birds in managed captive populations. These populations will need to be managed as a single metapopulation.

5. As many wild caught birds as possible should be secured from the private sector in Indonesia through the White Wash Campaign. This genetic stock is important to provide additional genetic variability to assist the recovery of the species in the wild.

6. Additional captive propagation centers should be established in Indonesia to improve the security of the captive population in Indonesia and to serve as sources of birds for release to the wild. Additional stock for this purpose will be made available from the managed captive populations in other countries and from the White Wash Campaign in Indonesia.

7. All aspects of the conservation work on the Bali starling should be accompanied by appropriate monitoring and research including monitoring of the wild population, released, and reintroduced birds. Guidelines are given below.

8. All conservation projects on the Bali starling should include a training component in particular guard training related to protection and the captive propagation project personnel.

9. All conservation projects on the Bali starling should include a vigorous and continuing public education component both in Bali and in all of Indonesia. This should include projects designed to encourage participation of people living in the vicinity of the park.

10. The people living in the enclave should be transmigrated out of the enclave of the National Park as soon as possible. The plantations should be restored by reforestation after the transmigration of the people in the enclave and termination of the licenses.

11. For the large number of visitors who are unable to view Bali starlings in the wild, a display facility should be established in an appropriate location in the Bali Barat National Park specifically designed for mass tourism and incorporating interpretive and educational components.

12. The birds in the current wild population should not be captured, handled or disturbed for any purpose at the present time.

13. All Curik Bali in Indonesia are the property of the Indonesian Government and permits are required to capture, move, breed, or dispose of any bird.

14. A management and propagation advisory group should be established to advise the Indonesian government on the criteria, design, and establishment of Captive Propagation Centers, establishment of holding and display areas, on selection of birds for the release program, and on proposed movements of birds.

RECOMMENDATIONS

I. Recommendations for Management of Bali Barat National Park

1. Maintain and where necessary enhance the current patrolling system for the Prapat Agung peninsula through staff training, motivation, and supervision.

2. Upgrade guard post facilities and guard welfare.
    a. Provision of basic domestic facilities.
        1. Larger water containers
        2. Cooking facilities
        3. Sleeping/living facilities

b. Provision of field equipment including portable communications equipment, motorbikes, binoculars, and compasses.

c. Improvement of boat service facilities to provide guards with fresh food and water.

3. Upgrade guard skills and motivation.

a. Improve discipline /self-defence by co-ordination and training with the local police.

b. Improve job responsibility, awareness, and skills.

c. Provision of civil service (pegawai negeri) status for guards. (Consensus was not reached on this point due to concerns that achieving such a status may have a negative effect on motivation and that financial incentives may be a more effective form of motivation).

d. Field-guarding courses should be provided for the park guards. These should include compass use, how to patrol, animal and plant identification, and the basics of nature conservation.

4. Administration and co-ordination.

a. Provision of radio communication with guards.

b. Provision of special recurrent budgets for logistic support and the guard's increased patrolling responsibilities.

c. Encourage full cooperation between the staff of the National Park and research project personnel.

5. Enclave removal

a. Transmigration of all inhabitants

b. Termination (or non-renewal) of licenses of PT Margarana - 1993. PT Dharma Jati Utama 2004, as soon as possible.

6. Resolution of the status of the Bali Barat National Park enabling restoration of the original Bali starling habitat including the area now under plantation forest.

7. Arming of the guard force is recommended. (Consensus not reached on this point due to concerns that the poachers might in turn also use firearms.)

II. Field Programme

Two levels: Basic monitoring and detailed ecological studies.

1. Basic monitoring of the wild population to determine the following:

   a. Total population prior to breeding season (end of dry season).

   b. Total population following breeding season (end of wet season).

   c. Bali starling movements and habitat utilization. Regular observations of foraging flocks are needed. A more detailed habitat/vegetation map is needed.

   d. Number of breeding pairs by locating active nest holes.

   e. Recruitment of young birds into the wild population by close observation of flocks to determine proportion of 1st year birds.

2. Basic monitoring of released birds to determine the following:

   a. Dispersal and movements immediately following release.

   b. Adaptivity to conditions in the wild (ability to find food and water) immediately following release.

   c. Surviving population, movements, habitat utilization and breeding success over time.

   d. Interaction with wild population.

3. The released population should be monitored by color-banding and marking the birds and close monitoring in the field; if these approaches fail to provide the necessary data then radio-telemetry should be evaluated for use.

4. Detailed study of wild population including released birds if the programme is successful.

   a. Food and habitat requirements, e.g. use of production forest.

b. Breeding biology and success (territory size, timing and duration of breeding season, clutch sizes, fertility rates, duration of incubation, hatching rates, number fledged, single/double-clutched?).

c. Impact on the wild population of visitors to the park, field research, patrolling, and development of park facilities (guard posts, etc.).

III. White-Wash Campaign

Since it is urgent to obtain as many wild caught birds, currently held in captivity in private hands, as possible to incorporate them into the captive breeding and release program as additional sources of genetic variation we urge that the following steps in the campaign be initiated as soon as possible. These birds should be the property of the Indonesian government and permits should be reqquired before tey can be transported, traded or used for captve breeding.

1. A public awareness campaign be initiated to ensure that participation in this effort is seen and recognized as an honor and privilege, as well as a significant contribution to the conservation of this unique Indonesian bird. A special letter of recognition should be sent to everyone who contributes to the campaign.

2. Wild caught birds offered to PHPA need to be accepted and either immediately released into the wild or incorporated into the captive breeding program as long as suitable space is available. Further that PHPA take possession of any wild caught birds as soon as suitable captive space is available and as captive bred birds for exchange or trade are available (if trade birds are necessary) for the transaction.

3. Trading captive bred birds for wild caught birds should occur as soon as captive bred birds and suitable captive breeding space is available. Initial captive bred birds available for such trade would come from either Surabaya or from overseas. Nonproductive or surplus birds from Surabaya could be used for this purpose until other birds are available and arrive from overseas.

4. All trade birds should be permanently identifiable by leg bands and with transponder implants.

5. All wild caught birds should be permanently identified and entered in a regional studbook.

6. The placement of the wild caught birds into captive facilities would occur unless there is clear proof that the birds were only recently captured from the wild. In cases where birds have been held as adults in captivity for a very short time (<12 months), consideration should be given to immediate release back into the wild via the pre-release training center if feasible and if the birds are in good shape and have high potential for success. Birds removed from the wild as chicks and hand reared would not be suitable for release back into the wild.

7. Initiate a training process for Indonesian veterinarians so that they can sex birds via laparoscopy. This would be coordinated by the Indonesian Association of Zoos and their veterinarians in cooperation with the appropriate government agencies. This may entail a training course conducted by a competent veterinarian from the US or UK via AAZPA and CBSG cooperation.

8. In cases where a holder of wild caught birds has several birds and desires to have the opportunity to breed the birds as part of the captive breeding effort we urge that the original wild caught birds still be turned over to PHPA and that they be replaced if possible by captive bred birds capable of breeding. Once the individual is successful in breeding the captive bred birds within suitable facilities which meet the husbandry and record keeping standards, then that individual would be encouraged to serve as an additional captive breeding center of Bali starlings.

9. All wild caught birds obtained by PHPA (and which are not being immediately released into the wild) should be placed in facilities where they can be maintained and bred in accordance with the established husbandry and record standards as described in this report.

10. Urge that information on age, origin, and time in possession be obtained from anyone offering a wild caught bird to PHPA.

11. Urge that there be an increase in guarding, monitoring and law enforcement during the White Wash Campaign to ensure that this period not be used as additional incentive to remove birds from the wild. Amnesty should not be granted if it is determined that the birds were obtained from the wild after the announcement of the White Wash Campaign.

12. Urge that by enforcement of current laws, or by establishing new laws or regulations, make possession, transport, and offering for sale of a Bali starling, be a violation of law punishable by significant fines or imprisonment.

IV. New Facilities for Captive Propagation Centers (CPC)

1. It is the recommendation of this group that new facilities be designated in Indonesia for captive breeding centers for Bali starlings. Taman Mini and Ragunan are two obvious choices since the facilities are appropriate and the interest is high. All applicants will need to meet suitable criteria to qualify as a Captive Propagation Center. Bali Barat National Park is potentially a good location for a captive breeding center.

2. Several conditions should be met for establishment of a Captive Propagation Center:

   a. This facility should have limited public access.

   b. The birds should be maintained in the Indonesian studbook and managed in the best interest of the species recovery plan.

   c. Keepers and managers should be trained in modern avicultural techniques.

   d. There must be veterinary services available to ensure the health of the birds maintained at a CPC.

   e. All CPCs should agree to follow husbandry guidelines as outlined in this document.

3. Recommendations for CPC at the Surabaya Zoo

   It is the recommendation of this group that the following steps be implemented or continued at the Surabaya zoo to help improve breeding results.

   a. Provide more privacy for breeding Bali starlings by removing public access to the south and east sides of the CPC.

   b. Continue periodic fecal examinations of all birds.

   c. Install opaque dividers between aviaries to stop all visual contact between breeding pairs.

   d. Install a device to control cat disturbances to the birds from the top of the cages.

e. Preserve all dead chicks and adults for post mortem examinations.

f. Continue ongoing training program for keeper, curatorial and veterinary staffs.

4. Recommendations for 2 potential founder Bali starlings at Bali Barat National Park (BBNT).

It is our recommendation that the 2 Bali starlings currently being kept in the display cages at Bali Barat National Park be relocated and replaced with birds suitable for exhibit only. The one bird in apparent good physical condition should be moved to the Pre-release Training Center (PTC); the other bird, with malformed upper and lower mandibles, is unsuitable for release and should be placed in the CPC at Surabaya Zoo. In exchange, two non-breeding birds can be sent to BBNT for display. It is a further recommendation that a new, more natural design for the display enclosure at BBNT should be investigated.

5. Exhibit (display) facilities should be supplied only with birds that are not suitable for captive breeding or release, or other needs of the release program.

V. Husbandry Guidelines

General Information

1. Enclosure Parameters:

a. Minimum dimensions should be 2.5M high x 2.5M wide x 4M deep for 1 pair.

b. Some vegetation is necessary.

c. Soil substrates are satisfactory.

d. Visual isolation from adjoining cages is very important, particularly when conspecifics are housed there.

e. Adequate horizontal perching (natural or artificial) should be provided.

f. Enclosure wire should have openings small enough (<1.1 cm) to exclude rodents and should be mounted on concrete curbing.

g. Ants can be controlled by placing food containers in slightly larger, water filled receptacles.

h. Fledgling management--remove shortly after independent from parents because parents will kill chicks when they re-nest. Large flight cages, with minimum human disturbances, are recommended to help prepare birds scheduled for release. (See recommendations for PRTCs).

2. Compatibility with other Species: It is possible to maintain and breed the Bali starling in mixed species exhibits; however, this leads to a number of husbandry problems and it is the consensus of this committee that the Captive Propagation Center facilities for the Bali starling should house only Bali starlings.

3. Diet: Local fruit as available (papaya, banana), live food (meal worms, ant pupae) should be provided at all times. Live food is especially critical during chick rearing. To avoid impaction, larva should be soft, freshly shelled, or cut into small pieces. A general multivitamin supplement is advisable.

4. Hand rearing is not advised because offspring will be unsuitable for future release.

5. Record Keeping: All birds should be banded with permanent metal ID bands. Chicks should be caught up and banded as soon as possible after fledging to avoid confusion in identity. Individual record cards must be maintained on all birds and their subsequent offspring. Information should include studbook number, date of acquisition, lineage and disposition date.

6. Nesting: Multiple nest boxes should be provided, either natural logs or artificially constructed. Sizes are indicated on the attached diagram. The interior dimensions are not critical, however, the entrance hole should be 7-9 cm in diameter. Orientation can be vertical or horizontal. Grass, leaves, and similar materials should be provided for the birds to use in padding the nest.

VI Records and Studbook

Records are imperative to captive breeding success and are essential to track and maintain control on all captive birds. Records should follow the recommendations prepared by the husbandry group.

1. An official regional studbook for Indonesia should be developed as soon as possible. The Indonesian studbook should be prepared in coordination with the North American and British regional studbooks. We urge the establishment of a European regional studbook as soon as possible. Establish an international studbook as soon as possible. Investigate the possibility of Bali starlings that might be found in Japan, Mexico, and Singapore and include them in the regional and international studbook program.

2. All Indonesian holders of Bali starling should be required to sign a specially prepared memorandum of participation which would require proper care, records and cooperative participation.

3. Use the Bali starling cooperative breeding and release program as a model to establish a cooperative species survival and captive propagation program in Indonesia similar to the North American SSP and European EEP programs.

4. We urge that the Indonesian Government impose a tax or other fee upon the holders of the Bali starling who are not designated as captive propagation centers.

VII. Bali Starling Education Programs

1. Objectives:

   a. Make public aware of the value of the National Park. Emphasize the Bali starling as the only endemic faunal species on Bali.

   b. Promote the Bali starling as the avian symbol of Bali.

2. Locality:

   a. National Park Headquarters Education quarters.

   b. Schools, visited by mobile unit.

3. Target Groups:

   a. All levels of the surrounding community.

4. Methods:

   a. Production of leaflets, explaining the Bali Starling Project and distribute at National Park amongst visitors, public services, hotels, etc.

b. A small library specialized in books, magazines and other documentation on nature conservation and natural history at the National Park headquarters, open especially to students, school children.

c. Regular presentations on nature conservation, natural history of the park, esp. Bali starling.

d. Short field trips organized regularly for schools, scouting groups, to the National Park territory and surroundings. These tours should not disturb the wild population.

e. Regular columns in the newspaper, on natural history especially in the National Park.

f. Regular talks on native biodiversity on radio/TV.

g. Permanent exhibitions explaining the Bali Starling Project at every Captive Propagation Center. (Surabaya Zoo, BBNP, other Zoos).

h. Major events in Bali Starling Project programme brought into publicity (eg. release of birds, habitat rehabilitation).

i. Employment of local guides for field trips.

j. Cooperation with the local tourist information centre.

k. Establishing nature lovers clubs.

l. Display aviary with non-breeding Bali starlings.

m. The establishing of a "Friends of Bali Starling Club" with the highest authority of Bali (The Governor) as its patron.

5. Personnel:

a. Bali Barat National Park staff.

b. Bali Starling Project staff

BALI STARLING

Leucopsar rothschildi

VIABILITY ANALYSIS

AND

SPECIES SURVIVAL PLAN

BALI STARLING WILD POPULATION STUDIES

Continuation of Bali Myna Project

The AAZPA and ICBP in a continued commitment to ensure the future survival of the Bali Starling in the world via a comprehensive captive breeding and release program in conjunction with continued monitoring and protection of the wild population agree to extend the cooperative agreement with the Indonesian PHPA and JWPT.

ICBP will continue to monitor the wild population but AAZPA will take over direct financial and management control of the captive breeding and release portions of the program.

AAZPA and CBSG SSC/IUCN will endeavor to develop a conservation program and a new set of agreements to implement the recommendations of the Bali Myna PVA workshop of March 22-24.

Signed: Date

Richard Grimmett — March 24, 1990.

Richard Grimmett
For ICBP

Donald Bruning — March 24, 1990

Donald Bruning
For AAZPA

Ulysses S. Seal — March 24, 1990

Ulysses S. Seal
For CBSG

Memorandum Of Understanding

Conservation management of the Bali Starling
Leucopsar rothschildi in Indonesia.

Renewal of Agreement:

This document is to renew the Memorandum of Understanding (MOU) for the Bali Starling which is between the government of the Republic of Indonesia, in this case represented by the Directorate-General of Forest Protection and Nature Conservation (henceforth called PHPA), the American Association of Zoological Parks and Aquaria (henceforth called AAZPA), the Jersey Wildlife Preservation Trust (henceforth called JWPT), and the International Council for Bird Preservation (henceforth called ICBP). This MOU was signed by the Representatives of PHPA, ICBP and AAZPA on the 15th day of June, nineteen hundred and eighty-seven and was amended to recognize JWPT as a full party to the MOU on the 26th day of October, nineteen hundred and eighty-seven.

The purpose of this document is to renew for a further two years, from the date of signing, this MOU so as to enable the existing parties to develop and implement the recommendations of the Viability Assessment and Conservation Plan Workshop which was conducted on the 24th day of March, nineteen hundred and ninety under the auspices of the Captive Breeding Specialist Group of the International Union for the Conservation of Nature and Natural Resources.

By signing this document all parties show their approval of the renewal of this MOU.

Signed:

Date

On behalf of
The Government of Indonesia:

Dr. Sutisna Wartaputra
Director-General PHPA

On behalf of ICBP

Dr. Christoph Imboden
Director-General ICBP

On behalf of AAZPA:

Dr. Donald Bruning
Chairman AAZPA---WCMC

On beh[illegible] J[illegible]

Jeremy Mallinson
Zoological Director

Please attach a signed copy of this document to the Memorandum of Understanding.

MEMORANDUM OF UNDERSTANDING

BALI STARLING PROJECT INDONESIA

Between the Parties

The Government of the Republic Indonesia, in casu represented by the Directorat-General for Forest Protection and Nature Conservation (henceforth called PHPA),

and

The International Council for Bird Preservation (henceforth ICBP), together with
The American Association of Zoological Parks and Aquaria (henceforth AAZPA),

herinafter jointly called the Parties.

PREAMBLE

Recognising that the Bali Starling or Jalak Putih Bali (Leucopsar rothschildi Stresemann 1912) is threatened with immediate extinction in the wild;

Recognising that the Bali Starling is the sole endemic bird species and genus of Bali Island (Indonesia) and a significant local, national and international natural heritage;

Acknowledging the facts that the Bali Starling has received the status of endangered species since 1966 (IUCN Red Data Book), that the Bali Starling is included in the Convention on International Trade in Endangered Species (CITES List I), which is signed by the Governments of the United States of America, the United Kingdom and the Republic of Indonesia, and that the species is protected under prevailing Indonesian Law, in particular by Decree of the Minister of Agriculture SK 421/Kpts/Um/8/1970;

The Bali Starling is an important attraction to domestic and international tourism to the Bali Barat National Park, and hence has, in addition to scientific, educational and aesthetic values, also economic attributes, which all should be carefully maintained and enhanced by knowledgeable preservation measures;

Aware that the direct causes of the Bali Starling's decline in its natural environment, North-west Bali, include amongst others poaching for the domestic and international animal trade, deterioration of suitable habitat and shortage of nesting opportunity due to past and present (fire)wood collection and probably include competition by the Black-winged Starling (Sturnus melanopterus tertius);

Aware that the preservation of the Bali Starling may only be achieved through common and long-term action;

Intending to arrest further decline of the remaining wild population of Bali Starlings through poaching and illegal keeping, habitat deterioration and possible competition and, instead, wishing to increase the wild population to a long-term safe level;

Stating that the Bali Starling Project (herinafter called BSP) has been drawn up as the sole body to coordinate, integrate and implement the activities of national and international governmental and non-governmental organisations to achieve the preservation of the species in an atmosphere of cordial national and international cooperation.

Article I

As far as available resources allow, the Parties to this Memorandum of Understanding (henceforth called MOU), undertake to carry out jointly the objectives and activities of the BSP and accept the responsibilities and authorities set out below in the Articles II, III, IV and V.

The selection, timing and funding of the activities will be agreed jointly between the Parties, but each of the Parties fully retains the prerogative to decide whether or not a particular part of the BSP can be endorsed, supported and implemented by the Parties in accordance with Articles II, III, IV and V.

Article II

The Government of Indonesia, in casu PHPA shall endeavour to provide guidance and support for implementation of the BSP by:

1. Nominating PHPA as the single counterpart-organisation for administrative facilitation and assistance, including linkage with other relevant national and local institutions, in particular the Surabaya Zoological Park (KBS) where the Captive Propagation Centre will be located;

2. Nominating a PHPA officer of the Bali Barat National Park for appointment by ICBP/AAZPA funding during the first year as a counterpart who will assist the Project Investigator (mentioned under Article III, point 1). As of the second year this counterpart's project-allowance will be fully borne by PHPA for the rest of the duration of the BSP;

3. Negotiating a guarantee - within restraints of current labour legislation - from the Management of the KBS that the KBS employee, who will be trained by ICBP/AAZPA (Article III, point 3) will remain assigned to the Captive Propagation

programme (CPP) throughout the full period of the BSP. This CPP Supervisor will remain on the payroll of the KBS;

4. Promoting awareness of the BSP within the Central and Local Governmental Services and within the country as a whole, and seeking the affiliation of other relevant national and local governmental and non-governmental institutions;

5. Rendering the ICBP/AAZPA the rights, privileges and duties appropriate to private international technical assistance organisations, such as giving favourable consideration to questions concerning entrance permits, taxes in particular exemption from import taxes and duties all material and equipment such as for instance vehicles, captive-bred Bali Starlings, scientific literature, audio, optical- and medical equipment, etcetera, sent in support of the BSP, and further facilitating the import of such material and equipment for approved activities and access to any facilities the Central or Local Government may have for the maintenance of such material and equipment.

Article III

The ICBP/AAZPA shall endeavour to provide material scientific and technical assistance for the BSP by:

1. Nominating and appointing, subject to approval by the Government of Indonesia, a Project Investigator, who will manage, coordinate and implement all BSP activities on behalf of the first project year, a counterpart nominated by PHPA to assist the Project Investigator (cf. Article II, point 2);

2. Seeking financial and material support from non-Indonesian, international sources for all objectives and activities not specified in Article II;

3. Providing for the training of key personnel, in particular for the training in captive breeding of one employee of the Surabaya Zoological Park, who will subsequently supervise the CPP for the duration of the BSP;

4. Providing selected Bali Starlings that will be the sole founder stock for a CPP at the CPC in the Surabaya Zoological Park, the offspring of which will be in principle destined for release in the wild in Indonesia;

5. Providing for the publication and exchange of information on pending and terminated BSP results, population trend, captive and wild breeding success and other relevant aspects of the Bali Starling, including scientific research work.

Article IV

All Bali Starlings imported into Indonesia as the founder stock for the CPP, will become and remain the property of the Indonesia Government, in casu PHPA, but will be placed at the full disposal of the BSP for the duration of the CPP. Any financial income resulting directly or indirectly from this CPP will remain in the operational budget of the BSP.

Article V

Within 2 months of signature of this MOU and within financial and administrative constraints of the Parties, there shall be produced a BSP Preservation Programme, following earlier produced outlines, and which will be the basis for action.

This MOU serves as a framework to the activities and successive phases of the BSP, and regulates the general aspects and major components of the BSP; further detailing is referred to separate project proposals that will be submitted to the Parties over the course of the period of the MOU.

Article VI

Other governmental and non-governmental agencies not party to this MOU, whose activities would be a significant benefit to the objectives and activities of the BSP, shall be eligible to be incorporated in this MOU as a party equal to the Parties, subject to full and written approval of all other Parties of this MOU.

Article VII

Notwithstanding this MOU, the Government of Indonesia reserves the full right to negotiate directly or through bodies with other governmental and non-governmental agencies in any field of wildlife research and conservation.

Article VIII

Failure to abide by any article of this MOU does not entail any judicial action or payment of compensation between the Parties, unless the Laws of the country are seriously contravened.

Article IX

The period of this MOU shall be three roman calendar years from the date of signature and subject to extension, whether or not modified, after expiration.

Any modification of this MOU shall be in writing and signed by the Parties to this MOU or their duly designated representatives.

Signed in Bogor, Indonesia on this 15 th day of June, nineteen hundred and eighty-seven.

On behalf of the Government of Indonesia

Rubini A.

....

Prof Dr Rubini Atmawidjaja
Director-General PHPA

On behalf of the International Council for Bird Preservation

Dr. Imboden

....

Dr Christoph Imboden
Director ICBP

On behalf of the American Association of Zoological Parks and Aquaria

Donald Brunning

....

Dr Donald Brunning
Chairman AAZPA — WCMC

MEMORANDUM OF UNDERSTANDING

AMENDMENT

BALI STARLING PROJECT INDONESIA

This document is to modify the Memorandum of Understanding for the Bali Starling Project Indonesia between the Government of the Republic Indonesia, in casa represented by the Directorate-General for Forest Protection and Nature Conservation (henceforth called PHPA), and the International Council for Bird Preservation (henceforth called ICBP) together with the American Association of Zoological Parks and Aquaria (henceforth called AAZPA).

Its purpose is to formally recognise Jersey Wildlife Preservation Trust (henceforth called JWPT) as a full Party to the Memorandum of Understanding signed by Rubini Atamawidjaja on behalf of PHPA, Christoph Imboden on behalf of ICBP and Donald Brunning on behalf of AAZPA.

By signing this document all existing parties show their acceptance of JWPT as a full Party to the MoU. Thus, where ever ICBP/AAZPA are referred to in the MoU this shall now be considered as ICBP/AAZPA/JWPT.

Signed

On behalf of the Government of Indonesia

.... 26/10/87 ....

Prof. Dr. Rubini Atamawidjaja — date
Director-General PHPA

On behalf of the International Council for Bird Preservation

.... 16/6/87 ....

Dr Christoph Imboden — date
Director ICBP

On behalf of the American Association of Zoological Parks and Aquaria

Donald Brunning .... June 30, 1987 ....

Dr Donald Brunning — date
Chairman AAZPA-WCMC

On behalf of Jersey Wildlife Preservation Trust

Jeremy J. C. Mallinson .... 20th June, 1987 ....

Jeremy Mallinson — date
Zoological Director

Please attach a signed copy of this document to the Memorandum of Understanding.

An overview to the

THREATENED BIRDS IN THE ASIAN PACIFIC REGION

T. H. Johnson and A. J. Stattersfield, October 1989

International Council for Bird Preservation
32 Cambridge Road
Girton
Cambridge CB3 OPJ
U.K.

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(numbers correspond with figure numbers)

1. Over 1,000 bird species around the world are currently threatened with extinction. Of these, 385 species live in the Asian Pacific Region, making this the region with the greatest number of threatened birds (328 species occur in the Asian Region and 65 occur in the Pacific Region, the boundary between the two regions being taken as between Papua New Guinea and the Solomon Islands; eight species are common to both regions). Asia and the Pacific are therefore vital for bird conservation and, as birds are good environmental indicators, the conservation of this region is crucial for the maintenance of the world's biodiversity.

2. Of the 328 threatened bird species occurring in the Asian Region, the greatest proportion, 182 species (55%), live in the archipelagos of Indonesia, the Philippines and Papua New Guinea. The mainland regions of China/the Koreas/Japan, South East Asia and the Indian Subcontinent all harbour approximately equal numbers of threatened bird species (91, 85 and 75 respectively).

3. The countries with the highest numbers of threatened bird species in the Asian Region are Indonesia (126), China (81), India (68), Philippines (42), Thailand (39), Burma (37), Vietnam (34), Malaysia (34), Japan (26) and Papua New Guinea (24).

4. The endemic species of a country are those species which are found only within the political boundaries of that country. The survival of an endemic depends therefore solely on its nation's conservation efforts. Indonesia and the Philippines harbour the greatest number of threatened endemic birds (91 and 34 species respectively). Many of these endemics are confined to single islands and so are especially vulnerable.

5. ICBP is currently looking at centres of bird endemism (including both threatened and non-threatened species) in order to identify sites critical for the conservation of biodiversity. The project has already identified possible sites in the Philippines and a similar analysis will be applied to the rest of the world.

6. The island nations of the Pacific have a surprisingly high number of threatened bird species (65) given their small size: the average area per threatened species for the Pacific Region is 8,500 sq km compared to 75,000 sq km per threatened species in the Asian Region, illustrating the special vulnerability of many of these species because of their very small ranges. French Polynesia and the Solomon Islands have the highest numbers (18) of threatened bird species (Papua New Guinea is included in the Pacific and Asian countries histograms, Figs 3 and 6, for relative comparison).

7. The major habitat type where threatened birds occur is forest (72% of birds in the Asian Region and 75% in the Pacific Region) with wetlands also being important for some Asian birds (13% of birds).

8. The major threat to the survival of threatened birds is habitat destruction, both forest destruction and wetland drainage, affecting 71% of birds in the Asian Region and 43% in the Pacific. Introduced species are also a major threat to Pacific birds, affecting 42% of birds; these aliens prey on the birds but may also modify and degrade habitat. Thus safeguarding and managing sufficient areas of natural vegetation to support viable populations of birds and other wildlife should be the main conservation priority for all countries in the Asian Pacific Region.

FIG 1. DISTRIBUTION OF THREATENED BIRDS: ASIA AND THE PACIFIC IN A WORLD CONTEXT

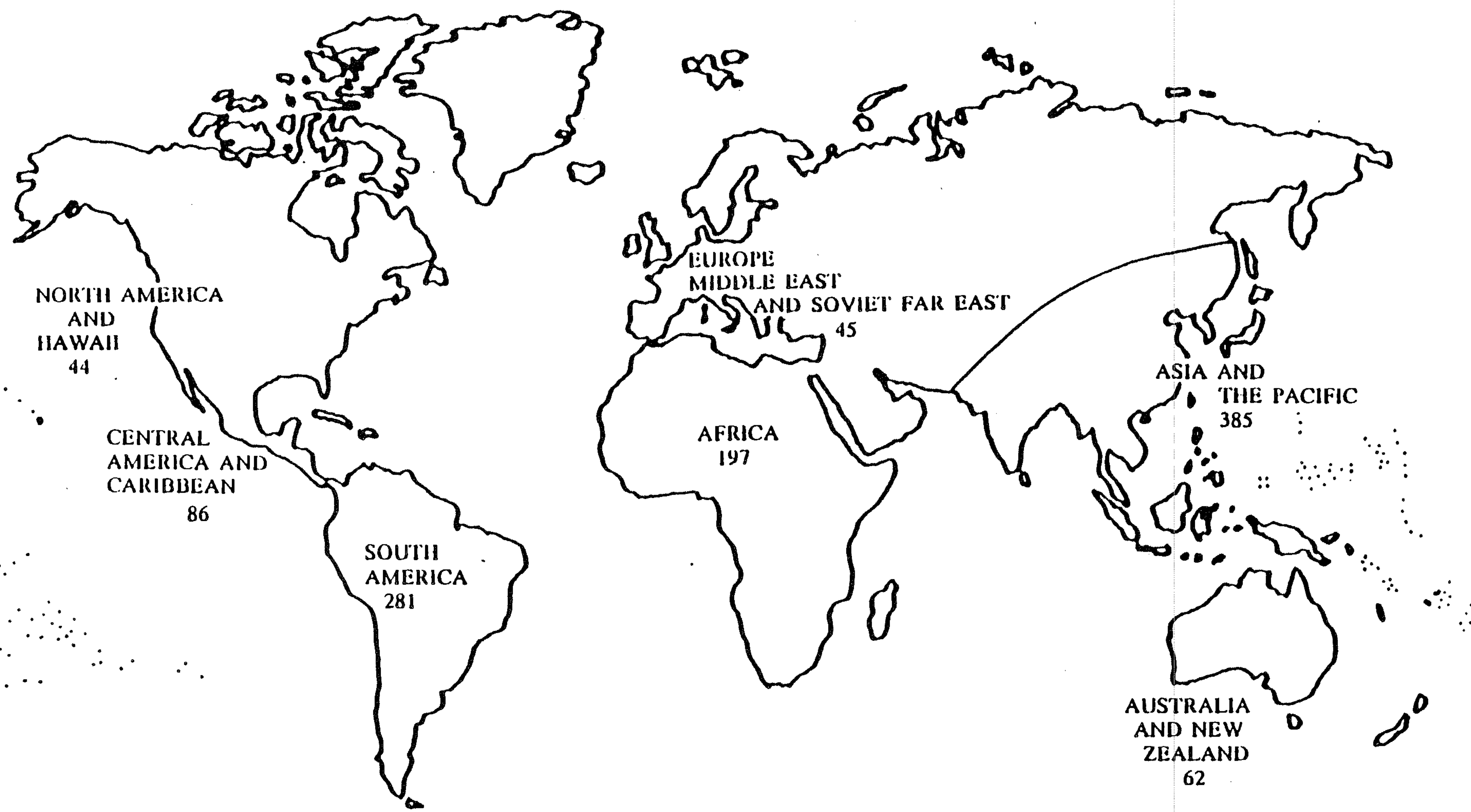

FIG 2. REGIONAL DISTRIBUTION OF THREATENED BIRDS: A CLOSER LOOK AT ASIA

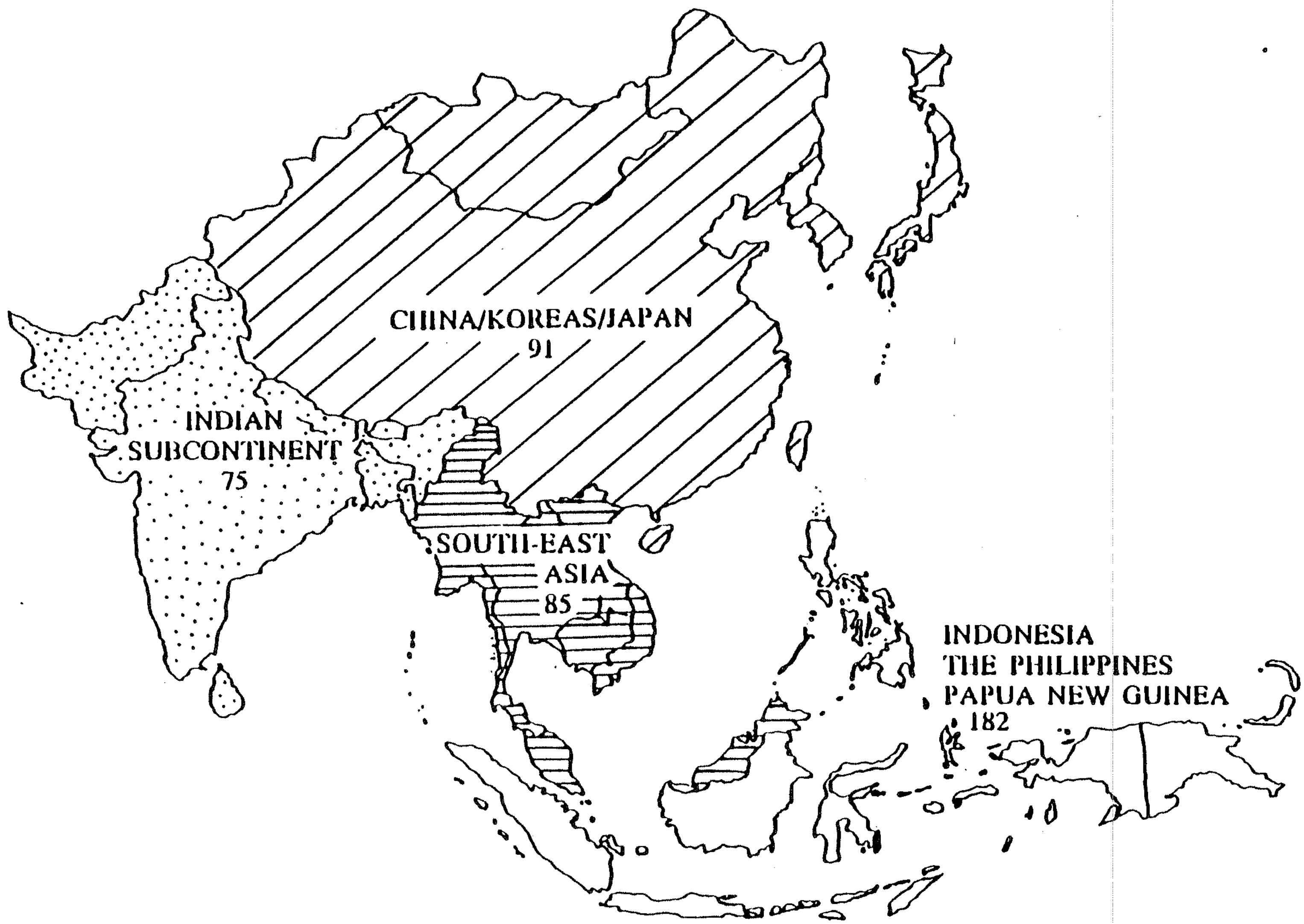

FIG 3. COUNTRY DISTRIBUTION OF THREATENED BIRDS IN ASIA: THE TEN WORST CASES

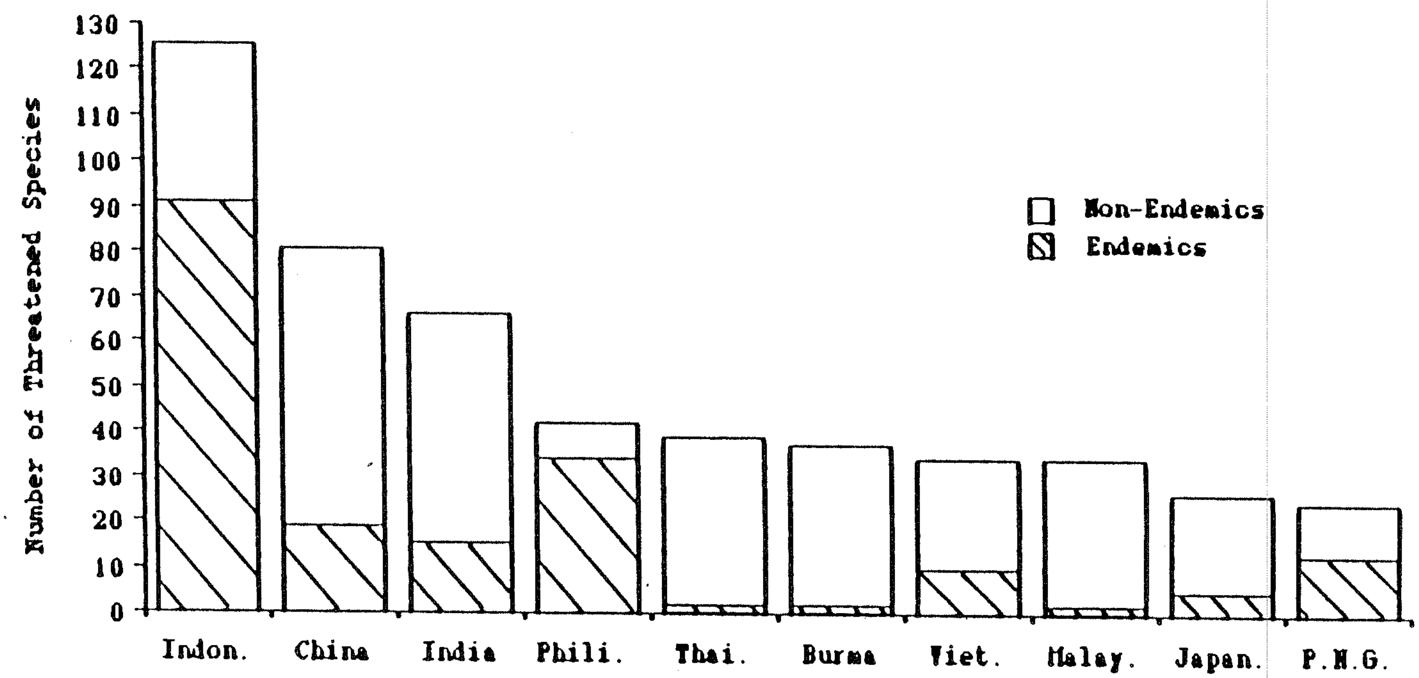

FIG 4. THREATENED ENDEMICS IN INDONESIA AND THE PHILIPPINES: A SPECIAL RESPONSIBILITY

Rank	Island•	No. of sp.+	No. of sp.*	Rank	Island•	No. of sp.+	No. of sp.*
1	Luzon (P)	14	10	26	Leyte (P)	3	
2	Sulawesi (I)	12	8	26	Samar (P)	3	
3	Java (I)	8	7	26	Semau (I)	3	
4	Sumatra (I)	8	6	26	Romang (I)	3	
4	Sumba (I)	8	6	26	Babar (I)	3	
6	Timor (I)	8	2	26	Peleng (I)	3	
7	Mindanao (P)	7	3	26	Ternate (I)	3	
8	Negros (P)	7	2	26	Saparua (I)	3	
9	Tanimbar (I)	6	2	26	Tual (I)	3	
10	Taliabu (I)	6	1	36	Tawi-Tawi (P)	2	1
11	Mangole (I)	6		36	Tanahjampea (I)	2	1
11	Sanana (I)	6		36	Waigeo (I)	2	1
13	Buru (I)	5	3	39	Guimaras (P)	2	
13	Biak (I)	5	3	39	Dinagat (P)	2	
15	Wetar (I)	5	2	39	Lombok (I)	2	
16	Damar (I)	5	1	39	Roti (I)	2	
16	Halmahera (I)	5	1	39	Leti (I)	2	
18	Mindoro (P)	4	4	39	Moa (I)	2	
19	Sangihe (I)	4	2	39	Haruku (I)	2	
20	Banggai (I)	4	1	39	Numfor (I)	2	
21	Seram (I)	4		39	Siau (I)	2	
21	Bacan (I)	4		48	Bali (I)	1	1
21	Ambon (I)	4		48	Cebu (P)	1	1
24	Flores (I)	3	2	48	Palawan (P)	1	1
25	Obi (I)	3	1	48	Boano (I)	1	1
26	Panay (P)	3					

• (P) = island in the Philippines (I) = island in Indonesia
+ = Total no. of threatened endemic bird species occurring on island
* = No. of threatened endemic bird species confined to island

FIG 5. HOT SPOTS IN THE PHILIPPINES:

IDENTIFYING SITES CRITICAL FOR CONSERVATION

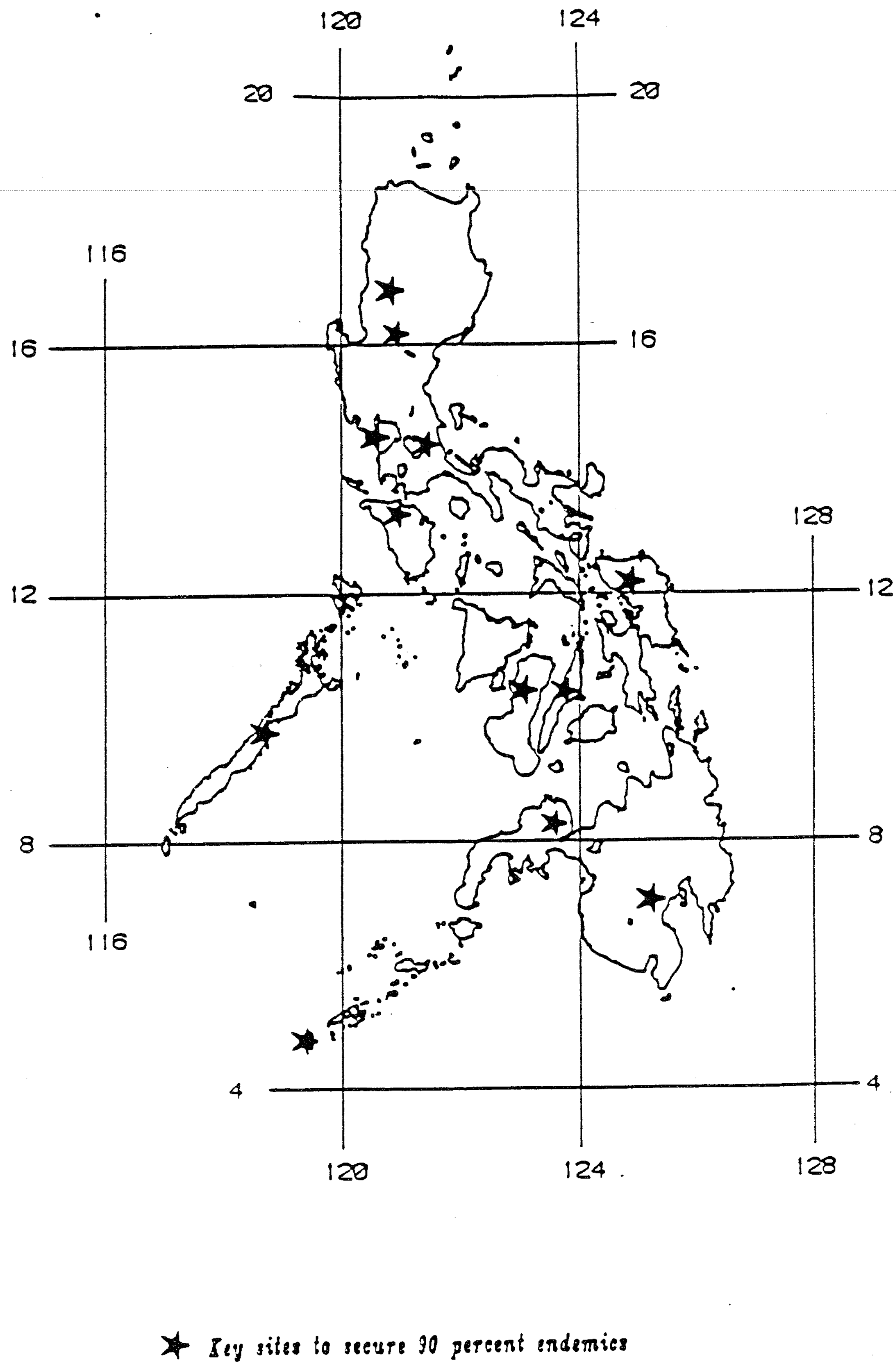

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FIG 6. REGIONAL DISTRIBUTION OF THREATENED BIRDS: A CLOSER LOOK AT THE PACIFIC

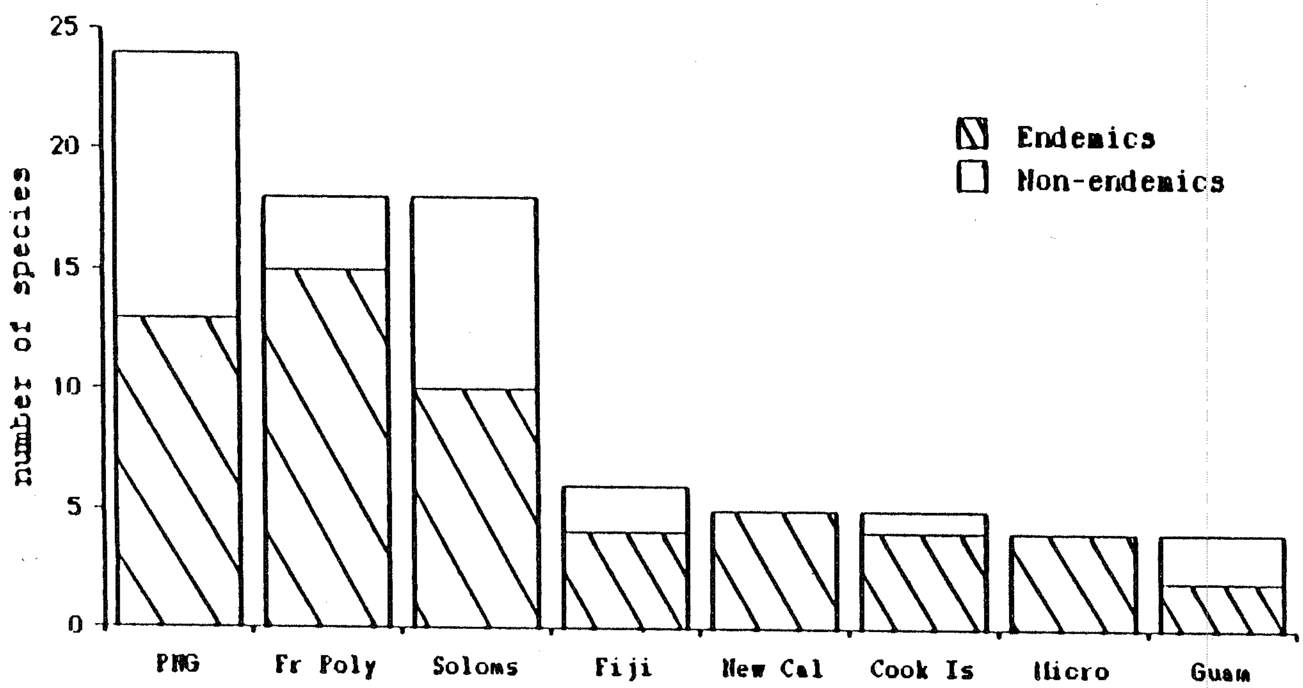
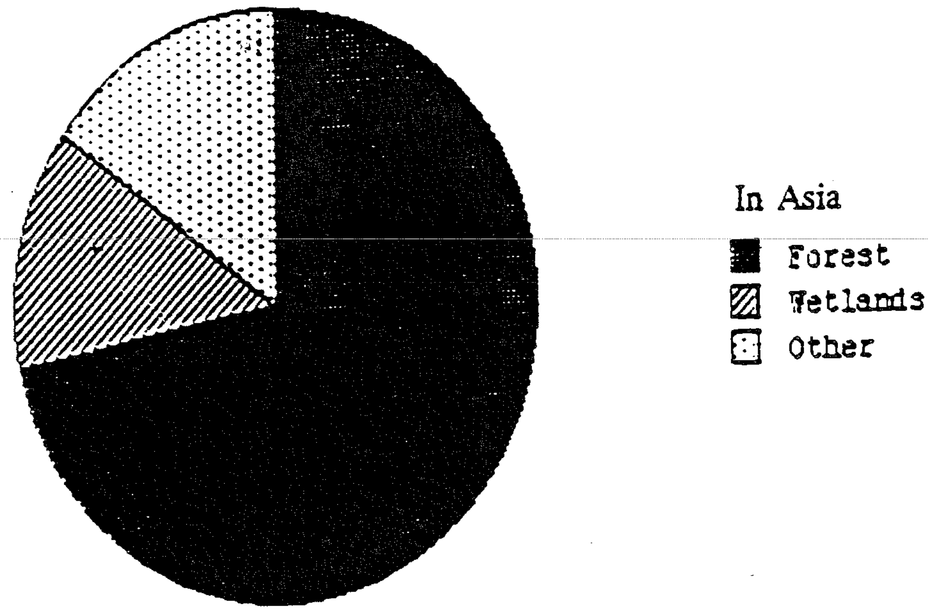


FIG 7. HABITAT TYPES OF THREATENED BIRDS



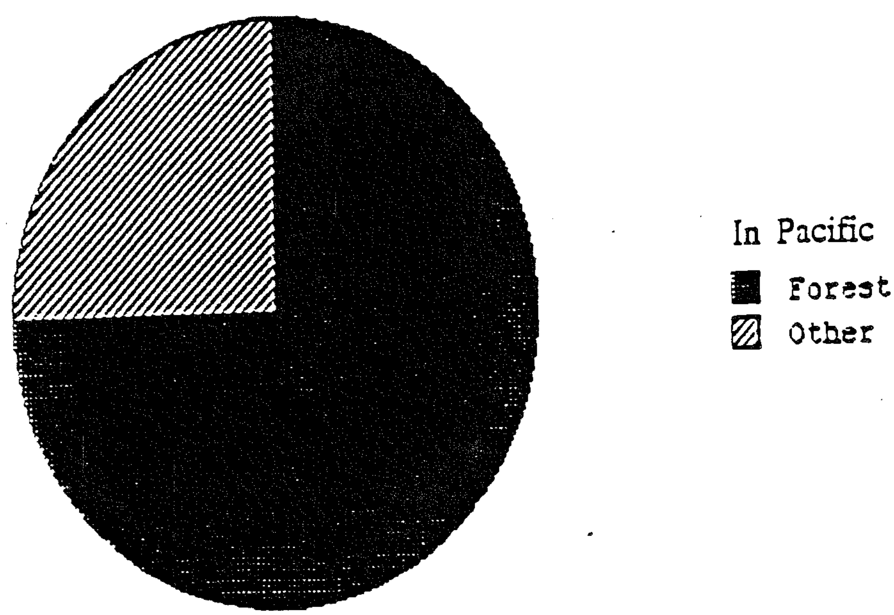


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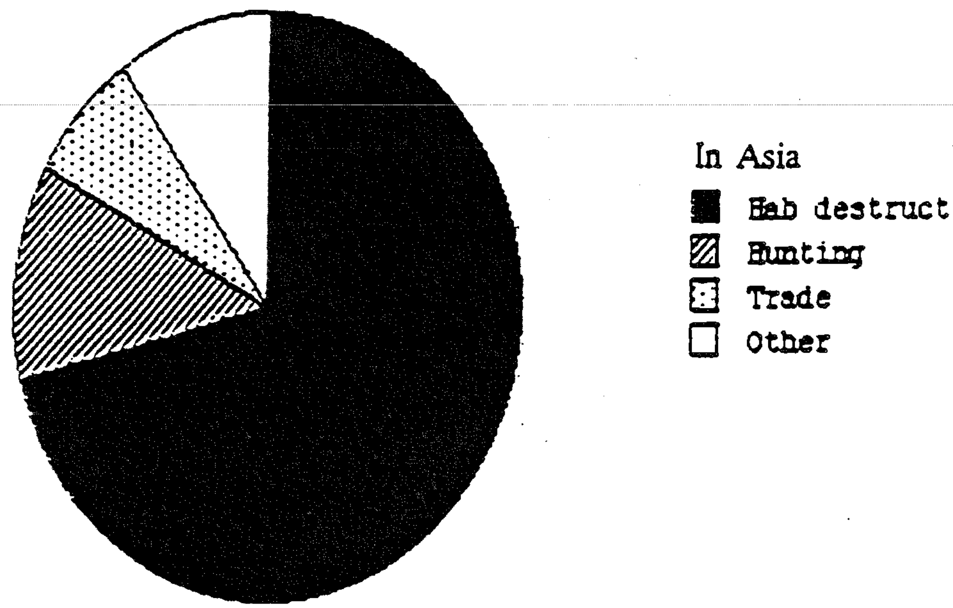
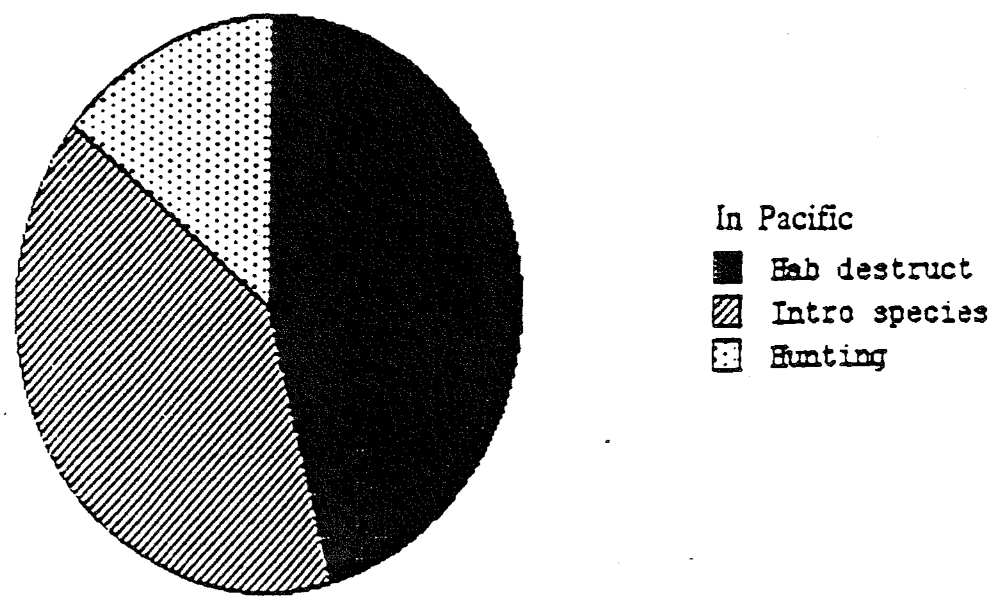
FIG 8. THREATS TO BIRDS





The Bali Starling *Leucopsar rothschildi* Stresemann 1912; its current Status and Need for Conservation

B.E. van Helvoort

Abstract. The Bali Starling Leucopsar rothschildi Stresemann 1912 is the only endemic bird-species of the island of Bali, Indonesia; in fact it is the only endemic vertebrate animal of the island. At present it is threatened with immediate extinction in the wild, were less than 35 birds survive (july 1989). The species is now limited to less than 4,000 hectares on the Prapat Agung Peninsula of the Bali Barat National Park. Without this species, the Balinese fauna is merely an impoverished version of the fauna of Java (with some eastern elements).

1. INTRODUCTION

A recent survey of threatened bird species of the world revealed that no less 1,000 bird-species or over 11% of the world's avifauna is presently threatened with extinction. Nearly one-third of all endangered bird-species occur in Asia, including South-East Asia. Regrettably, Indonesia is the world-champion with 126 bird-species threatened with extinction, of which 91 are endemic to Indonesia (COLLAR & ANDREW 1988) and for which Indonesia bears the primary responsibility. The main agent of extinction in Asia is habitat destruction (46%) but trade ranks third with 15%. Within Indonesia, the Bali Starling Leucopsar rothschildi Stresemann 1912 has the doubtful honour to lead not only the list of threatened birds:IT IS PROBABLY INDONESIA'S MOST THREATENED ANIMAL. Even on a world-scale this beautiful species ranks prominently amongst the most endangered bird species.

The Bali Starling is the only endemic bird-species, and indeed bird-genus, of the Island of Bali, West Indonesia. Not to mention the fact that the Bali Starling is Bali's only endemic vertebrate animal species. As such only the Bali Starling differentiates Bali's higher fauna from the surrounding islands.

It is known that approximately 310 bird species occur on Bali. For comparison, the neighbouring Island of Java in the west, which is 23 times as large as Bali, features 14 endemic bird-species but only 1 endemic genus (Psaltria) amidst its approximately 480 bird-species. Eight 'Javan' species, seven of which are endemic to Java, are threatened with extinction (COLLAR & ANDREW 1988).

Apart from the fact that the Bali Starling is the species that renders Bali's fauna unique, it is decidedly one of Bali's (many) tourist attractions: since 1986 an increasing number of "nature-and ornitho-tourists", including guided group-tours, have visited The Bali Barat National Park with the explicit intention to see this endangered species. As such the species is yet another source of the nation's foreign non-oil income. The species also raises scientific questions: How did it evolve? How can its parallelism to non-related African sturnids be explained ? etc. Not to mention its aesthetic and educational values. It would be a prudent and fitting act to choose the Bali Starling as a Provincial symbol for Bali.

Ever since 1966 the Bali Starling has been included in the Red Data Book published by the authoritative International Union for the Conservation of Nature and Natural Resources (IUCN). In 1970 the species obtained absolute protection under Indonesian Law. International trade is prohibited under the Convention on International Trade in Endangered Species (CITES).

A population census in October 1989 revealed that less than 30 birds survive in the wild (S. van BALEN 1989 pers.comm.) In sharp contrast, the world's captive population is estimated at some 700 birds. Instant action is most urgently needed.

In 1983 the Indonesian Directorate-General for Forest Protection and Nature Conservation (PHPA) requested the assistance of the International Council for Bird Preservation (ICBP), based in the United Kingdom, to implement a research-and feasibility-project : the Bali Starling Project was born. The project was embedded, in 1986, in the encompassing International Species Inventory System initiated in the mid-seventies by the American Association of Zoological Parks and Aquaria (AAZPA), U.S.A. and the New York Zoological Society (NYZS) to preserve endangered species through propagation in captivity and subsequent reintroduction into the wild. The Jersey Wildlife Preservation Trust (JWPT), an organisation with great expertise in that field, joined the international effort to preserve this unique species in 1987*.

The Bali Starling Project is due for revision in mid 1990, but suffers great financial problems, as it is mainly funded from a great many temporary and very limited grants from small organisations and individuals.

2. SPECIES DESCRIPTION

The Bali Starling was first discovered by scientists on 24 March 1911 near the North Balinese village Bubunan. It was described as : "Pure white; a terminal black bar, 25 mm wide, to all rectrices. Primaries, including the first, rudimentary one, with a black tip, increasing in width towards the middle. Iris dark brown; bill dirty brownish-yellow, base of lower mandible blackish-grey; bare orbital region dark blue; feet light-grey." It was placed in a new, mono-typic genus Leucopsar ('white starling') described as : "Structurally nearest to Gracupica Lesson but with bill differently shaped. Upper mandible with sharp, high, straight culmen, bent downwards near the tip. Nostrils completely covered by short bristles. Praeorbital, postorbital and superciliary regions bare. Feathers on occiput much elongated, forming a pendent crest." (STRESEMANN 1912).

Table 1 : Body dimensions of <u>Leucopsar</u> <u>rothschildi</u> from various sources.

CHARACTERISTIC	SEX	RANGE (mm)	AVERAGE (mm)	SAMPLE SIZE
Total length body	F	202-230	217.5	6
	M	212-245	231.4	5
Total length wing	F	121-133	128.2	8
	M	132-140	135.9	5
Total length tail	F	71-77	74.1	7
	M	80-82	80.8	5
Total length tarsus	F	31-38	35.4	7
	M	33-38	34.9	5
Total length crest	F	26-68	51.3	6
	M	43-90	64.6	5
(Exposed) culmen	F	22-24	23.1	6
	M	22-26	24.4	5
Height upper mandible	F	3.0-6.5	4.8	6
	M	5.0-7.0	5.9	5

To this description should be added the forwardly directed notches on the inner vanes of the 2nd to 5th primaries. Male and female plumage are precisely the same; there is only a slight difference in size but there is a large overlap between individual measurements to the extent that sexes are indistinguishable even in the hand. Table 1 presents some body dimensions.

Elsewhere in the family of the Sturnidae, the forwardly directed notches are only found in two sibling species of the pure African genus Lamprotornis, but this genus is by no means closely allied to Leucopsar. This feature is considered a case of parallelism (AMADON 1943, 1956), rendering the Bali Starling of particular taxonomical interest.

3. CLIMATE OF NORTH-WEST BALI

3.1. Rainfall

The north-western part of the Island of Bali, where the driest conditions are found (WALKER et al., 1980), features a dry monsoon climate. There is a wet season during the 'western winds'and a pronounced, lasting dry season during the 'eastern winds'.

In the past and current range of the Bali Starling the wet season extends, on average*, from December to April; the dry season from June to October. Year-to-year variation in intensity and timing is considerable and seasons have shifted by 4 months and more. In 4 out of 5 years the months January through March inclusive are 'wet' (monthly rainfall of 100 mm or more), coinciding with the height of the species' breeding season.

Typically, rainfall in Bali occurs in localised storms (WALKER et al. 1980) of which we could give some staggering examples. In this context it should be known that the Bali Starling disappears into the undergrowth for shelter at even the slightest drizzle. Information obtained locally indicates that Bali Starlings have been caught "masswise" (1970) when they were surprised by such storms in the open, soaken and disabled as they were then. They could "picked up from the fields like ripe fruits in the garden".

3.2. Temperature

As can be expected so close to the equator, temperature is extremely evenly distributed over the year, varying less than 3° C over the year (27-29° C). However, diurnal temperature variations are all the more significant. Day-and night-temperatures differ to the extent that a considerable amount of dew forms on the vegetation in the early morning. PAARDT (1929) observed the influence of local dew-formation on the delay of leaf-shedding of trees during the dry season on north-west Bali. We have repeatedly seen Bali Starlings drinking dew when no water was available during the dry season*.

4. POPULATION LEVEL AND DISTRIBUTION

4.1. Population Level 1911-1974

There are no accurate population censuses available prior to 1974 and cues to past population levels are scarce and to some extent contradicting. When PAARDT (1926) observed the species for the first time in 1911 (!) it occurred "very frequent in large flocks". In 1914, searching for the bird, he saw only 2 specimen. At the onset of the dry season of 1915 "we observed the bird frequently (...) even in flocks of 30 and more and sometimes many more." All PAARDT's observation almost certainly pertain to the area between the tiny Gunung Gondol Peninsula and the present day village Gilimanuk. STRESEMANN (1913), roving the eastern part of the bird's historical range, remarked that the Bali Starling "seems to be very rare". Except for the type-specimen that he shot in March 1911, he observed "... with certainty only one individual in the following week at exactly the same locality."

However, PLESSEN who surveyed the entire island and particularly the north-coast in 1925, exclaimed : "It were not just 5 or 10 they one could observe, no, hundreds ! (..) in smaller or larger flocks of at most 20 to 30 birds.", and states that the area around the present day village Teluk Terima, only 8 kilometres east of Gilimanuk, was probably its distribution centre. He also found that : "Within its distribution-limits this bird-species dominates all others, which are only scarcely represented here, contrary to the rest of Bali where (the other starling-species) are very frequent." Again this conflicts somewhat with PAARDT's statement, when he shot a pair in 1926 : "This was the only pair during more than 10 days on 300 hectares (...)." He also states that in the palm-savanna around Gilimanuk : "Amidst the numerous (Black-winged Starlings Sturnus melanopterus) Leucopsar is hardly noticed".

Summarizing, it seems that plausible that the Bali Starling occurred at lower densities on the eastern limits of its distribution on Bali, where it happened to be discovered first. In the west, coinciding with its present despondent resort in the Bali Barat National Park, it seems to have been more numerous. It is likely to have outnumbered other sturnids there, but this is certainly no longer the case, although today the Black-winged Starling is far less common in the Park than elsewhere on Bali. Overall the species seems definitely much more numerous in the past.

4.2. Population Level 1974-1989

There is a dire lack of even the barest cue as to the development of the wild Bali Starling population between 1925 and 1974, when the Indonesian Forestry Research Institute implemented a survey (SUNGKAWA et al., 1974). Since then almost yearly population counts are at hand, albeit of varying quality regarding effort, season and method (Table 2).

Notwithstanding that heterogeneity, it is clear at a glance that the wild Bali Starling population has declined to the extremely dangerous, in fact nearly hopelessly low level of (less than) 30 birds. One should apprehend that this includes the young and the old-aged : at the very best half of these birds, i.e. some 6-8 pairs, will breed in 1990. With luck they could produce (at most) some 6-8 young in the coming breeding season. That will be scarcely enough to replace the dead (not to mention the drain imposed on the population by poaching*).

Since 1981 the rate of decline of the Bali Starling population is a steady 25% per year, in spite of* all the concerted efforts made by the Bali Starling Project, the PHPA and the Bali Barat National Park to deliver the species from its grim fate.

4.3. Distribution 1911-1989

Leucopsar eventually appeared to be endemic to the Island of Bali and it appeared to be even Bali's only endemic vertebrate animal species. The only documented cases of its occurrence outside Bali, viz. in Jakarta, West Java, are obvious instances of escaped birds.

The Bali Starling was not at all distributed evenly over the island. In the mid-twenties it was only found in a narrow strip along the western third of the north-coast, from the present day villages Bubunan in the East to today's Gilimanuk in the West (PLESSEN 1926). It occupied roughly 30,000 hectares of uninhabited dry land and despite an intensive quest for it, it was not found elsewhere on Bali; reports to the contrary (HARTMAN 1970) are not substantiated with field research. This situation probably did not change much until the early seventies, although by then it was already quite rare in the eastern part of its distribution.

During the twenties the character of the region changed (PAARDT 1926, 1929; VOOGD 1937). Agricultural development progressed from the east, driven by an increase in human population. Even in those early days it was noted that Bali Starlings "shun people; as soon as a number of kampung-huts are build, the number of birds decreases; they let themselves noticeably be pushed back by humanity." (PAARDT 1926). This observation is supported by the distribution over time and space of the scarce specimen collected for musea (PLESSEN 1926A,B; PAARDT 1926; KURODA 1932,1933; collections at the Bogor and Leiden musea).

Table 2 : Population estimates 1974-1988. Some estimates have been adjusted for reasons of comparability. Numbers in brackets refer to birds outside the national Park; > means : 'at least as many as'.

MONTH,YEAR	ESTIMATE	REFERENCE
Oct 1974	100	SUNGKAWA et al 1974
Feb 1975	68-144 ("100")	NATAWIRIA et al 1975
Sep 1976	175 (+25)	SUWELO 1976
Jan 1977	>127	SIEBER 1978
? 1977	110	ALIKODRA et al 1978
Apr 1979	150-200 ("175")	IONGH 1979
? 1979	172 (+28)	SUTA ADI In: HAYWARD 1980
Aug 1980	>207 (+22)	HAYWARD 1980
Oct 1981	254	SUTA ADI pers.comm. 1983
Oct 1983	142	RUSTANDI pers.comm. 1983
Aug 1984	>104 (+1)	HELVOORT et al 1985
Oct 1987	47	ROCHADI et al 1987
Oct 1988	35	HELVOORT & SOETAWIDJAJA 1989

Since the start of the Bali Starling Project (1983) its range continued to recede from 6,000 hectares to some 4,000 hectares. Currently, the species is limited to -a small part of- the National Park. The last occasions on which single birds have been reported from outside the Park date back to 1984 and 1986.

5. ECOLOGY

5.1. Habitat

Contrary to a widespread believe, the Bali Starling is definitely not a (closed) forest bird. It seems to prefer Woodland and Tree-savanna, particularly when interspersed with forested valleys.

5.2. Food and Water

Basically the Bali Starling seems to be insectivorous, feeding on larger insects, but it is known from both the wild and captivity that they fourage on fruits, in the wild particularly during the height of the dry season, when insects are scarce. Then flocks seem to follow the fruiting of trees*, wandering from one area to another. They have been observed fouraging on dry reef-flats and feeding small skinks to their young. In captivity they even eat small fish.

There are no open water bodies in their current range. Birds have been observed drinking dew from leaf-tips. Water-stress may be important in the dry season.

5.3. Reproduction

The Bali Starling breeds in tree holes loosely lined with dry grass, twigs and an occasional feather. Normally 3 blue-green eggs [circa 32 * 21 mm.] are laid, of which typically 2 are hatched and 1 young survives. They probably produce only one brood per year due to the limited breeding season.

Breeding season lasts from January to April, but instances of earlier and later breeding have been reported [November-May]. The breeding season coincides with the rain season in North-west Bali.Possibly the abundant availability of insects late in the wet season, when the young are hatched plays a role. Bali Starlings are known to raise their young purely on insectivorous food in captivity.

6. CAPTIVE POPULATION

6.1. Captive Population dynamics

Table 3 : Captive world population of Bali Starlings from 1964 to present, based on the Rare Animals Census in the International Zoo Yearbook (1965-1983) with adjustments based on PKBSI (1980) and additions from the Regional Studbooks.

YEAR	WORLD CAPTIVE POPULATION	
	Total population	Known captive-breds
1964	50	5
1965	100	19
1966	11	17
1967	131	29
1968	115 (171)	39
1969	117 (173)	41
1970	121	48
1971	363	65
1972	492	106
1973	521	136
1975	598	319
1976	591	346
1977	615	383
1978	630	>373
1979	623	>464
1980	612	most
1981	567	most
1982	720	most
1990	c.700	majority

Bali Starlings were kept in captivity in Europe at least as early as 1928 and the first successful breeding attempt from two wild-caught birds occurred in 1931 (EZRA 1931a,b). The species remained a rare bird in captivity until 1970*; the world population ranged between 100 and 200 birds over that period. Between 1971 and 1981 a steep increase in captive Bali Starlings occurred*, superficially quite like the rapid expansion dictated by conservation biology (FRANKLE & SOULE 1980; SOULE 1986; SCHONEWALD-COX et al 1983). The captive world population seems now to have stabilized at some 700 birds, probably limited by the available keeping space and public attention. Details are given in Table 3.

We have made a population dynamic analysis, using age-specific ["horizontal"] life-tables, of 623 birds hatched in captivity in the period of rapid expansion, for which reliable pedigree information was available (HELVOORT 1988 unpubl.). This group comprises 65% of all birds hatched in captivity over that time-span. The analysis is based on information extracted from the Bali Starling Regional Studbook U.S.A. as per November 1987. The cumulative amount of Bali Starlings [dead, alive and unknown] listed in the U.S.A. Studbook is 1542.

The mean population generation time was found to be 6 years. The finite growth rate, lambda, for the complete population sample was 1.113, i.e. the captive North American population grew at a rate of 11.3 % per year over the period 1971-1978; it nearly doubled in 8 years. Between 1987 and 1989, and probably even earlier, the growth of the population has come to a halt and it is currently declining : from 487 in November 1987* to 410 in April 1989.

6.2. Captive Population Genetics

Biological conservation theory gives us an inspired rule of thumb as to the minimum short-term captive population level required to prevent an unacceptable rate of loss of genetic variation. The effective population size, the number of actually breeding individuals*, should be at least 50*.
The same rule of thumb requires an effective population size of 500, respectively 5,000 for the medium- and long-term preservation of original (wild) genetic variation in captivity. The concept of effective population size should not be applied to wild populations, for which the totally different concept of the minimum viable population has been developed (SOULE 1987).

We stress this approach to species conservation because we should not conserve 'a species', not even when its natural environment is also conserved in the process*. We must conserve at least the minimum conditions for the long-term [i.e. 1,000 and more years!] persistence and adaptation of the species to its natural environment : we must conserve the very process of natural evolution. In this approach there is a population-genetic, or if one likes, evolutionary element which is absent in the "species-and-its-environment conservation" approach. This is of paramount importance especially in any captive-propagation-for-reintroduction endeavour. Although a myriad of such conservation attempts can be browsed from the available literature, we are not aware of a single project that fulfils these requirements, including the Bali Starling Project.

From the population-genetic analysis mentioned in Section* good evidence was found that inbreeding in Bali Starlings is accompanied by an inbreeding depression*. Inbred Bali Starlings have a reduced viability, increased mortality rate, reduced life-expectancy and produce less young in their life-time. This makes inbred birds less suitable for captive propagation (or re-introduction?). Inbreeding should be avoided in the Bali Starling Captive Propagation Programme.

We could not detect, let alone quantify, other population-genetic defects. On theoretical grounds, corroborated with some experimental evidence from other species [including birds] it is expected that captive bred and captive raised Bali Starlings have unintentionally undergone an unknown amount of artificial selection of which we are not aware. It is likely that the genetic make-up of the population of captive bred birds eventually released into the wild differs from that of their wild relatives, even though the birds superficially [morphologically, physiologically] look perfectly the same to us simple humans.

HAASE (1985) found significant changes in the synchronization of male and female hormonal cycles in Common Mallard after only 1 generation of captive breeding, even though the circumstances under which the ducks were kept resembled those in the wild. It has been known for some years that captive Bali Starlings frequently accumulate large amounts of iron in their tissues (hemochromatosis), particularly the liver (GOSSELIN & KRAMER 1983; RANDELL et al 1981; WADSWORTH et al 1983); 80% of the birds on which a postmortem examination was done had excessive amounts of iron stored. In some cases this was the direct death cause, in many others it was suspected. There is reason to believe that there is a genetic base for this phenomenon*.

6.3. Captive Propagation

Biological conservation is very much a sort of crisis intervention science : generally conservationists are not allowed the time (and funds !) necessary to come to well designed conservation measures. Despite the caution we should take (See Sections 6.1. and 6.2.) we need to act now, not tomorrow. Captive propagation for reintroduction must be considered as our last resort, if and when all other efforts have failed.It is not a strategy to embark on light-hearted. The parabolic description of a dagger with two blades comes to mind : one blade may kill the enemy, but the other blade may [also] kill ourselves.

To avoid inbreeding a meticulously maintained studbook must be kept for the propagation group*. Great care must be taken not to reintroduce genetically inferior birds into the wild, where they may "infect" their wild conspecifics. Apart from that, the danger of zoo-born contagious diseases must be minimized and birds must be screened by a competent veterinarian before even taken to Bali*.

The number of descendants from each founder that are released into the wild must be monitored in order to avoid over-representation of certain 'breed-happy' individuals, i.e. family size should be completely equal and culling will be necessary. Redundant captive bred birds could be put to good use to replace wild-caught Bali Starlings in a kind of "white-washing" procedure.

Captive bred young, destined for release into the wild, should be transferred at the age of 8-10 weeks to the Pre-Release Training Centre in Bali, where they will be kept in absolute confinement, to prevent habituation or even imprinting on humans. The latter would make them tame and easy victims of poachers.

7. CONSERVATION MEASURES

It is not recommended to pay attention to artificial insemination and incubation, hand-raising, etc. for that would certainly introduce artificial selection.

The following is a concise list of the most urgent measures to be taken [the sequence does not imply any ranking according to priority]. Much more research on the wild and the captive populations are needed.

7.1. Public Awareness Programme

A public awareness programme initially directed at the population in the surroundings of the Bali Barat National Park would create understanding, popular support and hopefully participation. The programme would not necessarily have to limit itself solely to the Bali Starling, but should preferably also address more general concepts of nature conservation and the National Park.

A similar programme, directed at owners of captive Bali Starlings, may create practical support for the conservation attempt. It may just be possible to borrow such birds temporarily to introduce "fresh blood" into the propagation group* (see also below).

7.2. Guardening

Of preponderant importance is the protection of the remaining wild population in the Bali Barat National Park from any further poaching. An active policy of not only [defensive] patrolling, but also of pursuing suspected [groups of] individuals and law enforcement should be striven for. The exigency of improved guardening can not be overstated.

7.3. Habitat Re-unification

By virtue of the recent population decline there is now only one population in the wild. Up to 1986, however there were 2 sub-populations, separated [or at least greatly impeded in their exchange of individuals] by the existing 600 hectares plantation enclave in the Park. The management of the Park should be assisted at the provincial or even (inter)national level with its initiative to swap land at the periphery of the Park with the enclave.

7.4. Artificial Nest Boxes

The existing number of 90+ artificial nestboxes should be expanded. Other designs should be tried out and nestboxes should be installed at different habitat types and trees. Great care must be taken not to stimulate the possible nest-competitor Sturnus melanopterus.

7.5. Utilization of Private Birds

A "white-wash" operation along the lines of the successful national tax "white-wash" in 1985 or the perkutut Geopelia chinensis operation in 1980, should be sincerely considered*. See also our 1988 proposal.

7.6. (Re-)Introduction

A technique to prepare or train the captive bred young to their future life in a wild environment should be developed. Fouraging, particularly drinking, predator avoidance and partner selection are important elements.

In spite of the element of fauna falsification involved* the establishment of a feral population of Bali Starlings should be considered. The Baluran National Park, just across the Bali Strait in North-east Java has been recommended as a suitable candidate.

Re-stocking the currently surviving wild population in the Bali Barat National Park, or re-introducing the species into its past distribution outside the Park is only recommended if poaching has stopped completely. Even then it must be considered as the benteng terakhir (last resort).

7.7. RESEARCH

Research into the following aspects may be considered, provided sufficient time and resources [the list is not exhaustive] :

* continued monitoring of the population level;
* breeding-ecology and -dynamics, most urgently in the wild;
* (nest-)competition with other (sturnid) species;
* (seasonal) migration patterns in relation to food availability;
* habitat- and resources requirements;
* family-lines and founder-representation in the captive populations;
* qualification of the genetic variation in the captive populations;
* captive population dynamics;
* pathological genetics of the captive populations;
* behaviour, particular the relation between partner selection and captive breeding.

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BALI STARLING PROJECT III

(ICBP PHPA AAZPA JWPT)

Progress Report Jul 1987 - Sep 1990

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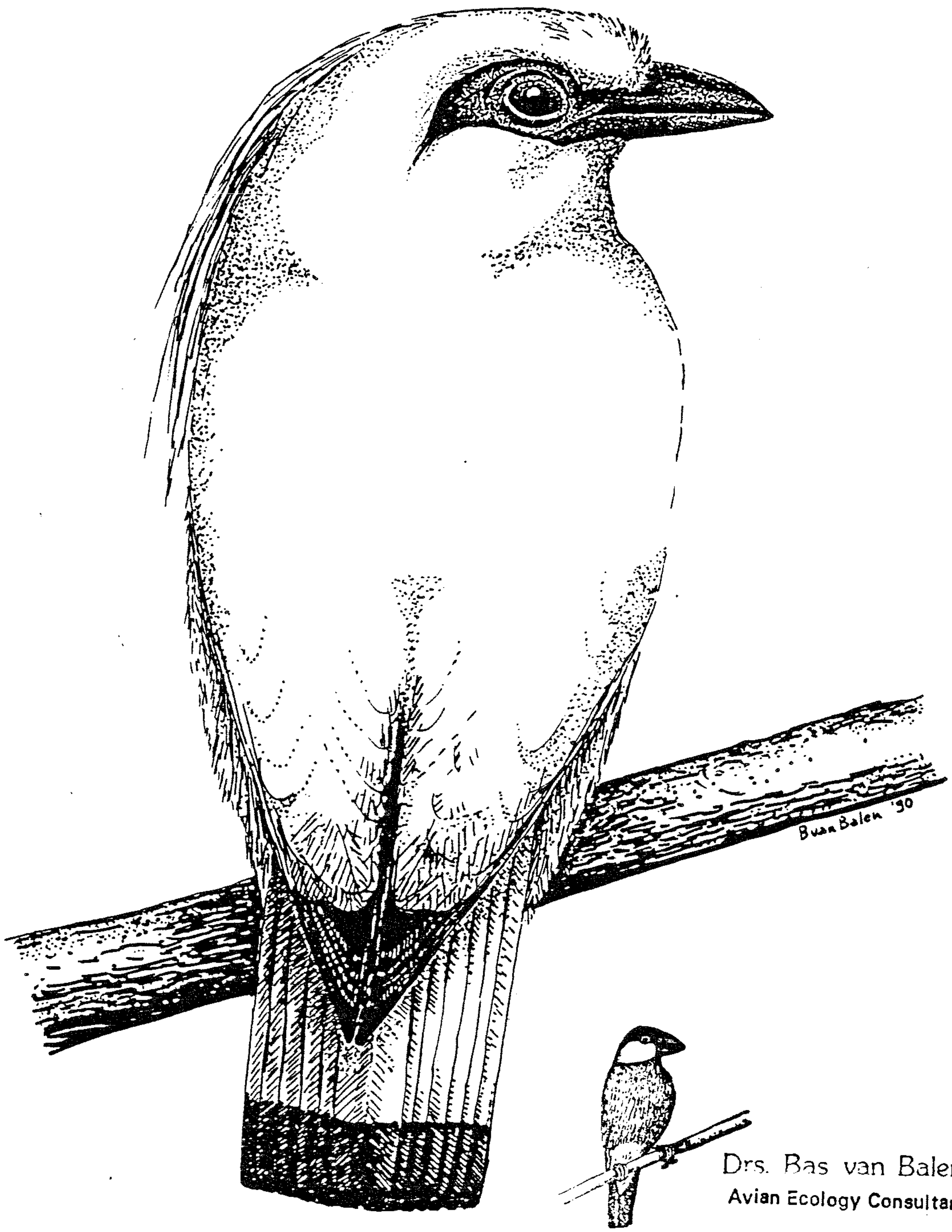

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BALI STARLING PROJECT III

(ICBP PHPA AAZPA JWPT)

PROGRESS REPORT JUL 1987 - SEP 1990

by

S. van Balen, B. van Helvoort & M.N. Soetawidjaya

Bogor/Gilimanuk, October 1990

CONTENTS

PREFACE

This report covers the period of more than three years (July 1987 - September 1990) of the third phase of the Bali Starling Project. The first phase (October 1983 - September 1984) comprised an ecological feasibility study (van Helvoort et al. 1985), the second phase (February - August 1986) formed the organisational and technical base for the planning and implementation of the third phase: the actual action phase, planned for five years during 1987/1992.
The third phase was initiated by B. van Helvoort (Project Investigator) and M.N. Soetawidjaya (PHPA Counterpart). Since April 1989, B. van Balen took over the position of Project Investigator.

An evaluation is given of the achievements hitherto during this third phase by reviewing the seven objectives of the Bali Starling Project, as outlined in the project proposal.

1. Continued monitoring of the remaining wild population, including yearly censuses, field observations and checking artificial nests.

Annual censuses (routine since 1987), involving more than 40 people of the Bali Barat National Park each time, and an almost daily monitoring by the project staff and PHPA wardens, closely followed developments in the remaining group of birds in the very restricted area of Teluk Kelor and a few other spots, mainly on peninsular Prapat Agung (See Figure 1). The area of distribution apprantly shrunk to a depressing extent: in former haunts where dozens have been seen not more than a few years ago (e.g., the Banyuwedang area), not even one bird was seen. In November 1989 during the last weeks of the dry season, a group of 11 birds was seen straggling throughout the Prapat Agung peninsula as far as Tegal Bundar at the south border. A group of at least eight birds was observed near Teluk Kelor one week after the starting of the rains and increased mating activity was observed: forming of pairs, displaying of single birds or pairs on exposed perches during considerably long sessions. The observation of juvenile birds (distinguished by their smaller size, clumsier behaviour and greyish wash over the

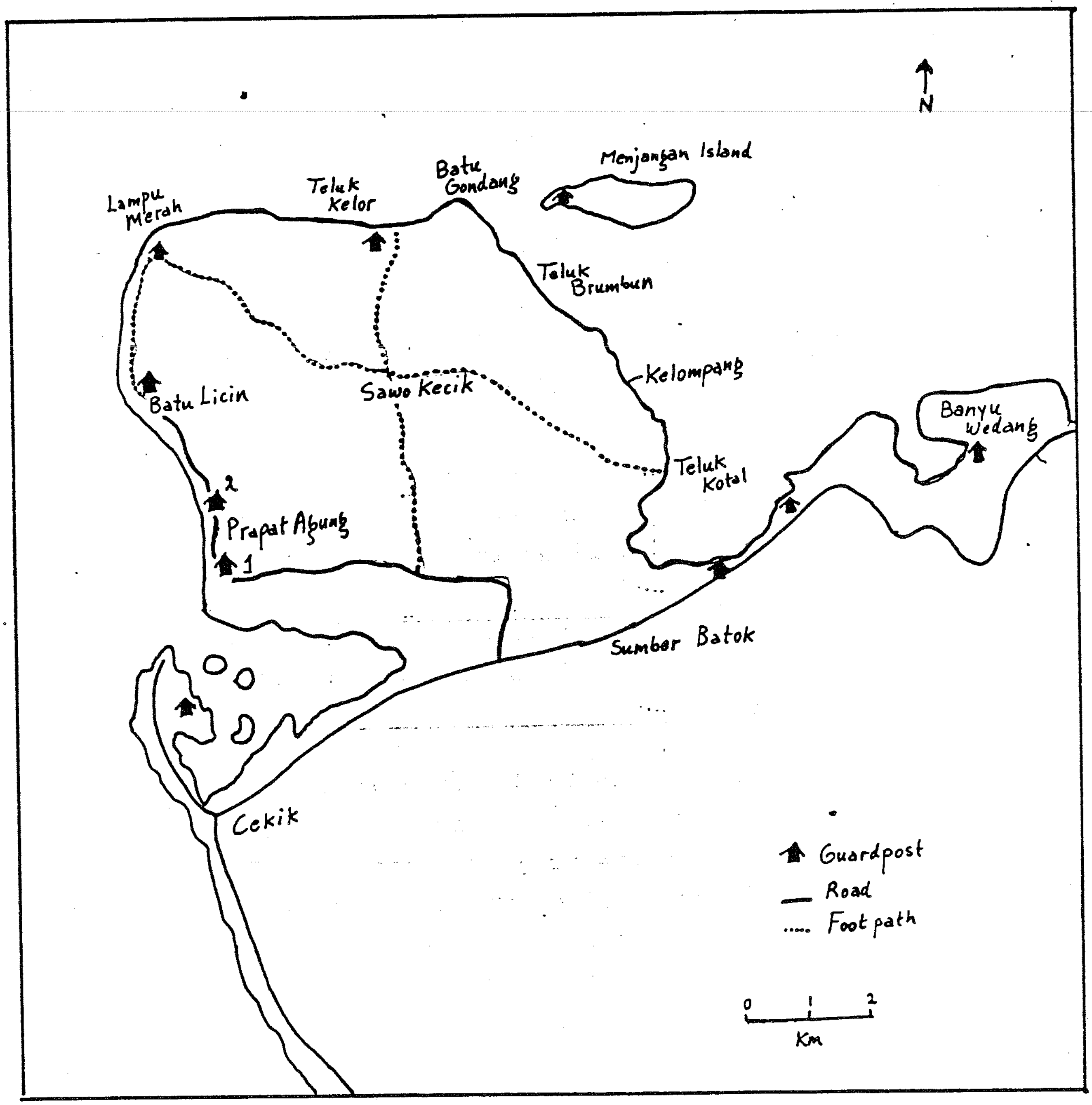

Figure 1. Map of the north-west part of Bali Barat National Park showing the localities mentioned in the text.

Table 1. Distribution of Bali Starlings over the different roosting sites in Prapat Agung peninsula, Bali Barat NP, 25-28 September 1989

	25 aft	26 mor	26 aft	27 mor	27 aft	28 mor	Max
1. Sawo Kecik	-	-	2	-	-	-	2
2. Pos Kehutanan	-	-	-	-	-	-	-
3. Prapat Agung 1	-	-	-	-	-	-	-
4. Prapat Agung 2	-	-	-	-	-	-	-
5. Batu Licin	-	-	-	-	-	-	-
6. Lampu Merah Dalam	-	-	-	-	-	-	-
7. Lampu Merah	-	-	-	-	-	-	-
8. Lampu Merah/Tel.Kelor	-	1	1	3	-	-	3
9. Teluk Kelor	4	2	1	5	5	5	5
10. Batu Gondang	9	11	13	13	13	9	13
11. Brumbun	2	2	-	-	-	2	2
12. Kelompang	-	-	-	-	-	-	-
13. Kotal	-	-	-	-	-	-	-
Additional birds *)	2	-	4	2	4	5	5
	17	16	21	23	22	22	30

*) birds presumably not entering or leaving a particular roosting site, but seen along the borders.

back) in a group of 25 birds in the beginning of 1990, and later associating with the released birds (at least two juvenile birds have been seen), prooved that the remaining group of wild birds was still productive. The most recent large group of starlings was seen on 4 May 1990, when a group of 21 birds, including some released birds, was observed at a roost (M. Rasma, pers. comm.). To prevent any disturbance of the birds at the Teluk Kelor site, entrance to the entire peninsula was prohibited for groups of tourists and permission was only given to small parties of serious visitors (consisting of less than 3-4 persons) under guidance of experienced wardens. Patrolling activities by the park wardens (which was almost nil outside the Teluk Kelor area and very much hampered in this area because of problems with the provision of drinking water) was increased by the provision of equipment such as maps, jungle knives, haversacks, rain coats, etc. Moreover, the seaworthy motorboat, especially constructed in 1988 for the Bali Starling project, was regularly used to overcome these logistic problems. In cooperation with the head of the national park and his staff, a new patrolling system was designed, which, in its full operation, would guarantee a coverage of the entire peninsula.

Poaching activities in and around the roosting and nesting sites were given much attention. Though disturbance of the birds seemed to have been under control and the group size did not seem to have changed between the last census in September 1989 and the weeks prior to the release in April 1990 (see below), evidence of poaching was found only a few weeks later, only some hundred meters away from the release site. Local informants reported the capturing of five Bali Starlings in late March by different groups of poachers, mainly from Java; in the third week of June 1990 evidence came available in the form of a bird in the hands of a dealer, which turned out to be one of the released birds!).

During 25-28 September 1989 the annual census was carried out. Procedures followed as closely as possible those of previous censuses (1984, 1987, 1988; see earlier reports by B. van Helvoort) and differed only in the choice of some census localities (omitting those where no birds had been

seen since the last years). During three mornings and three afternoons, roosting sites in thirteen localities were observed by teams of three men and numbers were registered during two hours (see Table 1). The total population of Bali Starlings in Bali Barat National Park was estimated at a minimum number of 24 birds (including one seen at Cekik), i.e., the largest day number, and a maximum number of 31 (including the Cekik bird), i.e., the total of maximum numbers counted at each site.
The 1990 census is planned to be carried out in the beginning of October.

2. Assess the results of the artificial nests installed in 1984 and 1986, and expand this component of the project with an additional quota of approximately 75 nest boxes

During 23-25 June 1989, after the Bali Starling's breeding season, 49 nest boxes and logs in the areas of Lampu Merah, Batu Licin and Prapat Agung have been inspected and cleaned. They comprised more than 50% of the artificial nest that have been put up in the park. Of these boxes and laogs, one box had disappeared; two boxes and two logs were so heavily damaged taht they were useless for nesting. Of the remaining 41, 31 boxes and logs contained evidence of having been used by birds: six with remains of very old nests, 20 with more or less recently used nests, and six were still in use: five by Black-winged Starlings Sturnus melanopterus and one by a pair of Magpie Robin Copsychus saularis. Problems encountered included the use of six nests by honey-bees and the numerous gecko's (sometimes up to six in one nest). The large lizards were found in 15 boxes/logs and most likely scare off birds that intend to use the nest sites. Ants (several species) were abundant in 11 nests. In none of the nests evidence of being used by Bali Starlings (e.g., feathers) was found.

In June-August 1990, 96 nest boxes and logs throughout the Prapat Agung peninsula have been inspected. All twelve boxes installed in 1984 were in good condition, whereas all twelve logs were in much poorer state, and most could not be used anymore. 30% of the 36 1986 boxes was worn-out, against 60% of the logs. Twelve nests contained bees, twenty gecko's, but still a high number seemed to have been used by birds (though the presence of twigs, leaves and feathers does not always exclude the possibility of having been used by small rodents), i.e. 54 (ca 56%), amongst other species Black-winged Starling Sturnus melanopterus (18 nests) and Magpie Robin Copsychus saularis (two); two nests, one in a log, another in a box, contained, apart from twigs and the remains of bluish egg shells, the unmistakable feathers of Bali Starling.

Though increased monitoring of the nest boxes/logs may yield more proof of use by Bali Starlings, it is believed that the need for artificial nests has decreased in the area, due to diminished numbers of potential users, including the Black-winged Starling, a species that also suffers heavily from poaching activities in the park. Therefore the production and putting up of additional nest boxes was prosponed. Moreover, a larger number of artificial nests may make effective monitoring even more difficult and the boxes would increasingly run the risk of being plundered by poachers. The bird, confiscated in early 1990, with a malformed bill due to handraising, may have been such plunder.

3. Set up a Bali Starling Captive Propagation Centre (CPC) at the Surabaya Zoological Park, E Java, and a Pre-release Training Centre (PTC) in the Bali Barat National Park, West Bali.

The renovation of the breeding units, consisting of 29 aviaries in KBS (Surabaya Zoo), was carried out in August-November 1987 and provided the breeding facilities for the group of Bali Starlings that was already present in the zoo (16 birds) and the founder group that was transported from USA and UK (see below).

The building of a brandnew PTC was completed in June 1988, under supervision of the BSP counterpart. The construction of the unit of ten aviaries of each 5x3x2 m, followed the design of the CPC, and as its location the grounds of the Bali Barat NP Research Centre at Tegal Bundar was chosen. The PTC is strictly closed to general public and sufficiently isolated to reduce any habituation of the birds to humans, including the keeper.

4. To start a Captive Propagation Programme (CPP) at the CPC with imported captive bred Bali Starlings as the founder stock, and train and condition juvenile Bali Starlings from the CPP prior to release on Bali

In 1987, 39 birds, captive bred in the United States and United Kingdom, of which seven died during the transport and shortly after arrival, arrived in the Surabaya Zoo.

Though in the following years egg hatching rate was satisfyingly high, most chicks died within a short time and only 17 birds, which could be used for release, have been raised during the programme until now. In Figure 2 breeding results **) during three years (1988-1990) are shown. A sharp increase in the number of eggs laid is clear in August after the introduction of new nest boxes following the design widely used in the USA, that induced many more birds to lay eggs. However, the death rate amongst the chicks remained disappointingly high. None of the British birds laid eggs, even after the instalment of the new nest boxes. Other suggestions for the improvement of the breeding success, i.e. the screening off the cages from neighbouring ones and from the many visitors to the Zoo, the recombination of unsuccesfull pairs and the application of an anti coccidiosis treatment have not been implemented yet.

On 10 August 1989 the Surabaya Zoo was visited by burglars and the KBS pair DN58316/DN58315 was stolen; this was followed by another burglary on 10 September 1989, when the American pair 787/1082 was stolen.

In july 1988 the first group of three birds* from the Surabaya Zoo was accomodated in the PTC in Bali Barat NP and entrusted to the care of the birdkeeper, Mr Slamet Suparto. In order to adjust the birds to the future new environment, they received a training of ca six weeks during which not only foraging in the wild, fear of humans (by a complete screening of the cages to avoid direct contact with visitors and the bird keeper) was focused on, but the birds had to be gradually accostumed to the boxes in which they were to be transported to the spot of release. In the field the birds would be .

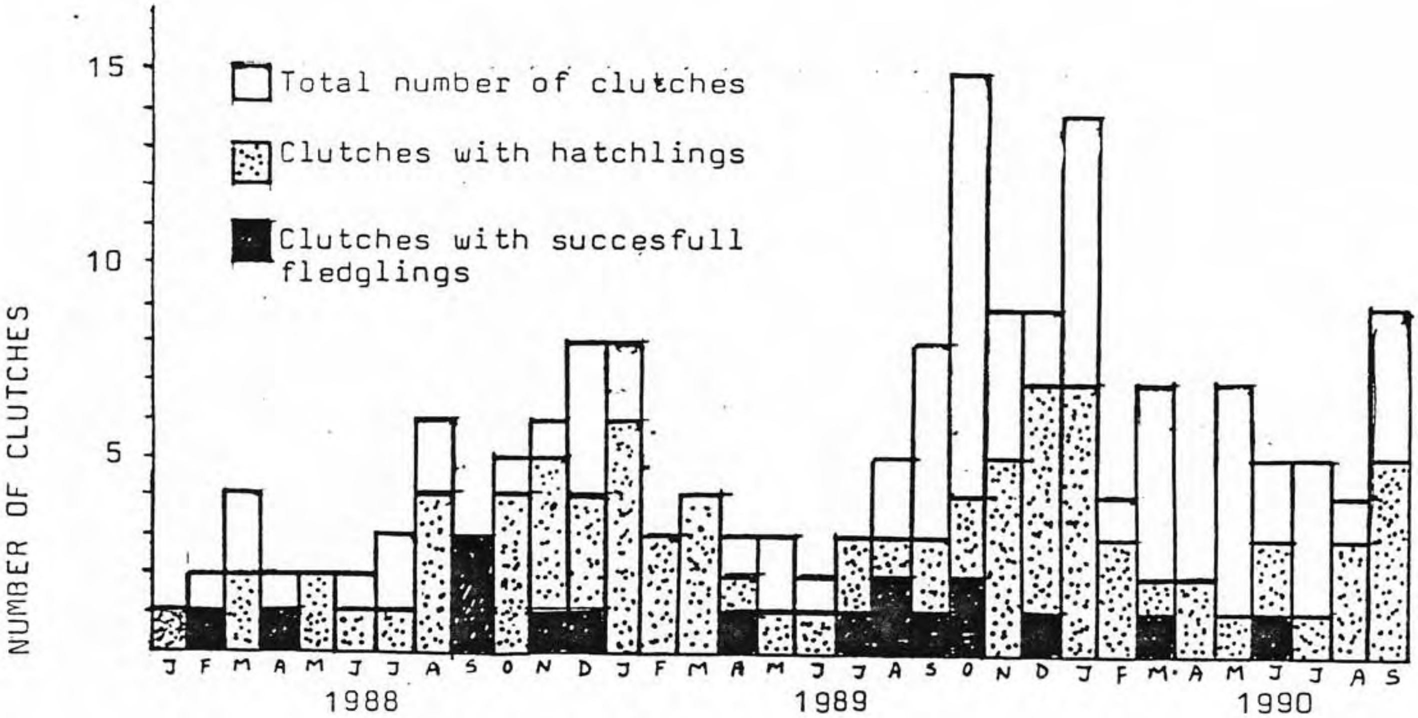

Figure 2a. Breeding data of the Bali Starlings in the Surabaya Zoo, 1988–1990.

Figure 2b. Breeding pairs housed in the Surabaya Zoo and their released offspring.

BREEDING PAIRS

RELEASED PROGENY

KBS	912x 926	787x1082	1634x1320	1143x 916	1626x1638	1635x1641	377x1387	1009x 849	1461x1088	1624x1478	1598x1206	1389x1643	812x 467	1625x1642	0160x0142	0135x0170	DN58314x58310	DN58326x58325	DN58313x58319	DN58318x58312	DN58328x58327	DN58320x58323	DN58316x58315
1																	*						
2																	*						
3																	*						
5		*																					
6			*																				
8		*																					
9				*																			
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12									*														
14		*																					
15									*														
25									*														
28				*																			
31									*														
42									*														
57			*																				

loose the birds too early from the site (the cage bird would always attract the released ones).

On 25 April 1989 eight captive breds (KBS 5-14, see Table 2) were brought over from the KBS breeding stock to Bali Barat. Data on age, parents, etc are listed in Table 2. Due to stress one of the birds died on 14 May 1989 (KBS 11); another bird (KBS 12) lost one of its legs and became unfit for release (the metal band attached to one of its legs got stuck in the net wire of the cage; trying to release itself, it injured the leg, probably aggravated by attacks of its cagemate; medical assistance from the local veterinary, Dr Ketut Sonen, and antibiotics could not prevent the loss of the larger part of tarsus and foot). Siblings KBS 9 and KBS 10, and siblings KBS 5 and KBS 8 were held together, which was presumed to be no problem; because of the temporary character of their staying in the PTC (initial plans were to release the birds within a few weeks) undesirable pair forming between the siblings seemed unlikely (see below). All other birds were kept separate because of their aggressive behaviour towards cagemates. The birds were given various kinds of fruits found in the wild, and known to be consumed by Leucopsar. They readily took little reptiles, arthropods such as millipedes and even scorpions that entered their cages; they also showed the right reactions towards birds of prey flying over.

In early 1990 two birds, confiscated in E Java, were added to the PTC group; one of these was considered for release, the other was assumed to be unfit, as its malformed bill suggested hand raising (the latter bird died on 23 June 1990 after a short period of sudden weakness; the bird appeared to be fully contaminated with feather mites, which it could not remove as its bill did not function as tweezers).

On 3 April 1990 another six captive bred birds were transported from KBS to Bali Barat (KBS 15-57; see Table2) and housed in the PTC.

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5. To train the CPC Supervisor in the USA in all aspects of the practise and theory of the captive propagation of birds

supervisor of the Bali Starling Captive Propagation Programme (CPP) in Surabaya, in August - October 1987. The complete course consisted of:

- a general training in the Captive Breeding of Endangered Species at the Jersey Summer School, England (four weeks)
- an individual programme focussed on the Bali Starling, also in Jersey (two weeks)
- an individual programme at several zoological parks in USA, all holders of significant numbers of Bali Starlings and future contributors to the founder stock for the CPP (four weeks).

Though conceptually a part of the Bali Starling Project, this training course was independently organized and funded by AAZPA and JWPT.

Mr Harwono Gepak became responsible for the daily supervision of the CPP; the BSP investigator paid approximately quarterly visits in 1987/1988, and monthly visits in 1989/1990 for consultation and coordination.

6. To release Bali Starlings bred at the CPC in Surabaya either in the species' former range (reintroduction) or in its present range (restocking)

The attempt to reintroduce the first group ended in one casualty and the complete disappearing of two other birds. The extremely dry conditions and strong wind at the time of release (August 1988), the birds' unfamiliarity with the area and the location of the release site away from any existing roosting site, may have been due to the failure.

The second attempt was planned in April 1990 near Teluk Kelor (see Figure 1), the last location where Bali Starlings were known to roost regularly. On 13 April 1990, on the day the birds were transported to the release site, transponders (for which a scanner was handed over by Dr Bruning to the Bali Starling Project on 4 September 1990) were inserted and colour rings applied (see Table 2 for numbers and codes). Special heavy duty metal rings, designed for the Bali Starling conservation programme, were applied to the two confiscated starlings (BS 002, 003). Breast feathers of the

Table 2. Data of the transpondered Bali Starlings

Band number	Colour Code	Transponder Code	Birth Date	Sire (Studbook	Dame nrs)	Release Date
KBS 5	bb	7F7F002E39	21.07.1988	787	1082	15.04.1990
KBS 6 4)	kb	7F7F00045	4.09.1988	1634	1320	18.04.1990
KBS 8	kk	7F7F00047C	5.09.1988	787	1082	18.04.1990
KBS 9	ob	7F7F007168	6.09.1988	1143	916	17.04.1990
KBS 10	ko	7F7F003760	6.09.1988	1143	916	17.04.1990
KBS 12	-	7F7F000B59	20.11.1988	1461	1088	- 2)
KBS 14	oo	7F7F00545E	25.11.1988	787	1082	15.04.1990
KBS 15	ok	7F7E6C3B32	11.04.1989	1461	1088	15.04.1990
KBS 25	bo	7F7E6D030E	12.07.1989	1461	1088	20.04.1990
KBS 28	o	7F7E6D1871	7.08.1989	1143	916	15.04.1990
KBS 31	b	7F7E6D2529	5.09.1989	1461	1088	19.04.1990
KBS 42	bk	7F7E6D2E44	27.10.1989	1461	1088	19.04.1990
KBS 57	k	7F7E6D3000	21.12.1989	1634	1320	17.04.1990
BS 002	o 1)	7F7E583235	-	-	-	21.04.1990
BS 003	-	7F7E6E440B	-	-	-	- 3)

1) orange plastic ring at one leg, metal (plain) ring at the other. (in stead of blueish metal ring at the other birds)

2) not released because of missing one leg

3) not released because of malformed bill.

4) poached in June 1990 and discovered in the hands of a dealer.

Table 3. Observations of released Bali Starlings on the release site (⊠) or elsewhere in the neighbourhood (X).

Date \ Ring nr KBS BS	5	6	8	9	10	14	15	25	28	31	42	57	002
15 Apr	⊠					⊠	⊠		⊠				
16	⊠					⊠	X		⊠				
17	⊠			⊠	⊠	⊠	⊠		⊠			⊠	
18	⊠	⊠	⊠	⊠	⊠	⊠	⊠		⊠			⊠	
19	⊠	⊠	⊠	⊠	⊠	⊠			⊠	⊠	⊠	⊠	
20	⊠		⊠	⊠	⊠		⊠	⊠	⊠				
21	⊠		⊠	⊠	⊠		⊠	⊠					⊠
22	⊠		⊠	⊠	⊠		⊠	⊠			⊠		
23				⊠	⊠		⊠	⊠			⊠		X
24	⊠		⊠	⊠	⊠		⊠	⊠					
25			⊠				⊠	⊠			⊠		
26								⊠			⊠		
27				⊠	⊠			⊠			⊠		
28 –								⊠					
30 –					⊠			⊠					
2 May –					⊠			⊠					
4 –							⊠	⊠			⊠		
6								⊠					
7 –				⊠			⊠	⊠			⊠		
10				⊠							⊠		
11 –					⊠			⊠		⊠	⊠		
20		⊠											
21 –							⊠				?X		
24	⊠	⊠	⊠	⊠			⊠				⊠		
25							X						
26 –				⊠							⊠		
28 –				X									
30 –		⊠			⊠			⊠					
21 Jun							⊠						

Prior to release the area was surveyed for a suitable site, which was found a hundred meters uphill south west of the Teluk Kelor guard post. Apart from security, the site also provided good orientation opportunities to the birds, being situated on the border of an open grass field on the hill slope. The project boat enabled the project staff to transport the birds and equipment over sea in a relatively short time with little effort. Procedures for the release did differ mainly from the previous one in timing (rainy season vs mid dry season), locality (Teluk Kelor/north peninsula vs Tegal Bundar/south peninsula) and release schemes (one by one, not alternatingly). Larger release cages were needed and a temporary, two compartment cage (2x2x2.50 m) was built on the site to serve as training accomodation. The two birds unfit for release (KBS 12, BS 003) stayed in the cage to assist the released birds finding back the supply of food and water in the first weeks.
On 15 April 1990, witnessed by the head of the National Park, Mr H. Rochadi (and his wife), section heads Mr Mufti (and his wife) and Mr Made Soeta Adi, and ca 15 wardens, the first four birds were released from the cage were they had been housed during the last two days. On 17 April three birds were released, followed by two, two, one and one, each consecutive day. Table 3 gives the data on visits of the birds to the release site, where during the first weeks food (bananas, papayas, mealworms, pellets) were provided. On 11 May and 21 June the site was visited again and throughout the day every visit of the starlings was noted down. Daily monitoring of the birds was done by the PHPA guards in the weeks directly after release. Reading of the ring codes, however, became increasingly difficult as the released birds became soon very wary. Only those birds that kept visiting the release site, could always be identified. In appendix 2 the release accounts for individual birds are given. Apparently the birds did not need much time for adjustment to the new environment. Most of them became independent of the provision of food and water very soon and were joining wild feeding and roosting flocks already on the first days of release. Some pairs between released and wild (first year) birds were formed within a week; copulation

was observed in the beginning of August 1990, at Sumber Batok eight km south east of the release site.

Though earlier designs of release procedures suggested ages of the birds of the birds to be released, as young as possible, it appears from the field observations, that age (below two years) did not influence release success, at least not negatively. Also being paired or not in the PTC seems to make no difference: KBS 5 and KBS 9 were seen weeks after release, and did apparently well, without their resp. siblings/cagemates KBS 8 and KBS 10; the other two birds observed weeks after release in good health were both held separate, though during a very short period, in the PTC.

7. To advise and assist Indonesian governmental institutions on matters of captive breeding, release of certain bred birds, habitat-management and improvement, information extension, research for the conservation of the Bali Starling and its environment

On 29 July 1989, BSP and Bali Barat NP organized an introduction day for local authorities (government officers, police and other civil services). Main purpose was to introduce the project, its objectives and problems to the participants and to ask for their assistance. The programme included introductory talks by the head of the national park, the Bali Starling Project investigator and staff of the Surabaya Zoo; an excursion to the PTC, a field trip to Teluk Kelor to see the Bali Starling habitat; a discussion on Menjangan Island; the presenting of framed posters to the participants. The meeting resulted into a number of articles in a local newspaper (Bali Pos) and a national magazine (Editor); see Appendix 3, where also other articles published during 1987-1990 are listed.

Framed posters (the ICBP/JWPT/AAZPA/PHPA Bali Starling poster) were distributed and put up in a large number of public places throughout Bali, i.e., schools, hotels and the airport in Denpasar.

Since 1988, BSP is represented on fairs organized by local authorities for their district services. The BSP/Bali Barat public as well as the organizing committees.

More than fourty people (see Appendix 4) of in total seven different nationalities, more or less directly involved in the Bali Starling conservation programme and experts in various fields of research and management, or merely interested in the project and its aims, came together in Bogor during a three day session, the Bali Starling Population Viability Assessment Workshop (22-24 March 1990). These three days of intensive informing, analysing and formulating of future steps in our attempts to save the Bali Starling resulted into a number of recommendations, that have been distributed amongst the participants and other interested people, in English and Indonesian, and will be followed by the proceedings, currently being prepared by Dr U.S. Seal,(chairman of the Captive Breeding Specialist Group) who directed the workshop. Recommendations referred to the follwing topics:

1. Management of Bali Barat National Park
2. Field programme: basic monitoring and detailed ecological studies.
3. White wash campaign
4. New facilities for captive propagation centers
5. Husbandry guidelines
6. Records and studbook
7. Bali Starling education programmes.

An increasing attention for the Bali Starling Project was attested by the growing number of Indonesian and foreign visitors that took the considerable effort to visit the PTC. Here explanation on the project by the BSP staff and by means of leaflets was being given.

Plans to build a cage near the Bali Barat NP head quarters in Cekik, with some unproductive starlings on display, have not been realized yet (two surplus birds brought over in April 1990, nrs 377 and 549, from the Surabaya Zoo to Bali Barat, and housed in a renovated cage near the PTC, were stolen ca one month later).

During 1987/1990 numerous groups of schoolchildren and students from universities on Java and Bali, and interested in the Bali Starling, visited the national park. Three students from universities on Java carried out studies for their of Bogor; habitat), I Ketut Nurana (Agricultural Un. of Bogor; captive breeding) and Yusup Cahyadin (Padjadjaran University, Bandung; feeding ecology) who started recently.

A visit to the Governor of the province of Bali is planned in October. A team of representatives of PHPA Bogor, Surabaya Zoo, Bali Barat National Park, ICBP and PKBSI (Indonesian Assiociation of Zoological Parks) will discuss the Bali Starling Conservation Programme. First reactions from the Governor about the programme were very positive and much is expected from the visit with regard to the until now rather unsuccesfull attempts to protect the starling's habitat in the national park and environs, to the proposed transmigration of the entire enclave village in the park and to an increased mobilisation of local authorities to safeguard the area from poaching, etc.

MISCELLANEOUS

In June 1987 a memorandum of understanding on the Bali Starling Project was signed by the representatives of the four parties involved in the conservation programme, i.e. the government of Indonesia, ICBP, AAZPA and JWPT. A renewal of the MOU took place in June 1990, for another two years, during the Bali Starling PVA workshop. As a matter of fact, cooperation was not restricted to these four parties and in the following section the different institutions, as far as not mentioned in the text, contributed significantly to the programme, are listed and a short explanation is given on the type of cooperation.

PKBSI: chairman Mr D. Ashari and PKBSI member Mr Ismu Suwelo made the contacts with the governor of Bali and arranged the meeting planned in October 1990. PKBSI was also closely involved in the arrangements made for sending over the American birds to the Surabaya Zoo, and the preparations of the White WashCampaign (see below).

Worldbank: in the "National Parks Management Project", carried out by a New Zealand team of consultants and Indonesian counterparts, the development of the Bali Barat National Park for tourism takes an important place. The advisory function of the Worldbank team is hoped for as to the protection of key sites for the preservation of Bali Starling habitat

Ministry of Human Population and Environment (KLH): a delegation of the minister's secretariat visited the Bali Barat NP and the Surabaya Zoo for the gathering of information on the Bali Starling conservation programme. A planned meeting with the minister of KLH, during which steps to be undertaken in a cooperative programme with KLH, PHPA and ICBP/BSP, would be discussed, has been prosponed until now.

In 1987 the idea of "white washing" illegally kept Bali Starlings was brought forward by Mr D. Ashari (PKBSI chairman): private keeprs of Bali Starlings would be politely requested to report their ownership; during a (yet to be determined) period, they will be given amnesty while the birds become property of the PHPA and will be added to the captive breeding stock or released into the wild. In 1988 a working plan was designed. 1989/1990 formed the preparation period during which an inventory of Bali Starlings in private hands was to be made, and existing laws were studied and amended. To date, a number of 40-45 birds has already been localized (E. Sumardja, pers. comm.) during one year of inventory. Next step will be undertaken in January 1991, after the campaign had been published in newspapers. Then the owners will be approached, and, after registration, a blood test and tagging the birds become state property, for which a certain tax will have to be paid.

CONCLUDING REMARKS

The Bali Starling PVA Workshop held in March 1990 provided a wealth of information and recommendations, guidelines and conclusions for the Bali Starling conservation programme, to which not much is to be added in this postscript. New, however, is the relative success achieved with the release of thirteen captive bred birds of which to date two to four birds (at least) are still doing fine in the wild. Furthermore much is to be expected from the meetings with the governor of Bali and the minister of KLH. The Indonesian government's concern about the Bali Starling's well-being is shown by the recent adoption of the Bali Starling by the province

APPENDIX 1. BREEDING DATA 1988-1990 Bali Starlings at the captive breeding center of the Surabaya zoological gardens

1. ♀ 912 x ♂ 926

1988

2 Mar E
12 Mar Ha
24 Mar one chick +

31 Mar E
16 Apr Ha
23 Apr chick +

7 May E
19 May Ha/chick +

20 Aug E
30 Aug Ha
14 Sep chick +
3 Oct KBS 7 separated
25 Dec KBS 7 +

6 Oct E
20 Oct Ha
14/16 Nov chicks +

20 Dec E

2. ♀ 787 x ♂ 1082

7 Jun E
19 Jun Ha
23 Jun chick +

10 Jul E
21/22 Jul Ha
22 Aug chick +

22 Aug E
5 Sep Ha
25 Oct KBS 5 & KBS 8 banded

6 Oct E
19 Oct Ha
6 Nov chick +

13 Nov E
27 Nov Ha
2 Dec chick +

10 Dec E
25 Dec Ha
30 Dec chick +

3. ♀ 1634 x ♂ 1320

24 Aug E
4 Sep Ha
27 Sep KBS 6 separated

7 Oct E
20 Oct Ha
7 Nov chick +

17 Nov E
1 Dec Ha
8 Dec chick +

20 Dec E

4. ♀ 1143 x ♂ 916

25 Aug E
6 Sep Ha
16 Sep chick +
6 Oct KBS 9 & KBS 10 separated

30 Oct E
11 Nov Ha
14 Nov chick +

20 Nov E
4 Dec Ha
8 Dec chicks +

20 Dee E

5. ♀ 1626 x ♂ 1638

28 Sep E
12 Oct Ha
9 Nov chick +

29 Nov E
5 Dec Ha
6 Dec chick +

19 Dec E

6. ♀ 1635 x ♂ 1641

18 Dec E

7. ♀ 377 x ♂ 1387

9. ♀ 1461 x ♂ 1088

1988 7 Nov E
20 Nov Ha
23 Dec KBS 11 & KBS 12 separated

24 Dec E

10. ♀ 1624 x ♂ 1478

13 Feb E
26 Feb Ha
5 Mar chick +

30 Mar E
3,5 Apr Ha
8,9 Apr chicks +

20 Apr E
4 May Ha
12 Jun chicks +

13 Jun E
28 Jun eggs broken

15. ♀ DN 58314 x ♂ DN 58310

3 Jan E
15 Jan Ha
18 Feb KBS 1 separated

27 Feb E
10 Mar Ha
3 Apr KBS 2, KBS 3 separated
16 Apr (KBS 4) +

5 Aug E
31 Aug eggs rotten

6 Nov E
20 Nov Ha
23 Dec KBS 13 separated

24 Dec E

16. ♀ DN 58326 x ♂ DN 58325

5 Aug E
19 Aug eggs rotten

7 Sep E
10 Sep egg rotten

17. ♀ DN 58313 x ♂ DN 58319

22 Jul E
6 Aug Ha
7 Aug chick +

20 Aug E
2 Sep Ha
11 Sep chick +

30 Oct E
15 Nov Ha
19 Nov chick +

8 Dec E

1989

1. ♀912 x ♂926

5 Jan Ha
11 Jan two chicks +

20 Jan E
4 Feb Ha
10 Feb one chick +

9 Mar E
21 Mar Ha
3 Apr one chick +

14 Apr E
27 Apr Ha
9 May chick (KBS 16) +
15 May chick (KBS 17) +

2 Jul E
14 Jul Ha
4 Aug chick (KBS 26) +

22 Aug E
30 Aug Ha
23 Sep chick (KBS 29) separated
~~18 Oct chick KBS 29 +~~

16 Oct E
26 Nov eggs rotten

2 Dec E
20 Dec Ha (KBS 55)

---

2. ♀ 787 x ♂1082

2 Feb KBS 14 separated

22 Jan E
10 Feb eggs broken

4 Mar E
14 Mar eggs broken

17 Apr E
3 May Ha
15 May Chick KBS 18 +
17 May chick KBS 19 +

9 Jul E
9 Aug eggs rotten

2 Sep E

10 Sep birds stolen

---

3. ♀ 1634 x ♂1320

3 Jan Ha
10 Jan chick +

10 Feb E
13 Feb eggs broken

20 Feb E, thrown out

6 Jun E
25 Jun eggs rotten

24 Sep E
10 Oct Ha
18 Oct chicks KBS 38 & 39 +

8 Nov E
22 Nov Ha
24 Nov : chick KBS 53 +

8 Dec E
21 Dec Ha (KBS 57)

4. ♀ 1143 x ♂ 916

1989 Jan eggs rotten

20 Jan E
4 Feb Ha
10 Feb chick +
23 Feb chick +

27 Apr E
28 Apr eggs broken

22 May E
4 Jun Ha
11 Jun chicks KBS 20 & 21 +

30 Jun E
11 Jul chick +

16 Jul E
7 Aug Ha
4 Sep KBS 28 separated

10 Sep E
21 Sep Ha
1 Oct chick KBS 37 +

14 Oct E
27 Oct Ha
5 Nov chick KBS 44 +
6 Nov chick KBS 45 +

4 Dec E
25 Dec eggs rotten

5. ♀ 1626 x ♂ 1638

1 Jan Ha
8 Jan chick +

29 Jan E
10 Feb Ha
12 Feb chick +

13 May E
14 May eggs broken

20 Jul Ha
23 Jul chick KBS 27 +

16 Oct E
31 Oct eggs rotten

8 Nov E
20 Nov Ha
25 Nov chick KBS 51 +
28 Nov chick KBS 52 +

13 Dec E
25 Dec Ha
27 Dec chick KBS 60 +

6. ♀ 1635 x ♂ 1641

1 Jan Ha
25 Jan chick +

17 Feb E
3 Mar Ha
11 Mar chick +
23 Mar chick +

22 Aug E
30 Sep eggs rotten

8 Nov E
29 Nov eggs rotten

10 Dec E
21 Dec Ha
27 Dec chick KBS 56 +

7. ♀ 377 x ♂ 1387

3 Sep E
5 Sep eggs broken

8 Oct E
11 Oct eggs broken

8. ♀ 1009 x ♂ 849

3 Aug E
11 Aug Ha
18 Sep chicks 34 & 35 +

8 Dec E
22 Dec Ha
24 Dec chicks KBS 58 & 59 +

9. ♀ 1461 x ♂ 1088

1988

11 Jan Ha
15 Jan chick +

---

22 Jan E
10 Feb Ha
20 Feb chick +

---

4 Mar E
16 Mar Ha
18 Mar chick +

---

29 Mar E
11 Apr Ha
28 May KBS 15 separated

---

12 Jul Ha
9 Aug KBS 25 separated

---

22 Aug E
5 Sep Ha
13 Sep chick KBS 32 +
14 Sep chick KBS 33 +
28 Sep KBS 31 separated

---

16 Oct E
27 Oct Ha
5 Nov chick KBS 43 +
14 Nov KBS 42 separated

---

28 Nov E
16 Dec eggs rotten

---

10. ♀ 1624 x ♂ 1478

31 Oct E
26 Nov eggs rotten

---

11. ♀ 1598 x ♂ 1206

7 Nov E
20 Nov Ha
23 Nov chick KBS 47 & 48 +

---

12. ♀ 1389 x ♂ 1643

23 Aug E
26 Aug eggs broken
31 Aug eggs broken

---

13. ♀ 812 x ♂ 467

1 Sep E
14 Sep Ha
21 Sep chick KBS 36 +

---

8 Oct E
27 Oct eggs rotten

---

2 Nov E
22 Nov eggs rotten

---

2 Dec E
27 Dec eggs rotten

---

14. ♀ 1625 x ♂ 1642

22 Sep E
30 Sep eggs rotten

---

9 Oct E
27 Oct eggs broken

---

8 Nov E
20 Nov Ha
24 Nov chicks KBS 49 & 50 +

---

13 Dec E
25 Dec Ha
26 Dec chicks 61 & 62 +

15. ♀ DN 58314 x ♂ DN 58313

1989

28 Jan E
11 Feb Ha
14 Feb chick +

29 May E
18 Jun eggs rotten

12 Sep E
30 Sep eggs rotten

31 Oct E
25 Nov eggs rotten

16. ♀ DN 58326 x ♂ DN 58325

1 Jan E
Jan eggs rotten

5 Sep E
1 Oct eggs rotten

14 Oct E
29 Oct eggs rotten

4 Dec E
25 Dec eggs rotten

17. ♀ DN 58313 x ♂ DN 58319

1 Jan E
15 Jan eggs broken

10 Oct E
16 Oct Ha
14 Nov KBS 40 & KBS 41 separated
4 Jan (KBS 41) +

26 Nov E
13 Dec Ha
14 Dec chick KBS 54 +

18 ♀ DN 58318 x ♂ DN 58312

9 Nov E
26 Nov eggs rotten

19. ♀ DN 58328 x ♂ DN 58327

13 Oct E
30 Oct eggs rotten

20. ♀ DN 58320 x o ♂ DN 58328

31 Oct E
5 Nov eggs broken

1. ♀ 912 x ♂ 926

1990

8 Jan KBS 55 separated
9 Jan KBS 55 +

23 Feb E
15 Mar eggs rotten

26 Apr E
6 Apr Ha
17 Apr chick (KBS 81) +

5 May E
29 May eggs rotten

8 Jun E
28 Jun eggs rotten

27 Jul E
14 Aug Ha
28 Aug (KBS 98) +

12 Sep E
29 Sep (KBS 107&108) Ha

3. ♀ 1634 x ♂ 1320

17 Jan KBS 57 separated

23 Jan E
8 Feb eggs rotten

26 Mar E

4. ♀ 1143 x ♂ 916

16 Jan Ha
18 Jan (KBS 65&66) +

31 Jan E
12 Feb Ha
16 Feb (KBS 73) +

26 Mar E

14 May E
1 Jun eggs rotten

13 Jun E
27 Jun Ha
4 Jul (KBS 92&93) +

11 Jul E
24 Jul Ha
26 Jul (KBS 94&95) +

6 Sep E
18 Sep Ha
27 Sep (KBS 105&106) +

5. ♀ 1626 x ♂ 1638

9 Jan E
23 Jan Ha
27 Jan (KBS 67) +

11 Feb E
21 Feb Ha
26 Feb (KBS 74) +

11 Mar E
4 Apr eggs rotten

3 May E
29 May eggs rotten

24 Jun E
3 Jul eggs rotten

19 Sep E

6. ♀ 1635 x ♂ 1641

5 Jan E
26 eggs rotten

6 Aug E
13 Aug eggs rotten

8. ♀ 1009 x ♂ 849

16 Jan E
27 Jan Ha
29 Jan (KBS70)+
1 Feb (KBS 71) +

21 Feb E
1 Mar Ha
16 Mar (KBS 76)+
3 Apr KBS 75 separated

8. Continued

1990 10 Apr E
25 Apr Ha
1 May (KBS 85&86)+

7 May E
20 May Ha
1 Jun (KBS 87)+

14 Jun E
26 Jun Ha
1,4 Jul (KBS 90&91) +

6 Aug E
21 Aug Ha
23 Aug (KBS 99/100)+

5 Sep E
18 Sep (KBS103/104) Ha

....

9. ♀ 1461 x ♂ 1088

1 Jan E
11 Jan Ha
16 Jan (KBS 63)+

6 Mar E
4 Apr Ha
17 Apr (KBS 79/80) +

4 Jun E
20 Jun Ha
29 Jun (KBS 89)+
6 Sep KBS 88 separated

25 Jul E
10 Aug Ha
14 Aug (KBS 96/97)+

27 Aug E
8 Sep Ha
11 Sep(KBS 101/102) +

16 Sep E
29 Sep (KBS 109/110) Ha

....

11. ♀ 1598 x ♂ 1206

24 Jan E
21 Feb eggs rotten

24 Sep E

....

10. ♀ 1524 x ♂ 1478

19 Sep E

....

13. ♀ 812 x ♂ 467

3 Jan E
23 Jan eggs broken

....

14. ♀ 1625 x ♂ 1642

10 Jan E
23 Jan Ha
27 Jan (KBS 68) +

28 Feb E
12 Mar Ha
14 Mar (KBS 77/78)+

2 May E
20 May eggs rotten

17 Jul E
25 Jul eggs rotten

....

15. ♀ DN 58314 x ♂ DN 58310

5 Mar E
21 Mar eggs rotten

....

16. ♀ DN 58326 x ♂ DN 58325

8 May E
25 May eggs rotten

4 Aug E

24 Sep E

17. ♀ DN 58313 x ♂ DN 58319

1990

2 Jan E
13 Jan Ha
18 Jan (KBS 64)+

31 Jan E
12 Feb Ha
15 Feb (KBS 72)+ ....

2 May E
23 May eggs rotten

18 Sep E

18. ♀ DN 58318 x ♂ DN 58312

13 Jan E
31 Jan eggs rotten ....

5 Mar E
27 Mar eggs rotten

19. ♀ DN 58328 x ♂ DN 58327

27 Mar E
10 Apr eggs rotten

17 Jul E
1 Aug eggs rotten

20. ♀ DN 58320 x ♂ DN 58323

13 Jan E
26 Jan Ha
27 Jan (KBS 69)+ ....

*) E: eggs laid
Ha: hatched
+: chicks dead

APPENDIX 2. Release accounts for the birds that have been released to the wild in April 1990.

KBS 5 Released on 17 Apr; after 18 Apr always observed being accompanied by KBS 8 (its sibling and cage mate in the PTC); on the first day of release seen together with two wild birds in a group with KBS 28 and KBS 15; during which occasion it was seen bobbing with the wild birds; not seen after 24 Apr.

KBS 6 Released on 18 Apr; last time seen on 30 May; poached.

KBS 8 Released on 18 Apr; seen mostly in close company with KBS 5 (often allopreening, etc.); consuming a large praying mantis on 20 Apr.; seen thereafter on 25 Apr and 24 May.

KBS 9 Released on 17 Apr; during the first week seen mostly accompanied by KBS 10, its PTC cage mate; on 10 May seen with KBS 42 and two wild birds near the release site, seen a few times thereafter; last time seen on 28 May, some 100m to the west.

KBS 10 Released on 17 Apr; first week mostly together with its cagemate KBS 9; seen alone on 11 May on the site.

KBS 14 Very first bird that was released on 15 Apr; stayed near the cage and even entered again; not seen after 19 Apr.

KBS 15 Released on 15 Apr in the first contingent; seen together with KBS 5, KBS 28 and two wild birds; didn't stay near the site the first days, when it was seen in the nearby valley; visited the release site on 17 Apr; on 22 Apr seen in a group consisting of KBS 28, KBS 31, KBS 57 and two juvenile and one adult wild bird, during which occasion the birds were observed busy with active anting in a large tree ca 200 m away from the release site; observed on 4 May on the site (Rasma, pers.

KBS 25 Released on 20 Apr; during the first days never far from the site and seen frequenting the site on 11 May; seen on 30 May in a group of five wild and four released birds near the site.

KBS 28 Released on 17 Apr; seen that day in a mixed group of wild and released birds (see KBS 5); on 18 Apr visiting the site with a juvenile wild bird; seen in a group of wild and released birds (see KBS 15) on 22 Apr; not seen thereafter.

KBS 31 Release on 19 Apr; seen on 22 Apr while anting (see KBS 15); not seen on the site until 11 May; not seen thereafter.

KBS 42 Released on 19 Apr, seen foraging on Lantana berries in the vicinity of the site; reappeaered at the site on 22 Apr apparently hungry and thirsty, throwing up Lantana seeds; visited the site regularly in May, not seen after the 26th.

KBS 57 Released on 17 Apr, frequenting the site during the first three days; on 22 Apr seen while anting not far fram the site (see KBS 15); not seen thereafter.

BS 002 Released on 21 Apr, after an unsuccessfull attempt the days before; left the cage and flew directly in easterly direction and was seen only once that day; seen on 23 Apr, ca one km from the site uphill, but seen thereafter.

APPENDIX 3. List of publications on the Bali Starling in local and international magazines/journals and newspapers, that appeared during 1987-1990.

Alikodra, H.S. 1987. Masalah pelestarian jalak Bali. Media Konservasi 1 (4): 21-28.

Anon. 1987. Welcome starling. Kompas, 22 November.

Anon. 1987. Jalak Bali sudah kembali tapi nasibnya belum aman. Kompas, 22 November.

Anon. 1989. Surabaya punya bisa, Bali punya nama. Kompas 16 February: p 12.

Anon. 1989. Jalak Bali terancam punah. Bali Post, 1 August, p 8.

Bruning, D.F. 1989. Bali high. A zoo success story: the endangered Bali Myna returns to its native isle. Animal Kingdom 92 (2): 38-43.

Hartojo, P. & I.S. Suwelo. 1987. Upaya pelestarian jalak Bali (Leucopsar rotschildii). Media Konservasi 1(4): 29-39.

Helvoort, B.E. van. 1990. The Bali starling Leucopsar rothschildi Stresemann 1912: its current status and need for conservation. Proc. Asean workshop on Wildlife Research and Management & Meeting on establishment of Asean Wildlife Society. PHPA-Bogor: pp 115-131.

Putra, D. 1989. Jalak Bali makin kritis. Bali Post, 28 August, p.1,10.

Santoso, Y.M. & D. Putra. 1989. Setelah jalak Bali tinggal 15. Editor 2 (50): 34.

Sayadi & D. Putra. 1989. Menuju akhir riwayat jalak. Editor 2(49):57-57

Suwelo, I.S. 1990. Jalak Bali tinggal 30 ekor di alam asli. Suara pembaruan, 15 June.

Suyono, A.H. & P. Rokhman. 1990. Jalak Bali si cantik yang nyaris punah. Trubus 21: 288-289.

APPENDIX 4. List of participants during the Bali Starling Population Viability Assessment Workshop, Bogor, 22-24 March 1990

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1. Soetisna Wartaputra (Director General PHPA)
2. Effendy Sumardja (Director Nature Conservation, PHPA)
3. B.Seibels (AAZPA)
4. K. Bell (AAZPA)
5. D. Bruning (AAZPA)
6. U. Seal (CBSG)
7. R. Grimmett (ICBP)
8. B. van Balen (ICBP)
9. B. van Helvoort (SECM, Bogor)
10. M. Noor Soetawidjaya (Bali Barat NP, PHPA)
11. V. Harwono Gepak (Surabaya zoo)
12. Liang Kaspe (Surabaya Zoo)
13. Istanto (Bali Barat NP)
14. Mufti (Bali Barat NP)
15. Ismu Sutanto Suwelo (PKBSI)
16. Jan Wind (World Bank)
17. H. Banjaransari (PHPA)
18. Soendji (TMII, Jakatta)
19. Soetikno W. (Puslitbang, LIPI)
20. Achmad Abdullah (PHPA)
21. Charles Santiapillai (WWF)
22. Kathy MacKinnon (WWF)
23. D. Ashari (PKBSI)
24. Jarwadi H. (IPB)
25. Noerdjito (MZB)
26. Soedaryanti (MZB)
27. Dewi Malia (MZB)
28. Djoko (PHPA)
29. Pandu (PHPA)
30. Endang Tri Margawati (Puslitbang, LIPI)
31. Francesco Nardelli (Sumatran Rhino trust)
32. Paolo Bertagnolio (Rome, Italy)
33. Yusup Cahyadin (Padjadjaran University, Bandung)
34. Kamil Oesman (ICBP Indonesia)
35. Dick Watling (World Bank)
36. Soegardjito (MZB/Puslitbang LIPI)
37. M. Hardi (Hasco, Jakarta)

STRATEGY FOR SAFEGUARDING THE INTEGRITY OF THE BALI BARAT NATIONAL PARK

H. Rochadi Hadisumitro

1. Introduction

This strategy concept for safeguarding the integrity of the Bali Barat National Park is based on a letter of the secretary of the Director General of PHPA (Directorate General for Forest Protection and Nature Conservation) No. 811/VI - Sek/89 dd 25 April 1989, concerning the conservation of rare animals.

2. Background of the Problems

a. The decrease of the Bali Starling population in the Bali Barat National Park area (in situ) and outside the park (ex situ).

b. The presence of the enclave of the estates PT Margarana and PT Dharma Jati Utama in Sumser Klampok.

3. Aims

The safeguarding of the integrity of the Bali Barat National Park forest, especially the core zone, Propat Agung forest and area around the village of Sumser Klampok has the following aims:

a. Increase the awareness of the community concerning the Conservation of Natural Resources.

b. Increase the welfare of the community by transmigration.

c. Guarantee the integrity of the area of BBNP in order to increase the Bali Starling population.

d. To establish an intact B B National Park area without enclave.

4. Institutions involved in the safeguarding of the integrity of BBNP.

The institutions involved in the safeguarding activities can be divided in the following categories.

a. Safeguarding Activities:

1. Police of the Buleleng Resort and Gerokjak Sector
2. The Forestry branch of the Bali Barat.
3. The State Court of Buleleng.
4. Bali Barat National Park.

b. Extension Activities:
   1. The Buleleng district office of the department of Information.
   2. The Buleleng district office of the department of Transmigration.
   3. The Police resort of Buleleng.
   4. The State Court of Buleleng.
   5. The Forestry branch of Bali Barat.
   6. The village head of the Sumder Klampok and Pejarakan.
   7. The Bali Barat National Park.

c. Carrying out the Transmigration:
   1. Local Government including I of the province of Bali.
   2. Local Government including II Buleleng district.
   3. The subdistrict of Gerokgak.
   4. Villagehead of Sumder Klampok.
   5. District office of Transmigration, Province of Bali.
   6. Transmigration Office, district of Buleleng.
   7. The office of National Defense, district of Buleleng.
   8. PT Dharma Jati Utama Estate.
   9. PT Margaroma Estate.
   10. Bali Barat National Park.

5. **The program of safeguarding the integrity of the BBNP.**

The programme of safeguarding the integrity of BBNP will be carried out through:

a. Short-term Programme Includes:
   1. Integrated extension with involved institutions.
   2. Regular and continuous integrated safeguarding with the institutions involved.
   3. Restriction of permits to enter core zone, i.e. forest habitat of the Bali Starling. Permits will only be given for:
      a) Research
      b) Restricted recreation under guidance of BBNP officers.
   4. The distribution of a list of trespassers amongst the institutions involved, for monitoring.
   5. The assistance with the transmigration of the entire village which is already programmed by the Local Government of Bali level 1 for the village of Sumber Klampok, in 1990/1991.
   6. The formation of protection units, consisting of each 4 men and increase the capabilities of their personnel who, through a shifting system are put

at the field posts (there are 8 protection units in the whole territory for the time being).

7. he provision of sufficient equipment to the security units whenever they are operating.

b. The Long Term Program Includes:

a) To abolish the enclave of the estates of PT. Dharma Jati Utama and PT. Margarana with the following options:

1. No extension of the permit to operate the estate after the present permit expires (PT. Margarana - 1993 and PT Darma Jati Utama - 2004).
2. The exchange of the estate area with another area outside the territory of the BB National Park.
3. The exchange of the estate area mentioned with the extension area of the BB National park or another forest area.

One of the procedures offered for option will be carried out to change the status of the enclave mentioned into a part of BBNP territory.

b) Increase the Bali Starling population through:

1. In situ/ex situ captive breeding.
2. Habitat rehabilitation.
3. Inventory of Bali Starlings outside the BBNP territories in order to investigate the possibilities for the release back into their natural habitat or the use as parent stock in the CPP.

c) The gradual abolishment of overlapping in management between the Forestry Service of the province of Bali towards an area of 77.727 hectares managed by the BBNP.

6. **Postscript.**

With the concept for safeguarding the integrity of the BBNP, it is hoped that disturbance and threats in all their forms, to the BBNP area can be suppressed to levels as low as possible, so that the Bali Starling population, the flagship species of the BBNP, can be increased.

Celik, May 1989.

008/ C / Bali /89

DEPARTEMEN KEHUTANAN

DIREKTORAT JENDERAL PERLINDUNGAN HUTAN DAN PELESTARIAN ALAM

TAMAN NASIONAL BALI BARAT

CEKIK - KANTOR POS GILIMANUK - BALI 82253

File

KONSEP PENGAMANAN HUTAN TERPADU TAMAN NASIONAL BALI BARAT

STRATEGY FOR SAFEGUARDING THE INTEGRITY OF THE BALI BARAT NATIONAL PARK

TAMAN NASIONAL BALI BARAT

MEI 1989

KONSEP PENGAMANAN HUTAN TERPADU
TAMAN NASIONAL BALI BARAT
(P H T T N B B)

I. DASAR :

Dasar Konsep Pengamanan Hutan Terpadu Taman Nasional Bali Barat (PHTTNBB) ini adalah Surat Bapak Sekretaris Direktorat Jenderal Perlindungan Hutan dan Pelestarian Alam Nomor 811/VI-Sek/89 tanggal 25 April 1989, tentang masalah kelestarian satwa langka.

II. LATAR BELAKANG PERMASALAHAN :

a. Menurunnya populasi jalak Bali di kawasan Taman Nasional Bali Barat (in-situ) dan di luar kawasan Taman Nasional Bali Barat (ex situ).

b. Terdapatnya pemukiman (enclave) perkebunan PT. MARGARANA dan PT. DHARMA JATI UTAMA di Sumber Klampok.

c. Sangat rendahnya kondisi sosial ekonomi penduduk di sekitar kawasan Taman Nasional Bali Barat terutama di sekitar mintakat inti.

III. TUJUAN :

Tujuan Pengamanan Hutan Terpadu (PHTTNBB) di Taman Nasional Bali Barat khususnya Mintakat Inti/Rimba Prapat Agung/sekitar desa Sumber Klampok adalah sebagai berikut :

a. Meningkatkan kesadaran masyarakat di bidang Konservasi Sumber Daya Alam.

b. Meningkatkan kesejahteraaan masyarakat melalui Transmigrasi.

c. Terjaminnya keamanan kawasan Taman Nasional Bali Barat sehingga diharapkan populasi jalak Bali meningkat.

d. Terwujudnya kawasan Taman Nasional Bali Barat yang utuh/kompak tanpa adanya pemukiman dalam kawasan (enclave)

IV. INSTANSI TERKAIT DALAM PENGAMANAN HUTAN TERPADU TAMAN NASIONAL BALI BARAT

Instansi yang terkait dalam kegiatan PHTTNBB ini dapat dikelompokkan sebagai berikut :

A. Dalam Kegiatan Pengamanan.

1. Kepolisian Resort Buleleng dan Sektor Gerokgak.
2. Cabang Dinas Kehutanan Bali Barat.
3. Kejaksaan Negeri Buleleng.
4. Taman Nasional Bali Barat.

B. Dalam Kegiatan Penyuluhan.

1. Kantor Departemen Peneranagn Kabupaten Buleleng.
2. Kantor Departemen Transmigrasi Kabupaten Buleleng.
3. Kepolisian Resort Buleleng.
4. Kejaksaan negeri Buleleng.
5. Cabang Dinas Kehutanan Bali Barat.
6. Kepala Desa Sumber Klampok dan Pejarakan.
7. Taman Nasional Bali Barat.

C. Dalam Pelaksanaan Transmigrasi.

1. Pemerintah Daerah Tingkat I Propinsi Bali.
2. Pemerintah Daerah Tingkat II Kabupaten Buleleng.
3. Camat Gerokgak.
4. Kepala Desa Sumber Klampok.
5. Kanwil Departemen Transmigrasi Propinsi Bali.
6. Kantor Departemen Transmigrasi Kabupaten Buleleng.
7. Badan Pertanahan Nasional Kabupaten Buleleng.
8. Perkebunan PT. DHARMA JATI UTAMA
9. Perkebunan PT. MARGARANA.
10. Taman Nasional Bali Barat.

V. PROGRAM PELAKSANAAN PENGAMANAN HUTAN TERPADU TAMAN NASIONAL BALI BARAT

Program pelaksanaan Pengamanan Hutan Terpadu Taman Nasional Bali Barat ditempuh melalui :

A. Jangka Pendek.

Program jangka pendek, meliputi :

1. Penyuluhan terpadu dengan instansi terkait.
2. Pengamanan terpadu secara teratur dan terus menerus dengan instansi terkait.
3. Membatasi izin masuk ke dalam mintakat inti/rimba habitat jalak putih bali.
   Izin masuk hanya diberikan untuk :
   a. Penelitian.
   b. Rekreasi terbatas dengan diantar petugas Taman Nasional Bali Barat.
4. Mengedarkan daftar nama-nama pelanggar kepada instansi terkait untuk monitoring/pemantauan.
5. Membantu kelancaran pelaksanaantrnsmigrasi bedol desa yang sudah diprogramkan Pemerintah Daerah Tingkat I Bali untuk desa Sumber Klampok sampai dengan tahun 1991.
6. Membentuk Satuan perlindungan yang beranggotakan 4 orang per Satuan dan meningkatkan kemampuan personilnya (untuk sementara di seluruh kawasan ada 8 Satuan Perlindungan), yang penugasannya secara bergantian langsung di Pos-Pos terdepan.
7. Memberikan sarana/prasarana yang memadai kepada Satuan Perlindungan yang ada dalam setiap operasi kegiatannya.

B. Jangka Panjang

Program jangka panjang, meliputi :

a. Meniadakan enclave perkebunan PT. DHARMA JATI UTAMA dan PT.. MARGARANA dengan alternatif :
   1. Tidak memperpanjang lagi ijin pengusahaan perkebunan setelah ijin HGU-nya habis (PT. MARGARANA Tahun 1993 dan PT. DARMA JATI UTAMA Tahun 2004)
   2. Mengganti areal perkebunan dengan kawasan lain di luar kawasan Taman Nasional Bali Barat, walaupun ijin HGU-nya belum habis.
   3. Atau mengganti areal perkebunan tersebut dengan areal perluasan Taman Nasional Bali Barat atau kawasan hutan lainnya.

   Salah satu dari ketiga alternatif tersebut ditempuh untuk merubah status enclave tersebut menjadi kawasan Taman Nasional Bali Barat.

b. Meningkatkan populasi jalak bali melalui :
   1. Penangkaran in-situ/ex-situ
   2. Pembinaan habitat
   3. Inventarisasi jalak bali di luar kawasan untuk kemungkinannya dikembalikan ke habitat aslinya, atau dipakai sebagai parent-stock/induk penangkaran.

c. Meniadakan overlaping/tumpang tindih pengelolaan dengan Dinas Kehutanan Propinsi Bali secara bertahap sehingga tercapai rencana pengelolaan Taman Nasional Bali Barat seluas 77.727 hektar.

VI. P E N U T U P

Dengan Konsep Pengamanan Hutan Terpadu Taman Nasional Bali Barat diharapkan semua bentuk gangguan/ancaman terhadap kawasan Taman Nasional Bali Barat dapat ditekan sekecil mungkin sehingga populasi jalak bali sebagai satwa primadona Taman Nasional Bali Barat dapat ditingkatkan.

Cekik, Mei 1989

Kepala Taman Nasional Bali Barat

DEPARTEMEN KEHUTANAN
TAMAN NASIONAL BALI BARAT

Ir. Harry Rochadi Hadisumitro
Nip. 080.030.817

BALI STARLING

Leucopsar rothschildi

VIABILITY ANALYSIS

AND

SPECIES SURVIVAL PLAN

BIBLIOGRAPHY ON BALI STARLING

AMADON, D. (1943) *The genera of Starlings and their relationships.* American Museum Novitates (1247) : 1-15.
ANNOTATION : 1 fig., tab., 12 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : A general review of the genera of the family Sturnidae [Starlings, Mynahs, Grackles]. Last review was by SHARPE [1890, 1909] who distinguished 50 genera of which 33 monotypic, comprising c. 100 species in his 'Handlist'[1909]. Author proposes 24 genera and excludes 7 genera [Hypocolius, Neocichla, Callaeas + Philesturnus + Heteralocha + Zavattariornis, Picathartes] . Genera are ordered and treated in phylogenetic sequence beginning with the most generalized and primitive. Under each genus are given : author & type-specimen; only the earliest absolute generic synonyms; all species included [where worthwhile reasons for adopting a particular sequence are given]; characters; discussion.
"It is very difficult to separate Acridotheres and Leucopsar from the new, enlarged genus Sturnus, and some will undoubtedly prefer to consider them as sub-genera only". Leucopsar differs from both Sturnus and Acridotheres by its notches on the primaries, its high-ridged culmen and its occipetal instead of frontal crest, and from Sturnus pagodarum in its long crest. Acridotheres and Leucopsar have a similar courtship display, absent in Sturnus [probably "bobbing" sensu HUGHES & TURNER 1975 is meant; BvH]. See also BEECHER [1978]

AMADON, D. (1956) *Remarks on the Starlings, family Sturnidae.* American Museum Novitates (1803) : 1-41.
ANNOTATION : 3 fig., tab., 75 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Follows main lines of his 1943 publication; in this paper several gnera then supressed are separated again, while Charitornis, previously recognized, has been made a synonym. Now 27 genera are proposed; 7 genera are considered doubtful [Pityriasis, Hypocolius, Callaeas + Philesturnus + Heterachloa. Zavattariornis, Picathartes]. Neocichla, previously excluded, is now reinstated, while Pityriarsis was formerly tentatively included under a separate sub-family. Treats: genera [phylogenetic order]; doubtful genera; family relationships; evolution; species dynamics; parallelism; bill adaptations; selection of races and species especially of Aplonis [island-races], Poeopter, Onychognathus, Lamprotornis, Spreo, Cosmopsarus, Cinnyricinclus, Sturnus, Acridotheres, Mino, Sarcops and Gracula. See also BEECHER [1978]
Leucopsar is closely allied to some East Indian species of Sturnus, as well as to Acridotheres. If Sturnus and Acridotheres are united, then Leucopsar should be included too. Leucopsar has unique notches on the primaries like 2 sibling species of the African genus Lamprotornis but is certainly not closely related [parralelism].

ANONYMUS (1984) *Bali Starlings for Bali.* Voice of Nature (21) : 8-10.
ANNOTATION : 5 fig., tab., ref., append., 1 map, index, English, summ.p. , . (ISSN:)
SYNOPSIS :

BAIER ,P. (1973) *Balistar in einer Volierenzucht.* Gefiederte Welt 11 () : 206.
ANNOTATION : fig., tab., ref., append., map, index, German, summ.p. , . (ISSN:)
SYNOPSIS :

BEECHER ,W.J. (1978) *Feeding adaptations and evolution in the Starlings.* Bulletin of the Chicago Academy of Science 11 (8) : 269-298.
ANNOTATION : 7 fig., tab., 16 ref., append., map, index, English, summ.p. 296, . (ISSN:)
SYNOPSIS : A partial review of sturnid systematics based on the evolution and distribution in the family of a feeding behavioural element called ´prying´ or ´open-billed probing´: the forcibly opening of the bill after it has been pushed into a substance, generally the soil, thereby exposing prey organisms. In prying species [exemplary developed in Sturnus vulgaris] the abductor [opening] muscles of the bill are strongly developed at the expense of the adductor [which is contrary to most avian species], accompanied by a recasting of the anterior portion of the skull [especially the jugal and the ectethmoid] narrowing the loral are in order to allow steroscopic vision IN the opened bill. Prying seems associated with food paucity seasons in arid, temperate climates, conferring a selectional advantage in cold-temperate zones with relatively brief ground-coverance by snow. Sections on : early sturnid phylogeny; feeding adaptations in the bird skull [especially lever-fulcrum mechanism of the quadrate, jugal and premaxilla, and their musculature]; ibid in skulls of 5 sturnid groups of progressive modification; adaptive evolution of prying in sturnids; comments on sturnid taxonomy. A number of changes are proposed to AMADON´s [1943] review of the family, both as to the generic position of some species, as wel as to the phylogeny. Specieal attention to the separation of Acridotheres from Sturnus/Sturnia. Sturnus melanopterus and S.nigricollis are placed in Acridotheres, but Acridotheres fuscus, Sturnus contra, S.burmanicus and Leucopsar rothschildi are retained. Leucopsar is thought to be closely related to Acridotheres but no additional evidence based on prying, skull- or bill-musculature [or anything else] is given. The family is thought to have evolved from the Sylviidae [Old World Warblers] via a primitive ´Lamprotornis-Aplonis´ ancestor; these 2 genera still survive on the periphery of the family´s distribution. The Indian Ocean and the Pacific archipelagos are assumed to have been "the perfect nursery" [isolation and adaptive radiation] from where temperate mainland was invaded as prying evolved. Fine paper, but: How did Lamprotornis [or its ancestor] reach Africa [over mainland Asia] without evolving prying alledgedly necessary to survive on the mainland ? no attention to paleo-climatic conditions and to plate tectonics.

BEMMEL ,A.C.V.van (1974) *Balispreeuwen.* Artis 20 () : 134-137.
ANNOTATION : 7 fig., tab., ref., append., map, index, Dutch, summ.p. , . (ISSN:)
SYNOPSIS : A popular accout on the Bali Starling Leucopsar rothschildi mostly based on literature [especially PLESSEN 1926, HARTMANN 1970, EZRA 1930, International Zoo Yearbook] with additional data from casptivity in the Amsterdam Zoological Garden [Artis]. Short notes on morphology, courtship behaviour, breeding, etc. Mentions possibility of restocking diminishing wild population from a reserve captive population in Zoos. Fine photographs [6] in characteristic attitudes and behavioural elements. First-ever recent/post-war paper in Dutch [?]. See also LENSINK [1975].

BETHAN ,I. (1985) *Jalak Bali , perlukah diimpor ?.* Suara Alam 7 (34) : 30-33.
ANNOTATION : 4 fig., tab., ref., append., map, index, Indonesian, summ.p. , . (ISSN:)
SYNOPSIS :

BREUNIG ,D. (1982) ***Zucht von Balistarren in der Zimmervitrine (Leucopsar rothschildi).*** Gefiederte Welt 106 () : 122-123.
ANNOTATION : 1 fig., tab., ref., append., map, index, German, summ.p. , . (ISSN:)
SYNOPSIS : Communication of a private breeder of his breeding attempts with Bali Starlings Leucopsar rothschildi in an indoor cage of 1.2 * 1.5 * 0.6 meter. Nestboxes: 25*25*30 cm, diameter entrance 6 cm. All attempts from 1978 to 1980 failed. In 1981 two clutches yielded 3 young. Detailed account on food & vitamines, clutch size, behaviour, etc.

ERTL ,H. (1973) ***Aufzucht junger Bali-stare (Leucopsar rothschildi).*** **Gefiederte Welt 97 () : 116-117.**
ANNOTATION : 2 fig., tab., ref., append., map, index, German, summ.p. , . (ISSN:)
SYNOPSIS : On the handraising of 2 hatchlings of circa 3-4 days old of the Bali Starling [Leucopsar rothschildi]. Chopped mealworms with ~~quark~~ curd resulted in immediate constipation, cured with insertion of an oil-wet needle in the cloaca. Chopped earthworms resulted in a respiration-worm infection [Syngamus], cured with a Thibenzol-solution [10 grams in 100 ml of water; 45 drops, 1 drop = circa 1 ml]. Flygrubs were not digested when not chopped, but when chopped were digested normally. At 10 days feather-sheaths broke; 12 days eyes open; 16 & 20 days fledging; at 7 weeks independent.

EZRA ,A. (1931) ***Successful breeding of Galeopsar salvadori and Leucopsar rothschildi.*** **Avicultural Magazine 9 ? () : 305-307.**
ANNOTATION : fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Alledged first successful captive-breeding record for the Bali Starling [Leucopsar rothschildi]. During 3 years, each year all eggs were eaten [by the parents]. From April to July 1931, one, single-housed pair laid 5 times, each time 3 eggs. First clutch disappeared in circa 10 days. Second and 3rd clutch were fostered out to wild Turdus merula and Turdus philomela/viscivorous respectively, but were disturbed. Fourth clutch was fostered out to Spreo sp. but the 3 young were half-reared and then deserted. The 5th clutch was left to be incubated by the parents; inspection at 14 days revealed 1 young which was successfully raised by the hen alone [the cock was found dead at 14 days]. Mealworms were given as food for young. Fledgeling and mother are of equal size, but young less white on back and naked orbital skin smaller. Adults very wild as was young.

EZRA ,A. (1931) ***Rothschild's Grackle (Leucopsar rothschildi).*** **Avicultural Magazine 9 (4) : 6-8.**
ANNOTATION : 1 fig., tab., 1 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : On what seems to be the first-ever Bali Stralings [Leucopsar rothschildi] in captivity in Europe. Author obtained 5 live [wild-caught ?] specimen in 1928 brought over "from the East" by Walter Goodfellow; 1 bird died. One pair nested several times 'last summer' but eggs disappeared, probably eaten by the parents [see also EZRA 1931, Avicult.Mag 9:305-307]. Stray observations: aggresive behaviour of 2 -possible- cocks in 1 aviary; birds do wonderfully well in aviaries; crest-display and bobbing mentioned; food given is like that for any other starling; considered hardy; sexes alike in colour and only behaviourial differences. "They certainly are well worth breeding, as we may never see any more of them." SIC!

FLETCHER ,A.W.E. (1967) *Rothschild's Mynah at semi-liberty.* Avicultural Magazine 72 () : 106-107.
ANNOTATION : fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Author aquired amongst others one [true?] pair of Bali Starlings [Leucopsar rothschildi] in 1965 [?]. Together with other softbills the pair was housed in an old, planted conservatory [10*4*2.3 meter] lined with plywood and wire-netting; various types of nestboxes were provided. No serious breeding attempt was made. Early September the pair escaped. During December through March, the birds spent most of their time inside, only venturing out if the sum was shining. From mid-April to end-May [article drafted 25 May] both birds have been out daily, only entering shortly at feeding time in the morning. For the rest of the day [and nightly ??] they were promimnent in the farden up to 800 meter away. Birds are in perfect condition and still keen on orange and mealworms, but ignoring softfood, so a good deal of natural food must be taken. At liberty, the birds normally keep close together, but now [late May] one bird never leaves the aviary, possibly indicating breeding.

FOXALL ,I.; BURTON ,P.J.K. (1975) ***Notes on the nesting of the White-cheeked Touraco Tauraco leucotis.*** Bulletin of the British Ornithologists' Club 95 (1) : 27-29.
ANNOTATION : fig., tab., 5 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : A male Turacus lenootis [= ...] attempting to nest, "chased the other occupants of the aviary, a pair of Rothschild's Grackles Leucopsar rothschildi and a Red-rumped Green-Woodpecker Picus erythropygus untill they were removed." Seems to be the first and only indication that a Bali Starling lost in aggresion from another species, except DOCTERSVANLEEUWEN pers.comm. 1983 who states they only lost from his Crown-Pigeons.

GOSSELIN ,S.J.; KRAMER ,L.W. (1983) ***Pathophysiology of excessive iron storage in Mynah birds.*** Journal American Veterinary Medical Association 183 (11) : 1238-1240.
ANNOTATION : 1 fig., 1 tab., 18 ref., append., map, index, English, summ.p. 1238, . (ISSN:)
SYNOPSIS : Complete necropsies were performed on 20 Bali Starlings [Leucopsar rothschildi] from Cincinnati and Dallas Zoos between January 1981 and May 1983 and on 3 Hill Mynahs [Gracula religiosa], grouped in 4 age-classes and compared to similare age-classes of 20 Quail [Cotunrix coturnix] plus 76 adult birds of 14 avian ordos. A progressive accumulation of iron with age as of as early as 10 days age in the liver was found in the two sturnids. This was not diet induced. The sturnids shared most of the histopathologic characteristics with idiopathic or heriditary hemochromatosis in African Bantus. The nature of this fundamental abnormality in mynahs with iron overload and humans with hemochromatosis is not known. In the wild mynahs will probably die from other causes before they succumb to the deleterious side-effects or iron overload.

GREENWELL ,G.A. (1980) *Preparing for the future in Rothschild's Mynah breeding.* The A.F.A. Watchbird 7 (2) : 39-41.
ANNOTATION : fig., tab., 12 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Analysis of breeding records of 75 Bali Starlings [Leucopsar rothschildi] at National Zoological Park, revealed that 1 pair entirely dominated [1970-1973 : 36 young; father+daughter 1973-1974: 15 young]. This may be a common situation, so may be outcrossing with excluded individuals is still possible. It appeared that 8 out of 37 collections had bred with wild-caught pairs and that in the winter of 1979-80 still 27 wild-caught birds and 58 1st generation birds were available. Due to regulation exchange of birds would be illegal, but new regulations will make exchange possible. Standardization of] record-keeping should be initiated. The captive stock coul eventually be reintroduced after protective measures are implemented to protect the original wild habitat.

HARRISON , C.J.O. (1963) ***The displays of some Starlings (Sturnidae) and their taxonomic value.*** **Ardea 51 () : 44-52.**
ANNOTATION : 3 fig., tab., 7 ref., append., map, index, English, summ.p. 51, . (ISSN:)
SYNOPSIS : A certain behavioural element, referred to as "nodding" [cf. HUGHES & TURNER (1975): "bobbing"] recurs with minor variations in Sturnus nigricollis, Sturnus melanopterus, Acridotheres gingianus, Acridotheres tristis and Acridotheres grandis. A similar display in Leucopsar rothschildi is considered homologous, but the head-movement is a little different. Function is not clear, but might be for sexual recogniction and pair formation [but both sexes bobb in Leucopsar; BvH]. "Leucopsar would appear to bear the same relationship to Acridotheres as does Creatophora to Sturnus, namely a single species which has diverged from the main genus in a number of small characteristics but still reveals close relationship with it". It is proposed that Sturnus melanopterus S. nigricollis and S. burmannicus be placed in Acridotheres (sensu AMADON 1943)

HARRISON ,C.J.O. (1963) ***Open-billed allopreening by Rothschild's Mynah.*** Ibis **105 () : 118-119.**
ANNOTATION : fig., tab., 1 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Description of allopreening (term from CULLEN, Ibis 1962:121). Analysis of evolutionary origin and function. The movement pattern in Leucopsar rothschildi resembles that of Sturnus vulgaris when probing for food (German: Zirkeln). It was also observed when Sturnus malabaricus, Sturnus nigricollis and Sturnus melanopterus preened themselves (autopreening). Probably allopreening is evoked by the simple stimulus "bill inserted in a crevice of some kind".

HARRISON ,C.J.O (1968) ***Rothschild's Mynah : an appeal for co-operation.*** **Avicultural Magazine 74 (1) : 19-20.**
ANNOTATION : fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : In 1961 or 1962 sudden large importations of Leucopsar rothschildi appeared in Europe (up to an alleged single consignment of 50 birds in England). In 1964 forest was disappearing (nesting sites) and many birds were seen in cages (Dr. Lee-Talbot). The insectivorous diet may make it difficult to establish a viable captive population. Danger of decreasing fertility. A register should be compiled : number, sex, location of birds in collections, breeding attempts and -success, etc. Address given. See also PARTRIDGE (1969). Probably the incipience of the present attempt by ICBP and PHPA to save Leucopsar rothschildi from extinction. No explicit mention is made of releasing

HARTERT , E. (1912) ***On some unfigured birds.*** Novitates Zoologicae 19 () : 374.
ANNOTATION : 2 fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Gives the first plates of 2 (then new) birdspecies: Leucopsar rothschildi Stresemann 1912 and Gracupica tertia (= Sturnus melanopterus tertius).

HARTMANN , F.R. (1970) ***Bali and its Mynah.*** Animal Kingdom 73 (3) : 26-29.
ANNOTATION : 1 fig., tab., ref., append., 1 map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : The Bali Starling Leucopsar rothschildi is discussed in relation to the region´s bio-geography (Wallace´s and Weeber´s Line) and to the bird´s population-genetics. This publication seems to be the source of the unconfirmed occurrence of Leucopsar rothschildi on Nusa Penida Island and North-East Bali. [e.g. SCHURRER 1977]. It is suggested that captive breeding may be a chance for survival, but it does not mention reintroduction or release into the original wild environment.

HAYWARD , J.R. , RINGROSE , A.J. , LEE , J.D. , MAGILL , W.J.D. (1980) ***Preliminary report of the Oxford expedition to West Bali.*** Unpublished handwritten MS () : .
ANNOTATION : fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Authors surveyed the actual Bali Barat National Park (then Nature Reserve) from 16 July to 4 August 1980, the north-coastal plane (4-8 August), Nusa Penida Island (9-10 August [sic]), sout-coastal palnes (14-18 August). Results are specified per locality. Total number of wild Bali Starlings Leucopsar rothschildi 229, incl. 22 birds outside the Park. In 1979: 200 (incl. 28 outside) according to Made Suta Adi. Nothing is reported on Nusa Penida. It is concluded that Leucopsar rothschildi "seems to have held its own over the past 3 years", but without protection it could certainly decline.

HODGES , J.R. (1981) ***Correspondence : Rothschild´s Grackle.*** Avicultural Magazine 87 (1) : 63.
ANNOTATION : fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Reaction on MORRISON (1981), who blames aviculturists and animal tarde for the disappearnce of Leucopsar rothschildi from the wild. Some other birdspecies mentioned.

HUGHES , A. (1973) ***The Bali Mynah.*** The Zoo-goer 2 (4) : 15-24.
ANNOTATION : 7 fig., tab., ref., append., 1 map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : A general account on Leucopsar rothschildi (IUCN status, distribution, history, etc.). The major part is devoted to the first second-generation caᵖtive breeding success, so far only known from Zurich Zoo, Switzerland. "The first obstacle to full-scale captive breeding of an endangered species has overcome . . . " which is further brought in relation to the preservation of this species.
Complete breeding cycle (1 case) was 57 days (4 Sep-1 Nov). Nest-construction 22 days. Incubation 13 days. Fledging (1 Nov) at age 22 days. Many behavioural observations in relation to breeding stage and sex. Much attention is paid to (elements of) vocalizations, which are classified as ". . . brief contact and location calls, stereotyped longer calls and finally highly variable "creative" calls . . . " Other observations concern: inseccessful mounting attempt followed by displacement behaviour of the male; changing guard at the nest; food and feeding routine; etc.

HUGHES , A. , TURNER , C.G. (1975) *Breeding and behaviour of Rothschild's Mynah Leucopsar rothschildi at the National Zoological Park, Washington.* International Zoo Yearbook 15 () : 116-120.
ANNOTATION : fig., tab., 6 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Five pairs of Leucopsar rothschildi (Bali Starling) produced 43 young between Dec 1970 and Feb 1974, pair A being wild-caught, pair B mixed and the others captive bred.
Nestboxes : installed on "cliffs" at 6-7.5 m high were chosen (23*23*23 cm with entrance 6 cm diameter and standard boxes 21*21*56 cm).
Clutch-size : 3 (2 clutshes).
Incubation : 12-14 days (pair A & C, each 1 clutch).
Nest period : 21-26 days, mean 23.4 (6 clutches pair A, 1 clutch pair C).
Both parents incubate, but male less than female.

Behavioural elements described: bobbing, allopreening, feather-plucking, crest-display, tail-twitching, 4 types of vocalizations. Only nestholes were heavily defended against conspecifics, but breeding pairs did not allow other pairs in the same aviary to establish themselves within a certain radius of the nest. A simular situation holds for Gracula religiosa in the wild (1 km apart).

IONGH , H.H.de (1983) *Is there still hope for the Bali Mynah ?.* Tiger Paper () : 28-32.
ANNOTATION : 2 fig., 2 tab., 14 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS :

IONGH , H.H.de , KOMARA , A. , MOELIONO , M. , SOEMARTONO , P. , SOEBRATA , S. , SPLIETHOF , P.C. , SUNARJA , I. (1982) *A survey of the Bali Mynah Leucopsar rothschildi Stresemann 1912.* Biological Conservation 29 () : 291-295.
ANNOTATION : fig., tab., ref., append., map, index, English, summ.p. , . (ISSN: 0006 3207)
SYNOPSIS :

JEGGO , D.F. (1981) ***Rothschild's Mynah (Leucopsar rothschildi) at Jersey Zoological Park.*** Avicultural Magazine 86 () : 29-32.
ANNOTATION : 1 fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : In 1971 the Jersey Zoological obtained 8 birds (wild-caught?) and over 100 birds have been (hand)reared successfelly since. Housing: 1 breeding pair in planted outdoor aviaries (most successful : 7.5*2*1.15 m), with unheated shelters, sometimes shared with pheasants , usually Polyplectron emphanum. Never in adjacent aviaries (fights), but always in sight or sound distance of other pairs. Diet: milk-moistened bread crimbs, a proprietary insectile mixture (Sluis), mince heart and hard-boiled eggs, small amounts of soaked dry fruit and diced fresh fruits (grapes, bananas, apples, orange) all sprinkled with mineral & vitamins (Vionate, Vitetrin), mealworms and crickets. Nestboxes: 20 mm plywood, 24*24*40 cm, entrance in front near top diameter 6 cm, perch just below it, inspection hatch. Nest-material: hay, fine twigs, leaves and feathers. Nest: untidy. Eggs: pale-blue. Clutch-size 3-4, usually 3. Incubation: 12-14 days, starting from 2nd egg. Fledging: at age 25-28 days. Rarely complete broods survive, mostly 1-2 young are successfully raised and 50-79% survive. Most casualties are in nest (cause unknown). Up to 4 broods per season per pair. Hand-rearing relatively simple. Fledgelings resemble parents, except for pale beak colour, paler blue orbital skin, a wash of grey on crown and mantle and an only rudimentary crest. Assuming adult plumage in 1st year. Usually removed c. 5 days post fledging.
Susceptible to parasitic infection, notably Gapeworm (Syngamus), tape (Cestodea) and coccidiosis. Detailed individual records are kept. Over 70 birds have been exported to 21 different collections in view of establishing a healthy captive population. Prices undercut those on illegal market, making illegal trade economically unviable.

KING , W.B. (1974) ***Aspects of international trade in Indonesian birds.*** **International Zoo Yearbook 14 () : 56-61.**
ANNOTATION : fig., 5 tab., 3 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Some official statistics on the legal bird trade from Indonesia from January 1970 to June 1971. No data available on illegal trade. Official statistics proved unreliable, although a fair start: import- and export-figures do not match; 90% had inadequate scientific names; etc. The role of Singapore as a transit-port is discussed.
Special mention is made on p.59 of Leucopsar rothschildi: after 2 June 1970 at least one shipment of Bali Starlings entered the USA in violation of the Endangered Species Act of 1969, and 2 shipments, totalling 55 birds, were refused. [It is not mentioned were al these birds ended up; BvH]

KURODA , N. (1932) ***A collection of birds from the island of Bali.*** **Tori 7 () : 262-268.**
ANNOTATION : fig., tab., text ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Communication on a collection of bird species from Bali, made by Mr. Kaoru Yasuda in 1929 and 1930. Specimen of 31 species were collected. Author claims 2 new records for Bali (Rhytidoceros plicatus undulatus & Phalacrocorax melanoleucos melvillensis), but 2 other species were at the time new reocrds too (Pandion haliaetus cristatus & Treron vernans purpurea, both from Tajakura, North-East-Bali). Most collections from Singaraja and Buleleng, North-Bali, but some from elsewhere, most notably Leucopsar rothschildi from Bubunan (1 female on 21 September 1930). Balinese names also given, but some suspicious.

KURODA , N. (1933) *A small collection of birds from Bali.* Tori 8 (36) : 64-66.
ANNOTATION : fig., 2 tab., text ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : A communication an a collection of bird species from Bali made by Mr. Kaoru Yasuda in 1931. Fourteen specimen of 10 species wer collected, amongst others 3 skins from Leucopsar rothschildi from Bubunan (31 March and 5 May 1931). No new records for Bali. Balinese names given, some suspicous.

LANDOLT , M. , KOCAN . R.M. (1976) *Transmission of avian pox from starlings to Rothschild's Mynah.* Journal of Wildlife Diseases 12 () : 353-356.
ANNOTATION : 4 fig., tab., 7 ref., append., map, index, English, summ.p. 353, . (ISSN:)
SYNOPSIS : Six out of 15 Leucopsar rothschildi in the Smithsonian Institute National Zoological Park, Washington, USA, were killed. They had lesions resembling avian pox. Inoculation with lesion material of 11 out of 21 captured wild Common Starlings Sturnus vulgaris, resulted in the killing of 6 of these 11 individuals on days 14, 15, 19, 20, 22 & 23. Only 4 (2 males and 2 females) of these 6 birds developed lesions typical for avian pox. None of the controls (10 wild birds) died or developed pox lesions. Four inoculated White Leghorns did not develop lesions as late as 4 weeks post-inoculation, nor did, originally, any other species in the aviary.
Lesions in Sturnus vulgaris mainly at angle of beak, eyelid, tongue, floor of mouth and feet, indicating mechanical transport rather than vascular. The Leucopsar rothschildi had lesions at the angle of the bill and eye.
Absence of lesions in 7 of the inoculated Sturnus vulgaris suggests aquired immunity, indicating the presence of the poc virus in the local wild population of Sturnus vulgaris.
Authors plead for a rigidly enforced quarantine period for all incoming birds.

LENSINK , B.M. (1975) *Balispreeuwen in Artis.* Artis 21 () : 147-151.
ANNOTATION : 8 fig., tab., ref., append., map, index, Dutch, summ.p. , . (ISSN:)
SYNOPSIS : Some of the young described in this paper may have been send to the Wuppertal Zoo: see SCHURRER (1977).

LINT , K.C. (1962) ***White Bali Mynahs seldom leave their island.*** Zoonooz 35 () : 10-11.
ANNOTATION : fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS :

MICHAELIS , H.J. (1970) *Der Balistar.* Falke 17 () : 358.
ANNOTATION : 1 fig., tab., ref., append., map, index, German, summ.p. , . (ISSN:)
SYNOPSIS : Mainly descriptive: crest female 41-65 mm, male 66-84 mm. In 1910 [error; BvH] the first description was based on 1 single specimen from Bali. An "interresting court display" is mentioned but not described.
The birds in the Alfred-Brehm Haus origin from the Kopenhagen Zoo (Denmark). According to unidentified reports the Bali Starling is alledgedly used for cultural purposes on Bali [error; BvH]. Not important paper, except for the reference to the origin of the German birds.

MORRIS , M.L. (1976) ***Prepared diets for zoo animals in the USA.*** **International Zoo Yearbook** 16 () : 13-17.
ANNOTATION : fig., 2 tab., 8 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Review of commercial ready-made diets of Zu/Preem Diets (manufactured by Hill's Division Riviana Foods Inc.; Topeka; Kansas 66601; USA).
Three 'philosophies' are common ("traditional", "natural", "substitute") which are briefly discussed. Further notes on nutritional requirements, ingredients, acceptance, formula, feeding trials, evaluation.
Composition discussed of:
Feline Frozen Diets (felids, cannids, hyenas)
Feline Canned Diet
Omnivore Diet (bear, etc.)
Ratite Diet (Emu, Casuarius)
Birds-of-Prey Diet (raptors)
Soft-billed Diet
Dry Primate Diet
Canned Primate Diet
Marmoset Diet

Leucopsar rothschildi has successfully reproduced on Soft-billed Diet : concentrated pellets of meat by-products, cereal, liver, eggs, cassein, fats. Pellets greenish-brown; no refrigiration needed. In fact the soft-moist consistency demanded by the ingredients is what the birds found most acceptable.

MORRISON , A. (1979) ***On the way out ?.*** **Hemisphere** 23 () : 344-347.
ANNOTATION : 7 fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Popular acount on Leucopsar rothschildi (Bali Starling) and a visit to North-West Bali in May 1978. Basicly it conveys the same recent information as MORRISON (1981), e.g. 19 birds in a Singapore shop in 1979, etc. (see there), but gives additional information on history (PLESSEN 1926, STRESEMANN 1912, EZRA 1930) and geography.
"(...) no mare than a few hundred now remain." The way-out (title) may be increased tourism. See HODGES (1981) for a comment.

MORRISON , A. (1981) ***A Note on the Javanese Aviculture.*** **Avicultural Magazine** 86 () : 108-110.
ANNOTATION : 3 fig., tab., 3 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Communication on cage-birds in Java, including imports from China. On the Semarang bird-market, 36 species were counted in 0.5 hours. Mortality is terrible but survivors are generally well-kept as pets; even insectivorous species are in good condition, mostly due to large quantities of ant-eggs. Special attention is given to Leucopsar rothschildi (Bali Starling) on p.109-110. Besides habitat destruction, illegal trapping (lime) is the most acute threat. Many are smuggled out of Indonesia; in 1972 c. 30 birds in the Singapore Bird Park and in May 1979 there were 19 Bali Starlings for sale in a Singapore shop.
American and European aviculturists are responsible for its disappearance from the wild (see HODGES 1981 for a comment).
In Jersey Wildlife Preservation Trust over 100 birds have been raised since 1971 (JEGGO 1981). In early 70's hundreds of birds were imported into Europe, the majority in hands of malafide aviculturists. Bonafide captive breeding (e.g. Jersey) makes dealing economically unviable (complaint of a dealer to author).

PAARDT , Th. van der (1926) *Manoek Putih : Leucopsar rothschildi*. **Tropische Natuur** 15 (5) : 169-173.
ANNOTATION : 2 fig., tab., ref., append., 1 map, index, Dutch, summ.p. , . (ISSN: none)
SYNOPSIS : Author lived in North-West Bali, working as a state-forester, for a total of c. 3 years. This article communicates miscellaneous observations concerning Leucopsar rothschildi (Bali Starling) between 1914 and 1926. It is one of the earliest accounts of observations from the wild on the species.

Leucopsar rothschildi groups were observed amidst "countless grey starlings" [Sturnus melanoptera ?; BvH]. The species is characterized as "very frequently in large flocks". In February 1914, only one pair was seen on a boat-trip from Gilimanuk, via Menjangan Island to Gunung Gondol [were the author lived since June 1915; BvH], although he frequently landed to search for it. Only in June 1915 another pair was observed, near Gunung Gondol. Since then, "sometimes and by exception" some birds were observed, always pairwise and very wary and shy. Author concludes that the birds must be migratory [!], arriving in September at the onset of the dry season. Then, birds were observed frequently over the whole area of North-West Bali, in October-November "flocks of 30 and sometimes many more".

"They shun people; as soon as a few huts are build, their number decreases; they let themselves noticeably be pushed back by humanity."

In June 1926 he shot 2 specimen (but only one could be recovered); the two were the only individuals in 10 days over 300 ha. Stomach content of 1 specimen: 100% ripe fruits of Lantana camara [the only record of food for wild birds up to 1990; BvH].

In general he agrees with the distribution over North-West Bali as reported by PLESSEN (1926), but, contra PLESSEN, he adds: "Near Gilimanuk I even found many."

The specimen shot by Paardt in June 1926 is probably specimen no. 4712 (collector Paardt) in the Zoological Museum of Bogor.

PARTRIDGE , **W.R. (1969)** ***Rothschild's Mynah (Leucopsar rothschildi) : Register and Report on 1968 Census.*** **Avicultural Magazine 75 (3) : 101-106.**
ANNOTATION : fig., tab., 1 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : To start a viable captive population of Leucopsar rothschildi (Bali Starling) in England, it is recommended to initiate a yearly census and a studbook. So far, young Leucopsar have yet to be bred from captive-bred parents. A toal of 59 males, 62 females and 50 birds of unknown sex (171 birds) are available in 55 collections, but it is believed that considerably more birds are unreported in private collections.

NOTES by BvH:
1. after the 1969 census in England (SPILSBURRY 1970) there was no census until 1985, when the British (/European) Regional Studbook was started.
2. the first young hatched by captive bred parents (second generation captive-breds) were born in the Zurich Zoo in 1966 (SPILSBURY 1970).
3. the total number of birds in England only (171) is much higher than the figure reported for the world population (115) for the same year in the International Zoo Yearbook; the 1969 figures are respectively 117 and 173.

PLESSEN , V. von (1926) *Verbreitung und Lebensweise von Leucopsar rothschildi Stres.*. <u>Ornithologisches Monatsberichte</u> 34 () : 71-73.
ANNOTATION : fig., tab., 1 ref., append., 1 map, index, German, summ.p. , . (ISSN:)
SYNOPSIS : On the distribution and biology of Leucopsar rothschildi (Bali Starling) in 1925. The best source for the species' historical range and numbers; see also PAARDT (1926).

From May 1925 author spent more than 3 months surveying the entire Island of Bali (map with route), with particular attention for the western third of Bali's north coast.
No Leucopsar rothschildi was found in the mountains north of Negara, around Negara or along the west coast. Only "a few miles east" of present-day Gilimanuk village, the first birds were seen. The center of its distribution was the Teluk Terima Bay. According to the map, Leucopsar rothschildi was, in 1925, distributed in a narrow lowland strip along the western part of the north coast, from Teluk Terima Bay [the distribution center on the periphery ?; BvH] to Bubunan, where the first specimen was discovered by Stresemann in March 1911. It was seen only sporadically higher up in the mountains and altogether absent from Menjangan Island "although the living conditions were very suitable" and the rest of Bali "in particular from the inhabitated parts". [cf. PAARDT 1926].

Sturnus contra and Gracula religiosa are very frequent on Bali, but Sturnus contra is almost absent in Leucopsar rothschildi's distribution [contra is most rural; BvH]. Within its range, Leucopsar dominates over all other starlings [but see PAARDT 1926; BvH].

Around Teluk Terima Bay PLESSEN observed "hundreds" in smaller or larger flocks of 20-30 individuals. The bird feeds gregariously on fruits, a.o. papaya [Carica papaya, a home garden tree !?]. One birds is always on the guard, which made approach very difficult.

For a general account of the area's topography, vegetation, etc. in the same period see PAARDT (1929) en VOOGD (1937).

PLESSEN , V. von (1926) *ber einde kleine Vogelsammlung aus Bali.* <u>Journal fr Ornithologie</u> 74 () : 549-556.
ANNOTATION : fig., tab., text ref., append., map, index, German, summ.p. , . (ISSN:)
SYNOPSIS : Baron Viktor Von Plessen collected, between 27 May and 2 August 1925, on Bali Island 103 specimen of birds, plus an unreported number of Leucopsar rothschild skins. The 103+ specimen comprised 50 species, of which 5 species are new records for Bali, and 1 is a ne subspecies (Gerygone sulphurea plesseni Stresemann 1926:22).
This collection advances the total number of COLLECTED and RETAINED species from Bali to 156 (actually 157, including Sula sula (VORDERMAN 1895)) but excluding "mere" observations (an additional 14 species).
Itenerary: Cupel, Negara, Pulukan, North-West Bali, Buleleng, Kintamani, Bangli (see map in PLESSEN (1926)).
Possible observation of Pitta guajana (previously collectewd by STRESEMANN (1913)) and Megapodius reinwardti (never confirmed for Bali [see RENSCH], but collected from Nusa Penida (MEISE 1941).
Also breeding data of 10 species; generally, about the end of the rain season [May-June].

SCHMIDT, C.R. (1968) ***Miscelaneous observations on birds in the Zurich Zoo, with special reference to breeding activity.*** **Avicultural Magazine 74 (2) : 61-67.**
ANNOTATION : 3 fig., tab., 19 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : On p. 66 breeding results of Leucopsar rothschildi (Bali Starling) in the Zurich Zoo, Switzerland, up to 1967.
Three males and one female, all wild-caught, arrived in 1963 (males) and 1964 (female).
April 1965 : 3 young hatched, all died. Incubation: 12 days.
June 1965 : all young hatched died (insufficient feeding?).
May 1966 : 2 young in nestbox fledged after 28 days
July and September 1966 : 2 broods of 4 young, 2 times 2 young died. Incubation: 10 days.
February 1967 : 2 young, of which one was still fed by parents at the time they hatched the next clutch of:
April 1967 : 4 young, all died.
June 1967 : 4 eggs, none hatched.
It seems that normal clutches consist of 4 eggs of which only 2 are hatched.
See also SCHMIDT (1973) and SPILSBURY (1970) for more recent information on the same Zoo, possibly Europe´s most productive Bali Starling breeder.

SCHMIDT, C.R. (1973) ***New Elephant house at Zrich Zoo.*** **International Zoo Yearbook 13 () : 241-243.**
ANNOTATION : 1 fig., tab., 3 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Just before July 1972, a pair of Leucopsar rothschildi (Bali Starling) at the Zrich Zoo, Switzerland, produced the 103rd and 104th young born In this Zoo.

SCHMIDT, R.E. (1983) ***Hypermature cataract in a Crested Mynah, Leucopsar rothschildi.*** **Journal of Wildlife Diseases 19 (2) : 158-159.**
ANNOTATION : 2 fig., tab., 6 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : An adult female Leucopsar rothschildi (Bali Starling) of unknown age, was euthanized because it had developed osteomyelitis: a lession of 1.0*0.7 cm on the 1st phalanx of the right foot. It had also been blind for approximately 4 months.
Histological examination of the eyes revealed abnormal lenses (smaller; amorphous, eosinophilic fragments), wrinkled capsules and retinal degeneration with loss of photoreceptor cell nuclei, indicating Hypermature Cataract (lens opacity in which necrotic cortical material is lost through absorption or extrusion) an possibly also Morgagnian Cataract.
Hypermature Cataract has never been reported in birds; Morgagnian Cataract only once. Cataract in birds is infrequently desribed (so far in older Canaries, Parrots, Predators). Inbreeding, local trauma, avian encephalomyelitis, vitamine E deficiency and genetic defects have been suggested as possible causes of Cataract in birds; it seems associated with senility.

SCHMIDT, D., RISSER, A.C., LINT, K.C., SCOLLAY, P. (1976) ***The beautiful Bali Mynah.*** **Zoonooz 49 () : 4-8.**
ANNOTATION : 5 fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS :

SCHRER, U. (1977) *Die Zucht von Balistarren in Zoo Wupertal.* Gefiederte Welt 101 () : 64-66.
ANNOTATION : 2 fig., 2 tab., 10 ref., append., map, index, German, summ.p. , . (ISSN:)
SYNOPSIS : Captive breeding of Leucopsar rothschildi (Bali Starling) in the Wuppertal Zoo, Germany, with background notes.
The Zoo obtained 6 captive-bred birds from the Amsterdam Zoo [Artis?]: 4 males and 2 females; hatched in 1973 and 1974. In July 1976 each of two pairs produced 1 nest resulting in 3 and 2 fledgelings (1 hatchling died in a brood of 2).
Clutch size : 3 eggs (2 clutches).
Incubation : 14 days (1 clutch of 3 eggs of 1 pair).
Fledging : at 22-24 days.
Notes on size, behaviour, etc.
In 1970 55 Bali Starlings were prevented from being imported into the USA (KING 1974).

NOTES: in 1970 Leucopsar rothschildi was officially protected in Indonesia [not in 1957 as on p.65] and it was also the year that the Magarsari social forestry system was established in the current National Park. Distribution is erroneously given as North-East Bali and Nusa Penida Island [cf. HARTMAN 1970?].

SIEBER, J. (1977) ***Versuche zur Erhaltung einer bedrohter Tierart, am Beispiel Bali-Star (Leucopsar rothschildi).*** **Gefiederte Welt 101 () : 63-64.**
ANNOTATION : fig., tab., 4 ref., append., map, index, German, summ.p. , . (ISSN:)
SYNOPSIS : On an attempt to save the endangered Leucopsar rothschildi (Bali Starling) through captive breeding at the Austrian Academy of Science, Vienna.

Parent stock [8 birds?] was obtained in 1972, smuggled via Singapore [wild-caught?]. Due to good breeding results in 1973 and 1974, the collection increased to 23 birds in 1975 [thus: 15 young?].
Number of pairs that have bred, breeding attempts, nests and clutches, clutch size, etc. not given individually.
Clutch size : "generally 2-3 eggs".
Eggs : 28-32 * 19-24 mm; 5-6 gram.
Incubation : 12-14 days; young born virtually naked.
Development : feather-sheaths break at c. 10 days; peep through nest entrance at 16-18 days; fledging at 21 days (at 2/3 of adult size); start to feed independently from parents at 4 weeks; rejected by parents at 6 weeks.

A FREE-FLIGHT INTRODUCTION experiment with captive-bred birds was undertaken with 8 birds (4 hatched in 1973, 4 in 1974) from June to late December 1975 on Lokrum Island (1 sq.km.) some 2 km from Dubrovnik, Yugoslavia.
At the end of the 1st week, 4 birds had crossed to the mainland [!!!]: 2 birds to Dubrovnik city, 2 further inland.
Shortly later 1 bird died on the island. After Christmas 2 birds were found dead (very likely killed by a raptor due to conspicuous plumage). The last bird just disappeared without a trace. Birds [seem to have been artificially fed and] lived around high trees and did hardly approach the coast.
Author concludes that even 2nd-generation [???] captive-breds can be released in the wild and adjust themselves and find food without starting help.

SIEBER, J. (1978) *Freilandbeobachtungen und Versuche einer Bestandaufnahme des Bali-Stars Leucopsar rothschildi.* Journal fr Ornithologie 119 () : 102-106.
ANNOTATION : fig., tab., 5 ref., append., 2 map, index, German, summ.p. 106, English p.106. (ISSN:)
SYNOPSIS : Communication on the results of a field study on wild Leucopsar rothschildi (Bali Starling) from December 1976 to January 1977, North-West Bali, Indonesia.

Author considers landuse development and civilization-following Sturnus melanopterus (Black-winged Starling) to have pushed Leucopsar rothschildi out of its original distribution (PLESSEN 1926) into the very dry north-western point of Bali (c. 10,000 ha). Leucopsar was best observed at drinking pools. It roosts in groups of 10-25 individuals in high trees, together with pigeons, drongos and Sturnus melanopterus. Contrary to PLESSEN's (1926) observations, Bali Starlings were always accompanied by Sturnus melanopterus and at least three outnumbered by the latter.
Bali Starlings feed gregariously, mostly pairwise, on fruits of Manilkara kauki, Morus indica, Passiflora foetida, Strychnos (ligustrina) lucida, and on insects at forest edges, competing with Black-winged Starlings. Leucopsar was never observed on the ground.
Contrary to the Black-winged, the Bali Starling is very allert and shy; one individual is always on guard.
Leucopsar was observed in flocks of 6-17 (once 25) birds. At 9 sites (about 1/3 of the total area) 127 birds were observed. The wild population is estimated not to exceed 500 individuals. Based on her experience with captive birds, the author is of the opinion that the maximum carrying capacity for 10,000 ha is 500 birds.
In 1975 a free-flight experiment was undertaken on Lokrum Island, Yugoslavia, with 4 pairs of captive-bred Leucopsar rothschildi. This erevealed that c. 40 ha of suitable habitat [?] was insufficient for 4 pairs as 4 birds were chased from the island by aggressive behaviour of the others.

SIEBER, J. (1983) ***Nestbau, Brut und Jugendaufzucht beim Balistar (Leucopsar** rothschildi)*. Zoologishe Garten N.F. Jena 53 (3-5) : 281-289.
ANNOTATION : 10 fig., tab., ref., append., map, index, German, summ.p. , English p.289. (ISSN:)
SYNOPSIS : Results of 4 years of observations on the breeding-behaviour and -ecology of 4 pairs (2 wild-caught, 2 captive-bred) of Leucopsar rothschildi (Bali Starling) in captivity, covering 11 nests and 12 young. This is probably the most comprehensive published source on captive (breeding) behaviour, with detailed information on pair-forming, courtship, displays, copulation, nest construction, clutch- and egg-size, incubation, brooding, feeding and raising of young.

In more than 70% of the cases the female was the passive partner in allopreening. Nest construction is initiated by the male who contributes most; the female joins in the later phases only. Rigid nest material.
Nest construction: 14-20 days.
Clutch size : 2-5, mostly 3;
Egg size : range : 32.5 * 19.5 mm to 28.0 * 22.0 mm;
mean : 30.8 * 22.3 mm (62 eggs, no sd);
mean weight : 8.2 gram [cf. 5-6 gr by same author in 1977];
Egg laying interval : each 2nd day;
Incubation : 12-14 days; overall 70% by female (at night 100%);
Hatching : at intervals of c. 48 hours for eggs of the same clutch;
Nestlings : weigth at hatching c. 7 gr; length c. 45 mm;
Feeding : 5-20 minutes intervals;
Development : eyes open between 2-9 days; fledging at about 23 days (once 30); parents feed until 7th week, therafter parents reject their offspring.

SPARKS, J.H. (1963) ***The plumage of the Red Avadavat Amandava amandava and its effect upon contact behaviour.*** Ibis 105 () : 558-561.
ANNOTATION : fig., tab., 8 ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : Short communication on the social function of allopreening as contact behaviour:
"As such, social preening has a greater social significance and is not altogether utilitarian in its function. It is not surprising therefore, that allo-preening has been evolved not only in the highly social estrilines, but als in the Cuban Finche Tiaris canora (Fringillidae), Babblers (Timaliidae), Psittaciformes and in Rothschild´s Grackle (Leucopsar rothschildi)."

SPILSBURY, D.T. (1968) ***Correspondence: Avicultural conservation.*** Avicultural Magazine 74 () : 111.
ANNOTATION : fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS :

SPILSBURY, D.T. (1970) *Rothschild's Mynah (Leucopsar rothschildi). Register and report on 1969 census.* Avicultural Magazine 76 () : 115-129.
ANNOTATION : fig., tab., text ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : A captive-population and -breeding census over 1969 of Leucopsar rothschildi (Bali Starling) in of zoological gardens and stray private individual collections mainly from England, but including birds in 11 other countries : Denmark, The Netherlands, Belgium, Germany, France, Switzerland, South-Africa, Sri Lanka, Hong Kong, Indonesia and USA.

Summary of the results of a questionaire (p.119-128):
173 specimen in 58 collections (on page 116 a total of 178 specimen is mentioned), of which 71 birds are known to be captive-bred and 64 to be wild-caught (remainder of uncertain origin).

Some points from the plethora of details:
* Longevity: 7-12 (-21?) year in captivity.
* Ascaridia and intra- * inter-specific fighting are recorded as death causes, but sufficient information is lacking on this subject.
* Reasonably catholic in its choice of site.
* Recorded nest material: twigs, grass, leaves, etc.
* Clutch-size: 2-5, normally 3-4.
* Nesting and egg-laying up to 6 times per year have been recorded, but normally no more than 3 broods a year can be raised by the parents, without taking resort to foster-breeding.
* An estimated 50-90% of the FERTILE eggs seem to be hatched.

Although data on incubation period, fledging, raising of young lack, this is the first and a remarkably early and comprehensive attempt to compile information on Bali Starling husbandry and captive-breeding from experiences from over the world. This "world" census of captive Bali Starlings comes to an estimated captive world population which is about 50% higher than the International Zoo Yearbook's 1969 census !

STOLK, A. (1983) *Bali-spreeuw Leucopsar rothschildi.* Onze Vogels 44 () : 431.
ANNOTATION : 1 fig., tab., ref., append., map, index, Dutch, summ.p. , . (ISSN:)
SYNOPSIS : A general account on the endangered Leucopsar rothschildi (Bali Starling, Sturnidae), mostly in captivity and on captive breeding in The Netherlands.
Clutch-size 3-4, sometimes more. One pair raised 9 young from 2 clutches. Incubation may be done by Turdus merula (Blackbird, Turdidae), Turdus philomelos (Song Thrush) or Turdus viscivorus [see also EZRA 1931 for the latter foster species], but young must then the hand-raised. Young fledge at 21 days after hatching; they eat 150-200 mealworms per day.

STRESEMANN, E. (1912) *Description of a new genus and a new species of birds from the Dutch East India Islands.* Bulletin of the British Ornithologists' Club 31 () : 4-6.
ANNOTATION : fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS :

STRESEMANN, E. (1913) *Die Vögel von Bali. Aus den zoologischen Ergebnissen II. Freiburger Molukken-Expedition.* Novitates Zoologicae 20 () : 325-387.
ANNOTATION : fig., tab., text ref., append., map, index, German, summ.p. , . (ISSN:)
SYNOPSIS : Detailed report on collected bird species from Bali during an unintended visit from 11 January to 16 April 1911 on the 2nd Freiburg Moluccas Expedition.

In total 350 specimens of 127 species were collected, including 53 new records for Bali and 1 new genus and species: Leucopsar rothschildi (Bali Starling, Sturnidae), and 2 forms later recognized as new subspecies by HARTERT (1915). The list includes 22 species collected earlier by A. Wallace (13-14 June 1856, 9 species [8 species according to HARTERT (1896) and 11 species if the 2 accounts are combined; BvH] and by Doherty (March-April 1896, increasing the Bali-list to 96 species). The complete Bali-list is brought to 149 collected species; a further 16 observed species are listed [most are confirmed later].

Main collection sites: Singaraja, Bubunan, Celukanbawang, Gitgit, Lake & Mount Brantan, Kintamani; all East and North Bali.

Most species with many details on their (then) known distribution in South-East Asia, measurements, moult, etc. A few species are treated more extensively: Surniculus lugubris, Centropus bengalensis (plumage and moult), Cisticola exilis, Aplonis panayaensis.

In a special section (p.378-383) zoo-geographic conclusions are given and tabulated for Sumatra, Java, Bali, Lombok and Sumbawa.

SUSANTO, H. (1977) *The White Starling is becoming rare.* Indonesian Nature and Science Newsletter 5 (1) : 1.
ANNOTATION : fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : A calculated 1,000 individuals of Leucopsar rothschildi (Bali Starling; Sturnidae) survive in the West Bali Wildlife Refuge (c. 20,000 ha), according the head of Nature Conservation Service on Bali, Mr. Kasidjan Hardjopranoto.

[NOTE: most likely a serious over-estimate; BvH]

Yusuf , E. (Ed.) (1978) *Again about Bali's Starling.* Indonesian Nature and Science Newsletter 6 (Jul) : 4-5.
ANNOTATION : fig., tab., ref., append., map, index, English, summ.p. , . (ISSN:)
SYNOPSIS : The West Bali Nature Reserve was re-measured (1974: 20,600 ha; 1975: 19,368.8 ha) to improve its potential mainly as habitat for Leucopsar rothschildi, "Which is threatened to be lost from its original habatat" An expedition has been carried out by the Ecological Institute of the National University of Jakarta (some results given). Bali Starling population is estimated at 1,000 birds, but only [sic] 550 were observed. On the domestic market 34 birds were found; another 527 were believed to be shipped abroad. A Bali Starling rehabilitation center is recommended.

TONDOK, E.M. (1974) ***Kehidupan dan penyebaran burung Jalak***. Kehutanan Indonesia 1 () : 110-111.
ANNOTATION : fig., tab., ref., append., map, index, Indonesian, summ.p. 111, . (ISSN:)
SYNOPSIS : Probably the first publication on Leucopsar rothschildi (Bali Starling; Sturnidae) in Indonesian. Rather superficial and several minor errors (Oriolus oriolus (sic) is considered a sturnid; Leucopsar rothschildi is described as having a yellow crest; etc.). Species-description, food (ants, catterpillars, dragonflies, grasshopers/crickets), social behaviour, poaching, breeding in the wild are briefly described.
It is recommended to plant Ochromoa sp. (balsa) trees for nest trees; increase, especially ants by planting Dadap Erythrina variogata (sic) trees; improve water-supply; improve protection, particularly around drinking pools. [Anno 1990 all still very actual; BvH]

BALI STARLING

Leucopsar rothschildi

VIABILITY ANALYSIS

AND

SPECIES SURVIVAL PLAN

SMALL POPULATION BIOLOGY OVERVIEW

INTRODUCTION

An endangered species is (by definition) at risk of extinction. The dominant objective in the recovery of such a species is to reduce its risk of extinction to some acceptable level - as close as possible to the background, "normal" extinction risk all species face.

The concept of risk is used to define the targets for recovery, and is used to define recovery itself. Risk, not surprisingly, is a central issue in endangered species management. Unfortunately, there is ample reason to suppose that we (as humans) are not "naturally" good at risk assessment. Recovery will be more often successful if we could do this better. There is a strong need for tools that would help managers deal with risk. We need to improve estimation of risk, to rank order better the risk due to different potential management options, to improve objectivity in assessing risk, and to add quality control to the process (through internal consistency checks). Among the risks to be evaluated are those of extinction, and loss of genetic diversity.

In the last several years such tools have been developing. The applied science of Conservation Biology has grown into some of the space between Wildlife Management and Population Biology. A set of approaches, loosely known as "Population Viability Analysis" has appeared.

These techniques are already powerful enough to improve recognition of risk, rank relative risks, and evaluate options. They have the further benefit of changing part of the decision making process from unchallengeable internal intuition to explicit (and hence challengeable) quantitative rationales.

In the following sections, Tom Foose, Bob Lacy, and Jon Ballou each describe aspects of Population Viability Analysis (PVA). The text, adapted from that used in other PVAs (Ballou et al. 1989, Lacy et al. 1989), provides an overview of some of the population biology concepts that form the foundation of Population Viability Assessment. Each contributor approaches the subject from their own expertise and experience, so the contributions differ somewhat in perspective and content. There is some overlap, which may help the newcomer by occasionally repeating a point in different language. After these general reviews, information on the captive and wild populations of the Bali Starling to provide a basis for a detailed PVA is presented, and recommendations for improving the probability of recovery of the taxon.

SMALL POPULATION OVERVIEW (J. Ballou)

The primary objective of single-species conservation programs is to reduce the risk of population extinction. A first step in doing this is to identify those factors that can potentially cause extinction in the population. The most fundamental threat is, of course, declining population size. If a population is declining in numbers, and no action is taken to reverse the trend, then extinction is imminent. However, if the population is not declining, its fate is less certain and predicting its future more complicated.

The foremost problem facing the conservation of small populations is that these populations are still highly vulnerable to extinction even through they may be maintaining their size or even increasing in number. Small populations are challenged by a number of factors that increase the likelihood of the population going extinct simply because the population is small.

CHALLENGES TO SMALL POPULATIONS

Challenges to small populations can be roughly categorized as demographic and/or genetic in nature. Beginning with demographic challenges, at the most basic level, the level of the individual, the population is threatened by Demographic Variation. Demographic variation is the normal variation in the population's birth and death rates and sex ratio caused by random differences among individuals in the population. The population can experience fluctuations in size simply by these random differences in individual reproduction or survival. These randomly caused fluctuations can be severe enough to cause the population to go

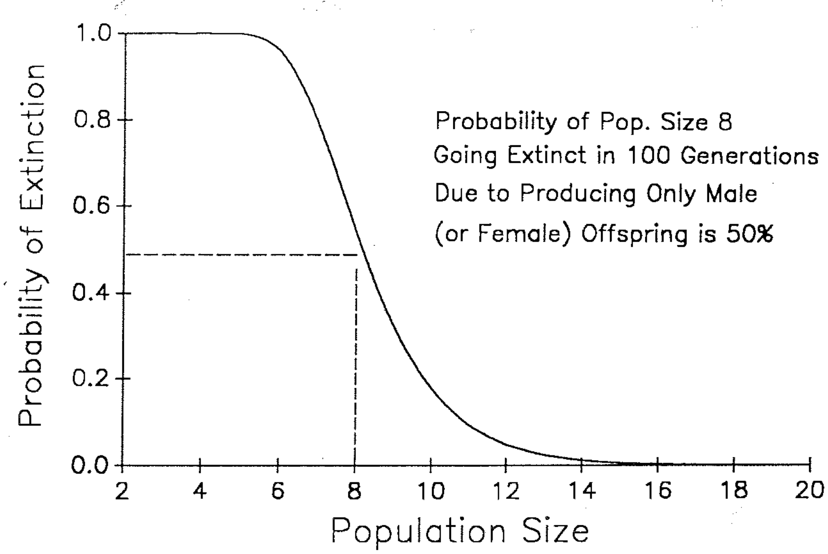

Figure 1. Example of demographic variation: Probability of extinction by 100 generations due solely to producing only one sex of offspring during a generation.

extinct. For example, one concern in extremely small populations is the possibility that all individuals born into the population
during one generation are of one sex, resulting in the population going extinct. Figure 1 illustrates the probability of this occurring over a 100 generation period in populations of different size. There is a 50% chance of extinction due to biased sex ratio in a population of size 8 sometime during this time period.

Similar consequences could result from the coincidental effects of high death rates or low birth rates. However, these risks are practically negligible in populations of much larger size. In general, the effect of any one individual on the overall population's trend is significantly less in large populations than small populations. As a result, demographic variation is a relatively minor challenge in all but very small populations (less than 20 animals).

A more significant threat to small populations is Environmental Variation. Variation in environmental conditions clearly impact the ability of a population to reproduce and survive. Populations susceptible to environmental variation fluctuate in size more than less susceptible populations, increasing the danger of extinction. For example, reproductive success of the endangered Florida snail kite (Rostrhamus sociabilis) is directly affected by water levels, which determine prey (snail) densities: nesting success rates decrease by 80% during years of low water levels. Snail kite populations, as a result, are extremely unstable (Bessinger 1986).

Another level of threat to small populations are Disease Epidemics and Catastrophes. Epidemics and catastrophes are similar to other forms of environmental variation in that they are external to the population. However, they are listed separately because we are just beginning to appreciate their role as recurrent but difficult to predict environmental pressures exerted on a population. They can be thought of as relatively rare events that can have devastating consequences on the survival of a large proportion of the population. Less devastating diseases and parasites are a natural accompaniment of all species and populations that may act to decrease reproductive rates and increase mortality.

Epidemics can have a direct or indirect effect. For example, in 1985 the sylvatic plague had a severe indirect effect on the last, remaining black-footed ferret population by affecting the ferrets prey base, the prairie dog. Later that same year, the direct effect of distemper killed most of the wild population and all of the 6 ferrets that had been brought into captivity (Thorne and Belitsky 1989).

Catastrophes are one-time disasters capable of totally decimating a population. Catastrophic events include natural events (floods, fires, hurricanes) or human induced events (deforestation or other habitat destruction). Both large and small populations are susceptible to catastrophic events. Tropical deforestation is the single most devastating 'catastrophe' affecting present rates of species extinction. Estimates of tropical species' extinction rates vary between 20 and 50% by the turn of the century (Lugo 1988).

Small populations also are susceptible to genetic challenges. The primary genetic consideration is the loss of genetic variation. Every generation the genes that get passed on to offspring are a random sample of the genes of the parents. In small populations, this random sample of genes is a small sample and may be unrepresentative of the genes of the parental generation. Some of the genetic variation present in the parents, may not, just by chance, get passed on to the offspring. This genetic variation is then lost to the population. This process is called genetic drift because the genetic characteristics of the population can drift or vary over time. In small populations, genetic drift can cause rapid loss of genetic variation - the smaller the population, the more rapid the loss of variation.

Inbreeding (matings between relatives) can also cause populations to lose genetic diversity. In small populations, all the animals quickly become related; they share common alleles. Offspring produced from related parents are inbred and because the parents are related, the offspring can get the same alleles from its mother and father. Inbred individuals are therefore more homozygous than non-inbred individuals and have lower levels of genetic diversity than animals born to unrelated parents.

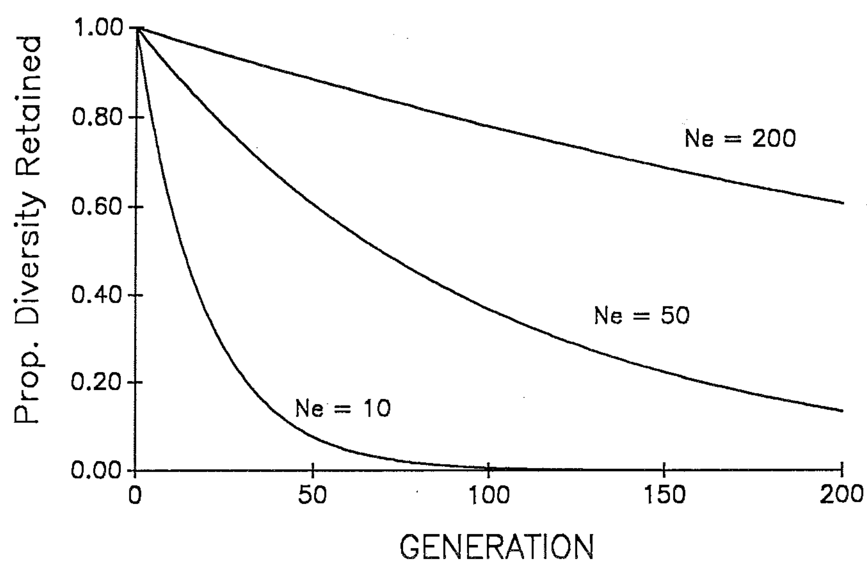

Figure 2. Loss of genetic diversity over 200 generation in populations with different effective sizes (Ne).

The loss of genetic variation in populations of different size is shown in Figure 2. The rate of loss is a function of the effective size of the population (Ne; the percent of diversity lost each generation is 1/2Ne). Technically, a population's effective size is the size of an ideal population that loses genetic diversity at the same rate as the real population. There is extensive literature on how to estimate a population's effective size (Lande and Barrowclough 1987); however, the number of animals contributing to the breeding pool each generation can be used as a very rough estimate of the effective size. The effective size of the population is therefore much less than the actual number of animals; estimates suggest that Ne is often only 10 to 30% of the total population. Seemingly large populations will lose significant levels of genetic diversity if their effective sizes are small.

Conservation programs include the maintenance of genetic diversity as a primary goal for several reasons. If species are to survive over the long-term, they must retain the ability to adapt to changing environments (i.e. evolve). Since the process of natural selection requires the presence of genetic variation, conservation strategies must include the preservation of genetic diversity for long-term survival of species. In addition to long-term evolutionary considerations, the presence of genetic diversity has been shown to be important for maintaining the fitness of the population. A growing number of studies show a general, but not universal, correlation between genetic diversity and various traits related to reproduction, survival and disease resistance (Allendorf and Leary 1986). Individuals with lower levels of genetic variation often have higher mortality rates and lower reproductive rates than individuals with more diversity.

Data on the effects of inbreeding in exotic species also show the importance of maintaining genetic diversity. Numerous studies have shown that inbreeding can significantly reduce reproduction and survival in a wide variety of wildlife (Ralls and Ballou 1983; Wildt et al, 1987; Figure 3). Inbreeding depression results from two effects: 1) the increase in homozygosity allows deleterious recessive alleles in the genome to be expressed (whereas they are not in non-inbred, more heterozygous individuals); and 2) in cases where heterozygotes are more fit than homozygostes simply because they have two alleles, the reduced heterozygosity

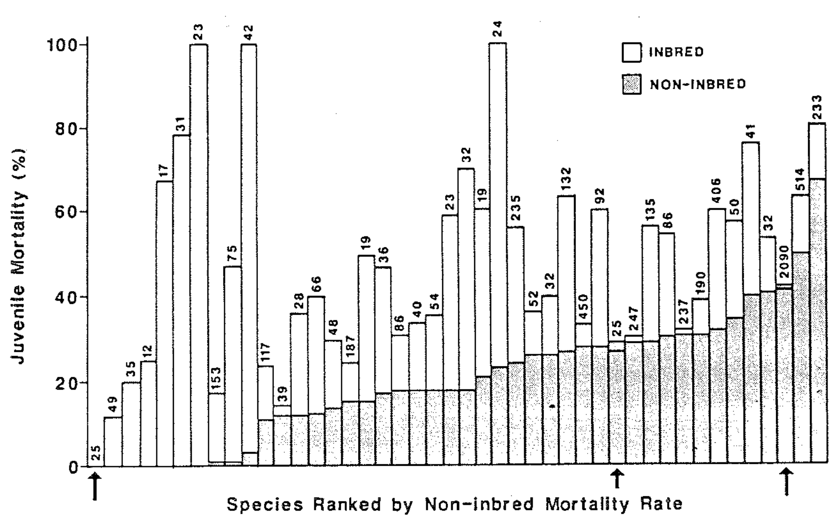

Figure 3. Effects of inbreeding on juvenile mortality in 45 captive mammal populations (From Ralls and Ballou, 1987).

caused by inbreeding reduces the fitness of the inbred individuals (overdominance). In both cases, the loss of genetic variation due to inbreeding has detrimental effects on population survival.

Small isolated populations, with no migration from other populations, lose genetic diversity and become increasingly inbred over time. Their long-term survival potential is jeopardized since they gradually lose the genetic diversity necessary for them to evolve and their short-term survival is jeopardized by the likely deleterious effects of inbreeding on survival and reproduction.

The genetic and demographic challenges discussed above clearly do not act independently in small populations. As a small population becomes more inbred, reduced survival and reproduction are likely: the population decreases. Inbreeding rates increase and because the population is smaller and more inbred, it is more susceptible to demographic variation as well as disease and severe environmental variation. Each challenge exacerbates the others resulting in a negative feedback effect termed the "Extinction Vortex" (Gilpin and Soule, 1986). Over time the population becomes increasing smaller and more susceptible to extinction (Figure 4).

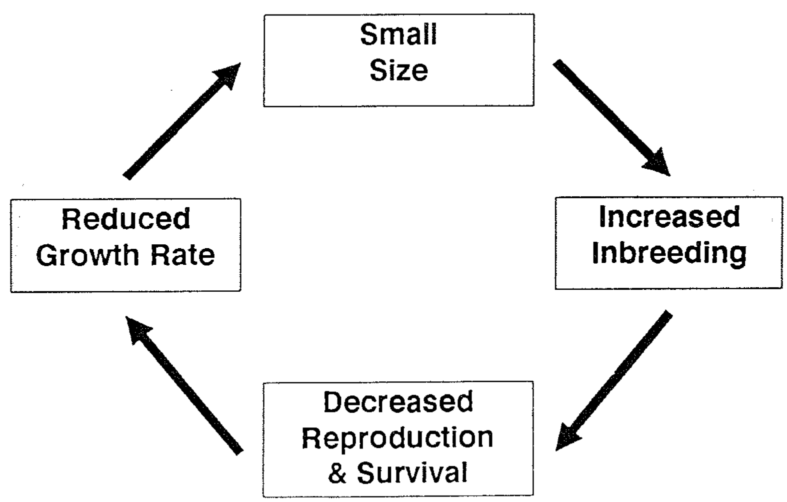

Figure 4. "Extinction Vortex" caused by negative feedback effects of inbreeding in small populations.

POPULATION VIABILITY ANALYSES

Many of the challenges facing small populations are stochastic and are result from random unpredictable events. Many can generally be assumed to decrease the likelihood of long-term survival of the population. However, because of their stochastic nature, their exact effects on population extinction and retention of genetic diversity can not be predicted with total accuracy. For example although inbreeding depression is a general phenomenon, its effects vary widely between species (Figure 3) and it is not possible to precisely predict how any one population will respond to inbreeding.

Nevertheless, conservation strategies that address these unpredictable issues of extinction and loss of genetic diversity must be developed and implemented. The process that has been developed over recent years to assess extinction probabilities and loss of genetic diversity is called Population Viability Analysis (PVA; Soule 1987). PVA is defined as a systematic evaluation of the relative importance of factors that place populations at risk. It is an attempt to identify those factors that are important for the survival of the population. In some cases, this may be easy - habitat destruction is often a critical factor for most endangered species. But at other times, the effects of single factors, and the interaction between factors, are more difficult to predict.

To try to gain a more quantitative understanding of the effect of these factors, computer models have been developed that apply a combination of analytical and simulation techniques to model the populations over time and estimate the likelihood of a population going extinct and the loss of its genetic variation. The model is first provided with information describing the life-history characteristics of the population. Depending on the model used, this includes data on age of first reproduction, litter size distribution, survival rates, mating structure and age distribution as well as estimates of the variation associated with each of these variables. A number of different external factors may also be considered. This may include levels of environmental variation, change in carrying capacity and severity of inbreeding depression. Models also allow consideration of threats facing the population: probability of catastrophes and their severity, habitat loss and disease epidemics (Figure 5). The models use the life-history variables, the external factors and the potential threats to project the population into the future,

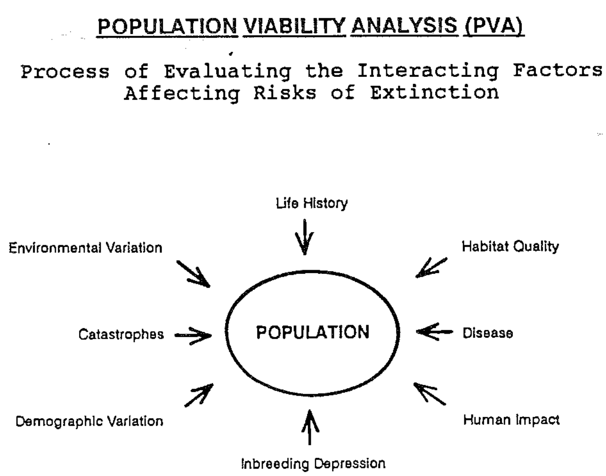

Figure 5. Population Viability Analyses (PVA) model the effects of different life-history, environmental and threat factors on the extinction and retention of genetic diversity in single populations.

measuring the level of genetic variation that is retained over time and recording if and when the population goes extinct (population size goes to zero). The simulations are repeated, often thousands of times, to provide estimates of the statistical variation associated with the results. The probability of extinction at any given time is measured as the number of simulations that the population had gone extinct by that time divided by the total number of simulations run (Figure 6). The levels of genetic variation are recorded as the percent of the original heterozygosity and number of original alleles retained in the population at any particular point.

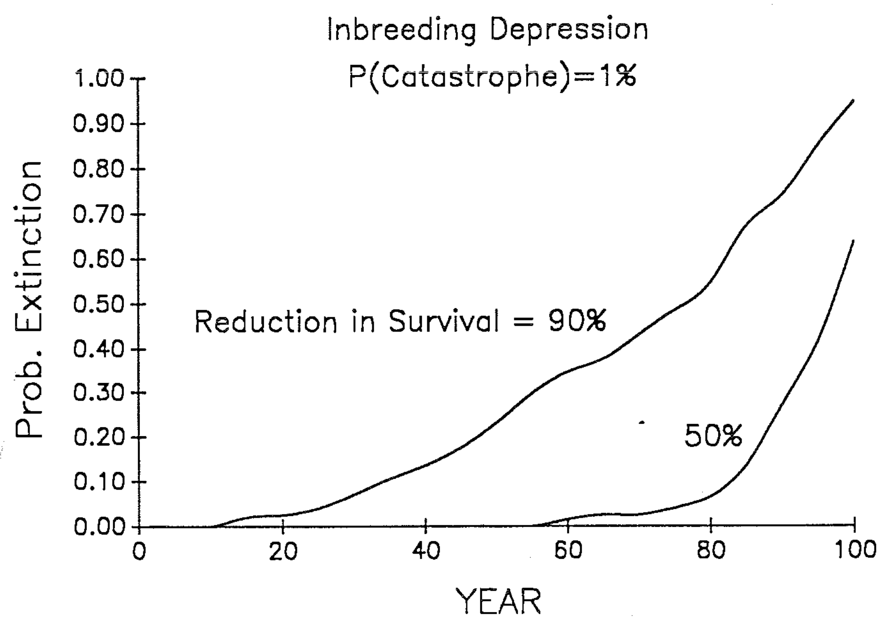

Figure 6. Hypothetical example of population extinction results from the VORTEX PVA model. The model includes negative effects of inbreeding and a catastrophe probability of 1%. The probability of extinction is shown over time for two different levels of catastrophe severity: a 90% reduction in survival vs 50% reduction in survival.

A number of population viability models have been developed. The model used by the Captive Breeding Specialist Group of the IUCN is VORTEX, written by Robert Lacy (Chicago Zoological Society). This model has been used extensively to develop conservation strategies for a number of species including the Black-footed ferret, Florida panther, Puerto Rican Parrot, Javan rhino and the four species of Lion Tamarins.

The true value of the model is not in trying to examine the effects of all variables simultaneously in the population. The interactions between these many factors is too complex to attempt to interpret the results of population projections based on more than just of few of these considerations. We can gain far more insight into the dynamics of the population by examining only one or two factors at a time - and picking those factors that we believe have an impact on the population and ignoring those that don't.

The primary use of the model in developing conservation strategies is its use in conducting "what if" analyses. For example 'what if' survival were decreased in the wild population as a result of a disease outbreak? How would that effect the extinction of the population and retention of genetic diversity? These 'what if' analyses can also be used to evaluate management recommendations. For example, how would the probability of population extinction change if the carrying capacity of the reserve holding the animals were increased by 10%?

Because the models don't examine all factors potentially contributing to extinction, the model results usually underestimate a population's probability of extinction. However, it is important to stress that the purpose of the PVA is not to estimate exact extinction probabilities but to identify the relative importance of the various factors being considered and to evaluate the effect of a range of management recommendations on the survival of the population.

IMPLICATIONS OF PVA ON MANAGEMENT GOALS

The concepts of population extinction and loss of genetic diversity are based on probabilities rather than certainties. The results from the PVA models provide us with information on the probability of extinction given certain assumptions about the biology and status of the population. As a result, we can not predict or guarantee what will happen to these populations with any absolute certainty.

This has some fairly strong implications when we are trying to develop conservation strategies to reduce the risks of extinction in the populations. We must be able to recognize that we will not be able to formulate and implement recommendations that will guarantee the survival of any population. We can only formulate and implement recommendations that will decrease the likelihood of extinction in populations over a given time period.

A common approach is to develop management strategies that assure a 95% chance of the population surviving for 100 years and maintaining 90% of its genetic variation over the same time period (Shaffer 1987; Soule et al, 1986). This would assure a high probability of survival and retain a large proportion of the population's ability to genetically adapt and evolve to changing environments. This approach defines the Minimum Viable Population (MVP) size to achieve these management objectives. Management strategies can only be fully evaluated if both degree of certainty and time frame for management are specified.

METAPOPULATIONS

The discussion to this point has focused on the extinction and genetic dynamics of a single population. However, often managers are faced with a species distributed over several interacting populations. When this is the case and animal movement (migration) between populations is high enough that the dynamics (extinction or genetic) of any single population is affected by dynamics of other nearby populations, the group of interacting populations is called a Metapopulation (Figure 7). The understanding of metapopulation dynamics has become increasingly important for the development of conservation strategies.

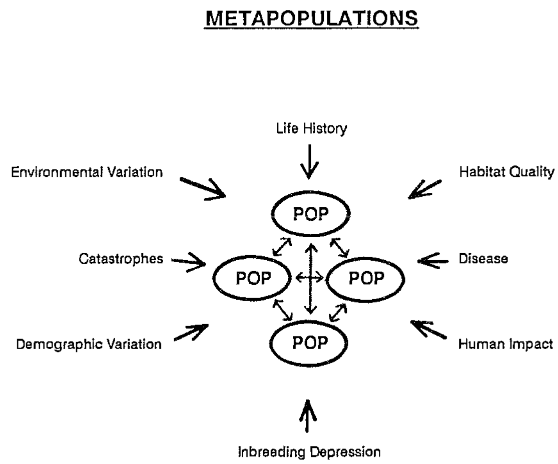

Figure 7. The interaction between population 'patches' results in a Metapopulation structure. Conservation strategies must consider the spatial distribution of the patches and its effect on correlated extinctions and recolonization between patches.

Metapopulation management focuses on the spatial distribution of the populations and how that influences both the genetic and demographic dynamics of the system. The metapopulation system can be thought of as a grouping of populations ('patches') of different sizes and distances from each other, with some patches periodically going extinct and being recolonized by migrants from other patches. The most important conservation considerations are rates of extinction for the individual patches and the re-colonization rates between patches (Gilpin 1987).

As we have discussed above, the extinction dynamics of any single patch is affected by any number of factors including size of population, rate of population recovery following a population decline, etc. From a metapopulation perspective, the simplest level is when patch extinction rates are uncorrelated with each other: the probability of extinction of any one patch is independent of any other patch. Environmental variation and catastrophes increase the extinction correlation between patches and this increases the likelihood of the entire metapopulation going extinct. So considerations of the spatial distribution between patches, and what that means in terms of how similarly they react to environmental variation and catastrophes is an important part of developing management strategies.

On the other side of the coin is the effect of spatial distribution on recolonization rates between patches. The closer patches are to each other, the higher the probability of a patch being recolonized following an extinction by migrants from a neighboring patch. Thus, distances between patches is positively correlated with recolonization and long-term survival of the metapopulation.

Patch extinction and recolonization also effect the retention of genetic diversity in the metapopulation. Small, fragmented and isolated populations rapidly lose genetic diversity. However, with migration between patches, gene flow among patches can be increased and the effective size of the total metapopulation is significantly increased. However, if recolonization following extinction repeatedly involves a very limited number of individuals (one pair or a pregnant female), then individual patches can be genetically invariant as a result of the recurrent founder effects.

The interaction between the positive aspects of recolonization and the negative effects of correlated patch extinction complicate the understanding of metapopulation dynamics, both at the genetic and demographic level. Unfortunately, computer models that combine aspects of single-population extinction and genetic considerations discussed above with considerations of metapopulation theory are not yet available for developing conservation management strategies.

Nevertheless, managers should be cognizant of the complexities of metapopulation systems. In general, populations distributed over several populations are more secure over the long-term than one population located at a single site. This is particularly true if there is gene flow between patches (either natural or through management intervention) and the patches are not susceptible to the same catastrophic threats. In many cases, a captive population can serve as a secure patch that can be used as a source to recolonize other patches through reintroduction efforts and as a reservoir for genetic diversity.

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Interactive Management of Small Wild and Captive Populations (T.J. Foose)

Introduction

Conservation strategies for endangered species must be based on viable populations. While it is necessary, it is no longer sufficient merely to protect endangered species *in situ*. They must also be managed.

The reason management will be necessary is that the populations that can be maintained of many species under the pressures of habitat degradation and unsustainable exploitation will be small, i.e. a few tens to a few hundreds (in some cases, even a few thousands) depending on the species. As such, these populations are endangered by a number of environmental, demographic, and genetic problems that are stochastic in nature and that can cause extinction.

Small populations can be devastated by catastrophe (weather disasters, epidemics, exploitation) as exemplified by the case of the black footed-ferret and the Puerto Rican parrot, or be decimated by less drastic fluctuations in the environment. Demographically, small populations can be disrupted by random fluctuations in survivorship and fertility. Genetically, small populations lose diversity needed for fitness and adaptability.

Minimum Viable Populations

For all of these problems, it is the case that the smaller the population is and the longer the period of time it remains so, the greater these risks will be and the more likely extinction is to occur. As a consequence, conservation strategies for species which are reduced in number, and which most probably will remain that way for a long time, must be based on maintaining certain minimum viable populations (MVP's), i.e. populations large enough to permit long-term persistence despite the genetic, demographic and environmental problems.

There is no single magic number that constitutes an MVP for all species, or for any one species all the time. Rather, an MVP depends on both the genetic and demographic objectives for the program and the biological characteristics of the taxon or population of concern. A further complication is that currently genetic and demographic factors must be considered separately in determining MVP's, although there certainly are interactions between the genetic and demographic factors. Moreover, the scientific models for assessing risks in relation to population size are still in rapid development. Nevertheless, by considering both the genetic and demographic objectives of the program and the biological characteristics pertaining to the population, scientific analyses can suggest ranges of population sizes that will provide calculated protection against the stochastic problems.

Genetic and demographic objectives of importance for MVP

Probability of survival (e.g., 50% or 95%) desired for the population;

Percentage of the genetic diversity to be preserved (90%, 95%, etc.);

Period of time over which the demographic security and genetic diversity are to be sustained (e.g., 50 years, 200 years).

In terms of demographic and environmental problems, for example, the desire may be for 95% probability of survival for 200 years. Models are emerging to predict persistence times for populations of various sizes under these threats. Or in terms of genetic problems, the desire may be to preserve 95% of average heterozygosity for 200 years. Again models are available. However, it is essential to realize that such terms as viability, recovery, self-sustainment, and persistence can be defined only when quantitative genetic and demographic objectives have been established, including the period of time for which the program (and population) is expected to continue.

Biological characteristics of importance for MVP

Generation time: Genetic diversity is lost generation by generation, not year by year. Hence, species with longer generation times will have fewer opportunities to lose genetic diversity within the given period of time selected for the program. As a consequence, to achieve the same genetic objectives, MVP's can be smaller for species with longer generation times. Generation time is qualitatively the average age at which animals produce their offspring; quantitatively, it is a function of the age-specific survivorships and fertilities of the population which will vary naturally and which can be modified by management, e.g. to extend generation time.

The number of founders. A founder is defined as an animal from a source population (the wild for example) that establishes a derivative population (in captivity, for translocation to a new site, or at the inception of a program of intensive management). To be effective, a founder must reproduce and be represented by descendants in the existing population. Technically, to constitute a full founder, an animal should also be unrelated to any other representative of the source population and non-inbred.

Basically, the more founders, the better, i.e. the more representative the sample of the source gene pool and the smaller the MVP required for genetic objectives. There is also a demographic founder effect; the larger the number of founders, the less likely is extinction due to demographic stochasticity. However, for larger vertebrates, there is a point of diminishing returns (Figure 1), at least in genetic terms. Hence a common objective is to obtain 20-30 effective founders to establish a population. If this objective cannot be achieved, then the program must do the best with what is available. If a pregnant female woolly mammoth were discovered wandering the tundra of Alaska, it would certainly be worth trying to develop a recovery plan for the species even though the probability of success would be low. By aspiring to the optima, a program is really improving the probability of success.

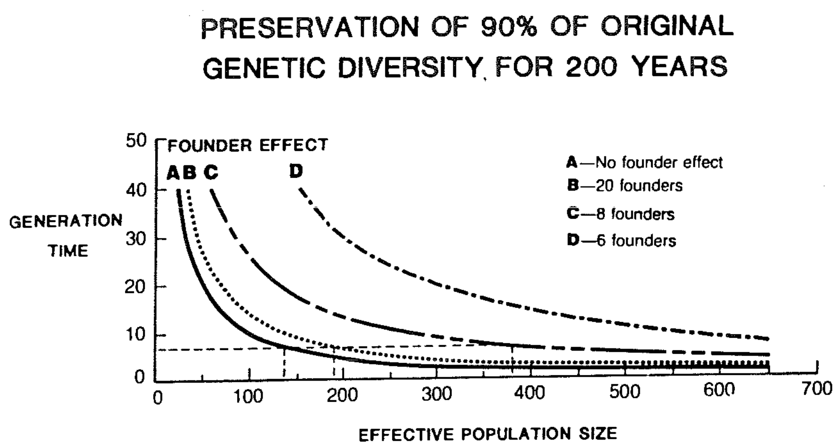

Figure 1. Interaction of number of founders, generation time of the species, and effective population size required for preserving 90% of the starting genetic diversity for 200 years.

Effective Population Size. Another very important consideration is the effective size of the population, designated N_e. N_e is not the same as the census size, N. Rather, N_e is a measure of the way the members of the population are reproducing with one another to transmit genes to the next generation. N_e is usually much less than N. For example in the grizzly bear, N_e/N ratios of about .25 have been estimated (Harris and Allendorf 1989). As a consequence, if the genetic models prescribe an N_e of 500 to achieve some set of genetic objectives, the MVP might have to be 2000.

Growth Rate. The higher the growth rate, the faster a population can recover from small size, thereby outgrowing much of the demographic risk and limiting the amount of genetic diversity lost during the so-called "bottleneck". It is important to distinguish MVP's from bottleneck sizes.

Population viability analysis

The process of deriving MVP's by considering various factors, i.e. sets of objectives and characteristics, is known as Population Viability (sometimes Vulnerability) Analysis (PVA). Deriving applicable results in PVA requires an interactive process between population biologists, managers, and researchers. PVA has been applied to a number of species (e.g., Parker and Smith 1988, Seal et al. 1989, Ballou et al. 1989, Lacy et al. 1989, Lacy and Clark, in press).

As mentioned earlier, PVA modelling often is performed separately with respect to genetic and demographic events. Genetic models indicate it will be necessary to maintain populations of hundreds or thousands to preserve a high percentage of the gene pool for several centuries. Recent models allow simultaneous consideration of demography, environmental uncertainty, and genetic uncertainty.

MVP's to contend with demographic and environmental stochasticity may be even higher than to preserve genetic diversity especially if a high probability of survival for an appreciable period of time is desired. For example, a 95% probability of survival may entail actually maintaining a much larger population whose persistence time is 20 times greater than required for 50% (i.e., average) probability of survival; 90%, 10 times greater. From another perspective, it can be expected that more than 50% of actual populations will become extinct before the calculated mean persistence time elapses.

Species of larger vertebrates will almost certainly need population sizes of several hundreds or perhaps thousands to be viable. In terms of the stochastic problems, more is always better.

Metapopulations and Minimum Areas

MVP's imply minimum critical areas of natural habitat, that will be vast for large carnivores like the wolf or tiger. Consequently, it will be difficult or impossible to maintain single, contiguous populations of the hundreds or thousands required for viability.

However, it is possible for smaller populations and sanctuaries to be viable if they are managed as a single larger population (a metapopulation) whose collective size is equivalent to the MVP (Figure 2). Actually, distributing animals over multiple "subpopulations" will increase the effective size of the total number maintained in terms of the capacity to tolerate the stochastic problems. Any one subpopulation may become extinct or nearly so due to these causes; but through recolonization or reinforcement from other subpopulations, the metapopulation will survive. Metapopulations are evidently frequent in nature with much local extinction and re-colonization of constituent subpopulations occurring.

Unfortunately, as wild populations become fragmented, natural migration for re-colonization may become impossible. Hence, metapopulation management will entail moving animals around to correct genetic and demographic problems (Figure 3). For migration to be effective, the migrants must reproduce in the new area. Hence, in case of managed migration it will be important to monitor the genetic and demographic performance of migrants

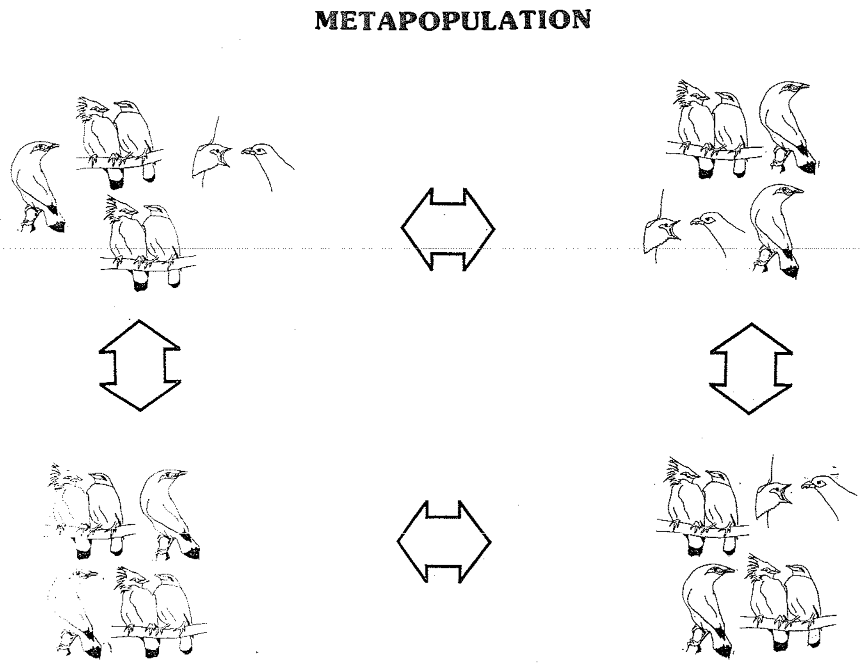

Figure 2. Multiple subpopulations as a basis for management of a metapopulation for survival of a species in the wild.

Managed migration is merely one example of the kinds of intensive management and protection that will be desirable and necessary for viability of populations in the wild. MVP's strictly imply benign neglect. It is possible to reduce the MVP required for some set of objectives, or considered from an alternative perspective, extend the persistence time for a given size population, through management intervention to correct genetic and demographic problems as they are detected. In essence, many of these measures will increase the N_e of the actual number of animals maintained.

The Bali Starling is already subject to intervention: animals are disturbed by residents, and the population is being reduced by poaching, and captive bred birds are being released into the wild population. Such interventions are manifestations of the fact that as natural sanctuaries and their resident populations become smaller, they are in effect transforming into megazoos that will require much the same kind of intensive genetic and demographic management as species in captivity.

MANAGED MIGRATION AMONG POPULATIONS OF BALI MYNAH

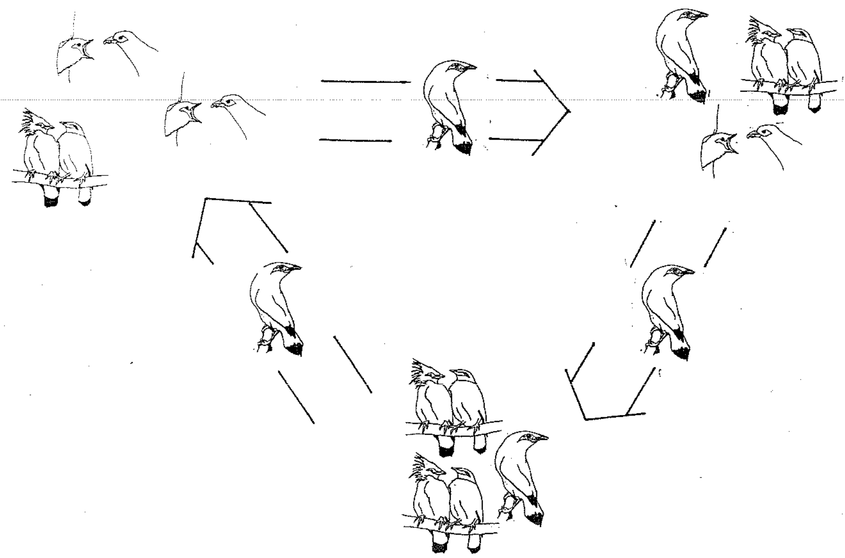

Figure 3. Managed migration among subpopulations to sustain gene flow in a metapopulation.

Captive Propagation

Another way to enhance viability is to reinforce wild populations with captive propagation. More specifically, there are a number of advantages to captive propagation: protection from unsustainable exploitation, e.g. poaching; moderation of environmental vicissitudes for at least part of the population; more genetic management and hence enhance preservation of the gene pool; accelerated expansion of the population to move toward the desired MVP and to provide animals more rapidly for introduction into new areas; and increase in the total number of animals maintained.

It must be emphasized that the purpose of captive propagation is to reinforce, not replace, wild populations. Captive colonies and zoos must serve as reservoirs of genetic and demographic material that can periodically be transfused into natural habitats to re-establish species that have been extirpated or to revitalize populations that have been debilitated by genetic and demographic problems.

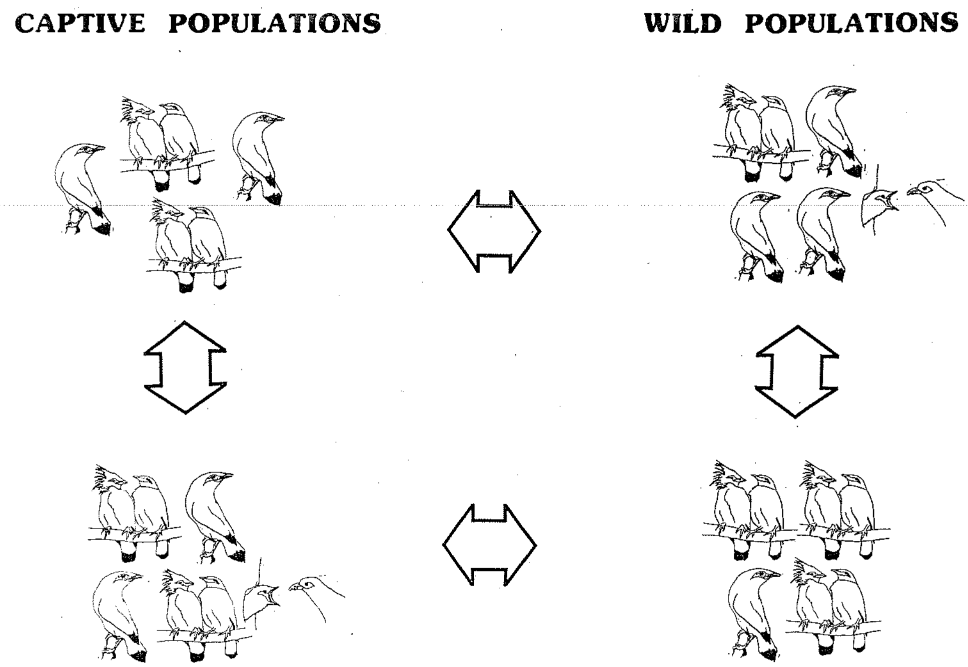

Figure 4. The use of captive populations as part of a metapopulation to expand and protect the gene pool of a species.

The survival of a great and growing number of endangered species will depend on assistance from captive propagation. Indeed, what appears optimal and inevitable are conservation strategies for the species incorporating both captive and wild populations interactively managed for mutual support and survival (Figure 4). The captive population can serve as a vital reservoir of genetic and demographic material; the wild population, if large enough, can continue to subject the species to natural selection. This general strategy has been adopted by the IUCN (the world umbrella conservation organization) which now recommends that captive propagation be invoked anytime a taxon's wild population declines below 1000 (IUCN 1988).

Species Survival Plans

Zoos in many regions of the world are organizing scientifically managed and highly coordinated programs for captive propagation to reinforce natural populations. In North America, these efforts are being developed under the auspices of the AAZPA, in coordination with the IUCN SSC Captive Breeding Specialist Group (CBSG), and are known as the Species Survival Plan (SSP).

Captive propagation can help, but only if the captive populations themselves are based on concepts of viable populations. This will require obtaining as many founders as possible, rapidly expanding the population normally to several hundreds of animals, and managing the population closely genetically and demographically. This is the purpose of SSP Masterplans. Captive programs can also conduct research to facilitate management in the wild as well as in captivity, and for interactions between the two.

A prime examples of such a captive/wild strategy is the combined USFWS Recovery Plan/SSP Masterplan for the red wolf. Much of the captive propagation of red wolves has occurred at a special facility in Washington state, but there is also a growing number of zoos providing captive habitat, especially institutions within the historical range of the red wolf.

Another eminent example of a conservation and recovery strategy incorporating both captive and wild populations is the black-footed ferret. This species now evidently survives only in captivity. Because the decision to establish a captive population was delayed, the situation became so critical that moving all the animals into captivity seemed the only option, circumstances that also applied to the California condor. Another option may have been available if action to establish a captive population had occurred earlier as was done with the Puerto Rican parrot and plain pigeon. Consideration of the survivorship pattern, which exhibited high juvenile mortality for ferrets, as it does for many mammals and birds, suggested that young animals destined to die in the wild might be removed with little or no impact on the population. The AAZPA and CBSG/SSC/IUCN are involved in these kinds of strategies and programs worldwide.

Population Viability Analysis (R. C. Lacy)

Many wildlife populations that were once large, continuous, and diverse have been reduced to small, fragmented isolates in remaining natural areas, nature preserves, or even zoos. For example, black rhinos once numbered in the 100s of thousands, occupying much of Africa south of the Sahara; now a few thousand survive in a handful of parks and reserves, each supporting a few to at most a few hundred animals. Similarly, the Puerto Rican parrot, the only psittacine native to Puerto Rico, was formerly widespread on the island and numbered perhaps a million birds. By 1972 the species was reduced to just 20 birds (4 in captivity). Intensive efforts since have accomplished a steady recovery to 46 captive and 34 wild birds at the end of 1988. In 1989, the Luquillo forest which is home to both the captive and wild flocks of Puerto Rican parrots was severely damaged by a hurricane. Apparently about half of the wild parrots were killed, most of the traditional nest trees were destroyed, the food supply was decimated, and it is unlikely that a viable population remains in the wild.

When populations become small and isolated from any and all other conspecifics, they face a number of demographic and genetic risks to survival: in particular, chance events such as the occurrence and timing of disease outbreaks, random fluctuations in the sex ratio of offspring, Captive propagation can help, but only if the captive populations themselves are based on concepts of viable populations. This will require obtaining as many founders as possible, rapidly expanding the population normally to several hundreds of animals, and managing the population closely genetically and demographically. This is the purpose of SSP Masterplans. Captive programs can also conduct research to facilitate management in the wild as well as in captivity, and for interactions between the two.

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When populations become small and isolated from any and all other conspecifics, they face a number of demographic and genetic risks to survival: in particular, chance events such as the occurrence and timing of disease outbreaks, random fluctuations in the sex ratio of offspring, and even the randomness of Mendelian gene transmission can become more important than whether the population has sufficient habitat to persist, is well adapted to that habitat, and has an average birth rate that exceeds the mean death rate. Unfortunately, the genetic and demographic processes that come into play when a population becomes small and isolated feed back on each other to create what has been aptly but depressingly described as an "extinction vortex". The genetic problems of inbreeding depression and lack of adaptability can cause a small population to become even smaller --which in turn worsens the uncertainty of finding a mate and reproducing -- leading to further decline in numbers and thus more inbreeding and loss of genetic diversity. The population spirals down toward extinction at an ever accelerated pace. The size below which a population is likely to get sucked into the extinction vortex has been called the Minimum Viable Population size (or MVP).

The final extinction of a population usually is probabilistic, resulting from one or a few years of bad luck, even if the causes of the original decline were quite deterministic processes such as over-hunting and habitat destruction. Recently, techniques have been developed to permit the systematic examination of many of the demographic and genetic processes that put small, isolated populations at risk. By a combination of analytic and simulation techniques, the probability of a population persisting a specified time into the future can be estimated: a process called Population Viability Analysis (PVA) (Soule 1987). Because we still do not incorporate all factors into the analytic and simulation models (and we do not know how important the factors we ignore may be), the results of PVAs almost certainly underestimate the true probabilities of population extinction.

The value of a PVA comes not from the crude estimates of extinction probability, but rather from identification of the relative importance of the factors that put a population at risk and assessment of the value (in terms of increased probability of population persistence) of various possible management actions. That few species recognized as Endangered have recovered adequately to be delisted and some have gone extinct in spite of protection and recovery efforts attests to the acute risks faced by small populations and to the need for a more intensive, systematic approach to recovery planning utilizing whatever human, analytical, biological, and economic resources are available.

Genetic Processes in Small and Fragmented Populations

Random events dominate genetic and evolutionary change when the size of an inter-breeding population is on the order of 10s or 100s (rather than 1000s or more). In the absence of selection, each generation is a random genetic sample of the previous generation. When this sample is small, the frequencies of genetic variants (alleles) can shift markedly from one generation to the next by chance, and variants can be lost entirely from the population -- a process referred to as "genetic drift". Genetic drift is cumulative. There is no tendency for allele frequencies to return to earlier states (though they may do so by chance), and a lost variant cannot be recovered, except by the reintroduction of the variant to the population through mutation or immigration from another population. Mutation is such a rare event (on the order of one in a million for any given gene) that it plays virtually no role in small populations over time scales of human concern (Lacy 1987a). The restoration of variation by immigration is only possible if other populations exist to serve as sources of genetic material.

Genetic drift, being a random process, is also non-adaptive. In populations of less than 100 breeders, drift overwhelms the effects of all but the strongest selection: Adaptive alleles can be lost by drift, with the fixation of deleterious variants (genetic defects) in the population. For example, the prevalence of cryptorchidism (failure of one or both testicles to descend) in the Florida panther (Felis concolor coryi) is probably the result of a strongly deleterious allele that has become common, by chance, in the population; and a kinked tail is probably a mildly deleterious (or at best neutral) trait that has become almost fixed within the panther.

A concomitant of genetic drift in small populations is inbreeding -- mating between genetic relatives. When numbers of breeding animals become very low, inbreeding becomes inevitable and common. Inbred animals often have a higher rate of birth defects, slower growth, higher mortality, and lower fecundity ("inbreeding depression"). Inbreeding depression has been well documented in laboratory and domesticated stocks (Falconer 1981), zoo populations (Ralls et al. 1979, Ralls and Ballou 1983, Ralls et al. 1988), and a few wild populations. The male-biased sex ratio of Key deer fawens may be a consequence of inbreeding, as might the low rate of twinning.

Inbreeding depression probably results primarily from the expression of rare, deleterious alleles. Most populations contain a number of recessive deleterious alleles (the "genetic load" of the population) whose effects are usually masked because few individuals in a randomly breeding population would receive two copies of (are "homozygous" for) a harmful allele. Because their parents are related and share genes in common, inbred animals have much higher probabilities of being homozygous for rare alleles. If selection were efficient at removing deleterious traits from small populations, progressively inbred populations would become purged of their genetic load and further inbreeding would be of little consequence. Because random drift is so much stronger than selection in very small populations, even decidedly harmful traits can become common (e.g., cryptorchidism in the Florida panther, biased sex ratio in the Key deer) and inbreeding depression can drive a population to extinction.

The loss of genetic diversity that occurs as variants are lost through genetic drift has other, long-term consequences. As a population becomes increasingly homogeneous, it becomes increasingly susceptible to disease, new predators, changing climate, or any environmental change. Selection cannot favor the more adaptive types when all are identical and none are sufficiently adaptive. Every extinction is, in a sense, the failure of a population to adapt quickly enough to a changing environment.

To avoid the immediate effects of inbreeding and the long-term losses of genetic variability a population must remain large, or at least pass through phases of small numbers ("bottlenecks") in just one or a few generations. Because of the long generation times of the

Puerto Rican parrot, the present bottleneck has existed for just one or two generations, and could be exited (successfully, we hope) before another generation passes and further genetic decay occurs. The Florida Key deer has evidently been in a bottleneck for thousands of years, perhaps 2-3 thousand generations. Although we cannot predict which genetic variants will be lost from any given population (that is the nature of random drift), we can specify the expected average rate of loss. Figure 5 shows the mean fate of genetic variation in randomly breeding populations of various sizes. The average rate of loss of genetic variance (when measured by heterozygosity, additive variance in quantitative traits, or the binomial variance in allelic frequencies) declines by drift according to:

$$V_g(t) = V_g(0) \times (1 - 1/(2N_e))^t,$$

in which V_g is the genetic variance at generation t, and N_e is the effective population size (see below) or approximately the number of breeders in a randomly breeding population. As shown in Figure 6, the variance in the rate of loss among genes and among different populations is quite large; some populations may (by chance) do considerably better or worse than the averages shown the Figure 5.

The rate of loss of genetic variation considered acceptable for a population of concern depends on the relationship between fitness and genetic variation in the population, the decrease in fitness considered to be acceptable, and the value placed by humans on the conservation of natural variation within wildlife populations. Over the short-term, a 1% decrease in genetic variance (or heterozygosity), which corresponds to a 1% increment in the inbreeding coefficient, has been observed to cause about a 1-2% decrease in aspects of fitness (fecundity, survival) measured in a variety of animal populations (Falconer 1981). Appropriately, domesticated animal breeders usually accept inbreeding of less than 1% per generation as unlikely to cause serious detriment. The relationship between fitness and inbreeding is highly variable among species and even among populations of a species, however. A few highly inbred populations survive and reproduce well (e.g., northern elephant seals, Pere David's deer, European bison), while attempts to inbreed many other populations have resulted in the extinction of most or all inbred lines (Falconer 1981).

Concern over the loss of genetic adaptability has led to a recommendation that management programs for endangered taxa aim for the retention of at least 90% of the genetic variance present in ancestral populations (Foose et al. 1986). The adaptive response of a population to selection is proportional to the genetic variance in the traits selected, so the 90% goal would conserve a population capable of adapting at 90% the rate of the ancestral population. Over a timescale of 100 years or more, for a medium-sized vertebrate with a generation time of 5 years such a goal would imply an average loss of 0.5% of the genetic variation per generation, or a randomly breeding population of about 100 breeding age individuals.

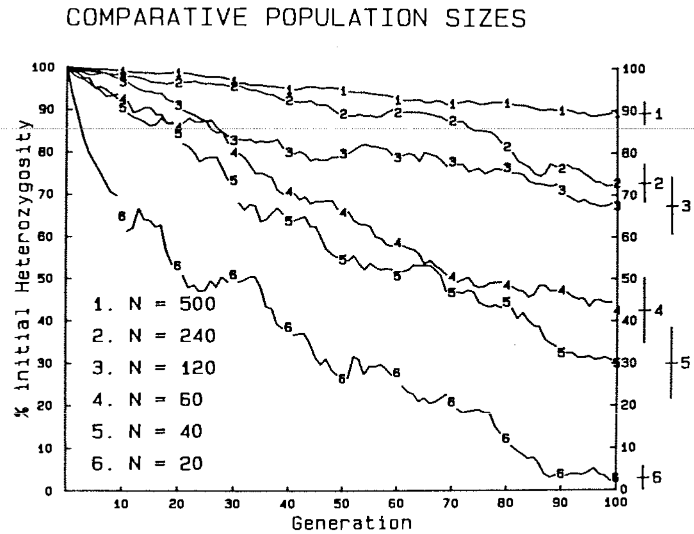

Figure 5. The average losses of genetic variation (measured by heterozygosity or additive genetic variation) due to genetic drift in 25 computer-simulated populations of 20, 50, 100, 250, and 500 randomly breeding individuals. Figure from Lacy 1987a.

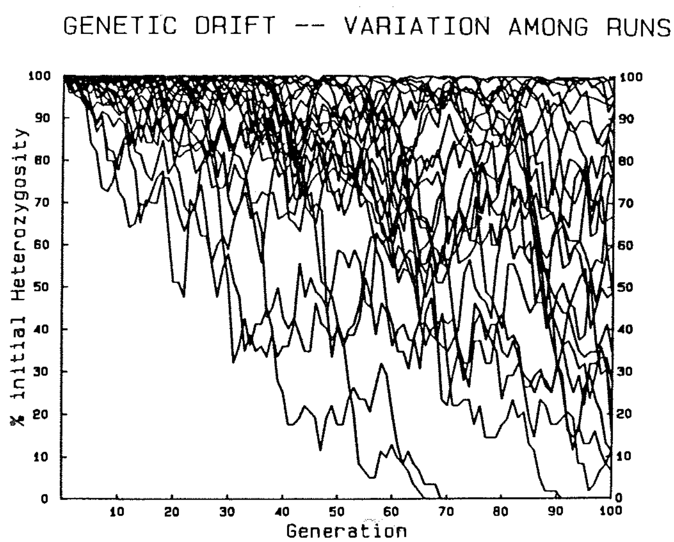

Figure 6. The losses of heterozygosity at a genetic locus in 25 populations of 120 randomly breeding individuals, simulated by computer. Figure from Lacy 1987a.

Most populations, whether natural, reintroduced, or captive, are founded by a small number of individuals, usually many fewer than the ultimate carrying capacity. Genetic drift can be especially rapid during this initial bottleneck (the "founder effect"), as it is whenever a population is at very low size. To minimize the genetic losses from the founder effect, managed populations should be started with 20 to 30 founders, and the population should be expanded to carrying capacity as rapidly as possible (Foose et al. 1986, Lacy 1988, 1989). With twenty reproductive founders, the initial population

would contain approximately 97.5% of the genetic variance present in the source population from which the founders came. The rate of further loss would decline from 2.5% per generation as the population increased in numbers. Because of the rapid losses of variability during the founding bottleneck, the ultimate carrying capacity of a managed population may have to be set substantially higher than the 100 breeding individuals given above in order to keep the total genetic losses below 90% (or whatever goal is chosen).

The above equations, graphs, and calculations all assume that the population is breeding randomly. Yet breeding is random in few if any natural populations. The "effective population size" is defined as that size of a randomly breeding population (one in which gamete union is at random) which would lose genetic variation by drift at the same rate as does the population of concern. An unequal sex ratio of breeding animals, greater than random variance in lifetime reproduction, and fluctuating population sizes all cause more rapid loss of variation than would occur in a randomly breeding population, and thus depress the effective population size. If the appropriate variables can be measured, then the impact of each factor on N_e can be calculated from standard population genetic formulae (Crow and Kimura 1970, Lande and Barrowclough 1987). For many vertebrates, breeding is approximately at random among those animals that reach reproductive age and enter the breeding population. To a first approximation, therefore, the effective population size can be estimated as the number of breeders each generation. In managed captive populations (with relatively low mortality rates, and stable numbers), effective population sizes are often 1/4 to 1/2 the census population. In wild populations (in which many animals die before they reach reproductive age), Ne/N probably rarely exceeds this range and often is an order of magnitude less.

The population size required to minimize genetic losses in a medium sized animal, therefore, might be estimated to be on the order of $N_e = 100$, as described above, with $N = 200$ to 400. More precise estimates can and should be determined for any population of management concern from the life history characteristics of the population, the expected losses during the founding bottleneck, the genetic goals of the management plan, and the timescale of management.

Although the fate of any one small population is likely to be extinction within a moderate number of generations, populations are not necessarily completely isolated from conspecifics. Most species distributions can be described as "metapopulations", consisting of a number of partially isolated populations, within each of which mating is nearly random. Dispersal between populations can slow genetic losses due to drift, can augment numbers following population decline, and ultimately can recolonize habitat vacant after local extinction.

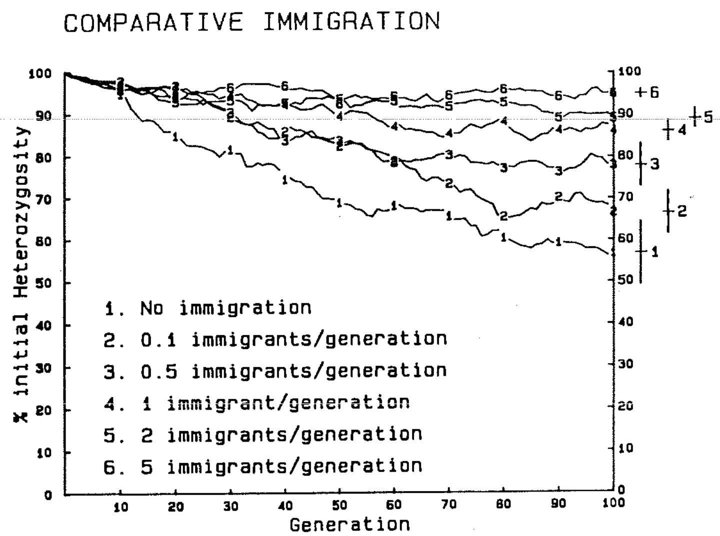

Figure 7. The effect of immigration from a large source population into a population of 120 breeding individuals. Each line represents the mean heterozygosity of 25 computer-simulated populations (or, equivalently, the mean heterozygosity across 25 non-linked genetic loci in a single population). Standard error bars for the final levels of heterozygosity are given at the right. Figure from Lacy 1987a.

If a very large population exists that can serve as a continued source of genetic material for a small isolate, even very occasional immigration (on the order of 1 per generation) can prevent the isolated subpopulation from losing substantial genetic variation (Figure 7). Often no source population exists of sufficient size to escape the effects of drift, but rather the metapopulation is divided into a number of small isolates with each subjected to considerable stochastic forces. Genetic variability is lost from within each subpopulation, but as different variants are lost by chance from different subpopulations the metapopulation can retain much of the initial genetic variability (Figure 8). Even a little genetic interchange between the subpopulations (on the order of 1 migrant per generation) will maintain variability within each subpopulation, by reintroducing genetic variants that are lost by drift (Figure 9). Because of the effectiveness of even low levels of migration at countering the effects of drift, the absolute isolation of a small population would have a very major impact on its genetic viability (and also, likely, its demographic stability). Population genetic theory makes it clear that no small, totally isolated population is likely to persist for long.

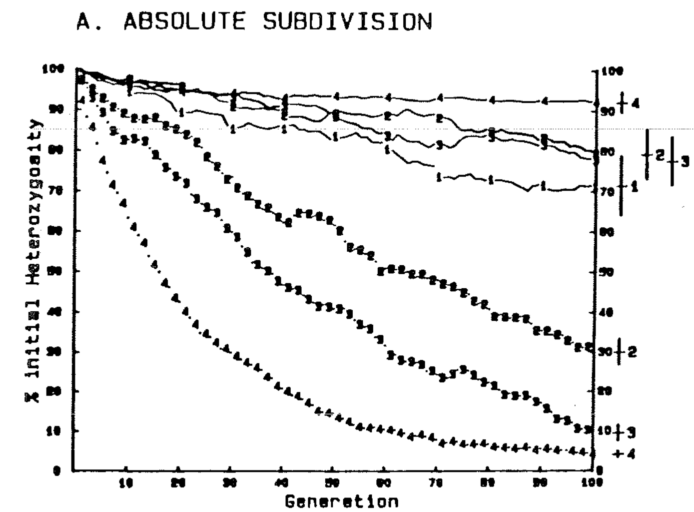

Figure 8. The effect of division of a population of 120 breeders into 1, 3, 5, or 10 isolated subpopulations. Dotted lines (numbers) indicate the mean within-subpopulation heterozygosities from 25 computer simulations. Lines represent the total gene diversity within the simulated metapopulation. Figure from Lacy 1987a.

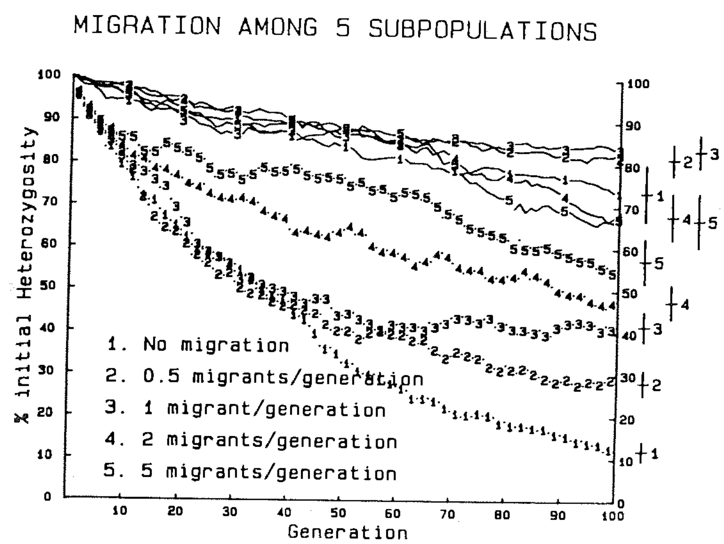

Figure 9. The effect of migration among 5 subpopulations of a population of 120 breeders. Dotted lines (numbers) indicate the mean within-subpopulation heterozygosities from 25 simulations. Lines represent the total gene diversity within the metapopulation. Figure from Lacy 1987a.

Demographic Processes in Small and Fragmented Populations (J. Ballou)

Extinction rates (persistence times) of populations are determined by the population size, growth rate, susceptibility to demographic challenges (sometimes measured as variation in growth rate), and its spatial distribution. In turn, growth rate, and population's susceptibility to demographic challenges is determined by the population's life history characteristics, and such random factors as the severity of demographic, environmental, genetic, disease and catastrophic events affecting the population.

Preliminary models are available for estimating persistence times for specific populations providing data are available on the demographic characteristics of the population. These model have been most useful for developing conservation strategies for small populations.

While the mean (expected) persistence time can be roughly estimated, these models show that persistence time is distributed as an approximate exponential distribution. Hence there is a high probability that the population will go extinct well before its calculated mean time. Model results that indicate long mean persistence times are therefore misleading since more than 50% of the time populations will go extinct before the indicated mean time period.

To protect against this, very large populations or a number of different populations will be needed to assure high certainty of population survival for significant periods of time. Furthermore, management decisions need to specify both time frame for management and degree of certainty as specific management goals (e.g. 95% certainty of surviving for 100 years) in order to accurately evaluate available management options and develop Minimum Viable Population Size ranges for populations.

Goals

Goals of single-species conservation programs are, in general, specifically directed towards mitigating the risks of extinction for those species of interest. This is best accomplished by understanding, identifying and redressing those factors that increase the probability of the population going extinct.

Small populations, even if stable in the demographic sense, are particularly susceptible to a discouraging array of challenges that could potentially have a significant impact on their probability of survival (Soule 1987). Among these challenges are Demographic Variation, Environmental Variation, Disease Epidemics, Catastrophes and Inbreeding Depression.

Challenges to Small Populations

Demographic Variation: This is the variation in the population's overall (average) birth and death rates caused by random differences among individuals in the population. The population can experience 'good' or 'bad' years in terms of population growth simply due to random (stochastic) variation at the individual level. This can have consequences for the population's survival. For example, one concern in captive propagation is the possibility that all individuals born into a small population during one generation are of one sex, resulting in the population going extinct. Figure 10 illustrates the probability of this occurring over a 100 generation period in populations of different size. There is a 50% chance of extinction due to biased sex ratio in a population of size 8 sometime during this time period. However, these risks are practically negligible in populations of much larger size. Similar consequences could result from the coincidental but random effects of high death rates or low birth rates.

In general, the effect of any one individual on the overall population's trend is significantly less in large populations than small populations. As a result, Demographic Variation is a minor demographic challenge in all but very small populations.

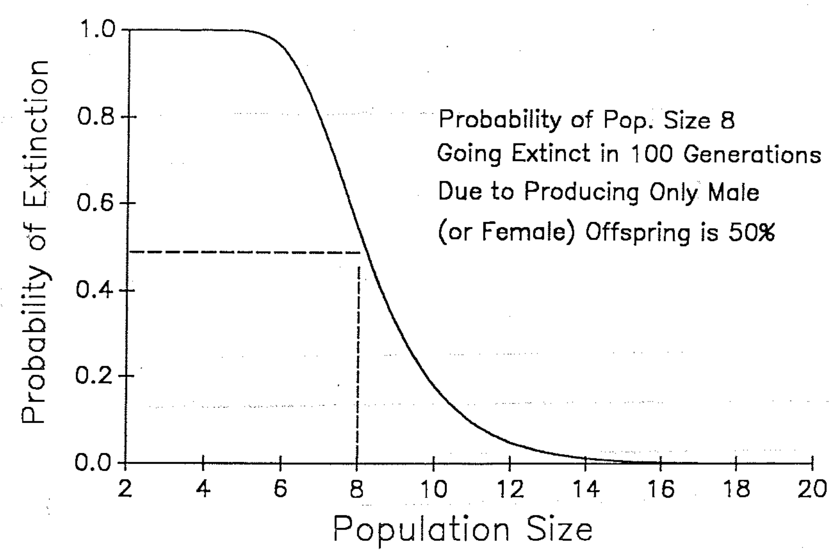

Figure 10. Example of Demographic Variation: Probability of extinction sometime during a 100 generation period due solely to producing only one sex of offspring.

Environmental Variation: Variation in environmental conditions clearly impact the ability of a population to reproduce and survive. As a result, populations susceptible to environmental variation vary in size more than less susceptible populations, increasing the danger of extinction. For example, reproductive success of the endangered Florida snail kite (Rostrhamus sociabilis) is directly affected by water levels, which determines prey (snail) densities: nesting success rates decrease by 80% during years of low water levels. Snail kite populations, as a result, are extremely unstable (Beissinger 1986).

Disease Epidemics: Disease epidemics and catastrophes are similar to other forms of environmental variation in the sense that they are external to the population. However, they are listed separately because we are just beginning to appreciate their role as recurrent but difficult to predict environmental pressures exerted on a population. They can be thought of as relatively rare events that can have devastating consequences on the survival of a large proportion of the population. Less devastating diseases and parasites are a natural accompaniment of all species and populations which may act to decrease reproductive rates and increase mortality rates.

Epidemics can have a direct or indirect effect. For example, in 1985 the sylvatic plague had a severe indirect effect on the last remaining black-footed ferret population by affecting the ferrets prey base, the prairie dog. Later that same year, the direct effect of distemper killed most of the wild population and all of the 6 ferrets that had been brought into captivity (Thorne and Belitsky 1989).

Catastrophes: From a demographic perspective, catastrophes are one-time disasters capable of totally decimating a population. Catastrophic events include natural events (floods, fires, hurricanes) or human induced events (deforestation or other habitat destruction). Large and small populations are susceptible to catastrophic events. Tropical deforestation is the single most devastating 'catastrophe' affecting present rates of species extinction. Estimates of tropical species' extinction rates vary between 20 and 50% by the turn of the century (Lugo 1988).

Inbreeding Depression: In small closed populations, mate choice is soon limited to close relatives, resulting in increased rates of inbreeding. The deleterious effects of inbreeding are well documented in a large variety of taxa. Although inbreeding depression has a genetic mechanism, its effects are demographic. Most data on exotic species come from studies of inbreeding effects on juvenile mortality in captive populations (Ralls, Ballou and Templeton 1988). These studies show an average effect of approximately 10% decrease in juvenile survival with every 10% increase in inbreeding. Data on the effects of inbreeding on reproductive rates in free ranging wild species is limited (lions; Wildt et al. 1987); however, domestic animal sciences recognize that inbreeding effects on reproduction are likely to be more severe than effects on survival. Inbreeding also may reduce disease resistance, and ability to adapt to rapidly changing environments (O'Brien and Evermann 1988).

Interacting Effects: Clearly, demographic challenges do not act independently in small populations. As a small population becomes more inbred, reduced survival and reproduction are likely; the population decreases. Inbreeding rates increase and because the population is smaller and more inbred, it is more susceptible to demographic variation as well as disease and severe environmental variation. Each challenge exacerbates the others resulting in a negative feedback effect (Figure 11). Over time the population becomes increasingly smaller and more susceptible to extinction (Gilpin and Soule 1986).

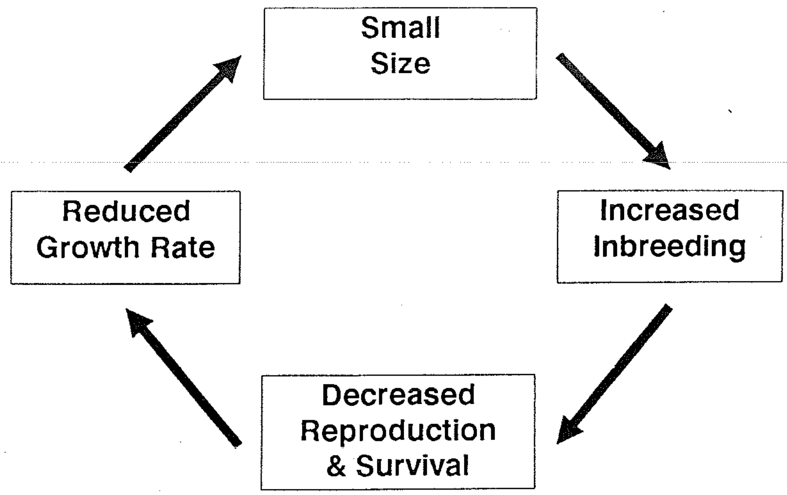

Figure 11. Negative feedback effects of inbreeding on small populations.

Susceptibility to Demographic Challenges

Populations differ in their susceptibility to demographic challenges. As mentioned above, population size clearly effects vulnerability. Large populations are relatively unaffected by demographic variation and are less apt to be totally devastated by environmental variation than small populations.

The severity of the demographic challenge is also important. A population in a fairly stable environment is less likely to go extinct than a population in a highly variable environment or an environment vulnerable to catastrophes.

A third important factor is a population's potential for recovering from these demographic challenges, in other words, the population's growth rate. A population at carrying capacity experiences normal fluctuation in population size; the degree of fluctuation depending on the severity of demographic challenge. Populations with low growth rates remain small longer than populations with rapid growth potential and therefore are more vulnerable to future size fluctuations.

A fourth important consideration is the population's spatial distribution. A population that is dispersed across several 'metapopulations,' or patches, is significantly less vulnerable to catastrophic extinctions than a same-sized population localized in a single patch. Extinction of one patch among many does not extinguish the entire population and colonization between patches could reconstitute extinct patches (Gilpin 1987).

Populations dispersed over a wide geographic range are also unlikely to experience the same environment over the entire range. While part of a population's range may suffer from extreme environmental stress (or catastrophes), other areas may act as a buffer against such effects.

Estimating Susceptibility with Persistence Time Models

A population's susceptibility to demographic challenges can be measured in terms of the amount of time it takes a population to go extinct. This is often referred to as the persistence time of the population. Ideally, persistence time should be estimated from data on all the variables discussed above. Persistence times are usually estimated from mathematical models that either simulate the population over a period of time (stochastic models) or estimate the population's expected (mean) persistence time (deterministic models).

Unfortunately, methods are not (yet) available to simultaneously consider the effect of all the above variables on persistence time. Usually, persistence times are estimated by considering the effects of only one or two variables. The effects of spatial distribution are the most important; however, they are also the most difficult and consequently are not considered (or only rudimentarily considered) in most persistence time models. These models assume a single, geographically localized population.

Goodman (1987) presents an example of a deterministic persistence time model. This model estimates the mean persistence time of a population given its size, growth rate and its susceptibility to environmental and demographic challenges.

In Goodman's model, susceptibility to demographic challenges is represented by the variance in the population's growth rate. A population that is very susceptible to environmental perturbations will vary drastically in size from year to year, which, in turn, will be reflected as a high variance in the population's growth rate. Goodman's model is:

$$\textbf{Mean Extinction Time} = \sum_{x=1}^{N} \sum_{y=x}^{N} \frac{2}{y(yV - r)} \prod_{z=x}^{Y-1} \frac{zV + r}{zV - r}$$

where: r = exponential annual growth of the population
V = variance in r
N = Maximum (ceiling) population size

The mean persistence times for populations of size 30 and 50 (which are at the upper limits of estimates for the Bali Starling population) with low growth potentials (.5% and 2% per year) are shown in Figure 12. These graphs are provided simply to introduce the concept of persistence time models and are not suggested as realistic models of the Bali Starling population. More realistic models, based on life history data collected from the field, are provided below.

The mean time to extinction is inversely related to the variation in the growth rate: if variance is extremely high, regardless of the population sizes or potential growth rates, the mean persistence time (time to extinction) is approximately 10 years. However, with variances of .2, mean persistence time varies from 42 to 57 years.

To provide perspective on the meaning of variance in r, if the growth rate is distributed as a normal random variable, a variance of .2 would mean that 75% of the growth rates experienced by the population would fall within the range of 50% increase per year and 50% population decline per year.

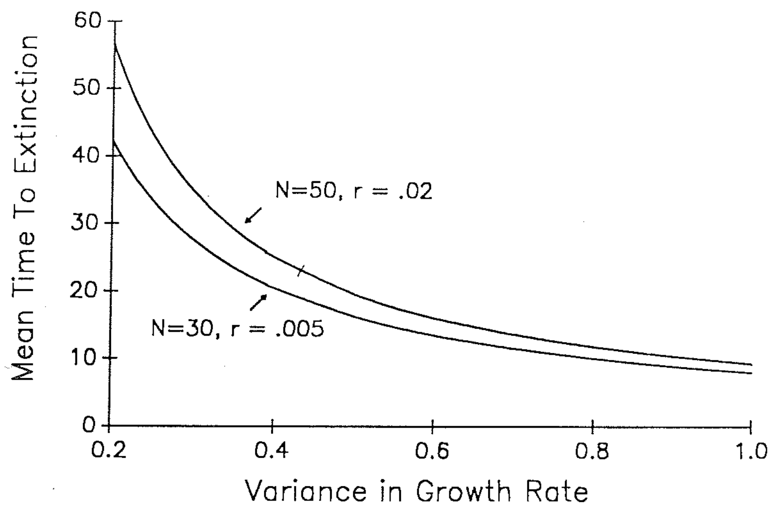

Figure 12. Mean time to extinction (persistence time) for a population of 50 animals with exponential growth rate of .02 (approx. 2% per year) and population of 30 animals with exponential growth rate of .005 (approx. 0.5% per year) under different levels of variation on growth rate. Variation in growth rate is a measure of the population's susceptibility to demographic challenges.

Persistence Time is Exponentially Distributed

An important characteristic of persistence time is that it has an approximately exponential distribution. The models provide the mean, or expected time to extinction; however, there is significant variation around this mean. Many population go extinct well before the mean time; a few go extinct long after.

The exponential distribution of persistence time for a population of 50 individuals with a growth potential of 2% and growth variance of .2 is shown in Figure 13. The mean persistence time is 57 years. However, since the distribution is exponential, there is a high probability that the time to extinction will occur before 57 years. In fact, there is a 33% chance that the time of extinction will be before 25 years.

Given that persistence times are approximately exponentially distributed, times to extinction can be estimated with various degrees of certainty. Again for the same population described in Figure 12, we can estimate the probability of extinction at different time periods (Figure 14). With growth rate variation at .2, mean time to extinction is 57 years; however, there is a 50% chance that the population will survive only to 40 years, only a 75% chance that the population will survive at least to 15 years, and a 95% chance that the population will survive at least to 4 years. In other words, there is a 5% chance that the population will go extinct in 4 years.

The Minimum Viable Population (MVP) Size concept is based on the premise that persistence times can only be defined with reference to degrees of certainty. Ideally, given a population's life history characteristics and management goal (a desired persistence time under a specified degree of certainty, e.g. 95% chance of surviving for 200 years), we could estimate the population size required to achieve the goal. This would be a Minimum Viable Population Size (MVP size) for the program (Shaffer 1981). However, since MVP size is a function of the specific management goals of the population, there is no one "magical" MVP size for any given population in any given circumstance.

Management Implications

The implication of exponentially distributed persistence time is that management strategies can not be based on the mean persistence time if a high degree of certainty is desirable. Although the mean persistence time of the modeled population is 57 years, management strategies should recognize that to be 95% certain that the population survives even 50 years would require a population size whose mean persistence time is 975 years. This would require well over 1000 individuals.

A second implication is that management strategies can only be fully evaluated if both degree of certainty and time frame for management are specified. For example, programs may be evaluated in terms of their potential for assuring a 95% chance of the managed population surviving for 200 years. It is critical that the management decision making process recognize that the process of extinction is a matter of probabilities, as are all its components (environmental and demographic variation, probability of catastrophe, etc.; Shaffer 1987).

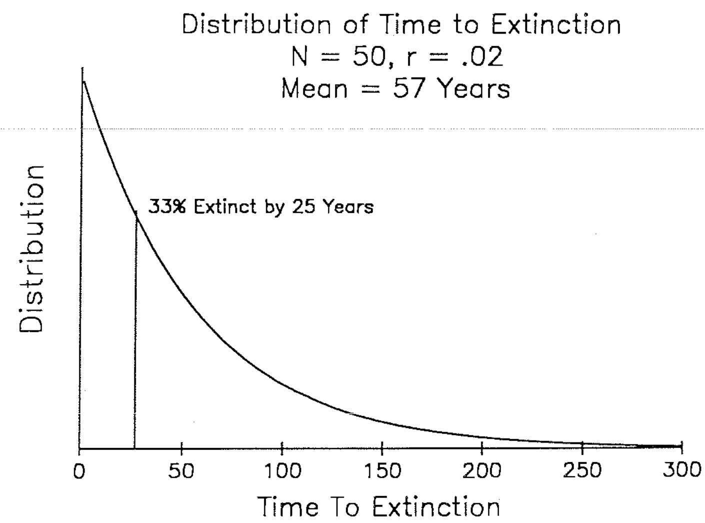

Figure 13. Exponentially distributed time for a population of 50 animals growing at an exponential rate of .02 with a variation in growth rate of 0.2. While the mean (expected) persistence time is 57 years, the exponential characteristic of the distribution shows that there is a high probability of extinction before this period (33% chance by 25 years).

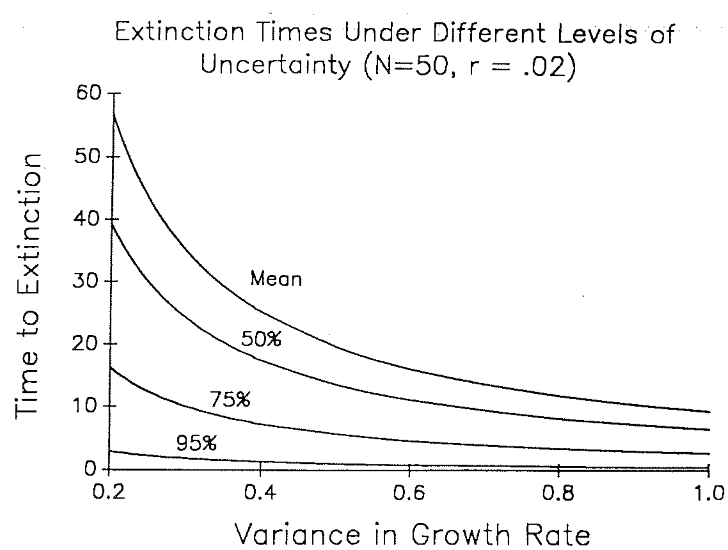

Figure 14. Extinction times under different levels of uncertainty. See text.

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GENETICS GLOSSARY

DNA

Deoxyribonucleic Acid; a chain of molecules contain units known as nucleotides. The material that stores and transmits information inherited from one cell or organisms to the next. The principle DNA is located on the chromosomes in the nucleus of cells. Lesser but still significant DNA is located in the mitochondria.

GENE

The segment of DNA that constitutes a functional unit of inheritance.

LOCUS

The section of the DNA occupied by the gene. Gene and locus (plural: loci) are often used interchangeably.

ALLELE

Alternative forms of a gene. Most strictly, allele refers to different forms of a gene that determine alternative characteristics. However, allele is used more broadly to refer to different copies of a gene, i.e. the 2 copies of each gene that every diploid organism carries for each locus.

ALLELE OR GENE FREQUENCY

The proportion of all copies of a gene in the population that represent a particular allele.

GENOTYPE

The kinds of alleles that an individual carries as its two copies of a gene. As an example, if there are two alleles (A, a) possible at a locus, there are then three genotypes possible: AA, Aa, and aa.

GENOTYPIC FREQUENCY

The proportion of individuals in the population that are of a particular genotype.

HETEROZYGOSITY

The proportion of individuals in the population that are heterozygous (i.e., carry functionally different alleles) at a locus.

HARDY-WEINBERG EQUILIBRIUM

A principle in population genetics that predicts frequencies of genotypes based on the frequencies of the alleles, assuming that the population has been randomly mating for at least one generation. In the simplest case, where there are two alleles (A, a) at a locus and these alleles occur in the frequency p_A and p_a, the Hardy-Weinberg law predicts that after one generation of random mating the frequencies of the genotypes will be: $AA = p_A^2$; $Aa = 2p_Ap_a$; $aa = p_a^2$.

EXPECTED HETEROZYSITY

The heterozygosity expected in a population if the population were in Hardy-Weinberg equilibrium. Expected heterozygosity is calculated from allele frequencies, and is the heterozygosity expected in progeny produced by random mating. 1 - SUM p_i's, where p_i = the frequency of allele i.

GENE DIVERSITY = FOUNDER ALLELE DIVERSITY

The expected heterozygosity of the current population relative to the wild population from which the founders have derived. Gene diversity is sometimes symbolized by P. $P = H_t/H_0$ where H_t and H_0 are the expected heterozygosities at times t and 0. Thus, the gene diversity of the population is the fraction of the wild heterozygosity retained.

GENOME

The complete set of genes (alleles) carried by an individual.

GENETIC DRIFT

The change in allelic frequencies from one generation to the next due to the randomness (chance) by which alleles are actually transmitted from parents to offspring. This random variation becomes greater as the population, and hence sample of genes, transmitted from one generation to the next, becomes smaller.

BOTTLENECK

A generation in the lineage from a founder when only one or a few offspring are produced so that not all of the founder's alleles may be transmitted onto the next generation.

FOUNDER

An animal from a source (e.g., wild) population that actually produce offspring and has descendants in the living derived (e.g., captive) population.

FOUNDER REPRESENTATION

The percentage or fraction of all the genes in the population at any given time that have derived from a particular founder.

EXISTING REPRESENTATION

The existing percentage representation of founders in the population.

TARGET REPRESENTATION

The desired or target percentage representation of founders. These target figures are proportional to the fraction of each founder genome that survived in the population. Achieving these target representation values will maximize preservation of genetic diversity.

ORIGINAL FOUNDER ALLELES

The total number of alleles (copies) of each gene carried at each locus by the founders. The number of original founder alleles is twice the number of original founder genomes.

ORIGINAL FOUNDER GENOMES

The set of all genes in a founder. The sum of all such sets are the founder genomes. The number of original founder genomes is half the number of original founder alleles.

FOUNDER ALLELES SURVIVING

The number of alleles still surviving at each locus in the population assuming that each founder carried two distinct alleles at each locus into the derived (captive) population.

FOUNDER GENOMES SURVIVING

The number of original founder genomes still surviving in the population. This metric measures loss of original diversity due to bottlenecks in the pedigree of the population.

FOUNDER GENOME EQUIVALENTS

The number of newly wild caught animals required to obtain the genetic diversity in the present captive population. This metric reflects loss due to both bottlenecks and disparities in founder representation.

FOUNDER EQUIVALENTS

The number of equally represented founders that would produce the same gene diversity as that observed in the surviving population, acknowledging the founder alleles that have already been lost due to bottlenecks. Founder equivalents measures the loss of genetic diversity due to the uneven representation of founder lineages in the surviving population.

EFFECTIVE POPULATION SIZE

A concept developed to reflect the fact that not all individuals in a population will contribute equally or at all to the transmission of genetic material to the next generation. Effective population size is usually denoted by N_e and is defined as the size of an ideal population that would have the same rate of genetic drift and of inbreeding as is observed in the real population under consideration. An ideal population is defined by: sexual reproduction; random mating; equal sex ratio; Poisson distribution of family sizes, i.e. total lifetime production of offspring; stable age distribution and constant size, i.e. demographic stationariness.

COEFFICIENT OF RELATEDNESS

The probability that an allele selected at random from one individual in the population is present in a second individual because of inheritance of that allele from a common ancestor. Equivalently, the proportion of genes in two individuals that are the same because of common descent. The inbreeding coefficient of an animal is equal to 1/2 the relatedness of the parents.

AVERAGE RELATEDNESS

The average or mean coefficient of relatedness between an animal and all animals (including itself) in the living, descendant (i.e., excluding the founders) population. The mean relatedness is twice the proportional loss of gene diversity of the descendant population relative to the founders and is also twice the mean or average inbreeding coefficient of progeny produced by random mating.

DEMOGRAPHY GLOSSARY

Age Age class in years.

P_x Age-specific survival.

Probability that an animal of a given age will survive to the next age class.

L_x Age-specific survivorship.

Probability of a newborn surviving to a given age class.

M_x Age-specific fertility.

Average number of offspring (of the same sex as the parent) produced by an animal in the given age class. Can also be interpreted as average percentage of animals that will reproduce.

r Instantaneous rate of change.

If $r < 0$ ...... Population is declining

$r = 0$ ...... Population is stationary (Does not change in number)

$r > 0$ .... Population is increasing

lambda Percent of population change per year.

If lambda < 1 ...... Population is declining

lambda = 1 ...... Population is stationary (Does not change in number)

lambda > 1 ...... Population is increasing

R_o Net reproductive rate.

The rate of change per generation.

If $R_o < 1$ ...... Population is declining

$R_o = 1$ ...... Population is stationary (Does not change in number)

$R_o > 1$ ...... Population is increasing

T Generation Time.

Average length of time between the birth of a parent and the birth of its offspring. (Equivalently, the average age at which an animal produces its offspring)

BALI STARLING

Leucopsar rothschildi

VIABILITY ANALYSIS

AND

SPECIES SURVIVAL PLAN

BALI STARLING POPULATION BIOLOGY

AND VIABILITY ANALYSIS

BALI STARLING PVA

Population Goals for Recovery

The overall goal of the Bali Starling recovery and conservation program is to achieve a population (or metapopulation consisting of a number of subpopulations) that will, with high probability, allow for the continued existence and adaptive evolution of the species Leucopsar rothschildi over much of its historical range. To accomplish this, the recovered population must have positive average population growth, be sufficiently stable demographically to be unlikely to go extinct during episodes of population decline (which can occur due to temporary stresses on the population or due simply to chance events in mortality and reproduction), and have sufficient genetic variation to allow for continued adaptation to a changing environment.

Population Viability Analysis suggests that the wild Bali Starling population is vulnerable to extinction in each of these four manners: (1) the continuation of poaching at historical rates which appears to have resulted in a steady decline of the population, (2) the population faces likely continuing decline of habitat and therefore of numbers if the enclave in the BBNP remains and continues to expand, (3) the population is so small that random fluctuations can lead to extinction, and (4) genetic variation has probably declined and is decaying at a rate that would cause inbreeding depression (reduction of viability and fecundity in offspring of breeding pairs that are closely related genetically) and preclude continued adaptive evolution.

The Bali Starling will be considered recovered only when the total number of Bali Starlings in Bali Barat National Park and surrounding habitat exceeds 500. There will also need to be a scientifically managed global captive population of at least 1000 birds in Indonesia, Europe, UK, USA., and other regions as a protection against catastrophes in the natural population and to protect a larger pool of genetic variation.

We propose explicit statement and refinement of the recovery goals for the Bali Starling by stating the above criteria, based on an understanding of demographic and genetic processes that interactively can contribute to extinction, necessary to define a "viable" population.

Explanation of goals for demographic recovery: The total collection of populations of the taxon may be considered a meta-population, within which are populations that exchange migrants rarely enough to allow each to experience independent demographic and genetic fluctuations. A population is considered to be those birds, perhaps further divided into smaller subpopulations, that exchange individuals sufficiently often so that each subpopulation exchanges, on average, at least one migrant per generation with other subpopulations of the population. Simulation modelling of some of the known causes of variability in Bali Starling populations indicates that wholly isolated populations of 100 adult starlings are not demographically stable for 100 years even if the mean population growth rate (r) is positive. The predicted probability of extinction within 100 years of such a population is more than 21% (without poaching), even if inbreeding has no deleterious effect on viability and reproduction in starlings. (A population size of 250 individuals reduces this risk to about 6% with no poaching). Extinction of such a population (100 birds) is virtually certain within 100 years if inbreeding depresses viability to the extent it does many other vertebrate populations (see simulation results below). Such a small wild population, on its own, should not be considered to constitute recovery of the species.

Isolated habitats, outside the BBNP, unable to support 100 adult starlings may be important to starling recovery, however. Natural or managed migration can connect a small resident subpopulation to those in other such habitat patches to constitute a larger, stable population (with a total of 250 or more adults).

Because every isolated population is vulnerable to extinction (for example, a severe fire or a disease epidemic can decimate even a large population), metapopulation viability requires at least three populations sufficiently discrete to be subject to independent fluctuations in numbers. If each population has a moderately low probability of extinction, and if the populations fluctuate independently from one another, then it is highly unlikely that extinction of the metapopulation will result from nearly simultaneous extinction of all its populations. Simulations suggest that populations of 100 adults with a 5% mean annual growth rate have a 6% probability of extinction within 100 years, if inbreeding depression does not compound demographic instability. For three populations each with a 6% probability of extinction, metapopulation extinction is expected to have a probability of just 0.0022% even if recolonization does not occur after local extinctions. If the wild population were to go extinct, it could be recolonized (though probably only by interventive management) from the extant captive populations, reducing the probability of metapopulation extinction still further.

Explanation of genetic goals for recovery: Populations of 50 breeding adults maintain sufficient genetic variation to minimize inbreeding (expected mean increase in the inbreeding coefficient less than 1%), and therefore have been recommended as minimum sizes for isolated populations of domestic livestock (Falconer 1981), and for short-term minimum sizes for wildlife (Franklin 1980). If subpopulations consist of fewer than 50 breeding adults, occasional migration between subpopulations (one or more per generation) can link genetically several subpopulations into viable populations with a total of more than 50 breeders.

For long-term maintenance of the genetic variation necessary for adaptive evolution, minimum total population sizes of about 500 have been suggested for species protection (Franklin 1980). A population of approximately 500 breeding adults will lose genetic variation in hereditary morphological traits no more rapidly than variation is regained by recurrent mutation. Thus, adequate genetic variation on which natural selection can act to adapt the population to novel stresses and environments is always available.

Goals for maintenance of a viable captive population: One of the populations contributing to overall taxon recovery can be a captive population. A viable captive population can be achieved more quickly than a reintroduced wild population (thus, more quickly contributing to taxon recovery), and can be used as a source of animals for reintroduction and augmentation of wild populations. The size required to achieve viability of a captive population may differ from that required for a wild population, however, because the risks to which each is vulnerable are different.

In captivity, mortality can be greatly reduced (and, often, fecundity can be increased) relative to a free-ranging population. Thus, captive populations of even modest size can be stabilized demographically and chance extinctions minimized. Genetic changes, however, would be at least as great in captivity as in a wild population: random genetic drift continues in captivity and inadvertent selection for domestication can occur as well. Therefore, the primary goal of a captive breeding program is to minimize the loss of the genetic diversity present in the founding stock, and to prevent, to the extent possible, natural selection for traits adaptive to captivity. Continued "adaptive" evolution in captivity is not desired if the ultimate goal of the captive program is to provide animals for return to the wild.

The obtain a good sampling of the genes present in the wild source population, **it is recommended that captive populations be started from at least 20 founders** (Foose et al. 1986, Lacy 1988). (A founder is defined as a wild-caught animal that contributes to the captive population by breeding.) Twenty founders will contain about 97.5% of the gene diversity of the source population (Nei 1987), and contain most genetic variants present at a frequency of greater than 2.5% in the wild population. Very rare genetic variants are likely to be omitted by such a sampling, and many more founders would be needed to capture such rare genes (Fuerst and Maruyama 1986, Allendorf 1986).

After establishment of a captive population, further loss of the genetic variation sampled from the wild in the founders can be minimized by expanding the captive population as rapidly as possible to the capacity of the captive habitat. Ideally, this expansion could occur in the first generation of captive breeding. Little further variation is sacrificed, however, if this expansion occurs within just two or three generations.

Seven progeny per founder result in the capture of at least 99% of the genes of each founder (each progeny independently samples 50% of the founder's genome), while 97% of a founder's genes are likely to be contained within five offspring. Thus, efforts to obtain 5 to 7 progeny per founder will minimize the probability that genetic variants present in the founders are lost during the early generations of captive breeding. With 95% assurance, <u>all</u> of the genes of a founder (all segments of its chromosomes) can be sampled by obtaining 12 progeny (Thompson, in prep.), although the minimal incremental value of obtaining all of a founders genes (rather than just 97% or 99% of the founder's genes) may not be worth the extra effort required to obtain 12 progeny.

The ultimate size of the captive population should be sufficient so that adequate genetic variation is maintained over the time that the captive population might be required for conservation. If the survival of the taxon were to be totally dependent on the captive population, a goal might be set of the maintenance of 90% of gene diversity for at least 200 years (i.e., inbreeding of no more than 10%) -- as has been suggested for captive breeding programs for conservation (Soule et al. 1986). Such a goal is ambitious, but is perhaps a good starting point for setting captive population goals until the wild population is considered less vulnerable. As the wild population became more secure and less reliance was placed on the captive population to assure taxon survival and to provide animals for reestablishing and supplementing wild populations, the goals for the captive population could be relaxed.

For the Bali Starlings, with a generation time of about 6-7 years, a captive population of about 150 randomly breeding adults derived from at least 20 founders (the effective population size or Ne) would accomplish this goal (Soule et al. 1986). This would require a total captive population of more than 300 adults and perhaps another 200 juveniles. Such a large commitment of resources to captive breeding of the Bali Starling has occurred if we consider the captive populations in the UK, Europe, Indonesia, and the USA. The scientific management of the population in Europe is just beginning however and we do not how many founders are represented in this population. Recent molecular genetic studies of the UK population suggests that no more than 5 founders are represented in population of about 110 birds. Therefore,

We recommend that the global captive population of Bali Starlings be managed with a goal of the preservation of 90% of the gene diversity of the source population for 100 years.

If founder stock to establish a captive population were not limiting, achieving this genetic goal would require an effective population size of about 80 birds and a total population size of at least 200. Because considerable genetic variation has been lost in the early generations of captive breeding, while the population was increased from the handful of founders to the current carrying capacity of the captive habitat, **the captive population will have to maintained at about 400 animals to achieve the genetic goal.** If a catastrophe decimates the wild population at any time, the captive population should be expanded quickly to the size (700) necessary to assure its long-term (200-year) viability in the absence of any possibility for further exchange with wild populations. These numbers may be reduced if more founders, than are know at present, can be found to have contributed to the captive population.

POPULATION BIOLOGY PARAMETERS

Accurate estimates of both means and variances of population parameters are essential to population viability analysis. Extensive field research is therefore a prerequisite to all population modelling and management. The numbers used in this analysis were obtained from field biologists working for the PHPA, ICBP, AAZPA, and JWPT during a workshop held in Bogor, Indonesia (22-24 March 1990), from reports prepared by van Balen and van Helvoort and Soetawidjaya (October 1990), and from analyses of the UK and USA regional studbooks. In a few cases, estimates were obtained from or verified with published data on captive populations of the species. We used consensus, best-guess estimates for much of the modelling, and also explored the effects of varying some of the less certain numbers on the results.

Current Population Size

Field biologists have been able to make fairly precise estimates of the present population size but direct evidence for age and sex composition (except nesting pairs) is lacking. Individual birds have not been marked for identification in the field studies. The population is not now fragmented into subpopulations it may have been subdivided by human settlement before 1984. There are possible small groups of birds outside of the park which are not being monitored but they would be extremely vulnerable to capture. There has been no successful supplementation of the wild population from the captive populations prior to 1990.

The survey and census teams conducted the annual census 25-28 September 1989 by observations of roosting sites in 13 localities. Based on these data, we used an estimate of 24-31 birds, 20 adult and 6 juveniles in our basic calculations. An additional 5 birds may have been removed by poaching during late March (1990), the month of the workshop. Recognizing that these numbers are clearly not viable even in the short term in the wild, we also modelled scenarios with 100 birds to estimate the viability of a larger number under the same conditions as being experienced by the present population.

The wild birds appear to produce only one clutch per year. However the Bali starling is capable of multiple clutching and breeding essentially continuously in captivity. This contrast suggests that there is an environmental limitation on reproduction in the wild. This may be a function of food availability based upon the timing of reproduction with the large increase in the availability of insects with the wet season. Clutch size ranges from 2-5 eggs in captivity with a mean of 3. The birds in the wild are thought to fledge about 1 chick per clutch. The proportion of females breeding successfully in the wild is unknown and likely to be variable but may be about 50% per year based upon the number of young birds observed.

Based on assumed biannual breeding, mean hatched clutch size of 3, 50% of females producing a fertile clutch, and 40%, 15% and 15% mortality in the first three years of life, it was be calculated that the average adult female with an active nest (50% of the adult females) could have 2.0 living chicks just after the hatching season (prior to any mortality of that year's chicks, females (all) would have an average of 0.45 1-year old offspring. Just prior to the breeding season, the average adult female would have 0.45 living juvenile offspring . Thus, the expected ratio of juvenile to adult birds may be estimated as between 0.45 and 1.45, depending on when the animals are counted.

Carrying Capacity

The Bali Starling population sustainable in the available habitat might, to a first approximation, be assumed to be equal to the historical population size. Carrying capacity estimates were based upon historical population sizes and might range from 100-500 birds for the current reserve area. A median estimate of 250 was agreed to be a reasonable estimate for the modelling. Environmental variance effects upon reproduction, mortality, and carrying capacity are unknown since the population has been declining steadily and there are no studies which have directly measured variations in productivity. For most of our analyses, we assumed that the present population (estimated at 26 starlings) is below the carrying capacity of the habitat. We examined scenarios with carrying capacities of 100 and 250, representing pessimistic and median estimates of habitat availability.

Regardless of the possible availability of unoccupied habitat, field biologists at the workshops agreed that habitat quality and quantity may decline substantially in the coming years. Areas of the Park (the enclave) are occupied by 700 families with the attendant use of the forest for wood collection and disturbance of the nesting sites. The most optimistic scenario expressed in the workshops was that the enclave would be removed within 3 years. It is possible that management practices (e.g., leading to increased nest site availability, decreased poaching) could improve some areas of habitat sufficiently to counteract losses of habitat in human occupancy. Serious declines were recognized as possible, but were not modelled specifically because the result of such losses would be certain and rapid extinction of the species in the wild.

Reproduction

Age of first reproduction in captivity is 15 months plus. Given the seasonality of breeding in the wild and the observation that only one clutch is produced annually in the wild, the age of first reproduction in the wild has been taken as 2 years. The birds are thought to be capable of reproduction throughout life based upon observations in captivity so no age dependant truncation was done.

The wild birds appear to produce only one clutch per year. However the Bali starling is capable of multiple clutching and breeding essentially continuously in captivity. This contrast suggests that there is an environmental limitation on reproduction in the wild. This may be a function of food availability based upon the timing of reproduction with the large increase in the availability of insects with the wet season. Clutch size ranges from 2-5 eggs in captivity with a mean of 3. The birds in the wild are thought to fledge about 1 chick per clutch. The proportion of females breeding successfully in the wild is unknown and likely to be variable but may be about 50% per year based upon the number of young birds observed. Assuming a 40% mortality in the first year, we estimate clutch sizes at birth to be less than 4. For most of our modelling, we assumed mean clutch size to be 2, distributed as 10% clutch of 1, 30% of 2, and 10% of 3.

Observations of nesting sites combines with the annual census indicates that the females produce a clutch with hatched chicks every other year, and we perhaps optimistically assumed in all scenarios examined that every reproductive-age female breeds biannually (has a 50% probability of producing a clutch in any given year) To allow for year to year variation we assigned a variance (standard deviation of $\pm$ 10% to this estimate). Starlings were assumed in the model to remain reproductive (without declining fecundity) throughout their life spans.

Mortality

There are no data on post fledge mortality, prior to reaching breeding age, in the wild. Suspected to be as much as 50%. Adult mortality ranges from 10-20% based upon studies of van Helvoort. Poaching and excessive take of bids from the wild has been a historical major source of loss from the population and the thought to be the primary basis for the decline in the population. Indeed there were birds removed as late as March and April of 1990. We selected an adult mortality of 15% per with SD=5% for the modelling.

If habitat is saturated, then mortality, especially of dispersing sub-adults, may be substantially higher. Such higher levels of mortality imposed by limited habitat were modelled with carrying capacities (see above) that impose random mortality across the population to limit numbers to no more than the set capacity each generation.

Effective Population Size

The genetically effective size of the wild population can be roughly estimated from the number of adults breeding over a period of one generation. Quantitative data are not available for such an estimate and the population has been in decline for the past 8 years. Given adult mortality rates (estimated at 15% per year), 52% of adults are expected to survive from 2 to the mean age of breeders (the generation time, 6 years). These data suggest that the effective population size is approximately 50% the number of adults. Since any variation in the number of offspring produced by these adults reduces the effective size, the effective population size probably falls between 25% and 50% of the number of adults. The effective population size of the existing wild population (26 birds, 20 adults) is probably about 5 to 10.

Genetic Variation and Inbreeding Depression

Preliminary research by Dr. Andrews on levels of genetic variation in the captive population of Bali Starlings in the UK as measured by DNA analysis (finger printing) indicate the 5 founders of the population indicated that the birds may have been similar to 1st degree relatives, i.e. siblings. This would indicate that they have been taken from the same nest or that the level of variation in the wild population is low. These results are preliminary and potentially subject to change with further analysis. In particular there is a need for examination of birds from the captive populations in the other regions. There is *direct* evidence of inbreeding depression in the captive population so that the species appears vulnerable to such effects.

The effect of inbreeding on viability and fecundity varies widely among mammals, with no clear taxonomic trends (Ralls, Ballou, and Templeton 1988). Having an estimates of the relationship between inbreeding and fitness in Bali Starlings, we modelled the possibility suggested by Helvoorts analysis of 0.7 to 2.4 lethal equivalents per diploid genome: (1) no effect of inbreeding on viability or fecundity, (2) general heterozygote superiority (a mode of selection that precludes removal of deleterious genes by natural selection, because every allele is equally deleterious when homozygous but beneficial when heterozygous) with an estimated severity of inbreeding depression of 1.5 "lethal equivalents" -- similar to the 50% the median observed in 40 populations of mammals studied by Ralls et al.

It is possible that wild Bali Starlings suffer more from inbreeding than does the median captive population, but selection may already have removed some of the genes responsible for inbreeding depression during past episodes of inbreeding and the very fact that the species is not yet extinct could be taken as evidence that they are not as severely effected by inbreeding as are many mammals. Inbreeding effects have to be considered in terms of the small population sizes in recent years and as a potential future threat if the wild population is not rapidly restored to 500-1000 birds. It may be that the population of this species has never been more than 2-5000 given the habitat requirements and its limited distribution only on the island of Bali.

Environmental Variation

The Bali starling is considered to be sensitive to human disturbance in captivity and by interference in the wild. There are about 700 families living in the Park who may act as a continuing source of disturbance to the population and interfere with its breeding. Major fires occur about every 20 years and may be an occasional catastrophic source of mortality. There are no data on diseases or parasites in the wild population. Data are needed on annual variation in rainfall as an index to variation in food resources.

We have no data on annual fluctuations in population demographic rates (litter sizes, mortality) for the Bali Starling except in terms of the continuing decline of the population due to poaching. Too few animals have been monitored (primarily because few animals exist) to assess synchrony in reproduction or mortality. We modelled annual environmental variation of magnitudes with standard deviations of 10-20% of the mean values as noted below.

Catastrophes

Disease epidemics are possible and areas of Bali are subject to severe fires about once every 20 years and to volcanic action perhaps 2-3 times per century. Catastrophes and their impact on the population include removals of birds for the market and the occasional fires. These as modelled separately in terms of a probable frequency of occurrence and in terms of an estimate of the severity of their effects upon reproduction and mortality. Poaching removals were treated in terms of mortality whereas fires were considered to produce a one time mortality and a one time reduction in breeding. It is unlikely that the species would survive a catastrophe that caused substantial mortality. (Numbers are perhaps now too low to give confidence in recovery even in the absence of catastrophe.) The results of modelling the possible effects of catastrophes, **suggest that if a catastrophe occurs, every effort should be made to rescue all remaining birds for return to the wild when conditions stabilize.** Fortunately, the availability of a captive population could allow recovery from epidemics and other catastrophes.

Time Period for Population Projections

The goals of managing any endangered species should include (minimally) recovery of several self-sustaining populations. A "self-sustaining" population must be defined in terms of an acceptably low probability of extinction over an acceptably long period of time. (No population is assured of persistence over any time scale and every population is certain to go extinct eventually.) Shaffer (1981) suggested that a viable population of grizzly bears (Ursus arctos horribilis) be defined as one with a 99% probability of persistence for 1,000 years. Because of the acute decline in numbers of the eastern barred bandicoot, a recent PVA for that species (Lacy and Clark, in press) examined population projections for only 25 years (beyond which there is very little probability of persistence of the population unless major management changes are instituted as is the case for the Bali Starling). A 200-year time frame for conservation planning was suggested by Soule et al. (1986). Most Species Survival Plans of the American Association of Zoological Parks and Aquariums use a 200-year goal for captive management.

We simulated the fate of wild Bali Starlings over 25 and 100 years, but included examination of population status at intermediate intervals. The goal was to facilitate management decisions that would leave options for the future. As we learn more about the birds, and as the status of the population changes, management will have to be an adaptive process. Reanalyses should lead to modified management. We do not want to manage with goals that could leave us with no or a debilitated Bali Starling population in just a few years.

POPULATION VIABILITY RESULTS

Life Table Determinations of Population Growth Rates

The demographic parameters above were analyzed by standard life-table analysis to determine the expected mean, long-term population growth rate under various scenarios of age of first reproduction, mean litter size, juvenile mortality, and adult mortality. Table 1 shows the results of these calculations, presenting growth rates as lambda, the annual growth rate of the population.

As can be readily seen in the tables, positive population growth (L) is only projected if the effects of the Type I catastrophe (poaching) is removed. Apparently, the wild population of starlings presently suffers from mortality that cannot be sustained for long. In the long term the current small population is at high risk of extinction due to natural sources of environmental variation and inbreeding.

Under the parameters most closely matching the available field data (mean age of first reproduction of 2 years, 15% adult mortality, mean clutch size of 1 including the 50% of females producing 0 hatchlings), and 20% loss every 2 years due to poaching we calculate that the Bali Starling population will decline about 10 - 15% per year. If the poaching occurs approximately annually then the decline will increase to 10-25% per year. In contrast a wild population without these removals could grow at 8-10% per year. The captive population could grow at 12-21% per year.

Stochastic Simulation of Population Extinction

The Models:

Life table analyses yield average long-term projections of population growth (or decline), but do not reveal the fluctuations in population size that would result from randomness and variability in demographic processes. To examine the probabilities of population persistence under various scenarios, we used a computer program (VORTEX), written by one of us (RCL) in the C programming language. Many of the algorithms in VORTEX were taken from a simulation program, SPGPC, written in BASIC by James W. Grier of North Dakota State University (Grier 1980a, 1980b, Grier and Barclay 1988). Grier makes his program freely available to anyone with a use for it, and we similarly will provide the source code and compiled versions (for use on microcomputers using the MS-DOS operating system) of VORTEX to anyone who has a use for it.

VORTEX models population processes as discrete, sequential events, with probabilistic outcomes determined by a pseudo-random number generator. VORTEX simulates birth and death processes and the transmission of genes through the generations by generating random numbers to determine whether each animal lives or dies, whether each adult female produces broods of size 0, or 1, or 2, or 3, or 4, or 5 during each year, and which of the two alleles at a genetic locus are transmitted from each parent to each offspring. Mortality and reproduction probabilities are assumed to be the same for each sex, and fecundity is assumed to be independent of age (after an animal reaches reproductive age). Mortality rates are specified for each pre-reproductive age class and for reproductive-age animals. The mating system can be specified to be either monogamous or polygynous. In either case, the user can specify that only a subset of the adult male population is in the breeding pool (the remainder being excluded perhaps by social factors).

Each simulation is started with a specified number of males and females of each pre-reproductive age class, and a specified number of male and females of breeding age. Each animal in the initial population is assigned two unique alleles at some hypothetical genetic locus, and the user specifies the severity of inbreeding depression (expressed in the model as a loss of viability in inbred animals). The computer program simulates and tracks the fate of each population, and outputs summary statistics on the probability of population extinction over specified time intervals, the mean time to extinction of those simulated populations that went extinct, the mean size of populations not yet extinct, and the levels of genetic variation remaining in any extant populations.

A population carrying capacity is imposed by truncation of each age class if the population size after breeding exceeds the specified carrying capacity. The program allows the user to model trends in the carrying capacity, as a geometric increases or decreases across a specified numbers of years.

The Values used for the Bali Starlings:

Values of variables and conditions for the simulations reported in the tables (1-3) and legends for column headings in the tables are summarized as follows:

The values for variables and conditions used in the simulations reported in Tables 1 - 3 were:

1000 runs for each scenario.

No inbreeding depression (Tables 1 and 2) or heterosis model with 1.5 lethal equivalents per diploid individual (Table 3).

Age first reproduction = 2 years for males and females (all scenarios).

Sex ratio at hatching = 1:1 (all scenarios).

Fertility: (Number eggs hatched in clutch)(all scenarios).

# Young	%Females	
0	50	(10% = SD)
1	10	
2	30	
3	10	

Monogamous in a given year (all scenarios).

All adult males in the breeding pool (all scenarios).

Mortality: (all scenarios).
Females and males:

Age range	%	SD
0 - 1	40	10
1 - 2	15	5
> 2	15	5

K or carrying capacity = 250 (Tables 1 and 3) or 100 (Table 2).

Probability of Catastrophe I 50% (ex. = Poaching effects)
Effect on reproduction 1.0 (no effect)
Effect on survival 0.8 (20% removal considered as deaths)

Probability of Catastrophe II 5% (ex. = Severe fire or rain delay)
Effect on reproduction 0.5 (50% failure for one year)
Effect on survival 0.5 (50% deaths in one year)

Scenarios were compared with no catastrophes, each type alone and with both combined. A second variation on the type I catastrophe was for a probability of 90% with no effects on reproduction and a 0.75 effect on survival. This extreme effect was necessary to achieve a population decline similar to that which has been observed during the past 8 years. (All tables).

Composition of starting population (examined for 26 and 104 birds)

Females and males:

Present population (26 birds)
3 each of age 1 year
10 each of age 2 or greater

Larger population (104 birds) (after growth or supplementation)
12 each of age 1 year
40 each of age 2 or greater

We did not harvest the population (effects of poaching treated as a catastrophe removal above).

Simulations were run for 25 years and 100 years because if current conditions prevail the population has a high probability of extinction within 5-10 years but conditions need to be established that provide at least a 95% per cent probability of survival for 100 years. Also the simulations were for 25 years since the population is now about 25 birds and has been declining at about 25% per year for the past 8 years. One objective of the simulations was to determine sets of conditions that might yield such a negative growth rate and then to determine the effects of selective modification of these conditions.

Legends for the column headings in Tables 1 - 3:

Column	Legend	Explanation
1	I	Type I Catastrophe occurrence or not: 0, 50, or 90.
2	II	Type II Catastrophe occurrence or not: 0, 5
3	P[E]	Probability of extinction as proportion of 1000 runs.
4.	T[E]	Mean time to extinction of populations going extinct.
5.	N	Mean size of surviving populations.
6.	H	Expected heterozygosity of surviving populations.
7.	A	Expected alleles remaining in surviving populations.
8.	L	Growth rate prior to truncation of population at K.

Results for the Wild Bali Starlings:

Carrying Capacity = 250 (Table 1).

Assuming a carrying capacity of 250 (Table I), the current population of 26 birds could survive for 100 years with greater than 99% probability and expand to carrying capacity (lines 1 and 6;) if it were not subject to either human induced mortality or losses due to natural events such as fire, reduced rainfall, or disease. However, natural events occurring on the average of once in 20 years reduce this probability of survival to 89% in 25 years and 74% over 100 years (lines 3 and 8). Addition of continued high poaching losses assures extinction within 10 years and reduction of poaching to half the present level yields a 74% probability of extinction within 25 years with a mean time to extinction of 15 years. Many of the simulated populations were extinct in 5-7 years.

If the wild population of birds were starting at 100 the probability of surviving 25 and 100 years 95% if only natural mortality were a factor (line 18) although the population size could be well below (173 vs 250) apparent carrying capacity. All other scenarios exhibit a negative growth rate with probabilities of extinction greater than 90% in 100 years and declining populations earlier.

Coincident with these losses is a loss of alleles (A) and heterozygosity (H) while the populations are small or declining. Under the best scenario (lines 1 and 6) for 25 and 100 years there will be a 50-75% of the alleles and a 10-15% reduction in heterozygosity. This rapid growth would however reduce the rate of inbreeding

Carrying Capacity = 100 (Table 2).

A reduction in carrying capacity or the population goal for recovery to 100 would increase the probability of extinction, increase the amount of inbreeding and increase the loss of alleles. These scenarios suggest that a population of 100 birds will not be self sustaining in the long term and potentially will require supplementation.

Carrying Capacity = 250 and Inbreeding Effects (Table 3).

The effects of inbreeding at the levels suggested by the analysis of the captive population increase the risk of extinction over the next 100 years to 40% (line 6) in the scenario with no losses due to human or natural catastrophes. The risk of extinction is 94% with the inclusion of natural events alone. This result suggests that it will be important to supplement the wild population with birds from the captive population over time to increase the genetic diversity of the wild population.

Further modelling of the wild population will need to be done on a continuing basis as the results are gathered from the current release studies. These scenarios suggest that it will be necessary to carry out additions to the wild population for 5-10 years until the numbers increase over a 100 birds. Also periodic supplementation may be necessary after catastrophic reductions in the population. Further genetic studies of the captive populations would be of value.

Table 1. Simulation conditions as described in the text with K=250, and no genetic load.

I	II	P[E]	T[E]	N	H	A	L
25 years, 26 starting population							
0	0	.005	16	154	.913	21	1.082
50	0	.470	17	15	.742	6.8	.960
0	5	.112	16	88	.864	16	1.050
50	5	.732	15	12	.724	6	.931
90	5	1.000	9.8	-	-	-	.809
100 years, 26 starting population							
0	0	.003	24	237	.860	13	1.088
50	0	.992	29	18	.523	3.9	.958
0	5	.262	39	167	.770	8.9	1.055
50	5	1.000	20	-	-	-	.927
90	5	1.000	9.6	-	-	-	.801
25 years, 100 starting population							
0	0	.000	-	234	.970	67	1.088
50	0	.040	21	50	.900	22	.972
0	5	.004	21	173	.960	51	1.058
50	5	.248	19	32	.860	16	.947
90	5	.968	14.9	4.3	.650	3.8	.811
100 years, 100 starting population							
0	0	.000	-	236	.920	23	1.089
50	0	.910	55	25	.640	5.6	.971
0	5	.058	59	173	.860	15	1.057
50	5	.997	37	12	.600	4.7	.944
90	5	1.000	15	-	-	-	.811

Table 2. Effect of reducing carrying capacity (K) to 100 ± 10 birds on risk of extinction of the Bali starling wild population. All other conditions the same as for table 1.

I	II	P[E]	T[E]	N	H	A	L
25 years, 26 starting population							
0	0	0	-	86	.907	19.3	1.078
50	0	.496	17	16	.742	6.9	.960
0	5	.103	15	56	.862	14.6	1.046
50	5	.748	15	12	.710	5.9	.944
90	5	.997	9.6	3	.594	3.0	.804
100 years, 26 starting population							
0	0	.005	29	93	.789	8.4	1.080
50	0	.997	30	4	.406	2.3	.956
0	5	.367	46	65	.680	5.8	1.047
50	5	1.000	21	-	-	-	-
90	5	1.000	9.7	-	-	-	.801
25 years, 100 starting population							
0	0	.000	-	94	.950	33.7	1.083
50	0	.045	22	33	.885	16.3	.971
0	5	.010	21	71	.927	26	1.051
50	5	.296	20	22	.834	11.9	.943
0	5	.976	15	4	.680	4	.812
100 years, 100 starting population							
0	0	.000		93	.825	10	1.081
50	0	.961	50	14	.522	3.7	.967
0	5	.212	64	66	.729	7	1.049
50	5	.999	34	4	.219	4	.941
90	5	1.000	15	-	-	-	.810

Table 3. Conditions as for table 1, with K=250, with 1.5 lethal equivalents used in a general Heterosis model (see VORTEX documentation section).

I	II	P[E]	T[E]	N	H	A	L
25 years , 26 starting population							
0	0	.007	22	101	.910	20	1.052
50	0	.697	18	10	.741	6.1	.940
0	5	.164	18	52	.860	14	1.020
50	5	.847	15	8	.716	5.5	.919
90	5	1.000	9.3	-	-	-	.800
100 years, 26 starting population							
0	0	.401	66	126	.840	12	1.021
50	0	1.000	23	-	-	-	.939
0	5	.939	47	53	.769	8.9	.999
50	5	1.000	18	-	-	-	.918
90	5	1.000	9.4	-	-	-	.799
25 years, 100 starting population							
0	0	.000	-	234	.974	67	1.082
50	0	.039	21	42	.901	21	.977
0	5	.009	22	162	.958	50	1.049
50	5	.316	20	26	.861	15	.940
90	5	.990	15	3	.609	3.2	.811

Captive Breeding Specialist Group

Species Survival Commission
IUCN -- The World Conservation Union
U. S. Seal, CBSG Chairman

POPULATION VIABILITY ANALYSIS DATA FORM - BIRDS

Species: Leucopsar rothschildi

Species distribution: NW Bali. Bali Barat National Park.

Study taxon (subspecies): No subspecies have been named. It has not been suggested to be a subspecies of any other form.

Study population location: Bali Barat NP. Captive populations in Indonesia and other parts of world. Studbooks in UK and USA (SSP).

Metapopulation - are there other separate populations? Are maps available?: (Separation by distance, geographic barriers?) This is the only population. Until 1984 there were 2 subpopulations due to enclave. Captive populations in different regions need to managed as global population. May be relict isolates. Maps in van Helvoort.

Specialized requirements (Trophic, ecological): Dry savanna; trees of sufficient age and diameter (>40 cm) for nest holes. Insects (esp during rearing young) & fruit. Water limiting resource.

Age of first reproduction for each sex (proportion breeding): 2 years.

a)Earliest: 15 months in captivity. 2 years in wild.

b)Mean: 2 years (50%).

Clutch size (N, mean, SD, range): 3 in wild; 2 to 5 ($2.9 \pm .7$) in captivity.

Number fertile: High infertility rates in captivity perhaps due to inbreeding.

Number hatched: 2 (occasionally 3).

Number fledged: 1 (rarely 2). 1.5 in captivity.

Laying Season: Year-round in captvity. January-April (Rainy season).

Laying frequency (interclutch interval): Annual in wild.

Are multiple clutches possible? Yes - up to 5 or 6 per year possible in captivity; rare in wild.

Duration of incubation: 14 days in captivity.

Hatchling sex ratio: 1:1 in captivity.

Egg weights:

12101 Johnny Cake Ridge Road, Apple Valley, MN 55124, USA tel. 612-431-9325 fax 612-432-2757
(home) 9801 Pillsbury Ave. S., Bloomington, MN 55420, USA tel. 612-888-7267 fax 612-888-5550

Hatchling weights (male and female): 7 g.

Age(s) at fledging: 22 d.

Adult sex ratio: 1:1 in wild.

Adult body weight of males and females: About 80 - 100 g.

Reproductive life-span (Male & Female, Range):
4 - 10 years in wild; 12+ years in captivity.

Life time reproduction (Mean, Male & Female):
Could be 20 - 50 fledged birds in captivity. Likely 2-8 in wild.

Social structure in terms of breeding (random, pair-bonded, polygyny, polyandry, etc; breeding male and female turnover each year?):

Monogamous in a season; possible life-time.

Proportion of adult males and females breeding each year:
About 50% of adults nest and breed each year.

Dispersal distance (mean, sexes): 3-10 km./day movements, but no data on marked birds.

Migrations (months, destinations):
No, stays on Bali in area of park.

Territoriality (home range, season): Yes, 'large'. No details known.

Age of dispersal:

Maximum longevity: Perhaps 20 years in captivity, 12 in wild.

Population census - most recent. Date of last census. Reliability estimate.:
25 - 30 fall 1989.

Projected population (5, 10, 50 years).:
Goal of 2000 in the population.

Past population census (5, 10, 20 years - dates, reliability estimates):
Estimated at -25% (decline) per year for past 6-8 years.

1925	600+
1984	60 - 120
1989	24 - 31

Population sex and age structure (young, juvenile, & adults) - time of year.:

Estimated at 3.3 juveniles and 10.10 adults for purposes of model.

Fecundity rates (by sex and age class): About 1 fledged per breeding pair per year.

Wild clutch size:

0	50%	2	30
1	10	3	10

Mortality rates and distribution (by sex and age) (neonatal, juvenile, adult);

0 - 1	40%	(includes hatching to fledging)
1 - 2	15	
Adult	15	

Population density estimate. Area of population. Attach marked map.:
Forest stated historically able to accomodate 700 - 2000 birds. About 30 sq km now; was 60-120 sq km historically. 24-31/ 3000 ha. which is about 1 bird/km sq.

Sources of mortality-% (natural, poaching, harvest, accidental, seasonal?).:
Poaching, predation-snakes eat young, seasonal rainfall effects. Inbreeding?

Habitat capacity estimate (Has capacity changed in past 20, 50 years?).:
100 - 500; Values of 250 and 100 examined in models. No timber cutting.

Present habitat protection status.:
National Forest. Staff and 20 guards. New wildlife laws being enacted. Declared NP in 1947. People living in park, wood collection. PHPA began protection in 1970s.

Projected habitat protection status (5, 10, 50 years).:
Will remain protected as National park (70 sq km).

Environmental variance affecting reproduction and mortality (rainfall, prey, predators, disease, snow cover ?).:
Diseases uncertain. Major fires about 3 times per century. Lesser fires about once per 10 years. Prolonged dry seasons. Volcanos perhaps 2x per century. No agrochemicals or insecticides used in area. Human disturbance. Perhaps water and insect availability limited. Nest sites.

Is pedigree information available?:
Studbooks on captive populations in UK and USA. Poor records prior to studbooks. Many birds of uncertain parentage and may be few effective founders based upon DNA studies. Needed on wild population.

Attach Life Table if available.

Date form completed: March 1990

Correspondent/Investigator: Participants in workshop and:

Name: B. E. van Helvoort

Address: c/o P.O. Box 109
Bogor 16001
Indonesia

Telephone: (0251) 322 804

Fax: c/o Asian Wetland Bureau
(0251) 32 57 55

References:

See briefing book and this PVA report.

Comments:

```
vortex

Welcome to VORTEX
Written by R.C. Lacy
Version 8.0, 20 August 1990

Input file name? (CR for keyboard)


Output file name? (S for screen)
BALIOUT

Do you want data files produced for plotting? Y

Do you want data from each run (answer Y),
  or just means across runs (answer N)? N


How many times do you want the simulation repeated? 10

Do you want the full table printed (first five runs only)? N


Do you want to incorporate inbreeding depression? Y

You can choose either a general HETEROSIS model, in which selection
    against homozygotes does not remove the genetic load, but which allows
    for user-defined number of lethal equivalents, or a
    RECESSIVE LETHALS model in which each founder starts with
    one unique, recessive lethal allele (and a unique, dominant non-lethal),
    and in which selection against homozygotes for the lethal alleles
    removes those alleles from the population.
Do you want a general HETEROSIS model (specify H) or a
    RECESSIVE LETHALS model (specify L)? H

How many lethal equivalents per diploid genome in the population? 1.5

At what age do females normally begin breeding? 2

At what age do males normally begin breeding? 2

What is the sex ratio (proportion males) at birth? 0.5

What is the maximum number of young per litter? 3

In an average year ...
  what percent of adult females produce 0 young? 50

  what percent of adult females produce 1 young? 10

  what percent of adult females produce 2 young? 30

  what percent of adult females produce 3 young? 10

What is the SD in percent females of producing litters (50.00) due to EV? 10

Monogamous (M) or polygamous (P) breeding? M

Are all adult males in the breeding pool
```

and equally likely to sire offspring? (Y or N) Y

What is the percent mortality of females between ages 0 to 1? 40

What is the SD in the above mortality due to EV? 10

What is the percent mortality of females between ages 1 to 2? 15

What is the SD in the above mortality due to EV? 5

What is the annual percent mortality of adult females (age >= 2)? 15

What is the SD in the above mortality due to EV? 5

What is the percent mortality of males between ages 0 to 1? 40

What is the SD in the above mortality due to EV? 15

What is the percent mortality of males between ages 1 to 2? 15

What is the SD in the above mortality due to EV? 5

What is the annual percent mortality of adult males (age >= 2)? 15

What is the SD in the above mortality due to EV? 5

What is the population carrying capacity? 250

What is the SD in K due to EV 25

Is there a trend projected in the carrying capacity? (Y or N) N

Enter the probability of catastrophe type I (as a percent): 50

Enter the severity of type I catastrophes as a mean multiplicative effect
(to which will be applied a binomial variance).
Note: 0 = total catastrophe, 1 = no effect.

Severity with respect to reproduction? 1

Severity with respect to survival? .8

Enter the probability of catastrophe type II (as a percent): 5

Enter the severity of type II catastrophes as a mean multiplicative effect
(to which will be applied a binomial variance).
Note: 0 = total catastrophe, 1 = no effect.

Severity with respect to reproduction? .5

Severity with respect to survival? .5

How many females of age 1 are in the initial population? 3

How many adult females (age > 2) are in the initial population? 10

How many males of age 1 are in the initial population? 3

```
How many adult males (age > 2) are in the initial population? 10

Do you want to harvest the population? N

Do you want to supplement the population? Y

What is the first year of supplementation? 2

What is the last year of supplementation? 6

At what interval, in years, do you want to supplement? 1

How many females of age 1 are to be added each time? 5

How many adult females (age > 2) are to be added each time? 0

How many males of age 1 are to be added each time? 5

How many adult males (age > 2) are to be added each time? 0

How many years do you want the simulation to run? 25

At what time interval do you want extinction reports? 5

Warning: Memory may be insufficient to do heterosis calculations
Run 1 ........................
        Final population size     5
        Expected heterozygosity   0.7400
        Observed heterozygosity   1.0000
        Number of alleles         4
        Effective no. alleles     3.85
Run 2 ........................
        Final population size     10
        Expected heterozygosity   0.8700
        Observed heterozygosity   1.0000
        Number of alleles         10
        Effective no. alleles     7.69
Run 3 ........................
        Final population size     6
        Expected heterozygosity   0.8472
        Observed heterozygosity   0.8333
        Number of alleles         7
        Effective no. alleles     6.55
Run 4 ........................
        Population did not survive.  Extinction at year 25.
Run 5 ........................
        Final population size     40
        Expected heterozygosity   0.9463
        Observed heterozygosity   1.0000
        Number of alleles         28
        Effective no. alleles    18.60
Run 6 ...............
        Population did not survive.  Extinction at year 16.
Run 7 ........................
        Final population size     11
        Expected heterozygosity   0.9050
        Observed heterozygosity   1.0000
        Number of alleles         13
        Effective no. alleles    10.52
```

```
Run 8 ........................
        Population did not survive.  Extinction at year 24.
Run 9 .........................
        Final population size    6
        Expected heterozygosity  0.7361
        Observed heterozygosity  0.8333
        Number of alleles        5
        Effective no. alleles    3.79
Run 10 .........................
        Final population size    26
        Expected heterozygosity  0.8802
        Observed heterozygosity  0.8846
        Number of alleles        14
        Effective no. alleles    8.35
Do you want to run another simulation? N

C:\LACY>
```

VORTEX -- simulation of genetic and demographic stochasticity

BALIOUT

HETEROSIS model of inbreeding depression
with 1.50 lethal equivalents per diploid genome

Monogamous breeding,
with 100.00 percent of adult males in the breeding pool.

First age of reproduction for females: 2 for males: 2

Sex ratio at birth (proportion males): 0.5000

In an average year ...
50.00 (EV = 10.00 SD) percent of adult females produce litters of size 0
10.00 percent of adult females produce litters of size 1
30.00 percent of adult females produce litters of size 2
10.00 percent of adult females produce litters of size 3

40.00 (EV = 10.00 SD) percent mortality of females between ages 0 and 1
15.00 (EV = 5.00 SD) percent mortality of females between ages 1 and 2
15.00 (EV = 5.00 SD) percent annual mortality of adult females (age >= 2)
40.00 (EV = 15.00 SD) percent mortality of males between ages 0 and 1
15.00 (EV = 5.00 SD) percent mortality of males between ages 1 and 2
15.00 (EV = 5.00 SD) percent annual mortality of adult males (age >= 2)

Carrying capacity = 250 (EV = 25.00 SD)

Frequency of type I catastrophes: 50.000 percent
with 1.000 multiplicative effect on reproduction
and 0.800 multiplicative effect on survival

Frequency of type II catastrophes: 5.000 percent
with 0.500 multiplicative effect on reproduction
and 0.500 multiplicative effect on survival

Initial population size:
3 females 1 years old
10 female adults (age > 2)
3 males 1 years old
10 male adults (age > 2)

Animals added from year 2 through year 6 at 1 year intervals:
5 females 1 years old
0 female adults (age > 2)
5 males 1 years old
0 male adults (age > 2)

Population simulated for 25 years, 10 runs

Deterministic population growth rate:
(based on females, with assumptions of
no limitation of mates and no inbreeding depression)
r = -0.057
lambda = 0.944
R0 = 0.753
Generation time = 4.94

Stable age distribution of females:

Age class	Proportion
0 to 1	0.275
1 to 2	0.153
2 to 3	0.121
3 to 4	0.096
4 to 5	0.075
5 to 6	0.060
6 to 7	0.047
7 to 8	0.037
8 to 9	0.029
9 to 10	0.023
10 to 11	0.018
11 to 12	0.014
12 to 13	0.011
13 to 14	0.009
14 to 15	0.007
15 to 16	0.006

Deterministic population growth rate:
(based on males, with assumptions of
no limitation of mates and no inbreeding depression)
r = -0.057
lambda = 0.944
R0 = 0.753
Generation time = 4.94

Stable age distribution of males:

Age class	Proportion
0 to 1	0.275
1 to 2	0.153
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6 to 7	0.047
7 to 8	0.037
8 to 9	0.029
9 to 10	0.023
10 to 11	0.018
11 to 12	0.014
12 to 13	0.011
13 to 14	0.009
14 to 15	0.007
15 to 16	0.006

Year 5

N[Extinctions] = 0, P[E] = 0.0000
N[Survivals] = 10, P[S] = 1.0000
Population size = 53.80 (3.98 SE, 12.59 SD)
Expected heterozygosity = 0.9843 (0.0005 SE, 0.0017 SD)
Observed heterozygosity = 1.0000 (0.0000 SE, 0.0000 SD)
Number of extant alleles = 81.80 (3.90 SE, 12.34 SD)
Effective number of alleles = 64.28 (1.90 SE, 6.02 SD)

Year 10

N[Extinctions] = 0, P[E] = 0.0000
N[Survivals] = 10, P[S] = 1.0000
Population size = 50.40 (7.22 SE, 22.83 SD)
Expected heterozygosity = 0.9685 (0.0028 SE, 0.0088 SD)
Observed heterozygosity = 0.9906 (0.0034 SE, 0.0109 SD)
Number of extant alleles = 48.20 (4.18 SE, 13.21 SD)
Effective number of alleles = 33.76 (2.60 SE, 8.22 SD)

Year 15

N[Extinctions] = 0, P[E] = 0.0000
N[Survivals] = 10, P[S] = 1.0000
Population size = 28.00 (7.11 SE, 22.49 SD)
Expected heterozygosity = 0.9178 (0.0227 SE, 0.0717 SD)
Observed heterozygosity = 0.9938 (0.0043 SE, 0.0135 SD)
Number of extant alleles = 23.70 (3.71 SE, 11.74 SD)
Effective number of alleles = 17.13 (2.54 SE, 8.05 SD)

Year 20

N[Extinctions] = 1, P[E] = 0.1000
N[Survivals] = 9, P[S] = 0.9000
Population size = 24.78 (7.68 SE, 23.05 SD)
Expected heterozygosity = 0.8502 (0.0406 SE, 0.1219 SD)
Observed heterozygosity = 0.9271 (0.0350 SE, 0.1049 SD)
Number of extant alleles = 15.44 (3.35 SE, 10.05 SD)
Effective number of alleles = 10.96 (2.26 SE, 6.78 SD)

Year 25

N[Extinctions] = 3, P[E] = 0.3000
N[Survivals] = 7, P[S] = 0.7000
Population size = 14.86 (5.00 SE, 13.22 SD)
Expected heterozygosity = 0.8464 (0.0303 SE, 0.0802 SD)
Observed heterozygosity = 0.9359 (0.0309 SE, 0.0818 SD)
Number of extant alleles = 11.57 (3.09 SE, 8.18 SD)
Effective number of alleles = 8.48 (1.92 SE, 5.07 SD)

In 10 simulations of 25 years:

3 populations went extinct and 7 survived.
This gives a probability of extinction of 0.3000 (0.1449 SE),
or a probability of success of 0.7000 (0.1449 SE).

Mean time to extinction was 21.67 years (2.85 SE, 4.93 SD).

Mean final population for successful cases was 14.86 (5.00 SE, 13.22 SD)

Age 1	Adults	Total	
1.00	5.14	6.14	Males
1.00	7.71	8.71	Females

During years of harvest and/or supplementation
mean lambda was 1.1884 (0.0043 SE, 0.1912 SD)

Without harvest/supplementation, prior to carrying capacity truncation,
mean lambda was 0.9243 (0.0026 SE, 0.2159 SD)

Final expected heterozygosity was 0.8464 (0.0303 SE, 0.0802 SD)
Final observed heterozygosity was 0.9359 (0.0309 SE, 0.0818 SD)
Final number of alleles was 11.57 (3.09 SE, 8.18 SD)
Final effective number of alleles was 8.48 (1.92 SE, 5.07 SD)
****

VORTEX -- simulation of genetic and demographic stochasticity

BALI01

No inbreeding depression

Monogamous breeding,
with 100.00 percent of adult males in the breeding pool.

First age of reproduction for females: 2 for males: 2

Sex ratio at birth (proportion males): 0.5000

In an average year ...
50.00 (EV = 10.00 SD) percent of adult females produce litters of size 0
10.00 percent of adult females produce litters of size 1
30.00 percent of adult females produce litters of size 2
10.00 percent of adult females produce litters of size 3

40.00 (EV = 10.00 SD) percent mortality of females between ages 0 and 1
15.00 (EV = 5.00 SD) percent mortality of females between ages 1 and 2
15.00 (EV = 5.00 SD) percent annual mortality of adult females (age >= 2)
40.00 (EV = 10.00 SD) percent mortality of males between ages 0 and 1
15.00 (EV = 5.00 SD) percent mortality of males between ages 1 and 2
15.00 (EV = 5.00 SD) percent annual mortality of adult males (age >= 2)

Carrying capacity = 250 (EV = 25.00 SD)

Initial population size:
3 females 1 years old
10 female adults (age > 2)
3 males 1 years old
10 male adults (age > 2)

Population simulated for 25 years, 1000 runs

Deterministic population growth rate:
(based on females, with assumptions of
no limitation of mates and no inbreeding depression)
r = 0.069
lambda = 1.072
R0 = 1.700
Generation time = 7.67

Stable age distribution of females:

Age class	Proportion
0 to 1	0.270
1 to 2	0.151
2 to 3	0.120
3 to 4	0.095
4 to 5	0.075
5 to 6	0.060
6 to 7	0.047
7 to 8	0.038
8 to 9	0.030
9 to 10	0.024
10 to 11	0.019
11 to 12	0.015
12 to 13	0.012
13 to 14	0.009
14 to 15	0.007
15 to 16	0.006

Deterministic population growth rate:
(based on males, with assumptions of
no limitation of mates and no inbreeding depression)
r = 0.069
lambda = 1.072
R0 = 1.700
Generation time = 7.67

Stable age distribution of males:

Age class	Proportion
0 to 1	0.270
1 to 2	0.151
2 to 3	0.120
3 to 4	0.095
4 to 5	0.075
5 to 6	0.060
6 to 7	0.047
7 to 8	0.038
8 to 9	0.030
9 to 10	0.024
10 to 11	0.019
11 to 12	0.015
12 to 13	0.012
13 to 14	0.009
14 to 15	0.007
15 to 16	0.006

Year 5

N[Extinctions] = 0, P[E] = 0.0000
N[Survivals] = 1000, P[S] = 1.0000
Population size = 37.92 (0.35 SE, 11.10 SD)
Expected heterozygosity = 0.9566 (0.0003 SE, 0.0089 SD)
Observed heterozygosity = 0.9933 (0.0005 SE, 0.0146 SD)
Number of extant alleles = 32.93 (0.18 SE, 5.65 SD)
Effective number of alleles = 23.86 (0.13 SE, 4.20 SD)

Year 10

N[Extinctions] = 1, P[E] = 0.0010
N[Survivals] = 999, P[S] = 0.9990
Population size = 54.22 (0.70 SE, 22.09 SD)
Expected heterozygosity = 0.9403 (0.0005 SE, 0.0161 SD)
Observed heterozygosity = 0.9740 (0.0008 SE, 0.0253 SD)
Number of extant alleles = 26.77 (0.18 SE, 5.81 SD)
Effective number of alleles = 17.76 (0.13 SE, 4.05 SD)

Year 15

N[Extinctions] = 1, P[E] = 0.0010
N[Survivals] = 999, P[S] = 0.9990
Population size = 78.73 (1.22 SE, 38.66 SD)
Expected heterozygosity = 0.9280 (0.0008 SE, 0.0268 SD)
Observed heterozygosity = 0.9562 (0.0011 SE, 0.0344 SD)
Number of extant alleles = 23.71 (0.19 SE, 5.93 SD)
Effective number of alleles = 15.07 (0.12 SE, 3.90 SD)

Year 20

N[Extinctions] = 5, P[E] = 0.0050
N[Survivals] = 995, P[S] = 0.9950
Population size = 115.07 (1.89 SE, 59.56 SD)
Expected heterozygosity = 0.9197 (0.0010 SE, 0.0306 SD)
Observed heterozygosity = 0.9413 (0.0011 SE, 0.0354 SD)
Number of extant alleles = 22.09 (0.19 SE, 5.98 SD)
Effective number of alleles = 13.75 (0.13 SE, 3.96 SD)

Year 25

N[Extinctions] = 5, P[E] = 0.0050
N[Survivals] = 995, P[S] = 0.9950
Population size = 153.99 (2.20 SE, 69.53 SD)
Expected heterozygosity = 0.9133 (0.0010 SE, 0.0320 SD)
Observed heterozygosity = 0.9282 (0.0012 SE, 0.0382 SD)
Number of extant alleles = 20.96 (0.19 SE, 5.87 SD)
Effective number of alleles = 12.78 (0.12 SE, 3.80 SD)

In 1000 simulations of 25 years:

5 populations went extinct and 995 survived.
This gives a probability of extinction of 0.0050 (0.0022 SE),
or a probability of success of 0.9950 (0.0022 SE).

Mean time to extinction was 16.20 years (2.20 SE, 4.92 SD).

Mean final population for successful cases was 153.99 (2.20 SE, 69.53 SD)

Age 1	Adults	Total	
16.71	60.43	77.13	Males
16.66	60.20	76.86	Females

Without harvest/supplementation, prior to carrying capacity truncation,
mean lambda was 1.0818 (0.0001 SE, 0.1193 SD)

Final expected heterozygosity was 0.9133 (0.0010 SE, 0.0320 SD)
Final observed heterozygosity was 0.9282 (0.0012 SE, 0.0382 SD)

Final number of alleles was 20.96 (0.19 SE, 5.87 SD)
Final effective number of alleles was 12.78 (0.12 SE, 3.80 SD)
****

VORTEX

Simulation model of stochastic population change
Version 8.0

Written by Robert Lacy
Chicago Zoological Park
Brookfield, IL 60513

20 August 1990

Stochastic simulation of population extinction

Life table analyses yield average long-term projections of population growth (or decline), but do not reveal the fluctuations in population size that would result from variability in demographic processes. When a population is small and isolated from other populations of conspecifics, these random fluctuations can lead to extinction even of populations that have, on average, positive population growth. The VORTEX program (earlier versions called SIMPOP) is a Monte Carlo simulation of demographic events in the history of a population. Many of the algorithms in VORTEX were taken from a simulation program, SPGPC, written in BASIC by James W. Grier of North Dakota State University (Grier 1980a, 1980b, Grier and Barclay 1988).

Fluctuations in population size can result from any or all of several levels of stochastic (random) effects. First demographic variation results from the probabilistic nature of birth and death processes. Thus, even if the probability of an animal reproducing or dying is always constant, we expect that the actual number reproducing or dying within any time interval to vary according to a binomial distribution with mean equal to the probability of the event (p) and variance given by $Vp = p * (1 - p) / N$. Demographic variation is thus intrinsic to the population and occurs in the simulation because birth and death events are determined by a random process (with appropriate probabilities).

Environmental variation (EV) is the variation in the probabilities of reproduction and mortality that occur because of changes in the environment on an annual basis (or other time scales). Thus, EV impacts all individuals in the population simultaneously -- changing the probabilities (means of the above binomial distributions) of birth and death. The sources of EV are thus extrinsic to the population itself, due to weather, predator and prey populations, parasite loads, etc.

VORTEX models population processes as discrete, sequential events, with probabilistic outcomes determined by a pseudo-random number generator. VORTEX simulates birth and death processes and the transmission of genes through the generations by generating random numbers to determine whether each animal lives or dies, whether each adult female produces broods of size 0, or 1, or 2, or 3, or 4, or 5 during each year, and which of the two alleles at a genetic locus are transmitted from each parent to each offspring. Mortality and reproduction probabilities are sex-specific. Fecundity is assumed to be independent of age (after an animal reaches reproductive age). Mortality rates are specified for each pre-reproductive age class and for reproductive-age animals. The mating system can be specified to be either monogamous or polygynous. In either case, the user can specify that only a subset of the adult male population is in the breeding pool (the remainder being excluded perhaps by social factors). Those males in the breeding pool all have equal probability of siring offspring.

Each simulation is started with a specified number of males and females of each pre-reproductive age class, and a specified number of male and females of breeding age. Each animal in the initial population is assigned two unique alleles at some hypothetical genetic locus, and the user specifies the severity of inbreeding depression (expressed in the model as a loss of viability in inbred animals). The computer program simulates and tracks the fate of each population, and outputs summary statistics on the probability of population extinction over specified time intervals, the mean time to extinction of those simulated populations that went extinct, the mean size of populations not yet extinct, and the levels of genetic variation remaining in any extant populations.

A population carrying capacity is imposed by a probabilistic truncation of each age class if the population size after breeding exceeds the specified carrying capacity. The program allows the user to model trends in the carrying capacity, as linear increases or decreases across a specified numbers of years.

VORTEX models environmental variation simplistically (that is both the advantage and disadvantage of simulation modelling), by selecting at the beginning of each year the population age-specific birth rates, age-specific death rates, and carrying capacity from normal distributions with means and standard deviations specified by the user. Thus, EV is simulated by sampling a normal distribution, with the standard deviations specifying the annual fluctuations in probabilities of reproduction and mortality and in carrying capacity.

Unfortunately, rarely do we have sufficient field data to estimate the fluctuations in birth and death rates, and in carrying capacity, for a wild population. (The population would have to be monitored for long enough to separate, statistically, sampling error from demographic variation in the number of breeders and deaths from annual variation in the probabilities of these events.) Lacking any data on annual variation, a user can try various values, or simply set EV = 0 to model the fate of the population in the absence of any environmental variation.

VORTEX can model catastrophes, the extreme of environmental variation, as events that occur with some specified probability and reduce survival and reproduction for one year. A catastrophe is determined to occur if a randomly generated number between 0 and 1 is less than the probability of occurrence (i.e., a binomial process is simulated). If a catastrophe occurs, the probability of breeding is multiplied by a severity factor specified by the user. Similarly, the probability of surviving each age class is multiplied by a severity factor specified by the user.

VORTEX also allows the user to supplement or harvest the population for any number of years in each simulation. The numbers of immigrants and removals are specified by age and sex. VORTEX outputs the observed rate of population growth (mean of N[t]/N[t-1]) separately for the years of supplementation/harvest and for the years without such management, and allows for reporting of extinction probabilities and population sizes at whatever time interval is desired (e.g., summary statistics can be output at 5-year intervals in a 100-year simulation).

Whenever VORTEX is run, it creates a file called VORTEX.BAT that contains the input data, ready for resubmission as a batch file. Thus, the simulation can be instantly rerun by using VORTEX.BAT as the input file. By editing VORTEX.BAT, a few changes could easily be made to the input parameters before rerunning VORTEX. Note that the file VORTEX.BAT is over-written each time that VORTEX is run. Therefore, you should rename the batch file if you wish to save it for later use.

Overall, the computer program simulates many of the complex levels of stochasticity that can affect a population. Because it is a detailed model of population dynamics, often it is not practical to examine all possible factors and all interactions that may affect a population. It is therefore incumbent upon the user to specify those parameters that can be estimated reasonably, to leave out of the model those that are believed not to have a substantial impact on the population of interest, and to explore a range of possible values for parameters that are potentially important but very imprecisely known.

VORTEX is, however, a simplified model of the dynamics of real populations. Some of its artificialities are the independence of environmental variation in birth and death rates (except during catastrophes), and the lack of density dependence of birth and death rates except when the population exceeds the carrying capacity. The first of these simplifications will likely lead to underestimates of extinction rates, because the various risks to a population occur independently in the model and are therefore distributed more evenly over time than may be the case in most natural populations. The lack of density dependence may cause underestimation or overestimation of extinction, depending on whether the population responds positively (increased breeding and reduced mortality) when numbers are low, as might be expected if intra-specific competition or aggression were common, or negatively, as might occur in social species or if mates are difficult to find.

VORTEX accepts input either from the keyboard or from a data file. By using data file input, multiple simulations can be run while the computer is unattended. (Depending on the computer used, the simulations can be relatively quick -- a few minutes for 100 runs -- or very slow.) Output can be directed to the screen or to a file for later printing. I would recommend that VORTEX only be used on a 80386 (or faster) computer with a math co-processor. It should run on slower machines, but Version 8.0 <u>requires</u> the math co-processor (and it would be hopelessly slow without one even if it worked). Presumably, the program should also run equally well on OS/2 systems and MS-DOS systems, but I have only tested it on MS-DOS machines.

The program can make use of any extended memory available on the computer (note: only extended, not expanded, memory above 1MB will be used), and the extra memory will be necessary to run analyses with the Heterosis inbreeding depression option on populations of greater than about 450 animals. To use VORTEX with expanded memory, first run the program

TUNE, which will customize the program EX286 (a Dos Extender) for your computer. If TUNE hangs up DOS, simply re-boot and run it again (as often as is necessary). This behavior of TUNE is normal and will not affect your computer. After TUNEing the Dos Extender, run EX286, and then finally run VORTEX. TUNE needs to be run only once on your computer, EX286 needs to be run (if VORTEX is to be used with extended memory) after each re-booting of the computer. Note that EX286 might take extended memory away from other programs (in fact it is better to disable any resident programs that use extended memory before running EX286); and it will release that memory only after a re-boot.

VORTEX is not copyrighted nor copy protected. Use it, distribute it, revise it, expand upon it. I would appreciate hearing of uses to which it is put, and of course I don't mind acknowledgement for my efforts. James Grier should also be acknowledged (for developing the program that was the base for VORTEX) any time that VORTEX is cited.

A final caution: VORTEX is continually under revision. I cannot guarantee that it has no bugs that could lead to erroneous results. It certainly does not model all aspects of population stochasticity, and some of its components are simply and crudely represented. It can be a very useful tool for exploring the effects of random variability on population persistence, but it should be used with due caution and an understanding of its limitations.

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VORPLOTS

Plotting program for use with VORTEX

VORPLOTS creates files from VORTEX output, in HPGL (Hewlett-Packard Graphics Language). These can then be plotted on an HP plotter, or on a printer (e.g., an HP LaserJet with the appropriate font cartridge) that can be create plots from HPGL files.

To plot results from VORTEX:

1) Be sure that you specify in the data input that you want data files produced for plotting. VORTEX will then place appropriate summary data into files:

POPSIZE.VOR -- mean population size (of extant populations) across years
EXTINCT.VOR -- number of simulation populations going extinct in each time interval
EXTANT.VOR -- proportion of simulated populations still extant at each year
HET.VOR -- mean proportion of initial (expected) heterozygosity remaining at each year

INBREED.VOR -- mean inbreeding coefficient at each year

As you do additional sets of runs (set = one set of input parameters to be simulated), VORTEX appends the plotter data to previously existing files (if any). Thus, the above data can be plotted for several sets of runs on one plot.

If you specified that you wanted plotter files for each run, as well as means across runs, VORTEX will also create:

NDATA -- population sizes each year of each run
HDATA -- expected heterozygosity each year of each run
HODATA -- observed heterozygosity each year of each run
NADATA -- number of alleles each year of each run
ENADATA -- effective number of alleles each year of each run

Note: the above files can be quite large, as they contain data from each year of each simulated population. For the above five files, VORTEX will over-write results from previous sets of runs when creating these files. Thus you must rename the files if you want to save results for plotting each run at a later time.

2) Edit the above files to produce the subsets that you want to plot.

For POPSIZE.VOR, HET.VOR, INBREED.VOR, EXTANT.VOR, and EXTINCT.VOR, the files will contain data from all the runs you have done. Delete those that you do not want to plot. (Important note: Copy the VOR file to a different name or directory before editing, if you plan to produce plots from various sets of simulations.)

The plotting program, VORPLOTS, scales the x and y axes appropriately for the first data set encountered in the file. Therefore, you should put the data from the largest population, with the longest simulation (in years) at the top of the file. Otherwise, some lines on the plot may go beyond the end of the axes.

3) Run program VORPLOTS.

VORPLOTS will create .PLT files from each of the .VOR files. Not all .VOR files need to exist (assuming that you do not want to produce all possible plots).

4) Reassign the output to the serial port (rather than the parallel port usually used for sending output to a printer). To do this, type:

MODE LPT1:=COM1:

Note: You may have to redefine the serial port communications protocol to match that expected by the plotter. Get help from your local computer expert on this matter, if need be. On Lacy's computer, the command PLOT will set the appropriate protocol for you.

After you are done plotting, you will need to reassign output to the parallel port before you can send output to a printer. To reassign output for printing, type:

MODE LPT1:
(or re-boot your computer).

5) Load paper in the plotter, be sure that the plotter is turned on and connected to the computer, and then type

PRINT POPSIZE.PLT
(or EXTINCT.PLT or NDATA.PLT or EXTANT.PLT or ...)

VORPLOTS tries to pick appropriate axes, labels, etc. for the graphs. Obviously, it cannot anticipate every type of data, and every desire you may have regarding the style of graph. If you know (or are willing to learn) the fairly simple commands of HPGL, you can modify the .PLT files to customise graphs to your taste.

GENES

Software package for genetic analysis of studbook data

Written by Robert Lacy,
Chicago Zoological Society

The programs GENES and OGENES were written to analyze pedigree data, with the purpose of facilitating management of captive populations. The programs have gone through many transformations, beginning with a program PEDGENE, then evolving into LACYGENE, and now GENES and OGENES. The programs have benefitted immensely from discussions with Jon Ballou, Georgina Mace, Tom Foose, Randy Rockwell, Nate Flesness, Paul Scobie, and many SSP propagation groups. In part because the programs have been modified so frequently, programming or logical bugs may remain. Please let me know if you run into serious problems.

GENES was written to accept ME/MA/PA data produced by the studbook management and analysis package SPARKS (written by and available from ISIS). OGENES is virtually the same, but takes pedigree data from an "Omaha format" studbook in a dBASE III file.

Both require a computer running MS-DOS. (The programs should work on OS/2 as well, but I have never tested that.) The data matrix used in inbreeding and founder analysis can get quite large with moderate size studbooks, and computer memory often limits the size of studbook that can be analyzed.
The current versions require a math co-processor.

The program can make use of any extended memory available on the computer (note: only extended, not expanded, memory above 1MB will be used), and the extra memory will be necessary to run analyses with the Heterosis inbreeding depression option on populations of greater than about 450 animals. To use GENES with expanded memory, first run the program TUNE, which will customize the program EX286 (a Dos Extender) for your computer. If TUNE hangs up DOS, simply re-boot and run it again (as often as is necessary). This behavior of TUNE is normal and will not affect your computer. After TUNEing the Dos Extender, run EX286, and then finally run GENES. TUNE needs to be run only once on your computer, EX286 needs to be run (if GENES is to be used with extended memory) after each re-booting of the computer. Note that EX286 might take extended memory away from other programs (in fact it is better to disable any resident programs that use extended memory before running EX286); and it will release that memory only after a re-boot.

GENES/OGENES stores data needed for inbreeding calculations (the "additive matrix") in memory. The program will automatically remove dead animals (except founders) from the matrix to make room for future generations. (Dead animals are unnecessary for calculation of future inbreeding coefficients and founder representations.) For a large studbook (too large for the entire data matrix to fit into memory), GENES/OGENES will analyze a subset of the studbook (until memory is full), and then stop to remove dead animals. The remainder (or the largest subset that will fit into memory) of the studbook will then be added to the data matrix. By alternating between adding animals and deleting dead animals, very large studbooks can be analyzed. With 640K of memory, studbooks with up to about 500 living animals can be analyzed. With several MB of RAM, studbooks of several thousand living animals can be analyzed.

GENES and OGENES are limited only by memory availability, but better memory use can be achieved by avoiding very large temporary studbook numbers such as 9000, 9001. GENES will also not accept temporary studbook numbers that begin with a 'T', or numbers with any non-numerical character. Those animals would be skipped in the analysis if they are in the studbook.

Unlike previous versions of the programs, neither GENES nor OGENES places the data matrix on a disk file. Instead the calculations are repeated (quickly) each time the program is run. The studbook analysis may require more memory than expected, because dead founders with descendants will not be removed from the matrix, and because the program may create some "pseudo-founders" to accommodate animals with one parent unknown or wild (see below). If memory is insufficient to hold the data set, the program will so inform you and will then abort.

OGENES assumes that the studbook data are in a dBase file of the "Omaha format". Minimally necessary is a file containing the following fields:

STUDBOOK	Numerical	Integral numbers.
NAME	Character	Field of a least 8 characters
SEX	C	M (or m), F (or f), or U
SIRE_NO	C	Sire's studbook #. WILD or UNK or any non-numerical entry will be treated as an animal unrelated to all others in the studbook. UNK animals are handled somewhat differently from WILD animals, however (see below).
DAM_NO	C	Dam's studbook #. Non-numerical entries unrelated to all others, as above.
AGE_TYPE	C	A for alive, anything else for dead.
CONTINENT	C	Two-letter code for the continent.
INBREED	N	Integral 3-digit numbers, representing 1000*F. The program can calculate these for you and enter them into the file.

OGENES places no restrictions on the sequence of animals in the studbook dBase file. Parents need not precede offspring in the studbook file, nor do they need to have smaller studbook numbers. Sire and dam fields can be right or left justified (or neither). (SPARKS takes care of the data format for running GENES.)

To run OGENES, simply type OGENES from the operating system, and answer the questions that appear on the screen. To run GENES, you must first produce a ME/MA/PA file from within SPARKS, exit SPARKS, and then type GENES from the operating system.

OGENES and GENES will, if asked politely, do:

Inbreeding calculations

-- calculate inbreeding coefficients, and the gene diversity (heterozygosity) retained within the population.

-- enter inbreeding coefficients into the studbook dbf file (OGENES only).

-- print out a matrix of inbreeding coefficients for hypothetical offspring that would be produced from every M x F cross of currently living animals. The user may request that this analysis be done only on those animals from a specified continent. (Note: With OGENES, clever use of the CONTINENT field will permit analysis of whatever subset of animals a user may wish to analyze. The program does not actually restrict the continent designations to NA, EU, AS, AF, SA, and AU. SPARKS can similarly, but much more powerfully, restrict the data window for the analyses to be performed by GENES.)

-- print out the average genetic relatedness of each living animal to the living population. An ordered list, by sex, is also printed.

-- provide the user the opportunity to test interactively any number of matings, determining the effect of each on inbreeding coefficients, mean relatedness, the gene diversity retained within the population, and the number of founder genome equivalents (see definitions, below). It is possible, by using this feature, to determine the set of matings (and the number of offspring from each) that will maximize retention of gene diversity (heterozygosity) in the population.

A caution: the inbreeding analysis assumes that UNK and WILD parents are unrelated to all other animals -- it cannot do otherwise. Thus, animals with unknown parents will be treated as wild-caught founders for the purpose of calculating inbreeding coefficients. Any unknown ancestry is ignored for the purpose of calculating average relatedness (i.e., the calculation is based only on the fraction of the genome that descends from known WILD founders). Any animal that cannot be traced back to any known WILD founders is assigned an average relatedness of 1.

Founder representation analysis

-- calculate founder contributions to each living descendant, summed and average founder contributions to the living population, the number of founder equivalents (see Lacy 1989 in Zoo Biology), and the number of living descendants of each founder. The number of founder equivalents is the number of founders of equal contribution that would have yielded the diversity of founder genes that have come through the pedigree. If all founders contribute equally, the founder equivalents is the actual number (hence the name, founder equivalents). If contributions are unequal, the founder equivalents will be less.

Gene drop analysis

-- a stochastic simulation of founder-allele transmission through the pedigree. The program was first written by Dr. Georgina Mace, British Federation of Zoos, in FORTRAN, and then translated into the C programming language and modified by Lacy. The program ignores dead animals with no living descendants when running the gene drop simulation, thereby much reducing the computer memory needed and the running time. In addition to the statistics calculated in the GD program written by Georgina, the GENES/OGENES version also calculates:

Proportion of the genome that is unique -- the probability that a gene in a living animal is unique within the living population (i.e., present in no other living animal). The proportion of genome unique is calculated both for only the descendant (i.e., non-founder) population and for the entire living population (including living founders). This provides a measure for identifying animals that are important to the maintenance of rare alleles (allelic diversity) within the population.

Target founder representations -- parity representations corrected for the irreversible loss of founder alleles that has already likely occurred in the pedigree: algorithm developed by Jon Ballou. Note that living wild-caught animals have the highest target representations, because none of their genes are yet irreversibly lost.

Number of founders -- A founder is a wild-caught animal that contributed to the living, captive-born descendant population by breeding. An animal with unknown ancestry may or may not be a founder; thus, the program will do all calculations including UNKnowns as founders and also excluding them. A wild-caught animal that has not left any descendants in captivity, but which is still alive (and therefore may yet leave descendants), is considered a potential founder. The program outputs the number of founders achievable if these potential founders are incorporated successfully into the breeding program.

If one parent is known (and captive), but the other parent is WILD or UNK (as would occur if a wild-caught female gave birth to an offspring sired in the wild), GENES/OGENES will treat the unknown parent as a founder. The "studbook number" of that pseudo-founder is set equal to the negative of the studbook number of the known (captive) parent. (This pseudo-founder is not added to your studbook, however. It is simply assumed to exist for the genetic calculations.) If an animal gives birth to several offspring with an UNK or WILD animal for the other parent, the program assumes that the unknown (pseudo-founder) parent is the same for all those offspring. The gene drop program outputs summary statistics for the entire data set (treating unknowns as wild-caught founders) and for those only founders recorded as truly WILD.

GENES/OGENES prints all statistics below for both the population as it exists (with and without UNKnowns being considered as founders) and also for the population as it could be if a genetically optimal mating scheme was followed.

Mean allelic retention -- the fraction of a founders genes that are present in at least one copy in the living descendant population.

Founder genomes surviving -- the summed allelic retentions; i.e., the number of founder alleles still in the population.

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A brief explanatory interlude (see also the list of genetic diversity definitions, below):

"Heterozygosity" is used for several different, though closely related, concepts by geneticists. Most simply, the heterozygosity of a population is the proportion of the individuals that are heterozygous at the genetic locus or loci of interest. This is often termed the "observed heterozygosity" of a population.

In a randomly mating population (i.e., one in Hardy-Weinberg equilibrium), the mean heterozygosity is expected to be
$H = 1 - \mathrm{sum}(p_i^2)$, in which p_i is the frequency of allele i. (The expected frequency of homozygotes for each allele is p_i^2.) The heterozygosity expected under Hardy-Weinberg equilibrium is often termed the "expected heterozygosity" or "gene diversity" of a population.

For many genetic loci (typically 50% to 90%), all individuals of a population are homozygous for a single allele, i.e., the locus is monomorphic. In population management, as in other evolutionary processes, such invariant loci are of relatively little interest. (Evolution requires variation.) Often, we are concerned with not the absolute heterozygosity (observed or expected), but rather the heterozygosity of a population relative to the heterozygosity of some starting reference population. This fractional heterozygosity has been termed the "panmictic index" of a population and is sometimes symbolized P. ($P_t = H_t/H_0$, in which P_t is the panmictic index at time t, and H_t and H_0 are the expected heterozygosities or gene diversities at times t and 0).

Inbreeding reduces the probability that an individual is heterozygous at any given locus, and the inbreeding coefficient, F, of an individual is defined as the fractional reduction of that individual's heterozygosity (across all loci) relative to the mean expected heterozygosity of the population. [$F_i = (H_e - H_i)/H_e$, in which F_i is the inbreeding coefficient of individual i, H_e is the expected heterozygosity of the population at some reference time point and H_i is the (observed) heterozygosity of individual i.] Note that the mean inbreeding coefficient (at time t, relative to reference time 0) of a small population that is in Hardy-Weinberg equilibrium is given by $F_t = (H_0 - H_t)/H_0 = 1 - P_t$.

In the gene drop simulation in GENES/OGENES (and, typically, in any founder analysis), the starting (observed) heterozygosity is set at 1.0, because each founder is given two unique alleles. The expected heterozygosity among the founders is $1 - \text{sum}\{[1/(2 \times N_f)]^2\}$, in which N_f is the number of founders, because $p_i = 1/(2 \times N_f)$. For reasons I won't explain here, this expected heterozygosity of the founders is also equal to the fraction of the (expected) heterozygosity of the wild population that is expected in the founder stock (i.e., the "gene diversity" of the founders relative to the wild population from which they came; $P_f = 1 - \text{sum}\{[1/(2 \times N_f)]^2\}$).

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With this clarifying (?!) background on the distinction between observed heterozygosity, expected heterozygosity, gene diversity, and inbreeding coefficients, we now continue with the output of GENES/OGENES:

Founder equivalents -- the number of equally represented founders, with the observed losses of founder alleles, that would yield the same gene diversity as observed in the living descendant population. Founder equivalents do not correct for the losses of alleles in population bottlenecks, whereas founder genome equivalents (below) do. (See Lacy 1989 paper in Zoo Biology.)

Founder genome equivalents -- the number of equally represented founders, with no loss of founder alleles, that would yield the same gene diversity as in the living descendant population. Thus, the fge is that number of newly wild caught animals that would be needed to obtain the genetic diversity in the present captive population.

Fraction of wild gene diversity retained (the "panmictic index") -- the gene diversity (or expected heterozygosity) of the living, captive population relative to the wild population from which the founders were taken.

Fraction of wild gene diversity lost -- 1 minus the gene diversity (heterozygosity) retained. If the population were randomly mating (few populations are), then the fraction of heterozygosity lost would be equal to the mean inbreeding coefficient of the population.

Mean inbreeding coefficient -- the mean inbreeding coefficient within the living descendant population. This is also equal to one minus the observed heterozygosity of the descendant population.

Founder genome equivalents and gene diversity will be maximized if all target founder representations are achieved within one generation, with no further loss of alleles. Breeding those animals with the lowest mean relatedness to the rest of the living population will bring this about to the extent that it is possible given the restrictions imposed by sexual reproduction and the linkage of genes from some (perhaps under-represented) founders with other (perhaps over-represented) founders.

The output files are labelled INBREED.PRN, FOUNDER.PRN, and GD.PRN. Any earlier files with these names will be over-written, so be sure to print the output files or rename them before running the program on another data set. The program also creates a temporary file (f.tmp) that will be deleted when the program terminates normally. If you stop execution prematurely (accomplished with ^C), you may want to (though you need not) erase the temporary file.

If none of this makes sense, try the program and see what happens.
Lacy welcomes comments on GENES/OGENES, to which he will respond if he has time. No guarantees of any sort are provided with the software: inadequate effort has gone into testing and debugging.

Use at your own risk.

Brief definitions of some measures of genetic diversity

Observed heterozygosity: Proportion of individuals in a population (or proportion of genetic loci within an individual) that are heterozygous (having two different alleles at a genetic locus).

Expected heterozygosity: The heterozygosity expected in a population if the population were in Hardy-Weinberg equilibrium. Expected heterozygosity is calculated from allele frequencies, and is the heterozygosity expected in progeny produced by random mating.

Gene diversity: Same as expected heterozygosity.

Founder: An individual obtained from a source population (often the wild) that has no known relationship to any individuals in the derived population (except for its own direct descendants) and which contributes genetically to the descendant population by reproducing.

Inbreeding coefficient: Probability that the two alleles received at a genetic locus are identical by descent from a common ancestor to both parents. The mean inbreeding coefficient of a population will be the proportional decrease in observed heterozygosity relative to the expected heterozygosity of the founder population.

Number of alleles: The mean number of different alleles per genetic locus.

Effective number of alleles: The number of equally frequent alleles that would produce the same gene diversity as that observed in the population. The effective number of alleles will always be less than or equal to the actual number of alleles.

Allelic retention: The probability that a gene present in a founder individual exists in the living, descendant population.

Founder genomes surviving: The sum of allelic retentions of the individual founders (i.e, the product of the mean allelic retention and the number of founders).

Founder equivalents: The number of equally represented founders that would produce the same gene diversity as that observed in the living, descendant population, given the rate of loss of alleles (decrease in allelic retention) that has occurred during past bottlenecks.

Founder genome equivalents: The number of equally represented founders with no loss of alleles (retention = 1) that would produce the same gene diversity as that observed in the living, descendant population. Equivalently, the number of animals from the source population that contain the same gene diversity as does the descendant population. The gene diversity of a population is 1 - 1 / (2 * fge).

Coefficient of relatedness: The probability that an allele sampled at random from one individual is present in a second individual because of descent of that allele from a common ancestor. Equivalently, the proportion of genes in two individuals that are shared because of common descent. The inbreeding coefficient of animal is equal to 1/2 the relatedness of the parents.

Mean relatedness: the mean coefficient of relatedness between an animal and all animals (including itself) in the living, descendant population. The mean relatedness is twice the proportional loss of gene diversity of the descendant population relative to the founders and is also twice the mean inbreeding coefficient of progeny produced by random mating.

Effective population size: The size of a randomly mating population of constant size with equal sex ratio and a Poisson distribution of family sizes that would (a) result in the same mean rate of inbreeding as that observed in the population, or (b) would result in the same rate of random change in gene frequencies (genetic drift) as observed in the population. These two definitions are identical only if the population is demographically stable (because the rate of inbreeding depends on the distribution of alleles in the parental generation, whereas the rate of gene frequency drift is measured in the current generation).

DNA FINGERPRINTING OF ROTHSCHILD'S MYNAH

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Captive breeding for reintroduction is becoming increasingly important for the conservation of a wide number of endangered species. To save a species from extinction, a self-sustaining wild population must be achieved. A prerequisite for this has to be that the individuals within that population possess a level of genetic diversity great enough to allow them to evolve (Berry, 1983). This means that particular attention must be paid to the maintenance of diversity within captive stocks, and especially among those individuals to be used in a reintroduction programme. This is important because, as an environment changes, natural selection acts upon the variation within a population, causing the species to evolve. If this variation is not great enough to allow a sufficiently rapid rate of evolution, the species may move towards extinction. Once variation is lost it cannot be easily replaced.

In 1979, Rothschild's Mynah (*Leucopsar rothschildii*) was first listed as "Endangered" in the IUCN Red Data Book. Over the past decade, its numbers have declined steadily in the wild due to poaching and habitat destruction. It is hoped that this trend can be reversed by management of the small remaining wild population, supplemented by a programme of re-introduction from captive bred stocks. The most successful breeder of Rothschild's Mynah in Britain is Jersey Zoo, which has already contributed birds to this programme (Mace & Jeggo, 1988), and it is to be hoped that other institutions will follow suit.

The captive population of Great Britain consists of about 110 birds descended from a very small founder population. In 1985, 93% of the captive stock's genome had been contributed by just five birds (Studbook Nos. 127, 131, 132, 133 and 134) (Mace & Jeggo, 1985). Apart from a small addition of birds from other zoos around the world (whose genetic backgrounds are unknown) most of the birds in Britain can be traced back to one, or more, of these 5 founders (see family tree). In an attempt to keep inbreeding to a minimum, inbreeding coefficients have been calculated for all possible pairings (Mace & Jeggo, 1989). It is now intended that any pairings which result in an inbreeding coefficient of 0.125, or more, are to be avoided.

However, in the calculation of these coefficients, it was assumed that the founders were unrelated. Given that they come from Bali and that at the time (1971) there were estimated to be over 500 in the wild, this was a reasonable assumption. With the advent of DNA fingerprinting it became possible to analyse the, hitherto, hidden relationships between individuals. My research project was to examine the British population, using fingerprinting, and to attempt to assess their genetic relatedness. Also, it was hoped that it would be possible to check the accuracy of the inbreeding coefficients, thereby allowing the avoidance of pairing of birds that were previously not known to be genetically similar. I was able to obtain samples (care of Dr. Georgina Mace at London Zoo) of three of the five founders (127, 131 and 133), but, unfortunately, the other two birds (132 and 134) died long before the project began. The results showed that these three birds were very similar. This means that the captive population was descended from three very closely related individuals, possibly members of the same family.

I originally hoped that most of the birds in the British population could be fingerprinted and the total amount of variation assessed. On the basis of these results, the birds that were most dissimilar (hopefully, the most distantly related) could be paired. This would increase the amount of heterozygosity and genetic diversity among the offspring. However, only one third of the population has been analysed. There were two main reasons for this:

i) some zookeepers/owners were reluctant to let blood samples be taken from their birds due to the small risk involved in the use of a hypodermic
ii) my construction of the family tree from Studbook data in 1988 made much of this work unnecessary since the relationship of the majority of birds could be clearly seen. This had not been done before due to the tree's complexity.

Genetic fingerprinting of zoo stocks can, in some cases, allow the assignment of parentage in individuals where it is unknown. Wild caught birds, or those from other zoos, can introduce new variation into a stock if they are paired correctly. The analysis of these birds would give a better global picture since the relatedness of our stocks to those of other institutions could be ascertained.

DNA fingerprinting is a complex technique and a brief explanation of what is involved is presented below. Those with a greater interest in the molecular biology behind it are advised to consult Jeffreys *et al.* (1985). Genetic fingerprinting is based on the fact that almost all organisms possess a large amount of DNA which appears to perform no function in the production of cellular protein. A small amount of this non-coding DNA is made up of a string of tandemly-repeated "units", that is, "units" that occur consecutively. Each "unit" has a highly conserved base-pair sequence and a tandem set is termed a "minisatellite". The remarkable variability found in DNA fingerprints is due to the number of times these units are repeated within each minisatellite. This can be anywhere from one to tens of thousands. These "hypervariable minisatellites", as they are called, are the foundation of the technique.

DNA for analysis can be obtained from a very small amount of tissue. Almost any tissue can be used, but the most frequently used are blood from live specimens or liver from post-mortem corpses. Since avian red blood cells are nucleated, the volume of blood required can be as low as 0.1ml. The tissue is lysed in buffer allowing the DNA to move out of the cells. The DNA is extracted from the resulting mixture by a number of chemical washes which remove proteins, lipids, etc. An enzyme is used to cut the DNA into a number of variously-sized fragments. (We routinely use the enzyme Hae III because of its reliability and low cost.) These fragments are loaded into an agarose gel through which an electric current is then passed. This is termed "gel electrophoresis". This current causes the negatively-charged DNA molecule to migrate through the gel in such a way that the fragments are separated depending on their size: since small ones move further per unit time than large ones. Blotting of the gel allows the transfer of the fragments to a sheet of nylon or nitrocellulose where the DNA is then fixed. (These sheets are termed "membranes" or "filters", the two words being used interchangeably.)

The filter is washed with a radioactive "probe" which binds to those DNA fragments that contain minisatellites and, when exposed to an X-ray film, will produce a series of dark bands. An individual is, therefore, represented by a series of bands, the exact relative positions of these bands being unique to that individual. By using an alternative probe it is possible to produce a different fingerprint from the same filter. This doubles the amount of information gained and thus, allows a greater insight into the variation present.

The really elegant aspect of DNA fingerprinting is that these minisatellites are inherited in a regular and systematic manner. One would expect an offspring to share approximately half its bands with its mother and half with its father. Also, it would share half its bands with any other offspring produced by its parents. The equation below is used to calculate the similarity coefficients between two individuals (Lansman *et al.* 1981, Wetton *et al.*, 1987):

$$D = \frac{2N_{AB}}{N_A + N_B}$$

where D = similarity coefficient

N_A = no. of bands in individual A

N_B = no. of bands in individual B

N_{AB} = no. of bands in both individuals

There is a certain degree of linkage between some of the bands but, for simplicity, it is assumed that each band is inherited independently. Also, it must be stressed that D is purely a measure of the similarity in the banding patterns of these individuals based on the presence, or absence, of particular bands.

In a large population with a large number of bands and a very low incidence of band-sharing, the expected mean similarity coefficients ($\bar{D}$) between individuals would be as follows:

RELATIONSHIP	$\bar{D}$
Identical twins	1.00
1st degree relatives (siblings, parent/offspring)	0.50
2nd degree relatives (uncle/niece, grandparents/grandchildren)	0.25
Unrelateds	0.00

However, these values are not those obtained in practice. For example, in the House Sparrow (*Passer domesticus*), which has a large population and high degree of variation (Wetton *et al.* 1987), the mean similarity coefficient for 1st degree relatives is 0.575, while that for unrelated individuals is 0.15. In the mynahs, therefore, we would expect to see coefficients which were higher than these due to their smaller effective population size and, thus, greater inbreeding.

As can be seen in Table 1, although there is no great difference between the Mynahs and the Sparrows regarding $\bar{D}$ for 1st degree relatives, $\bar{D}$ for unrelateds is very different. This indicates that there is considerably less variation present in the Mynahs than the Sparrows, which is what would be expected given the formers smaller population size. In the calculation of $\bar{D}_{UNRELATED}$, the Mynah Family Tree was used and only those birds with no known relationships were considered (127, 131, 133, 325, 506, etc.). There are several possible reasons for the high result obtained, of which the two most likely are:

i) the birds considered are a random sample from Bali, and therefore indicate that the level of variation in the wild is very low,

ii) the birds considered were not unrelated.

The results from the comparisons of the 3 founders (127, 131 and 133) lead to the conclusion that the birds used to start the British captive stock were not unrelated, (see Figure 1). It appears that they were 1st degree relatives. Since we had no prior knowledge of their pasts, DNA fingerprinting has shown us the previously hidden similarities between these birds. Unfortunately, because we know nothing about their backgrounds, the coefficients can only show the degree of relatedness between them and not their exact relationships. Suffice it to say that there is a distinct possibility that these birds came from the same family. If this is indeed the case, then the British stock is far more inbred than previously thought and, therefore, maintaining sufficient variation within it becomes more difficult.

Hopefully, other stocks around the world fared better regarding the relatedness of their founders. At this time we have no details of the remaining variation present in the wild, or that present in other institutions. Exchanges between zoos in different parts of the world would, obviously, be of benefit in maintaining the current degree of global variation. At the present time an exchange is being organised between Jersey Zoo and Riverbanks Zoological Park, Colombia, South Carolina. When the American birds arrive in this country they will be sampled and compared with the British stock. Their similarity, or otherwise, will be of great interest and I hope to present these data at the Symposium on Biotechnology and the Conservation of Genetic Diversity, 4 - 5th September 1990, London.

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FAMILY TREE: BRITISH POPULATION OF ROTHSCHILDS MYNAH

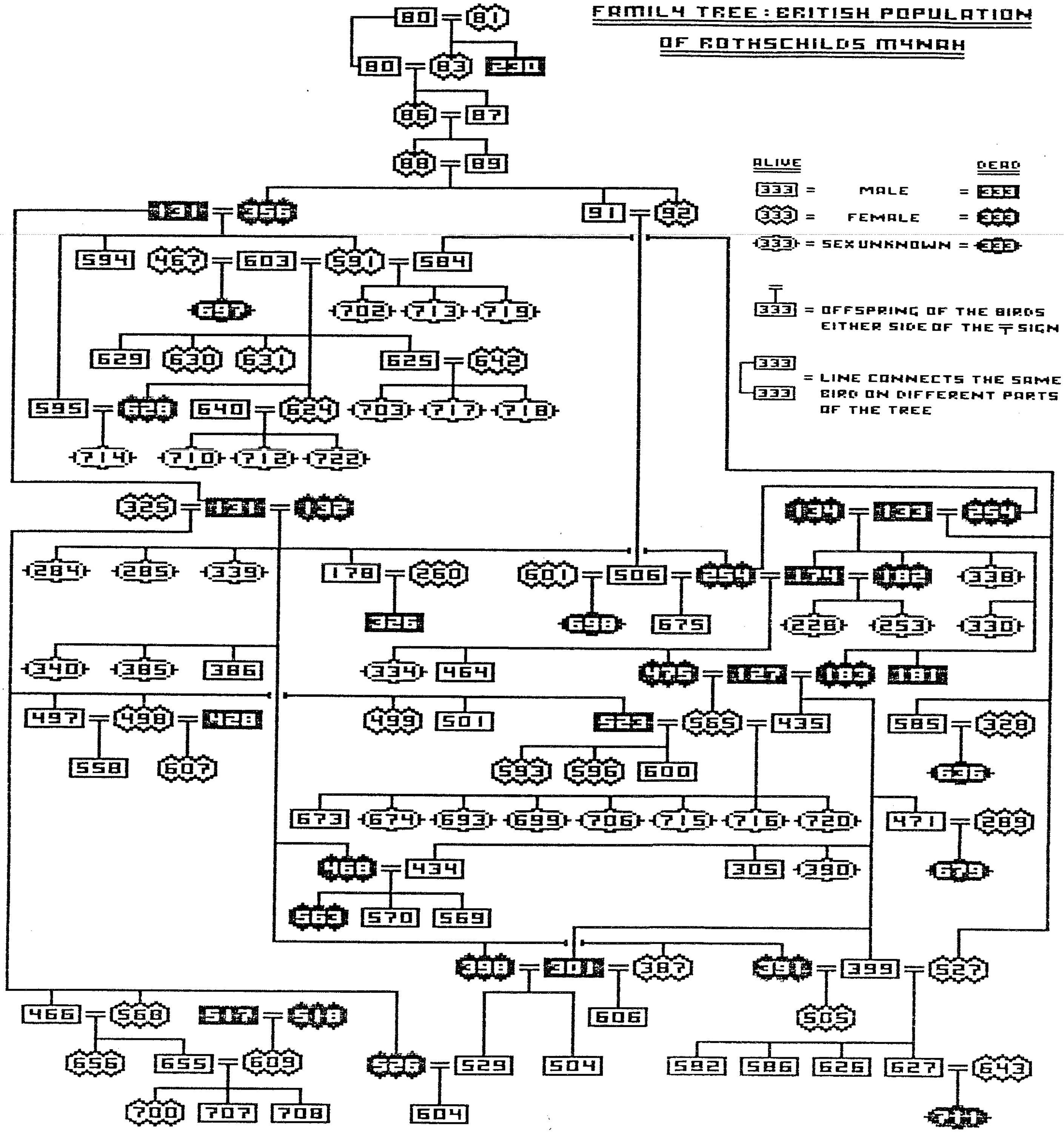
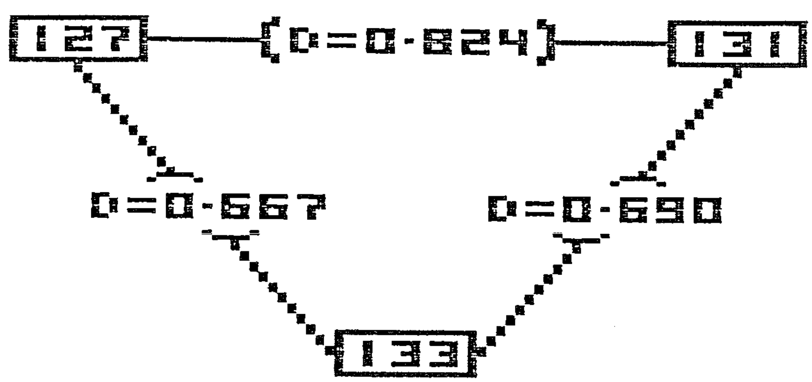


TABLE 1

The table shows a comparison of the mean similarity coefficients ($\bar{D}$) for UNRELATEDS and 1st DEGREE RELATIVES in a wild House Sparrow population and the British Isles captive stock of Rothschild's Mynahs. The figures in parentheses show the number of comparisons used in the calculation of the mean. The current mynah studbook (1989) and family tree were used to assign "1st degree" or "unrelated" to each comparison. The information for the sparrows was a personal communication from J. Wetton.

	$\bar{D}$ – UNRELATED	$\bar{D}$ – 1ST. DEGREE
SPARROWS	0·150 (51)	0·575 (833)
MYNAHS	0·470 (19)	0·630 (13)

FIGURE 1 The figure shows the three British population founders for which DNA samples were obtained and the similarity coefficients (D) between them.



BALI STARLING

Leucopsar rothschildi

VIABILITY ANALYSIS

AND

SPECIES SURVIVAL PLAN

MINUTES AND GEOGRAPHY

Bali Starling PVA Workshop

(Leucospar rothschildi)

Bogor, Indonesia

MINUTES

22 March 1990

Morning:

Greetings and introductory presentations (see text).

ASHARI- 2nd session chair. Wants to listen but has to chair--Layman so need support--introductions.

SEAL Define workshop--need for complete participation--work through data needed to develop a plan to prevent extinction, and reintroduce birds to wild. Briefing books--Note other Population Viability Assessment's (PVA). Accepts responsibility to produce the outline of a PVA here, and will circulate a draft to all major participants after the meeting for comments and revisions. All written papers given to us will be included in your own words. Request for names, addresses etc. Present an overview of PVA process. Ask questions as I go. Slides--

Interest in species increases as numbers decline. Started protection of Bali Mynah (Bali starling) early, but decline continued--Semen collection, in vitro fertilization, etc. technology to be shared. Captive populations of Bali starling started early so base of information available. Genetic variation may be greater in captive population than in wild, and therefore may be beneficial to wild population Expanding human population expand use of resources. Need to try to expand wild population but will be much lower than size available earlier. Humans using more than 20% energy available on planet. Not enough space in zoos to save the species of planet. Must maintain and support habitat to preserve bio-diversity. 1500 to 2000 species in next 30 years will go extinct without captive management. Must work in collaboration to save species. Will need captive breeding and preserve in wild.

Threats to survival: 1.Habitat Destruction. 2. Exploitation 3. Exotic Introductions 4. Population Fragmentation a. Catastrophes, b. people. Fragmentation ends possibility of colonization. Makes each small fragment more vulnerable to extinction. Captive propagation helpful to counteract.

Goals of Programs: 1. Survival, 2. Recovery, 3. Viable population, 4. Evolutionary potential

Problems of Small Populations:
--Stochastic problems--Demographic uncertainty, Environmental uncertainty, Genetic uncertainty--

--Catastrophes-1. storms and floods, 2. Fire, 3. Disease, 4. Unexpected--Black-Footed Ferret example of disease unexpected--From 100 to less than 20 in few months.

--Environmental Stochasticity. 1. Reproductive rates, 2. Mortality rates, 3. Carrying capacity--Time to Extinction--

--Demographic uncertainty. Distorted age distributions--Biased Sex Ratio-ex Mexican wolf-Gene pool to gene puddle-Rate of loss of genetic variation--Bali starling is vulnerable to inbreeding effects as found in captive populations. With 24-31 in wild the effective population size might be 8 or 12 so very fast loss of genetic diversity

--Extinction vortex--Comparative population sizes--Genetic drift--Strategy of maximize options and minimize regrets.

--Conservation strategy-viable populationsize depends on 1. genetic & demographic objectives, 2. biological characteristics of pop, 3. stochasticity

--Genetic and Demographic objectives of program. 1. probability of survival, 2. kind of genetic diversity to be present. 3. Amount of diversity to be present. 4. period of which diversity and survival probability maintained --Ne=500--would like 1,000

--Biological characteristics of population 1. generation time, 2. effective number of founders, 3. Ne/N ratio, 4. growth rate of population

-Ne function of 1. Number of animals reproduce, 2. sex ratio of reproducers, 3. variance in lifetime family sizes of reproducing birds
--For Bali Mynah may need to manage several pops and manage as metapopulation-

--Metapopulation objectives --Catastrophe avoidance--manage migration among pops of Bali Mynah--Protection--Intensive management--Natural sanctuaries as megazoos--Capt breed in response to crisis--New Iucn policy--Reintroduction possible--Heritage species programmes--Indonesia a mega-diversity country--CBSG--Small Population Specialist Group

--PVA's--People problems. 1. professional traditions, 2. agency missions, 3. political boundaries, 4. historical relationships, 5, ethnic traditions, 6. individual agendas--Crisis resolution--PVA examples--

ASHARI--Megadiversity countries 7 Indonesia only Asian country. Coincidence with group of 7 "newly industrialized countries"

SEAL Australia is making it 8.

ASHARI--happy or sad to be one of 8

SEAL--happy for number, sad for amount of work

ASHARI--number's in danger in Indonesia?

GRIMMETT-- around 1500 species of which 131 are regarded as globally threatened in Indonesia

ASHARI--number of endangered as percent of total numbers not large

SEAL--important to recognize planet-wide endangerment and no country bears sole responsibility for conservation--

ASHARI--many islands, ethnic groups, languages great problem.

SEAL--USA regards diversity as strength.

ASHARI--wish workshop set up 10 yrs ago & Bali Mynah as prolific as people.

EFFENDI--What are best collaborative approaches for Bali Mynah.

SEAL--Global responsibility for conservation-difficult-5 countries represented here interested in helping Indonesia in solving problems--provide animals for reintroduction-funding for program-construct budget-opportunity for specialists to spend time on site-short term loan of experts-Indonesia wants collaboration. How set up, who to train,develop local experts-reintroduction, protection, management of Indonesia capability to breed population--Poaching world-wide human problem, needs to be able to discuss and seek solutions-Need public education-best protection is local desire to conserve.-

EFFENDI--How

SEAL--poaching is environmental problem.-people problems different.-Sustainable population conservation--local conservation officer's, tourist dollars in local area-

ALIKODRA--Carrying Capacity how decided?

SEAL--Carrying capacity changes from year to year--

KAMIL OESMAN--As soon as declared endangered price escalates.

SEAL--rarity is attractive--Protected or not rarity is known and causes the money pressure-Must increase no's and stop trade-Convert Bali Mynah into commercial asset through cap breed-

ASHARI--numbers in captive breeding situation-

SEAL--1,000 living and more in private hands-

ASHARI--Number's known in private hands in Indonesia? 120 in zoos and parks-private 40 in Bali and 200 in Indonesia.

SEAL--important to try to recruit from private sector.

EFFENDI--Need recommendation to encourage people to become good breeders-

SOENDJI--Inbreeding problems in some private breeders.

SEAL--develop written protocols for captive breeding and help solve problems in given population

ASHARI--Life history by all is next-

SEAL--list of questions to get at life history of Bali Mynah-

ASHARI--general discussion now? Life history characteristics.

BAS Van Balen presentation:

BAS--Reproduction--breed season starts Nov./ Dec. and goes through April or May probably ends with start of dry season--5 or 6 Blackwinged Starlings in nest boxes last year-competitors don't overlap much - no complete data for east Java. Named tree species used as nesting trees-7 species-Clutch size (from 2 nests) 3--nest materials=dry twigs-territory size unknown-reports of aggression in wild, but no data-mortality-poaching, dry season, birds of prey, reptiles on nestlings-El Nino fluctuations coincide with drop in Bali Mynah populations -only one probable reports of sparrow hawks preying on Bali Mynah. Honey buzzards eat bees - not significant predation-geckos take over nest boxes,reptiles have been seen to eat nestlings --food-insects and other invertebrates and small reptiles-fruits -eat mainly in the undergrowth, ground feed in dry season, bark gleaning--social structure-dry season large flocks; single aged?-breeding season in single pairs and the nonbreeders are in small flocks. Habitat requirements -dry savannah with forested valleys now which may very well be marginal habitat - formerly found most abundant in drier monsoon forest and open monsoon forest--dispersal-daily movements of 3-10 km during the dry season speculated but none actually followed--distribution in 1925--distribution in 1984--distribution in 1989-25 to 30 birds-

BELL--Are birds killed at the same time as birds being poached?

BAS - poaching regarded as mortality factor, because of loss from wild population.

BELL-- seasonal poaching?

BAS--people need money at the end of fasting time (holidays).

BRUNING--Any indication that Macaques are predators?

BAS--no evidence they can reach the nest boxes.

BRUNING--Bees a problem?

BASs--take over the boxes. 11--No. of tree species?

BAS--only 7 found, of which 3 abundant in the National Park.

SEAL-- tree size (diameter)-

BAS H.-- 40 cm diameter or larger-

SEAL-- most likely to be harvested?

BAS H-- correlation between birds breeding in open savannah and the condition of the habitat-Vegetation along North coast has changed radically

WATLING-- in your assessment is the present restricted range of the Bali starling marginal?

BAS B-- no way of knowing given present knowledge.

WATLING-- wouldn't you expect the starlings to wander more if habitat is marginal?

BAS B-- no where to wander without loosing lives.

ASHARI-- number of guards enough?

KAMIL DASMAN - salaries?

BAS B-- need to be there permanently but logistics a problem-

EFFENDI-- salary limits but need to increase perception of locals-need to improve capability of the guards.

BAS B-- doing their best now--3 people only in field.

SUGARDJITO-- Data on what actually is eaten by birds? Food availability?

BAS B--competition for food,but competitors are disappearing too.-

SEAL--Use of pesticides or insecticides?

BAS B--none

SEIBELS--Snake exclusive Bali Mynah diet? How many snakes eat them?

BAS B--don't know but presumably none are so specialized.

3--Roosting trees, nesting trees-

BAS b--all birds disappeared from trees with biggest roosts

MUFTI--?Disease rather than poaching?

BAS B--Disease state not known-look healthy-

PAULO-- Rats near enclave settlements?

BAS B--plenty of rats occurring naturally - climb trees? Enclave of workers in national forest greatest threat-plan to move 700 families or individuals.

ASHARI--Lunch break-1315.

Reconvened at 1415. EFFENDI chair

BAS H--Slides--Tried to study behavior,but gave up-don't know diet-habitat-some dense some sparse-grass very dry and susceptible to fire-fires have been reduced-Bali Mynah need savannah?-use more forested areas in the area-not savannah--not forest species--limiting factor water?--utilize due from top of leafs?--food=fruit-Have some data--competition?-maybe.--measurements-bills, length by height-wings length---really no over lap so no competitor--nests-snake predator-nest boxes-boxes very heavy to be weather proof-no proven breeding by Bali Mynah in nest boxes.-deforestation, agriculture increase, roads built-wood collecting-bark collecting for tanning--planted forests on some edges of the park-who rules that area?-turf war-poaching--yearly survey done--return of birds by BRUNING--reintroduction planned-have considered intro. -1 area is unsuitable, and 1 might be-on Java--recommend releases only on Bali now because so few left--

release attempt described--analysis of captive world population--966 birds, 343 insufficient data; 341 born, --1971-8 252 birds reduction because of unequal sex ratio to 251; due to unequal family size down from 74 to 48--Single largest problem is non-breeders--Ne 20% of total--Inbreeding causes fewer young if female breeds at all--demographics-outbred replaces 2.6, inbred don't replace at all --evidence the no of sub-lethal equivalents is low--inbreed wild natural, inbreed & breed in captivity artificial-any surviving wild have better adaptation--wild population losing genetic diversity very fast--Real prob in Bali-must have viable wild population--

EFFENDI--questions

SEIBELS--problems with captive breed may be lack of attempts of breed in 80's due to over success earlier

BAS H--glad of captive breeding population, but records early on not good-

SEAL--hatched & fledged young sex ratio?

BAS H--no data about egg failure or

SEIBELS--sex ratio equal

BAS H--confirm

BRUNING--Natural vs artificial selection?

BAS H--Keep death at bay and push all to breed--No predation--don't want hand raised chicks reintroduced

SEAL--genetic selection in captivity has unknown biases-protections are to captive breed fewest generations-equal representation of founders and family size to reduce human choices-predation is gone-50-100 birds represented in cap populationand in wild 10-12 birds--must use what we have wisely.

BAS H--information lack on nest box breed 'cause we didn't get there at right time' -saw only 2 nests found and unused -

BRUNING--punch holes in trees, how long before could be used as nest?

BAS H--don't know, but Bali Mynah can't make own nests

GRIMMETT--Nest holes are available no shortage, don't need to worry about creating more.

KAMIL--situation now?

BAS B--rumors that there are birds in village-jungle fowl still being poached--

NOERDJITO--have found snares-there are 1-8 Bali Mynah Endangered--poaching still going on-identity known-well organized-need support from police and need to remove villagers-plantation managers asking govt. to remove all excess people--

KAMIL--optimistic or pessimistic

ENDANG--better management can make optimistic-

BELL--penalties for poaching?

KAMIL-- Rp 12,500 for 40 birds of paradise recently.

BELL--Need to increase penalties?

SEAL-- how many caught, convicted, fined in past 12 months?

EFFENDI--none ever convicted for lack of evidence -7$ present fine -new environment law changing to higher fine and possible jail-(10 years) -still hard to prove-(100 million rupiah fine)-Possession is illegal.

SEAL--what is practical and works-prevention more important that capture in past-design program to assist both-

Answering another question--more effective to use natural reproduction where possible. Technology can provide short term solutions.-technology can be used sometimes but not solution to Bali mynah

BRUNING--sexing will be most help--

EFFENDI--how use technology to improve breeding.

BAS H--can use fingerprinting to get a handle on how depauperate wild is-little time to be concerned about it.

SEAL--tomorrow put numbers to the problem. -inbreeding could further breeding in wild.

PANDU--?

BAS H--half won't breed so may have at most 6 or 7 young next year-seen 2 young this year in group of 20 birds.

PANDU--Need to discuss another population in addition to present wild population-coming from captive bred--

BAS B
--Bali Mynah project--objectives Bali Starling Project phase III 1987-1992.

1. continue monitoring remain wild population with census observations, check artificial nests; 2. assess results of art. nests installed in 84 and 86 and expand to 75 boxes; 3. Set up cap prop center at Surabaya zoo and pre-release train center in Bali Barat National Park; 4 To start Cap Propagation Program at Captive Propagation Centers with import. cap bred founders and prepare juveniles for release on Bali; 5. Train supervisor in captive propagation; 6. release captive bred birds; 7. advise and assist Indonesian government and non government institutions on cap breed release of certain birds, habitat manage and improve, information extension, research, for conserving Bali Mynah and environment--school contacts-local officials--

Recommendations: 1. peninsula should be closed off. 2. Permanent staffing of Telak Kelor and other posts on the peninsula; patrolling system. 3. Prosecution of any violation of the law in the park. 4. Removing of the enclave. 5. Improvement of Captive Propagation Program at Surabaya. 6. White Wash Campaign should start as soon as possible.--

EFFENDI--questions

BELL--How block off peninsula?

BAS--guards--beach patrols, roads-

BELL--increase in staffing?

BAS--yes-not an expert in guarding parks need information.

BAS--won't end but decrease problems

GRIMMETT--hardships on local population?

BAS--used to be closed and no hardship noted.

BAS H--cattle grazing was stopped abruptly with no problem -once you say no.

BAS H--Police dog might be help.

ASHARI--How many birds carrying capacity of habitat?

BAS H --200-500 maybe.

SEAL--not Minimum Viable Population but big step

ASHARI--focus on 1st 4 recommendations and 5 and 6 will follow

SEAL--Objectives x time need to proceed on many fronts in parallel.

MUFTI --Statement. Requested to provide in writing.

ISMU SUTANTO -- only 2nd generation birds should be released.

BELL--Must not delay more generations before release.

SOEGARDJITO --what to do with people on edge of the parks to get their support.-

BAS B--Tourist dollars are not going to National Parks, but destruction is attendant upon tourism.

SOEGARDJITO--supports local people and turning around.

ASHARI--Prince Philip told people are too poor to implement programs that work elsewhere-Can't succeed unless locals perceive pay off.

NOERDJITO--spoke in Indonesian.

BAS B-- people are landless becausethey immigrated from elsewhere, destroy cocanut trees in the plantation - if education etc improved, more come, so better to remove as soon as possible. Some important areas still under forestry and if Bali Mynah expands into those areas they will be lost. Suggests areas to move people to.

EFFENDI--thanks--

SEIBELS--History Bali Mynah captive population in USA (StudBook keeper) -- in one group 45 wasted in terms of breeding.--numbers turned loose in large flight cages.-some paired and bred.-2 pairs overbred -1981 he became studbook keeper--poor record keeping made studbook difficult--partially due to management in large groups--started with known parentage birds -master plan -repaired birds -broke up over bred pairs -maybe why lower productions --no more bulk production -can produce large nos if necessary-founders aging-carrying capacity in US 400 birds -100 active holders-use surplus birds for new breeders to try on etc. --EEP population been managed, but no regional studbook.

SEAL-- declining-no management group yet-EEP program will be started this year-

SEIBELS-- difficult recent years to starting up after a non breeding hiatus --management problems in large numbers--

BRUNING-- Easy to breed with qualifications-finding right combinations.

PAULO-- discover needs of special species -then have breeding-problems solvable.

HARWONO-- proper cages in Surabaya zoo--18 cages behind 14 cages. 53 Bali Mynah's 30 parents from USA and 6 chicks. Problems with chicks. parents haul chicks out of nest. 6 survived last year this year none survived. How manage to keep chicks alive?

SEAL-- 1st info. on breeding and deaths needed. --Many pairs are breeding and hatching so problem is death of chicks --need more information to decide why problems.

HARWONO-- check stools but no other parasite checks.

BRUNING-- Check parasites on parents.

BELL-- 1988,89. 85 young 17 survived. 14 died this year with no survivors.

GRIMMETT-- How much human disturbance? Seal off area?

HARWONO-- didn't know human disturbance was a problem.

BELL--Advised this last year. Other concerns are cats, parasites, recreational area next door.

EFFENDI--responded to Harwono in Indonesian --exchange followed.

BRUNING--Pairs successful in front or back.

PAULO--need visible barrier between cages.

BRUNING--fabric purchased in USA can't get shipped here.
34--Have checked feces once or twice a week and no parasites. Don't think the problem is that.

GRIMMETT--Need success at Surabaya-key-

EFFENDI--agrees

BRUNING--USA program AAZPA: To participate must sign memorandum of participation which implies they will follow recommendations of group. Need private individuals to be part of the system. Redundancy of attempts fruitful if communication good. Need to pair singles.

EFFENDI--questions

SEAL--core programs need institutions such as zoos. Can't yet work with most of private sector.

EFFENDI--Needed recruitment of more founders--150-200 outside of park-how to get back into park-allow owners to keep until needed & then they will give back--make Govt. owner of all birds. Effort called White Washed campaign. Information nationwide to inform private owners register birds and get permit to keep. Data on bird shared with government. Exchanges between captive bred for wild gene pool. Could US population release number to exchange with private owners? Aim to get all Bali bred birds reintroduced through acclimation program into wild-time schedule, 1 year information and Whitewash Program after year start enforcement--encourage private people to become breeders of captive birds --Then if these programs do not work seek USA birds. Public awareness needs increasing toward the wealthy. Try to get them to contribute to conservation instead of exploiting. White wash program for all protected animals in Indonesia. Big TV promotion that President and minister registered their animals so others should too.

GRIMMETT--plaudits and offers of help in any way they can (ICBP)

SEAL--identification of birds as registered?

EFFENDI--yes

ASHARI--Aspects to consider -psychological, proclaim registers as partners with goverment. -Keep to Bali Mynah first and not take on all protected animals right away -illegal trade still rampant-working pr with local officials, each province chooses animal and plant as theirs--assure no confiscation-replacement?

EFFENDI--no confiscation, but try to persuade to swap for cap bred later--Still need help with census of other animals. -Decisions are being made without census data to go from.

SEAL--congratulations on White Wash plan -extremely important-population participation plus. -Need to learn to adapt ourselves to changing needs.

GRIMMETT--will people try to get last ones out of wild before its too late? Need extra enforcement? Governor help?

EFFENDI--adjourned at 1735.

Suggestions submitted in writing:

NASTIORE S. DJAJALAKSANA --1. Urgency and extent of demand for the service or the management measure. 2. Ecological and biological requirements. 3. Available budget. 4. Available equipment and personnel. 5. Engineering constraints. 6. Institutional, political and social consideration.

ISMAJADI SOMSOEDIN --It will be better if Bird Park Taman Mini and Taman Safari, cisarua are also involved so then we will have three Captive Propagation Programs.

SOETIKINO --Improvement of understanding of local surrounding people about the importance of the protection/conservation of Bali Mynah should be done through many ways (official bodies, non-government bodies, informal leaders. 2. As suggested by Dr Sugarojito on more attention so the progress of local people. To do this, one way for the successful is to make the part of the protected area/ national park as a scientific tourist spot. If there are many tourist coming and the local or surrounding people can get the benefit by selling specific products, it would reduce the poaching.

March 23, 1990

Called to order at 0910 by PANDU

Welcome, hope for good rest, ready to start day with renewed hope and energy. Introductions.

EFFENDY--housekeeping.

SEAL --PVA forms -want to verify biological data given yesterday-went through form explaining, and verifying-

EFFENDY--husbandry

SEIBELS--Guidelines --Enclosure parameters-do not keep in multiple pairs-2Mx2Mx4M adequate to lodge a pair -no visual contact -for breeding better not to put in mixed exhibits -can be bred in mixed exhibits with success -diet in US commercial dog food, fruit cocktail, fish, omnivorous; iron retention syndrome a worry right now, liver damage, now preparing lo iron diet; -live food essential for raising chicks, meal worms, main; can use most live worms but best not to use those with chitinous case for danger of impaction.--hand-raising -not worth much -imprinted -don't reproduce -No hand raising of chicks less than 17 days of age -prefer none -record keeping -US been bad over years-every bird must be banded from hatch -records essential to be kept up to date --Feather plucking-believe a captive condition -In wild only if there has been a fight (BAS B)-excessive grooming of cage mate?-

BRUNING--Reproductive implications?

SEIBELS --no data --Nesting -catholic in nest sites in captivity-have nested in walls of building-offering a choice of 2 or 3 nest boxes seem to help-opening should not be too large-5-9 cm. good range-need grass and leaves to line cavity, aids pair bonding -give as wide a variety as possible, but not critical-eggs bright blue --chick rejection -not unusual, and not easily soluble -reduce disturbance, increase variety of live food, separate the males-

BELL--Use appropriate sexes in cage-new techniques for identifying birds-parasite checks, and health exams regularly (1xMMo)-

BRUNING--Hemochromatosis-significant losses over time so do need good post mortem, and when problem is identified modification of diet takes care of the problem.-ID with transponders-ID's for life-

SEIBELS--Plastic bands are useful only temporarily -not good for permanent ID -some risk with wire, but not outweighing need-

BRUNING--Use permanent metal bands, but use plastic band for quicker ID

SEIBELS--Colored aluminum don't loose colors, but only 4 colors

DICK --Transponder?

BRUNING--explained transponder--

EFFENDY--Price?

SEAL--2 different types at 2 different 7.00 per transponder 700.00 for reader -competition will drive price down -large numbers reduces prices.

HARWONO-- Plan to change padding,

HARWONO-- Chick rejection due to age of parents?

SEIBELS--Birds that were surplus were sent, chose on basis of inbreeding so that they could be bred with local birds. some were older-

GRIMMETT-- Hasn't affected fertility.

SEIBELS--Can't answer Harwono question.

BRUNING--might expect to happen 1st time breeders, but not experienced pair.

SEAL--demographics don't support that older birds throw out chicks

HARWONO--oldest female plays with her egg.

BRUNING--where is egg that is played with?

HARWONO--throws out and then plays with it.

GRIMMETT
--Starling Release--1. Birds trained to find own food in cage; 2. Birds trained to find own water in cage; 3. Birds conditioned to the vegetation that they would meet in wild habitat; 4. Weighed, color-banded and dyed red (on mid-ventral area with Rhodamine B); 5. Transferred to portable release cages and taken into field on daily basis to familiarize them with environment----

--Results in 88-- Bird 1-Released and not seen; Bird 2, released and departed but weak next day and dead 2nd; 3. released; free flying for ten days and gradually increased range-dependent on cage for food and water; brought back into captivity day 10 and released x2 later but weak and hung around-disappeared at 1 month and presumed dead.--

--Current situation-- 12 birds for release; 2. delay because of dry season, poaching and want to release 10+ --3. Release approach with main difference. 1. wet season, released together, released in area of wild roosts--4. considerations; need for extra protection, transponders? Use of radiotelemetry?--

EFFENDY--questions?

Dick--location of pre-release site in relation to release?

BAS H--200M north of pre=release facility.

BELL--Wet vs dry?

BAS H--April - May best times -not after July

BRUNING--How long to accustom birds in pre-release?

BAS H--within week

AUGARAJITO--food availability?

BAS B --assume enough but no data

ASHARI --yesterday said enough food available-

EFFENDY--in wet season

BAS B --still Bali Mynah in area

SEAL --Mortality is expected to be 80-100% in reintroductions or introductions. Survival doesn't happen till releases are in 100's--Encouraged that 1 of 3 lasted 10 days-tool to assist is telemetry-

KAMIL --How release?

BAS H --small cage in large aviary then cage to release site-1 in and 1 out-

KAMIL --need transition period-

BAS H --spend time in cage for a day before released

KAMIL --resident birds must be taken into consideration

EFFENDY --Interactions of people--

ISTANTO --big threat is people in the enclave and around the boundaries -need support to recommend that enclave be removed. Inside park production forest-fragmentation of habitat-recommend change production to refuge or natural forrest rare-lack of fresh water on peninsula for guards $ to supply-need solution to water problem--

EFFENDY--questions?

MADI?--Indonesian language--

ISTANTO--Answered in Indonesian. --

EFFENDY
--Question discussed conserving. Bali Mynah itself-people already understand need to conserve-why increase education -Buffer zone?-priorities?--

--Answer --people in enclaves were employees of plantation and used to be policed by armed guards,but no more -permission given to utilize the park to the residents -management not done by park service but by forest service-suggests remove enclave in total including administrators of the plantation, but need to get permission from goverment.

GRIMMETT --Summarize work we have done--

BAS B --exhibition, tours of park, toured school children,leaflets distributed, exhibit in headquarters--plan to go to schools,

GRIMMETT --Welcome help and advise from National Park in public relations campaign.

ISTANTO -- Comments in Indonesian --

EFFENDY -- Answered in Indonesian. --Illegal trade in Bali Mynah - price 750,000R's -suggest sell us birds to rich and lower price--answer no -stop sales and protect present population. --Urge improve patrol system.

SEAL--Interest on comments on technical training--

ASHARI --Interested in discussion on local human population. -Unmotivated locals will not have good conservation values. -Need to move whole village, we need to make supportive statement for Government to move. --Population ready to move.

EFFENDY --good recommendation.

BAS H --Strongly recommend that goverment implement policy (move enclave).

EFFENDY --discussed yesterday and then in Indonesian.
Educational program-most important to people on boarders, then all of Bali people. -Bali Mynah as identity of province -perceive only $ and not other values. -Need to produce more leaflets and brochures, all in use gone. -Need to train and upgrade personnel in the park. Still miscommunications with head of park. Might need some slight change in leadership in park. How to widely distribute the knowledge of the need to protect and breed. Husbandry publication for lay usage, as well as field biologists, keepers etc. Need for use in WW campaign -PHPA education program; public education species by species with dir. and Bali Mynah highest priority -film? -TV? -frequent exposure.

ASHARI --Start education with Governor of Bali and get his aid-
1st lady declared love the animal day November 5, birthday of zoo association. Need political base for the efforts-request audience with Governor of Bali.

EFFENDY --good idea and adds to what he already is planning.

KAMIL --Tell people not to capture Bali Mynah any more -remove the people for their own sake, and they will not capture them anymore.

EFFENDY-- Agree to remove enclave people-emphasize preserve. Bali Mynah is good for people of Bali, no conflict with bird vs people--PR.

SUGARNJITO --Didn't hear anything about effort to improve income of people surrounding the park -education not enough -care about economics not biology.

EFFENDY --programs of National park management to improve locals lot by hiring, shopkeeping, etc., expect welfare services to enter on declaration of National park --Management plans drawn up for each National park.

ASHARI --Won't be here tomorrow so apologize. --IZPA meets with ministers on conservation problems. --World Heritage Convention signed recently. --Brief all ministers so they have knowledge in international contacts. Biodiversity due to comb. 2 ecosystems. Use Bird park to educate on Indonesian birds -Aquarium for fresh water life from various islands is future hope for education.

EFFENDY --thanks for active participation in this workshop--lunch in same place from 1230-1330 --adjourned at 1134 for lunch--

WATLING: Comment added to minutes after meeting (I have edited - USS).

I fully support Pa Effendy's call for greater Public Awareness and Education, especially for the National Park environs.

However, I think one must distinguish immediate needs from even the short term priorities. I believe that Public Awareness is really of medium term benefit and as such will be vitally important for the Bali Starling re-introduction programme. Likewise transmigration of the enclave inhabitants may happen in the next one, two, or three years. But at the present rate of decline we are going to be very lucky to have an effective wild population in a couple years time. Thus for the present rapidly dwindling wild population the greatest priority must be to ensure guarding and law enforcement of the highest standard.

The Prapat Agung peninsula is logistically a simple area to be patrolled and protected. Once the system of guarding has been worked out, the onus of its management lies entirely with PHPA, there is virtually nothing anybody else can do help. So I urge PHPA to examine what they can do to upgrade the management of guarding and patrolling at Bali Barat. I believe that there is a wider issue at stake which should also be considered. The Bali Starling is a project with an international profile. If the bird should become extinct as a result of the current level of poaching in such a relatively simple location for protection then it .... will be a loss that could have been prevented.

Reconvened by Don BRUNING at 1340

SEAL--observe method of modeling --page 80 in briefing book --walking through parameters to be used in Bali Mynah model --will run new models on data achieved this AM -will include inbreeding with 1 lethal as suggested this AM.

GRIMMETT --populations?

SEAL--10 runs of the model

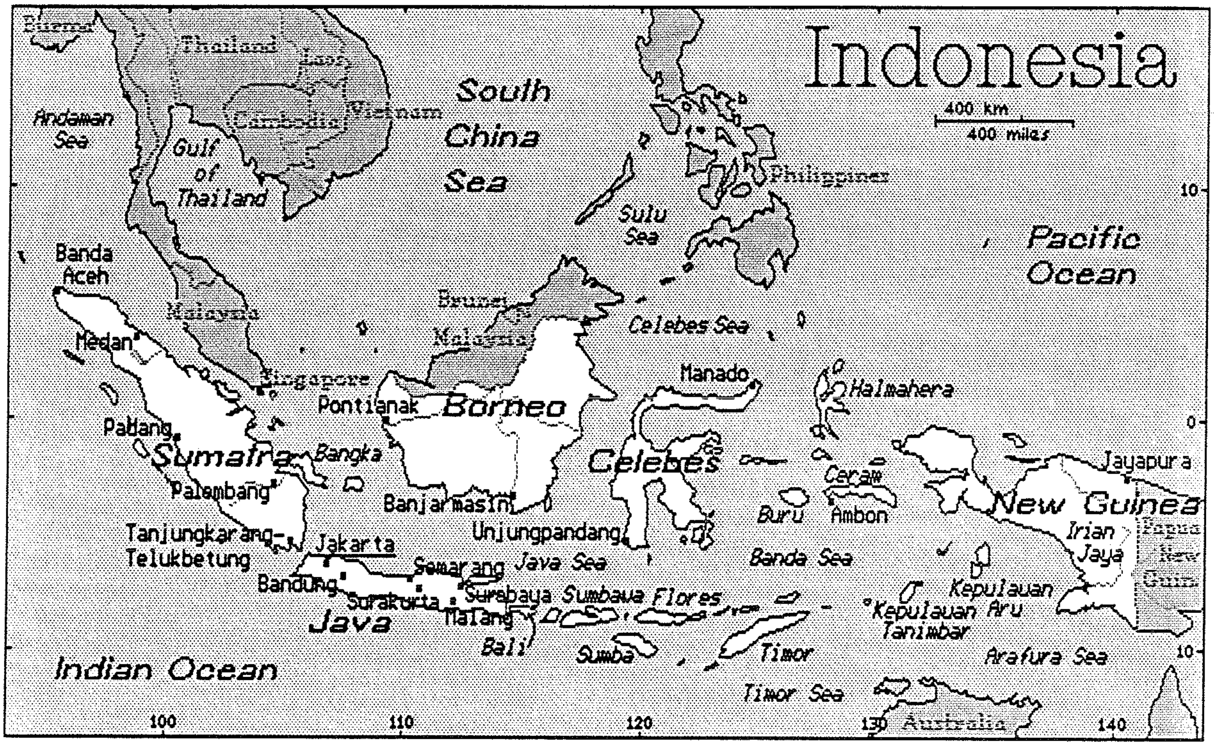
BRUNING--genetic and population goals

SEAL--already discussed ,but goal expand up to 2,000 birds (metapopulation)--numbers founders and rates of diversity loss in models -plenty of founders for 99% representation of genetic pool of last 25 years. Captive breeding how long? Strategies to achieve goal initially, and long term. Captive breed for short term-need to expand habitat to accommodate large wild populations.
BRUNING--questions?
BELL--current numbers?
SEAL--about 1,000 if include private collections.
PANDU--Why 0 catastrophe?
SEAL--baseline run without catastrophe--
BRUNING--What are the chances of catastrophe, and what are the potential happenings that could form a catastrophe?
PANDU--Fire about every 50 years.
SEAL--other ideas to include?
BAS B--drought about every 10 years and major drought about once in 20 years.
GRIMMETT--define drought.
BAS B--long dry season.
PANDU--volcanic eruption--3 active volcanos close-
SEAL--frequency?
ISTANTU--last in 63--2 or 3 / 100 yrs.
BRUNING--how bad eruption--how much damage.
BELL--larger refuge and more refuge areas--may decide not to go for 2,000 but must assess the consequences of smaller numbers.
SEAL--Must set best Biological goals. Will be long term effort.
BRUNING--next--

SEAL--Small groups to build a document that will be a draft recovery plan by tomorrow evening. Everyone must participate. Small group topics--1. Husbandry and management Guidelines especially captive management. For captive breeding centers, suggestions for more captive breeding centers; 2. Record keeping and studbooks; 3.White Wash campaign; Bali Barat; 4. Field program; 5. Education;

Broke into small groups at 1430

Small Group Reports read to entire group at 1600.



GEOGRAPHY OF INDONESIA

TOTAL AREA: 1,919,440 sq km (740,202 sq mi); LAND AREA: 1,826,440 sq km (703,181 sq mi)
COMPARATIVE AREA: slightly less than three times the size of Texas
LAND BOUNDARIES: 2,602 km (1,616 mi) total; Malaysia 1,782 km (1,107 mi), Papua New Guinea 820 km (510 mi)
COASTLINE: 54,716 km (33,998 mi)
MARITIME CLAIMS: (measured from claimed archipelagic baselines)
  CONTINENTAL SHELF: to depth of exploitation
  EXTENDED ECONOMIC ZONE: 200 nm
  TERRITORIAL SEA: 12 nm
DISPUTES: East Timor question with Portugal
CLIMATE: tropical; hot, humid; more moderate in highlands
TERRAIN: mostly coastal lowlands; larger islands have interior mountains
NATURAL RESOURCES: crude oil, tin, natural gas, nickel, timber, bauxite, copper, fertile soils, coal, gold, silver

LAND USE: 8% arable land; 3% permanent crops; 7% meadows and pastures; 67% forest and woodland; 15% other; includes 3% irrigated
ENVIRONMENT: archipelago of 13,500 islands (6,000 inhabited); occasional floods, severe droughts, and tsunamis; deforestation
TEMPERATURE: in degrees Celsius (Fahrenheit)

	Mar	Jun	Sep	Dec
Jakarta	27 (81)	27 (81)	27 (81)	27 (80)

PRECIPITATION: in centimeters (inches)

	Mar	Jun	Sep	Dec
Jakarta	0 (7.9)	10 (3.8)	8 (3.1)	19 (7.6)

NOTE: straddles Equator; strategic location astride or along major sea lanes from Indian Ocean to Pacific Ocean

PEOPLE OF INDONESIA

POPULATION: 187,651,163 (July 1989), growth rate 1.9% (1989)
BIRTH RATE: 28 births/1,000 population (1989)
DEATH RATE: 9 deaths/1,000 population (1989)
NET MIGRATION RATE: 0 migrants/1,000 population (1989)
INFANT MORTALITY RATE: 80 deaths/1,000 live births (1989)
LIFE EXPECTANCY AT BIRTH: 57 years male, 61 years female (1989)
TOTAL FERTILITY RATE: 3.4 children born/woman (1989)
NATIONALITY: noun--Indonesian(s); adjective--Indonesian
ETHNIC DIVISIONS: majority of Malay stock comprising 45.0% Javanese, 14.0% Sundanese, 7.5% Madurese, 7.5% coastal Malays, 26.0% other
RELIGION: 88% Muslim, 6% Protestant, 3% Roman Catholic, 2% Hindu, 1% other
LANGUAGE: Bahasa Indonesia (modified form of Malay; official); English and Dutch leading foreign languages; local dialects, the most widely spoken of which is Javanese
LITERACY: 62%
LABOR FORCE: 67,000,000; 55% agriculture, 10% manufacturing, 4% construction, 3% transport and communications (1985 est.)
ORGANIZED LABOR: 3,000,000 members (claimed); about 5% of labor force

GOVERNMENT OF INDONESIA

LONG-FORM NAME: Republic of Indonesia
TYPE: republic
CAPITAL: Jakarta
ADMINISTRATIVE DIVISIONS: 24 provinces (propinsi-propinsi, singular--propinsi), 2 special regions* (daerah-daerah istimewa, singular--daerah istimewa), and 1 special

capital city district** (daerah khusus ibukota); Aceh*, Bali, Bengkulu, Irian Jaya, Jakarta Raya**, Jambi, Jawa Barat, Jawa Tengah, Jawa Timur, Kalimantan Barat, Kalimantan Selatan, Kalimantan Tengah, Kalimantan Timur, Lampung, Maluku, Nusa Tenggara Barat, Nusa Tenggara Timur, Riau, Sulawesi Selatan, Sulawesi Tengah, Sulawesi Tenggara, Sulawesi Utara, Sumatera Barat, Sumatera Selatan, Sumatera Utara, Timor Timur, Yogyakarta*

INDEPENDENCE: 17 August 1945 (from Netherlands; formerly Netherlands or Dutch East Indies)

CONSTITUTION: August 1945, abrogated by Federal Constitution of 1949 and Provisional Constitution of 1950, restored 5 July 1959

LEGAL SYSTEM: based on Roman-Dutch law, substantially modified by indigenous concepts and by new criminal procedures code; has not accepted compulsory ICJ jurisdiction

NATIONAL HOLIDAY: Independence Day, 17 August (1945)

BRANCHES: executive headed by president, who is chief of state and head of Cabinet; Cabinet selected by president; unicameral legislature (DPR or House of Representatives) of 500 members (100 appointed, 400 elected); second body (MPR or People's Consultative Assembly) of 1,000 members includes the legislature and 500 other members (chosen by several processes, but not directly elected); MPR elects president and vice president and theoretically determines national policy; judicial, Supreme Court is highest court

CHIEFS OF STATE AND HEAD OF GOVERNMENT: President Gen. (Ret.) SOEHARTO (since 27 March 1968); Vice President Lt. Gen. (Ret.) SUDHARMONO (since 11 March 1983)

SUFFRAGE: universal over age 18 and married persons regardless of age

ELECTIONS: next parliamentary election in 1992; next presidential election in 1993

POLITICAL PARTIES AND LEADERS: GOLKAR (quasi-official party based on functional groups), Lt. Gen. (Ret.) Wahono; Indonesia Democracy Party (PDI--federation of former Nationalist and Christian Parties), Soeryad (chairman) and Nicholas Daryanto (secretary general); United Development Party (UDP, federation of former Islamic parties), John Naro

VOTING STRENGTH: (23 April 1987 general election) Golkar 73%, UDP 16%, PDI 11%

DIPLOMATIC REPRESENTATION: Ambassador Abdul Rachman RAMLY; Chancery at 2020 Massachusetts Avenue NW, Washington DC 20036; telephone (202) 775-5200; there are Indonesian Consulates General in Houston, New York, and Los Angeles, and Consulates in Chicago and San Francisco;

U.S. FOREIGN SERVICE POST: Ambassador Paul D. WOLFOWITZ; Embassy at Medan Merdeka Selatan 5, Jakarta (mailing address is APO San Francisco 96356); telephone (21) 360-360; there are US Consulates in Medan and Surabaya

FLAG: two equal horizontal bands of red (top) and white; similar to the flag of Monaco which is shorter; also similar to the flag of Poland which is white (top) and red

ECONOMY OF INDONESIA

OVERVIEW: Indonesia has extensive natural wealth but, with a large and rapidly increasing population, it remains a relatively poor country. GNP growth rates during the period 1985-87 were in the 2-3% range. Estimates show that the economy must grow at a 4-5% annual rate to absorb the nearly 2 million workers annually entering the labor force. Agriculture, including forestry and fishing, is the most important sector, accounting for 25% of GDP and over 50% of the labor force. The staple crop is rice. Once the world's largest rice importer, Indonesia is now nearly self-sufficient. Plantation crops--rubber and palm oil--are being encouraged for both export and job generation. The diverse natural resources include crude oil, natural gas, timber, metals, and coal. Of these, the oil sector dominates the external economy, generating more than 60% of the government's revenues and over 50% of export earnings in 1987.

GNP: $69.0 billion, per capita $880; real growth rate 3.8% (1987)

INFLATION RATE (CONSUMER PRICES): 9.3% (1987)

UNEMPLOYMENT RATE: 2.95% (1988)

BUDGET: revenues $10.5 billion; expenditures $13.9 billion, including capital expenditures of $4.7 billion (FY88)

EXPORTS: $16.5 billion (f.o.b., FY88); commodities--petroleum and liquefied natural gas 55%, timber 10%, coffee 6%, rubber 5% (1986); partners-- Japan 45%, US 20%, Singapore 8%, EC 3% (1986)

IMPORTS: $11.2 billion (f.o.b., FY88); commodities--machinery 25%, chemical products 23%, base metals 12%, transport equipment 12%, food, beverages, and tobacco 9%, textiles 5%, paper and printed matter 3% (1986); partners-- Japan 29%, US 14%, EC 13%, Singapore 9%, Saudi Arabia 6%, (1986)

EXTERNAL DEBT: $51.5 billion, medium and long-term debt (1988)

INDUSTRIAL PRODUCTION: growth rate 6.8% (1986)

ELECTRICITY: 11,000,000 kW capacity; 36,500 million kWh produced, 200 kWh per capita (1988)

INDUSTRIES: petroleum, textiles, mining, cement, chemical fertilizer production, timber, food, rubber

AGRICULTURE: subsistence food production; small-holder and plantation production for export; rice, cassava, peanuts, rubber, cocoa, coffee, copra, other tropical products; an illegal producer of cannabis for the international drug trade

AID: NA
CURRENCY: Indonesian rupiah (plural--rupiahs); 1 Indonesian rupiah (Rp) = 100 sen (sen no longer used)
EXCHANGE RATES: Indonesian rupiahs (Rp) per US$1--1808.3 (February 1990) 1,735.7 (1989), 1,685.7 (1988), 1,643.8 (1987), 1,282.6 (1986), 1,110.6 (1985)
FISCAL YEAR: 1 April-31 March

COMMUNICATIONS IN INDONESIA

RAILROADS: 6,964 km (4,324 mi) total; 6,389 km 1.067-meter gauge, 497 km 0.750-meter gauge, 78 km 0.600-meter gauge; 211 km double track; 101 km electrified; all government owned
HIGHWAYS: 119,500 km (74,209 mi) total; 11,812 km state, 34,180 km provincial, and 73,508 km district roads
INLAND WATERWAYS: 21,579 km (13,408 mi) total; Sumatra 5,471 km, Java and Madura 820 km, Kalimantan 10,460 km, Celebes 241 km, Irian Jaya 4,587 km
PIPELINES: crude oil, 2,505 km (1,555 mi); refined products, 456 km (283 mi); natural gas, 1,703 km (1,058 mi)(1989)
PORTS: Cilacap, Cirebon, Jakarta, Kupang, Palembang, Ujungpandang, Semarang, Surabaya
MERCHANT MARINE: 323 ships (1,000 GRT or over) totaling 1,498,454 GRT/2,264,176 DWT; includes 5 short-sea passenger, 14 passenger-cargo, 173 cargo, 5 container, 3 roll-on/roll-off cargo, 1 vehicle carrier, 89 petroleum, oils, and lubricants (POL) tanker, 1 chemical tanker, 2 liquefied gas, 6 specialized tanker, 24 bulk
CIVIL AIR: about 70 major transport aircraft
AIRPORTS: 466 total, 434 usable; 104 with permanent-surface runways; 1 with runways over 3,659 m; 12 with runways 2,440-3,659 m; 62 with runways 1,220-2,439 m
TELECOMMUNICATIONS: interisland microwave system and HF police net; domestic service fair, international service good; radiobroadcast coverage good; 763,000 telephones (1986); stations--618 AM, 38 FM, 9 TV; 1 international satellite ground station (1 Indian Ocean antenna and 1 Pacific Ocean antenna); 1 domestic satellite communications system

DEFENSE FORCES OF INDONESIA

BRANCHES: Army, Navy, Air Force, National Police
MILITARY MANPOWER: males 15-49, 48,053,245; 28,416,931 fit for military service; 2,040,135 reach military age (18) annually
MILITARY BUDGET: NA

TRAVEL IN INDONESIA

REQUIRED DOCUMENTS: Passport valid beyond 6 months of arrival and onward/return ticket required. Visa not required for tourist or business stay up to 2 months (non-extendable). Vaccination certificate not required unless arriving from an area infected with yellow fever, or from an area in the endemic zone.

HEALTH: Tapwater is not potable. Unwashed raw foods and undercooked meats are not safe to eat. Malaria suppressant recommended for travel outside Jakarta, Medan , Surabaya, and southern Bali. Inoculations against typhoid, cholera, tuberculosis, hepatitis, and dengue fever may be necessary for travel outside urban area; check with your physician. Health requirements change; check latest information.

U.S. CHAMBER OF COMMERCE: Citibank Bldg, 8th Floor, Jakarta J1; Tel (21) 332602.

FOREIGN CHAMBER OF COMMERCE: American-Indonesian Chamber of Commerce, 12 E. 41st St., Ste 701, New York, NY 10017; Tel 212-637-4505.

TOURIST OFFICES: Directorate General of Tourism, Jalan Kramat Raya 81, Jakarta; Tel 359001. Indonesia Tourist Promotion Office, 3457 Wilshire Blvd., Los Angeles, CA 90010; Tel 213-387-2078.

WEATHER AND CLOTHING: Hot and humid year round. Rainy season lasts from Nov to Apr. Lightweight clothes are worn year round with two changes per day frequently required.

TELEPHONE: When direct dialing to Indonesia from the U.S., dial 011 (international access code) + 62 [country code] + (city code) + local number.

TIME: Jakarta is 12 hours ahead of U.S. Eastern Standard Time, and 7 hours ahead of Greenwich Mean Time. See Time Zone Map for other parts of Indonesia.

ELECTRIC CURRENT: 220V, 50-CYCLES, AC

IMPORTANT!! All requirements/recommendations are subject to change. Be sure to check latest information.

Source: The Software Toolworks World Atlas (TM)
19808 Nordhoff Place, Chatsworth, CA 91311

BALI STARLING

Leucopsar rothschildi

VIABILITY ANALYSIS

AND

SPECIES SURVIVAL PLAN

CAPTIVE POPULATION

DEVELOPMENT OF AN SSP MASTERPLAN

1. DATA COMPILATION

The first step in development of an SSP Masterplan is to compile the basic data required for population analysis.

This compilation will often be in the form of a Studbook. However, ISIS should be involved in the compilation process: initially as a source of data for studbook development; ultimately as a repository of the assembled data. An important part of the compilation process is a "clean up" of the ISIS data.

The basic data required on each animal for population analysis and management are:

(A) Individual identification - a simple numeric lifetime identity.

To achieve this identification, it may be necessary to link a series of different ID numbers the animals has had as it moved from one institution to another in its captive history, e.g. the local ISIS specimen ID numbers.

(B) Sex

(C) Birth date

(D) Death date

(E) Parentage - if captive born

(F) Place of capture - if wild caught

(G) Institutions/facilities where it has been, with dates

(H) Available information on circumstances of death

With these data, genetic and demographic analyses can be performed.

2. GENETIC ANALYSES

(A) Construct the pedigree for each animal in the population.
This process may be literally the construction of a pedigree chart or more often will be an inherent part of various algorithms and computer programs, e.g. the additive relationship matrix or various "gene drop" computations.

(B) Identify all the founders of the population.

A founder is an animal:

(a) which is from outside the population (usually the wild)

(b) which has no known relationship to any other individual at its time of entry into the population.

(c) which has descendants in the living population.

(C) Compute the representation of founders ("bloodlines"), or better the probable distribution of founder alleles, in living individuals and the present population as a whole.

(D) Hence, determine the relative representation of founders (bloodlines) or probable distribution of founder alleles in the population.

(E) Locate any extreme bottlenecks in the history of particular founder lineages or bloodlines.

This step may be an inherent part of more sophisticated algorithms that calculate probable distributions of founder alleles rather than just crude founder representation.(i.e. gene drop analysis)

(F) Calculate the founder representation or founder allele distribution in offspring of the possible matings of living members of the population.

(G) Determine of the number and sex ratio of animals that actually reproduce in the population.

(H) Calculate the number of offspring of each living individual in the population and hence the mean and variance of lifetime family sizes.

(I) **Estimate the genetically effective population size (N_e) of the population and then the N_e/N ratio, where N is the total number of animals in the population.**

(J) **Calculate the inbreeding coefficients of existing individuals in the population and of the potential offspring of possible matings between these animals.**

(K) **Conduct various biochemical analyses that measure genetic variability (e.g. electrophoretic, DNA, and karyotypic studies).**

3. DEMOGRAPHIC ANALYSES

(A) **Determine the size of the current population and the number of institutions over which it is distributed.**

It will also usually be necessary to know this information roughly for other taxa with similar "captive ecologies", i.e. space and resource requirements, e.g. the Siberian Tiger SSP needs to be cognizant of the other tiger and large felid populations.

(B) **Determine the age and sex structure of the population.**

(C) **Compute the age-specific survivorships and fertilities of the population, i.e. construct a life table consisting of demographic parameters.**

(D) **Establish a carrying capacity that is a compromise between a minimum viable population (MVP) for genetic and demographic viability and a maximum number that will not preclude other taxa from the zoo ark.**

This carrying capacity should specify the number not only of animals but of the facilities over which they should optimally be distributed.

The lower limit of the carrying capacity, the MVP, will be determined primarily by reference to the long-term genetic objectives of the program and the biological characteristics of the population.

The genetic objectives of relevance are:

(a) The kind of genetic diversity that is to be preserved, e.g. average heterozygosity or allelic diversity.

(b) The amount of the original genetic diversity that is to be preserved.

(c) The period of time this level of genetic diversity is to be preserved.

The biological characteristics of the population of relevance are:

(a) The generation time of the population (under probable patterns of mortality and various actual or managed schedules of reproduction) and hence the number of generations that will occur during the absolute period of time (e.g. 200 years) over which the propagation program is to operate.

Generation times should actually be computed from demographic parameters. It is presumed the schedule of reproduction in the SSP population will be regulated to extend generation time for genetic reasons.

In any case, dividing the absolute number of years over which the propagation program is intended to operate by this generation time for the population will indicate the number of generations over which diversity is to be preserved.

(b) The effective number of founders that have established the population.

Bottlenecks in lineages of some founders may reduce them to only fractional effectiveness in the living population.

(c) The N_e/N ratio in the population.

(d) The growth rate of the population from founder number to carrying capacity.

In the absence of more refined or species-specific recommendations on the long-term genetic objectives, the guideline of 90% of average heterozygosity for 200 years may be used as a crude starting point. Reference to the graphs or algorithms that have been generated, considering effective number of founders, will prescribe an MVP for these genetic objectives.

This MVP will be in terms of effective population number N_e. Realities of managing the species (e.g., the need for or problem of uneven sex ratios for gregarious species, especially with difficult to manage males) should be considered to estimate likely N_e/N ratios, i.e. effective number to total number. Dividing the MVP by this N_e/N ratio will indicate the actual number of animals that must be maintained to produce the desired MVP.

A secondary consideration for determination of the MVP is demographic stochasticity and is significant if the MVP prescribed by genetic considerations is fewer than 50-100. Populations (N's) smaller than 50 and possibly even 100 may be particularly vulnerable to "crashes" or extinctions due to random demographic causes, e.g. epidemic diseases, natural disasters, or sex-ratio distortions.

The upper limit on carrying capacity should be derived by an analysis of:

(1) The amount of captive habitat (space and resources) that seems to be available for this and other taxa (esu's ?) with similar "zoo ecologies" (i.e. enclosure requirements, exhibit value, etc.)

(2) The number of taxa (esu's) that are in need of assistance from captive propagation and may be competing for this captive habitat.

The size of current populations and information on expansion plans can be used to estimate the captive habitat available. Information on status and trends of wild populations as well as considerations of taxonomic uniqueness can be used to decide the number of taxa that are in need of captive propagation.

Simple division of available habitat by the number of taxa will suggest the upper limit on carrying capacity.

If this number is less than the MVP, then prioritization and selectivity of the competing taxa will be necessary.

(E) **Using the data on these demographic parameters, analyze**

(a) **The rate of change, i.e. the growth or decline, of the population.**

(b) **Hence, the capacity of the population for self-sustainment.**

(c) **Whether the population is at, or when it will be at, the carrying capacity.**

(d) **How the fertilities and survivorships can be managed by "removals" of animals and regulation of reproduction (birth control) to stabilize the population at the desired carrying capacity.**

This process may entail much "what if" analysis to determine how managemental modifications to the patterns of survivorship and fertilities will affect population size, growth rate, age distribution, etc.

(F) **If the survivorships and fertilities are not adequate for the population to be self-sustaining, devise a program of research in reproductive, behavioral, other biology to resolve the problem.**

4. POPULATION MANAGEMENT

Once these genetic and demographic analyses are performed, an SSP Masterplan for propagation and management of the population can be formulated.

The SSP Masterplan should provide recommendations, institution by institution and animal by animal, for every individual in the population maintained by SSP Participants

Specifically, the Masterplan should:

(A) Designate which animals are surplus because they are

(a) from over-represented bloodlines or lineages

(b) too old to reproduce

(c) have already produced their share of offspring and have attained the oldest age class necessary or allowable for a stable age distribution in the SSP population.

(B) State explicitly that surplus animals should not be reproduced again.

Further recommendations on disposal of surplus will vary from program to program, time to time, and institution to institution. The issue of euthanasia will have to be confronted in this regard.

(C) Recommend which animals should reproduce.

(a) When.

A schedule over at least the next 1 to 5 years is needed.

(b) With whom.

These recommendations of course may entail relocation of animals between facilities.

(D) Explain the genetic and demographic criteria or objectives on which the surplus and reproduction recommendations are based. There should also be an explanation of how the Masterplan arrived at the particular carrying capacity established.

Normally, these genetic and demographic guidelines will include:

(a) An attempt to rapidly expand and stabilize the population at its established carrying capacity.

(b) A strategy to maximize preservation of genetic diversity.

Currently, the best methods to achieve this objective seem to be:

- **Adjust existing representation of founder lineages to be proportional to the probable distribution of alleles surviving from founders at initiation of the program. (i.e. toward target distribution)**

  Founder alleles are lost through random genetic drift, especially due to "bottlenecks" in pedigrees. Estimating the probability of loss and retention of alleles is possible through so-called "gene-drop" algorithms.

  Computer programs are available to calculate both the existing and target founder distributions. Arranging matings to change founder representation from the existing to the target distribution will maximize retention of genetic diversity.

  Adjustment of bloodlines may require considerably unequal reproduction by various individuals to rectify disparities that have developed in the past.

- **Equalize lifetime family sizes.**

  This process will become fully operative only once the past inequalities in founder representation have been corrected.

- **Manage inbreeding coefficients.**

  Observe that this is not the primary criteria for genetic management. Frequently, there should be an attempt to minimize inbreeding coefficients within the constraints of the previous criteria. However, there may be cases when inbreeding is deliberately employed to achieve some objective or solve some problem, e.g. purge of deleterious alleles in the Speke's gazelle program.

- **Perhaps subdivide the population into several parts or demes between which gene flow (i.e., usually exchange of animals but also increasing of gametes or embryos) is regulated.**

5. HUSBANDRY STANDARDS

Husbandry standards for the taxon, ideally culminating in production of a **Handbook** which can be kept current as new advances occur.

6. REVIEW AND RATIFICATION

Once the SSP Masterplan is formulated, it should be reviewed, revised if appropriate, and ratified by the Propagation Group.

The Masterplan should then be submitted to the SSP Subcommittee for their evaluation and hopeful endorsement. The SSPSC may suggest some modifications to the Masterplan.

7. IMPLEMENTATION

Once approved, the Masterplan should be distributed to each of the Participating Institutions through its Institutional Representatives. The Species Coordinators and Propagation Group should provide follow-up to encourage and facilitate implementation.

THE ZOOLOGICAL
SOCIETY OF LONDON
INSTITUTE OF ZOOLOGY

REGENT'S PARK LONDON NW1 4RY
TELEPHONE: 01-722 3333
TELEX: 265247 LONZOO G
FAX NUMBER: 01-483 4436

ROTHSCHILD'S MYNAH
(Leucopsar rothschildii)

British Isles Regional Studbook

30th October 1988

Director
PROFESSOR A P F FLINT
The Institute of Zoology includes the

Introduction

This Studbook covers the period 1st Jan 1988 - 30th October 1989. In future studbooks will be updated at the end of October each year to give more time for assessment of the population, and any resulting breeding recommendation to be implemented.

1988 was not a particularly successful year. This may have been partly due to a number of moves that took place relatively late in the breeding season.

Table 1 shows the overall changes: the population has increased from 102 to 110, though most of this change can be accounted for by new registrations and a net increase of two birds imported from Hong Kong. Births were outnumbered by deaths (32 to 38) and as can be seen in Table 2, the hatching and rearing success was very poor. A total of at least 93 eggs were laid to 21 pairs, but only 32 hatched, and only 6 of these survived to independence. These 6 chicks were from just 4 pairs.

One encouraging aspect of the breeding data (Table 2) was that of 10 new pairs established in 1988, 8 laid eggs and 5 hatched at least one chick successfully. The process of re-pairing does seem to have been beneficial in these cases.

Pedigree Drawings

Two pedigrees diagrams are included in this studbook. The first (Figure 1) was prepared by David Ashmouth of Nottingham University as part of his project on genetic studies on Rothschild's Mynahs, and shows the entire studbook population at the beginning of 1988, including both living and dead birds. It is easy to see the complexity of the pedigree that is developing, and David Ashworth is still collecting material for his genetic studies. Anyone who can help with blood samples or freshly frozen tissue from dead birds should telephone him on Nottingham (0602) 421421 ext. 4516.

The second pedigree (Figure 2) was prepared from a computer programme by Dr Alun Thomas of the University of Bath. This is restricted to living birds (at the start of 1988) and their ancestors. It shows very clearly the quite large number of birds we have that are alive but have not bred successfully.

News from Indonesia

The status of the wild population continues to decline, with just 37 birds recorded at the last count in Bali Barat National Park. However, the joint ICRP/AAZPA/Indonesian Government captive breeding and release programme is progressing well. Over 40 birds were sent to Indonesia in December 1987 from zoos in North America, and from the Jersey Wildlife Preservation Trust here in Britain. These were all sent to the Surabaya Zoo, where it is planned that most of the breeding will take place, and captive bred birds will then be taken to the Bali Barat National Park, and given a period of adjustment in isolated aviaries before being transferred to cages at the release site.

Meanwhile, by early September 1988 34 eggs had been laid by the birds at Surabaya Zoo, 11 of these hatched and two chicks were still surviving.

New from North America

In August 1988 the AAZPA Species Co-ordinator for Rothschild's Mynah produced a 'Masterplan' for the species. This includes detailed recommendations for general population management (including husbandry guidelines) and specific recommendations for each individual bird. The programme aims to manage a population of 400 birds in North American Zoos and bird collections, and currently they have about 300 involved in the programme.

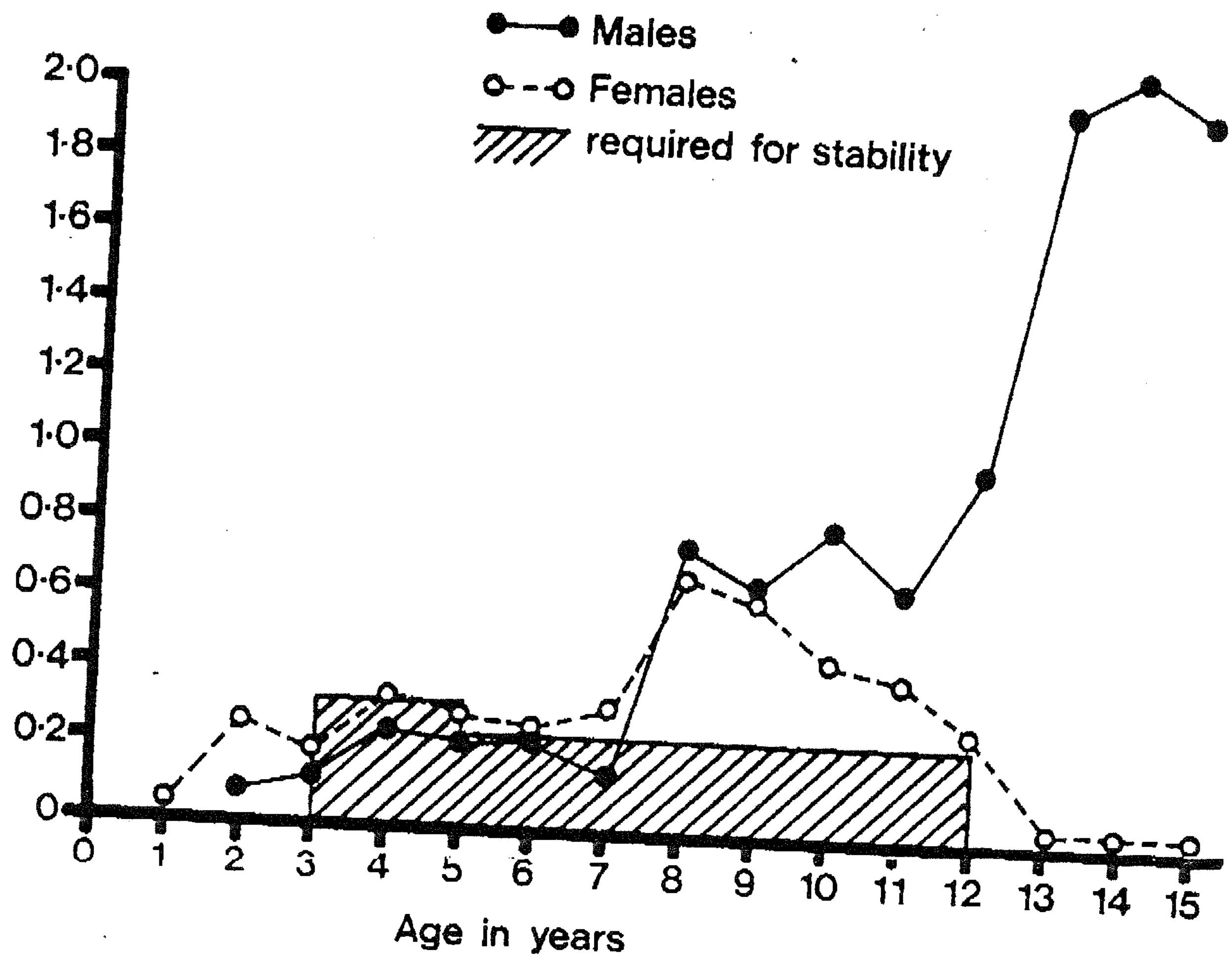
We hope that we will be able to exchange some birds with the North American programme, which will be of benefit to both them and us.

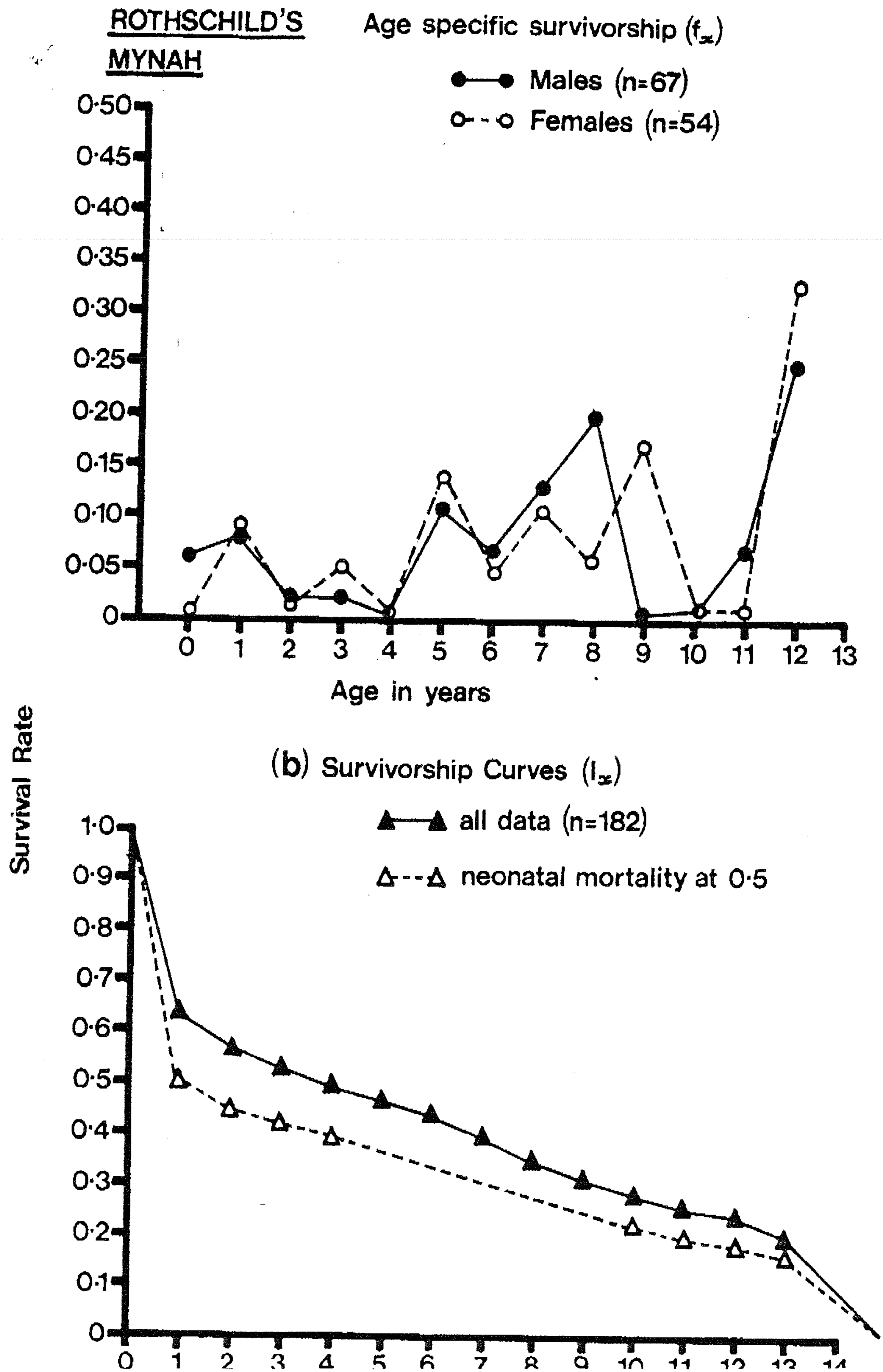
Thank you all for your co-operation and participation in this programme. David Jeggo and I will be considering breeding recommendations for 1989 as soon as possible, and will let you all know.

Georgina Mace
Regional Studbook Keeper

ROTHSCHILD'S MYNAH

(a) Age specific fecundity




ROTHSCHILD'S MYNAH
Age specific survivorship (f_x)
Males (n=67)
Females (n=54)
0·50
0·45
0·40
0·35
0·30
0·25
0·20
0·15
0·10
0·05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
Age in years
Survival Rate
(b) Survivorship Curves (l_x)
all data (n=182)
neonatal mortality at 0·5
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0

Census Report
BALI MYNAH Studbook

Taxon Name: **LEUCOSPAR**

Year	Specimen Counts		Lambda	
1990	201.189.90	(480)	1.00	.
1989	202.189.90	(481)	1.00	.
1988	206.198.78	(482)	0.95	.
1987	242.231.98	(571)	0.95	.
1986	257.231.103	(591)	0.95	5 yr ave.
1985	283.225.117	(625)	0.95	.
1984	286.218.135	(639)	0.96	.
1983	276.219.169	(664)	0.96	.
1982	272.217.162	(651)	0.98	.
1981	249.198.127	(574)	1.00	10 yr ave.
1980	212.179.123	(514)	1.01	.
1979	190.157.113	(460)	1.01	.
1978	158.149.116	(423)	1.03	.
1977	133.120.109	(362)	1.03	.
1976	118.107.95	(320)	1.03	15 yr ave.
1975	104.97.103	(304)	1.04	.
1974	98.84.76	(258)	1.05	.
1973	79.70.65	(214)	1.06	.
1972	58.45.71	(174)	1.07	.
1971	48.39.55	(142)	1.08	20 yr ave.
1970	39.27.44	(110)	1.17	.
1969	14.10.14	(38)	1.16	.
1968	14.9.13	(36)	1.16	.
1967	11.9.12	(32)	1.16	.
1966	9.6.11	(26)	1.16	25 yr ave.
1965	9.6.8	(23)	1.16	.
1964	9.5.7	(21)	1.16	.
1963	6.5.6	(17)	1.20	.
1962	4.3.1	(8)	1.21	.
1961	3.2.0	(5)	1.20	30 yr ave.

Age Pyramid Report
BALI MYNAH Studbook

Report Date:
14 Mar 1990

```
==============================================================================
Taxon Name: LEUCOSPAR
==============================================================================
Age                                   Males|Females
---              N = 246             ---------------              N = 234
 30-                                       |X
 29-                                       |
 28-                                       |
 27-                                      ?|?
 26-                                      ?|?
 25-                                     X?|?
 24-                                       |
 23-                                      ?|?X
 22-                                     X?|?X
 21-                              XXXX?????|?????X
 20-                                      X|
 19-                                    XX?|?
 18-                                     X?|?
 17-                                    XX?|?XXX
 16-                                 XXXXXX|XXX
 15-                            XXXXXXX????|????XXXX
 14-                                 XXXX??|??XXXXX
 13-                                    XXX|XXX
 12-                          XXXXXXXXXXX??|??XXXXX
 11-                                 XXXXX?|?XXXXXXXX
 10-                         XXXXXXXXXXX???|???XXXXXXXXXXXXXXXXX
  9-                      XXXXXXXXXXXXXX???|???XXXXXXXXXXXXXXX
  8-         XXXXXXXXXXXXXXXXXXXXXXXXXXXXX?|?XXXXXXXXXXXXXXXXXX
  7-                XXXXXXXXXXXXXXXX???????|???????XXXXXXXXXXXXXXXXXXXX
  6-                       XXXXXXXXXXXXXXX?|?XXXXXX
  5-                          XXXXXXXXXXXXX|XXXXXXXXXXXXXXX
  4-                            XXXXXXXXXX?|?XXXXXXXXXXXXXXX
  3-                          XXXXXXXXXXX??|??XXXXXXXXXXXXXXXXX
  2-                          XXXXXXXXXXX??|??XXXXXXXXXXXXX
  1-                        XXXXXXXXXXXXXX?|?XXXXXXXXXXXXXX
  0-                       XXXXXXXXX???????|???????XXXX
---- | - | - | - | - | - | - | - | - |  - | - | - | - | - | - | - | - | ---
     32  28  24  20  16  12   8   4       4   8   12  16  20  24  28  32
                                Number of Animals
```

X >>> Specimens of known sex...
? >>> Specimens of unknown sex...
1 Unknown sex Specimens of unknown age...

Fecundity & Mortality Report
BALI MYNAH Studbook

Report End Date:
14 Mar 1990

Taxon Name: **LEUCOSPAR**

	Fecundity [Mx]...				Mortality [Qx]...			
Age Class	Male	N	Female	N	Male	N	Female	N
0- 1	0.000	637.0	0.000	601.9	0.260	590.7	0.280	556.9
1- 2	0.050	516.8	0.090	496.0	0.250	461.2	0.260	440.3
2- 3	0.180	486.9	0.210	449.0	0.090	469.1	0.100	432.8
3- 4	0.210	437.5	0.230	400.2	0.080	420.0	0.080	383.0
4- 5	0.250	394.2	0.260	346.9	0.090	376.3	0.110	330.2
5- 6	0.260	351.9	0.190	303.3	0.080	338.7	0.060	294.2
6- 7	0.200	308.2	0.200	267.7	0.080	300.0	0.100	256.6
7- 8	0.150	274.9	0.200	231.4	0.060	265.1	0.090	222.3
8- 9	0.170	224.8	0.190	195.4	0.160	208.9	0.090	185.1
9-10	0.080	171.7	0.200	154.6	0.130	162.1	0.100	148.3
10-11	0.050	139.3	0.120	120.7	0.100	131.4	0.150	113.2
11-12	0.020	116.0	0.120	92.9	0.100	111.4	0.090	89.5
12-13	0.030	97.6	0.200	77.4	0.080	94.3	0.120	72.8
13-14	0.230	81.8	0.160	63.8	0.080	79.9	0.110	61.4
14-15	0.060	71.4	0.010	52.5	0.120	68.2	0.140	49.2
15-16	0.030	57.9	0.000	40.4	0.110	55.8	0.080	39.0
16-17	0.170	42.9	0.000	31.6	0.120	41.4	0.220	27.7
17-18	0.030	34.1	0.000	21.4	0.190	32.0	0.150	20.4
18-19	0.000	27.2	0.000	18.9	0.160	25.6	0.060	18.0
19-20	0.160	21.6	0.000	15.8	0.120	21.0	0.180	14.2
20-21	0.060	17.2	0.000	13.4	0.120	16.5	0.080	13.0
21-22	0.000	13.9	0.000	12.2	0.080	13.2	0.000	11.8
22-23	0.000	5.7	0.000	6.8	0.000	5.7	0.000	6.8
23-24	0.000	4.5	0.000	4.8	0.000	4.5	0.000	4.8
24-25	0.000	4.0	0.000	4.0	0.000	4.0	0.000	4.0
25-26	0.000	2.5	0.000	2.5	0.650	2.3	0.630	2.4
26-27	0.000	0.9	0.000	1.9	0.000	0.9	0.000	1.9
27-28	0.000	0.4	0.000	1.4	0.000	0.4	0.000	1.4
28-29	0.000	0.0	0.000	1.0	0.000	0.0	0.000	1.0
29-30	0.000	0.0	0.000	1.0	0.000	0.0	0.000	1.0
30-31	0.000	0.0	0.000	0.3	0.000	0.0	0.000	0.3
31-32	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0
32-33	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0

Male	Female	Mortality
T = 5.997	T = 5.589	30 day mortality: 10%
Ro = 0.722	Ro = 0.758	(142 out of 1461)
lambda=0.95	lambda=0.95	
r = -0.054	r = -0.050	

Effective Population Size
based on 29 years of data:
Ne = 13 [Reed, et al. (1986)]

	Male	Female
Newborns that bred:	105	106
Births/year:	25.5	24.5
% newborns that bred:	5%	5%

1 specimens of unknown age ignored...

1203 birth events to known age parents tabulated for Mx...
[240 parents (includes WILD) not found in data set ignored...]

1132 death events of known age tabulated for Qx...

WARNING: Values with small sample sizes (N) warrant less confidence...

Fecundity Rate [Mx]: the average number of same-sexed young born to animals in that age class. The Mx values are calculated by dividing the number of female (or male) births by the number of females (or males) alive at the beginning of an age class. The fecundity rates provide information on the age of first, last, and maximum reproduction.

Mortality Rate [Qx]: the proportion of individuals that die during an age class. It is calculated from the number of animals that die during an age class divided by the number of animals that were alive at the beginning of the age class (i.e.-"at risk")

Generation Length [T]: defined as the average age at which a female (or male) produces offspring. It is not the age of first reproduction. Males and females often have different generation lengths.

Net Reproductive Rate [Ro]: if each animal were to replace itself each generation the net reproductive rate would be 1.00 and the population would remain the same size. A growing population has an Ro greater than 1.0 and a declining population less than 1.0.

Growth Rate per Year [lamda]: a year growth rate of 1.11 means a 11% per year increase.

Intrinsic Rate of Increase [r]: the exponential rate at which a population with a stable age distribution grows.

Reference: Foose, T. & Ballou, J.(1988): Management of small populations, in International Zoo Yearbook, 27:26-41.

Hit any key to continue...

Effective Population Size [Ne]: the size of an idealized population that would have the same amount of inbreeding or of random gene frequency drift as the population under consideration. In an idealized population all individuals breed successfully, so only breeding individuals are included in calculating Ne.

Percent Newborns that Bred: probability that a new born survives to the mean age of reproduction (Generation Length [T]) and breeds.

Reference: Reed, J. Michael, Doerr, P. D., and Walters, J. R.(1986): Determining minimum population sizes for birds and mammals, in Wildlife Society Bulletin, 14:255-261.

Hit any key to continue...

	LIVING DESCENDANT POPULATION		POTENTIAL	
	with unknowns	w/o	w/ unkn	w/o
Number of founders:	67	33	103	35
Parity (%):	1.493	3.030	0.971	2.857
Mean retention:	0.794	0.776	0.906	0.837
Founder genomes surviving:	53.167	25.624	93.298	29.308
Founder Genome Equivalents:	22.912	11.465	93.297	29.308
Founder Equivalents:	23.571	11.819	99.436	33.216
Fraction of wild heterozygosity retained:	0.972	0.943	0.995	0.983
Fraction of wild heterozygosity lost:	0.028	0.057	0.005	0.017
Mean inbreeding coefficient:	0.055			

Living Population at: SAN DIEGO ZOOLOGICAL GARDEN **SANDIEGOZ**

Stud #	Sex	Hatch Date	Sire	Dam	Arrival Date	Local ID	Inbreed. Coeffic.	Living Offspring	Reprod. Offspring	Living Siblings	Founder Representation
5	F	13 Nov 1959	WILD	WILD	13 Nov 1961	______		. .	. .	. .	
19	?	22 Jun 1962	3	4	22 Jun 1962	______		. .	. .	0. 0. 4	F4=50% F3=50%
32	?	7 Jun 1963	3	4	7 Jun 1963	______		. .	. .	0. 0. 4	F4=50% F3=50%
47	?	19 Jun 1964	3	4	19 Jun 1964	______		. .	. .	0. 0. 4	F4=50% F3=50%
75	?	12 Jun 1966	3	4	12 Jun 1966	______		. .	. .	0. 0. 4	F4=50% F3=50%
80	?	14 Jun 1967	3	4	14 Jun 1967	______		. .	. .	0. 0. 4	F4=50% F3=50%
99	F	3 Oct 1967	______	______	3 Oct 1969	______		. .	. .	. .	
121	?	12 Apr 1968	WILD	WILD	12 Apr 1970	______		. .	. .	. .	
122	?	12 Apr 1968	WILD	WILD	12 Apr 1970	______		. .	. .	. .	
386	F	22 Jun 1974	244	243	31 Aug 1988	488351		. .	. .	2. 1. 0	F243=50% F244=50%
799	M	6 Sep 1979	655	426	3 Jun 1988	388805		. .	. .	. .	F157=56.3% F156=43.8%
840	F	24 Feb 1980	661	657	24 Feb 1980	887008		0. 1. 5	. .	3. 1. 1	
855	M	9 May 1980	539	550	14 Oct 1988	488443		0. 0. 2	. .	. .	F156=50.2% F157=50.2%
907	M	8 Sep 1980	702	425	13 Oct 1988	488442		. .	. .	3. 4. 0	F157=31.3% F156=18.8%
1224	F	6 Oct 1982	139	602	2 Aug 1988	488192		. .	. .	0. 2. 0	F139=50% F178=25% F177=25%
1486	F	25 Sep 1984	271	277	25 Sep 1984	026635		. .	. .	. .	F277=50% F271=50%
1654	M	18 Jul 1985	778	915	18 Jul 1985	029622		. .	. .	1. 5. 0	
1655	M	16 Mar 1987	1630	1627	16 Mar 1987	887016		. .	. .	2. 0. 0	
1657	M	18 Mar 1987	1630	1627	18 Mar 1987	887018		0. 1. 5	. .	2. 0. 0	
1659	F	21 Apr 1987	______	______	21 Apr 1987	387317		0. 1. 0	. .	. .	
1661	?	21 Apr 1987	______	______	21 Apr 1987	387318		. .	. .	. .	
1706	M	1 Jan 1987	______	______	1 Jan 1987	387907		. .	. .	. .	

Stud #	Sex	Hatch Date	Sire	Dam	Arrival Date	Local ID	Inbreed. Coeffic.	Living Offspring	Reprod. Offspring	Living Siblings	Founder Representation
1755	F	2 Aug 1988	______	1659	2 Aug 1988	488193		. .	. .	. .	
1757	?	12 Sep 1988	______	______	12 Sep 1988	488437		. .	. .	. .	
1814	?	5 Apr 1989	1657	840	5 Apr 1989	889039		. .	. .	0. 1. 4	
1815	?	7 May 1989	1657	840	7 May 1989	889178		. .	. .	0. 1. 4	
1816	?	2 Jun 1989	1657	840	2 Jun 1989	889179		. .	. .	0. 1. 4	
1817	?	2 Jun 1989	1657	840	2 Jun 1989	889180		. .	. .	0. 1. 4	
1818	?	4 Aug 1989	______	______	4 Aug 1989	489055		. .	. .	. .	
1819	?	5 Aug 1989	______	______	5 Aug 1989	489056		. .	. .	. .	
1820	?	11 Aug 1989	1657	840	11 Aug 1989	889282		. .	. .	0. 1. 4	
1821	?	10 Oct 1989	______	______	10 Oct 1989	489226		. .	. .	. .	
1822	?	10 Oct 1989	______	______	10 Oct 1989	489227		. .	. .	. .	

1 SUMMARY

An attempt is made to analyze the population-genetics of the American captive population of Bali Starlings (*Leucopsar rothschildi* Stresemann 1912) from a conservation point of view. Main aim is to obtain insight on which a propagation stratagem for the Captive Propagation Program of the Bali Starling Project III can be based.

The analysis is exclusively based on information extracted from the Bali Starling Regional Studbook USA (6 November 1987). Out of approximately 966 Bali Starlings hatched between 1971 and 1982 inclusive, 623 birds are included in two independent samples (252 and 371 birds each), each of which is divided in three sub-samples of outbred birds and inbreds birds (mean inbreeding coefficient *circa* 0.250 respectively 0.375)

Ten seperate age-specific (horizontal) life-tables compiled from the two samples, yield age-specific values for the vital parameters (survivorship and fertility), for a number of derived parameters (viability, mortality, survival/mortality rate, life-expectancy, maternity, reproductive value) and for a few population parameters (age-structure, net reproductive rate, intrinsic/finite growth rate, mean generation time, sex-ratio, family-size distribution, effective population size).

Primarily, three parameters, *viz.* survivorship, probability to survive to a certain age and fertility are compared between sub-cohorts of outbred and inbred Bali Starlings to search for a possible inbreeding depression in this species.

* No evidence for a reduction of cohort **survivorship** due to inbreeding is found, although there is an insignificant trend in that direction; this may be due to the method applied.
* Good evidence is found for a reduction of an individual's **probability to survive to a particular age**, when inbred (reduced viability, increased mortality rate, reduced life-expectancy)
* Good evidence is found also for a reduction (54-72%) in **fertility** when inbred (defined as an average adult female's life-time production of female young, and as the average number of female young per actually breeding adult female).

It is concluded that, in this species too, inbreeding is accompanied by an inbreeding depression and therefor inbred Bali Starlings are less suitable for the Captive Propagation Program; apart from obvious population-genetic reasons (reduced genetic variation in related re-introduced birds), inbred birds reduce both total production and production efficiency (in terms of human efforts: funds, time, zoo accommodation, expertise).

Outbred Bali Starlings of 3-5 years old have highest reproductive values, fertility and are most responsive to manipulation of, primarily, survival (in terms of effect on the population growth rate/production of young).

2 RINGKASAN

Suatu upaya untuk menganalisakan populasi terkurung burung Jalak Bali (*Leucopsar rothschildi* Stresemann 1912) di Amerika Serikat dari segi pelestariannya.
Sasaran utama adalah: memperoleh wawasan untuk mendasarkan strategi penangkaran di Pusat Penangkaran burung Jalak Bali (Surabaya) dari Bali Starling Project III.

Analisa ini disusun dari data dasar yang seluruhnya dikutip dari Bali Starling Regional Studbook USA (6 November 1987). Dari kurang-lebih 966 burung Jalak Bali yang menetas dalam kurungan waktu 1971-1982, 623 burung diliputi analisa ini dalam jumlah dua contoh yang saling tidak tergantung. Kedua contoh itu masing-masing dibagi tiga anak-contoh: burung yang tidak kawin-dalam ('outbred'), dan dua tingkat kawin-dalam ('inbred'; masing-masing sekitar 0.250 dan 0.375).

Berdasarkan kedua contoh itu, telah disusun sepuluh daftar-kehidupan horisontal ('age-specific life-table'), yang menghasilkan bagi tiap-tiap kelompok umur nilai-nilai tertentu buat parameter pokok (kelangsungan kehihupan dan kesuburan), buat sejumlah parameter lain (kematian, laju kelanjutan kehidupan/kematian, harapan kehidupan, keindukan, nilai kembangbiak) serta buat beberapa parameter populasi (penyusunan umur, laju kembangbiak bersih, laju perkembangan intrinsik/terbatas, jangka waktu generasi, perbandingan kelamin, penyebaran besarnya keluarga, besarnya effektip dari populasi).

Untuk mengetahui apakah kawin-dalam pada jenis ini pula disusuli tekanan kawin-dalam, kami memperbandingkan nilai-nilai dari tiga parameter antara kelompok burung yang telah dan yang tidak kawin-dalam.

* Tidak ada bukti bahwa **kelangsungan kehidupan 'cohort'** ditekankan akibat terjadinya kawin-dalam, maupun memang ada suatu kecenderungan yang tidak nyata ke arah itu; barangkali metoda yang diterapkan kurang cokcok.
* Diketemui bukti-bukti yang nyata bahwa **kemungkinan bahwa salah satu burung hidup terus sampai suatu umur tertentu** mengurang bilamana telah kawin-dalam ('viability' mengurang, laju kematian meningkat, harapan kehidupan mengurang).
* Diketemui bukti-bukti yang nyata bahwa **kesuburan** mengurang (54-72%) bilamana telah terjadi kawin-dalam.

Kami berkesimpulan bahwa juga dalam jenis ini, kawin-dalam 'ditemani' suata tekanan kawin-dalam. Oleh sebab itu burung-burung Jalak Bali yang telah kawin-dalam kurang patut ditangkarkan di Pusat Penangkaran Jalak Bali di Surabaya. Selain dari segi genetika-populasi serta variasi genetik pada burung-burung yang kelak dilepaskan di kawasan Taman Nasional Bali Barat, burung-burung yang telah kawin-dalam juga mengurangi baik hasil total maupun effisiensi dari Pusat Penangkaran burung Jalak Bali.

RINGKASAN

B E van Helvoort

Burung Jalak Bali yang tidak kawin-dalam, dengan umur 3-5 tahun menpunyai nilai-nilai tertinggi bagi laju kembangbiak serta kesuburan dan adalah paling peka (bila dilihat dari segi laju perkembangan populasi) akan manipulasi dari, terutama, kelangsungan kehidupan.

3 INTRODUCTION

Captive propagation of Bali Starlings (***Leucopsar rothschildi*** Stresemann 1912) for reintroduction into the wild started early 1988 at the Bali Starling Captive Propagation Center (CPC) in the Surabaya Zoological Garden (Kebun Binatang Surabaya; KBS), East-Java, Indonesia. A first sending of 44 captive bred Bali Starlings from the United States of America and England arrived on 15 November respectively 1 December 1987. During transport and the following quarantine period 8 'American' birds died. The 36 surviving Bali Starlings are the core of the propagation group; possibly this core will be supplemented with a few 'white-washed' illegally kept birds from Indonesia (HELVOORT 1988 *unpubl.*).

The ultimate aim of the third phase of the Bali Starling Project (BSP III) is the preservation (*sensu* FRANKEL & SOULÉ 1981) of this single island endemic, for which aim captive-propagation-with-reintroduction is only one of the tools available. **Guarding against catching for the Indonesian domestic pet-market is the most important objective.**

In order to establish a propagation stratagem for the Captive Propagation Program in Indonesia a population-genetic analysis of a captive population of Bali Starlings is indispensable. The analysis should provide insight in demographic and population-genetic characteristics of a representative population of captive-hatched and -raised Bali Starlings. The characteristics analyzed here are survival, reproduction and derived parameters in relation to inbreeding and inbreeding depression.

The analysis is exclusively based on the Bali Mynah Studbook per 6 November 1987 (this document is hereafter referred to as 'Bali Starling Regional Studbook USA (6 November 1987)'). The Bali Starling Regional Studbook USA contains pedigree information on circa 1700 individual Bali Starlings divided over circa 92 different collections (private and public), including some non-american collections.

However the Bali Starling Regional Studbook USA shows a number of flaws:

1. all inbreeding coefficients are miscalculated by a factor 10; possibly a computer program error is involved;
2. a significant number of inbreeding coefficients have been mis-calculated (e.g. studbook #799 and #1580 of the same parents would have different F's; or #1633-1637 with stated F's of zero actually have inbreeding coefficients of 0.3125, provided other pedigree information is correct;
3. many death dates precede birth dates (e.g. studbook #1576 and #1577);
4. apparently the Bali Starling Regional Studbook USA lags behind some 1 to 2 years, which may be an unavoidable effect of the great number of individual collections involved and the administration thereof;

5. often complete clutches/broods (same parents; hatched within 1 or 2 days) die on exactly the same day one or more years after birth; an unlikely event probably more likely to be an administrative error rather than reality (e.g. studbook #948-950);

6. in some cases -according to the Bali Starling Regional Stud-book USA information on location- parents were not present at the zoo on the date(s) that they hatched their young there (e.g. the dame of #885 and #993 has never been in the zoo where she allegedly hatched these birds);

7. birds that have died young or that never have brėd are most often not sexed; though practically unavoidable, this limits the utility of the Bali Starling Regional Studbook USA and the life-tables in this analysis;

8. recording of total number of eggs/clutch-size, infertile or un-hatched eggs ('abortions') and nest-death ('still-birth') and often even pre-independence death seems insufficient to set up completely informative life-tables; probably a result of the sensitivity of the Bali Starling to disturbances during incubation or brooding.

Neglecting sound demographic and (population-)genetic management, and most of all denying an inbreeding depression is an act of wishful thinking or indifference with very real potention for a disaster in normally outbreeding species; all the more so in the case of the Bali Starling Captive Propagation Program where the ultimate aim is reintroduction into the wild (*cf* FRANKEL & SOULÉ 1981, SOULÉ 1986, SOULÉ & WILCOX 1980, SCHONEWALD-COX *et al* 1983 and many other references).

4 MATERIAL AND ASSUMPTIONS

Pedigree information, birth- and death-dates, *etc.* of each separate Bali Starling included in this analysis is extracted **exclusively from** the Bali Starling Regional Studbook USA (6 November 1987).

Only Bali Starlings born in the years **1971 to 1982** inclusive have been analyzed. However not all the birds born in those years are included; a selection had to be made which was based on the following **criteria** :

1. birds must be **captive hatched** : no wild-caught birds or birds of unknown origin are included;
2. birds must have **known parents** whether wild-caught or captive bred: sire and dame must have studbook numbers;
3. both **birth- and death-dates** must be known and **not contradictory**;
4. **present status** (*i.e.* per 6 November 1987) must be either **´alive´** (code ´A´ in the Bali Starling Regional Studbook USA) or ´**death**´ (code ´D´) but not ´missing´ (code ´M´) or ´unknown´ (code ´U´).

The first two criteria -captive hatched; known parents- were chosen in order to make the analyzed sample similar to the propagation group in the CPC for which a stratagem is to de developed.

The last two criteria were chosen to minimize mis-information in the basic data and improve the reality values of this analysis.

With the above information life-span and inbreeding coefficient for each individual American Bali Starling and (life-time) fertility of female Bali Starlings can be calculated accurately and reasonably reliably and realistically. For the analyzed group as a whole, age- and sex-specific survival and -for female birds- fertility is calculated and subsequently included in a life-table.

In total, *circa* 966 Bali Starlings were hatched in captivity between 1971 to 1982 inclusive, of which in total **623** Bali **Starlings** met the above listed criteria; these birds comprise the sample **on which this analysis is** based.

[illegible] (inbreeding coefficient, F, is a relative measure; *cf* FRANKEL & SOULÉ 1981:60; RALLS, HARVEY & LYLES 1986:52, STRICKBERGER 1982:713, METTLER & GREGG 1969:57) is the group of wild-caught Bali Starlings that has been imported into the USA plus the group of Bali Starlings of unknown origin (code ´unknown´ in the Bali Starling Regional Studbook USA). **These birds are assumed to be unrelated and outbred.**

For both classes of founders this is not necessarily true: ´wild-caughts´ as well as ´unknowns´ may be related and/or inbred, the latter probably more likely so than the former, but -due to the low population levels in the wild- it is not entirely justified to assume wild-caught Bali Starlings to be unrelated and/or outbred, even prior to 1972, when the last wild-caught Bali Starling was recorded in the Bali Starling Regional Studbook USA (6 November 1987).

In this study, all inbred Bali Starlings are definitely inbred; but an unknown proportion of the birds considered ´outbred´ in reality may be inbred, for all unknown ancestors in their pedigree had to be assumed unrelated. In some cases this may not be true.

Therefor, **individual inbreeding coefficients are minima and group averages are *relative* to the base population** (but see RALLS, HARVEY & LYLES (1986:51) for the use of the concept of inbreeding and it´s implications for preservation).

It is further assumed that allele frequencies did not change over the years 1971-1982 (*cf* ALLENDORF & LEARY 1986:59-62); temporal changes in allele frequencies may obscure inbreeding depression.

7 DISCUSSION

Throughout this discussion it should be remembered that what we labelled as *inbred* birds are definitely inbred birds, while the sample of *outbred* birds may very well contain a (considerable?) number of -in reality- inbred birds. The reason for the latter is the simple fact that each unknown ancestor is assumed to be a bird unique to a particular birds ancestry. If two different Bali Starlings had *x* respectively *y* unknown ancestors it had to be assumed that none of the *x* and *y* ancestors is common to the two birds, which are therefor classified as *outbred*. To which extent this inaccuracy changes differences found between in- and outbred birds can only be guessed; in most instances, if dissimilarities are found, then they will probably be under-estimated to an unknown extent.

Further it should be noted that the American captive population of Bali Starlings experienced a rapid growth in the period 1970-1978, while it was more or less stable before and after (on different levels). During that time interval it grew from *circa* 52 birds to *circa* 270 birds (compilation from several sources, primarily International Zoo Yearbook, in HELVOORT *et al* 1985).

7.1 METHODOLOGY

The method adopted, *viz.* to produce age-specific life-tables of acceptable size through combination of successive year-cohorts into composite cohorts, assumes that (GOODMAN, 1980):

* the population is stable over the series of years that is combined into the single composite cohort;
* recruitment rate, or number of newborns per year has been constant over the period of the lives of the individuals in the life-tables (1971 to 6 November 1987);
* from year to year the age-specific mortality/survival rates (and maternity) have been equal over the period of combination.

The number of newborns between 1971 and 1978 is not constant; it varies from 10 to 59 (average 31.5 birds/year). None of the single year's number of newborns deviates significantly from the average (all P's >0.100), although there is a significant (P<0.020) relation between time and the number of newborns. The 1979-82 cohort reveals a similar picture, except for an average recruitment rate of 92.8 birds/year (range 61-146).

A few year-to-year age-specific mortality rates for a particular age-class deviate from the mean age-specific mortality rates over the years for that age-class. This is not unexpected by chance alone (there are 104 presently fixed age-specific mortality rates). Furthermore, there is no a priori reason to assume that age-specific mortality rates would vary over the 17 respectively 6 years of the two cohorts, unless zoo management in all collections has changed in a similar direction over those periods.

Age-specific maternity varies greatly from age-to-age within a particular year-cohort and from year-cohort to year-cohort for a particular age-class. The great majority of age-specific maternity values does not deviate from the average, basicly due to the large variances involved.

We nevertheless consider the life-tables as essentially meaningful age-specific life-tables which are sufficiently realistic to generate working-hypothesis.

7.2 SURVIVAL AND MORTALITY

The facts that:

1. each of the presently fixed sections of the survivorship curves seems to fit excellently to the model's assumption of linearity on a semi-logarithmic base;

and

2. within a (sub-)cohort age-specific mortality rates seem not to change with age,

both indicate that age-specific survival rate in the two samples of captive American Bali Starlings is essentially constant. Survival rate is independent of age for (probably at least) the first 6 to 10 years of captive life. Further, as the sub-cohorts of inbred birds have constant survival rates too, this *constancy* seems not to be affected by inbreeding.

After the first year of life, <u>outbred</u> captive Bali Starlings seem to have a constant survival rate of circa 0.79 to 0.94 (average 0.89) per year for the next 5 to 9 years of their life.
The corresponding ranges for <u>inbred</u> birds are:

* *0.77-0.97(-1.00), on average 0.87, for birds with F=0.250 (respectively F_{mean}=0.245);*
* *(0.50-)0.73-0.95(-1.00), on average 0.85, for birds with F=0.375 (respectively F_{mean}=0.368).*

Yearly survival rates of 0.8 to 0.9 are found in some wild tropical birds (BEZZEL 1977). Fourteen species of wild South-east Asian sturnids show a collective annual survival rate of 0.54 (McCLURE 1974). On average captive Bali Starlings seem to fare better than wild South-east Asian starlings; an expected and widely observed effect of captivity (BEZZEL 1977, MEAD 1985) due to the absence of most of the natural selection forces operating in the wild.

In general wild birds of over one year old have a constant annual survival rate (BEZZEL 1977, DESHMUKH 1986, MEAD 1985, PERRINS & BIRKHEAD 1983). In wild tropical birds, annual survival rate often even increases somewhat at older ages (DESHMUKH 1986), though it tends to decrease at older age in captive bird (BEZZEL 1977).

An increase or decrease of survival rate in captive Bali Starlings at older ages (probably over 15 to 18 years) can not yet be evaluated before all the birds of -at least- the 1971-78 cohort have died. Note that at least four wild-caught Bali Starlings survived a minimum of nearly 20 years in captivity!

Survival rates for Bali Starlings of less than one year old, which were excluded in the above discussion, are unrealistically high: more than 0.93 in outbred birds. Normally first-year survival in both wild and captive birds is (much) lower than at later ages (BEZZEL 1977, PERRINS & BIRKHEAD 1985, MEAD 1985, DESHMUKH 1986).

Apparently, in particular birth and death of nest-young is not (yet) sufficiently registered.
It is known that the English/European captive population of Bali Starlings suffers a high infant mortality at 5-7 days (MACE & JEGGO 1988). However, a similar problem can not be detected in the American captive population, possibly because infant mortality is insufficiently registred.

Other data, not recorded in the Bali Starling Regional Studbook USA (6 November 1987) but indispensable for a thorough analysis of survival in the first year, are clutch-size, number of clutches, number of eggs hatched and number of young fledged. This analysis is accordingly of limited value only.

Only female birds (both all females and outbred females only) show a significant positive correlation between age (x) and mortality rate (qx), but the associated regression coefficients do not statistically significant differ from zero. Many young birds die before being sexed (and are not sexed because they died before breeding). With time the proportion of unsexed birds decreases. Therefor amongst sexed birds, females in this case, survival rate at younger ages will be seemingly higher compared to all birds (sexed and unsexed). This in turn will cause seemingly higher survival rates for the younger age-classes, relative to survival rates of the older age-classes, although the latter do not differ from all birds. If this line of reasoning is correct, then a positive correlation between age and age-specific mortality rate may be expected.

We think it is not permitted to conclude that -in reality- survival rate amongst captive female Bali Starlings is correlated with age; the observed correlation is more likely an administrative artifact.

7.3 INBREEDING DEPRESSION ON SURVIVAL

7.3.1 OVERALL SURVIVORSHIP

Differential overall survivorship of birds of different inbreeding level is not observed in the two samples analyzed here; the trends observed are not consistent between the two cohorts, moreover, the trend in the 1971-78 cohort is not consistent with the population-genetic model (lower overall survivorship for more inbred birds).

It seems that either inbreeding in this species is not associated with an inbreeding depression, or overall survivorship is not a sensitive enough measure to detect the differential impact of increasing inbreeding levels (possibly because of insufficient sample sizes for inbred birds, i.e. less than 150 individuals), or the supposed accompanying inbreeding depression is mild.

It should be noted that overall survivorship *regression* curves (on which the above conclusions are based) are an aggregate measure over all birds and over time, which may explain the insensitivity of this measure.

7.3.2 SURVIVAL TO A PARTICULAR AGE-CLASS ($v_{x,i}$)

Probability to survive to a particular age-class, or the derived viability parameter, $v_{x,i}$, is an aggregate measure over *surviving* birds only and over time *up to age x*, not over all ages. This, together with the different statistical method (small sample correction; *weighed* linear regression) may explain the greater sensitivity of this measure to differential effects of inbreeding.

At any rate, in both samples the observed probability to survive to a particular age-class decreases significantly with increasing inbreeding level.
Inbred Bali Starlings have lower probabilities to survive to a particular age-class compared to outbred birds.

> *Inbred Bali Starlings live significantly shorter than outbred birds; they have less opportunity to produce young than outbred birds. It can be expected that -ceterus paribus- their life-time reproductive output is less than that of outbred birds.*

The number of lethal equivalents per individual up to any age between 0 and 10 years (a measure for the expression of (sub)lethal alleles in the offspring of related parents) ranges from circa 0.64 to circa 2.16 in American captive Bali Starlings (*cf* Table 4).

Six *Drosophila* species had between 0.44 and 2.16 lethal equivalents per individual from egg-to-adult; A French rural population of humans showed 4.74 lethal equivalents from conception-to-birth (several authors in METTLER & GREGG 1969) while several highly outbred French human populations showed 3.0 to 5.0 lethal equivalents (TEMPLETON & READ 1983). The average number of lethal equivalents in 10 Japanese human populations was 1.34 lethal equivalents per person; four species of fowl revealed 2.16 to 7.48 lethal equivalents per animal. A population of European Bison (Wisent) initially had circa 6 lethal equivalents per animal, which was reduced to 1.34 (not statistically different from zero) in a few generations of intense inbreeding (several authors in SOULÉ & WILCOX 1980). Life-time average number of lethal equivalents in human populations ranges from 5 to 8 (in TEMPLETON & READ 1983), while the Speke's Gazelle possessed 6.18 l.e./ind. from birth-to-30-days and 8.02 l.e./ind. from birth-to-one-year. The Speke's Gazelle is considered to suffer a *severe* inbreeding depression (TEMPLETON & READ 1983).

Thus, for a wide range of species and ages the average number of lethal equivalents is found to vary from (0-)1.34 to 8.0, and the results for the American captive population of Bali Starlings (0.64-2.16) seem to compare favourably.

It should be noted that eventually, the calculated number of lethal equivalents depends on the computed values of the individual inbreeding coefficients, compiled from the Bali Starling Regional Studbook USA. These in turn are values relative to the base population, which in this study is defined as the group of wild-caught birds and the birds from unknown origin; these birds are assumed to be unrelated and outbred.

As a result the number of lethal equivalents per bird is a *relative measure* itself, and more realistically should be considered reflecting the *progress of inbreeding since the foundation* of the captive population. The captive population is founded no more than at most 6-7 generations ago.

Alternatively, the moderately low values found here may indicate that the original wild population in Bali has experienced prolonged inbreeding, and has (may have) adapted to this reproduction strategy (TEMPLETON & READ 1983:243), possibly due to sustained or chronic low population levels in the past. Inbreeding in natural populations occurs more frequent than often assumed and many natural mating systems promote inbreeding (SELANDER 1983, RALLS, HARVEY & LYLES 1983).
In that case the wild population may have been largely ´purged´ (*cf* FRANKLE & SOULE 1981:68-69) from its (sub-)lethal alleles, explaining the low values of lethal equivalents in the American captive population. Similar effects have been found in domesticated animals, notably gallinaceous birds (SOSSINKA 1982).

> *Whatever the underlying causal mechanism may be, inbreeding in captive Bali Starlings is definitely accompanied by an inbreeding depression on survival, and must be avoided, most particularly in the captive propagation group in the Captive Propagation Center at Surabaya. Introduction of inbred or related Bali Starlings into the wild may very well depress the average survival rate of the mixed wild-captive population.*

Due to inbreeding´s trend to homozygosity, inbred birds ´loose´ their (sub-)lethal alleles more rapid than outbred birds. A preliminary analysis (data not given here) may indicate that as of age 3 most inbred birds are ´purged´ from their (sub-)lethal alleles, while that takes some 5-6 years in outbreds.

7.3.3 LIFE-EXPECTANCY AND LONGEVITY

Although the *absolute* values of age-specific life-expectancies given in this study are only preliminary approximations of the eventual values (when all birds in the two samples have died), they are more more or less comparable between (sub-)cohorts.

From Appendixes 2-4 it can be seen that life-expectancy at birth is higher for *outbred* Bali Starlings (6.9 years) than for *inbred* birds (*circa* 5.5 years). The magnitude of this reduction (20%) seems large enough to be considered indicative for a real depression of life-expectancy once the last birds have died.

It is known that wild-caught Bali Starlings (assumed to be outbred) have survived in captivity for at least 20 years, in one case possibly even 26 years.
On 6 November 1987 many (27%) outbred birds born in the years 1971-1978 were still alive, the oldest birds being 17 years old, while only 17% respectively 21% of inbred birds with F=0.250 respectively F=0.375 were still alive, the oldest birds being 14 years respectively 12 years old.

> ***In accordance with the above observed reduced probability to survive to a particular age-class, inbreeding is likely to depress the average life-span and longevity.***

7.4 INBREEDING DEPRESSION ON REPRODUCTION

7.4.1 OFFSPRING PER FEMALE

Results show that inbred female Bali Starlings *if breeding at all* produce less than one-third to one-half of the life-time production of outbred females, and probably cease to replace themselves as of inbreeding levels of 0.4 and more.

Reduced survival of inbred females can only partly explain this decline in number of young as most young are produced at less than 5 year's age.

As only females that have actually bred are included for this analysis, preferential restriction from breeding of inbred females by the Zoo's can not be a factor explaining the depression.

Additionally proportionally fewer inbred females come to breed at all, but this may very well be an effect of alert zoo management.
Nevertheless three effects combine to reduce the *average* life-time reproductive 'output' of inbred females (irrespective whether a particular inbred female has bred or not) to approximately one-fifth of that of outbred females :

- reduced life-span;
- reduced reproductive potential;
- reduced breeding attempts.

> ***Clearly this strongly lessens the value of inbred (female) Bali Starlings for a Captive Propagation Program, where apart from 'quality' also the quantitative aspects must be considered, if not for efficiency reasons, than for its impact on the wild population after re-introduction.***

7.4 .2 REPRODUCTIVE VALUE

Inbred (female) birds have lower age-specific reproductive values when compared to outbred (female) birds.

However, reproductive value is only a ratio, measuring estimated average future reproduction relative to that of newborns.

Inbred newborns have a lower estimated average future reproduction, *viz.* the average life-time production of young mentioned in the previous section, than outbred birds. Thus the *absolute differences* in estimated average future reproduction between outbreds and inbreds is larger than the corresponding age-specific reproductive values indicate.

Females of (3-)5-7 years old are of relative more importantance than other age-classes in a captive propagation program, because they are expected to produce more young. We have not analyzed whether young hatched by elder females have reduced survival or reproduction. If that is the case, then the greater ´production´ in this generation is offset by reduced ´production´ in later generations. Preliminary it seems advisable to cherish this age-group in order to increase the CPP´s output.

7.5 GROWTH AND OTHER POPULATION DEMOGRAPHIC PARAMETERS

7.5.1 NET REPRODUCTIVE RATE AND POPULATION GROWTH RATE

The net reproductive rate (R_0) or the multiplication rate per *generation time* in terms of female offspring per female, is considerably reduced in inbred Bali Starlings to approximately only 20% of the rate in outbred females.

Correspondingly, although the finite growth rate for a completely inbred population can not (yet) be meaningfully calculated, finite growth rate of a purely outbred population is higher than for a mixed population. The mixed population (35% inbred females, 65% outbreds) grows on average 11% per year, a purely outbred population 18% per year. The reduction being due to the minority of inbreds, it seems likely that the finite growth rate of purely inbred population is less than 1 and thus the population will decline.

It seems less efficient to import inbred Bali Starlings into Indonesia to be propagated in the CPC. Although inbreds still may produce young (but less likely so), at the same costs an outbred bird would increase the CPC´s ´production´. However, inbred birds that already proved to have bred are still useful in the Program; their proven breeding ability could offset the risk that an outbred bird will not breed at all or only after several years.

7.5.2 EFFECTIVE POPULATION SIZE

Obviously the most serious reduction of the total population size is caused by the simple fact that more than 61% of the birds never produced progeny and thus do not contribute to the genetic variation of future generations.

Additionally the genetic variation of *actually reproducing* birds is further reduced by some 35% due to over-representation of the progeny of a few 'breed-happy' pairs.

The British/European Bali Starling captive population experiences the same problem. Recently it is decided to give priority to stimulating more birds to breed at all (MACE & JEGGO 1988).

In general, culling to even family-size distribution seems less efficient than stimulating more pairs to breed. However, in the Captive Propagation Program care should be taken not to release too many young of a few 'breed-happy' pairs for the sake of quickly boosting the wild population. Culling of excess birds is not recommended, for they can be used for other purposes (exhibition, propagation to develop a self-sustaining Indonesian captive population, flooding of the market).

As could be expected, un-equal sex-ratio hardly reduces genetic variation in the next generation. In the CPP one can freely re-mate birds, irrespective of sex-ratio.

7.6 SENSITIVITY OF FINITE GROWTH RATE TO MANIPULATIONS

Outbred female Bali Starlings respond beter, in terms of increased production of young, to manipulations of both survival rate and fertility, than inbred birds. Up to about the age of 8 years female Bali Starlings respond better to manipulations of survival rate than to changes in fertility. Manipulations of both survival rate and fertility yield greatest effect, in terms of an increment population growth rate, for ages up to 4-5 years.

For the propagation group it is therefor probably most rewarding to concentrate on enhanced survival rate of outbred birds up to the age of 5 years, rather than to attempt to improve fertility. This is probably all the more true because all birds presently comprising the propagation group are proven breeders (but actually propagate birds of 3 years and older).

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BALI MYNAH

The highlight of the past 12 month's events undoubtedly occurred in April, when Species Coordinator Bob Seibels and Propagation Group member Kevin Bell travelled to Indonesia for a 2-week visit. The purpose of the trip was to access the status of the reintroduction project and to meet with officials of the various sponsoring agencies and the Indonesian government. The first meetings, held at Surabaya in central Java, were with officials of the International Council for Bird Preservation (ICBP). We attempted to define broad areas of responsibility for our 2 organizations, with the following result: the AAZPA is now primarily responsible for the captive management decisions made at the propagation center of the Surabaya Zoo. Alternately, ICBP will be responsible primarily for that portion of the project which deals with reintroduction and management of the wild population.

A new Project Officer was also approved: Bastian van Balen. He is an accomplished field ornithologist, speaks Indonesian, and has lived on Java and Bali for a number of years.

Next, we met with various staff members of the Surabaya Zoo. Following an in-depth tour of the propagation facilities, a number of recommendations were made to try to increase the numbers of birds produced for the release program. We were delighted to learn that 8 juveniles had been produced from the U.S.-bred stock shipped over in November 1987. These birds were, in fact, ready to be transported to the Pre-Release Training Center within Bali Barat National Park.

After winding up our discussions in Surabaya, we crated the birds, rented a van, and drove to the eastern tip of Java where we took a ferry across the Bali Straits to Bali Barat National Park. Unfortunately, we experienced a major disappointment at this stage of the trip: we discovered that the poaching situation within the park boundaries was not under control. Everyone from both ICBP and AAZPA agreed that no birds would be released from the Pre-release Training Center until the poaching problem could be remedied.

The remainder of our trip was spent securing commitments from various Indonesian government officials to take strong action against this major threat to the entire project. Reports from Project officer van Balen, over the next several months will, we hope, indicate progress on this front.

Several changes in communications procedures have been implemented since our trip, all of them aimed at providing more current information on the project to those of us in the U.S.

On the domestic side, the pairings recommended by the Masterplan are beginning to produce some offspring, at last. However, the total number of specimens maintained in the Studbook has fallen again:

1988 - 422 (172.168.82)
1989 - 390 (167.64.59)

The number of founders has declined from 13 in 1988 to only 9 in 1989. Most of these are approaching 20 years of age and are post-reproductive. We are currently seeking to bring in new founders, both from the United Kingdom population and possibly Europe.

Propagation Group

Bob Seibels, Riverbanks Zoo - Species Coordinator

Fred Beall, Baltimore Zoo (90)
Kevin Bell, Lincoln Park Zoo (92)
Bruce Bohmke, St. Louis Zoo (92)
Don Bruning, New York Zool. Park (91)
Mary Healy, San Antonio Zoo (91)
Pam Osten, Dallas Zoo (92)
Art Risser, San Diego Zoo & WAP (90)
Larry Shelton, Houston Zoo (91)
Greg Toffic, Woodland Park Zoo (90)

(B. Seibels)

BALI MYNAH

Since the open meeting of the Bali Mynah SSP Committee last September at the 1985 AAZPA Annual Conference in Columbus, Ohio, the Committee has focused upon 3 major objectives: 1) development through the International Council for Bird Protection (ICBP) of a cooperative captive breeding program with the Indonesian Forest and Nature Conservation Service (PHPA) at a location on Bali or Java; 2) simplification of the Bali Mynah Studbook through separation of birds into subgroups of known heritage and of unknown heritage ("Brand X"); 3) development of a protocol by the American Federation of Aviculture (AFA) through which responsible private aviculturists could obtain "Brand X" birds for propagation, thereby freeing valuable zoo space for known-heritage birds.

In connection with the ICBP proposal, 2 meetings have been held. On 28 October 1985, WCMC Chairman Don Bruning and Bali Mynah Species Coordinator Larry Shelton met with ICBP Director Christoph Imboden at the Bronx Zoo. The ICBP proposal was modified to better suit the objectives of the Bali Mynah Propagation Group. For example, Imboden agreed that AAZPA members were better qualified to judge the avicultural aspects of any Bali mynah conservation project than a field biologist like Bastiaan van Helvoort, who had prepared the ICBP report. Imboden also conceded that U.S.-bred Bali mynahs were not so genetically removed from the wild stock as to be unsuitable for a captive propagation program in Indonesia. The final ICBP proposal is ticketed at $17,000 or more. Of that sum, ICBP would provide $5,000; World Wildlife Fund-Indonesia, $1,500 and AAZPA institutions, or other organizations, the rest. To date, the Bronx Zoo has contributed $5,000; Brookfield Zoo, $3,000; Philadelphia Zoo, $2,000; San Diego Zoo, $1,000.

The 2nd meeting occurred on 15 January 1986 at the Bronx Zoo, and consisted of Bruning, Shelton, Studbook Keeeper Robert Seibels and van Helvoort (the ICBP field researcher on the Indonesian project). The meeting was most productive, and it opened channels for better communications.

Van Helvoort arrived in Indonesia in late February and was slated to finish his work there by the end of July. His reports have not been encouraging on the status of the Bali mynah in the wild. Since he had left Indonesia in October 1984, the wild population in Bali Barat National Park had been heavily poached. He estimates only 60 birds are left, or only half of his 1984 estimate. This was, ironically, due to increased staffing of the park; the experienced wardens were given desk jobs, and the new field team was no match for the local bird trappers. In 1984, nest boxes had been placed in the park because of a shortage of suitable nesting sites for the cavity-nesting mynah. However, there were no indications that the boxes had been utilized by the mynahs.

The Surabaya Zoo is van Helvoort's recommendation for the location of a captive propagation center for the Bali mynah in Indonesia. The zoo has a battery of aviaries which could be modified to make them more suitable as breeding facilities. Van Helvoort has asked the General Curator to prepare an estimate of costs for the suggested alterations. The zoo does have experience in breeding the species.

Van Helvoort deemed Nusa Penida, an island once mentioned as a possible release site for an experimental population of captive-bred mynahs, to be totally unsuitable for this purpose because of density of human population and lack of suitable habitat. He suggests that Balkuran National Park in east Java might be a suitable alternative. The park has adequate and suitable habitat, and poaching does not seem to be a problem within the park.

A Memorandum of Agreement for the Bali Mynah Project in Indonesia involving Indonesia (PHPA), ICBP, AAZPA, and the Jersey Wildlife Preservation Trust has been drawn up for signing. However, since no one representing AAZPA was able to attend a 24 July meeting in Indonesia for discussion and signing of the agreement, there is time for further analysis and discussion of the document.

l'Alliance mondiale pour la nature
The World Conservation Union

Secrétariat de l'UICN
IUCN Headquarters

Dr Ulysses S. Seal
c/o Minnesota Zoo
12101 Johnny Cake Ridge Road
Apple Valley, MN. 55124
U.S.A.

Gland, 28 September 1989 SSG/B1-2

Dear Ulie,

Thanks for your FAX on the grim future facing the Bali Mynah. I must admit that I read it with a feeling of alarm, but also considerable frustration. My frustration is not directed at you, but is rather exasperation at yet another conservation initiative that is has not yet addressed the root cause of the problem. And in this case, the problem is quite simple: the demand for Bali Mynahs by aviculturalists is simply too high, and it is totally unrealistic to expect a poor country like Indonesia to be able to protect this (and many other species) in the wild unless the problem of excessive demand is addressed. This is exactly the problem with many species of parrot. Experience tells us that once a species in a poor country gains a high commercial value, traditional conservation approaches are unlikely to be effective in preventing extinction.

I think that the five points you have put forward to save the species are fine and I support them fully, but another needs to be added as follows:

"6) Birds in captivity that are surplus to the genetic requirements of the managed captive population should be sold to aviculturalists; the justification for this is that the captive stock, and not the wild population, should become the chief source of birds for private owners. The long-term aim would be that aviculturalists should hold a self-sustaining population of this species, thus eliminating the demand for wild birds and allowing the PHPA to conserve the species more economically."

If I remember rightly, most of the wild birds being taken today are going to Indonesian owners. This suggests that Indonesians should be the first target market for surplus captive birds. I hope this is helful. With best wishes,

Yours sincerely,

Simon N. Stuart
Species Programme Officer
Species Survival Commission

cc: M. Rands w/incoming, J. Mallinson w/incoming

Avenue du Mont-Blanc, CH-1196 Gland, Suisse/Switzerland

CONSERVATION MANAGEMENT OF THE BALI MYNAH
Leucopsar rothschildi in Indonesia

Reintroduction into the wild

Project period: December 1989 - December 1990

Supervisors: PHPA (Department of Forest Protection and Nature Conservation), Government of Indonesia

ICBP (International Council for Bird Preservation), UK

AAZPA (American Association of Zoological Parks and Aquariums), USA

JWPT (Jersey Wildlife Preservation Trust), Jersey

Funding required: $19,780

ABSTRACT

In 1987, PHPA, ICBP and AAZPA launched a five-year programme to conserve the Bali Mynah. The programme has two basic objectives: (1) to conserve the wild population in Bali, and (2) to establish a captive-breeding population in Indonesia with a view to reintroducing birds into the wild in Bali. The project has had many notable successes since 1987 and a captive-bred population is being held on Bali and plans are being drawn up to release these birds into the Bali Barat National Park. This proposal has been prepared to seek funding for the reintroduction component of the programme.

INTRODUCTION

The Bali Mynah *Leucopsar rothschildi*, a beautiful white-and-black bird with a long white crest and blue facial skin, is the only endemic bird species on the island of Bali (Indonesia). It is threatened with immediate extinction in the wild, mainly due to the poaching of birds for the domestic cage-bird trade. In 1984, the wild population was estimated to be between 125 and 180 birds, but by 1988 the population was possibly as low as 35 birds. In contrast, there is a considerable captive population in the world's zoos, and it breeds readily in captivity if suitable facilities are provided.

In 1987, the International Council for Bird Preservation (ICBP), American Association of Zoological Parks and Aquariums (AAZPA) and Jersey Wildlife Preservation Trust (JWPT), in collaboration with the Indonesian Government, launched a five-year programme to conserve the wild population on Bali and establish a captive-breeding programme in Indonesia with a view to reintroduction.

RESULTS: JULY 1987 to JULY 1989

The main results during this two-year period are the following:

1. Monitoring of the remaining wild population

   Annual censuses were carried out in 1987 and 1988. The censuses involved simultaneous counts at dawn and dusk at all known roosts. The censuses involved over a quarter of all National Park personnel and served to motivate the staff as well as provide training in the field. The preparation for and implementation of the censuses also helped to deter (and gather information on) poaching activities. The censuses have determined that the wild population is declining by 25 per cent per year and in 1988 it was possibly as low as 35 birds.

2. Establishing a Captive Propagation Centre in Java

   In the autumn of 1987, 39 birds from American zoos and four birds from Jersey were flown to Indonesia. These birds are now breeding successfully at Surabaya Zoological Park, East Java, about 200 km west of Bali. AAZPA and JWPT have regularly provided advice on husbandry and veterinary techniques to the Zoological Park's staff. Furthermore, the Park's supervisor has attended training courses in Jersey and visited several American zoos, and now has a thorough understanding of the practise and theory of the captive propagation of birds.

3. Establishing a Pre-release Training Centre in Bali

   A Pre-release Training Centre has been built in the Bali Barat National Park where young birds, captive-bred at Surabaya Zoological Park, are being held prior to their release into the wild. Currently, seven young birds are being held and will be reintroduced at the onset of the rainy season (late 1989/early 1990). Further birds will be transferred to the Pre-release Training Centre in Bali from the Captive Propagation Centre when they are available.

4. Organising a Public Education Campaign

   Undoubtedly the greatest threat to the Bali Mynah is the continued trapping, by highly organised gangs of criminals, for the Indonesian cage-bird trade. The project has sought to turn public opinion and the law enforcement authorities against these gangs by organising a public-awareness campaign which has highlighted the threats to this unique and beautiful species. The campaign which has required talks and utilised posters, stickers and sign boards culminated in July 1989 in a Project Introduction Day. This was organised for the local police officers, members of the local government, army personnel and teachers, etc., and opened new paths to cooperation.

REINTRODUCTION INTO THE WILD

The captive-bred population is being held at the Pre-release Training Centre in the Bali Barat National Park and plans are now being drawn-up to reintroduce birds into the wild. The following activities will need to be undertaken as part of the reintroduction project:

1. Control of poaching

   Poaching would be the most serious threat to the reintroduced population. Gangs of poachers continue to operate in the Park and take wild birds for the cage-bird trade. There is therefore little point in releasing birds until this illegal activity has been brought under control. The Bali Starling Project Officer will aim to:

- monitor the wild population and ensure regular surveillance of the Mynah's roosting trees;
- close-off the core-area of the Park to visitors and closely monitor the economic activities of the local people;
- establish a better patrolling system involving the Park wardens and lobby on their behalf for better equipment and facilities; and
- liaise closely with the Director of the National Park, local police officers and government officials to ensure that a greater priority is given to catching the poachers and prosecuting them if caught.

Clearly these activities are also essential to the survival of the remaining wild population.

2. Preparation of the birds for reintroduction

The captive-bred population of Bali Mynahs at the Pre-release Training Centre will need to be carefully introduced to conditions in the wild. The Bali Starling Project Officer will:

- maintain the security of the Pre-release Training Centre which is vulnerable to poachers;
- train the captive-bred birds to look for their own food and water;
- reduce to an absolute minimum all contact with humans; and
- ensure that the captive-bred birds are healthy and not carrying infections potentially dangerous to the remaining wild population.

3. Monitoring the reintroduced population

Once released, the captive-bred birds will need to be monitored closely. The Bali Mynah Project Officer will:

- colour-ring all the captive-bred birds in a way that is clearly visible in the field;
- maintain a permanent presence in the field to monitor the progress of the reintroduction and guard against poachers; and
- bring back into captivity any birds which fail to adapt to the conditions in the wild.

OUTPUTS

A report will be prepared in 1990 which will analyse the results of the reintroduction of the captive-bred birds.

BUDGET (12 months 1989-1990)

	US$
Salary of Project Officer	10,500
Salary of Project Counterpart (PHPA Officer)	1,800
Field Assistants	1,440
Operation costs of the Pre-release Training Centre	1,380
Local travel	1,080
Field equipment (boat, ringing equipment, tents, etc.)	1,000
Project administration (*c.* 15%)	2,580
Total	$19,780

Guidelines for TNBB Display Cage

At the PVA workshop on Bali starlings, the AAZPA representatives were asked to make recommendations on cage design for an exhibit at Taman National Bali Barat. It was the consensus of opinion that this exhibit should appear as natural as possible. Public viewing should be limited and discreet to avoid disturbing the birds. Visitors should feel as if they are seeing the birds in the wild. To accomplish this we would suggest the following:

1. Public viewing should be limited to several simulated bird blinds (or one large blind with several viewing areas), which provide privacy for the birds. Dense shrubery should be planted to direct the public to these blinds and limit access to other areas of the exhibit.

2. The exhibit should be of sufficient height and width to allow ample flight space for the birds. We suggest minimum dimensions be 12m long by 4m high and 5m deep.

3. The wire mesh should be small enough to prevent predators from entering the cage (suggested size 2.1cm square openings). The gauge should be fairly light so that it will not appear as a major obstruction to the public. All wire mesh should be attached to a concrete curb that extends at least 50cm underground.

4. The exhibit should be heavily planted with species common to the national park area.

5. Graphics should explain all aspects of the mynah's natural history. The reintroduction project should be discussed along with information on where contributions can be sent.

6. The exhibit should be kept secure at all times.

7. Since this exhibit is primarily a display and not a breeding facility, it should house a minimum of three to five birds.

8. A small service building to be used for food preparation, storage, record keeping and security should be located near the display cage.

Recommendations for Pre-release Training Cages for Bali Starling

The primary purpose of a pre-release training cage is to prepare young Bali starlings for future release. To increase the probability of a successful release, the PTC should accomplish the following functions:

1. Insure the best possible health for the birds prior to release.

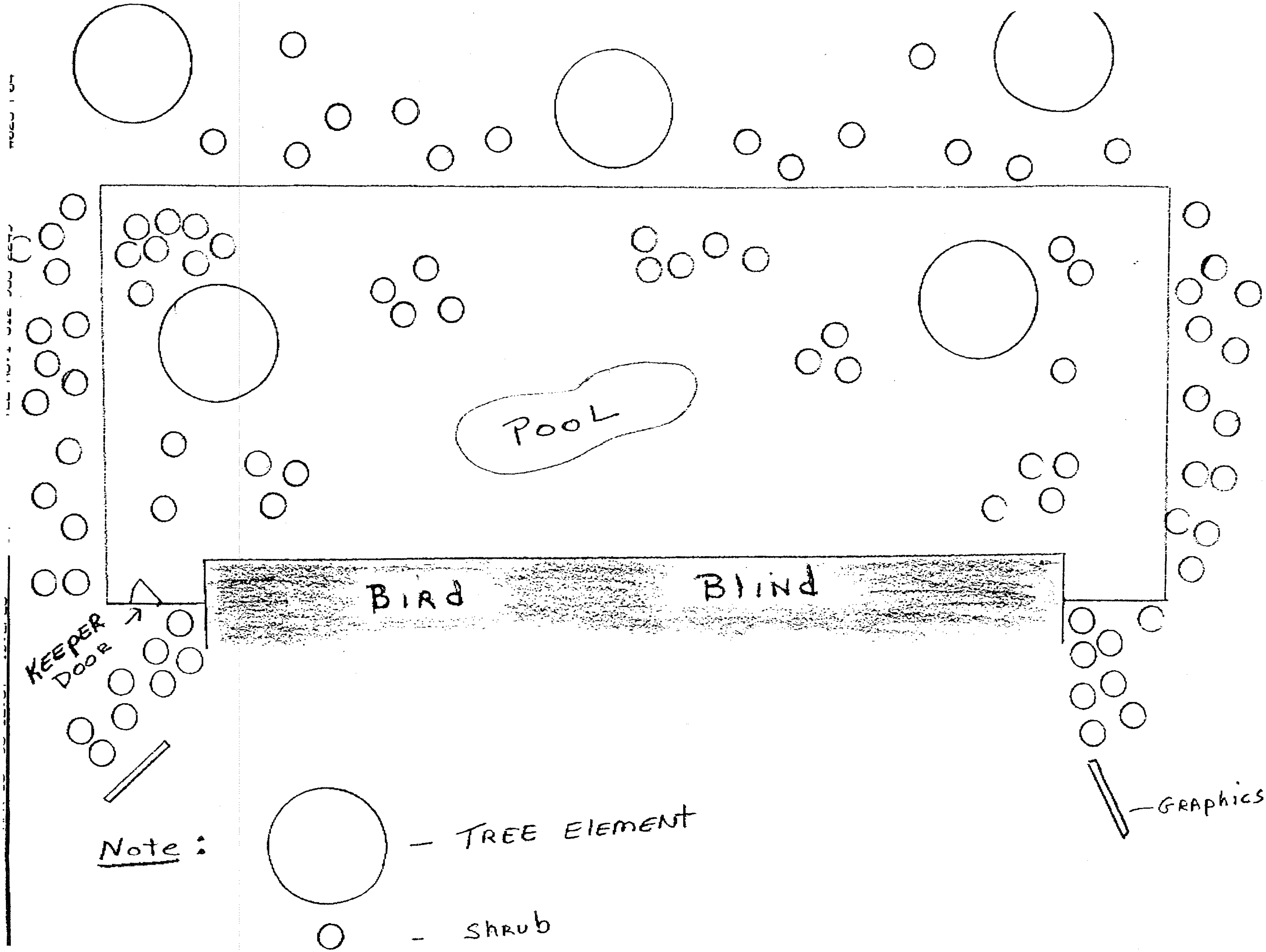
2. Provide ample space for flight to aid in the development of flight muscles.

3. Provide privacy and limited human contact.

4. Provide a natural diet that approximates what the birds will eat once they are released.

5. Have the capacity to hold 12 birds as a group.

To achieve the above, future PTCs should be constructed in a similar manner as the existing PTC at TNBB with one major exception: the outdoor flights should not be subdivided and should not be less than 12m. long. As with the existing PTC, wire mesh should have openings not more than 2.1cm. The mesh should be secured to a concrete curb to protect against predators. This facility must be located in a secure area with limited public access. To insure the birds privacy, the entire facility should be surrounded with dense vegetation.


POOL
Bird Blind
KEEPER DOOR
GRAPhics
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TREE ElEMENT
ShRub

March 13, 1990

TELEMETRIC MONITORING OF BALI MYNAHS

practical considerations, planned application, and logistics

prepared by Susan B. Elbin
Identification Specialist, NYZS, Bronx Zoo, NY

Purpose: to attach radio transmitters on captive-bred Bali Mynahs being reintroduced into their native habitat in Bali in order to assess survivorship within the first 2 weeks after release.

Considerations:

1. Animal size and transmitter package size. Smaller birds can support relatively heavier transmitter packages than can larger birds. However, it would be best to be as conservative as possible when fitting the mynahs with their transmitters. Transmitter size is a compromise between light weight and small size for aerodynamic and behavioral considerations and heavier weight of larger size for stronger transmission potential. The rule of thumb for passerine transmitter packages is to keep within 3-6% of the animal's body mass. A Bali Mynah weighing 65g could support a transmitter weighing 1.9 to 3.9 g. The transmitter package includes transmitter, battery, antenna, and material for attachment. The method and location of attachment may place additional weight constraints on the package.

2. Range of transmission. The greatest distance a radio-tagged animal will travel during the time between tracking periods dictate the power the transmitter must produce. The target release site is a park spanning 10 km.

3. Environmental conditions. The substrate and habitat features (hills, tress, buildings, soil type. etc) as well as the meteorological conditions (rain, humidity) can affect signals from the transmitter. Transmitter power may need to be adjusted accordingly. The target site is composed of hills and a major plateau. The soil is volcanic and the vegetation ranges from grass to dense forest.

4. Attachment method. There are many different ways to mount a transmitter on a bird: back-pack, necklace, poncho, leg mount, tail mount. The best placement for the Bali Mynah tracking project is a tail mount (weighing 3% of the bird's body mass, or approximately 2g). The transmitter will be molted with the feathers and can then be retrieved. We will be experimenting with different methods of attachment in our captive collection of 7 individuals: sewing, gluing, or taping the transmitters onto 1 or 2 retrices.

5. Field-testing the transmitters. We will fit our captive birds with transmitters in order to test the effect of the weight and placement on the birds behavior (especially flight and preening behavior).

6. Cost of basic equipment. The equipment needed for a basic location monitoring project of Bali Mynahs is listed below.

Estimated cost is based on the current price list published by Wildlife Materials, Carbondale, IL, and Telonics, Mesa, AZ. Exact specifications of the equipment (i.e. voltage, current, assignment of frequencies) will be determined in conjunction with the supplier at the time of purchase.

	WMI	TELONICS
Receiver(TRX-1000S)	$650	$1,475
Receiver carrying case	42	(incl)
Lid-mounted DC power pack	40	115
Receiver antenna (49-220MHZ range)	94	127
Headset	151	145
Transmitter(s) and transmitter antenna and battery for transmitter	120	not available
Attachment materials	(approx $20)	
Total Range	$1117	- 2002

Total price range for 2 receiver-antenna set-ups, 5 transmitters: $2554 - $4344

Additional Considerations:
The equipment list is dependent upon the goals of the monitoring project. If the goal is a short-term, one-time tracking of newly-released birds, we would need to supply 2 receivers and portable receiver antennas (and the field researcher(s)). If the study is to be expanded to monitor habitat use, distribution of birds, and long-term monitoring of individuals, we would need to provide 3 sets of receiver-antenna equipment (one to use, one in reserve, and one being repaired). We would need to train the local people in the use of radio telemetry techniques and interpretation of data. **Equipment cost could be minimized by borrowing one set of equipment from the soon-to-be-established Biotelemetry Unit of the Bronx Zoo.

Additional information needed:
Will there be a vehicle available for use in tracking?
Is it feasible to establish a base station on the plateau? These scenarios would require different types of antennas.
How many birds will be released?
When will they be released? during the non-breeding season The number of birds and the social unit (flock or pairs) will help us determine the number of radio-collared individuals we will need.

Susan Elbin is scheduled to visit the Migratory Bird Banding Laboratory in Laurel, MD, on the 2 of May 1990. The director of the research unit, Dr. Mark Fuller, is noted for his work in the use of telemetry in birds. Additional recommendations may be submitted as a result of that visit.

Operating voltage: 9.6 to 18 volts DC, 45 ma; no receiver functions affected by supply voltage variation from 9.6 to 18 volts

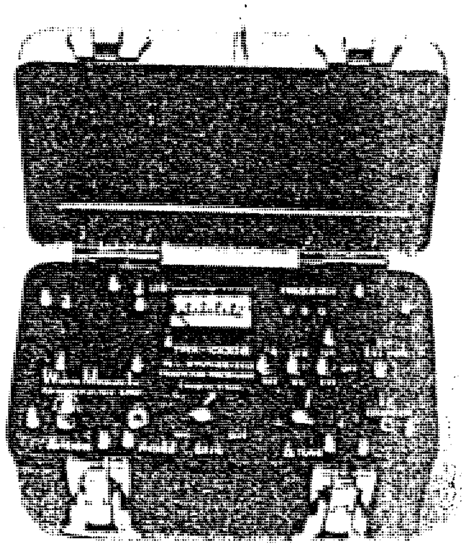
Battery pack: Rechargeable or non-rechargeable battery pack, accessible without removing receiver from case

Size and weight: 8" long x 5½" wide x 5" high; weight, 4 lb.

Fully guaranteed for 1 year after receipt against faulty workmanship and materials.

CAT. NO. B1a through B1d

TRX-1000S: This compact, state-of-the-art receiver weighs less than two pounds. Its weather resistant aluminum case is 7" long, 4" wide and 4¼" high. The receiver can be powered by an internal nicad battery which provides 6-8 hours tracking between charges, or by a DC power cord for a 12 V cigarette lighter. Its modern dual-conversion design features a crystal filter for single sideband signal reception. The noise-blanking circuit eliminates unwanted sound. High dynamic range circuitry makes the signal meter and flashing LED signal responsive to both strong and weak signals for precise direction location. For night tracking, the receiver has a signal meter backlight. A crystal-controlled synthesizer tunes in up to 200 different transmitter frequencies without interference. The receiver comes with a heavy leather carrying case which is convertible to shoulder strap or belt mounted use. The small size, advanced circuitry, and WMI's one year warranty for parts and labor make the TRX-1000S an exceptional value.



TRX-1000S Receiver tunes in up to 200 frequencies without interference.

Engineering Specifications

Noise figure (NF): 2.5 dB typical

Input impedance: 50 ohms +/-10%

Frequency range: Standard bands are 150-151 MHz, 150.8-151.8 MHz, 151-152 MHz, 160-161 MHz, 164-165 MHz, 216-217 MHz, 217-218 MHz and 218-219 MHz (other bands available on special request)

Frequency stability: +/- 1.0 KHz maximum (-20° to +70° C)

Image and spurious rejection: 60 dB or better

Minimum discernable signal: -150 dBm (.007 microvolts) or better

Circuit design: Modern dual conversion super hetrodyne circuit with 8-pole crystal filter and 40 dB AGC range

Manual gain range: 70 dB or better

Frequency readout: Digital, direct reading in 1 KHz steps; analog delta tune +/-3 KHz from center frequency

Frequency resetability: To +/-500 Hz

Signal metering: 0 to 1 scale meter with high dynamic range circuit and backlight for night tracking or LED indicator gives linear signal strength to brightness response for night-time use

Noise blanker: Removes most impulse and ignition noise to enhance tracking in difficult conditions

Operating voltage: 10 to 15 VDC through external DC jack (fused cigarette lighter cord enclosed) or internal 10-AA cell nicad pack gives 6 to 8 hours tracking

Size and weight: 7" long x 4" wide x 4½" high; weight, 2 lb. or less

Accessories: AC charger and DC external power cord, leather carrying case included

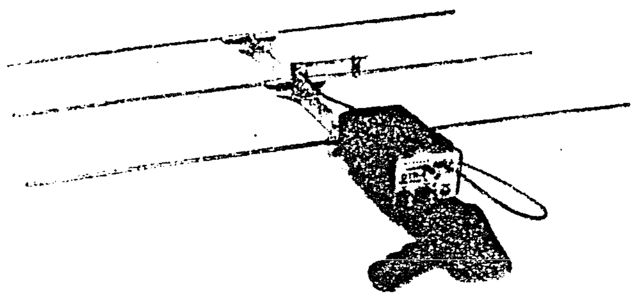
Warranty: One year on parts and labor

CAT. NO. B1e

Option

Lid-mounted DC power pack: allows the TRX-1000S Receiver operator to hunt for extended periods of time in remote areas, where house current may be

inaccessible. Installed in the aluminum receiver lid, 8 "AA" alkaline cells last 12-15 hours. As an auxiliary power source, these replaceable batteries offer convenience and freedom.
CAT NO. B1f



DTR-6 Receiver mounted on three-element directional folding antenna with pistol-grip handle

DTR-6: Our miniature receiver has been designed especially for falcon hunting, small research projects, and the tracking of 6 or fewer dogs. Its sensitivity, based on a Minimum Discernable Signal of -143 dBm to -145 dBm, is about 90% as good as the more expensive TRX-1000S. The receiver weighs one pound, and its dimensions include a 6" height, 3" length, and 2" width. The DTR-6 can be powered by 6 "AA" throw-away batteries or by a rechargeable nicad battery pack with 110-120 V recharge unit. The crystal-controlled design allows tracking of up to 6 transmitter frequencies simultaneously. Controls include on-off-volume, channel select and fine tune. An option is the flashing LED front panel, its brightness correlated with received signal strength. A leather carrying pouch with belt attachment, as well as a single earphone, accompany the receiver. It may also be mounted on a folding directional antenna with pistol-grip handle.

NOTE: LED option is listed on p. 40.

Engineering Specifications

Noise figure (NF): 3.5 dB typical

Input impedance: 50 ohms +/-10%

Frequency range: A variety of ranges includes 148 MHz, 150 MHz, 173 MHz, 216 MHz, 217 MHz, 222 MHz (other channels available on request)

Frequency Stability: +/-10 KHz maximum (-20° to +70° C)

Image and spurious rejection: 40 dB or better

Minimum discernable signal: -143 dBm minimum, -145 typical

Circuit design: Single conversion crystal-controlled channels with VFO fine tune

Manual gain range: 70 dB

Operating voltage: 6 "AA" replaceable batteries (regular batteries give approximately 12 hours of tracking time, alkaline batteries give 20 hours) OR rechargeable nicad batteries that come with 110-120 V recharge unit (6-8 hours of tracking from 18-24 recharge hours)

Size and weight: 6" x 3" x 2"; weight one pound

Accessories: Single earplug and leather case included

Warranty: One year on parts and labor

CAT. NO. B1g (with leather case and *without* rechargeable batteries)

CAT. NO. B1h (with leather case and *with* rechargeable batteries)

CAT. NO. B1i (with leather case, *with* rechargeable batteries and mounted on antenna with pistol-grip handle)

Accessories for Receivers

APS-164 Scanner: Lid-mounted attachment for Falcon Five Receiver to make its operation automatic and to provide digital read-out of pulse interval (0.160 to 9.999 seconds) to an accuracy of .001 seconds. The APS-164 has 64 memory cells which allow 64 different frequencies to be programmed into it and stored at one time. This procedure is as simple as dialing in the last three digits of the frequency and pressing "STO" button, then pressing the "ACT" button to activate channel. Scan speed is variable from 5 to 40 seconds per channel. Scanner may be used to automate system while tracking or may be interfaced with a strip-chart recorder to monitor animal activity or presence/absence at a given location. Size 8" x 5½" x 2¾" deep and replaces standard lid on Falcon Five Receiver. Guaranteed for 6 months from date of shipment against faulty workmanship and materials.
CAT. NO. B2a

antenna can be mounted permanently on a vehicle (Fig. 1 and 2), with a drilled hole through the cab for the crank shaft and antenna cable, the antenna is positioned over the center of the vehicle and the operator raises and lowers the antenna by turning a crank on the inside ceiling. OR, for temporary installation and easy removal, the antenna platform can be clamped to roof gutters (Fig. 3 and 4); the antenna cable goes through a window to the vehicle interior, and the antenna is positioned over the driver's window for easy access to operating crank.

Special features:

- Antenna raises fully, rotates in a complete circle, lowers easily.
- Unit is made of light-weight drawn aluminum, rust proof outside.
- BNC connectors attach coaxial cable to rooftop antenna and receiver.
- A receiver can be used from inside the vehicle.
- Rooftop rack stabilizes antenna when not in use.
- When raised, the 217 MHz antenna is 38 inches high.
- Guarantee of one year on parts and labor

CAT. NO. E1a Permanent Mount
CAT. NO. E1b Temporary Mount

TEMPORARY MOUNTING

Fig. 3: (at left) The 5-element antenna has been raised to its full height of 38 inches above the roof. The antenna cable fits through the front or back window for easy attachment to the handheld receiver.

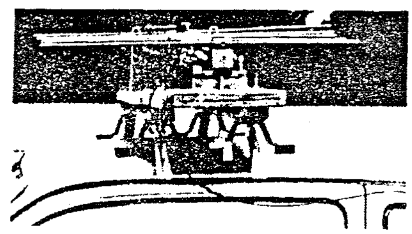
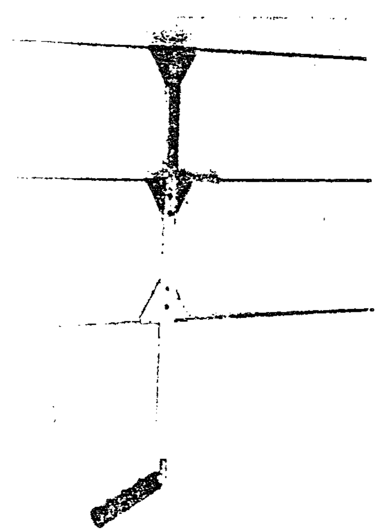


Fig. 4: (below) The 5-element antenna, positioned on a platform across the roof width, is clamped to roof gutters, removable with a 7/16" wrench. The operating crank is positioned just above the driver's window for easy raising, rotating and lowering of the antenna.

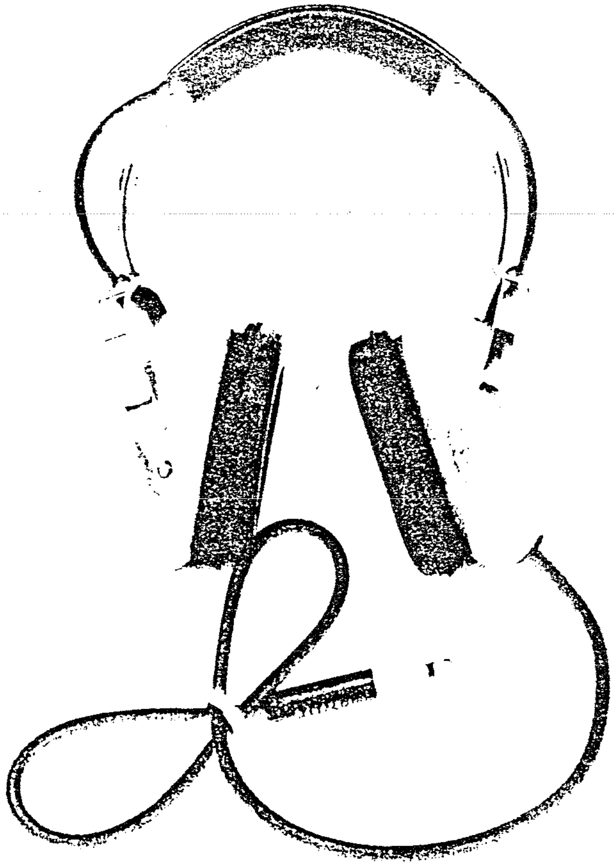
11-Element Antenna: Length of boom, 12 ft, longest element 40 inches (144 MHz); net weight 6 lbs.; 13.2 dBd gain; front-to-back ratio 28 dB; impedance 52 ohms. Ideal for mounting on vehicle (single) or in a double-yagi array on masts at fixed stations for triangulation purposes.
CAT. NO. E1c

7-Element Antenna: Length of boom 91"; length of longest element 38⅝" (151 MHz); net weight 4 lbs.; 10 dBd; front-to-back ratio typically 20 dB or better. Used for mounting on towers for triangulation or singly on vehicle for mobile tracking.
CAT. NO. E1d

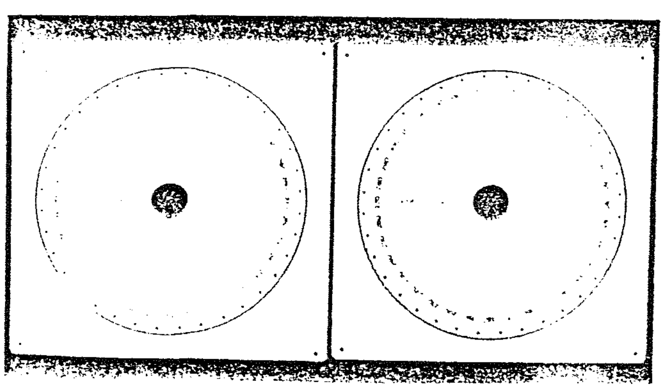
4-Element Antenna: Length of boom 44"; length of longest element 40" (144 MHz); net weight 3 lbs.; 9 dBd gain; front-to-back ratio 20 dB; impedance 52 ohms. Used primarily for mounting on vehicle in single- or double-array for ground tracking.
CAT. NO. E1e



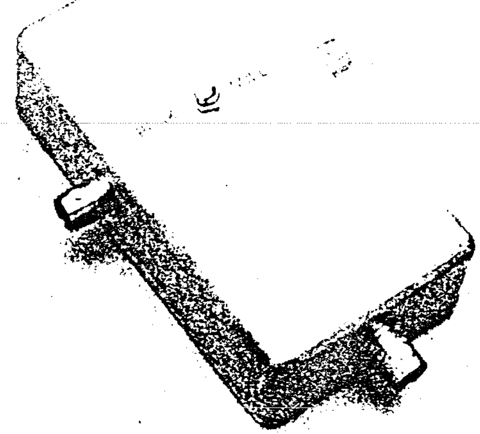
3-Element Miniature Folding Antenna: Folded dimensions, 33½" x 4" x 1½"; unfolded 151 MHz antenna has 33½" long boom; longest element is 40"; weight is 20 oz.; front-to-back ratio greater than 20 dB; gain 5.6 dB using dipole reference, or 7.7 dB with isotropic reference. Supplied with 6 ft. RG-58U cable with either BNC or UHF connectors (specify).
CAT. NO. E1f



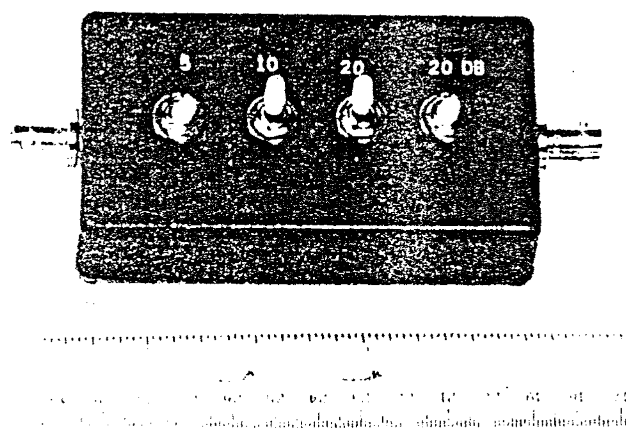
The David Clark Model H750 Headset: High-efficiency headphones, used by airline industry professionals, are considered among the best. Monaural, with circumaural ear cushions and padded, substantially constructed headpiece; 9 ohms impedance; frequency response rated at 100 to 5500 Hz; 1 milliwatt produces 105 dB sound pressure level at 1 KHz; noise reduction rating is 24. Net weight 445 grams.
CAT. NO. F1c



Degree Disc: Two sides of compass rose for mounting at base of rotatable antennas or in roof of vehicle (numbers rotate in reverse direction on these). Anodized aluminum; 14" x 14½".
CAT. NO. F1d



Peak-Null Box: Allows switching from a peak to null and vice versa without changing antenna mounting. 4¼" x 2¼" x 1¼".
CAT. NO. F1e



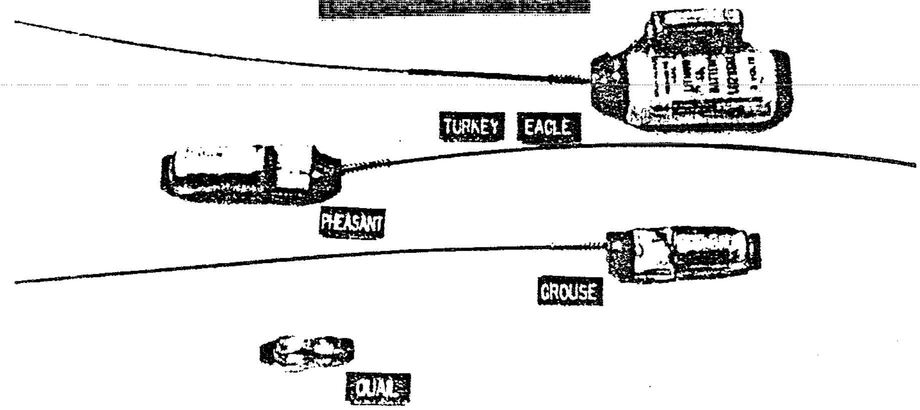
Attenuator: Connects between receiver and antenna to decrease signal strength to keep receiver from overloading on extremely strong (close) signals. Has toggle switches with 5, 10, 20, 20 dB attenuation settings, allowing any combination up to 55 dB attenuation; 4" x 2½" x 1".
CAT. NO. F1f

Antenna Cables:

1. RG-58U, 6 ft. long, BNC connector each end.
   CAT. NO. F2a
2. Same, with BNC one end and UHF on other.
   CAT. NO. F2b
3. Same, with UHF connector each end.
   CAT. NO. F2c
4. RG-58U, 17 ft. long, BNC connector each end.
   CAT. NO. F2d
5. Same, with BNC one end and UHF on other.
   CAT. NO. F2e
6. Same, with UHF connector each end.
   CAT. NO. F2f

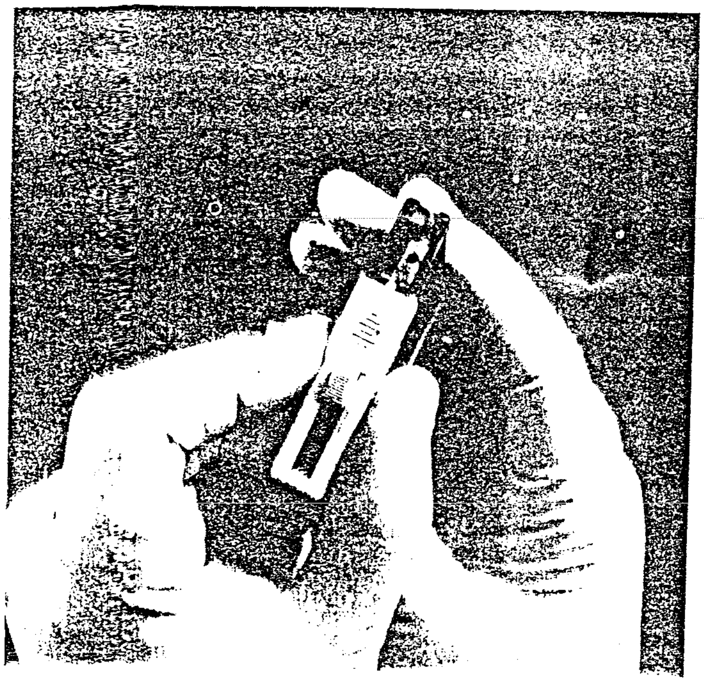
BATTERY POWERED

BIRD



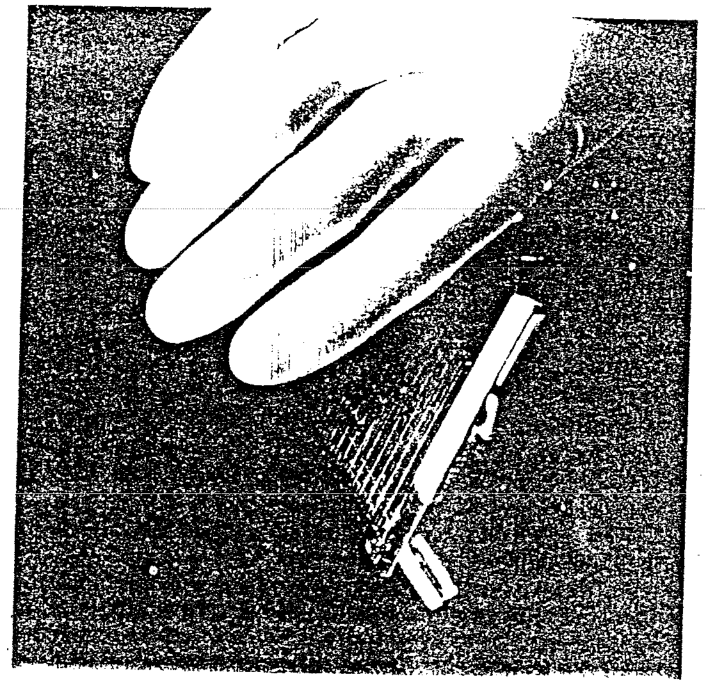
	Battery	Dimensions LxWxH (cm)	Mounted Weight (g)	Pulse Width (ms)	Pulse Rate (ppm)	Transm. Antenna (151 MHz)	Power Output (dBm)	Battery Life (days)	Typical Species
age	3.5v, 7ah, Li	7.2x3.8x3	95-105	15-20	55-65	11" whip	-5 to -7	975-1080	goose, turkey, eagle
	"	"	"	15-30	50-100	"	"	625-680	"
	"	"	"	15-20	55-65 (200+) *	"	"	975-1080	"
	"	"	"	15-30	50-100 (200+)	"	"	625-680	"
	"	"	"	25-35	90-110	"	"	350-390	"
	"	"	"	20-40	70-140	"	"	340-372	"
	"	"	"	25-35	90-110 (300+)	"	"	350-390	"
	"	"	"	20-40	70-140 (300+)	"	"	340-372	"
	3.5v, 3ah, Li	7.9x3.4x1.8	75-85	10-15	50-60	"	"	700-780	"
	"	"	"	10-25	45-90	"	"	370-410	"
	"	"	"	15-20	50-60 (150+)	"	"	450-508	"
	"	"	"	10-25	45-90 (150+)	"	"	370-410	"
	"	"	"	25-35	80-100	"	"	170-187	"
	"	"	"	20-40	70-140	"	"	147-162	"
	"	"	"	25-30	90-100 (150+)	"	"	173-191	"
	"	"	"	20-40	70-140 (200+)	"	"	147-162	"
	3.5v, 1.5ah, Li	6.4x2x1.7	33-43	10-15	45-55	10" whip	-8 to -10	350-388	small grouse, goose, heron, pheasant, owl
	"	"	"	10-25	45-90	"	"	190-209	"
	"	"	"	15-20	55-65 (200+)	"	"	211-234	"
	"	"	"	15-30	50-95 (200+)	"	"	135-150	"

1. Open Handle/Container



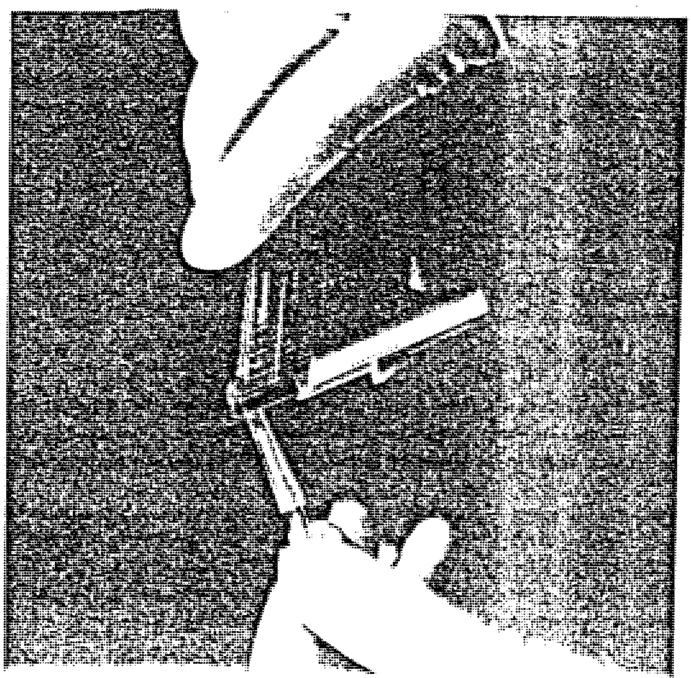
Hold sides of Sliding Cap and pull back to open Handle/Container.

2. Dispense Needle



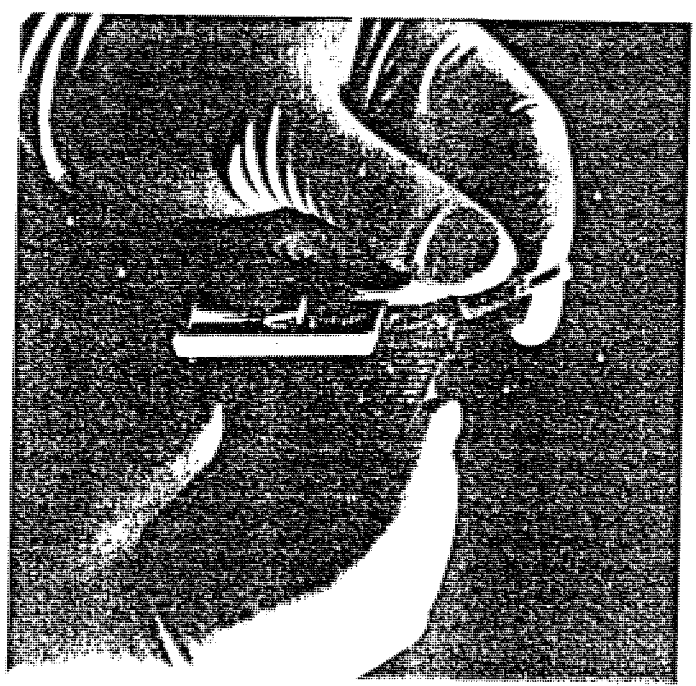
Tilt Handle/Container to dispense single Needle Unit.

3. Pull Out Needle



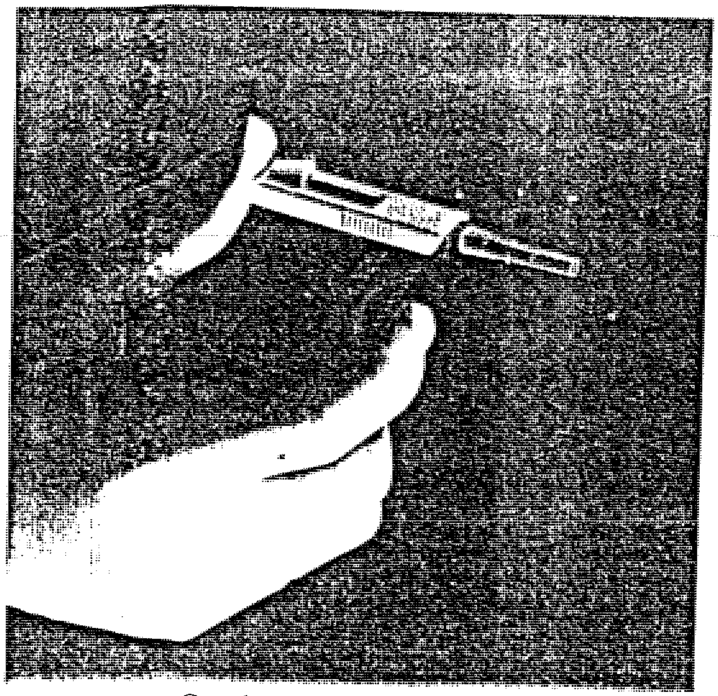
Gently remove Needle Unit, leaving Needle Cover in place.

4. Install Needle



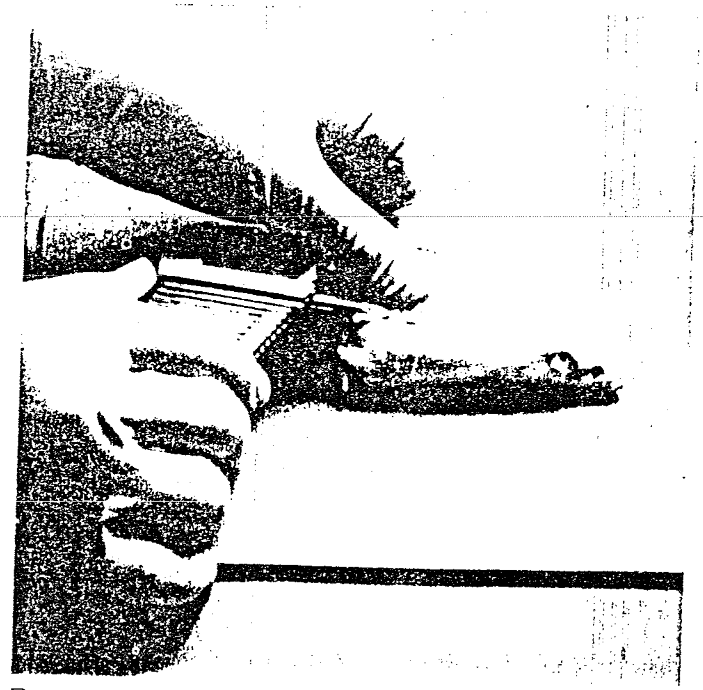
Hold Needle Unit as shown. Insert flat end into pocket and press down to snap into position. Note: Needle bevel should face right for right handed user and left for left handed user.

5. Lock Needle



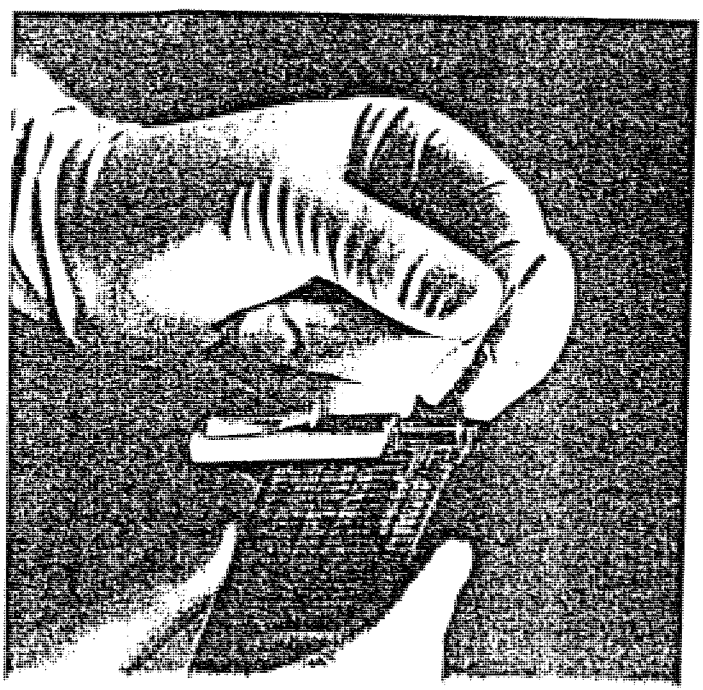
Push Sliding Cap forward to secure Needle Unit.
Note: Plunger should remain in pulled-back position.

6. Implant Transponder



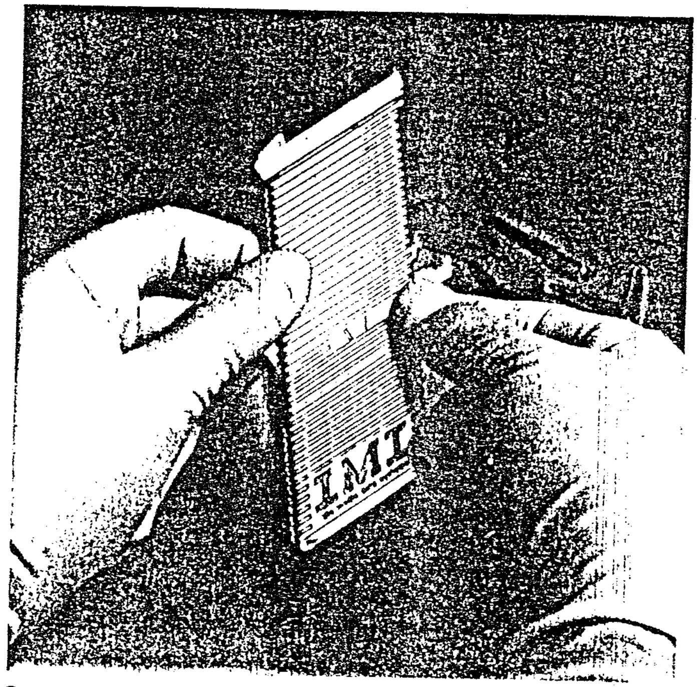
Remove Needle Cover. Hold device so that bevel faces upward and insert needle up to Plastic Sleeve. Drive Plunger forward to implant transponder.
Note: Do not withdraw needle prematurely.

7. Dispose of Needle

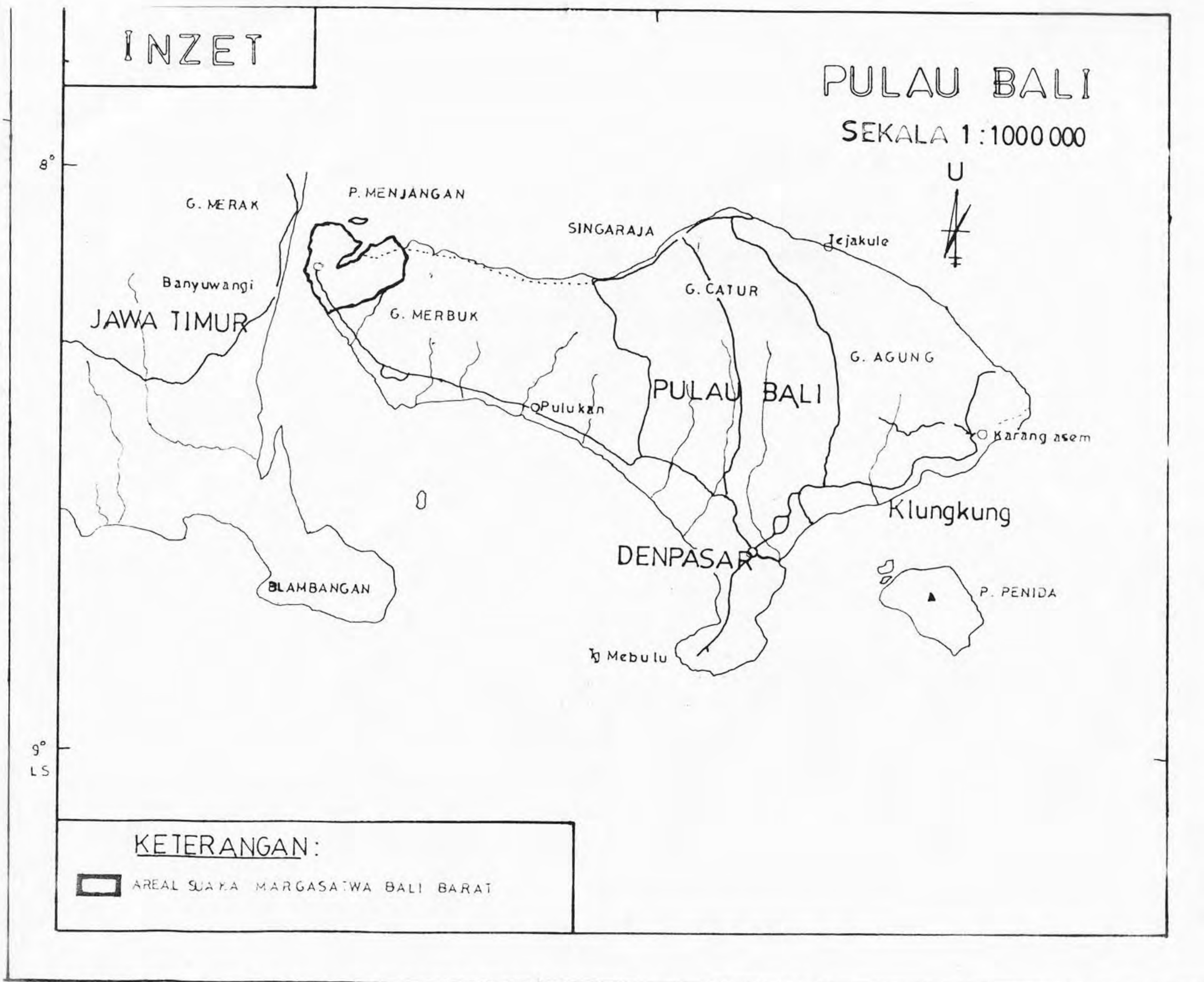


After transponder is delivered, withdraw needle and pull back Sliding Cap. Carefully lift out used Needle Unit. The next Needle Unit is ready for dispensing.
Note: Replace Needle Cover for safe disposal of used Needle Unit.

8. Stopper Instruction



Stopper is placed to secure bottom five Needle Units until upper five are used. Remove Stopper to release remaining Needle Units.



DI KLISE OLEH TAMAN NASIONAL BALI BARAT TAHUN (1987)