台灣雲豹「族群與棲地存續評估」保育研習會

CLOUDED LEOPARD — TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

中華民國八十四年十月十二～十五日
12 ～ 15 October 1995

台北市立動物園
Taipei Zoo
Taipei, Taiwan

Report

Ying Wang, See-wu Chu, David Wildt,
and Ulysses S. Seal (Editors)

行政院農業委員會
台北市動物園之友協會
台北市立動物園 贊助

台北市立動物園
保育繁殖專家群 SSC/IUCN 合辦

Sponsored by

Council of Agriculture, R.O.C.
The Zoological Society of Taipei
Taipei Zoo

SPECIES SURVIVAL COMMISSION

In Collaboration With

Conservation Breeding Specialist Group CBSG/SSC/IUCN

A contribution of the IUCN/SSC Conservation Breeding Specialist Group.

The primary sponsors of the workshop were: The Council of Agriculture, R.O.C., The Zoological Society of Taipei, and the Taipei Zoo.

Cover Photo: Provided by Tom Brakefield

*Wang, Y., S. Chu, D. Wildt, U.S. Seal (editors). 1995. Clouded Leopard (*Neofelis nebulosa brachyurus*) Population and Habitat Viability Assessment. IUCN/SSC Conservation Breeding Specialist Group: Apple Valley, MN*

Additional copies of this publication can be ordered through the IUCN/SSC Conservation Breeding Specialist Group, 12101 Johnny Cake Ridge Road, Apple Valley, MN 55124. Send checks for US $ 35.00 (for printing and shipping costs) payable to CBSG; checks must be drawn on a US Bank. Visa and Mastercard are also accepted.

The work of the Conservation Breeding Specialist Group is made possible by generous contributions from the following members of the CBSG Institutional Conservation Council

Conservators ($10,000 and above)

Australasian Species Management Prog.
Chicago Zoological Society
Columbus Zoological Gardens
Denver Zoological Gardens
Exxon Corporation
Fossil Rim Wildlife Center
Friends of Zoo Atlanta
Greater Los Angeles Zoo Association
International Union of Directors of Zoological Gardens
Metropolitan Toronto Zoo
Minnesota Zoological Garden
Omaha's Henry Doorly Zoo
Saint Louis Zoo
Sea World, Inc.
White Oak Conservation Center
Wildlife Conservation Society - NY
Zoological Society of Cincinnati

Guardians ($5,000-$9,999)

Cleveland Zoological Society
John G. Shedd Aquarium
Loro Parque
Lubee Foundation
North Carolina Zoological Park
Toledo Zoological Society
Zoological Parks Board of New South Wales

Protectors ($1,000-$4,999)

Allwetter Zoo Munster
Africam Safari
Audubon Institute
Bristol Zoo
Burgers' Zoo
Caldwell Zoo
Calgary Zoo
Cologne Zoo
Copenhagen Zoo
Detroit Zoological Park
El Paso Zoo
Federation of Zoological Gardens of Great Britain and Ireland
Fort Wayne Zoological Society
Fort Worth Zoo
Gladys Porter Zoo
Houston Zoological Garden
Indianapolis Zoological Society
International Aviculturists Society
Japanese Association of Zoological Parks & Aquariums
Jersey Wildlife Preservation Trust
Living Desert
Marwell Zoological Park
Milwaukee County Zoo
NOAHS Center
North of England Zoological Society, Chester Zoo
Oklahoma City Zoo
Paignton Zoological & Botanical Gardens
Parco Natura Viva Garda Zoological Park
Penscynor Wildlife Park
Philadelphia Zoological Garden
Phoenix Zoo
Pittsburgh Zoo
Royal Zoological Society of Antwerp
Royal Zoological Society of Scotland
San Antonio Zoo
San Francisco Zoo
Schoenbrunner Tiergarten
Sedgwick County Zoo
Sunset Zoo (10 year commitment)
Taipei Zoo
The WILDS
The Zoo, Gulf Breeze, FL
Urban Council of Hong Kong
Union of German Zoo Directors
Washington Park Zoo
Wassenaar Wildlife Breeding Centre
Wilhelma Zoological Garden
Woodland Park Zoo
Yong-In Farmland
Zoological Parks Board of Victoria
Zoological Park Organization
Zoological Society of London
Zurich Zoological Garden

Stewards ($500-$999)

Aalborg Zoo
Arizona-Sonora Desert Museum
Banham Zoo
Camperdown Wildlife Center
Cotswold Wildlife Park
Dutch Federation of Zoological Gardens
Erie Zoological Park
Fota Wildlife Park
Givskud Zoo
Granby Zoological Society
International Zoo Veterinary Group
Knoxville Zoo
Lincoln Park Zoo
National Geographic Magazine
National Zoological Gardens of South Africa
Odense Zoo
Orana Park Wildlife Trust
Paradise Park
Perth Zoological Gardens
Porter Charitable Trust
Riverbanks Zoological Park
Rolling Hills Ranch (5 year commitment)
Rostock Zoo
Royal Zoological Society of Southern Australia
Rotterdam Zoo
Thrigby Hall Wildlife Gardens
Tierpark Rheine
Twycross Zoo
Wellington Zoo
World Parrot Trust
Zoo de la Casa de Campo-Madrid
Welsh Mt. Zoo/Zool. Society of Wales
Zoologischer Garten Frankfurt

Curators ($250-$499)

Emporia Zoo
Edward D. Plotka
Racine Zoological Society
Roger Williams Zoo
Topeka Zoological Park
Tropical Bird Garden

Sponsors ($50-$249)

African Safari
Apenheul Zoo
Belize Zoo
Claws 'n Paws
Darmstadt Zoo
Dreher Park Zoo
Fota Wildlife Park
Great Plains Zoo
Hancock House Publisher
Kew Royal Botanic Gardens
Lisbon Zoo
Miller Park Zoo
National Audubon Society-Research Ranch Sanctuary
National Aviary in Pittsburgh
National Birds of Prey Centre
Jean H. Nudell
Ocean World Taipei Incorporation
Steven J. Olson
PAAZAB
Parco Faunistico "La Torbiera"
Potter Park Zoo
Shigeharu Asakura, Ph.D.
Tenerife Zoo
Tokyo Zoological Park
Touro Parc-France

Supporters ($25-$49)

Alameda Park Zoo
American Loriinae Conservancy
Bighorn Institute
Brandywine Zoo
DGHT Arbeitsgruppe Anuren
Folsom Children's Zoo & Botanical Garden
International Crane Foundation
Jardin aux Oiseaux
Lee Richardson Zoo
Natal Parks Board
Oglebay's Good Children's Zoo
Speedwell Bird Sanctuary
Tautphaus Park Zoo
Zoocheck Canada Inc.

11 January 1996

CONTENTS

CLOUDED LEOPARD - TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

REPORT

PREFACE

「族群與棲地存續分析技術用於本土野生貓科 — 以雲豹爲例 — 之保育研究」

序言

首先代表台北市立動物園由衷的感謝大家蒞臨本園，參加「族群與棲地存續分析技術用於本土野生貓科(以雲豹爲例)之保育研究」研習會。選擇台灣雲豹做爲研習主題的原因，在於台灣雲豹存在與否的答案未定，有關台灣雲豹的訊息亦多來自原住民的口述，眞象如何，實有進一步探討的必要。目前亞洲各地的雲豹都面臨滅絕危機，其保育工作亦正在積極的進行中。希望能藉由此次的研討會提供雲豹的保育繁殖新技術及圈養與復育可能性的評估，並研究運用圈養繁殖技術拯救瀕臨絕種之小族群動物之可能，此外也希望能對本園的雲豹繁殖提出改善意見，最終目標則是配合全球雲豹的保育工作。

我們知道保育繁殖專家群 (Conservation Breeding Specialist Group , CBSG) 是國際自然保育聯盟 (International Union of Nature and Natural Resources , IUCN) 所屬的一支，針對保育繁殖事務組成的專家小組，成立至今已有十六年歷史，二千多位專家參與，全球各地舉辦七十多場的族群與棲地存續分析研習會，在野生貓科方面亦有印尼蘇門達臘虎 (*Panthera tigris sumatrate*, 1992) 及美國佛羅里達州山獅 (*Felis concolor coryi*, 1989) 等的豐富研習經驗。很榮幸的此次的研習會能由台北動物園繼續承辦，誠摯的感謝行政院農業委員會的經費補助和台北市動物園之友協會的贊助，並對所有會務人員的辛勞努力，使本會得以如期舉行，在此敬致最大感謝！

這次研習會研習人員陣容堅強，包括有：國外方面由保育專家群主席 Seal 博士及專家群中對全球貓科動物有專門研究的 Johnson 博士、Belden 先生、Morris 先生、以及 Wildt 博士等專家；國內則爲各大學相關科系教授及研究生、政府各保育及其相關單位之先進和 Traffic 駐台代表及中華野鳥學會，並聘請師大教授王穎博士再度擔任協調人，農委會湯曉虞技正、師大環教中心王順美副研究員、林業試驗所保護系趙榮台主任及屏東技術學院夏良宙教授擔任小組主持人。研習內容包括：全球雲豹的現況、雲豹在分類系統上的問題、雲豹在台灣的歷史、全球貓科動物復育及移地 (translocation) 保育等計劃，並分析復育的可能性，以及現有可能提供的棲地及復育基本族群

的來源。研習過程中又細分討論小組爲：復育地點及棲地管理、復育及移地保育技術、圈養及野外的族群來源，以及保育教育等幾方面。期盼透過密集的腦力激盪，經由中外保育工作專家學者相互學習，提出確切的問題並討論尋求解答，然後將這些問題與解答作綜合討論，並彙集成完整具體且有建設性的報告。

本人對參加此次研習會所有人員致上萬分敬意及謝意，不論是分組研習人員、協調人員及幕後工作人員，此研習會的展開，實由各位群策群力盡心盡力的結果。本園對於野生動物保育工作向來是不遺餘力，期盼各位除了致力於研習的課程外，配合本園的國際交流，加上第五屆東南亞動物園協會年會的辦理，使本園在動物保育方面的工作更上一層樓。

台北市立動物園園長

暨研討會主持人

朱錫五

CLOUDED LEOPARD - TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

REPORT

EXECUTIVE SUMMARY AND RECOMMENDATIONS

摘要報告

由於棲地的破壞及可能的過度獵捕，台灣雲豹族群劇減，近40年來野外雲豹之蹤跡確定發現的只有三次，最近一次確定之記錄在1989至1990年之間於太魯閣地區發現一隻小雲豹的皮毛，因此其野外族群之命運未卜，可能已至滅絕邊緣，而據野生動物飼養登記者的記錄顯示，亦未發現有台灣雲豹的圈養族群。目前亞洲各地之雲豹族群多在瀕臨絕種的邊緣，有關其習性及族群現況的資料都極爲缺乏。

台灣雲豹是魯凱族文化的重要精神所在，而對其他族的原住民而言亦非主要獵物，且未聞危害農作與人員的案例。推測其族群減少的原因除了不經意的濫捕之外，棲地的縮減破碎化及獵物的減少應該佔了相當重要的因素。現今盜獵及開發壓力正逼近可能殘存雲豹族群的中高海拔山區，如何及時拯救雲豹的未來是一倍受關注的課題。

爲有效保護本種使其免於野外絕種，行政院農業委員會委託台北市立動物園及台北市立動物園之友協會於民國84年10月12日至15日以4天時間在園方舉行以台灣雲豹爲主題之族群與棲地存續分析技術研習會，邀請聯合國IUCN物種保存計劃CBSG (Conservation Breeding Specialist Group)的專家Dr. Ulysses Seal, Dr. Warren Johnson, Dr. David Wildt, Mr. Daniel Morris, 及Mr. Chris Belden 蒞臨現場指導，由師大生物研究所教授王穎擔任研討進行之聯繫工作。

四天的會議中前三天部份時間由原住民代表及國外專家針對雲豹及部份貓科動物現存概況、研究成果及目前族群所面臨的危機進行報告，Dr.Seal並於第三天下午講授VORTEX模擬程式及利用雲豹資料模擬族群變動預測，其餘時間由與會人士組成以下4個小組討論，分組議題如下：

一、政策與法律小組
二、棲地與族群保育小組
三、圈養族群繁殖小組
四、保育教育小組

每個小組各由國內相關的學者或專家擔任協調人，由與會者自行選擇組別參加，針對相關議題進行討論並提出行動綱領。第三天晚間由各組提出結論並進行討論，整合各組意見整理成以下之摘要建議：

一、在政策法律方面，小組同意雲豹保護是屬必要，需立刻提出對本種之行動綱領，並列出六項亟需完成之目標：

1.針對仍可能有雲豹的環境進行調查以瞭解其現況

2.研擬人工繁殖計畫
3.利用現代科技進行對現存私有種源進行鑑定
4.藉由環境教育來獲得社會大眾之支持
5.組成工作小組針對各相關議題進行整合包括國際交流及合作，擬定及實施復育各階段所需進行之事務
6.評估並選擇野放地點及其相關事務。

在實際執行上小組認爲應成立專責小組推動上述工作之進行，以透明化之決策過程整合各方面意見，包括學者、政府決策者、企業界、保育團體、動物園、民間飼養者、各棲地之主管機關如林務局、國家公園等及一般社會大眾來爭取雲豹物種保存政策之支持及施行。

二、有關野生雲豹棲地與族群的保育方面，就過去曾在阿里山(1955年前)、大武山(1982年)及太魯閣(1989-1990年間)等地發現雲豹之記錄顯示，中央山脈及雪山山脈可能是雲豹仍舊殘存的地區。因此對本區中現有之各保護區、保留區及國家公園等應加強保護，並建議將該區周邊之國有保安林優先劃爲野生動物重要棲地做爲緩衝，以保持上述地區之完整。此外，對台灣雲豹現有之野外族群概況應進行實地勘查，勘查之結果由雲豹保育諮詢小組決定是否進行復育，及若應進行復育時各階段的工作。如需進行復育，建議選擇復育棲地的條件應考量該地之人口密度(低於每平方公里50人)、森林面積(連續的10,000公頃以上)、獵物密度、狩獵壓力、當地住民之支持程度及遊客壓力。

建議之復育步驟包括下列四階段：
1.就現存之四個亞種雲豹選取最適種源
2.維繫已知種源之健康飼養族群做爲野放種源所需之基礎
3.根據前述標準實地進行復育地點之勘選
4.進行野放追蹤。

三、圈養族群管理小組認爲在目前雲豹野外族群存活之機會極少之情況下，應優先考慮由人工圈養繁殖的工作做起，
1.首先以最新生物技術(如DNA分析等)來辨識本省雲豹之亞種地位及現有飼養族群之種源，
2.同時應收集世界上所有有關本種之資料，並解決雌雄個體在飼養狀況下相殘而無法繁殖之困境。
3.組成人工繁殖研究小組。
4.爭取政府及民間之資助，以進行國際合作包括技術資訊之交流、人員訓練及研發對本種人工繁殖及飼養技術之突破。
5.辦理與本種飼養及繁殖各項有關的訓練課程及研討。

四、保育教育小組對雲豹保育活動的教育推廣方面，建議應一方面收集

有關雲豹之資料，一方面讓民眾瞭解雲豹在生態上及原住民文化上的意義，再藉由摺頁、歌曲、卡通、神話故事或影片製作等以喚醒國人的重視，並透過學校教育、博物館、動物園、國家公園及大眾傳播媒體的宣導使民眾認識雲豹特色與現存危機，從而喚起民眾及企業界對本種物種保存的支持與贊助。此外，爲了減少復育可能面臨的阻力，應主動邀請相關團體或人士參與復育計劃的規劃，對一般民眾或當地居民應以眞誠而積極的態度藉由公聽會、記者會或以書面說明等與其溝通，並製作新聞稿及短片讓民眾瞭解，以獲得大眾的支持。而影響推行此一工作之成效，下述六點乃爲關鍵：

1. 提供足夠的資料使吾人能確認台灣雲豹在台灣各不同階層人士中之精神文化及生態的意義。
2. 教導民眾尊重並瞭解雲豹生存之權益及價值(即其在生態上所扮演之角色)。
3. 解釋造成雲豹絕種的原因。
4. 教導人與自然共存所面臨之危機及轉機。
5. 敘述雲豹生活環境之特色，加強大眾對其生態環境的愛護與保護
6. 推展及加強國際宣導，建立全球一體的雲豹保育觀念。

五、另由VORTEX模擬推測雲豹族群之結果，以逢機變異的模式假設現有族群爲10隻，則即使在沒有近親交配缺陷(inbreeding depression)、天災及盜獵的壓力下，100年後族群滅絕的危機極高。若用無逢機變異的模式，則其族群呈正成長，低估了族群滅絕的危險性。此一現象顯示小族群對未來環境變異適應的脆弱性。若將族群數量增加到100隻，即可使族群滅絕的危機降至5%以下，且不受小群近親交配之影響。在基本模擬中若加入近親交配缺陷因素，將使100年後滅絕機率自15%增至64%，若再加入一歲死亡率增加的因素，則滅絕機會達100%，僅增加一歲死亡率的個別影響則滅絕率由15%增至66%。假如棲地的負荷量降至30隻，則絕種機會將由15%增至29%，若再加入近親交配缺陷的因素，將倍增至81%。因此，如果小族群由於棲地受限或狩獵壓力導至無法增加族群數量，其走向滅絕的命運將不可避免。

假如可發現一個小的台灣雲豹族群，必需考慮積極的經營管理、嚴格的保護及建立圈養族群的可行性，以避免最終滅絕的結果。及早擬定詳細行動計畫相當有用，以備進行調查發現殘存族群時的對策，並可避免保育決策上的衝突。在基本模擬腳本中，超過100隻以上的較大族群以0.058的逢機成長率增加，族群加倍的時間約須10至12年。

爲了有足夠的動物供野放以確保至少30隻動物存活並繁殖做爲野外族群的建立者，必需愼重考慮再引入計畫。爲了達成上述目

標，大約需要50隻以上不同親緣的雲豹，不同時間及地點分別釋放。再引入計畫需要更進一步的討論、模擬及規劃，同時需要更多有關雲豹族群的野外調查資料，才能獲得最恰當的策略。

假如再引入計畫要使用圈養繁殖的個體，必需先釐清這些動物的血統且沒有經過近親交配才行。假如私人的動物擁有者不能提供確定的種源來源，可能自印亞族群(泰國、寮國、柬埔寨、越南)引入新血統較佳。雲豹的亞種或地理族群目前仍無法利用遺傳標記辨識，因爲缺乏適當的樣本進行分子遺傳分析，必需等到遺傳分析完成才有可能對不明種源的圈養個體進行辨認。

EXECUTIVE SUMMARY

The clouded leopard is endangered throughout Asia, although there is no information on population sizes. As a result of habitat destruction and exploitation, the clouded leopard population in Taiwan has decreased in numbers and may be extinct. Only three sightings of clouded leopards have been recorded in the past 40 years. The most recent report was in 1989 when the skin of a small clouded leopard was found in the Taroko area. The Formosan clouded leopard was proclaimed an endangered species under the Cultural and Natural Heritage Act. Results from questionnaires and surveys of hunters within the past 10 years have yielded no records of clouded leopards. The distribution of possible suitable habitat stretches from Chatien Mountain in the north to Tawu Mountain in the south. Aside from this information, the general biology and other information pertinent to conserving this species is completely lacking.

The Formosan clouded leopard has many potential threats including habitat encroachment, human interference, non-target hunting, and a reduced prey base. As a consequence of differing attitudes among people towards the use of this species, a diverse spectrum of viewpoints exists regarding approaches necessary for its conservation, leading, in turn, to varied policies among governmental agencies. The clouded leopard is sacred to the Lukai tribe, and other aboriginal groups also have positive attitudes towards the species.

The Council of Agriculture wants to avoid complete extinction of the clouded leopard. As a first step in developing a unified approach for evaluating the status and developing possible scenarios for a restoration program on Taiwan, the Taipei Municipal Zoo held a Population and Habitat Viability Analysis Workshop October 12-15, 1995. The Workshop was organized by Professor Ying Wang, Department of Biology, National Taiwan Normal University and Professor Ulysses S. Seal, Chairman of the IUCN/SSC Conservation Breeding Specialist Group, Dr. David Wildt, of the National Zoological Park, Smithsonian Institution, Dr. Warren Johnson of the National Cancer Institute, Chris Belden of the Florida Game and Fish Department, and Dan Morris of the Omaha Henry Doorly Zoo were asked to participate as external consultants, providing lectures about small population viability, reproductive biology of the felids, molecular systematics of the felids, reintroduction of the Florida panther and other felids, captive management of clouded leopards, and current status of clouded leopards in the world. The workshop was facilitated by Professors Ying Wang and Seal.

Participants in the 4-day Workshop consisted of scholars, specialists in felid biology, NGO representatives, governmental officials, an aboriginal representative, national, and international experts. During the first day, the current status of the Formosan clouded leopard and other related research were presented to provide background for subsequent discussion.

Five working groups were formed to deal with the following issues:

1. Policies and strategies and international cooperation.
2. Habitat conservation and restoration.
3. Captive breeding and management.
4. Public education.
5. Population biology and simulation modeling.

Each working group was led by a Taiwanese facilitator. Attendants were free to join any of the groups. After a brief introduction of the participants of each group, an outline was developed for the subsequent day's discussion. A plenary session was convened in the morning of the second and third days, and each group presented the results of their discussions related to short and long-term conservation goals for the Formosan clouded leopard. During the afternoon session, individual group discussions resumed. During the afternoon session of the third day, the VORTEX model was presented in plenary session; captive clouded leopard data were incorporated into the model to make preliminary runs of risk analysis. A synopsis of those results is presented in the chapters of this report.

1. Policy and Strategies Working Group

There was consensus that Taiwan's national policy should promote an action plan to help save the clouded leopard as a unique species. Six major goals of a Regional Species Management Plan were identified.

1. Conduct large-scale biological surveys at the suspected distribution sites to determine if the clouded leopard still survives in nature in Taiwan.

2. Develop a captive management program.

3. Conduct detailed assessments of the origin, age, sex, parentage, health, nutritional, and reproductive status of every clouded leopard owned by private breeders, using modern conservation and biomedical technologies.

4. Build mass support of clouded leopard conservation through environmental education.

5. Establish a local Action Group whose responsibility will be to (a) promote international awareness, cooperation, communication, (b) generate and conduct a formal feasibility assessment, and (c) actively coordinate the detailed design of the regional species management and reintroduction plan, including for public review.

6. Conduct a formal site assessment for clouded leopard release to allow necessary land reclamation, acquisition, and preparation prior to reintroduction efforts.

Another major conclusion was that a working group on Formosan clouded leopards should be formed to monitor the progress of the population recovery. This group should meet regularly to review the problems facing this population and revise, if necessary, strategies to most effectively provide solutions. An action plan for recovery should be established by this group using an integrated database from wild and captive studies. Monies should be obtained from both public funds and private enterprise for the establishment of a Formosan clouded leopard foundation which could support long-term research, conservation efforts, and educational campaigns aimed at fostering a healthy view towards conservation of Formosan clouded leopards.

2. Habitat Conservation and Restoration Working Group

The group suggests that in the central mountain range and the snow mountain range clouded leopards may still exist. Therefore, there was a strong recommendation that more attention and protection be provided in these areas and also in the surrounding buffer areas. It is recommended that these areas be surveyed to determine if clouded leopards exist in the wild. After this survey it can be determined if a reintroduction program is necessary.

If reintroduction needs to be done, then recommended criteria for choosing habitat sites include human population density less than 50 people per square kilometer, forest area of 10,000+ hectares, prey density, low hunting pressure, local people support, and numbers of tourist visits.

Recommended steps for a clouded leopard restoration are:

1. Make the decision about which of the possible four subspecies of clouded leopard should be used for restoration, or decide that the restoration program should be abandoned.

2. Maintain a healthy, genetically-defined clouded leopard population in captivity to produce animals suitable for release.

3. Survey the habitat for specific restoration/release activities, and include characterizing available prey, existing vegetation, other species and a general assessment of the overall environment.

4. Monitor the released population. Important components or factors to consider will include tracking clouded leopard activities (especially home range) and survivorship of all released animals.

3. Captive Population and Husbandry Working Group

It was recognized that the probability of a wild population of clouded leopard existing in the field is extremely small. Therefore, captive breeding of animalsofknown provenance is recommended as a feasible resource for release stock. Several priorities for a captive breeding program were identified.

1. Use modern molecular biology techniques to identify the subspecific character of our native subspecies and to clarify the taxonomic status of the existing captive population.

2. Collect reproductive information on clouded leopards worldwide. This should include studies to resolve the problem of male and female incompatibility reflected in the frequent killing of estrous females by the male even in established pairs. Develop a clouded leopard husbandry manual.

3. Organize local institutions to form a working team on captive breeding strategies and planning.

4. Seek funds from government and private organizations to support international cooperation in information and technology exchange, especially training personnel to facilitate the advancement of captive breeding.

5. Conduct a training course on husbandry, reproductive technology, nutrition, housing design, and veterinary medicine for clouded leopards.

4. Public Education Working Group

Collect existing materials about the clouded leopard and educate people on relationship between clouded leopard and aboriginal cultures such as the Lokai. This can be done through songs, stories, movies, and other novel approaches. Museums, zoos, national parks and general propagation institutions canbe used to inform people know about the clouded leopard and to develop admiration and affection for the species. Get the support of the public for the program.

There are six key elements of an essential public education program plan.

1. Describe in detail the unique biology and the cultural and spiritual significance of the clouded leopard not only to aboriginals but to all Taiwanese to build a deep, accurate, and abiding understanding of this species for our culture.

2. Describe the importance of returning the clouded leopard to its appropriate ecological niche in Taiwan as well as explain the value of predator-prey relationships. People need to realize that extinction is forever, and that every species is invaluable.

3. Describe the historical and likely current population distribution of clouded leopards both in Taiwan and in other regions while explaining the threats and causes of species decline.

4. Describe potential lifestyle changes that may be more compatible with sustained ecosystem survival (for example, explaining different hunting and planting strategies that would ensure survival of endangered species and reduced wildlife consumption, especially for the non-aboriginal communities).

5. Describe specific clouded leopard habitat to encourage people to adopt behaviors and practices that would not directly or indirectly disrupt the natural environment.

6. Widely disseminate this information beyond the borders of Taiwan to build a global community view of the value of conserving the clouded leopard.

Various groups responsible for public education, including national parks, zoos, schools, and NGOs should work together and stress the relationship between the clouded leopard and its environment, and its position as a flagship and umbrella species for conserving entire ecosystems. The public also should be educated to reduce unnecessary fear of the clouded leopard. The clouded leopard should be promoted in the framework of ecotourism, but concurrently, tourists and others should be encouraged to avoid activities that might adversely affect the environment of clouded leopards.

5. Population Biology and Modeling Group

Survey data indicate that clouded leopard numbers in Taiwan are likely to be small if they indeed still exist. The total population must be well below carrying capacity. Snare hunting and poaching appear to have been the greatest threats to viability. The simulation modeling runs indicated that a population of 10 animals (remnant or reintroduced population) is at high risk of extinction even in the absence of inbreeding depression, catastrophes or poaching pressure in the stochastic simulations. If a small wild population of the Taiwan clouded leopard is discovered, careful consideration will need to be given to intensive management, careful protection, and the establishment of a captive population to prevent final extinction. A detailed planning program for such a possible discovery needs tobe undertaken since it may reduce conflicts over management choices in an emergency.

A reintroduction program will need to plan for the eventual release of sufficient animals to assure that at least 30 animals survive and breed to serve as founders for the wild population. This estimate assumes that the released animals are from a genetically diverse population (i.e., they are not all derived from a few pairs of captive parents). It is possible that 50-100 animals will have to be released to achieve this goal. The development of a reintroduction strategy will require much additional discussion, modelling, and planning. Planning such a program will benefit from information gathered in much needed field ecology and demography studies of a population of clouded leopards.

If the reintroduction program is to rely on captive breeding, it is essential that these animals be from known-origin stock and be out-bred. Given the uncertainties about the origins of animals in private ownership, it may be preferable to obtain fresh stock from the Indochinese population (Thailand, Laos, Kampuchea, Vietnam). Genetic markers are not available for the geographic populations or named subspecies of the clouded leopard because suitable biomaterials have not been collected for molecular genetic analysis. Until this is done it will be impossible to reliably identify the origin of captive animals whose pedigree history is unknown or unconfirmed.

The deterministic growth rate (r) is positive in all of these scenarios so that a deterministic model would greatly underestimate the risk of extinction. The stochastic estimate of growth rate is positive in many of these scenarios with a high risk of extinction. This reflects the vulnerability of small populations to the uncertainties of environmental fluctuations. Simply increasing the population size to 100 reduces the risk to less than 5% and virtually eliminates the effects of inbreeding depression. The probability of extinction in 100 years of 15% in the basic scenario increases to 64% with the inclusion of inbreeding depression. An increase of first year mortality increases the stochastic risk of extinction to 66% in the base scenario and to 100% if inbreeding depression is included. Reduction of the carrying capacity to 30 (from 100) increased the risk of extinction from 15% to 29% in the base scenario and to 81% with the inclusion of inbreeding. Thus a small population prevented from expanding whether by habitat limitations or hunting pressure is unlikely to survive. Larger populations of 100 or more under the base scenario conditions with stochastic r of 0.058 can grow to the habitat capacity with a population doubling time of about 10-12 years.

CLOUDED LEOPARD - TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

REPORT

STATUS OF CLOUDED LEOPARD AND ROLE IN ABORIGINAL TRADITIONS ON TAIWAN

Clouded leopard (Neofelis nebulosa)
(This section is extracted directly from a draft of the IUCN/SSC Cat Specialist Group Action Plan prepared by Kristen Nowell and Peter Jackson. This PHVA Workshop Report provides more current information for Taiwan.)

Current Status

Listed as CITES Appendix I as of 1975 [CITES 1982], as Vulnerable in the IUCN Red Data Book [IUCN 1978] and Endangered on the US Endangered Species List as of 1970 [McMahan 1982; U.S. Fish and Wildlife 1987].

1. Distribution

From Nepal, Sikkim, Bhutan, and the Assam Hills to Burma, Malaysia, lower Thailand, and Indochina to S China. In China it has been recorded as far north as Fukien; also found in Hainan, Taiwan, Borneo, and Sumatra. Distribution includes the Bengal/Assam Protected Area System which consists of the moist lowlands and swamp forests of the Ganges Delta, the lowlands of the Brahmaputra river and the forested hills of the Assam transition zone; the South Himalayas Protected Area System consisting of the Indian States of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh (marginally), Sikkim, Arunachal Pradesh, parts of N Pakistan, most of Nepal and Bhutan, and China (marginally); the Burmese Coast Protected Area System consisting of the coastal rain forests of Burma, including the delta and estuaries of the Irrawaddy and Salween rivers with a marginal extension into Thailand; the South Indochina and Annam Protected Area System consisting of most of Vietnam, marginal areas of Laos, S Kampuchea, the south coast of Thailand, and a small part of Burma; the South China Protected Area System consisting of a narrow fringe of land along the S coast of mainland China and including the island of Hainan, broadening W as far as the Red River in Vietnam; the Irrawaddy Protected Area System consisting of the Irrawaddy catchment between the Chin Hills to the W and the Shan plateau to the E including the dry central zone of Burma, the Chindwin and the Kachin regions and the northern hills leading up into the Himalayan mountains; the Indochina Protected Area System consisting of the large plains and valleys of the Mekong and Chao Phraya rivers apart from the S coastal fringe and extending up into the Himalayan foothills of S China; the Malay Peninsula Protected Area System consisting of the whole of west Malaysia, Singapore, a few small islands off the coast of Indonesia, the peninsular portion of S Thailand, and the S tip of Tenasserim, Burma; the Sumatra Protected Area System; the Borneo Protected Area System [MacKinnon & MacKinnon 1986]. Four subspecies have been named:

N.n. brachyurus (Wsinhoe 1826): Taiwan
N.n. diardi (Cuvier 1823): Sumatra, Borneo and Java
N.n. macrosceloides (Hodgson 1853): Nepal to Burma
N.n. nebulosa (Griffith 1821): S China to E Burma

2. Population

m. **TAIWAN**: The cat is probably extinct. The only recent evidence of the cat is in two remote, isolated areas of the Central Mountain Range- the Yushan National Park and a provincial forest in the Tawu Mountains. The most recent sighting was from Nantawushan in 1986 of a leopard found in a hunter's snare [Rabinowitz 1988].

3. Habitat:

It is a forest dweller, secretive, retiring and seldom seen. It has been found in secondary forests in low forest up to 7,800 ft in the Himalayan foothills. In Thailand, it is primarily arboreal, while in Borneo and Sumatra, it is found more often on the ground. In Sumatra, it is usually more strictly confined to the deeper forests than the other felids [Santiapillai 1987]. In Taiwan, it may occur in temperate forests of high mountains [IUCN 1978].

In Borneo, it preys on proboscis monkey, pig-tailed macaque [Davis 1962] and is also known to feed on orang-utans, deer and pigs [Payne et al. 1985]. It may occasionally try to catch fish in the swamps [Pieters 1938]. It probably spends a good deal of time on the ground hunting, and uses the trees as resting sites. Trees or large boulders may be used by the leopards to escape leeches. They favor primary forest but can effectively use selectively logged secondary forest. It preys on sambar deer, barking deer, mouse deer, bearded pig, common palm civet, grey leaf monkey, fish and porcupine. They occasionally take domestic stock but are not considered by the natives to be pests [Rabinowitz 1987].

In India, it is found in the evergreen forests of the northeast. It rests on treetops in nests amidst the branches and is active at dusk and dawn [Panwar 1984].

Overall, it is more arboreal than most other cats, preying on large birds and monkeys. However, it does hunt on the ground and is probably partially diurnal. Its favorite ground prey is wild pig. Pair bonding may occur and couple may hunt together. When hunting in trees, it uses its large paws to knock monkeys off their feet. It then makes its kill by piercing the back of the skull with its large canines. It is very agile in the trees, and like the margay, can hang upside down by its feet and can rotate the back feet 180 degrees. It also is noted for running upside down on branches. The ability to hunt monkeys in the trees may be an adaptation to reduce intra-specific competition with other felids. The only other sympatric felid which hunts arboreally is the Asian golden cat [Santiapillai 1987]. Lekagul & McNeely [1977] have reported that leopards may hunt together, especially after hazardous game, such as porcupines.

4. Principal Threats:

The species is still present in some numbers in Sabah and Sarawak and may still survive in Taiwan. Deforestation and poaching threaten it in these areas. In Thailand, it is considered highly endangered because of the high demand for skins. In Sumatra, the population appears to be healthy, but is threatened by continued forest clearance. In China, Bangladesh and Laos, skins are sold openly in markets. The cat is probably rare in Burma. In many areas the cat is also considered a delicacy and eaten in restaurants. In 1981, furs of this cat could bring (US) $124,270 in Japan. South Korea, not a CITES member, is a conduit for trade in this and other species. China also funnels fur products for consumption primarily to Japan [Milliken 1984].

m. **TAIWAN**: Hunted by aborigines for sale to the Chinese community. Increases in intensity of land use and the purchasing power of the Chinese have increased habitat loss, crop damage and hunting pressure. Major threats are deforestation and loss of prey species [Rabinowitz 1988]. Populations were initially devastated by the fur trade and for zoo specimens [IUCN 1978]. Since Taiwan is a densely populated area, most of the lowland forest has been cleared for agricultural land and for timber export, but about 30% of the island is still under forest, mostly in the mountains [Mackinnon & Mackinnon 1986].

5. Conservation Measures Taken:

m. TAIWAN:

(1) Legislation and enforcement: Not a member of the U.N., therefore, cannot be a party to CITES. The Government has imposed controls on the import, export, and re-export of all specimens of animals listed in Appendix I of CITES. The ban was placed in effect in 1987. All permits for trade need clearance from the Council of Agriculture [Anon. 1988b].

(2) Occurrence in protected areas: May occur in the Central Mountain Range in the Yushan National Park [Anon. 1987a].

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: No information

(5) Research: No information

6. Captive Propagation and research:

Some publications have dealt with this cat in captivity. The majority of the publications have been descriptive accounts of breeding, diet, housing, longevity and rearing [Fontaine 1965; Fellner 1965; 1968; 1970; Baudy 1971; Geidel & Gensch 1976; Murphy 1976; Acharjyo & Mishra 1981; Conway 1984; Ratanakorn 1988]. One recent study dealt with vaginal cytology and behavior [Yamada & Durrant 1988] and another on inducing estrus [Gillespie et al. 1984]. A few comparative behavioral studies have been done among species [Heran & Pejcha 1981]. Several surveys and reviews have also been published containing data from many species [Jones 1977; Hemmer 1979; Kawata 1982; Eaton 1984a; 1984b; Dvornich 1985]. Vocalization research has been carried out by Peters [1984]. Genetic studies on small cats have been represented by several studies [Wurster-Hill 1973; Wurster-Hill & Centerwall 1982; Collier & O'Brien 1985; Newman et al. 1985].

7. Studbook and ISIS status:

In 1984, IZY listed 84.67 with 68.53 being captive born in 48 collections worldwide. An international studbook is published by the Minnesota Zoological Gardens and an SSP has been established. Breeding in captivity has been difficult and there is a high mortality rate of the young. The species is fairly well represented in Chinese zoos. In the early 1980s it was displayed in 29 Chinese zoos, most of then wild-caught recently [T'an Bangjie 1984].

8. Education:

An education center exists at Gunung Leuser National Park in Sumatra [PADU 1988].

The Clouded Leopard in the Traditions of the Aboriginal Lukai Tribe.

Lukai tribe: one of nine tribes in Taiwan, only one with a written history. Ancestors of the Lukai tribe originally lived near the Taimari River, but were forced to move up-river by conflict with another tribe. History suggests that a clouded leopard (a pet owned by one of the tribe members) directed the tribe to the top of a mountain and eventually to a refuge comprised of a thick forest with adequate water. The clouded leopard sat by the water hole and refused to move. It was asked by the tribe if perhaps there was abetter location, but, because the clouded leopard would not move, it was decided that this should be the new tribal home. Eventually, this clouded leopard was released by the tribe into an area with abundant prey.

The tribe has a spiritual relationship with the clouded leopard, believing that this species provides strength, sufficient to withstand strife with other larger tribes. The words 'clouded leopard' translate into 'our old friend' or 'a noble animal'.

During the Dutch occupation, the tribe obtained guns (muskets) for the first time, but they avoided hunting the clouded leopard. Late during the Ching dynasty, when the Chinese arrived on Taiwan, hunting with steel-jawed traps became common. The incidental catching of a clouded leopard was considered a curse.

The speaker as a child hunting with his father, observed a muntjac without its heart and viscera, suggesting perhaps that it had been killed by a clouded leopard. They also were suspected of killing goats. In recent times, tribal members hunt less frequently and, therefore, travel less deeply into the forests where clouded leopards may remain. Nevertheless, the tribe plans to organize an excursion into these sacred areas with the hope of re-discovering the clouded leopard. The sacred area is in the central eastern part of the central mountain range, about a 1 day trip inland. There is a cliff from which the view is the largely flat-surfaced sacred area. The cost for this survey trip will be approximately US$3-4,000.

The Taywai tribe (which is much larger in population and located in souther Taiwan) is allowed to hunt the clouded leopard, but a price must be paid. For some tribes, the liver of the clouded leopard is considered a delicacy, and the killing of a clouded leopard is a symbol of respect. The Lukai tribe does not use the clouded leopard skin as part of their ceremonial dress. However, the Paiwanda tribe (located south of the Lukai tribe) do use the clouded leopard parts in ceremonial activities.

Hunters claimed to have seen clouded leopard tracks and sign in 1986. The abundance of the clouded leopard is difficult to establish because one always felt lucky to see this rare species. In sacred places, the clouded leopard was once abundant, but population numbers were dramatically and rapidly reduced by the use of steel-jaw traps, Steel traps should be banned on Taiwan for all animal catching. Snares are more humane, because death is rapid.

The Lukai tribe now recognizes the importance of wildlife. The older generation thinks of hunting as a pleasure, whereas younger members would be willing to accept a hunting ban. The culture of the Lukai and other aboriginal tribes appears to be gradually diluted by the Chines Taiwanese culture. However, in the country, the aboriginals are being encouraged to develop their own systems.

CLOUDED LEOPARD - TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

REPORT

POLICY AND STRATEGIES

台灣雲豹族群與棲地管理研討會政策與法律小組報告

小組主持人：湯曉虞　小組成員：何源三、陳建志、連國洲、王穎、朱錫五
資料整理者：梁明煌

一、推動雲豹物種保存計劃的原因

本小組成員均願意善盡自己的職責，全力來促請政府制定政策，展開有關雲豹的物種保存計劃。這是基於以下的原因：

· 台灣雲豹是倍受世界矚目，亟待保育的貓科物種。
· 雲豹是華盛頓公約列入附錄一的動物，是IUCN評定爲Vulnerable的物種。
· 雲豹也是CBSG保育繁殖專家小組首度擬借族群棲地管理研習營推動的物種保存對象。
· 台灣雲豹是魯凱族文化的重要精神所在，該族自稱是雲豹的傳人。
· 台灣雲豹更是文化資產保存法及野生動物保育法所列的瀕臨絕種動物。
· 台灣雲豹也是大武山自然保留區設置的主要原因之一。
· 目前台灣雲豹的族群已經非常稀少，許久已未見其蹤跡，可能已經在絕種的邊緣。
· 台灣雲豹是台灣山地森林內高層的肉食貓科動物，其絕種消失可能將影響森林生態系的平衡，爲了保護生態的完整性，有立即行動拯救的迫切需要。
· 國際生物物種保育專家小組普遍上已贊許重新引入鄰近地理區亞種生物族群的策略，以改善本地小族群的近親交配所造成的絕滅問題，並且已經運用在美國佛羅里達山獅的物種保存計畫上。
· 台灣民間尚有人工飼養的雲豹族群，即將在三年內禁止飼養，必須依法加以處理。其中部份個體也許可以作爲物種保存計劃所需的種源。
· 雲豹爲亞洲地區的動物，有四個亞種，在許多亞洲國家中數量都非常稀少，是亟待亞洲國家一同參與保育的物種。台灣雲豹僅產於我國，更是獨特，目前世界各地的動物園內均沒有此一亞種倖存。
· 我國接受聯合國下屬單位IUCN下的物種保存委員會指導，推動雲豹的物種保存計劃，等於已經加入聯合國的外圍組織。同時因爲我國的投入國際保育工作，更有助於提升我國政府的保育形象，減輕國際的壓力。
· 物種保存計劃的執行過程中將促使國內野生動物保育技術、學術研究水準及人才質與量的全面提升，這是一項科技轉移的最佳機會。

二、急須解決的問題

本小組成員也體認到下列三大類的問題必須先行或逐漸解決，才能順利展開物種保存計劃。說明如下：

(一)人工飼養部分：

· 由於舊的野生動物保育法的登記制度較不具誘因，現有民間飼養者多存觀望之心而未登記，因此登記有案的雲豹數量與實際數目仍有差距，差異多大目前不得而知。
· 可能尚有許多雲豹被走私進入台灣而未被查覺，民間飼養者的雲豹種源及品系都急需使用生物遺傳學鑑定技術來清查。

· 現有野生動物保育法規定，飼養保育類野生動物的民間業者僅能再繼續飼養三年，屆時這些民間飼養者必須面臨被收購管理的問題，部分業者可能會有私下放生山林之慮，造成公共危險。

(二)野外族群：

· 野外台灣雲豹的歷史分布點爲中央山脈森林區域，目前是否尚有倖存族群，倖存地點在哪？野外如有倖存族群，能否永續生存？都急須加以了解及確認。
· 南部橫向快速道路通過大武山自然保留區，瑪家水庫淹沒區對雲豹傳人故鄉及雲豹野外棲地是否有影響，也因缺乏雲豹的資料而無法判定。

(三)政策決策過程需要社會及各方民意支持：

· 國內民間保育團體的支持台灣雲豹亞種物種保存及復育計劃，或同意以鄰近亞種改善種源遺傳多樣性的物種保存計劃，將是計劃能否成功展開的重要關鍵，急需溝通及說服。
· 民間飼養業者願意提供雲豹樣本做遺傳形質檢查，或割捨飼養的雲豹，將雲豹交給研究繁殖中心作爲種源，並且樂意授與飼養繁殖技術，也是重要的關鍵，必須要有足夠的誘因。
· 新聞媒體的充分報導與環境教育的全面推動是獲得民眾關懷及黨政代表支持的最好工具。
· 國內保育學者及野生動物學界的建立共識、正面參與及鼓勵，更是物種保存計劃推展的重要開端。
· 野生動物保育法中央主管機關的決策者的樂意支持將此物種保存及生物多樣性保存政策列爲國內重大及優先的自然保育政策，並願意核撥巨資支援物種保存工作更是不可缺少。
· 國內外企業界、政府及民間長期的捐款贊助研究經費，是計劃得以延續的重要命脈。
· 國內必須要有負責執行雲豹物種保存研究的小組專門推動計劃，才不至於白費力氣。
· 國外保育團體及世界各地動物園的支持及CBSG的專家支援規劃工作時程、訓練人才、提供最新資訊、參與檢查每一個物種保存及復育階段的決策，才能避免或減少程序上的錯誤。

三、物種保存計劃推動的行動策略建議：

(一)行動計劃目標：

· 重新進行生物資源的普查工作以確定野外雲豹族群的倖存現況，確定是否可以自行永續生存
· 確定是否可從野外雲豹族群來繁殖後再釋回，或必須從人工飼養族群中補充，還是必須選擇鄰近或親緣相近的亞種來進行繁殖。
· 檢查國內人工飼養族群的種源、年齡、性別及精液的精子活力等，來判定國內是否尚有可以作爲繁殖的核心種源的族群及其大小

・進行各種保育教育以爭取民眾及各利害關係人的支持，並獲得法律及行政的許可展開組織的成立工作。
・組成物種保存計劃推動小組收集各種資訊，擬定各階段的政策及計劃理念並進行審愼的可行性評估
・進行雲豹舊有棲地的評估，對可能的出沒及釋放地點應及時加以保護，並且擬定棲地的管理政策。

(二)計劃推動方式建議：

1.推動政策的任務專責小組：

・爲繼續推動國際合作、連繫及後續的追蹤，建議大會先成立一個工作小組。
・建議由文資法及野動法的主管機關－行政院農業委員會修改生物資源調查策畫小組的組織，增加生物多樣性調查及物種保存任務，在此小組下負責指定學術單位或野生動物保育研究機關來推動物種保存政策及細部計劃的規劃。
・建議此一推動單位可以再組成一個物種保存諮詢小組，小組成員可以包括學者專家、國外顧問、民間團體、政府機關、有經驗的飼養業者及企業贊助單位。並且應依計劃的進度，適時的增聘野放地方的代表或原住民意見領袖。
・推動單位及諮詢小組必須根據此行動建議，討論及制定短程、中程及長程的政策及細部計劃目標與工作重點方向。

2.政策及計劃推動過程的注意事項：

・建議政策與計劃的規劃及決策過程，必須要透明化，要辦理多次公聽會，有充分的公共參與機會，
・政策決策過程中必須要尊重各種不同的異議聲音，務求獲得共識與支持。過程中不應該有過度政治精英強勢誤導。

3.爭取政策利害關係人支持的策略

以下列舉十種與政策有關的利害關係人，可用以下原則來爭取他們的支持。

1)民間的雲豹飼養者：建議設計出一套具有高度誘因的制度，包括錢、名、或法律豁免等機制，在保育類動物名錄修訂完成重新辦理登紀的期間內，鼓勵民間的雲豹飼養者主動登記、捐獻、或接受研究單位在合理價格下有價收購。整個收購及集中至繁殖中心管理的過程，應在野動法規定期限內完成。

2)世界瀕臨絕種生物保育協會：建議促請以台灣雲豹爲企業識別系統的民間團體世界瀕臨絕種生物保育協會WESPA，規劃國內外企業及民間募款工作，協助收購及搬運工作。

3)國內動物權團體：讓民間的團體參與政策與計劃的規劃及決策過程，利用調停、價值澄清、價值分析的方法、電腦模擬的工具及可行性評估的研究結果來說服及建立共識。

4)動物園：因爲雄性雲豹經常攻擊雌性雲豹，因此國外動物園多發展人工受精及物種繁殖技術，此工作初步可能要在硬體設施完善的台北動物園園內或鄰近地區進行。由於該園缺乏空間，

建議透過農委會、台北市建設局、台北市環境保護局爭取利用封閉的福德坑垃圾場加以綠化及棲地復育，以做爲初步的物種保存、收容及繁衍基地。此基地也可擴大作爲國家級的人工飼養動物的繁殖實驗基地。

5) 林地或國家公園主管機關：未來野生族群的普查及可能的釋放區址都可能在林地或國家公園主管機關的轄區內，必須爭取他們人力及行政的支持。未來也需請他們適時予以支援興建野外簡易的野化設施及監督釋放的工作。

6) 國內保育學者及野生動物學界：物種保存計劃的討論應該爭取國內保育及野生動物學者的參與，建立共識、並應採用團隊分工進行相關的研究。計劃所須的經費應盡量爭取民間經費的支應，而不是去爭食國內的研究經費大餅。計劃執行階段應多邀國外專家來台辦理各種研習營以增加學者自我成長的機會。

7) 新聞媒體：主動提出具體資料讓新聞媒體充分報導台灣雲豹物種保存的工作計劃，主動串聯媒體支援魯凱族文化尋根的調查工作。

8) 一般民衆：利用各種教育媒體及策略告訴全國民衆相關的資訊，辦理各種活動以吸引媒體報導，獲得民衆注意及關懷。

9) 野生動物保育法中央主管機關的決策者：透過CBSG專家及IUCN的正式行文邀請與敦促，並配合東南亞動物園協會會員的具名建議函及本研習營所制定的行動策略，才可能促成野生動物保育法中央主管機關的決策者的樂意支持。

10) 企業界：借協助其推動綠色行銷策略，發動國內外企業界、政府及民間長期的捐款贊助研究經費。

4.政策推動的階段；

本小組建議物種保存政策的推動可以分成可行性評估階段、準備階段、飼養野化及釋放追蹤等階段，首先要進行審慎的可行性評估階段。依次說明如下；

1) 可行性評估階段

- 建議要立即在台灣雲豹的歷史分布地點，重新進行生物資源的普查工作，以確定野外是否尚有倖存族群的蹤跡，如發現倖存族群，應確定其數量是否夠多到可以自行永續生存的族群大小，如族群過少應考慮捕捉回研究中心繁殖後再釋回的可行性及從人工飼養族群中補充的可行性。
- 針對國內人工飼養族群的種源應該立即予以檢查，並且針對其年齡、性別及精液的精子活力等因素來判定，國內是否尚有可以作爲繁殖的核心種源的族群大小，還是必須選擇鄰近的亞種來進行繁殖。
- 進行各種保育教育以爭取民衆及各利害關係人的支持，並獲得法律及行政的許可，展開組織的成立工作。

· 收集各種資訊，擬定各階段的政策及計劃理念，並進行審慎的可行性評估及環境影響評估，評估時應該邀請CBSG貓科動物的專家來台協助擬定方法及作業準則。

· 進行雲豹棲地的評估，對可能的出沒及釋放地點應及時加以保護，並且應擬定棲地的管理政策，

· 建議依照野生動物保育法將國有林內已編定的保安林地先劃定為野生動物的重要棲息地，依野動法規定，上述區域內任何的開發行為都必須進行環境影響評估作業。

2)準備階段

確定必須進行復育計劃後，即可進入第二階段

· 整合各種資源，收集國內民間繁殖場的種源。收購過程中，宜盡量避免支付公務預算，以免發生先例，而造成其他保育類動物繁殖場的飼養者也比照辦理爭取，增加政府收購的困擾。

· 透過國際物種血統書資料，搜尋適宜的種源，爭取國際動物園支持，取得動物園內或野生的雲豹精液支援，以增加基因的多樣性。

· 覓地及購地、規劃、及興建合乎動物福利及適於繁殖的場所設施，並規劃展開搬運工作的程序。

· 進行各種準備工作，先以家貓為對象，練習各種人工繁殖及受精等技術。

3)釋放地準備階段及釋放的工作計畫因為須等待以上兩個階段的工作成功後才能進行，因此建議交由未來的工作小組再行討論。

POLICY AND STRATEGIES

Reasons for Developing a Regional Species Management Plan for Conserving the Clouded Leopard

There was consensus that Taiwan's national policy should promote an action plan to help save and then conserve the clouded leopard as a unique species fo the following reasons:

1. This species is formally listed as 'vulnerable' by the World Conservation Union (IUCN) and is listed in Appendix I of CITES.

2. This species is a unique felid (cat) with possibly low genetic variation.

3. This species is a symbol of the indigenous Lukai Tribe, a people who believe they are spiritual descendants of the species.

4. This species is listed as 'endangered' according to Wildlife Conservation Law and Cultural and Natural Heritage Law.

5. This species is designated as a major protected species in the Dawu Nature Reserve of Taiwan.

6. This species is rare throughout Asia and may be on the brink of extinction.

7. Because this species is a carnivore, it is highest on the food chain in the mountain forests. Therefore, preserving the clouded leopard will help protect the integrity of the entire ecosystem.

8. Conserving the clouded leopard is the responsibility of this nation, and this action may well help improve the poor conservation image of Taiwan.

9. Conservation genetics and assisted reproduction research technology will be improved in this country as a result of project participation and with joint collaboration of specialists in the CBSG network.

Perceived Problems

In identifying a strategy to promote a regional species management plan for the clouded leopard, the working group recognized three problems. Each must be resolved before and during the process when the project is entering the phase of reintroducing animals or during restoration of the habitats for proposed release activities.

The first challenge is related to clouded leopards owned by private people. The new revised Wildlife Conservation Law prohibits private owners breeding protected wildlife species. Therefore, it is recommended that owners must stop breeding clouded leopards within 3 years. At the end of this period it will be the responsibility of the owners and the government to care for these animals. The actual number, origin and genetic provenance of clouded leopards in private hands are unknown. There is a need to identify the genetic background of these animals using molecular techniques, before they can be used as stock for reintroduction research. It also will be necessary to develop a high incentive mechanism to motivate private breeders to donate or offer these clouded leopards for sale at a reasonable price to the research program. Additionally, these private breeders have considerable information on the management and husbandry of the species that will be important to researchers. Economic incentive to develop a partnership with the private owners is important. Without an effective plan, there is concern that the private breeder could simply stop caring for the animals or illegally release them into local mountainous areas, thereby causing serious safety issues in rural areas.

The second set of challenges are related to the uncertainty of clouded leopard distribution and numbers in the wild. Therefore, there is an urgent need to conduct detailed surveys within inner forested areas, especially with the assistance of indigenous tribes while simultaneously using modern survey technology. There are limited data on species biology and habitat. Additionally, some of Taiwan's designated protected areas are facing two major developments: 1) the South Cross highway Project ;and 2) the Ma-Ja Water Reservoir Project. The environmental impact of these two efforts on the clouded leopard are unknown because of a severe lack of general habitat information and survey data. If field biologists were to find a self-sustaining wild clouded leopard population, then an environmental impact survey would be important.

The third set of challenges are related to generating a sufficient number of interested stakeholders in Taiwan (the host country). Needs include:

1. Win support from local grass-roots environmental groups, including those supporting radical animal rights. Some groups are likely to criticize the proposed need for captive breeding and the idea of releasing a subspecies of clouded leopard whose origin may be from a region other than Taiwan. Criticism also may arise from the uncertainty of success and the substantial cost of conducting such a high risk project.

2. Seek donation of captive clouded leopards owned by private breeders because of the need to recruit more captive animals into the planned program. There is an urgent need to enhance genetic diversity to improve the health condition of the core reproductive stock while increasing reproductive rate. Simultaneously, it will be necessary to obtain the assistance of private breeders in basic animal husbandry and management.

3. Develop a relationship with journalists to publicize the Action Plan to help address both criticism and collect positive responses. Simultaneously, this approach will teach the public to be more aware of conservation needs, priorities and this project itself.

4. That the project receive the recognition and high priority of the academic community. It must be emphasized that the financial needs of the clouded leopard program will not compete with other important scientific programs.

5. That the project receive the approval and strong endorsement of the senior administrators in the Council of Agriculture. These people should ensure that the project receives highest priority status. It is recognized that to achieve further international cooperation and long-term funding, it will be necessary for the project to undergo a protracted chain of review within the bureaucracy.

6. Recognizing that the project will fail unless there is sufficient, sustained financial support at all levels, including by local, national and international organizations and enterprises.

7. Recognizing that the project requires a group of specialists who are willing to commit a huge amount of time, energy and manpower. Without these resources, the project cannot succeed.

8. Recognizing that the project requires the expertise and state-of-the-art information of the Conservation and Breeding Specialist Group. Without this organization's commitment and cooperation, the project will not proceed smoothly.

Recommendations for the Action Plan

I. Goals of the Regional Species Management Plan:

Six major goals were identified.

1. Conduct large-scale biological surveys at the suspected distribution sites to determine if the clouded leopard still survives in nature in Taiwan. High priority biological information required includes distribution, home range, habitat and prey characteristics and reproductive behavior. This enormous effort may require developing new survey methods and cooperation by all wildlife research laboratories in this country.

2. Develop a captive management program using clouded leopard stock from captured wild animals, from animals owned by private breeders or by using artificial insemination and cryopreserved sperm (of appropriate subspecific designation) obtained from collaborators in other geographic regions.

3. Conduct detailed assessments of the origin, age, sex, parentage, health, nutritional and reproductive status of every clouded leopard owned by private breeders, using modern conservation and biomedical technologies.

4. Build mass support of clouded leopard conservation through environmental education. Targets include all stakeholders and the general public, especially the aboriginal communities. It is anticipated that this goal can be met by the Environmental Educational Institute, the national science museums, zoos and other local conservation groups.

5. Establish a local Action Group whose responsibility will be to (a) promote international awareness, cooperation, and communication, (b) generate and conduct a formal feasibility assessment and (c) actively coordinate the detailed design of the regional species management and reintroduction plan, including for public review.

6. Conduct a formal site assessment for clouded leopard release to allow necessary land reclamation, acquisition and preparation prior to reintroduction efforts.

II. Recommendations for Development of an Organizing Task Force

1. To continually and effectively promote the process, a Task Force Group should be established.

2. To legalize and prioritize the project plans, the Council of Agriculture should revise the organizational mission of its branch, Biological Resources Inventory Group, to include a mission to protect both biological diversity and endangered species. Under this new branch, a formal Task Force Group could be designated for conducting further planning and decision making.

3. To improve the quality of the decision making, the Task Force Group also should organize a consulting committee to review the project plan. Members of this committee could include wildlife managers, foreign consultants, scientists, policy researchers, nongovernmental representatives, experienced animal managers/keepers and aboriginals.

4. The Task Force Group should develop the regional species management plan by creating a masterplan that includes the project mission, objectives (short- and long-term) and specific operational procedures at different phases.

III. Recommendations for the Policy Making Process

Project planning and decision-making must not occur in a 'black box'. The process must be organized and systematic with hearings to allow public participation. All contradictory opinions should be respected with the ultimate product oriented as much as possible to an agreeable consensus with the final decisions reflecting majority opinion. The wishes of the political elite cannot supersede the decisions of the group.

IV. Strategies to Secure Support from the Stakeholders

1. Private owners. The Council of Agriculture needs to develop a mechanism that will provide private owners with incentives to cooperate as well as improve the public image of these private ventures and to alleviate excessive legal restrictions and harassment by the press. The motivation must be sufficient to induce private owners to become willing partners in the process as well as to accurately register the numbers of their clouded leopard stock. Owners also must be induced to donate or sell animals at a reasonable price to the project. The ability to acquire these animals will be directly related to incentives provided by the government. Additionally, expert private breeders should be invited to serve as project consultants to engender both trust and cooperation.

2. World Endangered Species Protection Agency (WESPA). WESPA is a local conservation group in Taiwan that uses the clouded leopard as its logo. Therefore, WESPA should be encouraged to help develop fund-raising initiatives to support the project, especially from multi-national corporations both within and outside of Taiwan.

3. Local animal rights groups. Local animal activist groups should be invited to attend and participate in conferences, public hearings and workshops related to the project. Conflicts inevitably will occur. However, mediation, persuasion, value clarification/analysis, gaming and simulation results (gathered from the VORTEX exercises) and positive results from the feasibility assessments are likely to be useful tools for building consensus.

4. The Taipei Zoo. Because of its facilities, resources and willingness, the Taipei Zoo has offered to serve as a candidate for building a state-of-the-art captive breeding facility for clouded leopards. Additionally, to be able to construct a facility in a semi-natural environment (thus perhaps enhancing reproductive ability), the Council of Agriculture also should consider building at an alternative site, but near the Zoo. One possibility includes a nearby closed dump site operated by the Environmental Protection Administration of Taipei city. This site also could be used for other activities by other organizations including the National Science Council and Academic Sinica.

5. Administrator of national forest lands and the national park system. These stakeholders are crucial and should be requested to become collaborators and co-sponsors. Requests should be made for assistance, expertise and manpower both in the project planning phase and in implementation, especially with the initial surveys, identifying possible release sites, site assessments and eventual monitoring.

6. Academic community. Academic scientists should be requested to participate in planning, reviewing and implementation of the project. They will need continued assurance that the project will not interfere or compete with funds currently being allocated for their personal scientific projects.

7. Journalists and the mass media. Project leaders should provide continuous, detailed and updated information to the press and media, providing information on the issues and the need for improved conservation and systematic research. In particular, members of the media might be invited to participate in the initial surveys for clouded leopards to be conducted by project experts, including aboriginals.

8. General public. Brochures should to be developed that explain the urgency and the needs to conserve the clouded leopard and these should be disseminated widely to the general public, especially students.

9. Decision-makers in the central government. The results of all workshops and the Action Plan itself should be submitted to the central governor. Additionally, support letters for the project from the CBSG and the South East Asia Zoo and Aquarium Association should be forwarded to this governmental authority. Dr. U.S. Seal, Chairman CBSG should have the opportunity to meet with the administrator of the Council of Agriculture to help persuade and urge the approval and initiation of the clouded leopard regional management plan.

10. Private enterprise. To gain the assistance of private enterprise, these organizations should be encouraged to use the clouded leopard or other endangered species as logos, for the purpose of marketing and raising funds to support the project.

V. The Mission of Each Phase

The Regional Species Management Plan for the clouded leopard was divided into four phases:

<u>1. Feasibility assessment - Missions:</u>

a. Conduct biological surveys to search for surviving animals in the wild. A top priority will be to determine if the captive breeding aspect of the plan will involve breeding clouded leopards that are wild-caught or from extant zoo or privately-owned populations.

b. Determine or confirm species origin, age, sex, parentage and health, nutrition and reproductive status of all clouded leopards owned by private breeders. These results will dictate if there will be a need to acquire living animals or cryopreserved sperm from other regions outside Taiwan.

c. Build public and legal support through a series of environmental education programs. Targets include all stakeholders and the general public, including the aboriginal communities.

d. Begin the feasibility initiative and start to design the detailed aspects of the management plan (including for reintroduction) and offer all information for public review.

e. Conduct site assessments in potential release areas while generating a habitat management policy and necessary land reclamation activities.

f. Legalize all protected areas in the national forests as critical habitats for sustaining wildlife according to conservation law. All development activities must submit environmental impact statements with only approved programs being allowed to progress.

2. Preparation phase - Missions:

a. Mobilize all available resources while the Task Force Group collects animals from the private owners.

b. Check the clouded leopard studbook so that the managers may be able to identify animals of appropriate genetic provenance to ensure subspecific purity and high genetic diversity.

c. Host biomedical workshops, especially focusing on health assessments, reproductive biology and assisted reproduction technologies, using the domestic cat as a learning 'model'. The purpose will be to train appropriate managers and researchers who will be responsible for health, reproduction, capture and transfer of clouded leopards and biomaterials (sperm).

d. Select appropriate reintroduction sites and begin the land acquisition process. Project managers should design and then build appropriate facilities both for the release activities and for the captive breeding program.

3. Releasing phase - Missions:

a. Select appropriate sites and start land acquisition process. Also the project manager shall begin designing and developing facilities.

b. Acquire stock from availabel resources (private breeders, zoo breeding programs, on Taiwan or in other regions).

c. Develop specific release and monitoring program according to task force recommendations which will be based upon the best available information.

CLOUDED LEOPARD - TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

REPORT

HABITAT CONSERVATION AND RESTORATION

台灣雲豹族群與棲地管理研討會棲地與族群保育小組報告

報告人：趙榮台記錄人：金志美、陳益明

小組成員：黃正龍、陳怡君、蔡明雅、夏榮生、楊秋霖、趙榮台、陳益明、陳元龍、連裕益、羅淑英、賴慶昌、金志美、方正儀、梁明煌、王穎、廖光正

一、過去分布記錄：

本小組不討論是否要必要復育雲豹，本小組的結論或建議都是在假設我們已經決定執行雲豹復育工作的狀況下提出的。

我們認爲欲復育雲豹，則有必要了解雲豹的棲地。這可以從雲豹過去的分布記錄得到資訊。從過去發現雲豹的記錄在阿里山(約1955年)、大武山(約1982年)及太魯閣(約1989-1990年)，可見中央山脈及雪山山脈山區都可能是雲豹賴以存活的地區。

二、復育地點選擇考慮條件：

1.人口密度(<50人/1km^2)

2.原生林或次生林(>10000ha)

3.調查人員安全

4.野放監測追蹤是否容易

5.加權因子：

- 獵物密度

  以野豬、山羌密度爲指標？或再加山羊？

  山羌　>50隻/100ha：10分

  50-30隻/100ha： 5分

  30-10隻/100ha： 3分

  <10隻/100ha： 1分

- 狩獵壓力大小

  位於公園內(壓力小)：10分

  位於保護區內(壓力中)：5分

  不具任何地位(壓力大)：1分

  周邊人口密度小：10分

  周邊人口密度中：5分

  周邊人口密度大：1分

- 遊客密度

  <100人/月：10分

  100-500人/月：5分

  500-1000人/月：3分

>1000人/月：1分

- 地方住民支持程度(支持人數百分比)

  非常支持(91-100%)：10分

  支持(71-90%)：5分

  無意見(51-70%)：3分

  不大支持(31-50%)：2分

  不支持(11-30%)：1分

  非常支持(0-10%)：0分

- 林型

  10000公頃天然林：10分

  10000公頃次生林：5分

  10000公頃人工林：1分

三、棲地的保育

現有各保護區、保留區、國家公園加強執行禁獵，嚴審開發案。更理想的狀況是將國有保安林地全部劃爲野生動物重要棲地，嚴禁狩獵及開發。

四、復育的步驟

1.族群現況普查。

2.野外數量尚足以永續存活。

1)保護其棲地。擴大保護範圍，嚴格執法，並整合零碎的棲地。

2)持續監測族群之數量及品質。

3.野外族群已滅絕或數量不足以永續存活。

1)全面保護雲豹可能的棲地。

2)收容民間飼養的族群。

- 解決未來業者可能觸法的問題。
- 經過適當評估後，未來可能做爲復育種源，或供教育、展示之用。

3)決定復育之雲豹爲哪一個亞種或族群，或爲哪幾個亞種或族群，或不做復育。

4)維持復育亞種或族群之圈養族群。

5)做可能復育地點之棲地調查。包種植被調查、動物族群調查和環境因子調查。

6)選擇適當之復育地點數處。

7)執行復育工作

- 執行復育工作的同時，加強教育、宣導。
- 考慮復育棲地是否需要再整理。
- 考慮是否需設餵食站。

・考慮是否要設圍籬。

8)進行監測

・偵測其存活及活動情形

・偵測其活動範圍

9)做復育地點之棲地調查

・與復育前之調查結果對照，可明瞭復育對棲地產生的影響。

HABITAT CONSERVATION AND RESTORATION

Historical Distribution of the Clouded Leopard

All suggestions and conclusions made by this working group were based on the assumption that it is necessary to restore the clouded leopard in Taiwan. The group determined that reviewing the historical records of the distribution of the clouded leopard is helpful to choosing specific sites for restoration. According to all limited information, a clouded leopard was sighted on Ali Mountain in 1955. A journalist reported sighting a clouded leopard on Tawu Mountain in 1982, and a newly killed cub skin was reported in 1989-1990. Therefore, we must suppose that the Central Mountain Range and the Hsyue Mountain Range of Taiwan contain suitable habitat for this species.

Criteria for Choosing Habitat Sites

The following criteria must be met:

1. a human population density of less than 50 people per square kilometer.

2. an overall forest area of at least 10,000 hectares.

3. guaranteed safety (in general) for the research people who will be working in these areas.

4. the habitat must be compatible with the feasibility of conducting radio-tracking and monitoring for the purpose of collecting crucial data for assessing project progress and success.

5. other factors must be compatible with the possibility of successful reintroduction including appropriate prey density, hunting activities, tourist density, local people support and forest type. The following factors need to be evaluated. The status of each factor is listed in order of preference.

a. For prey density (and assuming that muntjac and serow are main prey items):
When number of prey is greater than 50 individuals per 100 hectares
When number of prey is 30 to 50 individuals per 100 hectares
When number of prey is 10 to 30 individuals per 100 hectares
When number of prey is fewer than 10 individuals per 100 hectares

b. For hunting pressure:
If the site is in a national park
If the site is in a nature reserve
If the site is without any legal protection

c. Human population around the site:
If the site has low human density around the site
If the site has medium human density around the site
If the site has high human density around the site

d. For tourism density:
If there are fewer than 100 tourists per month
If there are 100 to 500 tourists per month
If there are 500 to 1,000 tourists per month
If there are more than 1,000 tourists per month

e. For local people support:
If there is high levels of support
If there is support
If there is no opinion
If there is little support
If there is no support 1 point
If there is opposition

f. For forest type:
For every 10,000 hectares of natural forests
For every 10,000 hectares of semi-natural forest
For every 10,000 hectares of plantation

Habitat Conservation

The working group urges stronger law enforcement within the territory of all national and locally protected areas and national parks. Additionally, protected forest areas should be given legal status as important wildlife habitat. Poaching and development should be strictly prohibited.

Steps for Restoration

1. Conduct extensive and detailed surveys for wild clouded leopards, and, if existing, establish population status and distribution.

2. If there are viable wild populations:

a. protect the extant habitat of the clouded leopard while expanding the protected area, integrating adjacent fragmented areas (whenever possible) and maintaining strict protective law enforcement.
b. continuously monitor the quantity and quality of the wild habitat and the wild clouded leopard populations.

3. If no clouded leopard populations exist or the populations are non-viable:

a. protect the habitat in the natural range of the species.
b. consolidate clouded leopards now in the ownership of private breeders. Captive breeding of clouded leopards by private owners could be illegal, and, therefore, consolidation appears to be a necessity. These clouded leopards (after genetic, health and reproductive evaluations) may become the core population for planned restorations or for exhibition for vital public education programs.

4. Make the decision about which of the possible four subspecies of clouded leopard should be used for restoration, or decide that the restoration program should be abandoned.

5. Maintain a healthy, genetically-defined population of clouded leopards in captivity to build a population suitable for the release project.

6. Survey the habitat for specific restoration/release activities, and include characterizing available prey, existing vegetation and other species and a general assessment of the overall environment.

7. Select one or more high priority sites for the restoration project.

8. Conduct the restoration. Important components or factors to consider will include:

a. an educational program conducted before, or at the least simultaneously with, release efforts.
b. the need for finding additional habitat.
c. the need for understanding how to initially set up feeding stations.
d. the need for building fences to contain the range or protect the clouded leopard and people from each other.

9. Monitor the released population. Important components or factors to consider will include tracking the activities (especially home range) and survivorship of all released animals.

10. Conduct a habitat study after clouded leopard release. Results should be contrasted to the quality and quantity of habitat before reintroduction to determine the impact of such restoration programs on the habitat itself.

CLOUDED LEOPARD - TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

REPORT

PUBLIC EDUCATION

雲豹PHVA研討會教育組總報告

報告人：王順美　　　　記錄：鄭世嘉、柯芸婷
參與者：胡雅美、左曼熹、王虎城、陳順其、陳蕙美、柯芸婷、林崇明、鄭世嘉、王順美、王穎、廖光正、趙榮台、紀純眞、劉秀鳳、楊振賢、賴雅芬、歐映青、林秀美

本小組在三天的研習會過程中承蒙各組的參與及指正，獲得許多初步的共識。本報告的內容是針對五大主題包括「實施雲豹保育教育的需求」、「造成台灣野生動物族群減少之因素」、「雲豹教育組之任務」、「雲豹保育教育計劃的進行方式」、「爭取實施復育計劃的溝通原則」等提出建議。

壹、實施雲豹保育教育的需求

本小組成員一致認爲現階段即有實施雲豹保育教育的需求，其理由爲以下四點：

一、它是獨一無二的，它是台灣貓科動物中體形最大的，是台灣特有亞種，它的族群快消失，在野外可能已在絕種邊緣。

二、對於某些原住民（例如：魯凱族、排灣族），雲豹可能是一種精神及文化的象徵，對他們文化的延續有很大的關係。

三、藉由雲豹保育教育的實施，可以喚起國內民眾及官僚體系對世界瀕臨絕種物種野生動物及棲地保育意識。

四、進行雲豹物種保存的計劃過誠中包括可能實施的復育計劃，都需要透過各種溝通及說服策略協助說服更多與計劃或政策利害相關的關係人的積極參與，並喚起大眾的支持。

貳、台灣野生動物族群減少之因素

本小組成員也認爲造成雲豹絕種的原因與台灣野生動物族群銳減的原因是相似的，也是保育教育的主要教育議題。小組在會議期間曾列舉如下原因：

一、濫捕

過去原住民狩獵是爲了生活才利用獵犬、長矛等原始工具捕捉野生動物，後來受大量槍械及陷阱技術的引進，及市場交易行爲的刺激，而進行過度的捕捉。這往往是受社會變遷及人類炫耀消費心理的影響，包括食補文化、養野生動物爲寵物，或以動物皮毛來裝飾他的財富。這都是與平地人的消費需求息息相關。捕捉方式器具及習慣改變，使得大小野生個體在深山中仍然無法倖免。

二、棲地的破壞

人類的高度利用山區野生動物的棲地，如開闢產業道路造成棲地被分割、生存環境破壞，各種動物的族群都大量消失。高山茶及蔬菜的墾殖皆佔據了棲地，種植時所用的農藥殺蟲劑，也因食物鏈的關係，累積在野生動物體內。

三、其他原因

以上兩項亦爲台灣一般野生動物所面臨的壓力。眞正雲豹數量快速之減少之因在哪？或許是獵具槍支引入？或許是其獵物梅花鹿及羌在那時後大量的減少？或許是雲豹本身的習性、遺傳變異性小有關。仍然値得我們去探討研究。

參、雲豹教育組之任務

本小組體認到實施雲豹保育教育計劃的急迫性，建議應該成立一個保育教育的行動小組。這個行動小組的工作任務爲以下兩項：

一、規劃、設計、製作及進行雲豹保育教育，喚起大眾的對雲豹的認識及保育的態度。

二、物種保存計劃的執行過程中，各項預定計劃包括可能進行的復育計劃，都可能有阻礙因子。此小組應協助說服所有的政策利害關係人積極參與討論達成共識，並喚起大眾的了解與支持。

肆、對雲豹保育教育計劃進行方式的建議

本小組也對雲豹保育教育計劃進行方式，從「教育內涵」、「教育對象與途徑」、「教育策略」及「短期行動計劃」等四方面來提出討論，並達成以下的共識。

一、教育內涵

1.介紹雲豹的生物學知識，在原住民文化、精神上的特質，以建立民眾對雲豹的正確且深刻的印象。

2.介紹雲豹的生態地位，建立民眾了解生態系每一物種存在之重要性，「EVERY SPECIES COUNTS」，體認及尊重每一個生存的物種，都有許多未知的價値觀念，並打破人定勝天的觀念。

3.介紹雲豹族群過去的分佈，族群量下降背後的原因。

4.介紹民眾如何過一種較符合環保的生活形式，並鼓勵減少使(食)用野生動物的需求及消耗量，以減少人類對雲豹及其獵物的干擾。

5.介紹雲豹的棲地、減少民眾破壞棲地的行爲和相關的保育法令。

6.介紹原住民文化中合乎永續利用原則的傳統狩獵、耕種觀念及方式。

7.介紹雲豹在世界其他地方倖存的現況及實施中的保育策略，建立民眾地球村之觀念，並協助雲豹在其他國家的復育。

二、教育對象與途徑

以下是從「社區教育：居民及原住民」、「社會教育：一般大眾」、「學校教育：學生與教師」及「戶外教育：遊客」等四個層面來談。

1.社區教育（包括棲地附近居民、原住民）

選定過去雲豹較常出沒地區附近的村落，透過村長或地方領袖，與當地居民（含不同年齡層、不同性別），進行訪談、文字、物品的收集，以了解當地居民對於雲豹的認識、狩獵情形及雲豹保育的觀念。

將地方領袖、有保育觀念的原住民人士、國家公園或林務局人員、自然文化景觀保育小組（農委會），組成一自然文化保育工作小組，就既有的文化特色、社經現況、居民對雲豹的認識及保育觀念，共同研擬地方的行動策略，並實際執行，隨時評估修正。

溝通的重點可以包括，例如雲豹在文化歷史上的意義，狩獵行爲的永續性考量，減少使用或食用野生動物，野生動物保育法落實，以鼓勵其守望、保護村落附近的雲豹及其他野生動物。

溝通策略可以運用人際間的說服、學校或村里活動中心的文宣展示、影片播放、村里民大會或節慶聚會來說明討論、甚至請附近住民加入村落附近野生動物的調查工作。

2.社會教育：一般大眾

博物館、動物園等社教機構可以做雲豹的特展及巡迴展，台北動物園的台灣鄉土動物區的展示可以加強融入相關原住民的文化特色。

大眾傳播媒體，如：報紙可以介紹雲豹特色、文化精神的象徵意義及其現存的危機，並克服大眾對於雲豹及野生動物的恐懼；廣播及電視可以安排播出雲豹特別節目，並進行現場的Call-in。說服各種廠商贊助雲豹的保育教育及保育工作。

3.學校教育：學生與教師

將雲豹有關的教材放在各級學校，甚至大學（包括：師大及師院）的通識課程或保育課程中，並在師資培訓的教師研習會中介紹。

在電腦的網路中增設一項雲豹佈告欄，讓有興趣者能更認識雲豹及其相關的訊息，並且促成廣泛的交談。

編製有關雲豹的輔助教材，提供雲豹出現的縣市的中小學校使用，並說服山地行政區的教育局，使雲豹的保育能逐漸與母語教育結合，教導山地學校老師具有編寫有關教案的能力。

4.戶外教育

結合國家公園、林務局和保護區等地的的解說教育與原住民多文化的教育，在各遊客、教育中心，播放影片、展示、設置雲豹有關的解說、摺頁或協助解說。

三、教育策略

本小組建議以下四種策略供教育小組的人員推動教育行動。

1.了解每一種教育對象之需求、價值觀，使用適當的訊息及方式與其溝通。

2.配合各級學校及社教單位的既定教　目標，將雲豹保育的內容融入其教育活動中。

3.教學過程儘量以活潑、生動的方式來進行，如：以歌曲、卡通、神話故事、短片等來吸引大　。

4.儘量以多種方式及一系列活動來穿插進行，使教學能具體的展現雲豹的特質，進一步帶動深刻的討論雲豹保育的概念。

四、短期行動計劃

本小組也對近期應該行動的工作提出以下四點建議：

1.藉由有關雲豹保育的摺頁製作，協助教育組人員釐清對於雲豹的認知，並發掘必要又欠缺的資料，同時可做爲各參與人員蒐集彙整資料時之參考。

2.從公私立文史博物館收集有關雲豹的報導、照片，並訪談原住民、飼主，以獲得資料（如：雲豹的繁殖、數量、覓食、族群減少之原因等），供發展教材之所需，並列出優先次序。

3.請每一位參加研習會的人員就其所在單位，思考進行雲豹保育教育的機會。

4.主動召集對於原住民部落保育教育有興趣的人士或相關單位或組織，共同合作協商雲豹保育教育。

伍、對爭取實施雲豹復育計劃時的溝通原則建議

一、目標：透過溝通程序及原則，以減少對此計劃的阻力、並增加助力。

二、可能的阻力：

復育計劃推動時將面臨以下可能的阻力：

1.學術團體、民間環保團體通常關心此計劃的投資報酬率，引入其他的雲豹亞種對台灣的生態系之影響、及外來的亞種是否會造成本地亞種基因特質的「反演化」。

2.當地居民可能不會同意計劃單位將其家園劃爲雲豹保護區，鄰近釋放區的一般民眾會擔心雲豹的引入將攻擊其家畜或人。

3.一般民眾不了解雲豹和雲豹復育之重要性，對問題冷漠、毫不關心。

三、溝通策略：

本小組參考美國佛羅里達山獅復育之經驗提出以下的溝通策略：

1.對於學術團體、民間環保團體

在進行復育計畫的規畫、決策時，主動邀請這些人士的參與，進行溝通，表現公開、包容、尊重的態度，以達成共識。此舉可以使得執行出現較少的爭議，特別是動物權、動物福利。執行過程中也較能將經費妥善運用。

2.對於一般民眾

主辦人員應打開心胸，傾聽不同意見或質疑，收集整理，並以眞誠的態度，釐清解釋其疑惑。綜合所有對復育計劃的疑惑，整理出書面回答資料，特別是有關雲豹價值，可行性評估及成本效益評估的研究結果。藉由製作新聞稿及短片、記者會，將復育計劃的內容及實施流程、時間、地點等公佈，讓民眾了解。藉由公聽會，與地方的官員、民意代表、民間保育團體、民眾溝通，並依時發表工作進度報告。

PUBLIC EDUCATION

Reasons for the Need to Conduct Conservation Education for the Clouded Leopard

1. This species appears to be unique within the Felidae family, and it is the largest endemic felid (cat) in Taiwan.

2. The clouded leopard is a spiritual symbol for the Lukei and Paiwan aboriginal tribes.

3. The public needs to be awakened to the need to conserve endangered species. The clouded leopard could be used as a flagship species for stimulating this awakening in Taiwan.

4. In the event that a reintroduction plan is permitted and implemented, public education will be crucial for securing public support.

Causes Related to the Population Decline of the Clouded Leopard (Information Important to the Education Process).

There are two primary threats in Taiwan that have caused the marked loss of this species during the past 50 years:

1. Exploitation to meet market demand. People enjoy displaying the clouded leopard pelt as an indicator of bravery, wealth or high social class. To meet a demand for consumption of mountain products, peoples living on the plains have over-hunted.

2. Habitat loss to human settlement. The building of roads and vegetable and tea farms fragmented natural habitat into smaller, often isolated patches. The residuals of pesticides (overused by agri-industry) in the mountains also appears to be adversely affecting wildlife. The actual impact of the latter threat on the clouded leopard is unknown. Nonetheless, both the above threats are important for all wildlife in Taiwan. However, it is urgent to find the specific cause of declining populations and perhaps the extinction of the clouded leopard in this country.

Missions of the Education Program.

1. Plan public education programs for the clouded leopard by telling the general public about the uniqueness of the species, largely for the purpose of building positive, proactive attitudes toward not only the species, but wildlife in general.

2. Conduct high profile education programs specifically highlighting the reintroduction program, largely to secure public awareness and support.

Public Education Plan.

A. Key components should include:

1. Describing in detail the unique biology and the cultural and spiritual significance of the clouded leopard not only to aboriginals but to build a deep, accurate and abiding understanding for all Taiwanese.

2. Describing the importance of returning the clouded leopard to its appropriate ecological niche in Taiwan as well as explaining the value of predator-prey relationships. People need to realize that extinction is forever and that every species is invaluable.

3. Describing the historical and likely current population distribution of clouded leopards in Taiwan and in other regions while explaining the threats and causes of species decline.

4. Describing potential lifestyle changes that may be more compatible with sustained ecosystem survival (for example, explaining different hunting and planting strategies that will ensure survival of endangered species and reduce wildlife consumption, especially for the non-aboriginal communities).

5. Describing specific clouded leopard habitat to encourage people to adopt behaviors and practices that would not directly or indirectly disrupt the natural environment.

6. Widely disseminate this information beyond the borders of Taiwan to build a global community view of the value of conserving the clouded leopard.

B. The targets and teaching approaches should include:

1. Local people, including aboriginal tribes. It is recommended that several villages in the historical range of the clouded leopard be selected. The purpose would be to secure all known historical information on the clouded leopard through an interview/survey process, including the opinions of adults versus children, males versus females, hunters versus non-hunters and the overall attitude about the consumptive use of wildlife and the need to conserve the clouded leopard.

2. Organizing a formal Task Force Team. The primary mission of this group should be educating local people about the historical significance of the clouded leopard, the importance of conservation and dealing with issues related to changing behaviors and attitudes to reduce consumptive uses by hunting and other means, including being guardians and protectors of indigenous wildlife. The Task Force Team should be comprised of local conservationists, leaders, national park authorities, sociologists, anthropologists and conservation educators. The final Action Plan must be based on

local needs, including social economical status, educational background, cultural sensitivities and what is known and believed about the clouded leopard.

3. Communicating by personal persuasion, pictures, printed materials and videos, all of which can be conducted at local schools or community centers, public meetings and even public festivals.

C. For the larger public, the education plan should involve:

1. Developing exhibits or interactive display activities for zoos and museums that highlight the significance of the clouded leopard. These activities should be permanent or circulated throughout Taiwan. At the Taipei Zoo, change the current clouded leopard exhibit to more accurately reflect the species importance to the country, especially to the cultural relationships with aboriginal tribes and the Taiwanese people in general.

2. Mass media dissemination of information through print media, radio and television, emphasizing the spiritual significance and dire status of the species.

3. Attempting to develop more national and international cooperation for clouded leopard conservation and education.

D. For school education involving students and teachers, the plan should:

1. Infuse all the essential knowledge about the clouded leopard, perhaps by developing formal conservation courses, especially at the university level. Specific teacher training workshops could be particularly effective as could be the combination of conservation training with traditional 'mother' language courses.

2. Involve informing through established computer networks, thereby reaching huge audiences.

3. Involve creating illustrative supplementary educational materials followed by their widespread distribution to schools and universities. Teacher training workshops should heavily rely on the use of these guideline materials.

E. Our national park system also should serve as a natural and high profile venue for education and should involve:

1. The use of exhibits, brochures, videos, films and lectures in national park visitor or education centers.

CLOUDED LEOPARD - TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

REPORT

CAPTIVE POPULATION AND HUSBANDRY

台灣雲豹族群與棲地管理研討會圈養族群繁殖小組報告

一、簡介

本小組討論採用下項思考程序

本小組成員是否贊成圈養，如贊成且能說明理由，本小組才能做進一步之討論。

贊成圈養並不能代表有能力養，因此必須整理出圈養的方式及未來圈養中所可能遇上之問題，因此將就各部分技術詳細討論。

贊成圈養和有能力養仍不代表眞正能養，固爲未能有適當的行政措施配合，無法實際去執行，動物是活的，在圈養中之經驗需要有經驗人士指點，飼養中之突發狀況需要有國際上有經驗的人士協助。

雲豹圈養之保育和管理之訓練有助於未來類似工作之進行。特別有助於提昇本園工作同仁在保育工作上之水準。

二、圈養是否必要，理由何在?

圈養是否必要及理由何在? 應由圈養雲豹的優缺點來討論。

圈養之優點及必要性：

1.瀕臨絕種動物第一步是立即圈養繁殖，而非改善棲息地或做其他的等待。

2.野外已無族群可供收集資料，即使野外尙有一線希望，要想由野外收集資料供保育之用也稍嫌太慢。

3.圈養下觀察方便。

4.圈養下易採用最新繁殖技術來繁殖。

圈養之缺點：

1.野外和圈養之環境不同。（但圈養後是可逐步野放）

2.圈養要有良好之理境。

3.棲地之瞭解必需同時進行。

三、圈養下所需之資訊

雲豹之基本資訊

1.雲豹之亞種如何區別。

2.雲豹之生物學資料。例如：何時發身，發情期之分布、長短、懷孕期、產仔數、產仔重、何時仔豹開眼、何時可離乳、何時換齒、齒式爲何、生長曲線（餵飼時需要）、毛色之變換等、正常血液數據。

3.雲豹之血統書。

4.雲豹之行爲（一般及社會行爲）。

雲豹之營養和飼養

1.基本營養需要，蛋白質、能量、維生素、礦物質。

2.特殊之營養需要(例如家貓必需胺基酸，特別需要Taunine)。

3.餵太肥太瘦之問題。

4.各階段之營養需要是否有所不同，特別是繁殖期（公、母）及幼畜期。

5.食物上有否禁忌。

6.飼料添加劑。

7.需要植物食物嗎?

8.餵料量。

9.改換食物之方法。

10.絕食多少天才會眞的餓，餓後之行爲會如何?

11.食物是否需煮熟，如不需是否有微生物過多之現象。

12.食物之溫度。

13.餵在高處還是低處，餵在空曠處還是隱蔽處。

14.脫毛和營養之關係。

15.運動需要否?

生殖或繁殖

1.生殖生理特性（含神經、內分泌問題）。

2.生殖行爲特性（例如發情徵候，母豹發情行爲...等）。

3.性行爲和社會行爲之關係。

4.配種時如何配對（自然繁殖），公的需要剪犬齒嗎?

5.環境、營養和繁殖之關係。

6.人工授精及相關資訊。

7.胚胎移置及相關資訊。

8.人工發情排卵。

9.體外授精。

10.人工哺育或母性的行。

11.近親繁殖。

12.生殖技術之相關問題（例如麻醉方法、藥物...）。

13.練習繁殖技術時，是否可以貓作練習對象。

14.精子異常之誘因。

健康和疾病

1.特別應注意之疾病。

2.疫苗注射種類、時間、類別（活毒、死毒...）、可靠性。

3.疫苗注射可否用家貓之疫苗。

4.常見疾病，內外寄生虫及驅虫藥及敏感性。

5.意外傷害造成之原因。

6.健康指標（外在狀況中脫毛、內在血液尿糞檢驗）。

動物舍

1.最小需要空間。

2.是否需要運動場。

3.個飼或群飼。

4.氣候環境是否合理。

5.社會或結構之環境對畜舍設計之影響。

6.增強設計上之環境（enrichenvironment豐富環境）。

7.安全。

8.地面材料。

9.棲材之需要。

10.舒適行爲之充分發揮（例需沙堆）。

四、圈養所需之行政支援

1.圈養政策之訂定及合理化。

2.進行一次雲豹之野外調查。

3.充份支持人員之國內外訓練。

4.推動合理化之動物福利。

5.給予民間飼養者之支持。

6.支持野生動物保育及合理化之圈養。

五、國際合作

1.瞭解國際間雲豹之研究及圈養單位。

2.促成國際合作（含人員、動物及資訊）。

3.推動國內內外貓科動物繁殖、飼養之技術。

4.圈養動物一般性飼養技術之訓練，特別是較難養動物往國外尋求合作及學習。

5.促成國際間對台灣雲豹復育可行性之探討或進一步之合作。

6.聘請野生動物圈養專家來台舉辦訓練及研習。

7.爭取國內外保育團體之支持。

8.設立資訊交流之總部。

CAPTIVE POPULATION AND HUSBANDRY

Need for a Self-Sustaining Captive Breeding Program for the Clouded Leopard

Captive breeding programs can serve as important reservoirs for genetic diversity useful for education and for learning about the basic biology of rare species. In some cases, captive populations hold the only known animals in existence. Further, on occasion, captive breeding has been used to produce young that subsequently have been released into natural or restored habitat.

This working group agreed immediately that a high priority was the establishment of a viable captive breeding program for the clouded leopard. The rationale was as follows. The clouded leopard is an endangered species native to Taiwan. Because other working groups were advocating the need to consider developing reintroduction programs, there was an absolute need to develop the management and husbandry skills to conduct successful captive breeding, an activity that will be critically supportive of a wild release program. Proper captive breeding programs allow defining the details related to basic biology, handling, behavior, nutrition, health maintenance, genetics and reproductive physiology. Such animals also can be used for practical kinds of research including sorting out the issues of subspecies, determining levels of genetic variation and developing assisted reproductive technologies like artificial insemination, *in vitro* fertilization and embryo transfer. Assuming that animals scheduled for reintroduction are to come from a captive breeding program (the only likely source for clouded leopards), then all of the skills developed in relation to a captive program have immediate application to any restoration plan.

Establishing a captive breeding program is not without disadvantages. This working group identified costs, the need to build state-of-the-art facilities and extensive training as concerns. Additionally, it was recognized that it is impossible to create clouded leopards in captivity that will be exactly the same biologically as counterparts naturally produced in nature. Nonetheless, the working group reached consensus that the advantages of developing captive breeding far surpassed the disadvantages.

The next step was identifying an array of general factors crucial to formulating and implementing a successful program. High priorities included intensive training in the disciplines of animal housing, husbandry, nutrition, health, disease, behavior and reproduction. Additionally, molecular genetics will be invaluable for dealing with as yet unresolved issues related to subspecific designations. It was agreed that training needs should be coupled with expanded international cooperation, especially identifying colleagues willing to provide expertise and direct assistance.

Related to the overall need for developing the captive breeding program were parallel requirements for strong administrative endorsement and support not only in terms of financial assistance, but in helping develop policies to address captive animal ownership, support for training, animal welfare and unequivocal support of simultaneous efforts to develop the successful reintroduction program.

Further Needs and Recommendations

It was recognized that captive wildlife managers in Taiwan have little experience with clouded leopards. Therefore, there is a need to develop a captive program that allows:

1. understanding basic husbandry/management requirements, including minimum space for effective health and reproduction, the need for exercise, the need to house animals in social groups or individually, the impact of climate, enclosure influence on stress and social interaction, the usefulness of enrichment activities, methods optimizing safety for both animals and keepers and the appropriateness of various cage, floor and perch materials.

2. maintaining optimal animal health, including disease control, ability to identify specific diseases affecting this species, vaccination protocols, treatment of external/internal parasites, alleviating or dealing with sexual incompatibility-induced trauma, recognizing general indices of health and illness and ensuring vigilance in avoiding animal obesity.

3. understanding the basic biology of the species, including onset of puberty, duration of the estrous cycle, behavioral cues associated with estrus, physiological and blood normal values and general social and reproductive behavior, length of gestation, infant growth curves, weaning, change in pelage, safe introduction of males and females, the need to cut canine teeth, hand-rearing of cubs and impact of inbreeding depression on overall reproductive efficiency.

4. understanding nutritive and feeding requirements, including protein and mineral needs, specific diets on the basis of age and reproductive status, food additives, need for greens or taurine, standard amounts of food per animal, diet changing protocols, the need for fasting days, preparation and proper handling of various foods, location of feeding stations (i.e., high versus low and open versus sheltered) and determining if hair loss is related to nutritional problems.

5. the potential use of assisted reproductive and other biotechnologies especially artificial insemination with fresh or frozen spermatozoa and the routine monitoring of female reproductive status and activity by fecal steroid hormone monitoring. Related to assisted reproduction is the potential of genome resource banks (frozen repositories of sperm, embryos, tissue, blood products and DNA) that can be useful for assisting in moving genes among clouded leopard populations while helping propagate pairs that are sexually incompatible. These biomaterials also will find use in sorting out issues related to subspecific designations, measuring genetic variation, monitoring disease

outbreaks and helping identify pathogens that may be influencing health status of the captive population.

Therefore, the working group recommended that a first step should be the development of a Clouded Leopard Husbandry Manual for Taiwan with the assistance and expertise of the Conservation Breeding Specialist Group and colleagues within the South East Asian Zoo Association. Secondly, intensive training workshops should be developed and implemented with the focus on basic husbandry, nutrition, veterinary medicine and reproduction. The latter should involve in-country training as well as the opportunity of Taiwanese to train in countries abroad.

Additionally, it is unclear at this time if any clouded leopards remain in nature in Taiwan. Until this is known, the source of animals for the captive breeding program cannot be determined. For example, if no indigenous clouded leopards are located, then it may be necessary to import clouded leopards from other countries. The origin of these animals will be critical and, again, is related to the disturbing, unanswered issue of the existence of multiple subspecies.

Therefore, this working group endorses, as a high priority, the need for molecular genetic surveys of all extant clouded leopard populations in all range countries to verify or nullify that truly distinct subspecies exist. Animals currently under the ownership of private breeders also should be tested. Results will form the basis for making future critical decisions about which animals to include both in the captive breeding program and for the reintroduction project.

Finally, to accurately track individual animals that will be transferred from institution-to-institution or from the wild-to-captivity or from captivity-to-the wild, it will be mandatory that each animal be precisely identified with a clear, unique and readable number. An International Clouded Leopard Studbook has been established with the studbook keeper being Norah Fletchall at the John Ball Zoo, U.S.A. Therefore, this working group recommends and insists that all captive clouded leopards associated with this formally proposed captive breeding and restoration project be registered with the International Studbook Keeper and accurately tattooed and implanted with a transponder microchip. The Taiwan zoo community should consider creating and managing a regional studbook to facilitate managing clouded leopards in this country and adjacent regions.

CLOUDED LEOPARD - TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

REPORT

POPULATION BIOLOGY AND MODELING

族群及圈養雲豹的資料，大部份圈養雲豹的產地及亞種種源也都不明。雖然並資料並不理想，但至少可作爲模擬計算的開始。

模擬參數資料的輸入

第一次繁殖年齡(Age of First Reproduction)：

VORTEX對繁殖(breeding)年齡的定義是指母獸生幼獸的時間，而非性成熟的年齡。因此，雖然圈養雲豹全年皆有交配，但大多數幼獸都在早春時期出生，兩歲時生第一胎幼獸。VORTEX也可使用生殖年齡的平均數(mean)或中數(median)，並估算其變異(variation)，來取代生產幼獸的最早年齡。雖然有些雌雲豹早在2歲時就生產，但圈養雲豹產第一胎的平均年齡是3歲，所以我們以此數值輸入模擬程式，且野外族群的生殖成熟時間一般可能較圈養族群晚，因此3歲是一個保守的估計。同理，雄雲豹可於2歲時開始繁殖(幼獸可在父獸2歲時產下)，個體間的競爭可能僅允許年齡較大的雄獸繁殖。然而，此一壓力的程度隨族群密度及年齡結構而變，有關雲豹此方面的資料則完全不清楚。此次模擬選擇3歲雄獸做父獸，假如雲豹的交配體系爲一夫多妻(polygynous)制，則雄性個體繁殖年齡的選擇在族群極小的情況下，才可能會顯現出小族群逢機變異的負面效果。假如雲豹的交配體系爲一夫一妻(monogamous)制，則可繁殖雄獸的數量將視族群中成體的性比(sex ratio)而定。

幼獸的生產(Cub Production)：

VORTEX將每胎產子數(number of cubs per litter)、生殖間隔(litter interval)、以及生產第一胎的雌成獸年齡比例結合成爲一個變數，稱爲每胎產子數(litter size)。由圈養雲豹家譜顯示，平均每胎產子數爲1.6隻，少數可達3隻。大約44%的雲豹每胎產子1隻，每胎2隻者約50%，每胎產3隻者約6%，然而圈養的雌雲豹只有25%曾經產子。兩次成功繁殖的最短間隔是1年，而平均可能將近2年，因此我們以2年做爲野外族群的平均生殖間隔時間。由與雲豹相似大小的貓科野生動物(bobcat 及lynx)資料顯示，若有足夠的食物來源也可以每年繁殖。因此，決定此一參數必須先進行一重要工作，即對健康野生雲豹族群的野外調查。此次模擬所用之數值爲50%成獸無繁殖(每胎產子數爲0)，22%的成獸每胎產子數爲1隻，25%爲產子2隻，3%爲產子3隻。

族群生物學與族群模式

台灣雲豹的可能棲地是將近一百萬公頃的崎嶇林地，此區域約佔全台灣面積的三分之一。這些殘存的棲地中有三分之一(約三十三萬公頃)是屬於三個國家公園與兩個野生動物保留區。由近年的狩獵現況及少有毛皮被保存的狀況顯示，台灣雲豹若有殘存族群也是非常稀少了。目前並不確定野外雲豹族群是否已滅絕，雖然近年來狩獵壓力降低，然而由於雲豹的夜行習性、山區地貌的崎嶇難行及觀察者所及地區有限，使得雲豹被發現的機會極微。假如有存活的雲豹，其族群也可能非常小且呈破碎化。由於沒有任何野外調查數據可資利用，野生動物學者僅能由10年的狩獵狀況調查及多年未有雲豹蹤跡報告來估計，台灣雲豹的數量可能瀕臨絕種。雖然對雲豹瞭解如此淺薄，此估計至少提供一個起點，以檢測未來台灣雲豹現存族群或是再引入計劃的管理策略。

復育及積極經營策略的需求與效果，如能被模式化以提供可實行之建議，可能是保存該族群最有效的方法。VORTEX是由Robert Lacy與Kim Hughes 所寫成的一套電腦模擬軟體，作為研究多重變數之間隨機性交互作用的工具。

現在的VORTEX程式是一種Monte Carlo模擬程式，對deterministic force的效果，及其它對野生動物族群的動態、環境與遺傳學上的隨機事件等對野生動物族群的影響進行分析。VORTEX針對族群動力學模式加入一些不連續(discrete)、有順序(sequential)的事件(例如出生、死亡、重大災害等)，這些事件的發生則由機率決定。這些事件的發生機率被模式化成為一些固定或是隨機的變數，這些變數是隨特定的統計分佈而形成。此程式模擬一個族群的方式是輸入各種來自於能行有性生殖雙套體之生物(diploid organisms)典型生活史之相關事件等一系列的步驟。

此電腦模擬程式結果並不能給一個絕對的答案，因為此模擬設計是先將參數輸入程式內模擬它們的交互作用，然後用來推測未來的結果。模擬過程中也考慮存在於自然界中的隨機過程(random process)。對於模擬結果的解釋則要依賴我們已瞭解的雲豹生物學知識、影響雲豹族群的種種狀況以及未來可能的變化等資訊而加以推論。

程式模擬的結果是受限於輸入資料的質與量。由於過去並沒有台灣雲豹野生族群的生物學資料，我們引用其他相似體型貓科動物野生

經由輸入無繁殖雌獸比例之標準偏差(SD)，繁殖上的變異(variation)就能在VORTEX程式中進行模擬。但因缺乏數據，我們假設此變異爲平均數的25%，變異原因是食物產量的波動加上雌獸達到性成熟年齡的變異。VORTEX模擬每年的繁殖百分比，此數據是從一個平均數爲60%，標準偏差爲12.5%的二項式分布中獲得。每胎產1隻與2隻的相對比例維持不變。圈養雲豹的出生性比率爲0.56(雄：雌=1.27)，我們使用此數值爲模擬的預定值。對照組則使用相等性比率。

老化(無生殖力)年齡（Age of Senescence）：

VORTEX假設動物在正常的繁殖速率下，終生具有繁殖能力。圈養雲豹壽命可超過15歲，但繁殖年齡則約爲12歲，因此以12歲做爲台灣雲豹繁殖的極限年齡。

死亡率(Mortality)：

此資料可以三種方式輸入VORTEX程式:(1)每一性別年齡層中，預估每年可能死亡的百分比及這些百分比的變異數(variance)，(2)每個性別年齡層中去除一固定數值(例如打獵捕獲的數目)，(3)因重大的自然災變，族群總數降低至一定數量，存活率因而降低。

野外族群的幼體存活率是相當多變的，影響這些變異的因素尚未能瞭解。最後，我們使用圈養雲豹族群的平均幼體死亡率(35%)做爲台灣雲豹野外族群幼體死亡率的最佳估計。圈養族群中雄幼獸與雌幼獸的死亡率相似，因此兩者的死亡率皆假設爲35%。我們也用50%的幼體死亡率進行模擬，以測試此一參數對族群動態敏感性的影響。

野外雲豹的存活與否深受人類行爲影響，例如狩獵、盜獵及除患(nuisance kill)等。假如雲豹在保護區內的存活率高，則圈養族群的平均死亡率將提供野外死亡率估計的較低下限，估計各年齡層平均死亡率爲7%。我們必需經過研究觀察未受狩獵影響的雲豹族群，以發展一套死亡率變動程序，來預測一未受盜獵且在棲地負荷量以下的族群死亡率。由環境變異所導至的標準偏差(SD)被考慮定爲平均值的25-50%。

狩獵台灣雲豹是違法的，而除患也幾乎不存在，因此人爲的雲豹死亡原因顯然是盜獵及偶然的被獸夾或套圈捕獲。盜獵的程度如何目前並不瞭解，但它確實是影響雲豹族群未來消長的主要變數。因此，

用不同盜獵程度作模擬，可以瞭解未來族群大小的可能趨勢。我們假設盜獵者對雲豹的性別或年齡不會有特別的選擇，而且，因爲我們無法合理預測每個性別年齡層對盜獵的相對脆弱程度，因此假設盜獵對每個階層的影響一樣大。我們也假設盜獵及偶然的獵捕將移除此族群一定比例的數量，而非一定數目的隻數。亦即當族群縮小時，雖然盜獵的比例大致不變，盜獵者將覺得越來越難捕到雲豹，即捕獲的數量可能越來越少。

我們將盜獵當成一種每隔三年發生一次的自然災難(catastrophe)，每次將使每一性別年齡層雲豹隻數減少相同量，減少量則視不同盜獵程度而定。我們以5%的盜獵程度來模擬可能的結果，也就是在模擬中輸入95%程度的影響存活率因子。

我們將獵物族群縮減當成第二種重大自然災害。在研究觀察bobcat及lynx的例子中，食物欠缺被認爲是一項對繁殖有顯著影響的因子(有時會導致全體無法繁殖)，而非影響成體的自然死亡率(此因子可能會影響由於狩獵所造成的人爲死亡率)。我們假設在台灣每10年將發生一次顯著的獵物族群縮減(在模擬中爲10%機率的隨機事件)，此因子減少了正常生產率20%或50%，但並不影響到個體存活率。

<u>棲地負荷量(Carrying Captacity)</u>：

K值決定此族群數量大小的上限，超過此值時就會產生死亡率增加的壓力而使族群數量大小回歸到K值。對於依族群密度大小而改變的存活率，VORTEX使用K值來設定此值的範圍。K值也能夠控制一些與族群密度有關的效應，當族群逐漸趨向K值時，這些效應將隨著做連續性的變化，但因這些效應在再引入計畫的早期不可能有顯著的影響，因此在此次的模擬程式中將這些效應剔除。

我們選擇1,000隻雲豹作爲全島的棲地負荷量，或等於選擇大約每10平方公里有1隻。在亞洲一些保護區中可能給予較高的族群密度，是以上述數值雖然具有爭議性，但當這個族群幾乎等於0且遠低於K值時，在此模擬計劃中所選擇的K值，它的影響是可以忽略的。若棲地遭受分割而成支離破碎的狀態時，則各分裂殘存的雲豹族群在短期內(如20年)將受到個別小棲地負荷量的限制。我們使用30、100及300等較小的K值進行分析，探討棲地嚴重破碎或其它棲地因素的限制對雲豹殘存族群或新引進小族群的影響。

<u>近親繁殖衰退(Inbreeding Depression)</u>：

此次VORTEX分析中，部份模擬選擇加入此因素，以檢查不同保護區破碎的情形所造成的影響。在此項目中我們輸入一假設值=3.14，做爲兩倍體整組基因(diploid genome)的致死量值(lethal equivalents)。由於雲豹缺乏這方面的資料，故選擇由40種經過測量研究的哺乳動物在這方面的中數值(median value)來代替。

最初年齡分佈(Starting Age Distribution)：

此次的模擬分析種源預設由一穩定的年齡結構開始，此結構根據現有的死亡率及繁殖率程序求得該族群在各性別年齡層的數量分布。另一種則假設由已知年齡組成之2及3歲人工飼養後野放的個體。

最初族群大小(Starting Population Size)：

使用10隻及200隻兩種雲豹族群大小做爲最初之族群進行模擬分析。就10隻族群的模擬而言，另每隔2年再加入10隻，直至野放數量達40或50隻爲止。

計畫的重覆性及年限(Iterations and Years of Projection)：

每一個模擬腳本重覆執行200次，整個計畫時間爲100年，模擬結果總結以一個以10年爲一區間的曲線圖表示。假如有需要參考其它結果及進一步的細節，每個表格化的模擬腳本均有對應的檔案可查。此次使用之模擬程式爲VORTEX 7.0b 版本。

輸入之資料樣本(Sample Input File)：

模擬一次所需輸入各變數之資料，列於本節之後，顯示於表中。

結　　果

模擬的結果：

非逢機模擬包括設定族群的成長率(r, lambda, 及Ro)，雌及雄個體之代齡，穩定之年齡分佈及雌雄成體性比。其成長率由Leslie矩陣計算得來，其值爲正表示族群能存活增長，其值爲零表示維持穩定，其成長率與族群起始的大小無關，但隨不同程度的天災、死亡率及生殖率而有變動(表一)。雲豹的代齡視首次生殖的年齡而定，約在5.5-7.0年之間，是以100年的模擬時間將包括14-16代。

經由許多重覆計算所得的各不同時段之均數及標準偏差，用來模擬逢機族群之成長率(r)、滅絕率(Pe)、N爲100年時之最終族群數、遺傳變異之維繫程度(He)及滅絕的平均時間(Te)，逢機族群之成長率及滅絕率對每次模擬所賦予之族群特性及生殖特性之數值及變異極爲敏感，亦與族群大小、近親交配衰退效應、性比及交配系統有關。本節末有一資料輸出樣本可供參考。

<u>逢機狀況下族群之成長率</u>：

在雲豹族群之模擬中皆有確定之正成長值，在deterministic模式中其族群皆會存活並成長，但在逢機狀況下的族群成長率多爲負值（表一及表二），甚至在成長率爲正值的情況下都有族群滅絕之虞，反應出小族群及環境變數的影響(圖一)。逢機的成長率必需大於5%，才能使100年內族群滅絕的機率低於10%。當逢機的成長率小於5%時，族群內的遺傳變異也會快速流失，反應出在這些狀況下族群緩慢浮動與成長的事實(圖二)。就長期的存活率而言，族群遺傳變異的流失應小於每代0.5%，即以雲豹族群爲例，在100年內族群遺傳變異的流失應不超過7%。

<u>有200隻個體的族群</u>：

族群成長率和繁殖參數有關，例如胎次間隔(interbirth interval)、某年中繁殖一胎的雌獸所佔比例、每胎隻數、首次繁殖年齡及出生時性比。得自血統書中記載圈養族群的資料顯示，只有25%的成年雌獸有繁殖，表示在每一特定年份中有75%的雌獸是不繁殖的，此種甚低的繁殖比例使族群成長率很低或甚至爲負值，再加上第一年幼獸死亡率的影響，此族群是不可能存活的。根據其他貓科動物的資料，假設雲豹的胎次間隔爲2年，亦即在每一特定年份中有50%的雌獸不繁殖，此種狀況的族群會有呈正值的成長率。圈養雲豹的首次繁殖年齡(AFR)約爲2歲，但多數個體直到3歲才開始生殖，此增加1年的影響在於族群成長率將降低50%(表一的001號及011號腳本)。在野外族群模擬中以3歲爲首次繁殖年齡，因爲圈養個體開始繁殖的年齡一

般較野外個體早。圈養雲豹的平均每胎隻數爲1.6隻，模擬中亦使用此數值，但對野外族群應進行此方面的調查，因爲此數值可能是因種而異的。許多較大型的貓科動物每胎隻數爲2.4隻，此使其族群成長潛力增加幾近二倍。圈養族群的出生性比爲0.56，此種偏移的結果可能是一個因種而異的數值，或是圈養族群近親交配的結果，或是單純的取樣誤差所造成。與一般哺乳動物爲0.50的性比相比，偏移的性比使族群成長率減低0.02(r)。族群成長率也和下列因素有關，包括各性別與年齡層的自然死亡率、環境變異的附加效應、人爲的死亡率及天災死亡率。圈養族群的資料顯示第一年幼獸的死亡率約爲35%，此值偏移5%可使成長率 r 改變約0.01。在部份腳本中以50%的第一年死亡率進行小族群的模擬。

<u>殘存族群爲10隻動物</u>：

假設有一個孤立的雲豹殘存族群或在一個小棲地碎片中的雲豹野生族群，此族群只有10隻動物，在不同的K值及第一年死亡率的影響下，模擬不同腳本所推測出的族群成長率及滅絕率。

模擬腳本分爲基本腳本、自然災難腳本(加入catastrophe因素)及近親交配腳本(加入inbreeding depression因素)。基本腳本在一較大族群上提供一平均6%的年成長率。基本的參數包括：首次繁殖年齡3歲、每年繁殖之雌獸比例50%、平均每胎1.6隻、7%的一齡以上死亡率。自然災難腳本模擬兩種較不劇烈的天災效應(發生頻率爲10%)，近親交配腳本採用3.14致死值。模擬時間100年並重覆100次。模擬結果(表、表二、圖三-圖十四)顯示在大多數的情況下這些小族群都有很高的滅絕危機，即使在狀況允許較大的族群成長時也對小族群不利，尤其是近親交配因素的加入具有不可抗拒的毀滅性，此一現象已在佛羅里達山獅的研究中出現。

表、第一年死亡率、棲地負荷量、天災及近親交配對雲豹小族群成長率與滅絕機率的影響。

僅有10隻雲豹的起始族群，隨時間的滅絕機率變化結果顯示(表二、圖三及圖四)，在50%的第一年幼獸死亡率下，有的族群很快就會滅絕，而大多數的族群都不會存活；而輕度之近親交配效應則使所有的族群在90年內全部滅絕。

由這些僅有10隻雲豹的族群所進行的族群預測顯示(表二、圖五及圖六)，假如第一年死亡率爲35%時，在早年存活的族群可繼續成

長，但是這些存活族群都將在100年後損失25-35%的起始遺傳變異度(圖六及圖七)，並有嚴重的近親交配現象(圖九及圖十)。上述現象可能減低族群的長期存活率，且使其在面對族群大小的變動及環境變異時更顯脆弱。假如棲地負荷量減爲30隻(圖十一至十四)，將使所有不利因素更顯嚴重而大大降低了族群的存活率。假如要免於滅絕，這種野生小族群需要持續深入的經營、補充及更新。

再引入40至50隻動物：

有關再引入的文獻及經驗指出，多數成功的再引入計畫需要50-100隻個體，可能隨時間漸進的成群分批釋放，並且謹慎進行後續追蹤以計畫下一步。族群模擬設計了一系列的腳本，將已知年齡的個體以10隻一群的方式每2年釋放一次，總共釋放約40至50隻動物。幾乎所有的模擬族群在測試狀況下都以0.033的成長率存活了，這樣的建立者數量具有足夠的野外族群遺傳代表性，且如果棲地負荷量可達300隻以上，則此族群可保留相當高的遺傳變異度。一個釋放計畫的設計必需在第一年進行深入的監測，以便熟悉當地環境找出最有效的狀況。此次模擬中的設計只是提供一個範例。

族群生物學及模擬總結

研究結果顯示台灣的雲豹族群假如尚存也僅存極少數量，其總數量必定遠低於棲地負荷量，圈套陷阱及盜獵顯然是對其生存最大的威脅。此次模擬顯示只有10隻動物的族群(殘存或是再引入族群)即使在缺乏近親交配衰退、天災或盜獵的逢機狀況下，仍有相當高的滅絕危機。而在所有模擬腳本中的非逢機族群成長率(r)皆爲正值，表示非逢機模式大大低估了滅絕的危機。在逢機模擬中成長率爲正值卻有高度滅絕危機，此反應了小族群對環境變動的不確定性抵抗力不佳。只要增加族群大小到100隻，就可以使滅絕危機降至5%以下，並可避免近親交配的影響。在基本模擬中若加入近親交配缺陷因素，將使100年内滅絕機率自15%增至64%；僅增加一歲死亡率的個別影響則滅絕率由15%增至66%，兩項因素同時影響將使滅絕機會達100%。假如棲地的負荷量由100隻降至30隻，則絕種機會將由15%增至29%，若再加入近親交配缺陷的因素，將倍增至81%。因此，如果小族群由於棲地受限或狩獵壓力導至無法增加族群數量，其走向滅絕的命運將不可避免。

假如可發現一個小的台灣雲豹族群，必需考慮積極的經營管理、嚴格的保護及建立圈養族群的可行性，以避免最終滅絕的結果。及早擬定詳細行動計畫相當有用，以備進行調查發現殘存族群時的對策，

並可避免保育決策上的衝突。在基本模擬腳本中，超過100隻以上的較大族群以0.058的逢機成長率增加，族群加倍的時間約須10至12年。

爲了有足夠的動物供野放以確保至少30隻動物存活並繁殖做爲野外族群的建立者，必需慎重考慮再引入計畫。爲了達成上述目標，大約需要50隻以上不同親緣的雲豹，不同時間及地點分別釋放。再引入計畫需要更進一步的討論、模擬及規劃，同時需要更多有關雲豹族群的野外調查資料，才能獲得最恰當的策略。

假如再引入計畫要使用圈養繁殖的個體，必需先釐清這些動物的血統且沒有經過近親交配才行。假如私人的動物擁有者不能提供確定的種源來源，可能自印亞族群(泰國、寮國、柬埔寨、越南)引入新血統較佳。雲豹的亞種或地理族群目前仍無法利用遺傳標記辨識，因爲缺乏適當的樣本進行分子遺傳分析，必需等到遺傳分析完成才有可能對不明種源的圈養個體進行辨認。

曲線圖說明

圖 1、雲豹族群滅絕的機率與逢機狀況下族群成長率的關係。包括最初族群量、幼體死亡率、生育年齡、災變頻率及近親繁殖衰變等影響的不同組合。注意在逢機狀態下族群雖具正成長率，亦會面臨絕種。但在 deterministic 模式下，正成長率則顯示族群成長及存活。

圖 2、逢機狀況下族群成長率與百年內雲豹存活族群中遺傳變異性保有之關係。腳本包括最初族群量、幼體死亡率、生育年齡、災變頻率及近親繁殖衰變等影響的不同組合。正成長率是維繫族群遺傳變異性之必要條件。

圖 3、族群個體數爲 10，負載量爲 100，幼體死亡率爲 50％之雲豹族群其存活率的預測。三個腳本爲（1）基本組合；（2）加入兩個災變（兩者發生頻率皆爲 10％，但一種造成剩 90％族群的存活，另一種則影響 80％個體的繁殖）；
（3）近親繁殖衰變（相當於 3.14 致死值）

圖 4、族群個體數爲 10，負載量爲 100，幼體死亡率爲 35％之雲豹族群其存活率的預測。三個腳本同圖 3。

圖 5、族群個體數爲 10，負載量爲 100，幼體死亡率爲 50％之野生雲豹族群平均存活量的預測。三個腳本同圖 3。某些族群在此時滅絕。

圖 6、族群個體數爲 10，負載量爲 100，幼體死亡率爲 35％之野生雲豹族群平均存活量的預測。三個腳本同圖 3。

圖 7、族群個體數爲 10，負載量爲 100，幼體死亡率爲 50％之野生雲豹族群其平均存留變異性的預測。三個腳本同圖 3。某些族群在此時滅絕。遺傳變異的原始值設定爲 1.00。此值的測定可顯示模擬族群近親交配的速率及程度。由於模擬時段爲 100 年，如以每代 6 年計，則包括 15～17 世代。是以 100 年時 0.85 之變異值顯示共損失 15％的變異度，亦即每代損失 1％之變異。

圖 8、族群個體數爲 10，負載量爲 100，幼體死亡率爲 35％之野生雲豹族群其平均存留變異性的預測。三個腳本同圖 3。某些族群在此時滅絕。

圖 9、族群個體數爲 10，負載量爲 100，幼體死亡率爲 50％之野生雲豹族群其平均近親係數的預測。三個腳本同圖 3。某些族群在此時滅絕。

圖 10、族群個體數爲 10，負載量爲 100，幼體死亡率爲 35％之野生雲豹族群其平均存留變異性的預測。三個腳本同圖 3。某些族群在此時滅絕。

圖 11、族群個體數爲 10，負載量爲 30，幼體死亡率爲 50％之野生雲豹族群其存活率的預測。三個腳本同圖 3。

圖 12、族群個體數爲 10，負載量爲 30，幼體死亡率爲 35％之野生雲豹族群其存活率的預測。三個腳本同圖 3。

圖 13、族群個體數爲 10，負載量爲 30，幼體死亡率爲 35％之野生雲豹族群其存留變異性率的預測。三個腳本同圖 3。

圖 14、族群個體數爲 10，負載量爲 30，幼體死亡率爲 35％之野生雲豹族群其近親交配係數的預測。三個腳本同圖 3。

圖 15、根據基本腳本針對三種不同野放的方式，雲豹族群 10 年內的預測。第一種方式爲野放雌雄各 5 隻，分別爲 2 及 3 歲大。在 2、4、6 及 8 年後，每次各再野放 10 隻。第二種方式增加一個有 33％機會發生大災變，這會對所有個體產生 5％致命的機會。第三種方式（40 隻野放）與第一種方式同，唯有差別在野放個體時的年限止於第 6 年。

圖 16、50 隻動物野放（第一種方式）百年內族群的年預測。此腳本族群之滅絕機率小。族群在第 10 到 50 年中呈線性增加，至其達到環境負載量時則呈高原之型態。

族群及圈養雲豹的資料，大部份圈養雲豹的產地及亞種種源也都不明。雖然並資料並不理想，但至少可作爲模擬計算的開始。

模擬參數資料的輸入

第一次繁殖年齡(Age of First Reproduction)：

VORTEX對繁殖(breeding)年齡的定義是指母獸生幼獸的時間，而非性成熟的年齡。因此，雖然圈養雲豹全年皆有交配，但大多數幼獸都在早春時期出生，兩歲時生第一胎幼獸。VORTEX也可使用生殖年齡的平均數(mean)或中數(median)，並估算其變異(variation)，來取代生產幼獸的最早年齡。雖然有些雌雲豹早在2歲時就生產，但圈養雲豹產第一胎的平均年齡是3歲，所以我們以此數值輸入模擬程式，且野外族群的生殖成熟時間一般可能較圈養族群晚，因此3歲是一個保守的估計。同理，雄雲豹可於2歲時開始繁殖(幼獸可在父獸2歲時產下)，個體間的競爭可能僅允許年齡較大的雄獸繁殖。然而，此一壓力的程度隨族群密度及年齡結構而變，有關雲豹此方面的資料則完全不清楚。此次模擬選擇3歲雄獸做父獸，假如雲豹的交配體系爲一夫多妻(polygynous)制，則雄性個體繁殖年齡的選擇在族群極小的情況下，才可能會顯現出小族群逢機變異的負面效果。假如雲豹的交配體系爲一夫一妻(monogamous)制，則可繁殖雄獸的數量將視族群中成體的性比(sex ratio)而定。

幼獸的生產(Cub Production)：

VORTEX將每胎產子數(number of cubs per litter)、生殖間隔(litter interval)、以及生產第一胎的雌成獸年齡比例結合成爲一個變數，稱爲每胎產子數(litter size)。由圈養雲豹家譜顯示，平均每胎產子數爲1.6隻，少數可達3隻。大約44%的雲豹每胎產子1隻，每胎2隻者約50%，每胎產3隻者約6%，然而圈養的雌雲豹只有25%曾經產子。兩次成功繁殖的最短間隔是1年，而平均可能將近2年，因此我們以2年做爲野外族群的平均生殖間隔時間。由與雲豹相似大小的貓科野生動物(bobcat 及lynx)資料顯示，若有足夠的食物來源也可以每年繁殖。因此，決定此一參數必須先進行一重要工作，即對健康野生雲豹族群的野外調查。此次模擬所用之數值爲50%成獸無繁殖(每胎產子數爲0)，22%的成獸每胎產子數爲1隻，25%爲產子2隻，3%爲產子3隻。

族群生物學與族群模式

台灣雲豹的可能棲地是將近一百萬公頃的崎嶇林地，此區域約佔全台灣面積的三分之一。這些殘存的棲地中有三分之一(約三十三萬公頃)是屬於三個國家公園與兩個野生動物保留區。由近年的狩獵現況及少有毛皮被保存的狀況顯示，台灣雲豹若有殘存族群也是非常稀少了。目前並不確定野外雲豹族群是否已滅絕，雖然近年來狩獵壓力降低，然而由於雲豹的夜行習性、山區地貌的崎嶇難行及觀察者所及地區有限，使得雲豹被發現的機會極微。假如有存活的雲豹，其族群也可能非常小且呈破碎化。由於沒有任何野外調查數據可資利用，野生動物學者僅能由10年的狩獵狀況調查及多年未有雲豹蹤跡報告來估計，台灣雲豹的數量可能瀕臨絕種。雖然對雲豹瞭解如此淺薄，此估計至少提供一個起點，以檢測未來台灣雲豹現存族群或是再引入計劃的管理策略。

復育及積極經營策略的需求與效果，如能被模式化以提供可實行之建議，可能是保存該族群最有效的方法。VORTEX是由Robert Lacy與Kim Hughes 所寫成的一套電腦模擬軟體，作爲研究多重變數之間隨機性交互作用的工具。

現在的VORTEX程式是一種Monte Carlo模擬程式，對deterministic force的效果，及其它對野生動物族群的動態、環境與遺傳學上的隨機事件等對野生動物族群的影響進行分析。VORTEX針對族群動力學模式加入一些不連續(discrete)、有順序(sequential)的事件(例如出生、死亡、重大災害等)，這些事件的發生則由機率決定。這些事件的發生機率被模式化成爲一些固定或是隨機的變數，這些變數是隨特定的統計分佈而形成。此程式模擬一個族群的方式是輸入各種來自於能行有性生殖雙套體之生物(diploid organisms)典型生活史之相關事件等一系列的步驟。

此電腦模擬程式結果並不能給一個絕對的答案，因爲此模擬設計是先將參數輸入程式內模擬它們的交互作用，然後用來推測未來的結果。模擬過程中也考慮存在於自然界中的隨機過程(random process)。對於模擬結果的解釋則要依賴我們已瞭解的雲豹生物學知識、影響雲豹族群的種種狀況以及未來可能的變化等資訊而加以推論。

程式模擬的結果是受限於輸入資料的質與量。由於過去並沒有台灣雲豹野生族群的生物學資料，我們引用其他相似體型貓科動物野生

經由輸入無繁殖雌獸比例之標準偏差(SD)，繁殖上的變異(variation)就能在VORTEX程式中進行模擬。但因缺乏數據，我們假設此變異爲平均數的25%，變異原因是食物產量的波動加上雌獸達到性成熟年齡的變異。VORTEX模擬每年的繁殖百分比，此數據是從一個平均數爲60%，標準偏差爲12.5%的二項式分布中獲得。每胎產1隻與2隻的相對比例維持不變。圈養雲豹的出生性比率爲0.56(雄：雌=1.27)，我們使用此數值爲模擬的預定值。對照組則使用相等性比率。

老化(無生殖力)年齡（Age of Senescence）：

VORTEX假設動物在正常的繁殖速率下，終生具有繁殖能力。圈養雲豹壽命可超過15歲，但繁殖年齡則約爲12歲，因此以12歲做爲台灣雲豹繁殖的極限年齡。

死亡率(Mortality)：

此資料可以三種方式輸入VORTEX程式:(1)每一性別年齡層中，預估每年可能死亡的百分比及這些百分比的變異數(variance)，(2)每個性別年齡層中去除一固定數值(例如打獵捕獲的數目)，(3)因重大的自然災變，族群總數降低至一定數量，存活率因而降低。

野外族群的幼體存活率是相當多變的，影響這些變異的因素尚未能瞭解。最後，我們使用圈養雲豹族群的平均幼體死亡率(35%)做爲台灣雲豹野外族群幼體死亡率的最佳估計。圈養族群中雄幼獸與雌幼獸的死亡率相似，因此兩者的死亡率皆假設爲35%。我們也用50%的幼體死亡率進行模擬，以測試此一參數對族群動態敏感性的影響。

野外雲豹的存活與否深受人類行爲影響，例如狩獵、盜獵及除患(nuisance kill)等。假如雲豹在保護區內的存活率高，則圈養族群的平均死亡率將提供野外死亡率估計的較低下限，估計各年齡層平均死亡率爲7%。我們必需經過研究觀察未受狩獵影響的雲豹族群，以發展一套死亡率變動程序，來預測一未受盜獵且在棲地負荷量以下的族群死亡率。由環境變異所導至的標準偏差(SD)被考慮定爲平均值的25-50%。

狩獵台灣雲豹是違法的，而除患也幾乎不存在，因此人爲的雲豹死亡原因顯然是盜獵及偶然的被獸夾或套圈捕獲。盜獵的程度如何目前並不瞭解，但它確實是影響雲豹族群未來消長的主要變數。因此，

用不同盜獵程度作模擬，可以瞭解未來族群大小的可能趨勢。我們假設盜獵者對雲豹的性別或年齡不會有特別的選擇，而且，因爲我們無法合理預測每個性別年齡層對盜獵的相對脆弱程度，因此假設盜獵對每個階層的影響一樣大。我們也假設盜獵及偶然的獵捕將移除此族群一定比例的數量，而非一定數目的隻數。亦即當族群縮小時，雖然盜獵的比例大致不變，盜獵者將覺得越來越難捕到雲豹，即捕獲的數量可能越來越少。

我們將盜獵當成一種每隔三年發生一次的自然災難(catastrophe)，每次將使每一性別年齡層雲豹隻數減少相同量，減少量則視不同盜獵程度而定。我們以5%的盜獵程度來模擬可能的結果，也就是在模擬中輸入95%程度的影響存活率因子。

我們將獵物族群縮減當成第二種重大自然災害。在研究觀察bobcat及lynx的例子中，食物欠缺被認爲是一項對繁殖有顯著影響的因子(有時會導致全體無法繁殖)，而非影響成體的自然死亡率(此因子可能會影響由於狩獵所造成的人爲死亡率)。我們假設在台灣每10年將發生一次顯著的獵物族群縮減(在模擬中爲10%機率的隨機事件)，此因子減少了正常生產率20%或50%，但並不影響到個體存活率。

棲地負荷量(Carrying Captacity)：

K值決定此族群數量大小的上限，超過此值時就會產生死亡率增加的壓力而使族群數量大小回歸到K值。對於依族群密度大小而改變的存活率，VORTEX使用K值來設定此值的範圍。K值也能夠控制一些與族群密度有關的效應，當族群逐漸趨向K值時，這些效應將隨著做連續性的變化，但因這些效應在再引入計畫的早期不可能有顯著的影響，因此在此次的模擬程式中將這些效應剔除。

我們選擇1,000隻雲豹作爲全島的棲地負荷量，或等於選擇大約每10平方公里有1隻。在亞洲一些保護區中可能給予較高的族群密度，是以上述數值雖然具有爭議性，但當這個族群幾乎等於0且遠低於K值時，在此模擬計劃中所選擇的K值，它的影響是可以忽略的。若棲地遭受分割而成支離破碎的狀態時，則各分裂殘存的雲豹族群在短期內(如20年)將受到個別小棲地負荷量的限制。我們使用30、100及300等較小的K值進行分析，探討棲地嚴重破碎或其它棲地因素的限制對雲豹殘存族群或新引進小族群的影響。

近親繁殖衰退(Inbreeding Depression)：

此次VORTEX分析中，部份模擬選擇加入此因素，以檢查不同保護區破碎的情形所造成的影響。在此項目中我們輸入一假設值=3.14，做爲兩倍體整組基因(diploid genome)的致死量值(lethal equivalents)。由於雲豹缺乏這方面的資料，故選擇由40種經過測量研究的哺乳動物在這方面的中數值(median value)來代替。

最初年齡分佈(Starting Age Distribution)：

此次的模擬分析種源預設由一穩定的年齡結構開始，此結構根據現有的死亡率及繁殖率程序求得該族群在各性別年齡層的數量分布。另一種則假設由已知年齡組成之2及3歲人工飼養後野放的個體。

最初族群大小(Starting Population Size)：

使用10隻及200隻兩種雲豹族群大小做爲最初之族群進行模擬分析。就10隻族群的模擬而言，另每隔2年再加入10隻，直至野放數量達40或50隻爲止。

計畫的重覆性及年限(Iterations and Years of Projection)：

每一個模擬腳本重覆執行200次，整個計畫時間爲100年，模擬結果總結以一個以10年爲一區間的曲線圖表示。假如有需要參考其它結果及進一步的細節，每個表格化的模擬腳本均有對應的檔案可查。此次使用之模擬程式爲VORTEX 7.0b 版本。

輸入之資料樣本(Sample Input File)：

模擬一次所需輸入各變數之資料，列於本節之後，顯示於表中。

結　　果

模擬的結果：

非逢機模擬包括設定族群的成長率(r, lambda, 及Ro)，雌及雄個體之代齡，穩定之年齡分佈及雌雄成體性比。其成長率由Leslie矩陣計算得來，其值爲正表示族群能存活增長，其值爲零表示維持穩定，其成長率與族群起始的大小無關，但隨不同程度的天災、死亡率及生殖率而有變動(表一)。雲豹的代齡視首次生殖的年齡而定，約在5.5-7.0年之間，是以100年的模擬時間將包括14-16代。

經由許多重覆計算所得的各不同時段之均數及標準偏差，用來模擬逢機族群之成長率(r)、滅絕率(Pe)、N爲100年時之最終族群數、遺傳變異之維繫程度(He)及滅絕的平均時間(Te)，逢機族群之成長率及滅絕率對每次模擬所賦予之族群特性及生殖特性之數值及變異極爲敏感，亦與族群大小、近親交配衰退效應、性比及交配系統有關。本節末有一資料輸出樣本可供參考。

逢機狀況下族群之成長率：

在雲豹族群之模擬中皆有確定之正成長值，在deterministic模式中其族群皆會存活並成長，但在逢機狀況下的族群成長率多爲負值（表一及表二），甚至在成長率爲正值的情況下都有族群滅絕之虞，反應出小族群及環境變數的影響(圖一)。逢機的成長率必需大於5%，才能使100年內族群滅絕的機率低於10%。當逢機的成長率小於5%時，族群內的遺傳變異也會快速流失，反應出在這些狀況下族群緩慢浮動與成長的事實(圖二)。就長期的存活率而言，族群遺傳變異的流失應小於每代0.5%，即以雲豹族群爲例，在100年內族群遺傳變異的流失應不超過7%。

有200隻個體的族群：

族群成長率和繁殖參數有關，例如胎次間隔(interbirth interval)、某年中繁殖一胎的雌獸所佔比例、每胎隻數、首次繁殖年齡及出生時性比。得自血統書中記載圈養族群的資料顯示，只有25%的成年雌獸有繁殖，表示在每一特定年份中有75%的雌獸是不繁殖的，此種甚低的繁殖比例使族群成長率很低或甚至爲負值，再加上第一年幼獸死亡率的影響，此族群是不可能存活的。根據其他貓科動物的資料，假設雲豹的胎次間隔爲2年，亦即在每一特定年份中有50%的雌獸不繁殖，此種狀況的族群會有呈正值的成長率。圈養雲豹的首次繁殖年齡(AFR)約爲2歲，但多數個體直到3歲才開始生殖，此增加1年的影響在於族群成長率將降低50%(表一的001號及011號腳本)。在野外族群模擬中以3歲爲首次繁殖年齡，因爲圈養個體開始繁殖的年齡一

般較野外個體早。圈養雲豹的平均每胎隻數爲1.6隻，模擬中亦使用此數值，但對野外族群應進行此方面的調查，因爲此數值可能是因種而異的。許多較大型的貓科動物每胎隻數爲2.4隻，此使其族群成長潛力增加幾近二倍。圈養族群的出生性比爲0.56，此種偏移的結果可能是一個因種而異的數值，或是圈養族群近親交配的結果，或是單純的取樣誤差所造成。與一般哺乳動物爲0.50的性比相比，偏移的性比使族群成長率減低0.02(r)。族群成長率也和下列因素有關，包括各性別與年齡層的自然死亡率、環境變異的附加效應、人爲的死亡率及天災死亡率。圈養族群的資料顯示第一年幼獸的死亡率約爲35%，此值偏移5%可使成長率 r 改變約0.01。在部份腳本中以50%的第一年死亡率進行小族群的模擬。

殘存族群爲10隻動物：

假設有一個孤立的雲豹殘存族群或在一個小棲地碎片中的雲豹野生族群，此族群只有10隻動物，在不同的K值及第一年死亡率的影響下，模擬不同腳本所推測出的族群成長率及滅絕率。

模擬腳本分爲基本腳本、自然災難腳本(加入catastrophe因素)及近親交配腳本(加入inbreeding depression因素)。基本腳本在一較大族群上提供一平均6%的年成長率。基本的參數包括：首次繁殖年齡3歲、每年繁殖之雌獸比例50%、平均每胎1.6隻、7%的一齡以上死亡率。自然災難腳本模擬兩種較不劇烈的天災效應(發生頻率爲10%)，近親交配腳本採用3.14致死值。模擬時間100年並重覆100次。模擬結果(表、表二、圖三-圖十四)顯示在大多數的情況下這些小族群都有很高的滅絕危機，即使在狀況允許較大的族群成長時也對小族群不利，尤其是近親交配因素的加入具有不可抗拒的毀滅性，此一現象已在佛羅里達山獅的研究中出現。

表、第一年死亡率、棲地負荷量、天災及近親交配對雲豹小族群成長率與滅絕機率的影響。

僅有10隻雲豹的起始族群，隨時間的滅絕機率變化結果顯示(表二、圖三及圖四)，在50%的第一年幼獸死亡率下，有的族群很快就會滅絕，而大多數的族群都不會存活；而輕度之近親交配效應則使所有的族群在90年內全部滅絕。

由這些僅有10隻雲豹的族群所進行的族群預測顯示(表二、圖五及圖六)，假如第一年死亡率爲35%時，在早年存活的族群可繼續成

長，但是這些存活族群都將在100年後損失25-35%的起始遺傳變異度(圖六及圖七)，並有嚴重的近親交配現象(圖九及圖十)。上述現象可能減低族群的長期存活率，且使其在面對族群大小的變動及環境變異時更顯脆弱。假如棲地負荷量減為30隻(圖十一至十四)，將使所有不利因素更顯嚴重而大大降低了族群的存活率。假如要免於滅絕，這種野生小族群需要持續深入的經營、補充及更新。

再引入40至50隻動物：

有關再引入的文獻及經驗指出，多數成功的再引入計畫需要50-100隻個體，可能隨時間漸進的成群分批釋放，並且謹慎進行後續追蹤以計畫下一步。族群模擬設計了一系列的腳本，將已知年齡的個體以10隻一群的方式每2年釋放一次，總共釋放約40至50隻動物。幾乎所有的模擬族群在測試狀況下都以0.033的成長率存活了，這樣的建立者數量具有足夠的野外族群遺傳代表性，且如果棲地負荷量可達300隻以上，則此族群可保留相當高的遺傳變異度。一個釋放計畫的設計必需在第一年進行深入的監測，以便熟悉當地環境找出最有效的狀況。此次模擬中的設計只是提供一個範例。

族群生物學及模擬總結

研究結果顯示台灣的雲豹族群假如尚存也僅存極少數量，其總數量必定遠低於棲地負荷量，圈套陷阱及盜獵顯然是對其生存最大的威脅。此次模擬顯示只有10隻動物的族群(殘存或是再引入族群)即使在缺乏近親交配衰退、天災或盜獵的逢機狀況下，仍有相當高的滅絕危機。而在所有模擬腳本中的非逢機族群成長率(r)皆為正值，表示非逢機模式大大低估了滅絕的危機。在逢機模擬中成長率為正值卻有高度滅絕危機，此反應了小族群對環境變動的不確定性抵抗力不佳。只要增加族群大小到100隻，就可以使滅絕危機降至5%以下，並可避免近親交配的影響。在基本模擬中若加入近親交配缺陷因素，將使100年內滅絕機率自15%增至64%；僅增加一歲死亡率的個別影響則滅絕率由15%增至66%，兩項因素同時影響將使滅絕機會達100%。假如棲地的負荷量由100隻降至30隻，則絕種機會將由15%增至29%，若再加入近親交配缺陷的因素，將倍增至81%。因此，如果小族群由於棲地受限或狩獵壓力導至無法增加族群數量，其走向滅絕的命運將不可避免。

假如可發現一個小的台灣雲豹族群，必需考慮積極的經營管理、嚴格的保護及建立圈養族群的可行性，以避免最終滅絕的結果。及早擬定詳細行動計畫相當有用，以備進行調查發現殘存族群時的對策，

並可避免保育決策上的衝突。在基本模擬腳本中，超過100隻以上的較大族群以0.058的逢機成長率增加，族群加倍的時間約須10至12年。

爲了有足夠的動物供野放以確保至少30隻動物存活並繁殖做爲野外族群的建立者，必需愼重考慮再引入計畫。爲了達成上述目標，大約需要50隻以上不同親緣的雲豹，不同時間及地點分別釋放。再引入計畫需要更進一步的討論、模擬及規劃，同時需要更多有關雲豹族群的野外調查資料，才能獲得最恰當的策略。

假如再引入計畫要使用圈養繁殖的個體，必需先釐清這些動物的血統且沒有經過近親交配才行。假如私人的動物擁有者不能提供確定的種源來源，可能自印亞族群(泰國、寮國、柬埔寨、越南)引入新血統較佳。雲豹的亞種或地理族群目前仍無法利用遺傳標記辨識，因爲缺乏適當的樣本進行分子遺傳分析，必需等到遺傳分析完成才有可能對不明種源的圈養個體進行辨認。

曲 線 圖 說 明

圖 1、雲豹族群滅絕的機率與逢機狀況下族群成長率的關係。包括最初族群量、幼體死亡率、生育年齡、災變頻率及近親繁殖衰變等影響的不同組合。注意在逢機狀態下族群雖具正成長率，亦會面臨絕種。但在 deterministic 模式下，正成長率則顯示族群成長及存活。

圖 2、逢機狀況下族群成長率與百年內雲豹存活族群中遺傳變異性保有之關係。腳本包括最初族群量、幼體死亡率、生育年齡、災變頻率及近親繁殖衰變等影響的不同組合。正成長率是維繫族群遺傳變異性之必要條件。

圖 3、族群個體數爲 10，負載量爲 100，幼體死亡率爲 50％之雲豹族群其存活率的預測。三個腳本爲（1）基本組合；（2）加入兩個災變（兩者發生頻率皆爲 10％，但一種造成剩 90％族群的存活，另一種則影響 80％個體的繁殖）；
（3）近親繁殖衰變（相當於 3.14 致死值）

圖 4、族群個體數爲 10，負載量爲 100，幼體死亡率爲 35％之雲豹族群其存活率的預測。三個腳本同圖 3。

圖 5、族群個體數爲 10，負載量爲 100，幼體死亡率爲 50％之野生雲豹族群平均存活量的預測。三個腳本同圖 3。某些族群在此時滅絕。

圖 6、族群個體數爲 10，負載量爲 100，幼體死亡率爲 35％之野生雲豹族群平均存活量的預測。三個腳本同圖 3。

圖 7、族群個體數爲 10，負載量爲 100，幼體死亡率爲 50％之野生雲豹族群其平均存留變異性的預測。三個腳本同圖 3。某些族群在此時滅絕。遺傳變異的原始值設定爲 1.00。此值的測定可顯示模擬族群近親交配的速率及程度。由於模擬時段爲 100 年，如以每代 6 年計，則包括 15～17 世代。是以 100 年時 0.85 之變異值顯示共損失 15％的變異度，亦即每代損失 1％之變異。

圖 8、族群個體數爲 10，負載量爲 100，幼體死亡率爲 35％之野生雲豹族群其平均存留變異性的預測。三個腳本同圖 3。某些族群在此時滅絕。

圖 9、族群個體數爲 10，負載量爲 100，幼體死亡率爲 50％之野生雲豹族群其平均近親係數的預測。三個腳本同圖 3。某些族群在此時減絕。

圖 10、族群個體數爲 10，負載量爲 100，幼體死亡率爲 35％之野生雲豹族群其平均存留變異性的預測。三個腳本同圖 3。某些族群在此時減絕。

圖 11、族群個體數爲 10，負載量爲 30，幼體死亡率爲 50％之野生雲豹族群其存活率的預測。三個腳本同圖 3。

圖 12、族群個體數爲 10，負載量爲 30，幼體死亡率爲 35％之野生雲豹族群其存活率的預測。三個腳本同圖 3。

圖 13、族群個體數爲 10，負載量爲 30，幼體死亡率爲 35％之野生雲豹族群其存留變異性率的預測。三個腳本同圖 3。

圖 14、族群個體數爲 10，負載量爲 30，幼體死亡率爲 35％之野生雲豹族群其近親交配係數的預測。三個腳本同圖 3。

圖 15、根據基本腳本針對三種不同野放的方式，雲豹族群 10 年內的預測。第一種方式爲野放雌雄各 5 隻，分別爲 2 及 3 歲大。在 2、4、6 及 8 年後，每次各再野放 10 隻。第二種方式增加一個有 33％機會發生大災變，這會對所有個體產生 5％致命的機會。第三種方式（40 隻野放）與第一種方式同，唯有差別在野放個體時的年限止於第 6 年。

圖 16、50 隻動物野放（第一種方式）百年內族群的年預測。此腳本族群之減絕機率小。族群在第 10 到 50 年中呈線性增加，至其達到環境負載量時則呈高原之型態。

POPULATION BIOLOGY AND MODELLING

Introduction

The potential habitat for the Formosan clouded leopard occupies nearly 1 million hectares of rugged, forested habitat, comprising about a third of the total area of Taiwan. Within the remaining habitat, about a third, or 330,000 ha are in protected areas, including three National Parks and two wildlife preserves. Recent hunters' reports and the lack of skins indicate that few if any clouded leopards remain within Taiwan. The complete absence of wild clouded leopards across the island is uncertain, however, due to trapping and poaching pressures being less intense in recent times, the roughness of the terrain, the nocturnal habits of the leopard and the distribution of human observers, which tend to be centered in the National Parks. If the clouded leopard still exists, it is very likely that the population is small and fragmented in distribution. These estimates are admittedly not based upon systematic field surveys but rather an evaluation based upon 15 years of surveys of hunters and the lack of any reports of animals from any source. They provide a starting point for examining the future outlook of Formosan clouded leopards under existing or proposed reintroduction scenarios and management strategies.

The need for and effects of reintroduction and intensive management strategies can be modelled to suggest which practices may be the most effective in restoring this population. Information and experience gained in reintroduction studies with the bobcat, lynx and Florida panther offer a starting point for design of a clouded leopard reintroduction program. VORTEX, a simulation modeling package written by Robert Lacy and Kim Hughes was used as a tool to study the interaction of multiple life history and population variables treated stochastically.

The VORTEX program is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental and genetic stochastic events on wildlife populations. VORTEX models population dynamics as discrete, sequential events (e.g., births, deaths, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or as random variables that follow specified distributions. VORTEX simulates a population by stepping through the series of events that describe the typical life cycle of sexually reproducing, diploid organisms.

VORTEX is not intended to give absolute answers, since it is projecting stochastically the interactions of the many parameters which enter into the model and because of the random processes involved in nature. Interpretation of the output depends upon our knowledge of the biology of the clouded leopard, the conditions affecting the population and possible changes in the future.

The output of the model is limited by the input. Because no biological information was available for the former wild population of clouded leopards in Taiwan, we employed information from wild populations of similar-sized felids as well as information on captive clouded leopards that are mostly of unknown geographic and subspecies origin. However, this does provide a starting point for exploratory models.

Input Parameters for Simulations

Age of First Reproduction

VORTEX defines breeding as the time when young are born, not the age of sexual maturity. Thus, although captive clouded leopards can mate year round most births occur in the early spring. First births occur at 2 years of age. VORTEX also uses the mean/median age of reproduction (with an estimate of variation, as discussed below) rather than the earliest age of cub production. Thus, although some female clouded leopards give birth at 2 years of age, the average age of first cub production among the captive animals was 3 years so we used this value in the model. Also it is likely that reproductive maturity in the wild animals will be delayed relative to the captive animals so this is a conservative estimate. Similarly, whereas males are capable of breeding at two years old (siring cubs which would be born when the father is 2 years), social constraints may limit breeding to older animals. The degree of social constraint, however, may vary with density and age structure, which are unknowns for any population of clouded leopard. For this model, we chose 3 years as the age of males siring cubs. If the mating system in clouded leopards is polygynous, populations would have to become extremely small for the choice of male reproductive age to have a significant demographic effect. If it is monogamous the availability of males might become limiting depending upon the adult sex ratio in the population.

Cub Production

VORTEX combines number of cubs per litter, litter interval and the proportion of adult-age females producing their first cubs into a single variable called litter size. Studbook data on captive clouded leopards indicate that the mean litter size is 1.6 with few litters of size three. About 44% have litters of one, and 50% litters of two, with litters of three being about 6%. However only 25% of captive adult females have produced litters. The shortest interval between successfully reared litters is 1 year, although the average is likely closer to 2 years. We used 2 years as the average reproductive interval for a wild population. Wild populations of similar-size felids (bobcat and lynx) indicate that they can produce litters annually with adequate prey availability. It will be important for a field study of a healthy wild population of the clouded leopard to determine this parameter. For the models of the wild population we used 50% as the frequency of litters of zero, leaving 50% of females producing cubs (22% litters of one, 25% litters of two, 3% litters of three).

Variation in reproduction is modelled in VORTEX by entering a standard deviation (SD) for the percent females producing litters of zero. Lacking empirical data, we assumed that such variation (due to fluctuations in food abundance and variations in the age at which females reach sexual maturity) was 25% of the mean. VORTEX then determines the percent breeding each year of the simulation by sampling from a binomial distribution with the specified mean (60%) and SD (12.5%). The relative proportions of litters of one and two are kept constant. The studbook data indicate 0.56 (1.27) sex ratio at birth for clouded leopards, so we used this sex ratio as the default value. Comparisons were made with an equal birth sex ratio.

Age of Senescence

VORTEX assumes that animals can breed (at the normal rate) throughout adult life. Captive clouded leopards can live more than 15 years, but reproduction appears to cease by age 12. We chose 12 years as the maximum age at which Formosan clouded leopards in the model produce cubs.

Mortality

Mortalities can be entered in VORTEX in three ways: 1) as the percentage of animals in each sex-age class expected to die each year, with a corresponding variance; 2) as a fixed number removed (e.g., harvested) in each sex-age class; and 3) as a catastrophic event that reduces the normal survival rate by some fixed amount.

Cub survival is quite variable among wild felid populations, and the factors affecting this variability are not understood. Consequently, we used the average cub mortality rate from the captive population as our best estimate of cub mortality for a Formosan wild clouded leopard population (35%). In the captive population, males have a similar cub mortality rate to females, so we assumed a rate of 35% for male cubs and 35% for female cubs. We also used a value of 50% cub mortality for a wild population to test the sensitivity of the population dynamics to changes in this parameter.

Survival of wild clouded leopards will be strongly related to human influences, such as hunting, poaching and nuisance kills. If survival of clouded leopards in protected areas is consistently high then the average mortality rates observed among the captive population provide a lower limit estimate of mortality in a wild population. This was estimated at an average of 7% across the age classes. Studies in un-hunted populations need to be done to develop a mortality schedule that might be expected in the absence of poaching for a population below carrying capacity. The SD due to environmental variation was considered to be 25-50% of these mean values.

There is no legal hunting of Formosan clouded leopards, and nuisance killing likely will be very rare, so the only significant human source of mortality may be poaching and incidental catches in the snares widely used by aboriginal hunters. The potential level of incidental take is unknown although it may be the primary variable affecting the future status of these cats. Thus, the modelling procedure was used to project future population sizes under various levels of mortality for one year and older animals. We made the assumption that snares would not be selective for particular sex-age classes of clouded leopards, and because we could not make a reasonable guess as to relative vulnerabilities of each sex-age class, we considered deaths in snares to affect each to an equal extent. We also assumed that incidental take would take a fairly constant proportion of the population rather than a fixed number of cats; that is, if the population diminished, it would be more and more difficult to find clouded leopards, thereby taking a smaller number, although approximately an equal proportion.

We manipulated the level of this loss by including it as a "catastrophe" that occurred approximately every 3 years with a reduction in the survival of each sex-age class by the same amount. We then could vary the level of losses by simply altering the amount by which survival was reduced. We examined the effect of 5% losses which was entered in the model as a 95% factor affecting survival.

We also incorporated in some scenarios a second "catastrophe" to correspond with the effects of occasional prey population collapses. Prey failures in bobcats and lynx have been observed to significantly reduce reproduction (sometimes resulting in total reproductive failures), but with no increase in natural adult mortality (although it may affect human-caused mortality in populations subjected to hunting). We presumed that significant prey population failures occurred about once in 10 years in Taiwan (considered a stochastic event in the model occurring with a probability of 10%), which reduced reproduction by 20% or 50% of normal but did not affect survival.

Carrying Capacity

K defines an upper limit for the population size, above which additional mortality is imposed in order to return the population to K. VORTEX uses K to impose density-dependence on survival rates. It also has the capability of imposing density-dependent effects that change continuously as the population approaches K, but because such effects are not likely to be of significance in the early stages of a reintroduction program or in greatly reduced populations, we elected not to include them in the model.

We chose an overall K for the island of 1,000 clouded leopards, or about 1/10 km^2 as a possible target population size. Whereas this value is certainly arguable, given suggested higher densities historically in some protected areas in Asia, the effect of this arbitrary choice of a value for K on the model projection is negligible, as the population is currently near zero or extinct and well below K. The imposition of carrying capacity would only have meaningful effects in the near future (i.e., next 2 decades) if fragmentation of the leopard's range occurs to the extent that each separate, remnant population becomes limited by its own individual carrying capacity. We examined the effects of smaller Ks of 30, 100 and 300 animals based upon either intense fragmentation or other limiting habitat characteristics. This is pertinent for following the dynamics of possible small remnant populations that might be discovered and of reintroductions in habitats of limited capacity.

Inbreeding Depression

We used the option for inbreeding depression included within VORTEX for some runs of the model. This option was added when we sought to examine the effects of fragmentation of the various protected areas. For this option we assumed 3.14 lethal equivalents per diploid genome, which (absent specific information for clouded leopards) is the median value from 40 other mammalian species.

Starting Age Distribution

We initialized the model runs with either a stable age distribution that distributes the total population among each sex-age class in accordance with the existing mortality and reproductive schedules or a known age distribution of 2 and 3 year old animals for the reintroduction scenarios.

Starting Population Size

We tested two estimates of starting population size of 10 and 200 clouded leopards for resident populations. The reintroduction scenarios were started with 10 animals followed with further additions of 10 animals at 2 year intervals until either 40 or 50 animals had been added to the population.

Iterations and Years of Projection

Each scenario was iterated 200 times, and projections were made for the next 100 years. Output results were summarized at 10 year intervals in the time series figures. Each tabulated scenario has a corresponding file number for reference and future retrieval of other results, if necessary. The simulations were run using VORTEX version 7.0b.

Sample Input File

A sample input file used to initialize the model for one of the reintroduction scenarios is included at the end of this section. The information input for each request is shown in the order in which they appear in the program.

Results

Output of the Model

The deterministic outputs include a value for the growth rate of the population (r, lambda, and Ro), the generation time for males and females, the stable age distribution and the adult male-to-female sex ratio. The deterministic growth rate was calculated by a Leslie matrix algorithm. Positive values are necessary for a population to survive, and in principle a zero value would characterize a stable population. The deterministic growth rate is not sensitive to differences in starting population size, but varies with level of catastrophes, mortalities and reproductive values (Table 1). The generation times for the clouded leopard varied from 5.5 to 7.0 years depending most strongly on the age of first reproduction. Thus, there are about 14-16 clouded leopard generations in 100 years.

Means and standard deviations, calculated over the number of iterations at each time interval, are given for stochastic population growth rates (r), probabilities of extinction (Pe), final population size (N=100), retention of genetic heterozygosity (He) and the mean time to extinction (Te). Stochastic population growth rates and the probability of extinction are sensitive to the values and the variances entered for each of the demographic and reproductive parameters. They are also sensitive to population size, inbreeding depression effects, sex ratio, and breeding system. A sample output file may be found at the end of this section.

Stochastic Growth Rate

All of the scenarios tested for the clouded leopard had positive deterministic growth rates. In deterministic models these populations would survive and grow. However, many of the stochastic growth rates were negative (Tables 1 and 2). Extinctions occurred even in scenarios with positive stochastic growth rates reflecting effects of small population sizes and variable environments (Fig. 1). The stochastic growth rate had to be about 5% or greater to reduce the probability of extinction in 100 years to less than 10%. There also was rapid loss of heterozygosity in the populations with stochastic growth rates of less than 5% reflecting the fact that population sizes were fluctuating and growing slowly under these conditions (Fig. 2). For long term viability, population conditions should be such that the loss of heterozygosity is less than 0.5% per generation which would be about 7% or less in 100 years for the clouded leopard.

Populations of 200 Individuals

Population growth rates are sensitive to the reproductive parameters of interbirth interval or proportion of females producing a litter in a given year, the size of the litter, the age of first reproduction and the birth sex ratio. Data for the captive population, taken from the studbook, indicate that only 25% of adult females reproduce so that 75% do not produce a litter in a given year. This value results in low or negative growth rates. When combined with the first year mortality rates reported for the captive population, the population is unlikely to survive. Based upon information from other felids, we set the interbirth interval at 2 years or 50% of females producing no litter in a given year. This yields positive growth rates in these populations. The age of first reproduction (AFR) is reported as 2 years for some males and females in the captive population. However, many animals do not breed until the age of 3 years. Increase of this age from 2 to 3 years reduces the population growth rate by 50% (scenarios 001 and 011 in Table 1). We used the value of 3 years for modeling the wild population since captive animals frequently reproduce at a younger age in captivity than in the wild. The mean litter size in the captive population is reported as 1.6. We used this value in all simulations; however, this value should be measured in wild populations to determine if it is a species characteristic value. An increase in litter size to 2.4 which is characteristic for many of the larger felid species would nearly double the potential growth rate of the population. The birth sex ratio of 0.56 reported for the captive population may be a species characteristic value or the result of inbreeding in captivity or simply a sampling error. We compared this value with the more usual value for mammals of 0.50. The growth rate is reduced about 0.02 (r) with this skewed sex ratio.

Population growth rates are also sensitive to 'natural' mortality rates in each of the age and sex classes, to the added effects of environmental variation, to human induced mortality, and to catastrophe-induced mortality. First year mortality rates in the captive population are about 35%. A 5% shift in this value can change the r by about 0.01. Some scenarios with 50% first year mortality were included in the studies of the small populations.

Remnant Populations of 10 Animals

Population growth rates and extinction risks were modeled for a small, wild clouded leopard population, as might occur in an isolated remnant population or in small habitat fragments. The initial population size was 10 animals, and the effects of variable carrying capacity (K) and first year mortality (0-1 Mort) on three scenarios were investigated. The three scenarios were a base which provided for about a 6% deterministic annual growth rate in larger populations. Basic parameter values included: 3 years as age of first reproduction, 50% of females breeding each year, 1.6 mean litter size and 7% mortality rate for animals older than 1 year. The effects of two mild catastrophes (both at 10% frequency) and inbreeding depression (heterosis model with 3.14 lethal equivalents) on this base scenario were modeled. The simulations were run for 100 years and were repeated 100 times. The results (Table 2, Fig. 3-14) summarized below, indicate that these small populations are at high risk of extinction under most conditions including conditions that are favorable for the growth of larger populations. The addition of inbreeding depression, which has been observed in Florida panthers, is overwhelming.

Summary of effects of first year mortality and carrying capacity and the added effects of catastrophes and inbreeding depression on the growth rates and extinction probability of small clouded leopard populations.

Scenario	**r(det)**	**r(stoch)**	**Pe%**	**N**
A. N=10, K=100, 35% First year mortality				
Base	.058	.048	15	96
Catastrophes	.045	.032	20	88
Inbreeding	.058	-.002	64	54

Scenario	r(det)	r(stoch)	Pe%	N
B. N=10, K=100, 50% First year mortality				
Base	.019	-.005	66	59
Catastrophes	.006	-.028	89	20
Inbreeding	.019	-.047	100	-
C. N=10, K=30, 35% First year mortality				
Base	.058	.039	29	24
Catastrophes	.045	.024	36	20
Inbreeding	.058	-.010	81	12

The probabilities of extinction over time for the starting population of 10 animals (Table 2, Fig. 3 and 4) indicate that extinction begin early in population with 50% first year mortality and that most populations do not survive. Addition of a mild inbreeding effect leads to extinction of all the populations by about 90 years.

Population projections for these populations of 10 clouded leopards (Table 2 and Fig. 5 and 6) suggest that populations that survive the early years continue to grow if the first year mortality is 35%. However, all of these surviving populations have lost 25-35% of their initial heterozygosity by 100 years (Fig. 6 and 7) and have become significantly inbred (Fig. 9 and 10). This likely will reduce long-term viability, making the population vulnerable to the effects of varying population sizes and environmental challenges. Reduction of the carrying capacity to 30 individuals (Fig. 11-14) makes all of these detrimental effects more severe and greatly reduces the probability of any population surviving. Such small wild populations will require continuing intensive management, supplementation, and replacement if extinction occurs.

Reintroductions of 40-50 Individuals

The literature and experience with reintroductions indicate that most successful programs have required 50-100 animals. These may be released in groups over time and followed by careful monitoring to learn how to proceed further. We examined a series of scenarios which added animals of known ages in groups of 10 every 2 years for a total of 40 or 50 animals released (Table 2, Fig. 15-16). Nearly all of the modeled populations survived with growth rates of 0.033 under the conditions tested. This number of animals, as founders, would provide adequate genetic representation of the source wild population and allow the retention of high levels of genetic heterozygosity if the carrying capacity is 300 animals or greater. The release program needs to provide for intensive monitoring in the first years to allow learning the most effect conditions under the local environmental conditions. The design modeled here simply provides an example.

Population Biology and Modeling Summary:

Survey data indicate that clouded leopard numbers in Taiwan are likely to be small, if they still exist. The total population must be well below carrying capacity. Snare hunting and poaching appear to have been the greatest threats to viability. The modeling runs conducted here indicated that a population of 10 animals (remnant or reintroduced population) is at high risk of extinction even in the absence of inbreeding depression, catastrophes or poaching pressure in the stochastic simulations. The deterministic growth rate (r) is positive in all of these scenarios so that a deterministic model would greatly underestimate the risk of extinction. The stochastic estimate of growth rate is positive in many of these scenarios with a high risk of extinction. This reflects the vulnerability of small populations to the uncertainties of environmental fluctuations. Simply increasing the population size to 100 reduces the risk to less than 5% and virtually eliminates the effects of inbreeding depression. The probability of extinction in 100 years of 15% in the basic scenario increases to 64% with the inclusion of inbreeding depression. An increase of first year mortality increases the stochastic risk of extinction to 66% in the base scenario and to 100% if inbreeding depression is included. Reduction of the carrying capacity to 30 (from 100) increased the risk of extinction from 15% to 29% in the base scenario and to 81% with the inclusion of inbreeding. Thus, a small population prevented from expanding whether by habitat limitations or hunting pressure is unlikely to survive.

If a small wild population of the Taiwan clouded leopard is discovered, careful consideration will need to be given to intensive management, careful protection and the establishing of a captive population to prevent final extinction. It would be useful to undertake a more detailed planning program for such a possible discovery, especially if a survey is undertaken. The development of a response plan before such a discovery can greatly reduce conflicts over management choices in an emergency. Larger populations of 100 or more under the base scenario conditions with stochastic r of 0.058 can grow to the habitat capacity with a population doubling time of about 10-12 years.

A reintroduction program will need to plan for the eventual release of sufficient animals to assure that at least 30 animals survive and breed to serve as founders for the wild population. This estimate assumes that the released animals are from a genetically diverse population (i.e., they are not all derived from a few pairs of captive parents). It is likely that 50 or more clouded leopards will have to be released to achieve this goal. Release of this number of animals would likely best be spaced over time and space. The development of a reintroduction strategy will require much additional discussion, modeling and planning. Planning such a program will benefit from information gathered in much needed field studies of a population of clouded leopards.

If the reintroduction program is to use captive bred animals, it is essential that they be from known origin stock and not be inbred. Given the uncertainties about the origins of animals in private ownership, it may be preferable to obtain fresh stock from the Indochinese population (Thailand, Laos, Kampuchea, Vietnam). Genetic markers are not available for the geographic populations or named subspecies of the clouded leopard because suitable samples have not been collected for molecular genetic analysis. Until this is done, it will not be possible to reliably identify the origin of captive animals whose pedigree history is unknown or unconfirmed.

Table 1. Formosan Clouded Leopard - Variable Mortality, Sex ratio, Interbirth Interval										
File #	Variables			Results						
	Birth Sex Ratio	0 - 1 Mort %	Fem % 0 Birth	Population Growth		100 Years				Te
				Deter r	Stoch r	Pe	N 100	SD	He	
First Year Mortality=50%, N=200, K=300.										
001	.50	35	50	.114	.110	0	298	8.1	94.5	-
010	.56	35	50	.090	.087	0	297	8.4	94.5	-
011*	.56	35	50	.058	.055	0	294	11.6	95.0	-
Effect of 70% First Year Mortality, N=200, K=300.										
005	.50	30	70	.037	.032	0	274	32.3	94.2	-
006	.56	30	70	.016	.010	.01	210	74.6	92.4	81
0B6	.50	35	70	.025	.019	0	255	54.1	94.0	-
Effect of 75% First Year Mortality, N=200, K=300.										
002	.50	35	75	-.004	-.015	.16	80	77.7	85.0	89
003	.50	30	75	.008	.002	0	166	87.0	90.6	-
0A3	.56	30	75	-.013	-.024	.295	64	62.5	83.7	82

表格說明

在本表中僅* 腳本 011 爲採用 3 歲爲首次生殖年齡，其他腳本皆爲兩歲。

表一及表二的文字及符號列皆同。圖案 “#” 係指 VORTEX 輸出之圖案號數，在模擬近親交配所產生的衰變時，選擇 40 種動物的中數值 3.14 致死值來計算兩種獨立災變的模擬各分別爲 10 %的機率。其中之一對生殖無影響但對族群造成 90 %的存活。另一係對 80 %族群的生殖有影響，但不造成死亡。Deterministic 的生長率 r 係由 Leslie 矩陣計算而得。逢機族之成長率 r 則爲一種腳本各種變化重覆計算之平均值。Pe 爲滅絕率，N 爲 100 年時存活族群之平均族群大小，SD 爲其標準偏差。He 爲存活族群之平均存留變異性，Te 爲平均滅絕時間。K是環境負載量，AFR 係初次生殖年齡(以生仔時之年齡計算)，0-1Mort %爲幼獸（第 1 年）死亡率。

Table 2. Formosan Clouded Leopard - Small Populations and Extinction Risk									
File #	Variables		Results						
	Inbreeding 3.14	Catastrophes	Population Growth		100 Years				Te
			Deter r	Stoch r	Pe	N 100	SD	He	
N=10, K=100, 0-1 Mort=35%, AFR=3									
012	N	N	.058	.048	.15	96	10.3	67	23
013	N	Y	.045	.032	.20	88	21.8	65	27
014	Y	N	.058	-.002	.64	54	30.4	73	46
N=10, K=100, 0-1 Mort=50%, AFR=3									
018	N	N	.019	-.005	.66	59	33.2		33
019	N	Y	.006	-.028	.89	20	24.5		34
020	Y	N	.019	-.047	1.00	-	-	-	34
N=10, K=30, 0-1 Mort =35%, AFR=3									
015	N	N	.058	.039	.29	24	5.3	47	33
016	N	Y	.045	.024	.36	20	7.3	48	38
017	Y	N	.058	-.010	.81	12	6.7	58	53
Reintroductions, K=300, AFR=3, 0-1 M=35%. Releases of 10 animals at 2 year intervals for a total of 50 in scenarios 101 and 103 and 40 in 104.									
101	N	N	.038	.032	0	273	44.6	90.8	-
103	N	33%	.021	.013	.04	194	90.0	84.9	65
104	N	N	.038	.033	.01	263	55.8	89.3	58

The age of first reproduction (AFR) was 2 years for all of the scenarios in this Table, except 011 which was 3 years. The column headings and symbols are the same for Tables 1 and 2. File # refers to the VORTEX output file number. Inbreeding was included under the heterosis option with 3.14 lethal equivalents, the median value for 40 mammal species, used. The two independent catastrophes were at a 10% frequency, with one no effect on reproduction and a severity of 0.90 on survival, the other had a severity of 0.80 on reproduction with no effect on survival. The 'Deterministic r' was calculated with a Leslie matrix algorithm. The stochastic r is the mean value over all the iterations for a scenario. Pe is the probability of extinction. N is the mean population size of surviving populations at 100 years and SD is the standard deviation. He is the mean remaining heterozygosity in the surviving populations. Te is the mean time to extinction. K is the carrying capacity. AFR is the age of first reproduction (birth of litter). 0-1 M is first year mortality.

Figure Legends:

Fig. 1. Relationship of stochastic growth rate and probability of extinction for populations of clouded leopard varying in starting population size, first year mortality, age of first reproduction, occurrence of catastrophes and inclusion of inbreeding depression. Note that extinction occurs even with positive stochastic growth rates. In deterministic models, a positive growth rate would always result in a growing and surviving population.

Fig. 2. Relationship of stochastic growth rate and the proportion of heterozygosity remaining in surviving clouded leopard populations at 100 years. The scenarios vary in starting population size, first year mortality, age of first reproduction, occurrence of catastrophes and inclusion of inbreeding depression. A positive growth rate is necessary to retain genetic heterozygosity in the population.

Fig. 3. Projections of probability of survival for wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of 100 animals and a first year mortality rate of *50%*. The three scenarios are the (1) base scenario alone, (2) addition of two catastrophes (both with a 10% frequency with one having a 0.90 effect on survival and the other with a 0.80 effect on reproduction), and (3) addition of inbreeding depression (heterosis option with 3.24 lethal equivalents).

Fig. 4. Projections of probability of survival for wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of 100 animals and a first year mortality rate of *35%*. The three scenarios are the same as in Fig. 3.

Fig. 5. Projections of mean surviving population size for wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of 100 animals and a first year mortality rate of *50%*. The three scenarios are the same as in Fig. 3. Some populations have become extinct during this time.

Fig. 6. Projections of mean surviving population size for wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of 100 animals and a first year mortality rate of *35%*. The three scenarios are the same as in Fig. 3. Some populations have become extinct during this time.

Fig. 7. Projections of mean remaining heterozygosity for wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of 100 animals and a first year mortality rate of *50%*. The three scenarios are the same as in Fig. 3. Some populations have become extinct during this time. The starting level of heterozygosity is set at 1.00. This measure provides an estimate of the level and rate of inbreeding in the simulated populations. Since the generation time is about 6 years under the conditions of these simulations the 100 years represent 15-17 generations. Thus, a 100 year heterozygosity value of 0.85 would represent a loss of 15% or about 1% per generation.

Fig. 8. Projections of mean remaining heterozygosity for wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of 100 animals and a first year mortality rate of *35%*. The three scenarios are the same as in Fig. 3. Some populations have become extinct during this time.

Fig. 9. Projections of the mean inbreeding coefficient for wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of 100 animals and a first year mortality rate of *50%*. The three scenarios are the same as in Fig. 3. Some populations have become extinct during this time.

Fig. 10. Projections of the mean inbreeding coefficient for wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of 100 animals and a first year mortality rate of *35%*. The three scenarios are the same as in Fig. 3. Some populations have become extinct during this time.

Fig. 11. Projections of probability of survival for wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of *30* animals and a first year mortality rate of *50%*. The three scenarios are the same as in Fig. 3.

Fig. 12. Projections of mean surviving population size for wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of *30* animals and a first year mortality rate of *50%*. The three scenarios are the same as in Fig. 3.

Fig. 13. Projections of remaining heterozygosity in wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of *30* animals and a first year mortality rate of *35%*. The three scenarios are the same as in Fig. 3.

Fig. 14. Projections of the mean inbreeding coefficient for wild clouded leopard populations with a starting population of 10 animals in a habitat with a carrying capacity of *30* animals and a first year mortality rate of *35%*. The three scenarios are as in Fig. 3.

Fig. 15. Annual population projections for 10 years for three clouded leopard reintroduction scenarios using the base scenario parameters. The base reintroduction scenario started the introduction of 5 male and 5 female animals which were two and three years old. Ten additional animals were added to the population at years 2, 4, 6 and 8 after the initial introduction. The 'hunts' scenario added a catastrophe with a 33% probability of occurrence which increased the mortality 5% across all age classes. The base-40 scenario stopped the additions at year 6 for a total of 40 animals released.

Fig. 16. Annual population projections for 100 years of the base-50 reintroduction scenario. There is a low probability of extinction in this scenario. The population increases approximately linearly from year 10 to year 50 when the effects of setting an upper limit to population size occur.

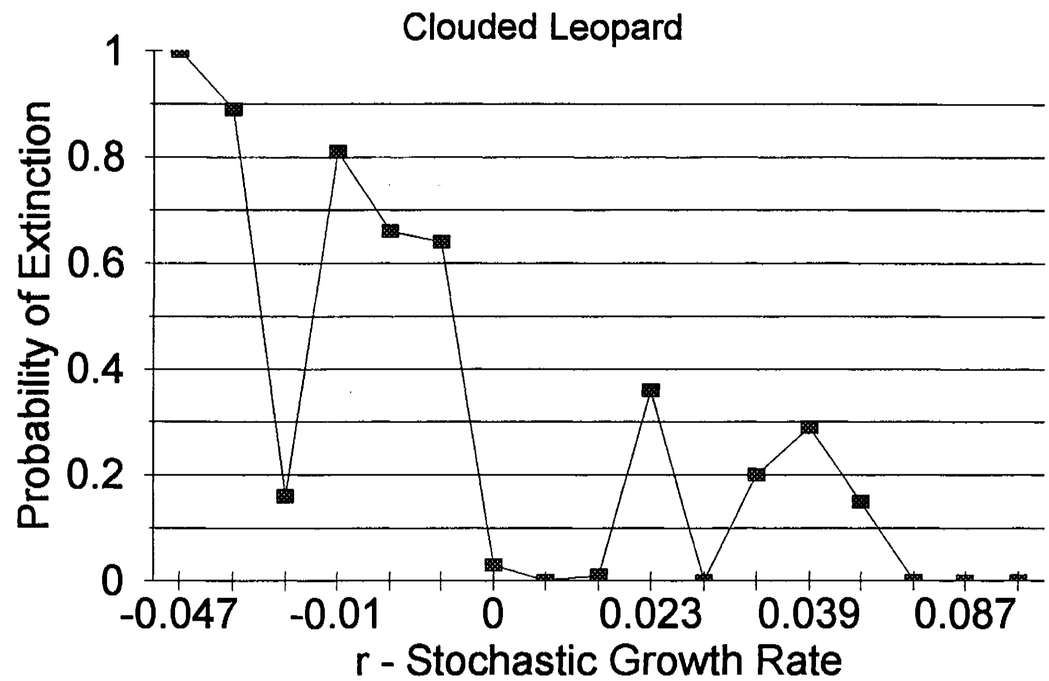


Figure 1. Relationship of stochastic growth rate and probability of extinction.

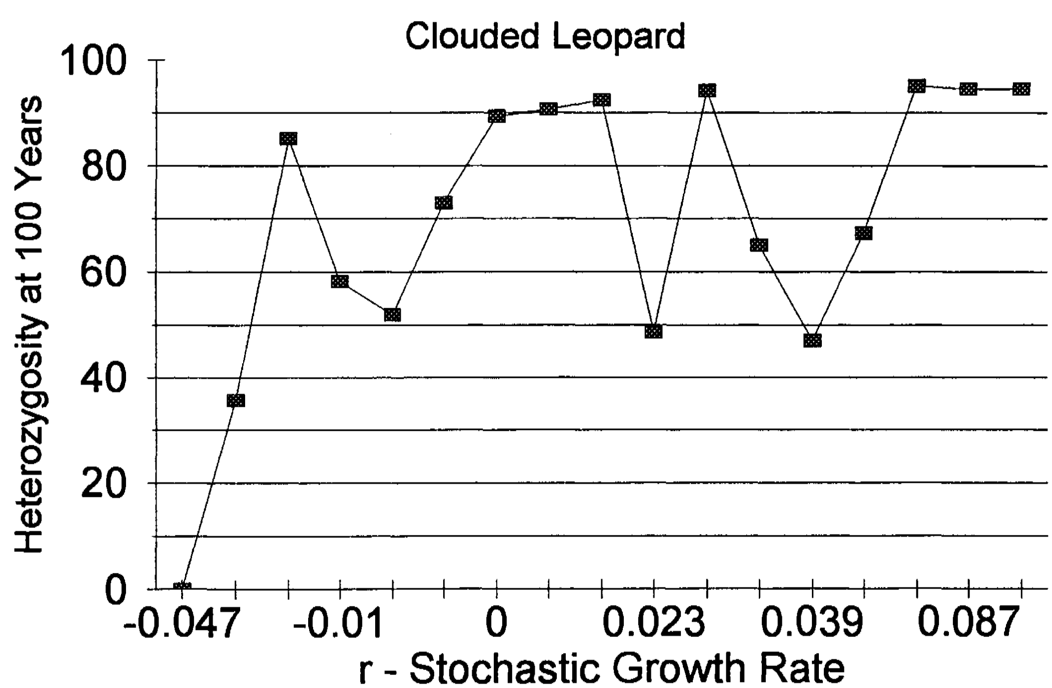


Figure 2. Relationship of stochastic growth rate and the proportion of heterozygosity.

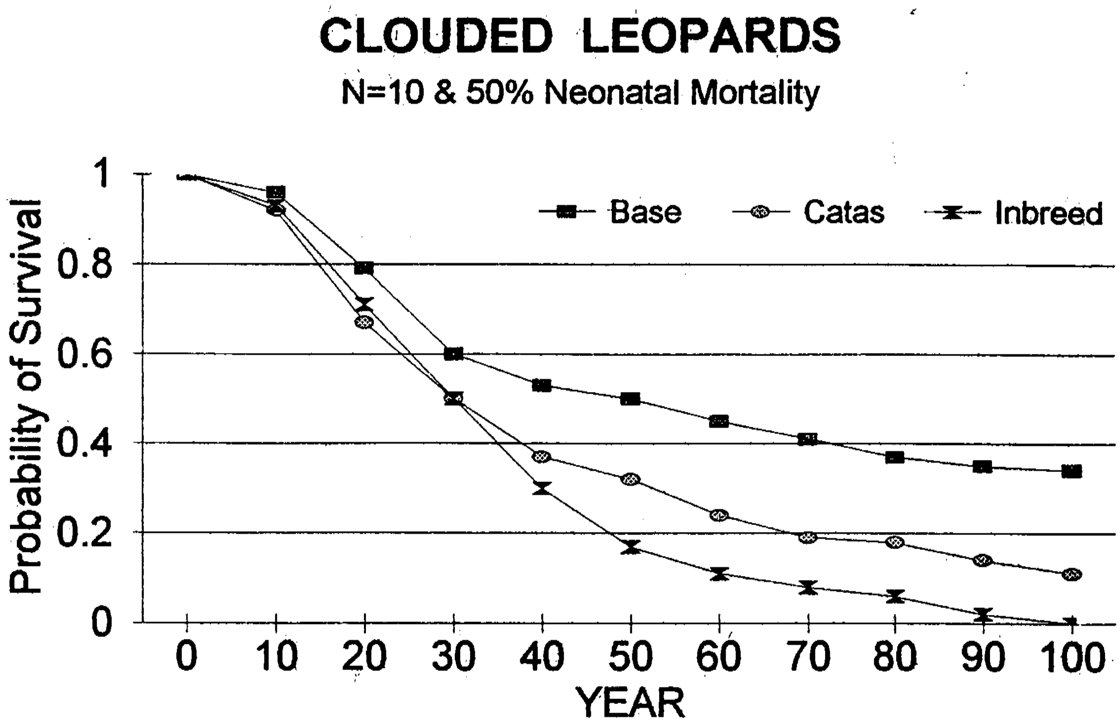


Figure 3. Projections of probability of survival for wild clouded leopard populations.

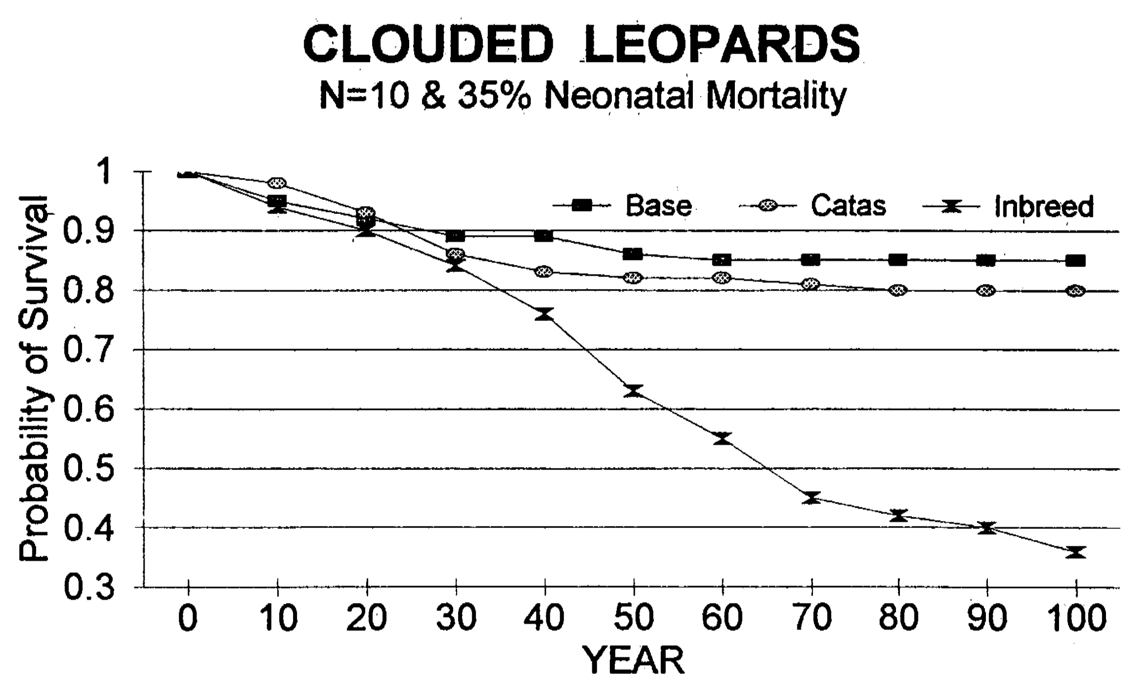


Figure 4. Projections of probability of survival for wild clouded leopard populations.

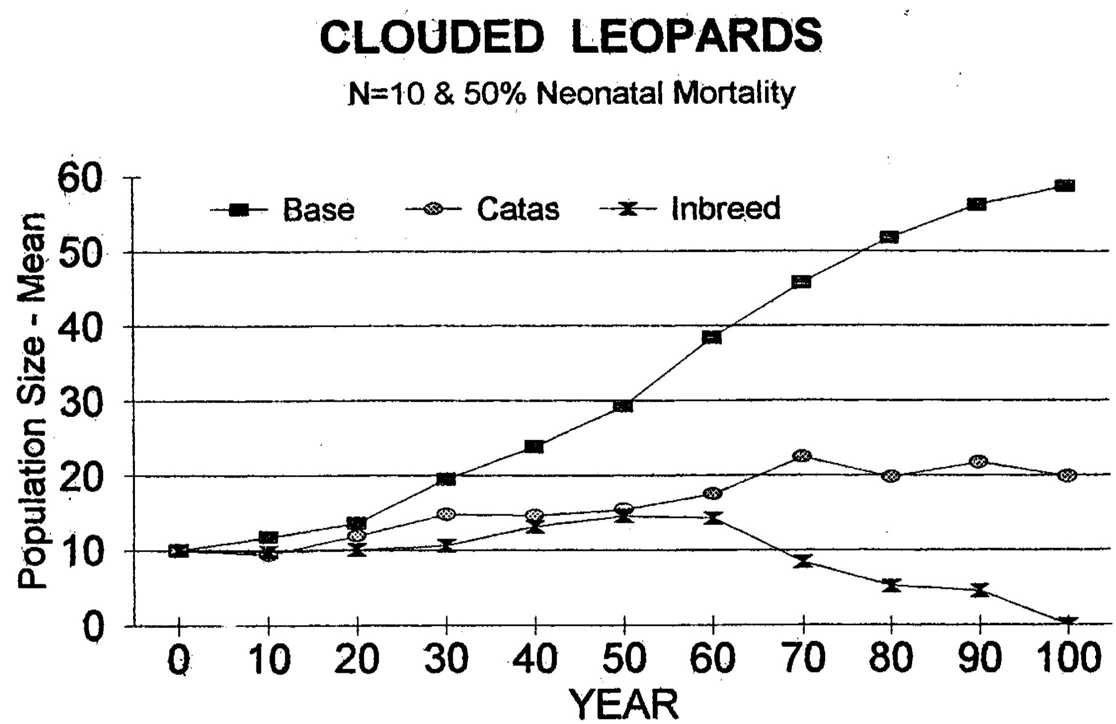


Figure 5. Projections of surviving population size for wild clouded leopard populations.

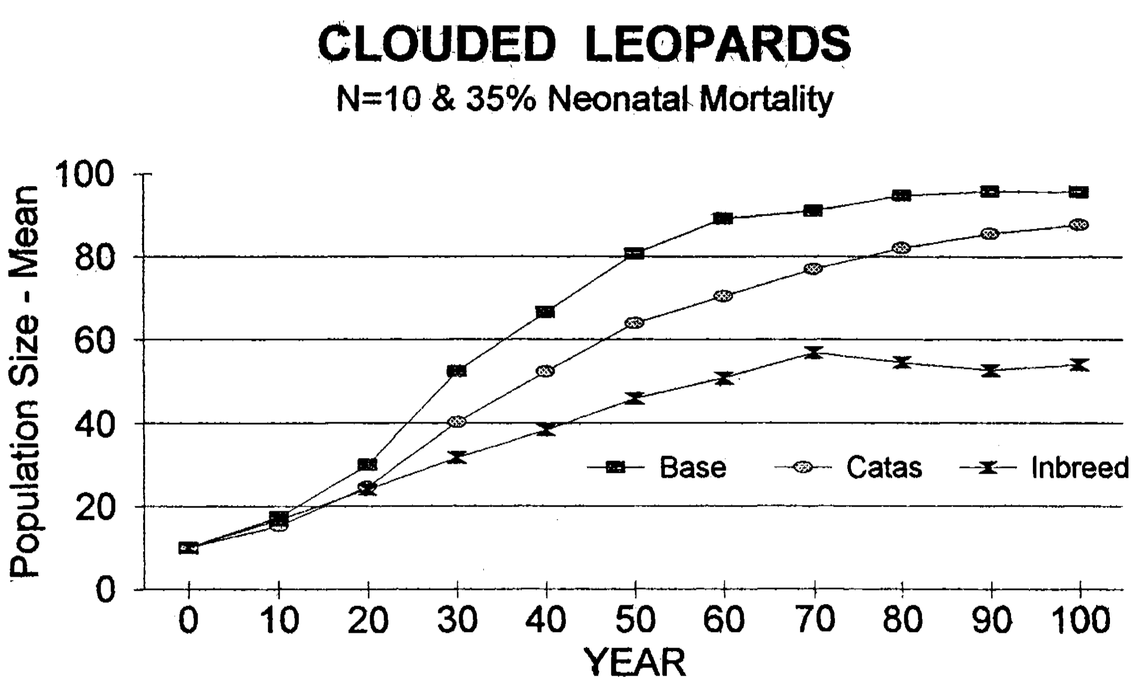


Figure 6. Projections of surviving population size for wild clouded leopard populations.

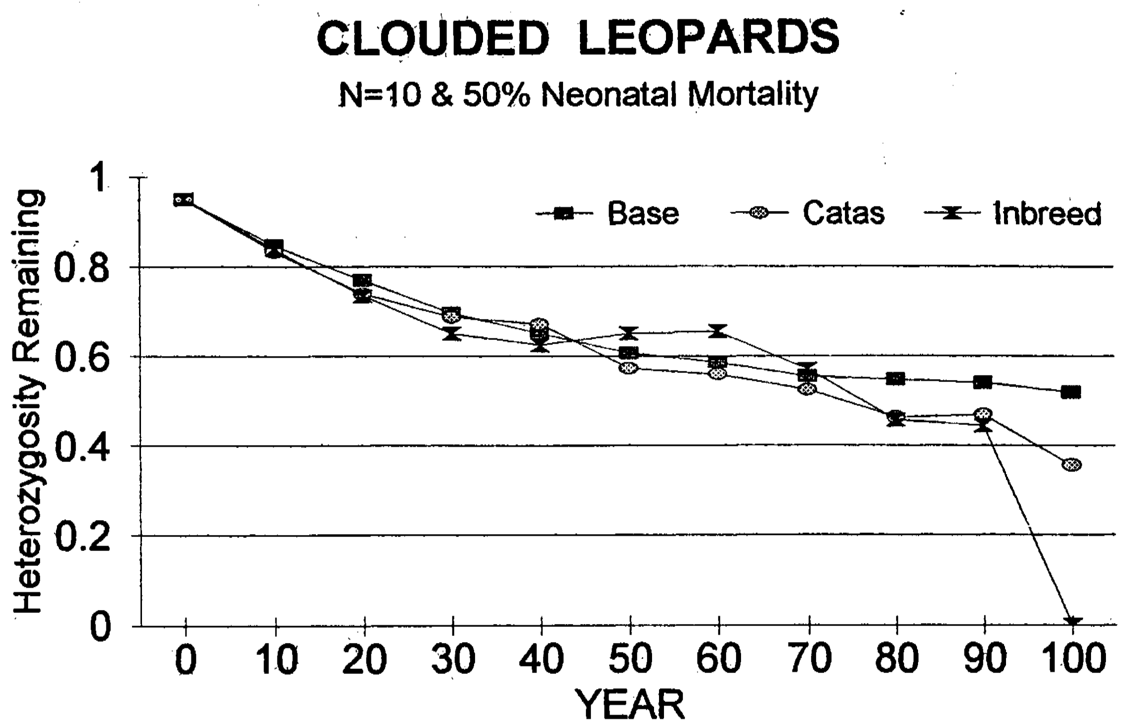


Figure 7. Projections of mean heterozygosity for wild clouded leopard populations.

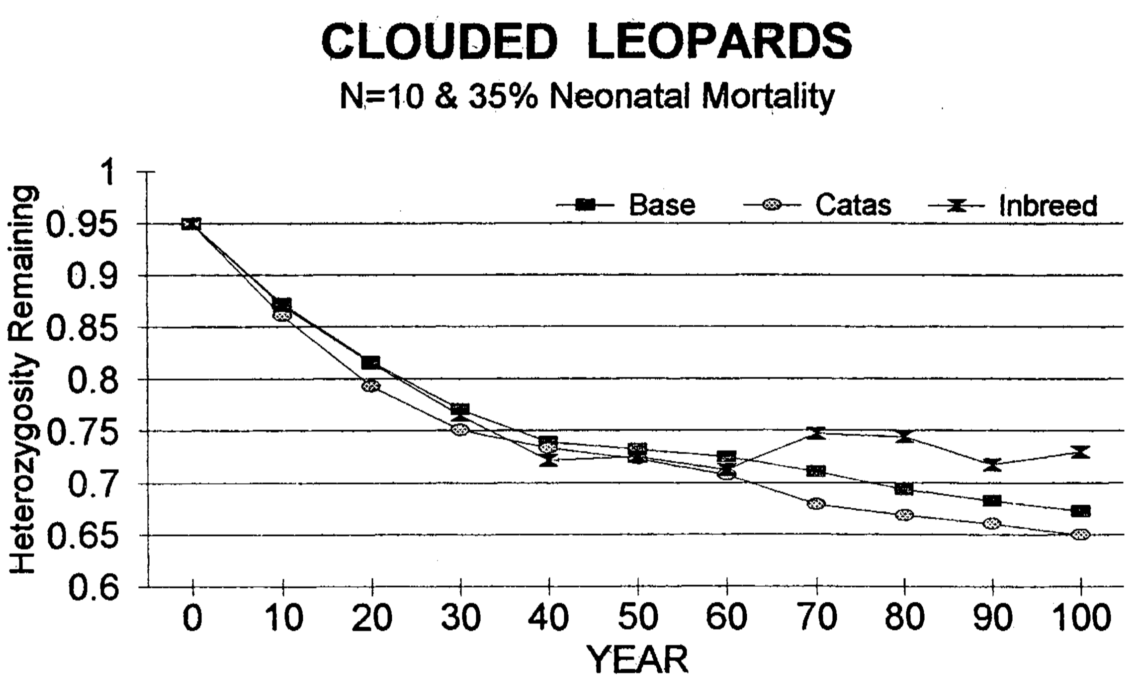


Figure 8. Projections of mean heterozygosity for wild clouded leopard populations.

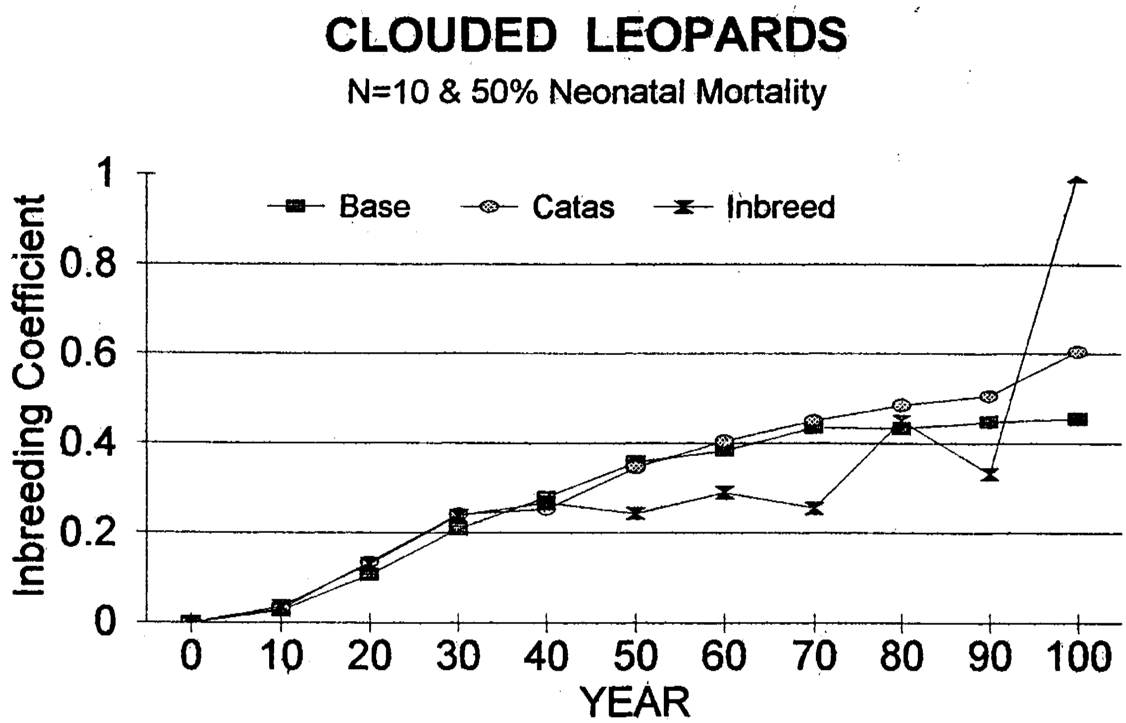


Figure 9. Projections of the inbreeding coefficient for wild clouded leopard populations.

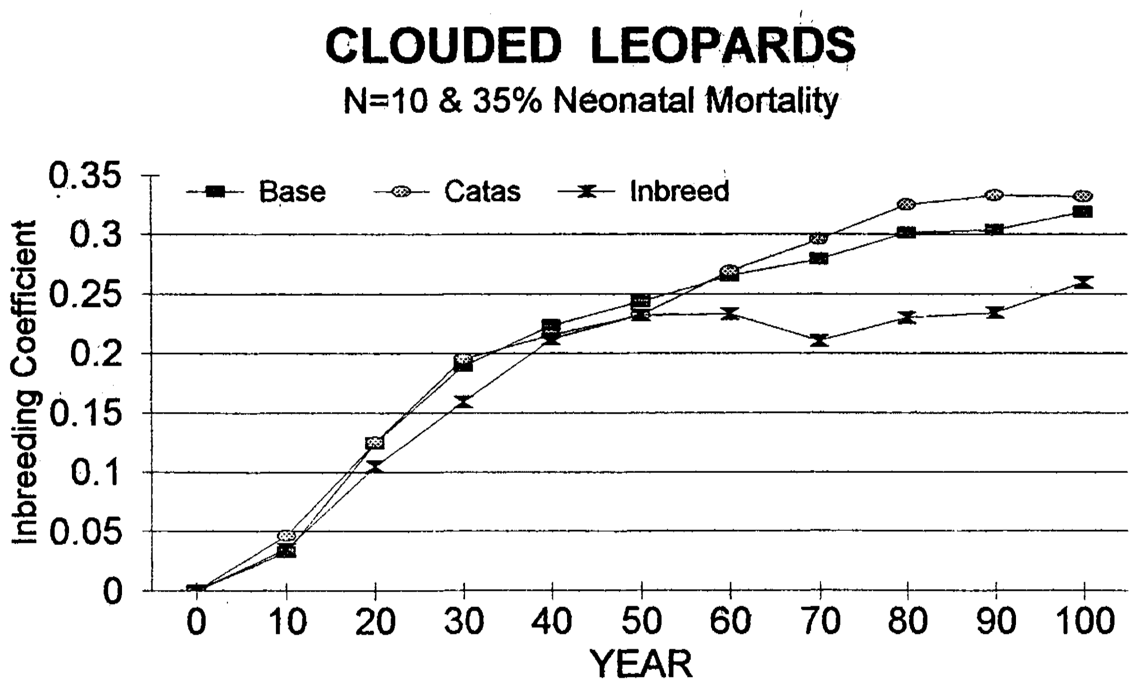


Figure 10. Projections of the inbreeding coefficient for wild clouded leopard populations.

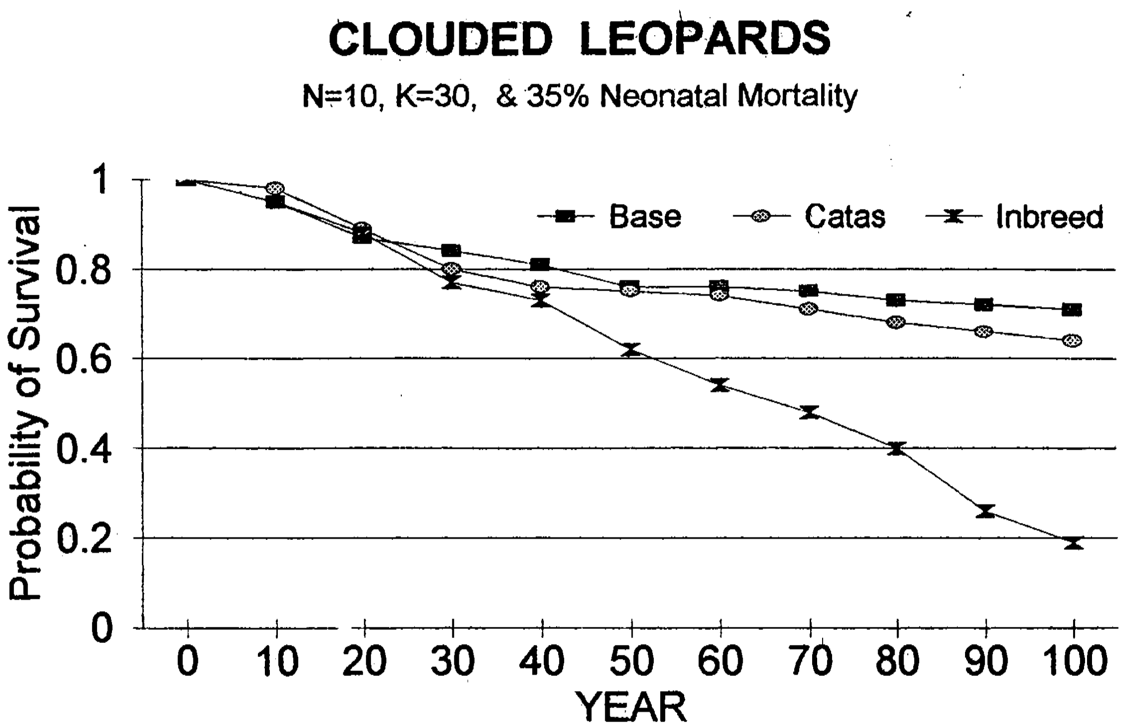


Figure 11. Projections of probability of survival for wild clouded leopard populations.

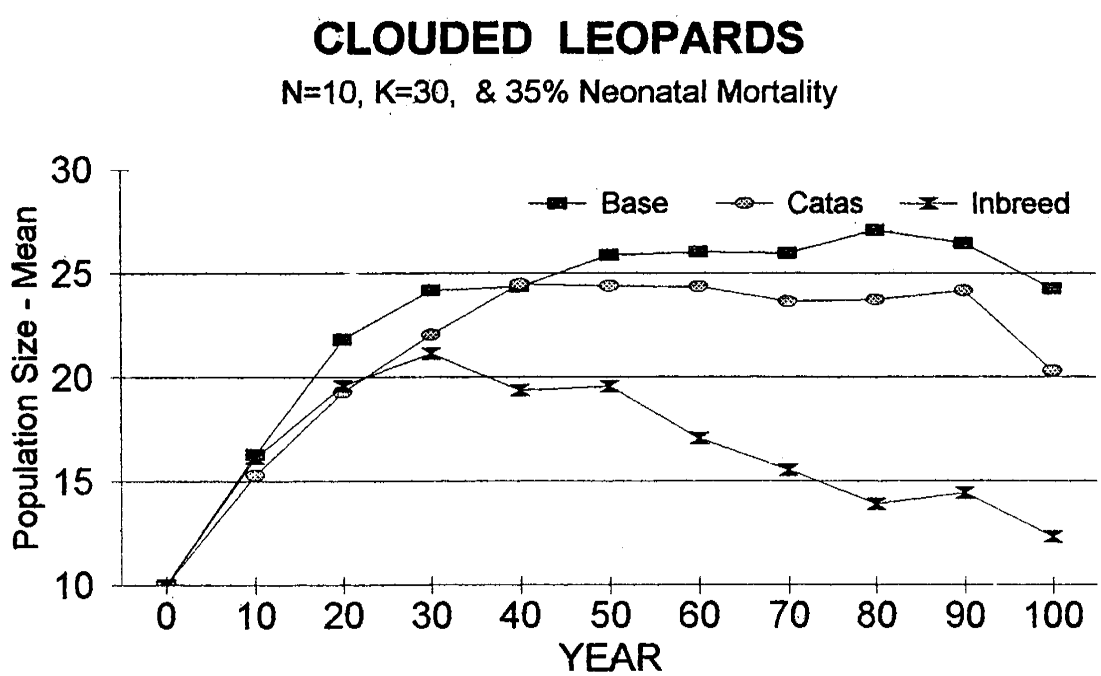


Figure 12. Projections of surviving population size for wild clouded leopard populations.

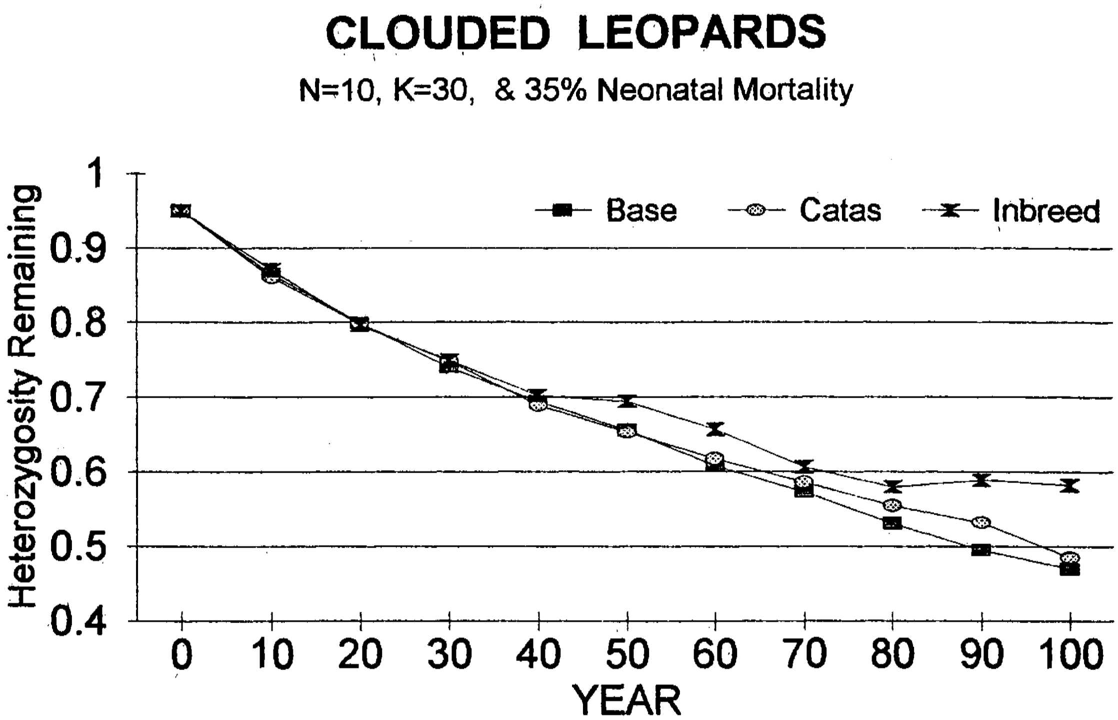


Figure 13. Projections of remaining heterozygosity in wild clouded leopard populations.

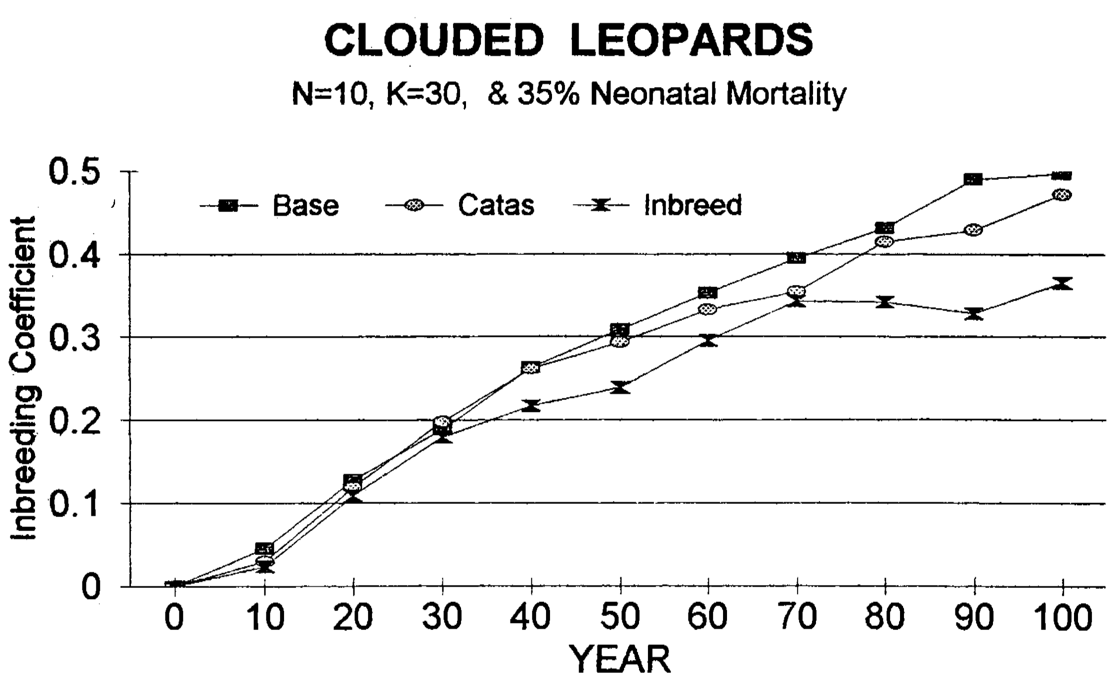


Figure 14. Projections of the inbreeding coefficient for wild clouded leopard populations.

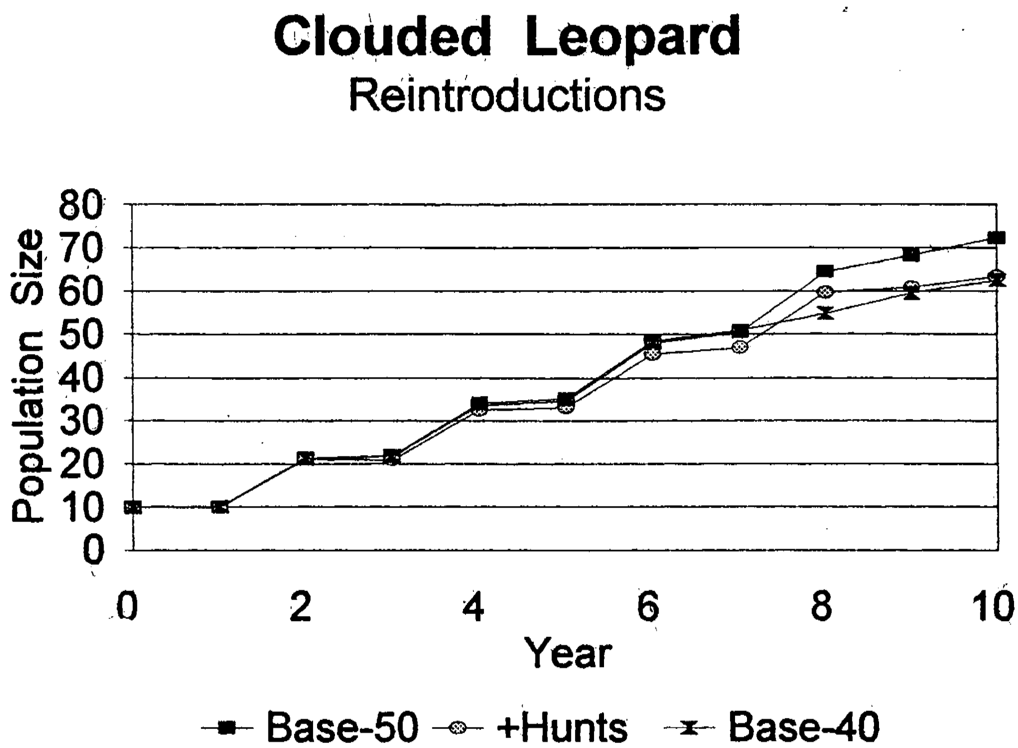


Figure 15. Annual population projections for 10 years for three reintroduction scenarios.

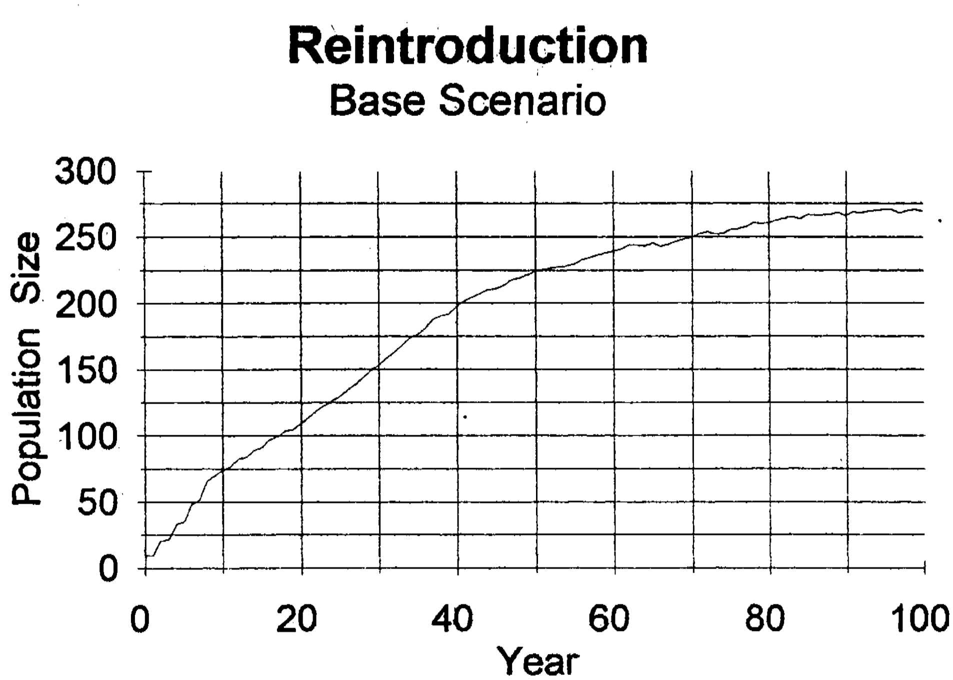


Figure 16. Annual population projections for 100 years for base-50 reintroduction scenario.

INPUT FILE FOR VORTEX (This is the 'hunts' reintroduction scenario in Figure 15.)

CLOUD.103 ***Output Filename***
Y ***Graphing Files?***
N ***Each Iteration?***
Y ***Screen display of graphs?***
200 ***Simulations***
100 ***Years***
10 ***Reporting Interval***
1 ***Populations***
N ***Inbreeding Depression?***
N ***EV correlation?***
2 ***Types Of Catastrophes***
P ***Monogamous, Polygynous, or Hermaphroditic***
3 ***Female Breeding Age***
3 ***Male Breeding Age***
12 ***Maximum Age***
0.500000 ***Sex Ratio***
3 ***Maximum Litter Size***
N ***Density Dependent Breeding?***
50.000000 ***Population 1: Percent Litter Size 0***
22.000000 ***Population 1: Percent Litter Size 1***
25.000000 ***Population 1: Percent Litter Size 2***
3.000000 ***Population 1: Percent Litter Size 3***
12.500000 ***EV--Reproduction***
50.000000 ***Female Mortality At Age 0***
20.412415 ***EV--FemaleMortality***
7.000000 ***Female Mortality At Age 1***
3.000000 ***EV--FemaleMortality***
7.000000 ***Female Mortality At Age 2***
3.000000 ***EV--FemaleMortality***
7.000000 ***Adult Female Mortality***
3.000000 ***EV--AdultFemaleMortality***
50.000000 ***Male Mortality At Age 0***
20.412415 ***EV--MaleMortality***
7.000000 ***Male Mortality At Age 1***
3.000000 ***EV--MaleMortality***
7.000000 ***Male Mortality At Age 2***
3.000000 ***EV--MaleMortality***
7.000000 ***Adult Male Mortality***
3.000000 ***EV--AdultMaleMortality***
33.000000 ***Probability Of Catastrophe 1***
1.000000 ***Severity--Reproduction***
0.950000 ***Severity--Survival***

1.000000 ***Probability Of Catastrophe 2***
1.000000 ***Severity--Reproduction***
1.000000 ***Severity--Survival***
Y ***All Males Breeders?***
N ***Start At Stable Age Distribution?***
0 ***Initial Females Age 1***
3 ***Initial Females Age 2***
2 ***Initial Females Age 3***
0 ***Initial Females Age 4***
0 ***Initial Females Age 5***
0 ***Initial Females Age 6***
0 ***Initial Females Age 7***
0 ***Initial Females Age 8***
0 ***Initial Females Age 9***
0 ***Initial Females Age 10***
0 ***Initial Females Age 11***
0 ***Initial Females Age 12***
0 ***Initial Males Age 1***
3 ***Initial Males Age 2***
2 ***Initial Males Age 3***
0 ***Initial Males Age 4***
0 ***Initial Males Age 5***
0 ***Initial Males Age 6***
0 ***Initial Males Age 7***
0 ***Initial Males Age 8***
0 ***Initial Males Age 9***
0 ***Initial Males Age 10***
0 ***Initial Males Age 11***
0 ***Initial Males Age 12***
300 ***K***
0.000000 ***EV--K***
N ***Trend In K?***
N ***Harvest?***
Y ***Supplement?***
2 ***First Year Supplementation***
8 ***Last Year Supplementation***
2 ***Supplementation Interval***
0 ***Females Age 1 Supplemented***
5 ***Females Age 2 Supplemented***
0 ***Females Age 3 Supplemented***
0 ***Males Age 1 Supplemented***
5 ***Males Age 2 Supplemented***
0 ***Males Age 3 Supplemented***
N ***AnotherSimulation?***

VORTEX -- simulation of genetic and demographic stochasticity

CLOUD.103
Thu Oct 19 03:15:10 1995

1 population(s) simulated for 100 years, 200 iterations

No inbreeding depression

First age of reproduction for females: 3 for males: 3
Age of senescence (death): 12
Sex ratio at birth (proportion males): 0.50000

Population 1:

Polygynous mating; all adult males in the breeding pool.

Reproduction is assumed to be density independent.

50.00 (EV = 12.50 SD) percent of adult females produce litters of size 0
22.00 percent of adult females produce litters of size 1
25.00 percent of adult females produce litters of size 2
3.00 percent of adult females produce litters of size 3

50.00 (EV = 20.41 SD) percent mortality of females between ages 0 and 1
7.00 (EV = 3.00 SD) percent mortality of females between ages 1 and 2
7.00 (EV = 3.00 SD) percent mortality of females between ages 2 and 3
7.00 (EV = 3.00 SD) percent annual mortality of adult females (3<=age<=12)
50.00 (EV = 20.41 SD) percent mortality of males between ages 0 and 1
7.00 (EV = 3.00 SD) percent mortality of males between ages 1 and 2
7.00 (EV = 3.00 SD) percent mortality of males between ages 2 and 3
7.00 (EV = 3.00 SD) percent annual mortality of adult males (3<=age<=12)
EVs may have been adjusted to closest values
possible for binomial distribution.
EV in mortality will be correlated among age-sex classes
but independent from EV in reproduction.

Frequency of type 1 catastrophes: 33.000 percent
with 1.000 multiplicative effect on reproduction
and 0.950 multiplicative effect on survival

Frequency of type 2 catastrophes: 1.000 percent
with 1.000 multiplicative effect on reproduction
and 1.000 multiplicative effect on survival

Initial size of Population 1:

Age 1	2	3	4	5	6	7	8	9	10	11	12	Total
0	3	2	0	0	0	0	0	0	0	0	0	5 Males
0	3	2	0	0	0	0	0	0	0	0	0	5 Females

Carrying capacity = 300 (EV = 0.00 SD)

Animals added to population 1, year 2 through year 8 at 2 year intervals:
5 females 2 years old
5 males 2 years old

Deterministic population growth rate (based on females, with assumptions of no limitation of mates, no density dependence, and no inbreeding depression):

r = 0.021 lambda = 1.021 R0 = 1.152
Generation time for: females = 6.69 males = 6.69

Stable age distribution:

Age class	females	males
0	0.114	0.114
1	0.055	0.055
2	0.049	0.049
3	0.044	0.044
4	0.039	0.039
5	0.035	0.035
6	0.032	0.032
7	0.028	0.028
8	0.025	0.025
9	0.023	0.023
10	0.020	0.020
11	0.018	0.018
12	0.016	0.016

Ratio of adult (> = 3) males to adult (> = 3) females: 1.000

Population 1

Year 10
N[Extinct] = 0, P[E] = 0.000
N[Surviving] = 200, P[S] = 1.000
Population size = 65.26 (1.12 SE, 15.77 SD)
Expected heterozygosity = 0.979 (0.000 SE, 0.002 SD)
Observed heterozygosity = 0.997 (0.000 SE, 0.007 SD)
Number of extant alleles = 70.24 (0.52 SE, 7.29 SD)

Year 90
N[Extinct] = 7, P[E] = 0.035
N[Surviving] = 193, P[S] = 0.965
Population size = 188.98 (6.57 SE, 91.26 SD)
Expected heterozygosity = 0.858 (0.007 SE, 0.096 SD)
Observed heterozygosity = 0.868 (0.007 SE, 0.096 SD)
Number of extant alleles = 16.25 (0.51 SE, 7.08 SD)

Year 100
N[Extinct] = 8, P[E] = 0.040
N[Surviving] = 192, P[S] = 0.960
Population size = 193.79 (6.50 SE, 90.01 SD)
Expected heterozygosity = 0.849 (0.007 SE, 0.101 SD)
Observed heterozygosity = 0.858 (0.008 SE, 0.105 SD)
Number of extant alleles = 15.38 (0.48 SE, 6.68 SD)

In 200 simulations of Population 1 for 100 years:
8 went extinct and 192 survived.

This gives a probability of extinction of 0.0400 (0.0139 SE),
or a probability of success of 0.9600 (0.0139 SE).

8 simulations went extinct at least once.
Of those going extinct,
mean time to first extinction was 65.50 years (5.98 SE, 16.91 SD).

No recolonizations.

Mean final population for successful cases was 193.79 (6.50 SE, 90.01 SD)

Age 1	2	Adults	Total	
13.54	13.04	70.42	96.99	Males
13.86	12.77	70.16	96.79	Females

During years of harvest and/or supplementation
mean growth rate (r) was 0.4396 (0.0077 SE, 0.2165 SD)

Without harvest/supplementation, prior to carrying capacity truncation,
mean growth rate (r) was 0.0131 (0.0008 SE, 0.1133 SD)

Final expected heterozygosity was 0.8491 (0.0073 SE, 0.1013 SD)
Final observed heterozygosity was 0.8581 (0.0076 SE, 0.1052 SD)
Final number of alleles was 15.38 (0.48 SE, 6.68 SD)

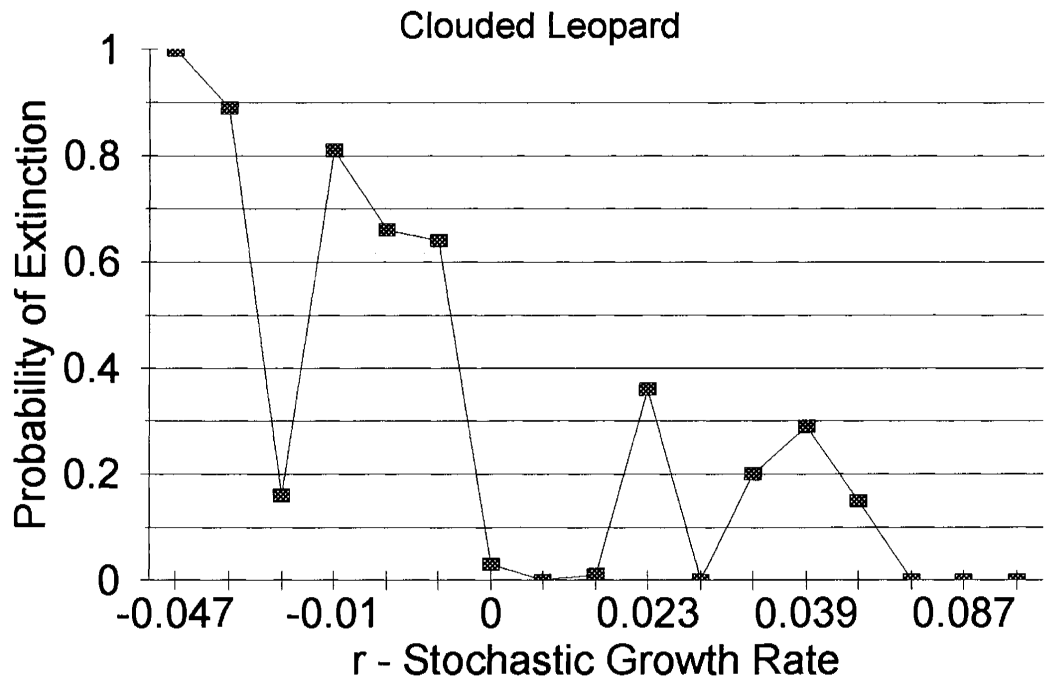


Figure 1. Relationship of stochastic growth rate and probability of extinction.

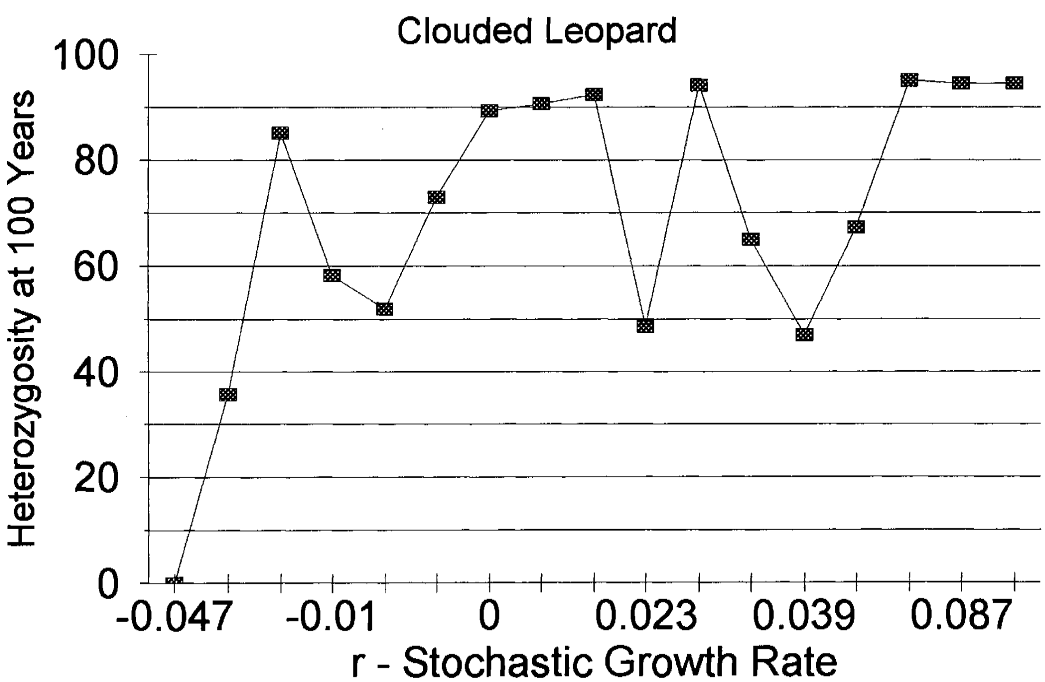


Figure 2. Relationship of stochastic growth rate and the proportion of heterozygosity.

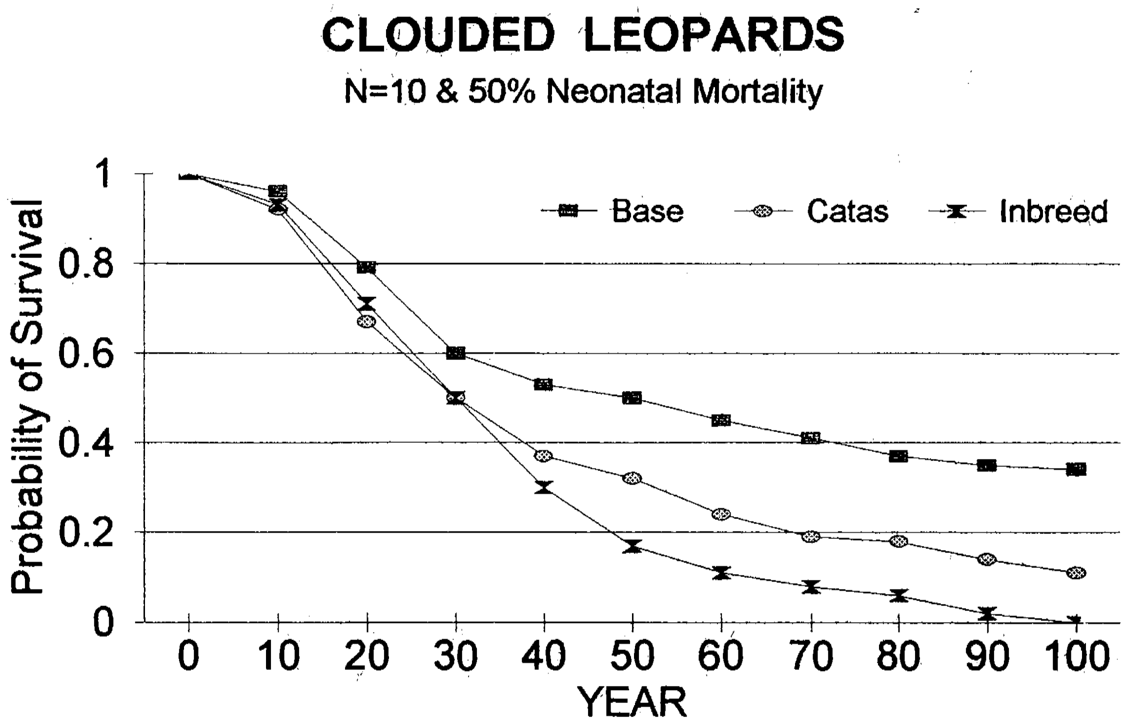


Figure 3. Projections of probability of survival for wild clouded leopard populations.

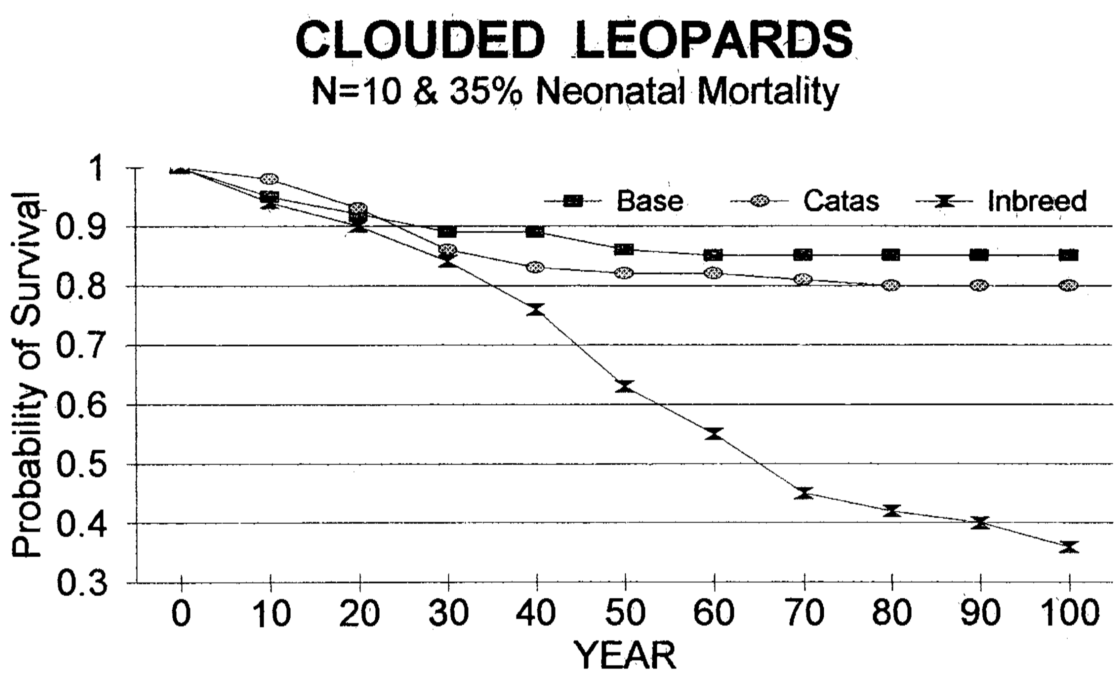


Figure 4. Projections of probability of survival for wild clouded leopard populations.

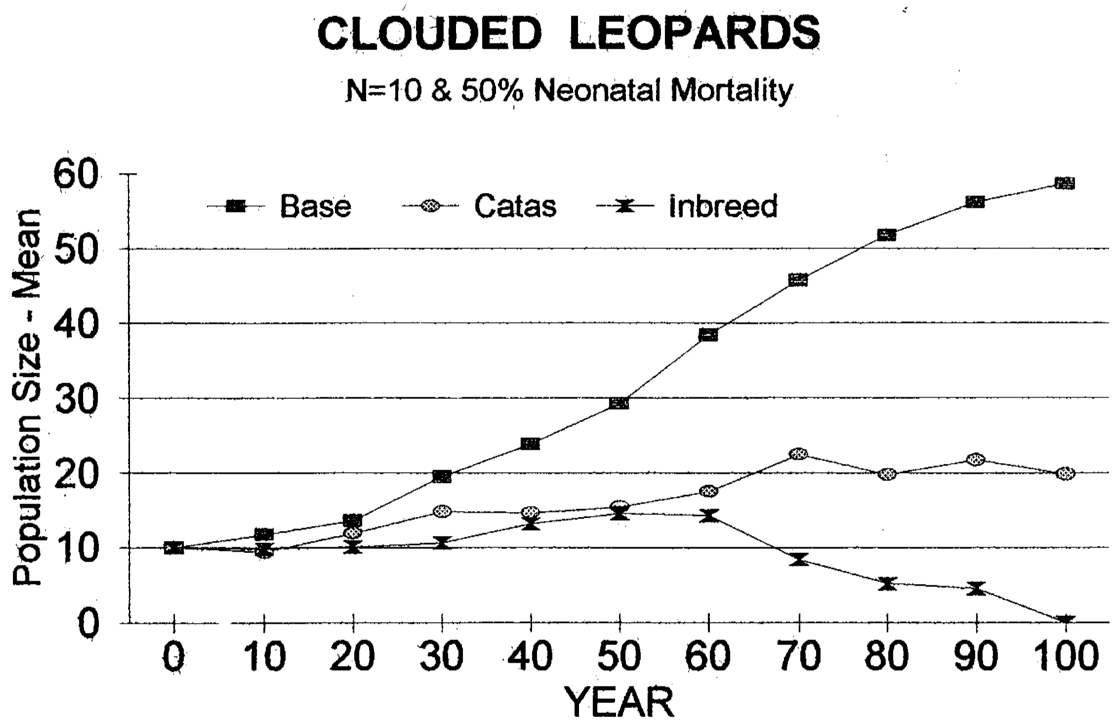


Figure 5. Projections of surviving population size for wild clouded leopard populations.

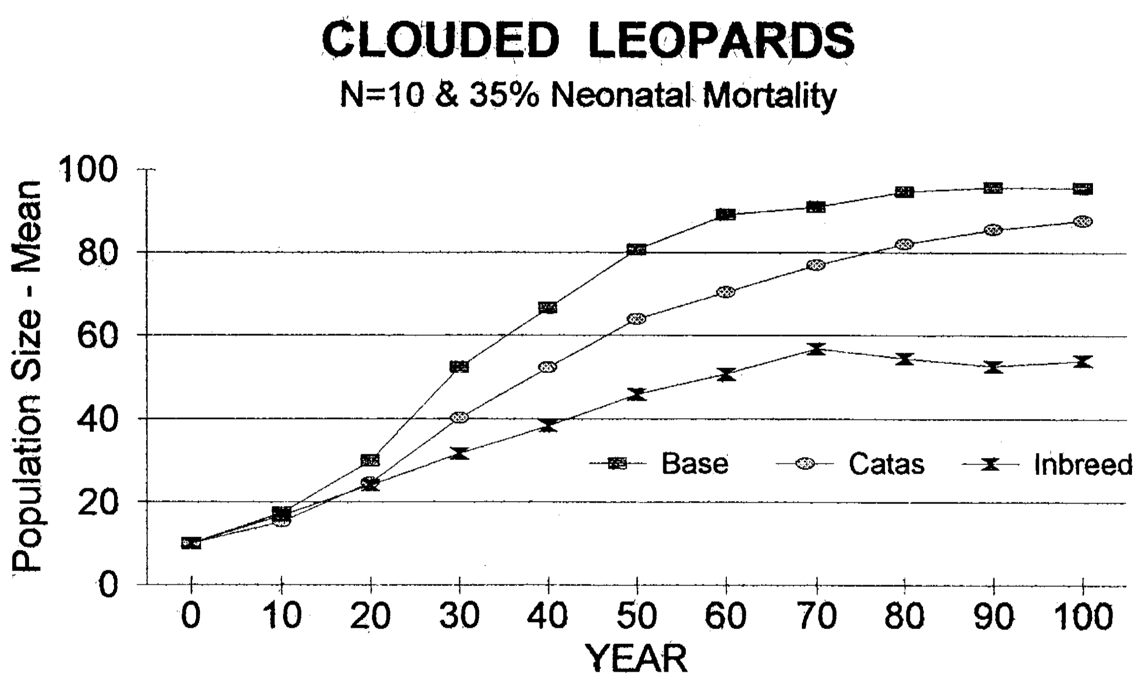


Figure 6. Projections of surviving population size for wild clouded leopard populations.

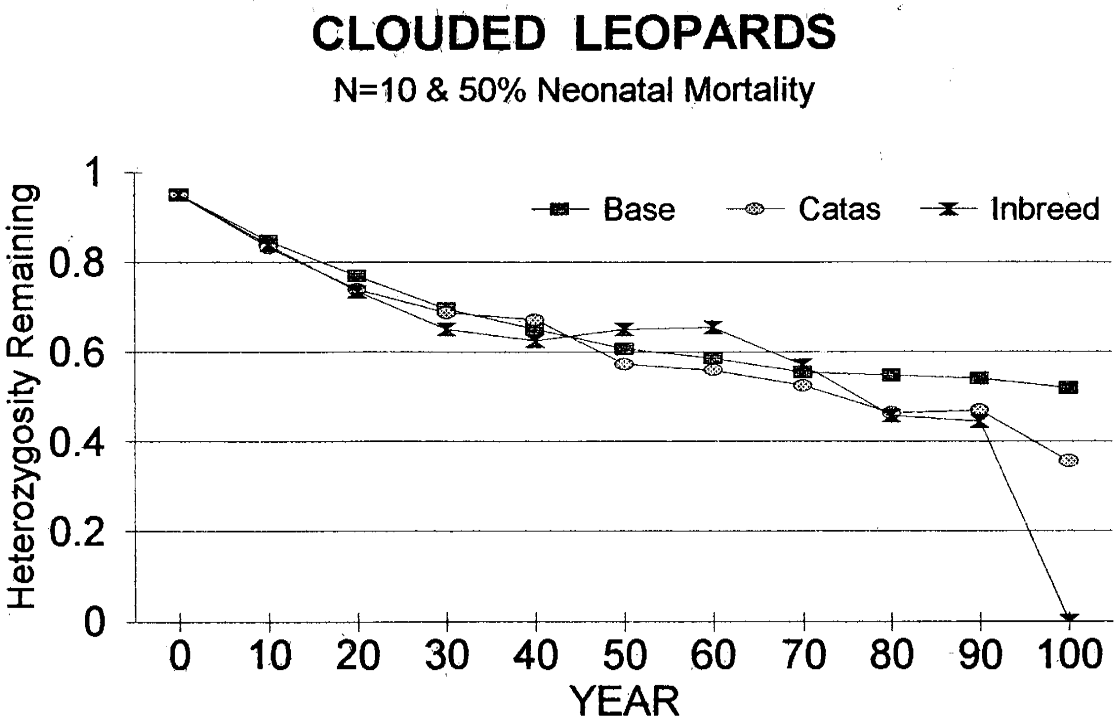


Figure 7. Projections of mean heterozygosity for wild clouded leopard populations.

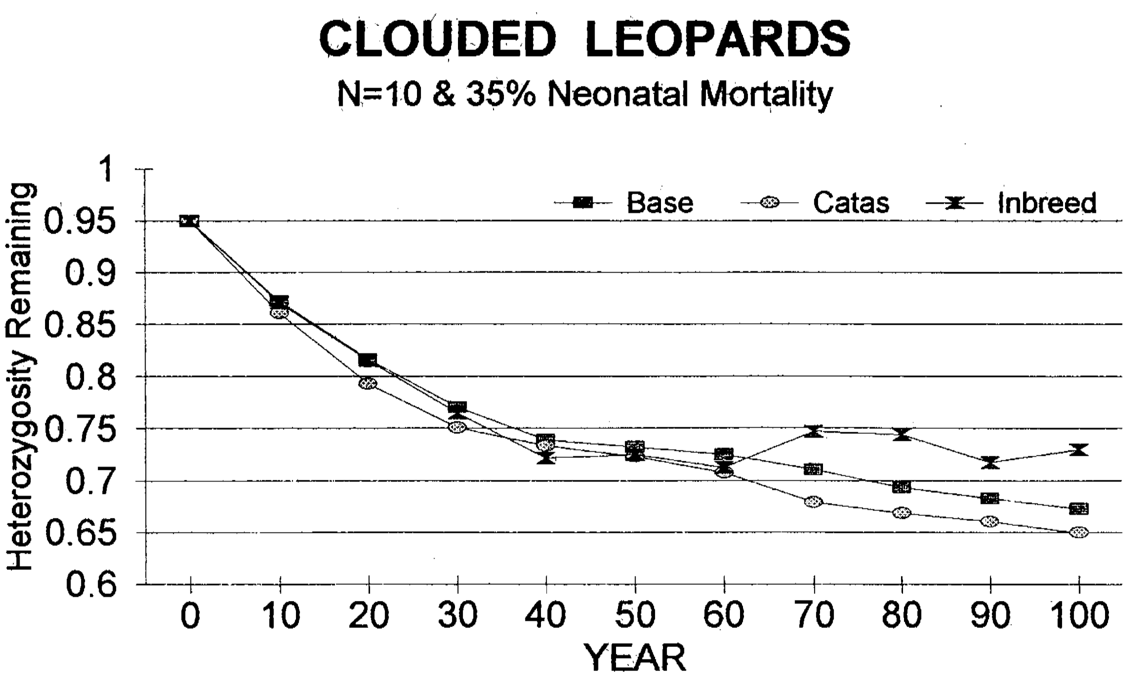


Figure 8. Projections of mean heterozygosity for wild clouded leopard populations.

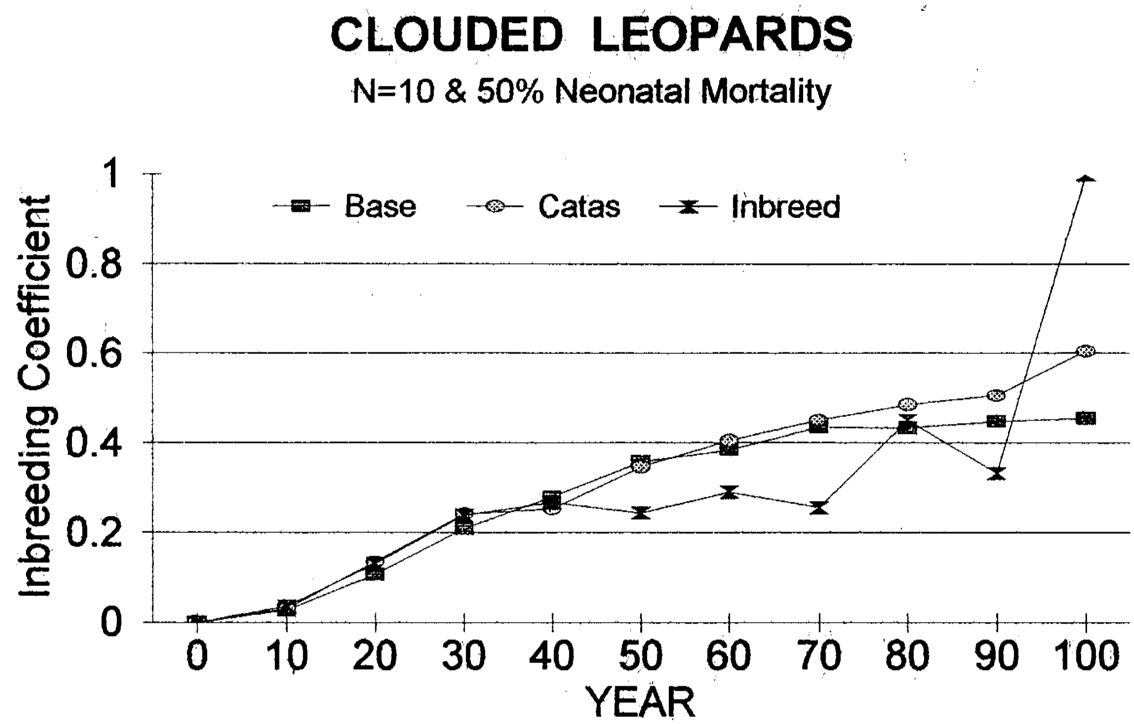


Figure 9. Projections of the inbreeding coefficient for wild clouded leopard populations.

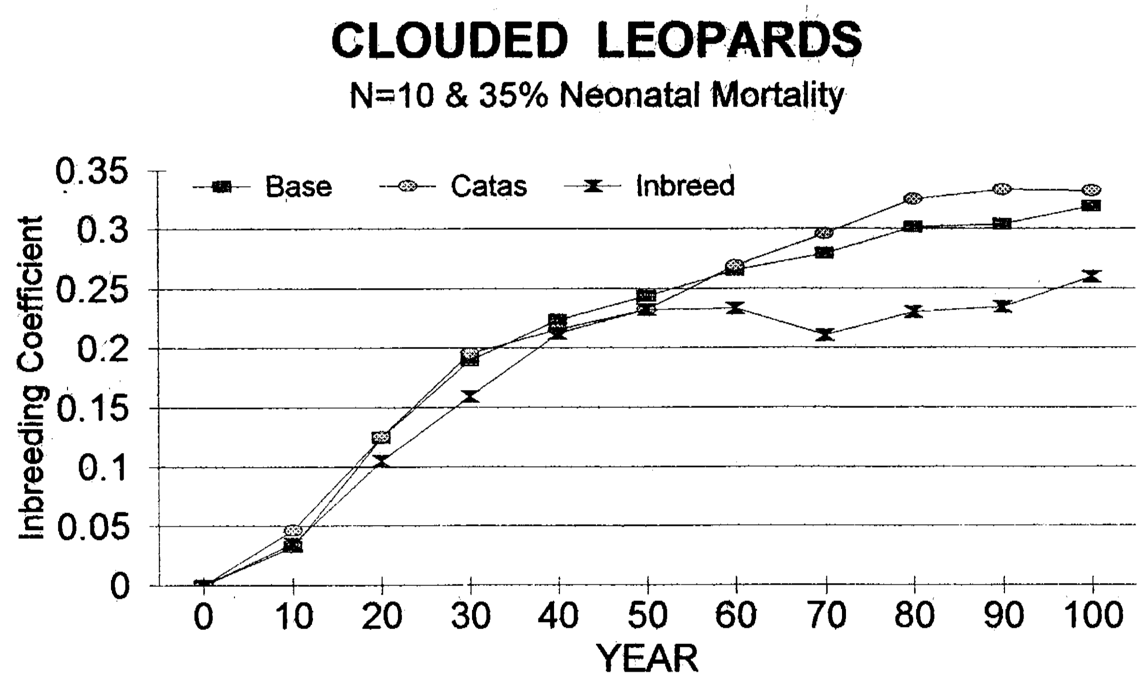


Figure 10. Projections of the inbreeding coefficient for wild clouded leopard populations.

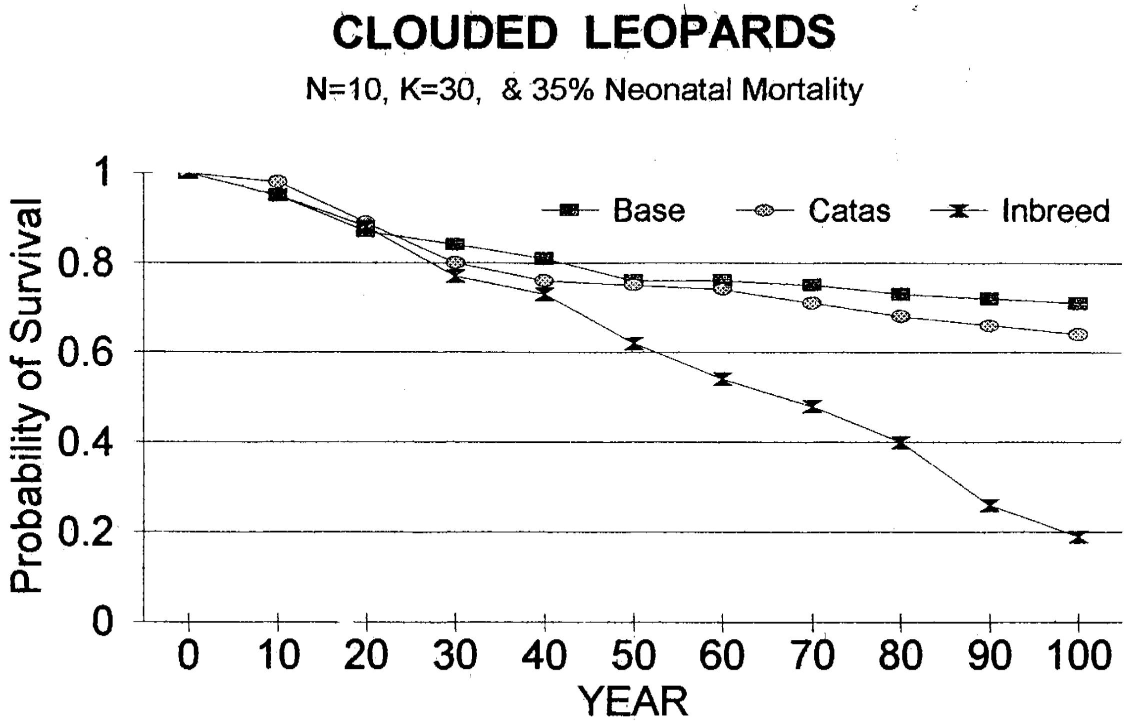


Figure 11. Projections of probability of survival for wild clouded leopard populations.

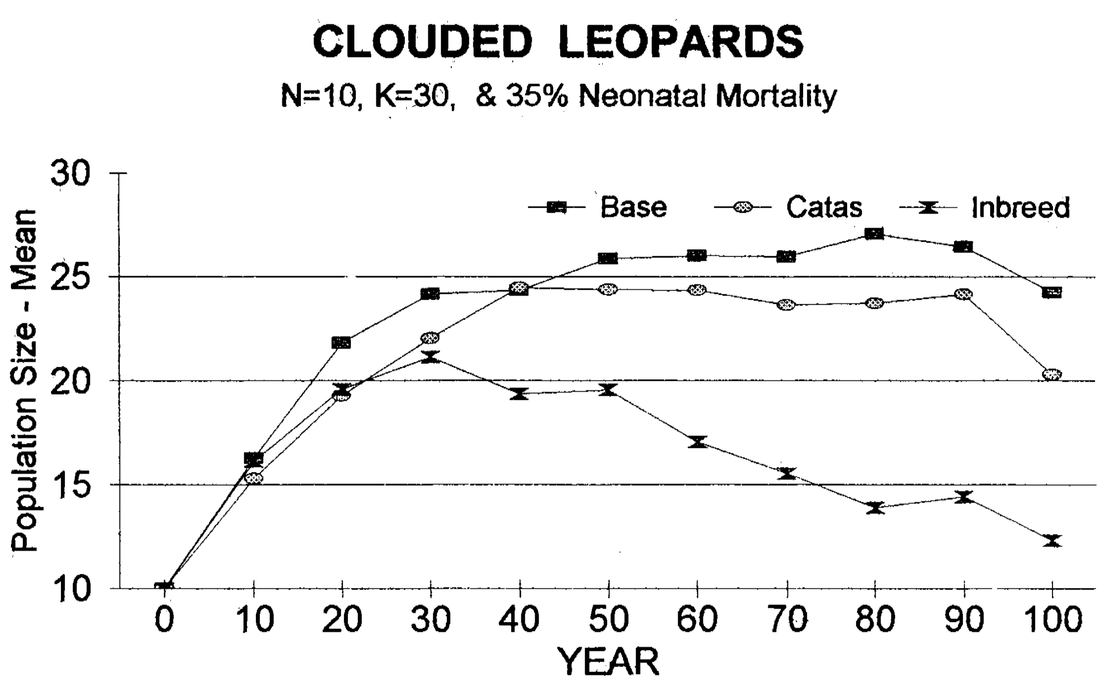


Figure 12. Projections of surviving population size for wild clouded leopard populations.

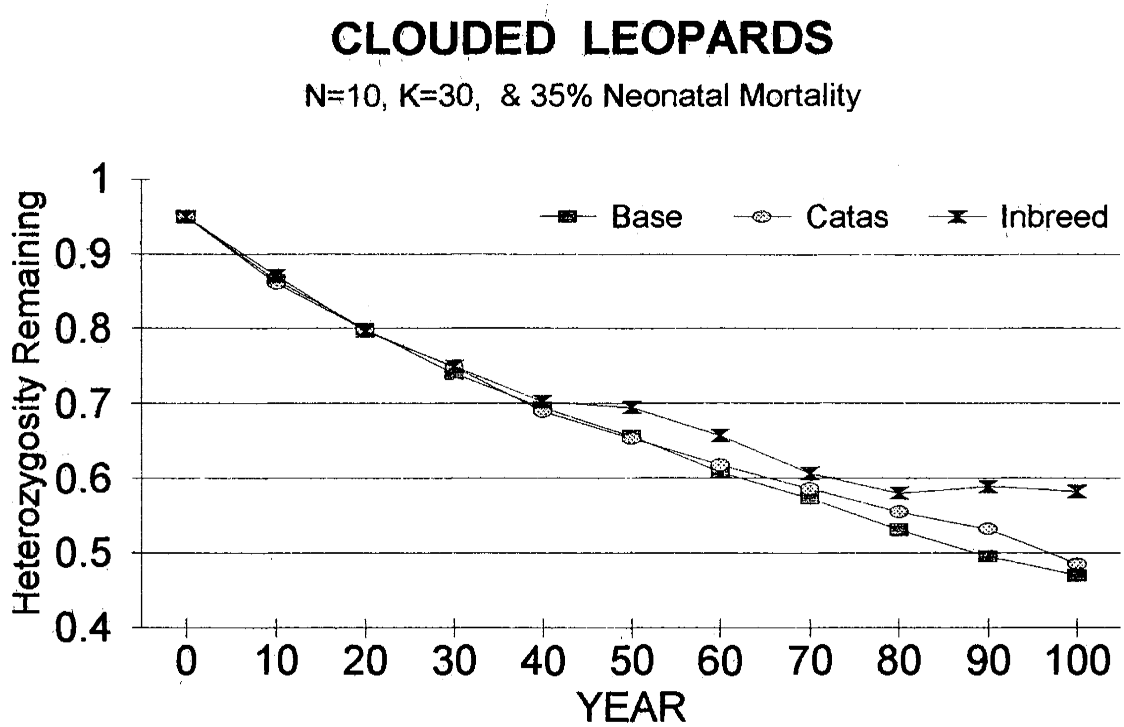


Figure 13. Projections of remaining heterozygosity in wild clouded leopard populations.

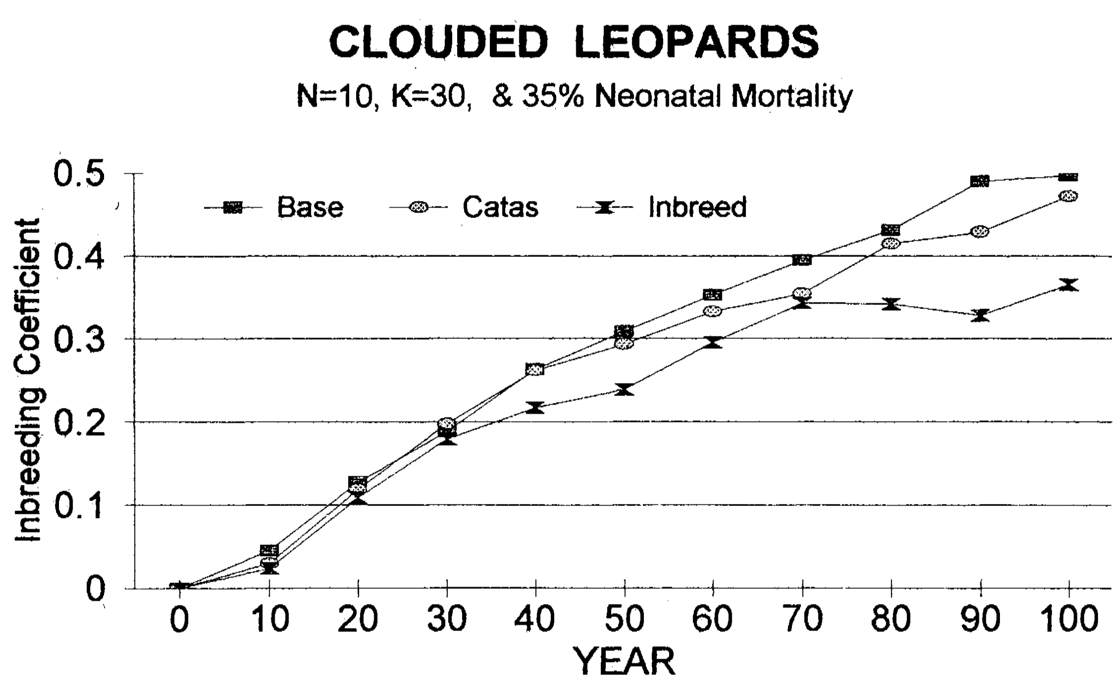


Figure 14. Projections of the inbreeding coefficient for wild clouded leopard populations.

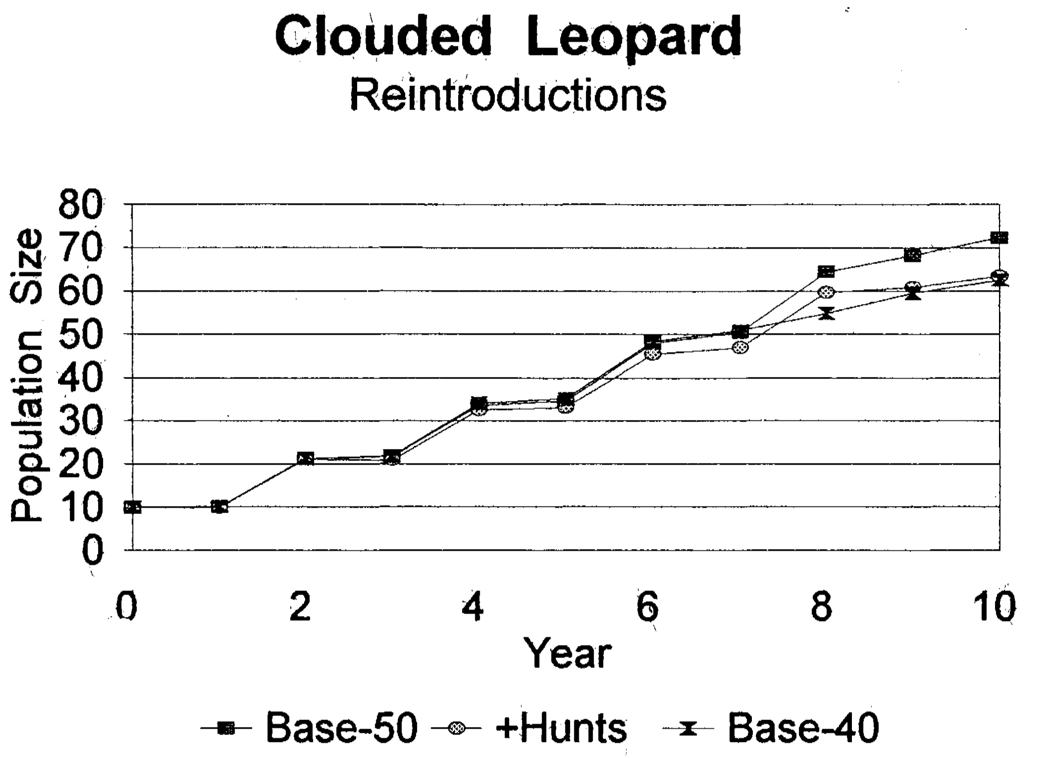


Figure 15. Annual population projections for 10 years for three reintroduction scenarios.

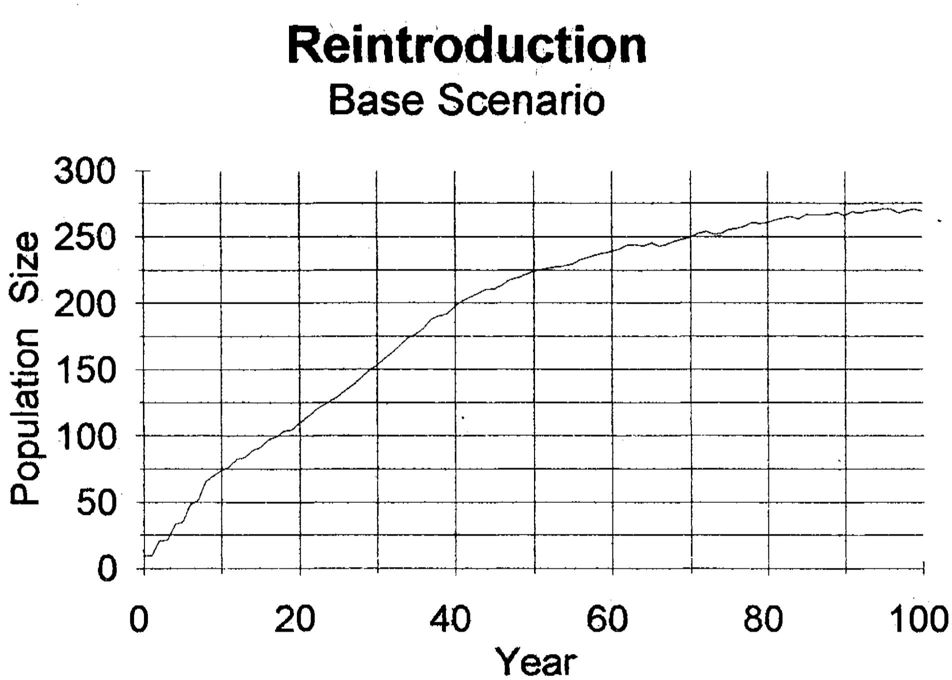


Figure 16. Annual population projections for 100 years for base-50 reintroduction scenario.

CLOUDED LEOPARD - TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

REPORT

APPENDIX I

MATERIALS ON TRANSLOCATION, MOLECULAR GENETICS, REPRODUCTIVE BIOLOGY AND CAPTIVE HUSBANDRY

Conservation Breeding Specialist Group: Appended Material

The Florida Panther Story

When the first explorers came to the New World, mountain lions (*Felis concolor*) were one of the most widely distributed mammals, occurring from British Columbia to Patagonia and from the Atlantic to the Pacific coast. As one of 30 recognized subspecies, the original range of the Florida panther (*F. c. coryi*) is considered to have extended from eastern Texas or western Louisiana through the southeastern states, including Arkansas, Louisiana, Mississippi, Alabama, Georgia, to parts of Tennessee and South Carolina.

The decline of the mountain lion began with the first European immigrants who settled in the New World. The animal not only killed livestock, but it was believed to be equally dangerous to people; legends of its ferociousness spread throughout the frontier. Early settlers considered the animal a nuisance to their livelihood. As civilization advanced, mountain lions were destroyed at every opportunity, and bounties were offered for their scalps. By the mid- to late-nineteenth century, the mountain lion had been extirpated from the vast majority of the eastern states and could only be found in a few inaccessible mountain ranges and coastal swamps.

Partial protection was given to the panther in 1950 by designating it a game animal and allowing it to be hunted only during the open season for deer. In 1958, the panther was removed from the native game list and given complete legal protection by the Florida Game and Fresh Water Fish Commission (GFC). The U.S. Fish and Wildlife Service (FWS) listed the Florida panther as endangered in 1967.

Even after panthers were legally protected from deliberate killing, human development continued to encroach on the diminishing panther habitat. As late as 1977, it was not known whether a viable or reproducing population of panthers still occurred in Florida, and if so, where the population would be found.

The Florida Panther Recovery Team was appointed by the FWS in 1976 to prepare and assist in coordinating the implementation of a recovery plan for the Florida panther. The Florida Panther Recovery Plan was approved by FWS in 1981. The goal of this Recovery Plan was to prevent the extinction of the Florida panther and to re-establish populations in as much of the former range as was feasible. The objectives listed to accomplish this goal were (1) to maintain existing populations, (2) to improve public opinion and behavior with regard to the recovery and management of the panther, and (3) to re-establish populations in as much of the former range as feasible.

In October 1976, the GFC Wildlife Research Laboratory commenced an investigation to locate and geographically delineate at least one population of Florida panthers. A breeding population was found in south Florida from Lake Okeechobee southward, primarily in the Big Cypress and Everglades regions.

A study was initiated in 1981 to evaluate this population and determine steps necessary to prevent its extinction. The current estimate of the south Florida population of Florida panthers is 30 to 50 animals; hence, the panther may be teetering on the brink of extinction. The population shows a clumped pattern of dispersion where approximately half the animals inhabit public lands. The major limiting factor appears to be the availability of suitable habitat. The present threats to the survival of the Florida panther are varied and interrelated.

Development keeps chipping away at the remaining panther habitat. Private lands steadily are being lost as panther habitat which means that the panther's survival may be entirely dependent on habitat situated on the less productive public lands. It is probable that the Florida panther is involved in a slow, but rather certain extinction process and that genetically the population numbers are critically low. The animals in this population show signs which indicate the population may be suffering from inbreeding depression.

The Florida Panther Recovery Plan was revised in 1987 by the Technical Subcommittee of the Florida Panther Interagency Committee. The goal of this revised plan is to achieve three viable, self-sustaining populations within the historic range of the animal. To accomplish this goal, at least two additional populations will need to be re-established.

In addition to efforts to manage panthers in south Florida, the GFC has formed a commitment to reintroduce Florida panthers into suitable areas within the state. Successfully introducing Florida panthers into such areas would help reduce the risk of extinction for the subspecies. This project is divided into four phases: (1) determine where areas of suitable habitat exist; (2) determine the feasibility of using translocated wild panthers in the re-establishment of the subspecies; (3) determine the feasibility of using captive-raised offspring in the re-establishment of panther populations; and (4) introduce Florida panthers into unoccupied areas where feasible.

The first step in determining reintroduction feasibility is to determine whether suitable habitat still exists outside of southern Florida. The best way to determine whether an area is suitable is to introduce panthers and monitor their behavioral response and survival. The objective of this study was to identify potential panther reintroduction sites in Florida and to determine the feasibility of using captive-bred offspring and/or translocated wild panthers in the re-establishment of Florida panther populations.

Panther habitat evaluation criteria were developed using data gathered in Florida panther radio-telemetry studies in southern Florida and from a review of the literature. These criteria were used to create a rating system for candidate reintroduction sites. The Osceola/ Okeefenokee area was considered the best candidate site for panther reintroduction. A field survey to determine the presence or absence of panthers was conducted in this area. No panther sign of any kind was found.

Based on the experiences of the Red Wolf Reintroduction Program, it was determined that key people needed to be contacted to obtain support for the panther reintroduction study prior to a general public awareness of the proposal. Due to anticipated landowner concerns over depredation, the GFC developed a policy that Florida panthers would not be introduced unless compensation for livestock losses as a result of panther predation was provided. The Buckeye Cellulose Corporation agreed to indemnify the Commission against livestock losses up to $10,000 during the translocation phase of the study and the Barnett Bank of Florida during the reintroduction of captive-reared animals phase of the study.

To inform the general public about the Panther Reintroduction Feasibility Study, press conferences were held immediately after key contacts were made. Meetings were also held with representatives of the many hunting clubs in the area, and public meetings were held.

Seven mountain lions captured in western Texas were released in the Osceola/ Okeefenokee area as surrogates for evaluating the feasibility of translocating Florida panthers. Two adult male, two adult females and one yearling female mountain lion were surgically sterilized, radio-collared, moved to the release site and held in soft-release pens 7-15 June 1988. An additional adult male and female were released on 22 March 1989. Following their release, all animals were located 6 days each week from a Cessna 172 airplane fitted with 2 H-configuration antennas.

All four lions that were in the wild more than 35 days established home ranges that overlapped one another within a 2,000 km^2 area. They made kills of large prey at a predicted frequency, and adapted well to their new environment before the hunting season. Once the hunting season began, however, the lions were either killed or disturbed to the extent that they left their established home ranges. Subsequent wanderings resulted in their encountering urban areas and livestock operations that probably would not have otherwise been encountered. These encounters necessitated the early removal of study animals.

Ten mountain lions were initially released into northern Florida on 22 February 1993 for the next phase of this study. These included four males and six females. Nine additional mountain lions were released as the study progressed. Six (two males and four females) of these 19 animals were born in captivity at Gillman Paper Company's White Oak Plantation near Yulee, Florida; three (females) were captured in the wild in western Texas and held in captivity for periods of 3 to 7 years; and the remaining 10 animals (six males and four females) were captured in the wild in western Texas and transported to Florida. All these animals were radio-collared; the males were sterilized, and then the animals were held in soft-release pens for 14 days prior to release.

This phase of the study was completed on 30 June 1995, and the final report is being prepared. In general, it was found that an initial stocking of at least 10 mountain lions can be used to establish a population in northern Florida and southern Georgia. The captive-raised mountain lions adapted more quickly and easily to the study area and established home ranges and a social structure, but were the cause of most of the human/lion interactions that created negative attitudes toward the program, which may prevent the reintroduction of

Florida panthers into northern Florida and southern Georgia.

Based on the results of a CBSG Genetic Management Workshop, eight young female mountain lions were released into the Florida panther population in the spring of 1995. The objective of this management action was to increase the genetic viability of the Florida panther without swamping its genetic make-up.

In summary, a small inbred population of Florida panthers consisting of 30 to 50 individuals was found in southern Florida. Many years of multi-disciplinary research and management have gone into preventing the extinction of this population. Although much work remains, the Florida panther can serve as a model of the sinister effects of inbreeding in a small population and the steps, including reintroduction and genetic management necessary to prevent its extinction.

雲豹的分子遺傳學

許多貓科物種都是於最近時期才演化出來的。它們的化石記錄，最古老的大約距今三百至五百萬年之間，有些物種的化石距今未到十萬年（Savage and Russel, 1983）。這種分散情形使得對決定這些物種演化關係的工作變得複雜化。如同過去發現的人類（Homo spaien）， 黑猩猩（Pan troglodytes），金剛猩猩（Gorilla gorilla）一樣，貓科演化發生時期過短，造成在其祖先所具有的多形性遺傳變異（polymorphisms）做分配時，其演變出來的子代在遺傳變異上具有重複性的關係（reciprocal monophyletic associations, Avise 1994）。

許多種方法已被用來分析這種在貓科間演化史上分類的關係（phylogenetic）。這些研究已經反映在形態學與分子學的技術闡釋，並且建立更有代表性的樣本。最先的研究努力包括比較細胞核物質學（comparative karyology, Wurster-Hill and Centerwall 1982），兩種貓科科體內反轉錄病毒（endogenous retroviruses）的研究（Benveniste 1985），白蛋白在免疫學上的距離（albumin immunological distance, Collier and O'Brien 1985），比較形態學（comparative morphology, Salles 1992），同源酵素電泳allozyme electrophoresis （O'Brien et al. 1987; Pecon Slattery et al. 1994）, 以及二位元蛋白質電泳分析（two-dimensional protein electrophoresis, Pecon Slattery et al. 1994）。近期間，對於努力解開演化史上分類的關係上，已經將焦點放在細胞粒線體的基因組（mitochondrial genome）方面（Janczweski et al. 1995; Johnson et al. Submitted; Masuda et al. Submitted）。

這些遺傳研究的結果，支持將38種貓科物種（Nowak, 1991）區分成三個主要組別之假設。第一個組別爲豹貓類系統（ocelot lineage）。此系統於10-12 百萬年前演化出來，形成在中南美洲小型有斑點的貓科物種。第二組別爲家貓類系統（domastic cat lineage）。它們於8-10 百萬年前演化形成，现今爲分佈於地中海地區的小型貓類。再更近現代的時期，較大型的貓科物種系統（pantherine lineage）萌發出來，這面包 括豹屬（Panthera genus）等大型貓類與許多中型的物種，分佈於世界各地。對於這三組物種已得到進一步的解答，但其彼此間的關係尚有許多仍待解決的問題（Janczweski et al. 1995; Johnson and O'Brien Submitted; Johnson et al. Submitted; Masuda et al. Submitted）

有關雲豹方面的知識

用形態學上的特徵來分類，雲豹已經可從其他38種貓科物種（基於專家的認定）分出成單獨的一種（e.g. Hemmer 1978; Herrington 1986; Salles 1992）。許多分類學者就依據形態學將雲豹歸於此屬內唯一物種。此唯一性也由分子遺傳資料分析，得到更進一步的支持。分子遺傳研究將豹屬的成員（包括獅子、花豹、美洲豹、以及老虎）作分級時，已經很清楚地將雲豹置於豹類系統中（Collier and O'Brien 1985; O'Brien et al. 1987; Pecon Slattery et al. 1994; Janczweski et al. 1995）。一些尚未發表的最近研究工作顯示，利用粒線體的限制碎片長度多形質變異

（polymorphism variation）以及直接對粒線體DNA序列分析（sequencing），更加支持雲豹與豹屬關聯的假設，就如同大部份遺傳系譜的分枝一樣（Johnson et al. Submitted; Johnson and O'Brien Submitted）。

現今一般認爲有四種雲豹亞種存在。這種區分只是針對數隻動物，根據其形態上的比較，由一些差異的比較做分類，但並未經由分子遺傳技術作更精密的驗證。

對於雲豹的異對偶基因性（heterozygosity），我們只有做過表面的評估。從美國來的20隻圈養雲豹平均有2.3％的對偶基因異質性，與在南非柯魯格國家動物園內野生的獅子（Panthera leo）相似（Miththapala et al. 1991；Newman et al. 1985）。然而，與其他9種貓科物種比較，雲豹多形質的（polymorphic）基因只產生極少數不同的酵素，而在這幾種貓科物種中，只有獵豹（Acinonyx jubulatus）的對偶基因異質性狀況表現的比雲豹低。

對管理可能做爲復育的圈養雲豹族群，有數點遺傳因素需要考慮。包括對提供遺傳物質的動物來源之決定，及維持已是低基因歧異度的族群，使歧異度不再衰退。

要完全了解雲豹族群，最好是能詳細知道野外族群的分子遺傳特性，包括亞種族群的確定及遺傳異基因型（genetic heterozygosity）情況的估計。從其他數種貓科物種的研究經驗來看，顯示兩種分子標誌（molecular maker）的型式對族群基因變異及差別的特性與關連，爲很有效的評量工具（estimator）：粒線體的DNA基因與細胞核微衛星（nuclear microsatellite, 二個、三個、以及四個核甘酸重複組）基因座。用粒線體基因的好處，是因爲在它們迅速的基因趨異演變時，遺傳物質主要是在母體，沒有基因重組的現象，並能擴大遺傳的理論來解釋變異的方式。微衛星爲理想的細胞核標示，這是因爲發現許多貓類的基因座，能從高突變速率產生很多的變異基因，然後取用少量含這些變異基因的動物組織，做聚合酵素連鎖反應（polymerase chain reaction, PCR）格式化分析。

微衛星與粒線體標示已廣泛運用在許多種類的貓科物種分析上，提供一個廣大的背景資源來幫助解釋雲豹的研究結果。從全部地理範圍內的雲豹都發展此種標示，也增加確認未知來源動物遺傳背景的可能性，而對這種確認可以加入對此物種所進行的保育計畫面。

亞 種 物 種 的 決 定

亞種物種的決定需要結合適當數量的有來源個體（voucher specimen），以及相關技術配合。同時，必須收集從每種亞種，或由地形區隔所分之物種，大約6個經證實個體的遺傳物質。假如在這物種內的遺傳變異低，則必須再取樣30至50個個體，以便能在微衛星基因座取到足夠的變異量樣本，便於決定此個體標本的遺傳背景。先前存在台灣特有雲豹的遺傳特性辨視，可以用博物館或私人收藏的標本中萃取其DNA做遺傳分析，並比較其他不同區域來的雲豹標本研究而得。

這些生物材料一般大部份都從包括血液或組織的DNA中萃取出來。血液樣本通常都從紅血球細胞、白血球細胞、及一些原生質成份中分離出來。血液與組織必須冷凍保存以避免衰敗破壞。另外提供鹽類溶液讓血液能存在室溫中，以便能從當中萃取DNA。DNA已經能成功地從150年之久的保存標本的小碎片（2-4 cm^2）萃取出來，甚至這些標本已經過保存處理也可萃取出來。

結論

超過15年對貓科動物的遺傳研究，以分子遺傳方式做爲基礎，在貓科方面產生許多有價值的資料，而且也對於貓類保育遺傳學重要的技術與方法有所瞭解。基於這瞭解，產生許多保育研究機構必須做爲優先研究的主題：

1、特別討論雲豹族群基因變異，並用地理區域分佈模型與亞種分類等級來連結觀察的方法。

2、發展適合的分子標誌（molecular marker）做爲辨認動物標本的來源地理區域及辨視個體動物。

3、利用其他生理學、免疫學、以及流行病學方面的知識，如生物生殖學、主要組織相容複合體（major histocompatibity complex, MHC）變異的等級、以及曝露於疾病的感染，連結雲豹族群的各種基因特性。

Conservation Breeding Specialist Group: Appended Material

Molecular Genetics of Clouded Leopard (*Neofelis neofelis*)

Introduction

Most cat species evolved relatively recently. The oldest fossil records of these species are only 3-5 million years old, and some first appear < 100,000 ago (Savage and Russel, 1983). This recent radiation has complicated the task of determining the evolutionary relationships among the 38 commonly recognized cat species. As has been found between human (*Homo sapien*), chimpanzee (*Pan troglodytes*) and gorilla (*Gorilla gorilla*), felid evolution has occurred too rapidly for shared ancestral polymorphisms to sort into reciprocally monophyletic associations (Avise, 1994).

The phylogenetic relationships among the Felidae have been addressed by a variety of methods. These studies have reflected evolving morphological and molecular techniques and access to more representative samples. The first efforts included comparative karyology (Wurster-Hill and Centerwall, 1982), the study of two felid endogenous retroviruses (Benveniste, 1985), albumin immunological distance (Collier and O'Brien, 1985), comparative morphology (Salles, 1992), allozyme electrophoresis (O'Brien et al., 1987; Pecon Slattery et.al., 1994) and two-dimensional protein electrophoresis (Pecon Slattery et al., 1994). More recently, efforts to resolve phylogenetic relationships have focused on the mitochondrial genome (Janczweski et al., 1995; Johnson et al., submitted; Masuda et al., submitted).

These genetic studies support the hypothesis that the 38 felid species (Nowak, 1991) can be divided into three major groups. The first group, the ocelot lineage, diverged 10-12 million years ago (MYA) and led to the small spotted cats of Central and South America. The second group, the domestic cat lineage, diverged 8-10 MYA and resulted in small cats which are currently distributed around the Mediterranean region. More recently, the felid species of the Pantherine lineage emerged, including the big cats of the *Panthera* genus and many medium-sized species with world-wide distribution. Further resolution has been achieved among the species of these groups, but many relationships remain unresolved (Janczweski et al., 1995; Johnson and O'Brien, submitted; Johnson et al., submitted; Masuda et al., submitted).

Knowledge about Clouded Leopard Phylogenetics

The uniqueness of the clouded leopard compared with the other 38 commonly recognized felid species (depending upon the expert) has long been recognized based on morphological characteristics (e.g., Hemmer, 1978; Herrington, 1986; Salles, 1992). This is evident in the classification of the clouded leopard by most taxonomist as the only species of its genus. This uniqueness has been generally further supported by molecular genetic data. Molecular genetic studies have placed the clouded leopard clearly within the Pantherine lineage, with different genetic techniques allying it to varying degrees with members of the *Panthera* genus (lion, leopard, jaguar, snow leopard and tiger) (Collier and O'Brien, 1985; O'Brien et al., 1987; Pecon Slattery et al., 1994; Janczweski et al., 1995). Some recent unpublished work, using mitochondrial restriction fragment length polymorphism variation and direct sequencing of two mtDNA fragments, have added further support to the hypothesis that the clouded leopard is allied with the *Panthera* genus, albeit as the most ancestral offshoot (Johnson et al., submitted; Johnson and O'Brien, submitted).

There are currently four commonly recognized clouded leopard subspecies. These divisions were established based on morphological differences from relatively few animals and have not been scrutinized with molecular genetic techniques.

Heterozygosity within clouded leopards has been evaluated only superficially. A captive population of 20 animals from United States zoos had a percent average heterozygosity (H) of 2.3, similar to free-ranging lions (*Panthera leo*) in Kruger National Park (Miththapala et al., 1991; Newman et al., 1985). However, relative to nine other felid species, the clouded leopard had polymorphic sites for the fewest number of enzymes, with only the cheetah (*Acinonyx jubulatus*) showing less heterozygosity.

There are several genetic concerns for the management of a captive population of clouded leopards for possible reintroduction, including determining the genetic stock that animals will come from and maintaining the genetic diversity within this reduced population.

Complete understanding of the clouded leopard population would benefit from a detailed characterization of the molecular genetics of wild populations, including subspecies determination and estimation of genetic heterozygosity. Experience with other felid species has demonstrated two types of molecular markers which are powerful estimators of the extent and character of population genetic variation and differentiation: (1) mitochondrial DNA genes and (2) nuclear microsatellite (di-, tri-, and tetra-nucleotide repeats) loci. Mitochondrial genes are ideal because of their rapid genetic divergence, primarily maternal inheritance, lack of recombination and ample genetic theory for interpreting patterns of variation. Microsatellites are ideal nuclear markers because there are a large number of loci known in cats, abundant genetic variation due to high mutation rate and their PCR format assay makes them feasible to analyze with limited amounts of tissue.

Both microsatellite and mitochondrial markers have been used with a wide variety of cats, providing a broad background to aid in the interpretation of the results from clouded leopards. The development of these markers with animals from throughout the geographic range of clouded leopard also increases the possibility that the genetic background of animals of unknown origin might be determined and that they might be incorporated into the conservation program.

Subspecies Determination

Subspecies determination requires a combination of an adequate number of voucher specimens (of known origin) and the appropriate techniques. At a minimum, genetic material must be collected from about six voucher specimens for each subspecies or geographic area of interest. If genetic variation within the species is low, 30-50 individuals are needed to adequately sample the amount of variation in micro-satellite loci and to facilitate determining the genetic background of the specimen. The uniqueness of the clouded leopards which previously occupied Taiwan could be accomplished through the genetic analysis of DNA extracted from hides from museums and private owners, in conjunction with studies of specimens from the rest of the clouded leopard's geographic range.

The biological material most commonly collected for the extraction of DNA includes whole blood and tissues. Blood samples are often separated into the red blood cell, white blood cell and plasma components. Blood and tissues should be kept frozen to prevent degradation. Salt solutions are also available which allow blood to be stored at room temperature for eventual extraction of DNA. DNA has also been successfully extracted from small (2-4 cm^2) pieces of hide (pelts) of up to about 150 years old, even those which have been treated for preservation.

Conclusions

As the result of more than 15 years of genetic research with felid species, there now is a valuable data base of molecular genetic patterns for the Felidae and an understanding of the techniques and methods required to address many of the questions important to felid conservation genetics. Based on this knowledge, there are a number of high priority issues that should be considered by the conservation research community:

1. Characterize the genetic variation in clouded leopard populations and link observed patterns with geographic patterns and subspecies classification.

2. Develop the appropriate molecular markers that can be used to identify the geographic origin of specimens and to recognize individual animals.

3. Link genetic characteristics of clouded leopard populations with other physiological, immunological and epidemiological aspects such as their reproductive biology, level of MHC variation, and exposure to infectious diseases.

Citations

Avise JC (1994) Molecular Markers, Natural History and Evolution. Chapman and Hall, New York

Benveniste RE (1985) The contributions of retroviruses to the study of mammalian evolution. In: MacIntyre RJ (ed) Molecular Evolutionary Genetics. Plenum Press, New York. pp 359-417

Collier GE, O'Brien SJ (1985) A molecular phylogeny of the Felidae: Immunological distance. Evolution 39:437-487

Ewer RF (1973) In: The Carnivores. Cornell University Press, Ithaca, NY pp. xv & 494

Janczewski DN, Modi WS, Stephens JC, O'Brien SJ (1995) Molecular evolution of mitochondrial 12S RNA and cytochrome b sequences in the Pantherine lineage of Felidae. Mol Biol Evol 12:690-707

Johnson WE, Dratch PA, Martenson JS, O'Brien SJ (submitted) Resolution of recent radiations within three evolutionary lineages of Felidae using mitochondrial restriction fragment length polymorphism variation. J Mam Evol

Johnson WE, O'Brien SJ (submitted) Phylogenetic reconstruction of the Felidae using 16s and NADH-5 mitochondrial genes. J Mol Evol

Masuda RM, Lopez JV, O'Brien SJ, Pecon Slattery J, Yuhki N, O'Brien SJ (submitted) Molecular phylogeny of mitochondrial cytochrome b and 12s rRNA sequences in the Felidae: Ocelot and domestic cat lineages. Mol Phyl Evol

Nowak RM (1991) Walker's Mammals of the World, Vol. 2. John Hopkins University Press, Baltimore

O'Brien SJ, Collier GE, Benveniste RE, Nash WG, Newman AK, Simonson JM, Eichelberger MA, Seal US, Janssen D, Bush M, Wildt DE (1987) Setting the molecular clock in Felidae: The great cats, *Panthera*. In: Tilson RL, Seal US (eds) Tigers of the World. Noyes Pub., New Jersey pp 10-27

Pecon Slattery J, Johnson WE, Goldman D, O'Brien SJ (1994) Phylogenetic reconstruction of South American felids defined by protein electrophoresis

Salles LO (1992) Felid phylogenetics: Extant taxa and skull morphology (Felidae, Aeluroidae). Am Mus Novit 3047:1-67

Savage DE, Russell DE (1983) Mammalian Paleofaunas of the World. Addison-Wesley, London

Wozencraft C (1993) Order Carnivora, Family Felidae. In: Wilson DE, Reeder DA (eds) Mammal Species of the World. Smithsonian Institution Press, 2nd edition. Washington DC. pp 288-299

Wurster-Hill DH, Centerwall WR (1982) The interrelationships of chromosome banding patterns in procyonids, viverrids and felids. Cytogenet Cell Genet 34:178-192

雲豹繁殖生物學的新知

介 紹

有關野生雲豹的繁殖生物學或是繁殖策略的領域尚不十分清楚。然而，在動物園的圈養族群中，已有相當豐富的繁殖生理及內分泌學的資料（見此段的最後節錄部份）。

許多的研究主題都著眼於下列的項目：1) 致力於雲豹族群內或族群之間精液與精子特性的研究；2) 雄性與雌性荷爾蒙的狀態，特別是雌性的繁殖週期長度；3) 發展方法來模擬卵巢的活動與排卵；4) 人工授精；5) 試管授精（*in vitro* fertilization, IVF）的初步工作；6) 精液冰凍保存技術與基因組來源庫（genome resource back, GRB）；7)營養對雄性生殖能力的影響。雖然建立了豐富的資料庫，但有些研究顯示此種種動物仍有其獨一無二的特性；這種特性對圈養管理以及自然與人工繁殖方面，可能出現一些必須克服的問題。因此，如同所有良好研究，這些系統化研究已經產生大量有潛力值得優先研究的主題（如下）。

繁殖是物種存活所必須，因此，理所當然地，繁殖生物學應優先研究。例如：測定下列的能力 (1) 啓發動物的生殖活力 (2) 假如動物是季節性繁殖者，管理者可以利用適當量的個體隻數，在適當的時間做繁殖。這方式顯然與雲豹非常有關，因爲它們有高度的性別不相容傾向（sexual incompatibility）。利用現今圈養方法，通常可以發現雄獸對雌獸做出致命的身體攻擊，即使那些已經表現出明顯發情現象的雌獸也不例外。因此，一個雲豹圈養所產生的普遍問題，就是管理者不願將遺傳方面適合的個體做配對，因爲害怕雌獸會受到創傷致死。未與雄獸配對的”被隔離”雌獸，成爲全球圈養雲豹很普遍的現象。同時存在的另外一個問題，即一般在動物園族群中，缺乏遺傳方面有價值的雄獸。例如，大部份已知存在北美洲的雲豹（大部份爲圈養）只是從少數幾隻個體繁殖而來，這地區內留下有遺傳方面價值的個體（$n < 10$）相當稀少。

由於良好引導繁殖研究的結果，產生了一個共識，最終能夠繼續引導發展出一致性與影響性的實用繁殖技術，例如人工授精，試管受精，以及胚胎移植（embryo transfer）。舉例來說，雲豹的人工受精可能有很深遠的利益，不只用於所有繁殖與遺傳上健康的雌獸。最終的目的是要在所有現存的雲豹族群中，維持高基因歧異度，而人工受精能夠利用來移動族群間的基因（經由生殖細胞），並避免移動活體動物的危險及路途移動造成的動物壓力來達成這個目的。這些策略最後也可以從野外族群取得有價值的基因，並將其傳遞至動物園族群中，最後就不需再從野外移入動物來補充圈養之不足。事實上，逐步實行這些方法，可提昇圈養族群基因的存活性，同時確定野生的雲豹仍存在原始棲地，以保護自然生態。

有關雄獸繁殖生物學知識

在麻醉手術台上利用電激射精（electroejaculation）的技術，可安全收集到雲豹精液與精子。這種技術已經用在許多雄獸上，並做過評估，許多相關論文中有許多值得探討的資料，包括有睪丸容量、精液容量、精子容量、精子的運動性、每次射精中活動精子的數量、以及在一次射精中畸型精子所造成的影響。多次的重覆電激射精，已能辨視出雄獸所產生不同品質的精液樣本。在另一方面，雖然個體間有些自然變異，但大部分雲豹每次射精約都有 500～600 微升（μl），包含了約 25,000,000 個精子，其中約有70% 的精子有活動力。精液精本並不呈一般牛奶色，相對地，只是有些不透光而已。此外，精液的液體必須在射精後很快地將之慢速離心。若將精子與精液保存在一起，則會造成精子在30分鐘內死亡。這些精子的沉澱（sperm pellet）在一般組織培養基中能夠再被懸浮並繼續活動，特別是在漢姆斯 F10（Ham's F10）培養基中。

令人感到興趣的是，從平均每次射精中，幾乎有 70% 精子細胞的都是畸型的，而其中主要的不正常現象是精子尾巴緊縮環繞。現在已獲悉這些不正常型態的精子不能穿透卵子，並使其受精，因此這種在雲豹的畸型精子症（tetratospermia）情形並不屬於正常狀況。此外，相似的狀況也在獵豹（*Acinony jabatus*）的精子上觀察到，這個現象被認爲是此物種歷史中遺傳歧異度的流失的主要原因。這與在其他貓科動物發現的現象相當一致，如在佛羅里達山獅（*Felis concolor coryi*)以及亞洲獅（*Panthera leo persica*) 的近親影響方面所測量資料之比較。不良的精子品質，常發生在可測量的遺傳歧異度缺乏情形，然而相同的結論尚無法用在雲豹上面，因爲缺乏它們的分子遺傳資料，包括野外族群基因組的歧異度。大部分雲豹精子資料，只是近期從北美洲數隻雲豹收集而來，其遺傳基礎相當有限。因此，是否從野外捕捉到的雲豹會有類似的精子缺陷，實尚未得知。最後，對此物種腎上腺荷爾蒙(adrenal hormones)在血液內的濃度研究，已持續一段時間。與其他一些的貓科物種比較，雲豹在神經末稍有高濃度的糖類皮質素(glucocorticoids)，這與它敏感害羞的天性有關連。壓力對繁殖力有負面影響，有一些生理證據顯示，雲豹對壓力的敏感性與其精液特性可能有相關。

有強力的證據顯示，雲豹精子在試管內與同種(conspecific)或不同遺傳物質(heterologous)之卵子間的交互作用具有獨特性。試管內的受精 (IVF) 對有“正常精蟲”的物種可經常進行，例如家貓及老虎電激射精產生的正常精子，就可順利進行 IVF。相反地，試管內受精對於一些具有畸型精子的物種，如獵豹，則很少有成功的機會，而且最近努力用 IVF 在具有畸型精子的獵豹上的工作，至今尚未有一個形成受精卵的成功例子。同樣情形，許多野生貓類物種的精子，包括獵豹與老虎的精子，在試管中很快與家貓的卵子產生交互作用（受精試驗的一種方式）；然而雲豹的精子仍然無法穿透家貓卵子的任何功能性膜層 (functional layer)。這些問題與精子不當的移動顯然不相關，因爲這些精子當因生化刺激出現短時間內突然移動時，並沒有促使受精的成功。即使提供精子不同遺傳形質 (heterologous) 的精液（例如對其他物種有影響的精液），情形仍然不見改善。這些結果暗示 (1) 從這些雲豹而來的所有精子，有遺傳上的生物問題，或是 (2) 這些精子非常獨特，與一般貓類的精子活動步驟不同，需要做進一步基礎的研究與考量。

有關雌獸繁殖生物學的知識

縱覽國際雲豹血統書顯示：雌獸75％ 生產胎次發生在 1～5 歲的年齡之間。性成熟期約在17～28個月的年齡範圍內，而懷孕期的範圍爲 85日～121日（平均值爲 93日）。國際繁殖記錄對於圈養的雌性雲豹做分析，顯示 46％ 的生產日期發生在 3 月與 4 月。這現象指出大部分生殖週期發生於 12 月底至次年的 2 月之間。關於這些生產記錄，最近對動物園內圈養的雲豹族群，利用長期監視糞檢荷爾蒙代謝，獲得更進一步的證實。以測定糞中二氫基動情素（estradiol）的資料做基礎，得到雲豹動情週期的時間爲 24±2 天，而其月經期持續期爲 6±1 天。平均懷孕期爲 89±2 天。另一方面，非懷孕時的黃體期間是 47±2 天。假如雌獸的光照時間維持一天 12 小時，它們整年都會有很規律地週期性生殖變化。當雌獸接受到長短不定的自然光照，則在夏末秋初時會有季節性泌乳不發情(seasonal lactational anestrus)現象。一隻雌獸在生出三隻小獸後，有泌乳不發情現象產生。有 9 個偶然發現的例證，顯示雲豹因黃體內泌素（progestagen）分泌提高，未經交配即行自然排卵。利用糞中固醇類代謝的監視是非常重要的，因爲它提供了一個縱向的方法，以完全不會受傷害的方式來評估繁殖行爲，減免了令人捉摸不清的潛在傷害壓力。

誘發排卵

外源性荷爾蒙（exogenous hormone）的處理，對人類及動物人工性刺激卵巢濾泡成長及排卵有影響作用。這些荷爾蒙處理後的雌性動物，經由繁殖技術的幫忙，能自然交配並產生胚胎。如同大部分的哺乳動物一樣，雲豹對親生殖腺素荷爾蒙（gonadotropin）的肌肉性注射能產生反應，而這種方法也經常用於許多貓類的誘發排卵。這些外源性荷爾蒙包括馬絨毛膜的生殖荷爾蒙（equine chorionic gonadotropin, eCG）激發濾泡成長，以及人類絨毛膜生殖荷爾蒙（human chorionic gonadotropin, hCG）刺激排卵。這些荷爾蒙的運用結合人工受精的方法，已經產生 7 種貓科物種後裔，包括雲豹在內。

再者，現在已經很肯定雲豹對這些生殖荷爾蒙非常敏感。例如，雖然雲豹的體重只有家貓的 4 倍，事實上只要更少量的 eCG 與 hCG 刺激，卵巢就能產生相同的反應。有時卵巢受到過度刺激，因而可能導致不正常卵巢固醇類的分泌，同時也影響雌性素（estrogen）與助孕素（progesterone）的比例，結果減少卵受精的機會，以及減少正常胚胎著床與發育。另一個值得重視的問題是此物種有相當高的自然排卵發生率。排卵中的雌獸分泌濃度極高的助孕素，使原先處理之 eCG 與 hCG 的影響變無效。

人工受精

如上所述，必須將精液中的精漿移去以獲得電激射精的精子，可用低速離心（800XG，10分

鐘）及精液沈澱在 Ham's F10 的培養基中的再懸浮來完成。母獸可以先用 eCG (75-10IU,i.m.)，再用 hCG (75IU,i.m.;在給了eCG 80小時之後)來誘發排卵。給 hCG 38-40 小時之後，母獸開始排卵。據目前所熟知的情形，在貓的人工受精過程面， 只有在排卵後實行授精才會受孕。這是因爲當使用人工受精麻醉方式（爲了保定母獸）會阻礙母獸的排卵（即，母獸的卵巢只有黃體）。因此，雲豹的人工受精不能在 hCG 處理後 38 小時內進行。第二點；置於子宮的精子位置爲一決定性的因素，理想中是用腹腔鏡檢查法將其置於子宮角的前部。誤置精子於陰道、子宮頸或甚至是子宮角的後端，都將導致無法懷孕。一種使用腹腔鏡透過腹部的子宮內人工受精技術已經被使用，而且發現對於石虎、山獅、老虎、豹貓、雪豹、獵豹產生懷孕都產生了效果。最近獵豹 9 次懷孕記錄是用腹腔鏡的人工受精方法所產生。雲豹先用 eCG 與 hCG 刺激排卵，然後用腹腔鏡做人工受精，產生了一次懷孕記錄（2 隻小獸在正常的懷孕期後產下）。然而，人工受精用在雲豹並不像用在獵豹那麼有效率，需要有更多的研究來確定人工受精的成功率，是否與精子或卵子品質不良，或是外源性荷爾蒙的處理造成不適當的排卵，或是不理想的卵巢反應有關。

基 因 組 來 源 庫 及 精 子 冷 凍 保 存

基因組來源庫（Genome Resource Bank, GRB)是用來對生物材料(biomaterial）（如精子、胚胎、卵子、組織、血液物質與 DNA）做有計畫收集、保存及使用，以便用來進行保育相關工作及研究。基因組來源庫有極具意義的優點，包含 (1) 容許族群間的基因能有方便且安全的傳遞方法，並幫助維持基因的歧異度，(2) 幫助減少圈養動物的總數，且達成基因歧異度的目標水準，(3) 提供"保險"，防止包括流行疾病所產生的巨大災變，以及 (4) 成爲其他生物材料資源，如組織、血液副產品及 DNA等， 做爲有關分類與亞種區分之鑑別工具，監控親緣關係的遺傳疾病，並定位有關這方面研究討論的主題。

雲豹的精子能在冷凍時存活，並在解凍後表現出理想的活動力。冷凍保存精子以沉澱（pellet）方式處理較利用吸管抽取理想。傳統的方法是加入一些防凍液（20% 蛋黃，11% 乳糖以及 4% 甘油）將精子洗滌出來。此稀釋後精子被降溫至 5℃，並持續冷藏 30 分鐘。一塊乾冰用一塊含有許多釘子的板子壓出許多鋸齒凹洞的表面。然後用吸量管（30 μl 的量）將這些冷藏的精子注入這些鋸齒凹洞內，並冷凍 30 分鐘，最後將此乾冰塊投入液態氮中。這些沉澱被裝入一個有標籤的玻璃瓶內，並用液態氮保存。當需要時，單獨一個或數個沉澱體（視所需精子濃度）以磷酸緩衝鹽溶液解凍取出，然後用腹腔鏡技術（如上述）進行受精工作。雖然雲豹子代尚未使用這種解凍精子的人工授精法產生，但此方法在石虎、豹貓及獵豹上都有成功的範例。

營 養 在 繁 殖 上 的 重 要 性

營養是貓類繁殖一項重要的管理因素。目前有足夠的資料明顯指出，肥胖減少貓類精子的濃度與活動力，雲豹也不例外。此外，必須避免只餵食肌肉性食物而不添加礦物質與維生素的飼糧。貓類若只吃特定食物，結果將沒有精子產生，或只產生低濃度與低活動性的精子。

結　論

超過 15 年有系統的研究，使圈養雲豹的繁殖生物學產生了一個有價值的資料庫。其他的成就包括 (1)能利用電激射精經常且安全地收集到活的精子，(2) 精子保存技術已經發展出讓體外精子活動性能持續，(3) 利用糞檢內分泌技術已經能仔細確認繁殖週期（發情的期間及間隔），這是一種能準確決定繁殖狀態而沒有傷害性的方法，(4) 目前知道雲豹比其他貓類有較高頻率的自然排卵現象，(5) 人工受精已經有一成功的例子，而且也知精子必須在排卵開始之後放入子宮角前的前端，(6) 有一種荷爾蒙控制的誘發排卵方法被分辨出來，(7) 精子能夠耐受冷凍保存的壓力，而且解凍後仍能呈現活動性，(8) 不理想的營養狀況將減少精子數目及其活動性。

但在另一方面，仍有許多問題需再考慮 (1) 因爲性別間的不合，無法做到經常性的配對繁殖管理，(2) 電激射精中含高百分率的畸型精子，其原因是否與圈養族群異基因型有關，(3) 利用外源性親生殖荷爾蒙處理，並不能經常產生與“正常”類似的卵巢反應，其中一部分原因可能是雲豹對這些荷爾蒙過度靈敏的感受性所致，(4) 在試管受精方面有困難，這是由於精子與卵子的功能不佳或交互作用微弱。最令人覺得缺乏的，則是完全沒有野外雲豹的繁殖生物學資料。

基於以上的結論，有許多極優先的主題需由保育研究組織再加以考量：

．發展與引導有系統的研究，決定雲豹族群內基因變異的數量，在這當中，搜尋目標放在每次射精時，對多型質（pleiomorphic）的精子之相關因素做經常性的觀察。

．了解在動物園飼養的雲豹，發掘其許多畸型精子之主要來源。新收集或在不同區域國家野外捕獲的雲豹之精液樣本，有必要做詳細取樣與評量。

．給雲豹血液高濃度的自然腎上腺荷爾蒙，設計有系統的研究，調查另一種環境或是圈養環境豐富化的影響，改善繁殖效率。近期的研究證明建議，在貓類所排泄糞便中做糖類皮質素（glucocorticoids）的檢測，是值得研究的課程。

．發展並導引有系統的研究，了解如何刺激雲豹精子，使試管內及體內的卵能夠受精。

．在任何可能的時間中，利用糞便荷爾蒙代謝，評估檢測雌雲豹的繁殖活動，分辨個體有無生殖活動的現象，了解自然排卵與改良輔助繁殖技術的影響範圍，加強對親生殖荷爾蒙的處理，以及做到準確的人工受精時間。

·對於改良荷爾蒙處理，進而效控制卵巢活動方面，發展與導引有系統的研究，尤其是刺激卵巢的反應，以模擬自然排卵，加強人工受精的成功率。

·測定引起人工受精低成功率的因素，發展導引有系統的研究，而其焦點可以特別放在與疾病原因有關的所產生的低品質精子、低品質卵子、不正常的內分泌環境（由不良的外源性親生殖荷爾蒙處理所引起）、以及基因歧異度的消失。

·發展利用基因組來源庫（GRB），包括對生殖細胞，胚胎，組織，血液產物及 DNA 做有計畫的收集。對維持與保證基因歧異度而言，這種冷凍收藏方法，然後從非活體動物進行基因移轉，有極深遠的利益。再者，GRB 可提供生物材料的來源，訂立分類與疾病監控討論的主題。對於成立這類貯存處細節策略是可行的，對這方面的組織規劃，可請 IUCN 的保育繁殖專家群幫助。

·當利用新鮮精子來達成例行且持續的人工授精成功率之問題解決後，接著就要研究如何開始利用冷凍精子來幫助管理雲豹繁殖，並且保持其在國內及其他地區族群的基因歧異度。

Conservation Breeding Specialist Group: Appended Material

Current Knowledge about the Reproductive Biology of Clouded Leopards

Introduction

Nothing is known about the reproductive biology or mating strategies of free-living clouded leopards. However, there is substantial data on the reproductive physiology and endocrinology of clouded leopards maintained under zoo conditions (see specific citations at this end of this section).

Most research has fallen under the following categories: 1) semen and sperm characteristics within and among clouded leopards over time; 2) hormonal patterns in both males and females, especially longitudinal reproductive cyclicity in females; 3) developing methods to stimulate ovarian activity and ovulation; 4) artificial insemination (AI); 5) preliminary work on *in vitro* fertilization (IVF); 6) semen cryopreservation technology and genome resource banking (GRB); and 7) the impact of nutrition on reproductive status of males. Although generating a substantial database, these studies also have identified some unique characteristics of the species that may present challenges to captive management and the use of both natural and artificial (or assisted) breeding. Thus, like all good research, these systematic studies have spawned a host of potential high priority research issues (see below).

Reproductive biology studies are a high priority because reproduction, of course, is the essence of species survival. An ability (for example) to detect (1) reproductively active from inactive animals or (2) if an animal is a seasonal breeder allows managers to attempt propagation using only appropriate individuals at appropriate times. This appears particularly relevant for the clouded leopard because of the species' high propensity for sexual incompatibility. Using current breeding regimens, it is quite common for males to make lethal physical attacks on females, even those that are demonstrating overt estrus. Therefore, a common problem with captive breeding of clouded leopards is an unwillingness of managers to pair genetically-appropriate individuals because of fear that the female will be injured, traumatized or killed. One result has been a worldwide distribution of 'isolated' females that are not paired with males. The problem is compounded further by a general lack of genetically valuable males in zoo populations. For example, it is known that most clouded leopards from North America (the region with the most animals in captivity) are descended from only a few founders, leaving an extraordinarily few genetically valuable animals ($n < 10$) in the region.

As a result, there is general consensus that well-conducted reproductive studies eventually could lead to developing consistently effective assisted reproductive techniques like AI, IVF and embryo transfer. For example, the advantages of AI for the clouded leopard would be profound, not the least would be the ability to utilize all reproductively and genetically healthy singleton females. Because the ultimate goal is to maintain a high level of genetic diversity in all extant clouded leopard populations, AI also could be used to move genes among populations (via germ plasm) rather than take the more dangerous and stressful route of moving living animals. This strategy also might eventually allow valuable genes to be 'captured' from wild populations, introduced into zoo populations, the result being that no additional animals would need to be removed from the wild. This approach, in fact, would have the benefit of boosting the genetic viability of captive populations while ensuring that wild clouded leopards remain in native habitat to protect nature.

Knowledge about Male Reproductive Biology

The technique of electroejaculation done under a surgical plane of anesthesia is safe for collecting semen/sperm from clouded leopards. Many males have been evaluated using this technique, and there is considerable data in the literature on testes volume, semen volume, sperm count, sperm motility, number of motile sperm per ejaculate and the incidence of pleiomorphic (or malformed) sperm in an ejaculate. Repeated electroejaculations over time can identify males that produce different quality semen samples. However, although there is some natural variation within individuals, most clouded leopards produce an ejaculate of about 500-600 μl containing 25 million total sperm of which about 70% are motile. Semen samples are not milky in appearance, but rather slightly opaque, and it is essential that the seminal fluid be removed from the ejaculate as soon as possible by low speed centrifugation. Maintaining the sperm and seminal fluid together is lethal to sperm with most cells dying within 30 min. The sperm pellet can be resuspended and motility sustained in common tissue culture medium, especially Ham's F10.

Interestingly, almost 70% of all sperm cells from an average ejaculate are malformed, the most predominate abnormality being a tightly coiled tail defect. It now is well-known that these 'abnormally-shaped' sperm cannot penetrate and fertilize eggs, so this condition of 'teratospermia' in the clouded leopard is not normal. However, it is similar to the condition observed in the cheetah (*Acinonyx jubatus*), which is thought to be related to the remarkable and historic loss in genetic diversity in that species. These findings would be consistent with the impact of inbreeding which also has been measured in other felids like the Florida panther (*Felis concolor coryi*) and Asiatic lion (*Panthera leo persica*) where poor sperm quality occurs simultaneously with a measurable lack of genetic diversity. A similar conclusion cannot yet be made for the clouded leopard because of the paucity of data on molecular genetics, including genomic diversity in natural populations. However, it is important that most sperm data collected to-date comes from clouded leopards in North American with the extremely narrow genetic base. Therefore, it is unknown if similar sperm defects would be observed in freshly wild-caught individuals. Finally, substantial studies have been made on circulating concentrations of adrenal (or stress) hormones in this species. Compared to some other felid species, the clouded leopard has high peripheral concentrations of glucocorticoids which may be consistent with this species' shy temperament. Stress can adversely affect reproductive capacity, and it is worth noting that there could be a relationship between what appears to be physiological evidence of stress sensitivity and semen characteristics.

There is strong evidence that clouded leopard sperm are unique in terms of ability to interact with conspecific and heterologous eggs *in vitro*. IVF can occur routinely in 'normospermic' species like the domestic cat and tiger where normal sperm forms dominate the electroejaculate. In contrast, IVF success is less in a species like the teratospermic cheetah, and all IVF efforts to-date with the teratospermic clouded leopard have never resulted in a single fertilized egg. Likewise, sperm from many wild felid species, including the cheetah and tiger, will readily interact with domestic cat eggs *in vitro* (a type of fertilization 'test'); however, again clouded leopard sperm are resistant to penetrating any functional layer of the cat egg. The problem does not appear related to inadequate motility because biochemical stimulates have been shown to cause short-term bursts in sperm motility without enhancing fertilization success. Supplementing sperm with homologous serum (shown to be effective in other species like the human) also has failed to provide improvement. All of these results together suggest that (1) there is an inherent biological problem with all sperm from these clouded leopards or (2) these sperm are unique, resistant to conventional felid sperm processing procedures and simply require more basic research attention.

Knowledge about Female Reproductive Biology

A survey of the international studbook revealed that 75% of all clouded leopard litters were born to females between 1 and 5 years of age. Sexual maturity ranged from 17 to 28 months with gestation ranging from 85 to 121 days (mean, 93 days). An analysis of international breeding records for captive female clouded leopards reveals that 46% of parturitions occur in March and April, indicating that most estrual periods occur from late December through February. These birth records largely have been corroborated by recent monitoring of fecal hormone metabolites in a substantial sized population of zoo-maintained clouded leopards. On the basis of fecal estradiol profiles, duration of the estrous cycle was 24 $\pm$ 2 days (mean $\pm$ S.E.M.), with estrus lasting 6 $\pm$ 1 days. Mean gestation length was 89 $\pm$ 2 days, whereas duration of the nonpregnant luteal phase was 47 $\pm$ 2 days. If females are maintained under a 12 hour light:dark cycle, they will cycle regularly throughout the year. Females under natural light fluctuations experience a seasonal anestrus during the late summer and early fall. One female has been shown to demonstrate a lactational anestrus after birth of three cubs. On nine occasions, clouded leopards were observed to spontaneously ovulate based on elevated excreted progestogen in the absence of mating. The use of fecal steroid metabolite monitoring is extremely important because it offers a method of longitudinally assessing reproductive activity using a completely atraumatic approach, thereby eliminating the potential confounding impact of stress.

Ovulation induction

Exogenous hormone treatments are effective in animals and humans for artificially stimulating the ovary to grow ovarian follicles and ovulate. These females then can mate naturally or embryos can be produced by assisted reproduction techniques. Like most mammals, the clouded leopard responds to intramuscular injections of the hormones (gonadotropins) routinely used for ovulation induction in many felid species. These include equine chorionic gonadotropin (eCG) to provoke follicle growth and hCG to stimulate ovulation. These hormones have been used in conjunction with AI to produce offspring in seven felid species, including the clouded leopard. However, it now is well established that this species is exquisitely sensitive to these gonadotropins. For example, although weighing 4 times the body mass of the domestic cat, the clouded leopard actually requires less eCG and hCG to stimulate a comparable ovarian response. Ovarian hyper-stimulation can sometimes occur, and there is concern that this could result in abnormal ovarian steroid secretion, influencing estrogen/progesterone ratios, thereby reducing the chance of eggs to fertilize and/or embryos to implant and develop normally. The problem is accentuated by the relatively high incidence of spontaneous ovulation within the species. These ovulating females secrete high concentrations of progesterone which can negate the effectiveness of the administered eCG/hCG. The result can be normal follicular stimulation, but an absence of ovulation, so that successful AI cannot occur.

Artificial insemination

As described above, it is necessary for electroejaculated sperm (designated for AI) to be processed to remove seminal plasma. This can be accomplished by low speed centrifugation (800 x g, 10 min) with resuspension of the sperm pellet in Ham's F10 culture medium. The female can be induce to ovulate with eCG (75-100 IU, i.m.) followed by hCG (75 IU, i.m.; given 80 hours after hCG). Thirty-eight to 40 hours after hCG, the female will ovulate. It now is well known that cats scheduled for AI will only become pregnant if the insemination is performed after ovulation. This is because various anesthetics used at the time of AI (to restrain and sedate the female) will block ovulation in preovulatory females (i.e., females whose ovaries only contain corpora lutea). Thus, AI in the clouded leopard should not be attempted before 38 hours after hCG. Second, it is crucial that the sperm be placed within the uterus, preferably in the anterior aspect of the uterine horn by laparoscopy. Depositing sperm in the vagina, cervix or even posterior aspect of the uterine horn will not allow pregnancy. A transabdominal, laparoscopic intrauterine AI technique has been described and has been found effective for producing pregnancy in the leopard cat, puma, tiger, ocelot, snow leopard and cheetah. To-date nine pregnancies have been produced in cheetahs using laparoscopic AI. One pregnancy has occurred in an eCG/hCG stimulated clouded leopard after laparoscopic AI (two cubs produced after a normal length gestation). However, AI in the clouded leopard is not as efficient as in the cheetah, and more research is needed to determine if the low AI success rate is related to poor sperm or egg quality or to inadequate or suboptimal ovarian response to the exogenous hormone treatments.

Genome Resource Banking and Sperm Cryopreservation

A Genome Resource Bank (GRB) is the organized collection, storage and use of biomaterials (sperm, embryos, oocytes, tissue, blood products and DNA) used for the purposes of conservation. The advantages of GRBs are profound, including (1) allowing the easy and safe movement of genes among populations to help maintain genetic diversity, (2) helping reduce the total number of animals needed in captivity to achieved targeted levels of genetic diversity, (3) providing 'insurance' against catastrophes, including disease epidemics and (4) as a resource for other biomaterials like tissue, blood by-products and DNA that are useful for addressing issues related to taxonomy, subspeciation, paternity and disease surveillance and forensics.

Clouded leopard sperm can survive freezing, showing reasonable post-thaw motility. Cryopreserving sperm in pellets versus straws in preferable. The conventional technique involves adding a cryoprotective diluent (20% egg yolk, 11% lactose and 4% glycerol) to washed clouded leopard sperm. The diluted sperm is cooled at 5 degrees Centigrade for 30 minutes. A block of dry ice (solid carbon dioxide) is obtained and indentations made on the surface of the block with a board containing multiple nail heads. The cooled sperm then is pipetted (in 30 μl drops) into the holes in the dry ice, allowed to freeze 30 minutes and then the dry ice block inverted over a bath of liquid nitrogen. The pellets then are packaged in a labeled vial and stored in liquid nitrogen. When necessary, individual or multiple pellets (depending on needed sperm concentration) are thawed in phosphate buffered saline and then inseminated using the laparoscopic technique (described above). Although clouded offspring have not yet been produced by AI with thawed sperm, success has been achieved in the leopard cat, ocelot and cheetah.

Importance of Nutrition on Reproduction

One management factor of great importance in felid reproduction is nutrition. There now is sufficient data to indicate that obesity significantly reduces sperm concentration and sperm motility in cats, including clouded leopards. Additionally, feeding muscle meat only without mineral and vitamin supplementation must be avoided. Cats fed on such diets produce either no sperm or sperm of poor concentration and motility.

Conclusions

As a result of more than 15 years of systematic research, there now is a valuable database on the reproductive biology of the captive clouded leopard male and female. Among other accomplishments, (1) viable sperm can be collected routinely and safely by electroejaculation, (2) sperm processing techniques have been developed that allow sperm motility to be sustained, (3) the reproductive cycle (duration and interval of estrus) has been characterized in detail by fecal hormone technology, a tool that allows the accurate, noninvasive determination of reproductive status, (4) it now is known that this species can ovulate spontaneously at a relative high frequency compared to other felid species, (5) artificial insemination has been successful on one occasion, and it is known that sperm must be deposited in the anterior aspect of the uterine horn after ovulation has commenced, (6) one hormonal regimen has been identified to induce ovulation, (7) sperm can withstand the stress of cryopreservation by demonstrating post-thaw motility and (8) suboptimal nutrition will reduce sperm count and sperm motility.

On the contrary, there remains concern about the (1) inability of managers to routinely pair animals for natural breeding because of sexual incompatibility, (2) high percentage of malformed sperm in electroejaculates and if this cause is related to heterozygosity in the captive population, (3) the inability to routinely produce an ovarian response mimicking 'normal' by the use of exogenous gonadotropins, in part, because the species is exquisitely sensitive to these hormones, (4) the difficulty in achieving successful *in vitro* fertilization as a result of poor sperm and/or egg function or interaction. The greatest unknown is the absolute total lack of information on the reproductive biology of wild clouded leopards.

Based on these conclusions, there are a number of *high priority issues* that should be considered by the conservation research community:

1. Develop and conduct systematic studies that will determine the amount of genetic variation in clouded leopard populations, in part, for the purpose of searching for a possible link to the common observation of many pleiomorphic sperm per ejaculate.

2. To understand the origins of the important finding of many malformed sperm in zoo-maintained clouded leopards, there is a need to collect and evaluate in detail semen samples from freshly collected, wild-caught animals in various range countries.

3. Given the naturally high circulating concentrations of adrenal (stress) hormones in clouded leopards, systematic studies should be designed to investigate the impact of altered and/or enriched captive environments on improving reproductive efficiency. Recent evidence suggests that fecal monitoring of excreted glucocorticoids is possible in felids and, therefore, should be the preferred course of study.

4. Develop and conduct systematic studies to understand how to stimulate clouded leopard sperm to readily fertilize eggs *in vitro* and *in vivo*.

5. Whenever possible, monitor reproductive activity in female clouded leopards by fecal hormone metabolite assessments for the purpose of identifying active versus inactive individuals, the incidence of spontaneous ovulation and improving assisted reproduction technologies, especially enhanced gonadotropin therapies and timed artificial inseminations.

6. Develop and conduct systematic studies to improve hormone treatments to more effectively control ovarian activity, especially for stimulating ovarian responses that mimic natural ovulation to enhance AI success.

7. Develop and conduct systematic studies to determine the cause of low AI success, especially focusing on the etiology being related to poor sperm quality, poor egg quality, an abnormal endocrine milieu (caused by suboptimal exogenous gonadotropin treatments) and/or overall loss in genetic diversity.

8. Develop and use a genome resource bank (GRB) comprised of an organized collection of germ plasm, embryos, tissue, blood products and DNA. It is recognized that such frozen repositories offer profound advantages for maintaining and insuring genetic diversity and moving genes rather than living animals. Further, a GRB would serve as a resource of biomaterials for addressing issues related to taxonomy and disease surveillance and forensics. The details of a strategy for formulating such a repository are available, and organization of this aspect can be assisted by the IUCN's Conservation Breeding Specialist Group (CBSG).

9. Once the problem of achieving routine, consistent AI success with fresh sperm is resolved, then studies should begin on using frozen sperm to help manage clouded leopards and maintain genetic diversity both within this country and in partnership with other regions.

Useful Citations

Brown, J.L., D.E. Wildt, L.H. Graham, A.P. Byers, L. Collins, S. Barrett and J.G. Howard. 1995. Natural versus chorionic gonadotropin-induced ovarian responses in the clouded leopard (*Neofelis nebulosa*) assessed by fecal steroid analysis. Biol. Reprod. 53:93-102.

Brown, J.L., S.K. Wasser, D.E. Wildt and L.H. Graham. 1994. Comparative aspects of steroid hormone metabolism and ovarian activity in felids, measured non-invasively in feces. Biol. Reprod. 51:776-786.

Donoghue, A.M., L.A. Johnston, D.L. Armstrong, L.G. Simmons and D.E. Wildt. 1993. Birth of a Siberian tiger cub (*Panthera tigris altaica*) following laparoscopic intrauterine insemination. J. Zoo Wildl. Med. 24:185-189.

Howard, J.G., A.M. Donoghue, L.A. Johnston and D.E. Wildt. 1993. Zona pellucida filtration of structurally abnormal spermatozoa and reduced fertilization in teratospermic cats. Biol. Reprod. 49:131-139.

Howard, J.G., A.P. Byers, J.L. Brown, S.J. Barrett, M.Z. Evans, R.J. Schwartz and D.E. Wildt. 1995. Successful ovulation induction and laparoscopic intrauterine artificial insemination in the clouded leopard (*Neofelis nebulosa*). Zoo Biol. (in press).

Howard, J.G., M. Bush and D.E. Wildt. 1986. Semen collection, analysis and cryopreservation in nondomestic mammals. In: Current Therapy in Theriogenology, D. Morrow, ed., W.B. Saunders Co., Philadelphia, pp. 1047-1053.

Newman, A., M. Bush, D.E. Wildt, D. van Dam. M. Frankenhuis, L. Simmons, L.G. Phillips and S.J. O'Brien. 1985. Biochemical genetic variation in eight endangered feline species. J. Mammal. 66:256-267.

Wildt, D.E., J.G. Howard, L.L. Hall and M. Bush. 1986. The reproductive physiology of the clouded leopard. I. Electroejaculates contain high proportions of pleiomorphic spermatozoa throughout the year. Biol. Reprod. 34:937-947.

Wildt, D.E., J.G. Howard, P.K. Chakraborty and M. Bush. 1986. The reproductive physiology of the clouded leopard. II. A circannual analysis of adrenal-pituitary-testicular relationships during electroejaculation or after an adrenocorticotropin hormone challenge. Biol. Reprod. 34:949-959.

Yamada, J.K. and B.S. Durrant 1989. Reproductive parameters of clouded leopards (*Neofelis nebulosa*). Zoo Biol. 8:223-231.

Conservation Breeding Specialist Group: Appended Material

Current Knowledge about Husbandry of the Clouded Leopard *(Neofelis nebulosa)*

Overview

This document was prepared for distribution to the participants of the Clouded Leopard Population Habitat and Viability Analysis conducted in October 1995 at Taipei Zoo, Taipei, Taiwan. It is a compilation of information from various colleagues at the editors institutions, experiences of the editors and information collected from other sources knowledgeable in clouded leopard husbandry. It is intended to be a dynamic draft document that can be used, edited and expanded by all concerned with the husbandry of this species.

Introduction

The clouded leopard ranges throughout South East Asia. It is a shy and retiring species making field work difficult. Consequently, knowledge of its habits or natural history is primarily anecdotal. The primary threats for this species are human encroachment and the loss and fragmentation of suitable habitat.

Success in clouded leopard captive breeding has been erratic. Pairs that have been established have reproduced repeatedly when allowed. Unfortunately, the number of established pairs worldwide has been low. The lack of successful pairs has contributed to a skewed founder representation in the North American captive population. That coupled with the few number of new founders introduced to this population has hampered captive breeding programs. This is unfortunate because ther is considerable expertise in the North American institutions.

The introduction of animals at a young age seems to be one of the key issues in successful pairings. When working with the larger felids like the tiger, pairs are often split up and new mates introduced to help maximize genetic diversity. Splitting breeding pairs of clouded leopards to establish new pairs has not been successful to our knowledge. This makes genetic management a real challenge because each animal is only represented once in its reproductive lifetime. The continued advancement of assisted reproductive techniques would greatly enhance the ability to manage this species both genetically and demographically.

The following information is primarily from the Henry Doorly Zoo's collection and some anecdotal information from other North American zoos. The North American Clouded Leopard Species Survival Plan, under the direction of Susan Millard, Coordinator, is assembling data for a husbandry manual, which eventually will be available to all regions.

Captive Management

Individual identification methods

Identification should be carried out by:

1. Permanent tattooing of studbook number should on the inside of the thigh.
2. Implantation of Trovan transponder between the shoulder blades.
3. Full face photograph to be included in the animal's permanent record.

Recommended Crating and Transport Procedures

All crates should conform to IATA standards for international shipment. Transport procedures should include the accompaniment of animals by qualified personal on any shipment longer than 12 hours duration. For international transport a licensed broker should be used to avoid complications with port authorities. Proper permits should be obtained with flexibility in timing to allow for dealing with logistical problems.

Pest Control

An active and aggressive program should be followed by a qualified pest control applicator that preferably is employed by the institution and not contracted. If a contracted person is the only possible option, they should be accompanied by an animal keeper.

Enclosures

Enclosure size considerations for clouded leopards is dictated by purpose. Enclosure size for off-display breeding could be as large as the areas described in the 'holding section' of this document. Many clouded leopards have been housed in six meter diameter, round corn crib (Behlen) cages. The most important feature is adequate height, preferably 3.6 meters or higher. This is especially important if the animals are exposed to many humans. Being elevated offers the clouded leopard a better view of the surroundings and they naturally use vertical space when threatened. The displays used at the Omaha zoo are minimally 4.5 meters tall and are decorated with a combination of artificial rock-work, natural stone and logs. The outside exhibit are minimally 10.6 x 5.5 meters and the cage construction material consists of a galvanized steel frame with 5 x 15.25 cm vertical mesh 0.06 cm in diameter. The mesh is painted black to allow for better viewing. The inside displays are minimally 5.33 x 9.75 meters in size. Floors of inside and outside displays are covered with DEX O TEX which is a multi-part, seamless epoxy coating. Floor drains in these exhibits are simple 15.2 cm x 10.1 cm slot cuts to channel fecal material out of the exhibits. Drainage is to a rear area so that there can be no clogged drains in the animal area enclosure. The inside exhibits have glass panes consisting of two pieces of tempered glass with a thin plastic laminate between them. The center two panes of the inside display are in their own frames and can be swung open to allow replacing logs and other cage materials.

All exhibits have two doors on each end as well as a door separating the inside and outside exhibits. Two of the doors on each end are located 1.83 meters high to allow the cats access to the top dens.

Group Composition

Traditionally, these animals are housed separately or as established pairs. Once established, a pair rarely needs to be separated until just before the female gives birth. The Cincinnati Zoo currently is effectively housing one male with two females.

Introduction of Animals

Introducing animals to others is challenging unless the cats are young. Single-sexed groups of up to three animals have been successful. In all cases, these animals were introduced at a young age. Introduction of adult age animals into a breeding situation is the issue of most concern to the managers. The chances for success are greatest when both animals are less than 1 year of age. There has been reasonable success if both animals are less than 2 years of age, but a more intensive introduction regime is required. Clouded leopard introductions have traditionally occurred in the typical manner followed for most felid species. The male and female are housed separately until the female exhibits behavioral estrus. The animals are together during the day for increasing periods until they appear sufficiently familiar with each other to leave together overnight. The clouded leopard is crepuscular to nocturnal in habits, so most problems occur at night when animal keepers traditionally are not on duty. Keepers have frequently found animals either dead or badly wounded in the morning causing them to be hesitant to continue introductions. This has contributed to the limited genetic representation and marking the clouded leopards as nearly impossible to manage in captivity. At the Omaha's Henry Doorly Zoo, we have had both failure and success in introductions. The failures have led us to develop techniques that minimize the risks associated with introducing these cats.

One technique is using closed circuit television to monitor and videotape of animals at night. Animals are placed in adjacent cages separated by cage material described above that allows visual, auditory and olfactory contact. Individual animals appear to express stronger and more obvious behavioral changes indicative of receptivity when separated by such barriers in comparison to solid barriers. Not all estral females vocalize or rub the bars unless they are in close proximity to a male. Three other typical behaviors have been observed when the animals are housed in close proximity. 1) First antagonistic or aggressive behavior, expressed by hissing, growling or spitting, all of wich pass in a short period of time. Direct introduction of animals at this time is not recommended fighting usually occurs; 2) this is followed by disregard with the animals usually spending little time at the common barrier and making no effort to be in close proximity; 3) close proximity occurs when the female is in heat. The estral female manifests signs consistent with other felids, including prusten, cheek rubbing, rolling, crying and lordosis. Females previously failing to exhibit signs of heat when isolated, will often act differently when placed in close proximity to a male. Most such behaviors by leopards are expressed at night when monitored by video recording. When the male and female no longer exhibit any aggressive behavior and are interacting at the common barrier we start allowing them to stay together for 24 hour periods. The closed circuit cameras allow night observation without disturbing the animals. Video taping is continued to monitor pair compatibility and detect breeding attempts. Another technique that we are plan to test is the use of mechanical excluders to allow the female free access to the male. There is sufficient size difference between healthy males and females that this tactic may be feasible to test with minimum risk.

Finally, care also must be exercised when reintroducing pairs that have been separated for births, medical or management reasons. We have found contact through a screen facilitates the process. We also have allowed the female access to a common screen with the male while raising her offspring in a nestbox. Care must be taken to ensure that a cub cannot get a leg through the screen into the male's enclosure.

Feeding

Feeding usually is recommended five times per week. Fast days (usually Wednesday and Sunday) use of fast days helps keep our animals from becoming overweight. All cats are offered knuckle bones on Sunday to stimulate activity and to keep their teeth clean. Feeding is done by either shifting the animal off display and placing the food on the clean floor or in a stainless steel feeding tray that keeps the food clean. Feed should be left overnight in the enclosure because many cats prefer to play with their food rather than eating it immediately. This practice, however can attract rats, mice and roaches so must be done in conjunction with an aggressive pest control program.

Watering

Clean water should be provided at all times in one of two ways. The first is to provide a small stream of water constantly running into a small bowl embedded in concrete. The bowl is allowed to overflow to a trench drain. A second larger diameter water line is provided to flush the bowl in the event that the cats defecate in it. An alternative is self-filling water bowls manufactured by Farnam Company that feature a small stainless steel bowl resting inside a heavier very durable cast housing. The bowl is easily removable for cleaning. It is important to install a shut off valve near the water-bowl to allow monitoring of intake when necessary. Finally locate all watering devices in an area with good drainage. We have tested "LIXIT" dog watering devices but most cats prefer a bowl because of the way they lap water.

Holding Areas, Dens, Nest Boxes.

Holding areas used at Henry Doorly Zoo allow great flexibility working with the cats.

Each den area or work module is includes of two lower dens that are about 13 sq meters in area. The main area measures 2.75 meters by 4 meters and can be separated from a 1.22 by 1.52 meter area that serves as squeeze cage. This area is in the path the animals use whenever shifted to the outside enclosure. The 1.07 by 1.5 meter screen is made of a galvanized steel frame with 5 by 15.25 cm vertical mesh .06 cm in diameter. When using this divider to introduce cats a second layer of the same material is fastened to the divider reduce the openings. The squeeze cage simply is a second wall containing a door that allows the animal to pass through to the outside. The door is mounted on overhead tracks that allow the wall to be pulled forward, squeezing the cat to the front. These squeeze cages are operated manually, and one person easily can restrain a clouded leopard. The cage material throughout is same as the divider described above. The height of the bottom dens are typically 4.5 meters high whereas the squeeze area (located under the upper dens) is about 1.2 meters high. The upper dens typically are 3.6 meters wide to 2.7 to 4.5 meters long, depending on location in the complex. The height of the upper dens is 2.1 meters and these are adjoined by a mesh fronted 1.22 meter square cubicle on each end. These cubicles are useful for separating cats and also have been used as accessory denning and birthing areas. Dens are interconnected and have access to both the inside and outside exhibits. Slabs for these dens are elevated from the floor 0.76 meters to provide for positive drainage and to allow cats to be more easily examined. All cage and den floors are sealed with either a fumed silica sealer or coated with a seamless-filled epoxy coating. All drains in both dens and displays are located outside of animal areas. Both the displays and the dens have operable skylights to allow light and improve ventilation. Each den and display has separate heat and lighting controls, and the air source is 100% fresh air. The cage material described above is black vinyl-coated galvanized steel to protect it from the severe corrosive properties of cat urine. These dens certainly are sufficiently large for clouded leopards as they were designed to hold any size of cat. While these enclosures could be scaled down slightly, the extra space always is useful when inserting den boxes or cage furniture. Finally, resting boards are important because they provide a comfortable location above the floor for the animals to use. Our resting boards are made from artificial or cultured marble (fiberglass) that is commonly used as countertops. These are durable and easy to keep clean and disinfected.

Management of Pregnant Animals, Animals with Newborn

Animals are assumed pregnant if a successful breeding has occurred and is not followed by another display of estrus behavior. The female is separated from the male at about sixty days at which time ultrasound may be performed to confirm pregnancy. If ultrasound is deemed unnecessary then it is the keepers responsibility to monitor physiological changes such as teat enlargement and behavioral shifts. This truly requires critical observation, a skill that only can be developed through working with the animals on a daily basis.

At the time the female is separated from the male she is placed on 7 days per week feeding until the cubs are weaned. The pregnant female is moved into an adjacent den to the male and given access to an epoxy-coated plywood den box described in an attachment to this document. It is important that the entrance hole should be sized to allow the female to pass carrying a cub if necessary. The hole should be positioned sufficiently high from the floor of the box to not allow the cubs to stumble out prematurely. Females that have not previously given birth should be provided two den boxes at opposing ends of the cage. A female insecure in her nest box will attempt to move the cubs even if there is no where to go. The second box provides her with an alternative. The box should be elevated above the floor of the den about 0.5 meters and the entire enclosure should be bedded with straw should she decide to take the cubs from the nest box. One invaluable feature of nest boxes is incorporation of a closed circuit camera and LED light array system in the box lid. This allows video tape monitoring of the mother's and cubs activity after birth. This allows assessing nursing and allows the public to see the cubs grow up. After a birth is detected the areas containing the female should not be entered for 24 hours. The female should have access to water at all times but she rarely eats during the 24 hours after parturition. On subsequent days, the keepers should enter the area to do the minimum of work necessary. This process lengthens every day until normal routines are resumed, usually within a week. The cubs are left undisturbed for the first week minimally, depending on female behavior. Cubs should not be weighed or sexed until an opportunity occurs when the female is away from the box. Cubs are handled with rubber gloves that have been soiled with feces from the den. It is important to keep these encounters to a minimum of time and using people familiar to the dam. As the cubs get older, additional space should be provided to the female so that she can get away from the cubs when they pester her.

Behavioral and Social Organization

Behavioral indicators of stress

Stress is most commonly indicated in this species by biting and plucking of hair. This condition is difficult to reverse although some success has been achieved by providing enrichment items like horse knuckles, dead rats, and feather ropes among others.

Olfactory Behavior, Scent Marking, Flehman

Clouded leopards exhibit behavioral characteristics similar to other felid species. They are not particularly vocal with the exception of the female in estrus.

Environmental Enrichment

Environmental enrichment approaches are not limited to those described under 'Behavioral Indicators of Stress'. Animals also can be provided blocks of ice in the summer, 'boomer' balls and other durable toys. New scents also can be introduced into the exhibits using old perfume to stimulate activity.

Workshop on Applying PHVA Techniques for Wildlife Conservation--Clouded leopard (Noefelis nebulosa) in Taiwan

Clouded Leopard Participant List

Chung-ming Lin
Assistant Researcher
Environmental Protection Division,
Ministry of Education
5th Floor, No. 102 Ai-Kwo E. Rd., Taipei,
Taiwan 100, R. O. C.
PH:011-886-039-2-321-4898

Shung-fung Lu
Specialist
Taiwan Forestry Bureau
No. 2, Sec. 1, Hang-Chou S. Rd., Taipei,
Taiwan, R. O. C.
PH:011-886-039-2-3515441 EXT. 328

Hsiao-yi Tang
Senior Specialist
Council of Agri.
No. 37, Nanhai Rd., Taipei, Taiwan 100
R. O. C.
PH:011-886-039-2-312-4058

Ying Wang
Professor
Inst. of Biology, National Taiwan Normal Univ.
No. 88, Sec. 4, Tingchou Rd.,
Inst. of Biol. National Taiwan Normal Univ., Taipei, Taiwan 117 R. O. C.
PH:011-886-039-2-934-6443

Jung-tai Chao
Researcher and Section Chief
Forest Protection Taiwan Forestry Res. Inst.
No. 53, Nanhai Rd. , Taipei, Taiwan 100
R. O. C.
PH:011-886-039-2-309-1846

Cheng-tein Lin
Graduate Student
Inst. of Biology, National Taiwan Normal Univ.
No. 88, Sec. 4, Tingchou Rd.,
Inst. of Biol. National Taiwan Normal Univ., Taipei, Taiwan 117 R. O. C.
PH:011-886-039-2-934-6443

Tung-Sheng Shia
Specialist
Taiwan Forestry Bureau
No. 2, Sec. 1, Hang-Chou S. Rd., Taipei,
Taiwan, R. O. C.
PH:011-886-039-2-3515441 EXT. 328

J. L. Hwang
Graduate Student
Inst. of Biology, National Taiwan Normal Univ.
No. 88, Sec. 4, Tingchou Rd.,
Inst. of Biol. National Taiwan Normal Univ., Taipei, Taiwan 117 R. O. C.
PH:011-886-039-2-9346443

Shuw-ing Lou
Specialist
Yang-ming Mountain National Park Headquarters
Yang-ming Mountain National Park Headquarters, Taipei, Taiwan
PH:011-886-2-8617904

Ching-chang Lai
Research Assistant
Inst. of Biology, National Taiwan Normal Univ.
No. 88, Sec. 4, Tingchou Rd.,
Inst. of Biol. National Taiwan Normal Univ., Taipei, Taiwan 117 R. O. C.
PH:011-886-039-2-934-6443

Yi-chun Chen
Ph. D. Candidate
Inst. of Biology, National Taiwan Normal Univ.
No. 88, Sec. 4, Tingchou Rd.,
Inst. of Biol. National Taiwan Normal Univ., Taipei, Taiwan 117 R. O. C.
PH:011-886-039-2-934-6443

Pei-jen Chen
Associate Professor
Inst. of Environmental Education,
National Taipei Teachers' College
No. 134, Sec. 2, Ho-Ping E. Rd., Taipei, Taiwan, R. O. C.
PH:011-886-039-2-732-1104 EXT. 336

Yung-ting Co
Graduate Student
The Graduate Inst. of Environmental Education, National Taiwan Normal Univ.
No. 88, Sec. 4, Ting-chou Rd., Taipei, Taiwan 117
PH:011-886-039-2-935-5232 EXT. 22 or 23

Ming-hwang Liang
Associate Professor
Chung-hwa Polytech College
4F-3, No. 48, Wang Ang Street, Wen-shen Dist., Taipei, Taiwan
PH:011-886-039-35-374-281 EXT 672

Shun-mei Wang
Associate Professor
The Graduate Inst. of Environmental Education, National Taiwan Normal Univ.
No. 88, Sec. 4, Ting-chou Rd., Taipei, Taiwan 117
PH:011-886-039-2-935-5232 EXT. 15

Cheng-yi Fang
Graduate Student
Graduate of Forestry, National Taiwan Univ.
308 Room, Department of Forestry, National Taiwan Univ., Taipei, Taiwan
PH:011-886-039-2-3630231 EXT. 2519

Hui-mei Chen
Graduate Student
The Graduate Inst. of Environmental Education, National Taiwan Normal Univ.
No. 88, Sec. 4, Ting-chou Rd., Taipei, Taiwan 117
PH:011-886-039-2-935-5232 EXT. 22

Wen-horn Lin
Graduate Student
Graduate of Forestry, National Taiwan Univ.
2F, No. 149-2, Chang Chuen Rd., Taipei, Taiwan 104 R. O. C.
PH:011-886-039-2-563-0534

Liang-chou Hsia
Associate Professor
Ping ton Technology College
Ping ton Country, Taiwan, R. O. C.
PH:011-886-039-8-7701094

Yuan-san Ho
Deputy Director
Taiwan Endemic Species Research Inst.
No. 1, Ming-Sheng E. Rd., Chi-Chi Town, Nan-To Country, Taiwan, R. O. C.
PH:011-886-039-49-761-260

Shun-chi Chen
Instructor
National Taipei Teachers' College
No. 20, lane 136, Sec. 2, Ho-Ping E. Rd., Taipei, Taiwan, R. O. C.
PH:011-886-039-2-735-1509

Chuen-ji Lin
Chief of Management Division
Taiwan Endemic Species Research Inst.
No. 1, Ming-Sheng E. Rd., Chi-Chi Town, Nan-To Country, Taiwan, R. O. C.
PH:011-886-039-49-761-258

Guang-jeng Liaw
Department Chief
Taiwan Endemic Species Research Inst.
No. 1, Ming-Sheng E. Rd., Chi-Chi Town, Nan-To Country, Taiwan, R. O. C.
PH:011-886-039-49-761-260

Shao-wen Kao
Senior Curator
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei, Taiwan, R. O. C.
PH:011-886-039-2-939-2097

Yen-long Chen
Assistant
Taiwan Endemic Species Research Inst.
No. 1, Ming-Sheng E. Rd., Chi-Chi Town, Nan-To Country, Taiwan, R. O. C.
PH:011-886-039-49-761-274

Ellen C. M. Chin
Curator
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei, Taiwan, R. O. C.
PH:011-886-039-2-938-2300 EXT. 206

Men-shi Chou
Specialist
National Museum of Natural Science
National Museum of Natural Science, Taichung, Taiwan
PH:011-886-039-4-3226940

Kuo-jou Lien
Curator
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei, Taiwan, R. O. C.
PH:011-886-039-2-938-2300 EXT. 206

King-shi Cho
Primitive
Primitive Association
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei, Taiwan, R. O. C.
PH:--

Yi-ming Chen
Senior Curator
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei, Taiwan, R. O. C.
PH:011-886-039-2-938-2300

Ya-mai Hu
Amateur naturalist
Housewife Union
4F, No. 4, Alley 27, Lane 55, Sec. 1, Shiu-Ling Rd., Taipei, Taiwan
PH:011-886-039-2-931-7373

Tiger Wang
Volunteer
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei, Taiwan, R. O. C.
PH:011-886-039-2-809-3250

Lu Dau-jyi
Amateur naturalist
Traffic Taipei
Taipei P. O. Box 109 Taipei, Taiwan, R. O. C.
PH:011-866-2-3629787

Jen-jyh Chen
Curator
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei, Taiwan, R. O. C.
PH:011-886-039-2-938-2300

Ming-chieh Chao
Curator
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei,
Taiwan, R. O. C.
PH:011-886-039-2-938-2300

Vincent Y. C. Wen
Curator
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei,
Taiwan, R. O. C.
PH:011-886-039-2-938-2300

Pao-chung Chen
Depty Director
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei,
Taiwan, R. O. C.
PH:011-886-039-2-938-2300

Chen, Mei-ting
Amateur naturalist
Taipei City Zoo
2F No. 76-1, Sec 1, Hsin-Kuang Rd.,
Taipei, Taiwan, R. O. C.
PH:011-886-039-2-9382300

Chih-wen Chen
Curator
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei,
Taiwan, R. O. C.
PH:011-886-039-2-938-2300

Jenny Cheng
Education Official
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei,
Taiwan, R. O. C.
PH:011-886-039-2-938-2300 EXT. 346

Tina Chen
Curator
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei,
Taiwan, R. O. C.
PH:011-886-039-2-938-2300

Ming-hui Chen
Education Official
Taipei City Zoo
No. 30, Sec. 2, Hsin-Kuang Rd., Taipei,
Taiwan, R. O. C.
PH:011-886-039-2-938-2300

CLOUDED LEOPARD - TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

REPORT

APPENDIX II

STATUS AND LITERATURE

Clouded leopard (Neofelis nebulosa)
(This section is taken directly from a draft of the IUCN/SSC Cat Specialist Group Action Plan prepared by Kristen Nowell and Peter Jackson.)

Current Status

Listed as CITES Appendix I as of 1975 [CITES 1982], as Vulnerable in the IUCN Red Data Book [IUCN 1978] and Endangered on the US Endangered Species List as of 1970 [McMahan 1982; U.S. Fish and Wildlife 1987].

1. Distribution
From Nepal, Sikkim, Bhutan, and the Assam Hills to Burma, Malaysia, lower Thailand, and Indochina to S China. In China it has been recorded as far north as Fukien; also found in Hainan, Taiwan, Borneo, and Sumatra. Distribution includes the Bengal/Assam Protected Area System which consists of the moist lowlands and swamp forests of the Ganges Delta, the lowlands of the Brahmaputra river and the forested hills of the Assam transition zone; the South Himalayas Protected Area System consisting of the Indian States of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh (marginally), Sikkim, Arunachal Pradesh, parts of N Pakistan, most of Nepal and Bhutan, and China (marginally); the Burmese Coast Protected Area System consisting of the coastal rain forests of Burma, including the delta and estuaries of the Irrawaddy and Salween rivers with a marginal extension into Thailand; the South Indochina and Annam Protected Area System consisting of most of Vietnam, marginal areas of Laos, S Kampuchea, the south coast of Thailand, and a small part of Burma; the South China Protected Area System consisting of a narrow fringe of land along the S coast of mainland China and including the island of Hainan, broadening W as far as the Red River in Vietnam; the Irrawaddy Protected Area System consisting of the Irrawaddy catchment between the Chin Hills to the W and the Shan plateau to the E including the dry central zone of Burma, the Chindwin and the Kachin regions and the northern hills leading up into the Himalayan mountains; the Indochina Protected Area System consisting of the large plains and valleys of the Mekong and Chao Phraya rivers apart from the S coastal fringe and extending up into the Himalayan foothills of S China; the Malay Peninsula Protected Area System consisting of the whole of west Malaysia, Singapore, a few small islands off the coast of Indonesia, the peninsular portion of S Thailand, and the S tip of Tenasserim, Burma; the Sumatra Protected Area System; the Borneo Protected Area System [MacKinnon & MacKinnon 1986]. Four subspecies have been named:

N.n. brachyurus (Wsinhoe 1826): Taiwan
N.n. diardi (Cuvier 1823): Sumatra, Borneo and Java
N.n. macrosceloides (Hodgson 1853): Nepal to Burma
N.n. nebulosa (Griffith 1821): S China to E Burma

2. Population
a. BANGLADESH: It is isolated in small pockets and rarely occurs outside the 8% forest cover. Populations are in general declining. It can still be found in the evergreen

forests of Chittagong and the Hill Tracts. Its presence in Sylhet is doubtful [Khan 1984]. It was common in the evergreen forests until 1960. It probably did not occur in the Sal Forest and the Sunderbans mangrove forest [Khan 1986]. Overall, cats are occasional or rare, distributed primarily in forest habitat [Sarker & Sarker 1984]. Now they may be extinct [Khan 1984].

b. BHUTAN: Excellent habitat still exists in the lower hills. It is not an infrequently sighted cat in the S foothills and at higher elevations [Deb Roy & Kharabanda 1984].

c. BRUNEI: No information

d. BURMA: It is found in dense forests of the N and S. Status is probably rare [Salter 1983].

e. CHINA: It is distributed in many places in C and SW China, with limits reaching as far north as to the border of NW China. They have been found in the Chinese provinces of Guagdong, Guangxi, Hunan, Hubei, Zhejiang, Anhui, Fujian, Jiangxi, Sichuan, Yunnan, Guizhou, Shaanxi, Gansu, Chinghai, and also on the islands of Taiwan and Hainan [T'an Bangjie 1984]. Has a wide range and is comparatively common in Jiangxi and Anhui. In Jiangxi province, this cat has declined to 30% of its mid 1950 population is presently estimated at several hundred. In some other populations they have declined to less than 10% [Lu Houji & Sheng Helin 1986]. It is found also in SW and the E parts of China [Tang Guang You & Li Wei 1987].

f. INDIA: It is rare in Arunachal Pradesh in NE India, bordering Tibet, but endangered elsewhere in the NE [Chatterjee & Sin 1984]. It can also be found in parts of Assam, where it is rare, and Meghalaya, where it is endangered [Panwar 1984], and has been reported from the Himalayan state of Sikkim and from the N of West Bengal State [Anon. 1986a]. Overall distribution rates a status of "endangered category I" [Panwar 1984]. It still can be found N and S of the Brahmaputra and is still being sold to zoos in India [Wright 1984a].

g. INDONESIA: Although it is found in all the eight provinces, it occurs only in a few discontinuous areas. It has been found in the Barisan Selatan National Park, and in the province of Jambi in a logged lowland forest. It is also known from the Tigapulu Hills straddling the Riau/Jambi provincial border, and known to be present in the Torgamba production forest along the Riau/North Sumatra border [Santiapillai 1987]. There are probably still healthy populations remaining in Gunung Leuser National Park [Kurt 1970]; Torgamba production forest [R. Blouch, pers. comm. cited in Santiapillai & Ashby 1988]; Tigapulu hills, mainly below 700 m in protected and production forest [Blouch & Simbolon 1985]; Kerinci-Seblat National Park [FAO 1981a]; Gumai Pasemah Game Reserve [Blouch 1984]; Barisan Selatan National Park [FAO 1981b]; and Way Kambas Game Preserve [R Widodo, pers. comm. cited in Santiapillai & Ashby 1988]. However, in only two areas does the cat appear to be safe from immediate threat, in Gunung Leuser and Kerinci-Seblat National Parks [Santiapillai & Ashby 1988].

h. KAMPUCHEA: Information on cat status is unknown since the war began. In addition, confusion exists because the same Khamer word is used for all the small cats [Thouless 1987].

i. LAOS: No information

j. MALAYSIA: It still inhabits many areas of Sabah and Sarawak and seems to be in no immediate danger of extinction [Anon. 1987a; Rabinowitz 1988]. Most sightings (86%) in Borneo were on the ground usually along roads or trails or in selectively logged forest. Sightings occurred from sea level up to 123 m in the Crocker Range, Sabah [Rabinowitz 1987].

k. NEPAL: It is assumed to be absent from the subtropical Terai forests because they are more open than tropical forests. In 1987, a pair of cubs were captured near Janakpur in the E Nepalese Terai and brought to the Kathmandu Zoo. A subadult male was captured in Nawalparasi district in a village about 50 km E of Butwal. A fourth individual was stoned to death near the city of Pokhara near the Panchayat Training Center [Dinerstein & Metha, in press].

l. SINGAPORE: No information

m. **TAIWAN**: The cat is probably extinct. The only recent evidence of the cat is in two remote, isolated areas of the Central Mountain Range- the Yushan National Park and a provincial forest in the Tawu Mountains. The most recent sighting was from Nantawushan in 1986 of a leopard found in a hunter's snare [Rabinowitz 1988].

n. THAILAND: It is endangered [IUCN 1978].

o. VIETNAM: No information

3. Habitat:

It is a forest dweller, secretive, retiring and seldom seen. It has been found in secondary forests in low forest up to 7,800 ft in the Himalayan foothills. In Thailand, it is primarily arboreal, while in Borneo and Sumatra, it is found more often on the ground. In Sumatra, it is usually more strictly confined to the deeper forests than the other felids [Santiapillai 1987]. In Taiwan, it may occur in temperate forests of high mountains [IUCN 1978].

In Borneo, it preys on proboscis monkey, pig-tailed macaque [Davis 1962] and is also known to feed on orang-utans, deer and pigs [Payne et al. 1985]. It may occasionally try to catch fish in the swamps [Pieters 1938]. It probably spends a good deal of time on the ground hunting, and uses the trees as resting sites. Trees or large boulders may be used by the leopards to escape leeches. They favor primary forest but can effectively use selectively logged secondary forest. It preys on sambar deer, barking deer, mouse deer, bearded pig, common palm civet, grey leaf monkey, fish and porcupine. They occasionally take domestic stock but are not considered by the natives to be pests [Rabinowitz 1987].

In India, it is found in the evergreen forests of the northeast. It rests on treetops in nests amidst the branches and is active at dusk and dawn [Panwar 1984].

Overall, it is more arboreal than most other cats, preying on large birds and monkeys. However, it does hunt on the ground and is probably partially diurnal. Its favorite ground prey is wild pig. Pair bonding may occur and couple may hunt together. When hunting in trees, it uses its large paws to knock monkeys off their feet. It then makes its kill by piercing the back of the skull with its large canines. It is very agile in the trees, and like the margay, can hang upside down by its feet and can rotate the back feet 180 degrees. It also is noted for running upside down on branches. The ability to hunt monkeys in the trees may be an adaptation to reduce intra-specific competition with other felids. The only other sympatric felid which hunts arboreally is the Asian golden cat [Santiapillai 1987]. Lekagul & McNeely [1977] have reported that leopards may hunt together, especially after hazardous game, such as porcupines.

4. Principal Threats:

The species is still present in some numbers in Sabah and Sarawak and may still survive in Taiwan. Deforestation and poaching threaten it in these areas. In Thailand, it is considered highly endangered because of the high demand for skins. In Sumatra, the population appears to be healthy, but is threatened by continued forest clearance. In China, Bangladesh and Laos, skins are sold openly in markets. The cat is probably rare in Burma. In many areas the cat is also considered a delicacy and eaten in restaurants. In 1981, furs of this cat could bring (US) $124,270 in Japan. South Korea, not a CITES member, is a conduit for trade in this and other species. China also funnels fur products for consumption primarily to Japan [Milliken 1984].

In the Indochina Protected Area System, parts of the area support very high densities of people and all natural vegetation has long been cleared for agricultural use. In others areas where civil disturbances played a role, human population is low and extensive forest areas remain. In areas of shifting cultivation, the pattern of land use is very destructive and the hilly catchments of the major rivers have suffered. Much of the denuded forest areas have been invaded by lalang grass, but extensive areas have been planted with coffee, tea, rubber, and teak plantations. Coconut and sugar palm are commonly grown around villages [Mackinnon & Mackinnon 1986].

The South Indochina and Annam Protected Area System has high population density and most of the lowland forest has been cleared, but since much of the unit is mountainous, some 27% of the unit is still clothed in closed forest. The unit has large areas of irrigated rice-land, extensive oil palm plantations, and extensive dry field agriculture. There are also extensive plantations of bananas, various other fruits, coffee, and tea. Hillsides deforested by warfare activities or shifting cultivation are under a variety of secondary vegetation types from lalang grassland to Melastoma shrubland, bamboo thickets and secondary forest. New plantations are being established of Dipterocarpus, Pinus, Eucalyptus, and Acacia. Some of the open land is used for grazing of cattle and buffaloes [Mackinnon & Mackinnon 1986].

In the Irrawaddy Protected Area System, although officially 50% of the area is forested, much of this is logged over, fallow, or intensively managed forests. Probably only 31% of original forests remain and even this includes some fairly disturbed vegetation. Extensive areas are developed as farmland, although planted only part of the year. Other areas are extensively managed semi-natural teak plantations. Much of the moister hill forests have been destroyed through shifting agriculture and have become lalang grasslands [Mackinnon & Mackinnon 1986].

In the South Himalayas Protected Area System, most of the natural vegetation has been destroyed or modified by human activities. The good timber trees have been felled from many slopes. Forests have been felled on some slopes for cultivation and grazing, resulting in severe land degradation and erosion [Mackinnon & Mackinnon 1986].

In the South China Protected Area System, the area is very heavily populated and almost all of the lowland forests have been cleared. Where the land can be irrigated, the principal crop is rice, but in the hills, cassava is the most common food crop, together with a wide range of vegetables and some fruit and cash crops such as coffee and tea. About 20% of the area remains under forest, but most of that is disturbed, and in mountains and hilly areas or on the limestone karst formations, much of the vegetation is secondary bamboo [Mackinnon & Mackinnon 1986].

In the Bengal/Assam Protected Area System, much of the original vegetation has been destroyed or modified by the high density of human inhabitants. There are extensive rice fields, farms, plantations of bananas and sugarcane in coastal regions, and tea in the hills. The lowlands are some of the most densely populated areas on Earth with over 200 persons per km 2. Some hills tribes practice slash and burn agriculture in the mountains. Only 20% of the area remains under natural vegetation, almost entirely in the mangroves and mountains [Mackinnon & Mackinnon 1986].

In the Burmese Coast Protected Area System, although population density is only moderate, most of the rainforest, and almost all of the freshwater swamp has been cleared for agriculture. Much of the cleared rainforest on hilly terrain has been replaced by creeping bamboo. Flat areas are irrigated for paddy rice; hill farms grow hill rice, cassava, yams and vegetables for local consumption. Some forest areas are exploited for timber [Mackinnon & Mackinnon 1986].

In the Irrawaddy Protected Area System, although officially 50% of the area is forested, much of this is logged over, fallow, or intensively managed forests. Probably only 31% of original forests remain and even this includes some fairly disturbed vegetation. Extensive areas are developed as farmland, although planted only part of the year. Other areas are extensively managed semi-natural teak plantations. Much of the moister hill forests have been destroyed through shifting agriculture and have become lalang grasslands [Mackinnon & Mackinnon 1986].

a. BANGLADESH: The Chittagong Market has been flooded with skins, possibly coming from Burma. Populations are declining because of poaching and poisoning as well as habitat destruction [Khan 1984]. Despite the existence of the Bangladesh Wildlife Advisory Board, there is no comprehensive nationwide system of protected areas within this country and very little of the country's vegetation is protected within conservation areas. It is one of the most densely populated areas of the world and only 9% of the country is still forested. Only 0.3% of the country's land area is designated as protected areas, and a further 0.2% is proposed. These areas are neither adequate nor representative of the country's range of habitats. Reserves are designated primarily for timber exploitation and in no way guarantee long-term conservation of species [Mackinnon & Mackinnon 1986].

b. BHUTAN: Threatened by intensive forestry works of rainforest, evergreen and semi-evergreen areas in the lower foothills [Deb Roy & Kharabanda 1984]. In Bhutan, the forests remain in good condition, though logging is now making inroads. Some hill tribes practice slash and burn agriculture. About 48% of the unit remains under natural vegetation. Sixty-four percent of the original forest cover remains and more than 20% is included within the protected area system. As human and livestock populations grow, the major threat is forest loss to shifting cultivation, cattle grazing, forest fires, illegal timber felling, and wood-based industries [Mackinnon & Mackinnon 1986]. The southernmost forest belt has been almost completely cleared for human settlement [Mahat 1986].

c. BRUNEI: The least populated state of the realm. Because of oil revenues there has been little need for commercial exploitation of the national forests and over 70% of the original swamp and heath forests, mangrove and lowland forests remain [Mackinnon & Mackinnon 1986].

d. BURMA: Burma may be supplying skins for the Chittagong Market in Bangladesh [Khan 1984]. It is threatened by habitat loss and direct killing for skins [Salter 1983]. Steadily increasing population growth is causing habitat clearance for agriculture and timber. Although 13% of the country is designated as forest reserves, these areas are managed primarily for timber exploitation. Existing wildlife sanctuaries total 0.7% of the country but most are very small and are not legally protected against logging. Many have suffered damage due to habitat destruction and uncontrolled hunting and are of negligible value to wildlife [Mackinnon & Mackinnon 1986].

e. CHINA: Pelts and bones are sold openly [T'an Bangjie 1984]. Threatened by over-hunting for fur and carcasses; furs are seen often, but less often than golden cat, suggesting a smaller population [Wang Zong-Yi & Wang Sung 1986]. Only a very small area of S China is currently protected with proposals for another 2.6% of the land area. Even with the establishment of proposed reserves, most habitats, other than sub-alpine, will be inadequately protected [Mackinnon & Mackinnon 1986].

f. INDIA: One threat is for the zoo trade. Indian Zoos are still allowed to collect lesser cats under the Wildlife Protection Act. The cats are not treated well, and this is a drain on wild populations. Habitat destruction is a second threat. There is large-scale denudation of forests in Sikkim and North Bengal. Forest plantations of exotics lack undergrowth and there has been a spread of extensive tea gardens. A major threat is habitat destruction due to slash and burn agriculture and the fact that most forests in Meghalaya and Arunachal Pradesh and Manipur come under Village councils, who can deal directly with outside contractors who fell forests indiscriminately. Only about 3.5% of the total geographic area of Meghalaya State is under protection as a Reserve Forest. Kaziranga National Park in Assam is threatened by erosion from the Brahmaputra River, National Highway No. 37 which runs through the park and has increasing traffic, and the proposed construction of a railway along the southern boundary [Choudhury 1987]. A third major threat is pressure from hunting and trapping. Tribal people from the northeast eat the meat of anything which can be killed, and the cat skins can be sold. Since the only market in live animals is illegal, animal dealers are turning to skins acquired from trappers which are then smuggled to Bangladesh [Wright 1984b]. Poaching for furs and for meat continues virtually unchecked. A severe decline has occurred in Rajasthan because of the unchecked fur trade. They could go extinct in this area soon [Sharma & Sankhala 1984]. Tribal people from Nagaland, Mizoram and Meghalaya also kill these cats for food and sell the pelts for a few rupees [Wright 1984a].

g. INDONESIA: The primary forest in Sumatra has been shrinking rapidly. The conversion of forests to agriculture is particularly serious. Between 65-80% of the forests in the lowlands has already disappeared [Whitten et al. 1984] and in the mountains, perhaps 15% has disappeared. There is direct evidence of the clouded leopard in only about 3% of the island of Sumatra [Santiapillai & Ashby 1988]. The Barisan Selatan National Park has suffered seriously from illegal logging, uncontrolled firewood collecting, and shifting cultivation caused by transmigrants from Java and Bali. Being at least, a partially arboreal hunter, tree-felling is an especially serious threat to this cat. Another serious threat is poison which is readily available in Sumatra. Organochlorides, such as DDT are used as poison in agricultural communities near game preserves to kill predators that attack cattle and poultry. Poison could also be used deliberately to kill the leopard for its pelt. A skin can be sold on the market for $2,000 (US). Although trade is banned, skins are still exported illegally. Singapore has acted as a conduit for illegal trade [Santiapillai 1987]. This cat is less capable of adjusting to human habitation than some of the other small cats [Santiapillai 1989].

h. KAMPUCHEA: The main threat to the cats is habitat destruction. Many forests were cleared during the reign of Pol Pot as "re-education" of the populace. Recently, forests are being cleared along the northern border in an effort to seal off the Khmer Rouge and KPNLF inside Thailand, and verges along roads are being cleared. However, deforestation is on a small scale as it is used as cover by the guerrillas and, as the country has experienced a population decline, there is no shortage of cultivated land. Poaching is not a problem, as the populace cannot have guns, and soldiers are afraid that shooting will attract the attention of the Vietnamese troops [Thouless 1987].

i. LAOS: No information

j. MALAYSIA: Often, the cats are shot on sight in Sabah, but there is virtually no market for the skin or body parts [Rabinowitz 1987]. In Sarawak, hunting seems to be no threat and only 1% of trophies and pets seen in native villages involved clouded leopard. The Malaysian constitution reserves rights over land matters to the respective state governments; this has been a major barrier to the establishment of a comprehensive national park system. In W Malaysia, almost all Malaysian wildlife is dependent on lowland rainforests that have suffered the greatest damage from logging and clearance for settlement. Although population densities are low in Sabah and Sarawak, substantial areas of lowland forest have already been cleared for timber and plantations. Shifting agriculture and widespread hunting also threaten wildlife [Mackinnon & Mackinnon 1986].

k. NEPAL: Threatened primarily because of conflict with human habitation, even within the National Parks. Many parks are subject to intensive use by the populace [Green 1981]. In Nepal, farmers have cleared most of the forest. Some hill tribes practice slash and burn agriculture [Mackinnon & Mackinnon 1986].

l. SINGAPORE: An extremely populous and highly developed country, most of the natural vegetation has been cleared for agricultural, industrial, and urban development. Three small reserves exist but they are too small to make any major contribution to conservation in the realm. Currently a center for illegal trade [Mackinnon & Mackinnon 1986].

m. **TAIWAN**: Hunted by aborigines for sale to the Chinese community. Increases in intensity of land use and the purchasing power of the Chinese have increased habitat loss, crop damage and hunting pressure. Major threats are deforestation and loss of prey species [Rabinowitz 1988]. Populations were initially devastated by the fur trade and for zoo specimens [IUCN 1978]. Since Taiwan is a densely populated area, most of the lowland forest has been cleared for agricultural land and for timber export, but about 30% of the island is still under forest, mostly in the mountains [Mackinnon & Mackinnon 1986].

n. THAILAND: Protected areas cover about 10% of the total land area. Notable exceptions are rainforests, freshwater swamp, and mangroves, habitats of which little remains. Most lowland forests have been cleared or settled and are at risk from hydroelectric or other developments [Round 1985] and many natural wetlands have been drained for agriculture. Protection and management are good in some of the major national parks, but inadequate in most of the wildlife sanctuaries. There remains much encroachment and illegal hunting [Mackinnon & Mackinnon 1986].

o. VIETNAM: Three national parks have been declared and another 80 are planned that will cover 3% of the total land area. Some animals were hunted for food during the war and became extinct in the region. While natural habitat may remain, populations of some animals may be gone. There is some legislation to protect endangered species, but it is not enforced, and the trade for wildlife in food continues [Mackinnon & Mackinnon 1986].

5. Conservation Measures Taken:

a. BANGLADESH:

(1) Legislation and enforcement: All species of cats were legally protected by the Bangladesh Wildlife Preservation Act of 1973. All cats belong to the 3rd schedule of the Act which means that none of them can be legally hunted, killed or captured [Khan 1986].

(2) Occurrence in protected areas: No information

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: The skins of most species are sold openly. Recently, government officials have seized dozens of illegal cat skins and fewer skins are being sold due to increased vigilance of law enforcement authorities [Khan 1986]. Chittagong Market is flooded with skins that are sold for $10-$20 (US) and may have been smuggled in from Burma and India [Khan 1984].

(5) Research: No information

b. BHUTAN:

(1) Legislation and enforcement: The Butanese Government has provided good protection and the Buddhist population does not engage in much poaching, although poachers may enter from India [Deb Roy & Kharabanda 1984].

(2) Occurrence in protected areas: Can be found in the Manas Wildlife Sanctuary [Anon. 1986a].

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: No information

(5) Research: No systematic or formal survey has been done [Deb Roy & Kharabanda 1984].

c. BRUNEI:

(1) Legislation and enforcement: No information

(2) Occurrence in protected areas: No information

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: No information

(5) Research: No information

d. BURMA:

(1) Legislation and enforcement: No information

(2) Occurrence in protected areas: May occur in Tamanthi and Pakchan Reserves [Mackinnon & Mackinnon 1986].

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: No information

(5) Research: No information

e. CHINA:

(1) Legislation and enforcement: It has protected status but bones and pelts are sold openly [T'an Bangjie 1984].

(2) Occurrence in protected areas: Occurs in Wolong Nature Reserve in Szechuan province, 136 km from Chengdu, adjoining Jiuzhaigou Reserve [PADU 1988].

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: Officially, skins have disappeared from trade since CITES was ratified [Milliken 1984]. In 1987, a restaurant owner in Huizhou was fined for trading in clouded leopards he obtained from a farmer in Zijin County, about 100 km northeast of Huizhou [Anon. 1987b]. Open buying and selling of pelts continues without intervention and skins can be bought in markets for $50-$75 (US). In Sichuan, skins average $30. Furs of leopard, snow leopard, clouded leopard, and golden cat are collectively termed leopard skin by Chinese fur agents [T'an Bangjie 1984].

(5) Research: No information

f. INDIA:

(1) Legislation and enforcement: As of 1980, this country was a party to CITES [McMahan 1982]. The Wildlife Protection Act was passed in 1972, but Jammu and Kashmir have not accepted it. Although the states of the northeast have accepted the Act, it has not been possible to control tribal hunting [Wright 1984b]. This cat is listed in the Act as Schedule I and has the highest protection. In 1979 a complete ban on export of all wild pelts was enforced [Panwar 1984].

(2) Occurrence in protected areas: Can be found in the Manas Tiger Reserve [Anon. 1986b; Choudhury 1988] but status is definitely very rare, and should be listed as endangered [Deb Roy 1984]. Has been sighted in Namdapha National Park at an altitude of about 800 m, Mehao Sanctuary, and has been captured in Pakhni Sanctuary, Arunachal Pradesh [Chatterjee 1984]. About 2,200 sq km in Arunachal Pradesh of protected areas harbor the cat, 30 sq km in Maghalaya; 400 sq km in Manas Tiger Reserve in Assam and other

sanctuaries in Assam [Panwar 1984]. It is found also in Balpakharam Sanctuary, Meghalaya [Wright 1984b] and may exist in Buxa Reserve [Mackinnon & Mackinnon 1986].

(3) Occurrence in secure and non-secure habitats outside protected areas: It is present in the Kalimpong Division of West Bengal, where it is arboreal [Sanyal 1984]. It is also found in another 8,000 sq km in Arunachal Pradesh; 1,970 sq km in Maghalaya; and 2,000 sq km in West Bengal middle hills of Darjeeling in unprotected area [Panwar 1984]. It occurs in excellent unprotected habitats in Kameng, Siang, Lohit and Tirap forest divisions.

(4) Regulation of harvesting: Skins of this species could be easily bought in 1982 in Srinigar [Anon. 1982].

(5) Research: No information

g. INDONESIA:

(1) Legislation and enforcement: As of 1980, this country was a party to CITES [McMahan 1982]. It has been legally protected against killing since 1973 [Santiapillai 1987].

(2) Occurrence in protected areas: Has been found in the Barisan Selatan National Park [FAO 1981a]; and Gunung Leuser National Park in the N part of Sumatra where it is found in primary forest, forest limited to the valley slopes, and secondary forest habitats such as pine forests [Kurt 1970; Ghiglieri 1986]. It is known from the Gumai Pasemah Game Preserve [Blouch 1984] in the extreme W of S Sumatra, and in the Way Kambas Game Reserve in the province of Lampung where over 70% of the lowland forest has been indiscriminately logged and converted into grassland. It has also been reported in the mangrove swamps in the same reserve. It also occurs in the largest national park, Kerinci-Seblat which, because of its remoteness and size, remains a stronghold [FAO 1981b; Santiapillai 1987]. It has also been sighted in S Kalimantan, in the orang-utan study area [IUCN 1986]. In Borneo, it occurs in the Tanjung Puting Proposed National Park on the S coast of the province of Central Kalimantan [PADU 1988].

(3) Occurrence in secure and non-secure habitats outside protected areas: It is reported from the lowland forest in the S part of Jambi province. It is found also in Torgamba production forest, and the Tigapulu hills [Santiapillai & Ashby 1988].

(4) Regulation of harvesting: The only populations that appear to be safe from immediate threat are those in Gunung Leuser and Kerinci-Seblat National Parks. Elsewhere, they are threatened by habitat loss, poisoning, and the illegal pelt trade [Santiapillai & Ashby 1988].

(5) Research: A research center exists at Gunung Leuser National Park in Sumatra [PADU 1988].

h. KAMPUCHEA:

(1) Legislation and enforcement: The Kampuchean reserves are not managed at all, but are not very threatened at present [Mackinnon & Mackinnon 1986]. The species is not protected by law [IUCN 1978].

(2) Occurrence in protected areas: Occurs in Lomphat Reserve [Mackinnon & Mackinnon 1986].

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: No information

(5) Research: No information

i. LAOS:

(1) Legislation and enforcement: A ban on trade in all species of wildlife was imposed by the Government in October 1986. Two Thai wildlife dealers were jailed in 1987 for attempting to illegally export 10 clouded leopards to Taiwan [Anon. 1988a].

(2) Occurrence in protected areas: No information

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: Skin have been recently reported in the local markets [Salter 1983].

(5) Research: No information

j. MALAYSIA:

(1) Legislation and enforcement: As of 1980, this country was a party to CITES [McMahan 1982].

(2) Occurrence in protected areas: No information

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: No information

(5) Research: No information

k. NEPAL:

(1) Legislation and enforcement: As of 1980, this country was a party to CITES [McMahan 1982].

(2) Occurrence in protected areas: There has been one reliable record from the Langtang National Park in an area N of Melamchigaon [Green 1981]. It occurs also in Royal Chitwan [Mackinnon & Mackinnon 1986].

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: No information

(5) Research: In 1986, a subadult male was radio-collared and released in Royal Chitwan National Park in riparian evergreen forest. The cat exhibited only terrestrial behavior, frequently resting in grassland among dense patches of grass. It did not remain in the relocation area but headed back towards its original capture location [Dinerstein & Metha, in press]. J. L. D. Smith is carrying out a study on the carnivore/herbivore community in Chitwan National Park [Jackson 1989].

l. SINGAPORE:

(1) Legislation and enforcement: Not a member of CITES, currently a center for illegal trade [Mackinnon & Mackinnon 1986].

(2) Occurrence in protected areas: No information

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: No information

(5) Research: No information

m. TAIWAN:

(1) Legislation and enforcement: Not a member of the U.N., therefore, cannot be a party to CITES. The Government has imposed controls on the import, export, and re-export of all specimens of animals listed in Appendix I of CITES. The ban was placed in effect in 1987. All permits for trade need clearance from the Council of Agriculture [Anon. 1988b].

(2) Occurrence in protected areas: May occur in the Central Mountain Range in the Yushan National Park [Anon. 1987a].

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: No information

(5) Research: No information

n. THAILAND:

(1) Legislation and enforcement: This cat is banned from export except as authorized by special Ministerial decree. Products (skin, skull) may no be exported [Pong Leng EE 1974]. The Thai reserves vary from quite well protected to unprotected or abused [Mackinnon & Mackinnon 1986].

(2) Occurrence in protected areas: It can be found in Huay Kha Khaeng-Thung Yai Complex near the Upper Kwae Yai River [Anon. 1988c]. It also occurs in Khao Yai, Khao Soi Dao, Nam Nao/Phu Khieu and Khao Kitchakut Reserves [Mackinnon & Mackinnon 1986].

(3) Occurrence in secure and nonsecure habitats outside protected areas: No information

(4) Regulation of harvesting: No information

(5) Research: Studies are being conducted on the cat community in Huai Kha Khaeng [Rabinowitz, in litt.].

o. VIET NAM:

(1) Legislation and enforcement: The Vietnamese Reserves, such as Cuc Phuong, Ca Mau, and Dalat are quite well managed, but most of the Vietnamese Reserves are still at the proposed stage and have no protective infrastructure [Mackinnon & Mackinnon 1986]. The

cat is not protected by law [IUCN 1978].

(2) Occurrence in protected areas: Occurs in Nam Cat Tien and Cuc Phuong Reserves [Mackinnon & Mackinnon 1986].

(3) Occurrence in secure and non-secure habitats outside protected areas: No information

(4) Regulation of harvesting: No information

(5) Research: No information

6. Captive Propagation and research:

Some publications have dealt with this cat in captivity. The majority of the publications have been descriptive accounts of breeding, diet, housing, longevity and rearing [Fontaine 1965; Fellner 1965; 1968; 1970; Baudy 1971; Geidel & Gensch 1976; Murphy 1976; Acharjyo & Mishra 1981; Conway 1984; Ratanakorn 1988]. One recent study dealt with vaginal cytology and behavior [Yamada & Durrant 1988] and another on inducing estrus [Gillespie et al. 1984]. A few comparative behavioral studies have been done among species [Heran & Pejcha 1981]. Several surveys and reviews have also been published containing data from many species [Jones 1977; Hemmer 1979; Kawata 1982; Eaton 1984a; 1984b; Dvornich 1985]. Vocalization research has been carried out by Peters [1984]. Genetic studies on small cats have been represented by several studies [Wurster-Hill 1973; Wurster-Hill & Centerwall 1982; Collier & O'Brien 1985; Newman et al. 1985].

7. Studbook and ISIS status:

In 1984, IZY listed 84.67 with 68.53 being captive born in 48 collections worldwide. An international studbook is published by the Minnesota Zoological Gardens and an SSP has been established. Breeding in captivity has been difficult and there is a high mortality rate of the young. The species is fairly well represented in Chinese zoos. In the early 1980s it was displayed in 29 Chinese zoos, most of then wild-caught recently [T'an Bangjie 1984].

8. Education:

An education center exists at Gunung Leuser National Park in Sumatra [PADU 1988].

Literature

Acharjyo, L. M. And Ch. G. Mishra. Some Notes on the Longevity of Two Species of Indian Wild Cats in Captivity. J. Bombay Nat. Hist. Soc. ; 78(1):155-156. Apr. 1981. Wr 183.

Anonymous. 1986b. Manas Dam Project Shelved. Cat News 4:2.

Anonymous. 1986a. Lesser Cats in Eastern India. Cat News 5:23-26.

Anonymous. 1982. Fur Sales in Kashmir. Oryx 16(4):312.

Anonymous. 1987a. Clouded Leopard Study. Cat News 7:25.

Anonymous. 1988a. Laos Gaols Thai Wildlife Dealers. Cat News 9:22.

Anonymous. 1987b. Chinese Restaurant Fined for Trading in Clouded Leopard. Cat News 7:25.

Anonymous. 1988c. Rich Wildlife Area Saved. Cat News 9:20.

Anonymous. 1988b. Taiwan Bans Trade in Threatened Animals. Cat News 9:22.

Bartz, C. R.; Montali, R. J. Canine and Feline Calicivirus. In Max J. Appel (Ed.) Virus Infections of Carnivores, P.467-468. (Elsevier Science Publ., Amsterdam et Al.); 1987.

Bartz, C. R.; Montali, R. J. Feline Herpesvirus, Type 1. In Max J. Appel (Ed.) Virus Infections of Carnivores, P.395-396. (Elsevier Science Publ., Amsterdam et Al.); 1987.

Baudy, R. E. Notes on Breeding Felids at the Rare Feline Center. International Zoo Yearbook ; 11:121-123.; 1971.

Baudy, R. E. Breeding Techniques for Felines Destined for Release in the Wild. Florida Panther Conference, Orlando, Florida, 1976. Proceedings, P. 99-108. (Florida Audubon Society, Maitland, Florida).

Blouch, R. A. 1984. Current Status of the Sumatran Rhino and Other Large Mammals in Southern Sumatra. IUCN/WWF Report No. 4, Bogor. 37 Pp.

Blouch, R. A. & Simbolon, K. 1985. Elephants in Northern Sumatra. IUCN/WWF 3033 Report # 9 Bogor.

Chatterjie, A. K. & Sen, A. K. 1984. Status of Leopard Cats in Arunachal Pradesh. Pages 89-93 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSP

Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Chatterjie, A. K. 1984. Some Points on Clouded Leopard. Page 275 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSC Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Choudhury, A. 1987. Railway Threat to Kaziranga. Oryx 21(3):160-163.

Choudhury, Anwaruddin The Clouded Leopard in Assam. Oryx ; 27(1):51-53. 1993. Wr 238.

Choudhury, A. 1988. Conservation in Manas Tiger Reserve. Tigerpaper 15(2):23-27

Cites. 1982. Identification Manual Volume 1: Mammalia. United Nations Environment Programme.

Citino, S. B. Transient Felv Viremia in a Clouded Leopard. J. Zoo Anim. Med. ; 17(1):5-7. 1986. Wr 236.

Collier, G. E. & O'Brien, S. J. 1985. A Molecular Phylogeny of the Felidae: Immunological Distance. Evolution 39(3):473-487.

Conway, K. 1984. Sliding Door Nestboxes at Front Royal. Animal Keeper's Forum 11(12):484-494.

Davies, Richard G. Sighting of a Clouded Leopard (Neofelis Nebulosa) in a Troop of Pigtail Macaques (Macaca nemestrina) in Khao Yai National Park, Thailand. Nat. Hist. Bull. Siam. Soc. ; 38(1):95-96. 1990. Wr 226.

Davis, D. D. 1962. Mammals of the Lowland Forest of North Borneo. Bull. Nat. Mus. Singapore 31:1-129.

Deb Roy, S. D. 1984. Clouded Leopard. Page 275 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSC Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Deb Roy, S. D. & Kharabanda, B. C. 1984. Bhutan Cat Notes. Page 61 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSP Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Dinerstein, E & Metha, J. N. In Press. Oryx.

Dinerstein, Eric and Jai N. Mehta The Clouded Leopard in Nepal. Oryx; 23(4):199-201. 1989. Wr 216.

Dvornich, K. M. 1985. Questionnaire Results on Small Felids. Mimeo., Woodland Park Zoo, Seattle. 12 Pp.

Eaton, R. L. 1984b. Status of Felids in Western Hemisphere Zoos with Emphasis on Smaller Species. Zool. Garten. 54(6):383-400.

Eaton, R. L. 1984a. Survey of Smaller Felid Breeding. Zool. Garten. 54(1-2):101-120.

FAO. 1981a. Bansan Selatan Game Reserve Management Plan. 1982-1987. FAO Field Report #21 Bogor.

FAO. 1981b. Kerinci-Seblat Proposed National Park Preliminary Management Plan 1982-1987. FAO Field Report #14 Bogor.

Fellner, V. K. 1968. Erste Naturliche Aufzucht von Nebelpardern (Neofelis Nebulosa) in Einem Zoo. Zool. Garten. 35(3):8-136.

Fellner, V. K. 1970. Einige Beobachtungen Zur Zweiten Naturlichen Nebelparder-aufzucht Im Vergleich Zur Ersten. Zool. Garten. 38:68-72.

Fellner, V. K. 1965. Natural Rearing of Clouded Leopards (Neofelis Nebulosa) at Frankfurt Zoo. Int. Zoo Yb. 5:111-113.

Fontaine, P. A. 1965. Breeding Clouded Leopards (Neofelis Nebulosa) at Dallas Zoo. Int. Zoo Yb. 5:113-114.

Geidel, B. & Gensch, W. 1976. The Rearing of Clouded Leopards (Neofelis Nebulosa) in the Presence of the Male. Int. Zoo Yb. 16:124-126.

Ghiglieri, M. P. 1986. A River Journey Through Gunung Leuser National Park, Sumatra. Oryx 20(2):104-110.

Gillespie, D.; Rogers, B. & Bondurant, B. 1984. Use of Surgical Implants in Inducing Estrus in Exotic Felids. Pages 147-148 in AAZPA Regional Proceedings.

Green, M. J. B. 1981. A Check-list and Some Notes Concerning the Mammals of the Langtang National Park, Nepal. J. Bombay Natural History Soc. 78:77-87.

Hemmer, H. 1979. Gestation Period and Postnatal Development in Felids. The World's Cats 3(2):90-100.

Heran, I. & Pojcha. 1981. Comments upon the Sexual Differences in the Comfort Behavior of the Pallas' Cat, Otocolobus manul. Vestnik Ceskoslovenske-spolencnosti Zoologicke 45:19-26.

IUCN. 1986. Cat Specialist Group Meeting. Some Notes for the Record. Cat News 5:11.

IUCN. 1978. Red Data Book 1. IUCN: Gland, Switzerland.

Jackson, P. 1989. The Status of Conservation of Wild Cats. Mimeo. SSC/IUCN: Gland, Switzerland. 19 Pp.

Jones, M. L. 1977. Record Keeping and Longevity of Felids in Captivity. The World's Cats 3(3):132-138.

Joshua, Jackie. Development of an Ethogram for the Clouded Leopard. J. Colo.-Wyo. Acad. Sci. ; 22(1):6. 1990. Abstract Only. Wr 220.

Kawata, K. 1982. Small Is Beautiful Too! A Review of Small Cats in Zoos. Zool. Soc. Of Milwaukee County, Alive 2:5-11.

Khan, M. A. R. 1986. The Status and Distribution of the Cats in Bangladesh. Pages 43-49 in Cats of the World: Biology, Conservation, and Management, S. D. Miller & D. D. Everett (Eds.), National Wildlife Federation: Washington, D.C.

Khan, M. A. R. 1984. The Status and Distribution of the Cats in Bangladesh. Pages 55-59 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSC Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Kratochvíl, Josef. The Karyotype and System of the Family Felidae (Carnivora, Mammalia). [Karyotyp Und System Der Familie Felidae (Carnivora, Mammalia).]. Folia Zool. ; 31(4):289-304. 1982. In German with Russian and English Summ. Wr 190.

Kurt, F. 1970. Final Report to IUCN/SSC and WWF International of WWF Project 596. Leuser Reserve, Sumatra. Mimeo. 139 Pp.

Lekagul, B. & McNeely, J. A. 1977. Mammals of Thailand. Association for the Conservation of Wildlife: Bangkok.

Lu Houji & Sheng Helin. 1986. The Status and Population Fluctuation of the Leopard Cat in China. Pages 59-62 in Cats of the World: Biology, Conservation, and Management, S. D. Miller & D. D. Everett (Eds.), National Wildlife Federation: Washington, D.C.

Mackinnon, J. & Mackinnon, K. 1986. A Review of the Protected Areas System in the Indo-Malayan Realm. IUCN & UNEP: Gland, Switzerland. 284 Pp.

Mahat, Gopal. 1985. Protected Areas of Bhutan. In: Conserving Asia's Natural Heritage, J. Thorsell (Ed.), IUCN.

McMahan, L. R. 1982. The International Cat Trade. Mimeo. Traffic (U.S.A.): Washington, D.C. 33 Pp.

Mehta, Jai N. And Ram Gopal Dhewaju. A Note on the Record of Clouded Leopards in Nepal. Tigerpaper ; 17(1):21-22. 1990. Wr 221.

Milliken, T. 1984. Japan's Trade in Cat Skins. Pages 159-164 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSC Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Murphy, E. T. 1976. Breeding the Clouded Leopard at Dublin Zoo. Int. Zoo Yb. 16:122-124.

Newman, Andrea; Mitchell Bush; David E. Wildt; Dick Van Dam; Maarten Th. Frankenhuis; Lee Simmons; Lyndsay Phillips and Stephen J. O'Brien. Biochemical Genetic Variation in Eight Endangered or Threatened Felid Species. J. Mammal. ; 66(2):256-267. 1985. Wr 198.

Padu 1988. Protected Areas Directory. Conservation Monitoring Center: Cambridge.

Panwar, H. S. 1984. Conservation of Wild Cats in India. Pages 63-80 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSC Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Patton, Sharon and Alan R. Rabinowitz Parasites of Wild Felidae in Thailand: a Coprological Survey. J. Wildl. Dis. ; 30(3):472-475. 1994. Wr 246.

Payne, J.; Francis, C. M. & Phillips, K. 1985. A Field Guide to the Mammals of Borneo. The Sabah Society: Malaysia. 332 Pp.

Peters, G. 1984. On the Structure of Friendly Close Range Vocalizations in Terrestrial Carnivores (Mammalia: Carnivora: Fissipedia). Z. Saugertierkunde 49:157-182.

Pieters, D. 1938. Along Jungle Streams and Game Trails. The Swamp Forest Country of Southern Sumatra. Mimeo. 143

Pong Leng Ee. 1974. Wildlife Trade in Thailand. Int. Zoo Yb. 14:23-28.

Pospisil, J.; F. Kase and J. Vahala. Basic Haematological Values in Carnivores - Ii. The Felidae. Comp. Biochem. Physiol. & Comp. Physiol. ; 87(2):387-391. 1987. Wr 207.

Prakash, Ishwar. Asian Predators of Livestock. Parasites, Pests and Predators. S. M. Gaafar, Walter E. Howard and Rex E. Marsh, Editors. ; P. 405-410. 1985. Wr 205.

Rabinowitz, A.; Andau, P. & Chai, P. P. K. 1987. The Clouded Leopard in Malaysian Borneo. Oryx 22(2):107-111.

Rabinowitz, Alan The Clouded Leopard in Taiwan. Oryx ; 22(1):46-47. 1988. Wr 209.

Rabinowitz, Alan; Patrick Andau and Paul P. K. Chai The Clouded Leopard in Malaysian Borneo. Oryx ; 21(2):107-111. 1987. Wr 206.

Ratanakorn, P. 1988. Captive Breeding of Clouded Leopard in Thailand. Poster Presented at the 5th World Conference on Breeding Endangered Species in Captivity, Cincinnati, Oh.

Ratanakorn, P. Captive Breeding of Clouded Leopard (*Neofelis Nebulosa*) in Thailand. Proc. World Conf. Breeding Endangered Species Captivity ; No. 5. P. 640-645. 1988. Wr 231.

Reza Khan, Mohammad Ali. The Status and Distribution of the Cats in Bangladesh. Cats of the World: Biology, Conservation, and Management. S. Douglas Miller and Daniel D. Everett, Editors. ; P. 43-50. 1986. Wr 208.

Round, P. D. 1985. The Status and Conservation of Resident Forest Birds in Thailand. Assoc. for the Conservation of Wildlife: Bangkok.

Salter, R. E. Summary of Currently Available Information on Internationally Threatened Wildlife Species in Burma. FAO-fo:bur/80/006, Field Document 7/83.

Santiapillai, C. 1987. Clouded Leopard in Sumatra. Cat News 6:18-21.

Santiapillai, Charles The Status and Conservation of the Clouded Leopard (Neofelis Nebulosa Diardi) in Sumatra. Tigerpapaer ; 16(1):1-7. 1989. Wr 215.

Santiapillai, Charles and Kenneth R. Ashby The Clouded Leopard in Sumatra. Oryx ; 22(1):44-45. 1988. Wr 209.

Sanyal, P. 1984. Clouded Leopard- Arboreal. Page 275 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSC Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Sarker, S. U. & Sarker, N. J. 1984. Mammals of Bangladesh- Their Status, Distribution and Habitat. Tigerpaper 11(1):8-13.

Seal, U. S. Carnivora Systematics: a Study of Hemoglobins. Comparative Biochemistry and Physiology ; 31(5): 799-811.; 1969.

Sharma, V. & Sankhala, K. 1984. Vanishing Cats of Rajasthan. Pages 117-135 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSC Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Tan Bangjie. 1984. The Status of Felids in China. Pages 33-47 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSC Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Tang Guang You & Li Wei. 1987. Wildlife of China. Tigerpaper 14(3):1-10.

Thouless, C. 1987. Kampuchean Wildlife- Survival Against the Odds. Oryx 21(4):223-228.

U. S. Fish and Wildlife. 1987. Endangered and Threatened Wildlife and Plants. Washington, D.C. 32 Pp.

Ulbrich, F.; G.-M. Klemm; H.-E. Schneider and D. Weyhe. Incidence of Feline Rhinotracheitis (Herpes Virus Infection) among Clouded Leopards in Zoological Garden of Dresden. Proc. Int. Symp. Dis. Zoo Anim. ; 26:325-330. 1984. In German with English, French, and Russian Summ. Wr 206.

Wang Zong-yi & Wang Sung. 1986. Distribution and Recent Status of the Felidae in China. Pages 201-208 in Cats of the World: Biology, Conservation, and Management, S. D. Miller & D. D. Everett (Eds.), National Wildlife Federation: Washington, D.C.

Weinheimer, Christina J. Clouded Leopard (*Panthera Nebulosa*) Husbandry at the Buffalo Zoological Gardens. AAZPA (Am. Assoc. Zool. Parks Aquariums) Regional Conf. Proc. ; P. 227-232. 1987. Wr 208.

Whitten, A. J.; Damanik, S. J.; Anwar, J. & Hisyam, N. 1984. The Ecology of Sumatra. Gadjah Mada University Press: Yogyakarta.

Wright, A. 1984a. A Note on the Wild Cats of the Northeastern Region of India. Pages 81-84 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSC Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Wright, A. 1984b. Marbled Cat - Endangered. Pages 276-277 in the Plight of the Cats. Proceedings of the Meeting and Workshop of the IUCN/SSC Cat Specialist Group. Madhya Pradesh, India. 282 Pp.

Wurster-Hill, D. H. 1973. Chromosomes of Eight Species from Five Families of Carnivora. J. Mammalogy 54(3): 753-760.

Wurster-Hill, D. H. & Centerwall, W. R. 1982. The Interrelationships of Chromosome Banding Patterns in Canids, Mustelids, Hyena, and Felids. Cytogenet. Cell Genet. 34:178-192.

Yamada, Joan K. And Barbara S. Durrant. Reproductive Parameters of Clouded Leopards (*Neofelis Nebulosa*). Zoo Biol. ; 8(3):223-231. 1989. Wr 215.

Yamada, Joan K. And Barbara S. Durrant. Vaginal Cytology and Behavior in the Clouded Leopard (*Neofelis Nebulosa*). AAZPA (Am. Assoc. Zool. Parks Aquariums) Annu. Conf. Proc. ; P. 102-106. 1987. Wr 209.

CLOUDED LEOPARD - TAIWAN

Neofelis nebulosa brachyurus

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

REPORT

APPENDIX III

IUCN POLICY STATEMENTS

THE IUCN POLICY STATEMENT ON CAPTIVE BREEDING

Prepared by the
SSC Captive Breeding Specialist Group

As approved by the 22nd Meeting of the IUCN Council Gland, Switzerland

4 September 1987

SUMMARY: Habitat protection alone is not sufficient if the expressed goal of the World Conservation Strategy the maintenance of biotic diversity, is to be achieved. Establishment of self-sustaining captive populations and other supportive intervention will be needed to avoid the loss of many species, especially those at high risk in greatly reduced, highly fragmented, and disturbed habitats captive breeding programmes need to be established before specks are reduced to critically low numbers, and thereafter need to be coordinated Internationally according to sound biological principles, with a view to the maintaining or re establishment of viable populations in the wild.

PROBLEM STATEMENT

IUCN data indicate that about 3 per cent of terrestrial earth is gazetted for protection. Some of this and much of the other 97 per cent is becoming untenable for many species, and remaining populations are being greatly reduced and fragmented. From modern population biology one can predict that many species will be lost under these conditions. On average more than one mammal, bird, or reptile species has been bst in each year this century. Since extinctions of most taxa outside these groups are not recorded, the loss rate for all species is much higher.

Certain groups of species are at particularly high risk, especially forms with restricted distribution, those of large body size, those of high economic value, those at the top of food chains, and those which occur only in climax habitats. Species in these categories are likely to be bst first, but a wide range of other 10rms are also at risk. Conservation over the bng term will require management to reduce risk, including *ex situ* populations which could support and interact demographically and genetically with wild populations.

FEASIBILITY

Over 3,000 vertebrate species are being bred in zoos and other captive animal facilities. When a serious attempt is made, most species breed in captivity, and viable populations can be maintained over the long term. A wealth of experience is available in these institutions, including husbandry, veterinary medicine, reproductive biology, behaviour, and genetics. They offer space for supporting populations of many threatened taxa, using resources not competitive with those for *in situ* conservation. Such captive stocks have in the past provided critical support for some wild populations (e.g. American bison, *Bison bison*), and have been the sole escape from extinction for others which have since been re-introduced to the wild (e.g. Arabian oryx, *Oryx leucoryx*).

RECOMMENDATION

IUCN urges that those national and intemational organizations and those individual institutions concerned with maintaining wild animals in captivity commit themselves to a general policy of developing demographically selfsustaining captive populations of endangered species wherever necessary.

SUGGESTED PROTOCOL

WHAT: The specific problems of the species concemed need to be considered, and appropriate aims for a captive breeding programme made explicit.

WHEN: The vulnerability of small populations has been consistently under estimated. This has erroneously shifted the timing of establishment of captive populations to the last moment, when the crisis is enormous and when extinction is probable. Therefore, timely recognition of such situations is critical, and is dependent on information on wild population status, particularly that provided by the IUCN Conservation Monitoring Centre. Management to best reduce the risk of extinction requires the establishment of supporting captive populations much earlier, preferably when the wild population is still in the thousands. Vertebrate taxa with a current census below one thousand individuals in the wild require close and swift cooperation between field conservationists and captive breeding specialists, to make their effort complementary and minimize the likelihood of the extinction of these taxa.

HOW: Captive populations need to be founded and managed according to sound scientific principles for the primary purpose of securing the survival of species through stable, self-sustaining captive populations. Stable captive populations preserve the options of reintroduction and/or supplementation of wild populations.

A framework of international cooperation and coordination between captive-breeding institutions holding species at risk must be based upon agreement to cooperatively manage such species for demographic security and genetic diversity. The IUCN/SSC Captive Breeding Specialist Group is an appropriate advisory body concerning captive breeding science and resources.

Captive programmes involving species at risk should be conducted primarily for the benefit of the species and without commercial transactions. Acquisition of animals for such programmes should not encourage commercial ventures or trade. Whenever possible, captive programmes should be carried out in parallel with field studies and conservation efforts aimed at the species in its natural environment.

DRAFT GUIDELINES FOR RE-INTRODUCTIONS

Introduction

These policy guidelines have been drafted by the Re-introduction Specialist Group of the IUCN's Species Survival Commission (Guidelines for determining procedures for disposal of species confiscated in trade are being developed separately by IUCN for CITES.) in response to the increasing occurrence of reintroduction projects world-wide, and consequently, to the growing need for specific policy guidelines to help ensure that the re-introductions achieve their intended conservation benefit, and do not cause adverse side-effects of greater impact. Although the IUCN developed a Position Statement on the Translocation of Living Organisms in 1987, more detailed guidelines were felt to be essential in providing more comprehensive coverage of the various factors involved in re-introduction exercises.

These guidelines are intended to act as a guide for procedures useful to re-introduction programmes and do not represent an inflexible code of conduct. Many of the points are more relevant to re-introductions using captive-bred individuals than to translocation of wild species. Others are especially relevant to globally endangered species with limited numbers of founders. Each re-introduction proposal should be rigorously reviewed on its individual merits. On the whole, it should be noted that re-introduction is a very lengthy and complex process.

This document is very general, and worded so that it covers the full range of plant and animal taxa. It will be regularly revised. Handbooks for re-introducing individual groups of animals and plants will be developed in future.

1. Definition of Terms

a. "Re-introduction ":

An attempt to establish a species (The taxonomic unit referred to throughout the document is species: it may be a lower taxonomic unit [e.g. sub-species or race] as long as it can be unambiguously defined.) in an area which was once part of its historical range, but from which it has become extinct (CITES criterion of "extinct": species not definitely located in the wild during the past 50 years of conspecifics.). ("Re-establishment" is a synonym, but implies that the re-introduction has been successful) .

b. "Translocation ":

Deliberate and mediated movement of wild individuals or populations from one part of their range to another. IUCN/SSC Draft Reintroduction Guidelines 2 *c. "Reinforcement/Supplementation":*

Addition of individuals to an existing population.

d. "Conservation/Benign Introductions":

An attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and eco-geographical area.

2. Aims and Objectives of the Re-Introduction

a. Aims:

A re-introduction should aim to establish a viable, free-ranging population in the wild, of a species or subspecies which was formerly globally or locally extinct (extirpated). In some circumstances, a re-introduction may have to be made into an area which is fenced or otherwise delimited, but it should be within the species' former natural habitat and range, and require minimal long-term management.

b. Objectives:

The objectives of a re-introduction will include: to enhance the long-term survival of a species; to re-establish a keystone species (in the ecological or cultural sense) in an ecosystem; to maintain natural biodiversity; to provide long-term economic benefits to the local and/or national economy; to promote conservation awareness; or a combination of these.

Re-introductions or translocation of species for short-term, sporting or commercial purposes - where there is no intention to establish a viable population - are a different issue, beyond the scope of these guidelines. These include fishing an(I hunting activities.

3. Multi disciplinary Approach

A re-introduction requires a Multi disciplinary approach involving a team of persons drawn from a variety of backgrounds. They may include persons from: governmental natural resource management agencies; non-governmental organizations; funding bodies; universities; veterinary institutions; zoos (and private animal breeders) and/or botanic gardens, with a full range of suitable expertise. Team leaders should be responsible for coordination between the various bodies and provision should be made for publicity and public education about the project.

4. Pre-Project Activities

a. Biological:

(I) Feasibility study and background research

• An assessment should be made of the taxonomic status of individuals to be re-introduced. They must be of the same subspecies as those which were extirpated, unless adequate numbers are not available. An investigation of historical information about the loss and fate of individuals from the re-introduction area, as well as molecular genetic studies, should be undertaken in case of doubt. A study of genetic variation within and between populations of this and related taxa can also be helpful. Special care is needed when the population has long been extinct.

• Detailed studies should be made of the status and biology of wild populations (if they exist) to determine the species' critical needs; for animals, this would include descriptions of habitat preferences, intra specific variation and adaptations to local ecological conditions, social behavior, group composition, home range size, shelter and food requirements, foraging and feeding behavior, predators and diseases. For plants it would include biotic and abiotic habitat requirements, dispersal mechanisms, reproductive biology, symbiotic relationships (e.g. with mycorrhizae, pollinators), insect pests and diseases. Overall, a firm knowledge of the natural history of the species in question is crucial to the entire re-introduction scheme.

• The build-up of the released population should be modeled under various sets of conditions, in order to specify the optimal number and composition of individuals to be released per year and the numbers of years necessary to promote establishment of a viable population.

• A Population and Habitat Viability Analysis will aid in identifying significant environmental and population variables and assessing their potential interactions, which would guide long-term population management.

(ii) Previous Re-introductions

• Thorough research into previous re-introductions of the same or similar species and wide-ranging contacts with persons having relevant expertise should be conducted prior to and while developing re-introduction protocol.

(iii) Choice of release site

• Site should be within the historic range of species and for an initial reinforcement or re-introduction have very few, or no, remnant wild individuals (to prevent disease spread, social disruption and introduction of alien genes). A conservation/ benign introduction should be undertaken only as a last resort when no opportunities for re-introduction into the original site or range exist.

• The re-introduction area should have assured, long-term protection (whether formal or otherwise).

(iv) Evaluation of re-introduction site

• Availability of suitable habitat: re-introductions should only take place where the habitat and landscape requirements of the species are satisfied, and likely to be sustained for the for-seeable future. The possibility of natural habitat change since extirpation must be considered. The area should have sufficient carrying capacity to sustain growth of the re-introduced population and support a viable (self-sustaining) population in the long run.

• Identification and elimination of previous causes of decline: could include disease; over-hunting; over-collection; pollution; poisoning; competition with or predation by introduced species; habitat loss; adverse effects of earlier research or management programmes; competition with domestic livestock, which may be seasonal.

• Where the release site has undergone substantial degradation caused by human activity, a habitat restoration programme should be initiated before the reintroduction is carried out.

(v) Availability of suitable release stock

• Release stock should be ideally closely-related genetically to the original native stock.

• If captive or artificially propagated stock is to be used, it must be from a population which has been soundly managed both demographically and genetically, according to the principles of contemporary conservation biology.

• Re-introductions should not be carried out merely because captive stocks exist, nor should they be a means of disposing of surplus stock.

• Removal of individuals for re-introduction must not endanger the captive stock population or the wild source population. Stock must be guaranteed available on a regular and predictable basis, meeting specifications of the project protocol.

• Prospective release stock must be subjected to a thorough veterinary screening process before shipment from original source. Any animals found to be infected or which test positive for selected pathogens must be removed from the consignment, and the uninfected, negative remainder must be placed in strict quarantine for a suitable period before retest. If clear after retesting, the animals may be placed for shipment.

• Since infection with serious disease can be acquired during shipment, especially if this is intercontinental, great care must be taken to minimize this risk.

• Stock must meet all health regulations prescribed by the veterinary authorities of the recipient country and adequate provisions must be made for quarantine if necessary.

• Individuals should only be removed from a wild population after the effects of translocation on the donor population have been assessed, and after it is guaranteed that these effects will not be negative.

b. Socio-Economic and Legal Activities

• Re-introductions are generally long-term projects that require the commitment of long-term financial and political support.

• Socio-economic studies should be made to assess costs and benefits of the e-introduction programme to local human populations.

• A thorough assessment of attitudes of local people to the proposed project is necessary to ensure long term protection of the re-introduced population, especially if the cause of species' decline was due to human factors (e.g. over-hunting, over-collection, loss of habitat). The programme should be fully understood, accepted and supported by local communities.

• Where the security of the re-introduced population is at risk from human activities, measures should be taken to minimize these in the re-introduction area. If these measures are inadequate, the re-introduction should be abandoned or alternative release areas sought.

• The policy of the country to re-introductions and to the species concerned should be assessed. This might include checking existing national and international legislation and regulations, and provision of new measures as necessary. Re-introduction must take place with the full permission and involvement of all relevant government agencies of the recipient or host country. This is particularly important in re-introductions in border areas, or involving more than one state.

• If the species poses potential risk to life or property, these risks should be minimized and adequate provision made for compensation where necessary; where all other solutions fail, removal or destruction of the released individual should be considered.

In the case of migratory/mobile species, provisions should be made for crossing of international/state boundaries.

5. Planning. Preparation and Release Stages

• Construction of a Multi disciplinary team with access to expert technical advice for all phases of the programme. IUCN/SSC Draft Reintroduction Guidelines 6

• Approval of all relevant government agencies and land owners, and coordination with national and international conservation organizations.

• Development of transport plans for delivery of stock to the country and site of re-introduction, with special emphasis on ways to minimize stress on the individuals during transport.

• Identification of short-and long-term success indicators and prediction of programme duration, in context of agreed aims and objectives.

• Securing adequate funding for all programme phases.

• Design of pre- and post- release monitoring programme so that each re-introduction is a carefully designed experiment, with the capability to test methodology with scientifically collected data.

• Appropriate health and genetic screening of release stock. Health screening of closely related species in re-introduction area.

• If release stock is wild-caught, care must be taken to ensure that: a) the stock is free from infectious or contagious pathogens and parasites before shipment and b) the stock will not be exposed to vectors of disease agents which may be present at the release site (and absent at the source site) and to which it may have no acquired immunity.

• If vaccination prior to release, against local endemic or epidemic diseases of wild stock or domestic livestock at the release site, is deemed appropriate, this must be carried out during the "Preparation Stage" so as to allow sufficient time for the development of the required immunity.

• Appropriate veterinary or horticultural measures to ensure health of released stock throughout programme. This is to include adequate quarantine arrangements, especially where founder stock travels far or crosses international boundaries to release site.

• Determination of release strategy (acclimatization of release stock to release area; behavioral training - including hunting and feeding; group composition, number, release patterns and techniques; timing).

• Establishment of policies on interventions (see below).

• Development of conservation education for long-term support; professional training of individuals involved in long-term programme; public relations through the mass media and in local community; involvement where possible of local people in the programme.

• The welfare of animals for release is of paramount concern through all these stages.

6. Post-Release Activities

• Post release monitoring of all (or sample of) individuals. This most vital aspect may be by direct (e.g. tagging, telemetry) or indirect (e.g. spoor, informants) methods as suitable.

- Demographic, ecological and behavioral studies of released stock.
- Study of processes of long-term adaptation by individuals and the population.
- Collection and investigation of mortalities.
- Interventions (e.g. supplemental feeding; veterinary aid; horticultural aid) when necessary.
- Decisions for revision rescheduling, or discontinuation of programme where necessary.
- Habitat protection or restoration to continue where necessary.
- Continuing public relations activities, including education and mass media coverage.
- Evaluation of cost-effectiveness and success of re- introduction techniques.
- Regular publications in scientific and popular literature.

DRAFT GUIDELINES FOR THE DISPOSITION OF CONFISCATED ANIMALS[1]

STATEMENT OF PROBLEM

When live animals are confiscated, the government holding these specimens must dispose of them appropriately. Disposition should maximise conservation value and concurrently provide a humane solution to the problem of ultimate placement of the specimens involved. In these guidelines, we hope to offer advice on what constitutes appropriate disposition.

STATEMENT OF NEED

With improved interdiction of the illegal trade in animals there is an increasing demand for information to guide confiscating agencies in the disposal of specimens. This need has been reflected in the formulation of specific guidelines for several groups of organisms such as parrots (Birdlife International in prep) and primates (Harcourt in litt.). However, no general guidelines exists.

Signatories to the Convention of the International Trade in Endangered Species (CITES) are legally required to return illegally traded, CITES listed, animals to the "state of export . . . or to a rescue centre or such other place. " (Article VIII, para. 4(d). There is ambiguity as to what should be done with these animals once repatriated. The Netherlands, in an attempt to clarify this section of the convention, submitted a draft resolution to the Eighth Meeting of the Conference of the Parties in Kyoto in March of 1992 entitled "Return to the Wild of Confiscated Live Animals of the Species Included in Appendices II & II. " The resolution was withdrawn, but the need for interpretation and/or amendments to this section was generally agreed on by the Parties . The following guidelines do not attempt to interpret whether"repatriation"necessarily implies "reintroduction, " but our working assumption is that it does not.

The lack of specific guidelines has meant that disposition of confiscated animals has been done in an inconsistent manner (Appendix I). In some cases, release of confiscated animals into existing wild populations has been made after careful evaluation and with due regard for existing guidelines (IUCN

---

[1] Drafting Committee: Josh Ginsberg, Institute of Zoology, Zoological Society of London, Bill Conway, NYZS The Wildlife Conservation Society, Mike Woodford, Chairman, IUCN Veterinary Specialist Group, Oliver Ryder, CRES, San Diego Zoological Society.

1987). In other cases, such releases have been made without adequate consideration of the health and safety of the existing wild population.

MANAGEMENT OPTIONS

In determining the disposition of confiscated animals, priority must be given to the well-being and conservation of existing wild populations of the species involved, with all efforts made to ensure the humane treatment of the confiscated individuals. Options for disposition include:

Return to the Wild

1) Re-introduction , or an attempt to establish the confiscated individuals in an area which was once part of the range of the species but from which it has become extirpated.

2) Supplementation or Reinforcement of an Existing Population: the addition of confiscated individuals to an existing population of the same taxa.

3) Conservation/Benign Introductions: an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and eco-geographical area.

There are several benefits of returning animals to the wild, either through re-introduction or supplementation of an existing population:

a) In situations where the existing population is severely threatened, such an action might improve the long-term conservation potential of the species.

b) Such action makes a strong political/educational statement concerning the fate of animals and may serve to promote strong conservation values (e.g. Aveling & Mitchell 1982, but see Rijksen & Rijksen-Graatsma 1979).

Problems which must be considered and accounted when returning animals to the wild for include but are not limited to (see IUCN-RISG in prep).:

a) Disease. Animals held in captivity and illegally transported may be exposed to a variety of pathogens. Release of these animals to the wild may result in introduction of disease to con-specifics or unrelated species with potentially catastrophic effects.

b) Cost. The cost of returning animals to the wild in an appropriate manner can be prohibitive for all but the most endangered species (Stanley Prince 1989; Seal et al 1989, IUCN-RISG in prep).

c) Source of individuals. If provenance of the animals is not known, or if there is any question of the source of animals, supplementation may lead to inadvertent pollution of distinct genetic races or sub-species.

d) Welfare. While release to the wild may appear to be humane, it may be nothing more than sentence to a slow death. Survival prospects for released animals must at least approximate those of wild animals of the same sex and age class (Int. Academy of Animal Welfare Sciences 1992).

Captivity

4) Captivity: placement through donation of the confiscated animals in captivity, either in the country of origin, the country of export (if different), the country of confiscation, or in a country with adequate and/or specialised facilities for the species in question.

5) Sale of the animals to the pet trade, or to local zoos. Direct sale of the confiscated animals to traders, or sale of the animals to foreign or local zoos or research facilities.

The benefits of placing the animal in captivity include:

a) Educational value.

b) Potential for captive breeding to replace wild-caught animals as a source for trade.

c) Potential for captive breeding for eventual reintroduction.

d) Revenue from sale to offset costs of confiscation and holding.

Disadvantages of placing animals in captivity, but not in an established programme for captive breeding and reintroduction include:

a) Encouraging further trade. In his discussion of primates, Harcourt (in litt) strongly argues that ANY trade is likely to promote further illegal trade either directly, by promoting a market, or more commonly indirectly by sending the signal to illegal traders that the State is involved in trade. Birdlife International (in prep), is ambivalent about the severity of this problem when it concerns animals commonly traded in the country of confiscation. They offer the following requirements which must be met for permissible sale by the confiscating authority:

1) The species to be sold is already available in the confiscating country in commercial quantities; and

2) Importers and dealers under indictment for, er convicted of, crimes related to import of wildlife are prevented from purchasing the animals in question.

b) Disease. Confiscated animals may serve as vectors for disease and, thus, must be subject to extremely stringent quarantine. The potential consequences of the introduction of alien disease to a captive facility are equally serious as that of introducing disease to wild populations.

c) Cost of placement. We do not believe that it would encourage trade significantly if the institution receiving a donation of confiscated animals were to reimburse the confiscating authority for costs of care and transport. However, for common species, or species with no great display interest, it is unlikely that there will be funds and/or cage space available to maintain these animals.

d) Use of Cage Space. Increasingly, the international zoo community is setting conservation priorities for cage space (Seal & Foose 1992). Although placing animals of low conservation priority in limited cage space may benefit those individuals, it may detract from conservation efforts as a whole.

Killing or "Sacrificing" Animals

6) Euthanasia: the humane killing of the confiscated animals.

7) Research: donation of the animals involved to accredited universities or medical laboratories for research purposes.

Killing confiscated animals is clearly the least palatable option for disposition. In many circumstances, however, the confiscating authorities will encounter the following circumstances:

a) Placement in captivity is impossible, or will further promote trade, thus resulting in increased threat to the wild populations

b) Return to the wild in some manner is either impossible, or prohibitively expensive as a result of the need to conform to biological (IUCN-SSC RISG in prep) and animal welfare guidelines (International Academy of Welfare Sciences.

In these circumstances, euthanasia, or donation of the animals to an in-country research facility, may offer both the best solution from the point of view of conservation and often, the welfare of the animals involved.

DETERMINATION OF APPROPRIATE DISPOSITION

Each of the above options have advantages and disadvantages, both in terms of their conservation value for a particular species, and in terms of the level of humane treatment afforded the confiscated animals. The decision as to which option to employ will depend on various legal, social, economic and biological factors. In Figure One we provide a flow diagram to assist in making decisions concerning the disposition of confiscated animals. We have written the diagram so that it may be used for both threatened and common species. The conservation status of a species, however, will influence whether or not it is part of an active conservation breeding/reintroduction programme, and whether or not local or international agencies will be willing to make an investment in expensive and difficult tasks such as genetic determination of provenance or the establishment of reintroduction, benign introductions, or supplementation of extant wild populations.

Transfer of Animals to Captive Breeding/Reintroduction Programmes

For those species where active captive breeding and reintroduction programmes exist (see Appendix II), and for which further breeding stock/founders are required, we suggest that confiscated animals be transferred to appropriate holding facilities after consultation with the appropriate scientific authorities. If necessary, costs of transfer and maintenance in holding facilities should be borne by the programme. If the species in question is part of a captive breeding programme, but the taxa (sub-species or race) is not part of this prograrnme (e.g. Magquire & Lacy 1990), other methods of disposition must be considered.

Return to the Wild

For those species or taxa which can not be transferred to existing programmes, return to the wild, following appropriate guidelines, will only be possible if 1) appropriate habitat exists for such an operation and 2) sufficient funds are available, or can be made available, for this action. In the majority of cases, at least one, if not both of these requirements will fail to be met. In this situation, donation, sale, use of the animals in medical research, or euthanasia of the animals involved must be considered. If a particular species or taxa is confiscated with some frequency, and such confiscations are recorded (e.g. CITES listed specimens), it may prompt planning for reintroduction/supplementation/benign introduction programmes.

Captivity

Transfer or sale of the confiscated animals to a captive facility, or to the pet trade, will occasionally provide a solution to the disposition of confiscated animals. For the concerns discussed above, however, sale may be inappropriate, and captive facilities may be unwilling to accept animals of little conservation or display interest. In these circumstances, placement of the animals in a medical research facility, or euthanasia, will be the only alternatives.1315193, Page 5

Euthanasia

Euthanasia of confiscated animals will ra;rely be a popular choice for confiscating authorities. From the point of view of conservation of the species involved, however, euthanasia carries far fewer risks when compared to retuluing animals to the wild. Euthanasia will also act to discourage trade in the animals as traders will soon learn that animals illegally imported do not reach the rnarket at any price. Euthanasia may also be the most humane option: unless adequate finances are available for rehabilitation of confiscated animals, the "hard release" (release without any provisioning, training, or support) of these species may result in a slow death due to starvation, disease, or predation.

REFERENCES

Aveling R. & Mitchell A. H. (1982). Is rehabilitating orang utans worthwhile? Oryx 1 6: 263-271.

Birdlife International (in prep). Parrots: An Action Plan for their Conservation. (Birdlife International, Cambridge: England).

Harcourt, A. H. (in litt.) Options for unwanted or confiscated primates. Discussion paper drafted for the IUCN-SSC Primate Specialist group and the Primate Society of Great Bntain.

International Academy of Animal Welfare Sciences (1992). Welfare guidelines for the re-introduction of captive-bred mammals to the wild. (Universities Federation for Animal Welfare, Potters Bar: United Kingdom).

IUCN (1987). The IUCNposition statemer t on translocation of living organisms: introductions, reintroductions and restocking . (IUCN, Gland: Switzerland).

IUCN-SSC RISG (in prep). Draft guidelines for reintroductions.

Magquire, L. A. and Lacy, R. C. (1990). Allocating scarce resources for conservation of endangered sub-species: parfitioning zoo space for tigers. Conservation Biology 4, 157- 156.

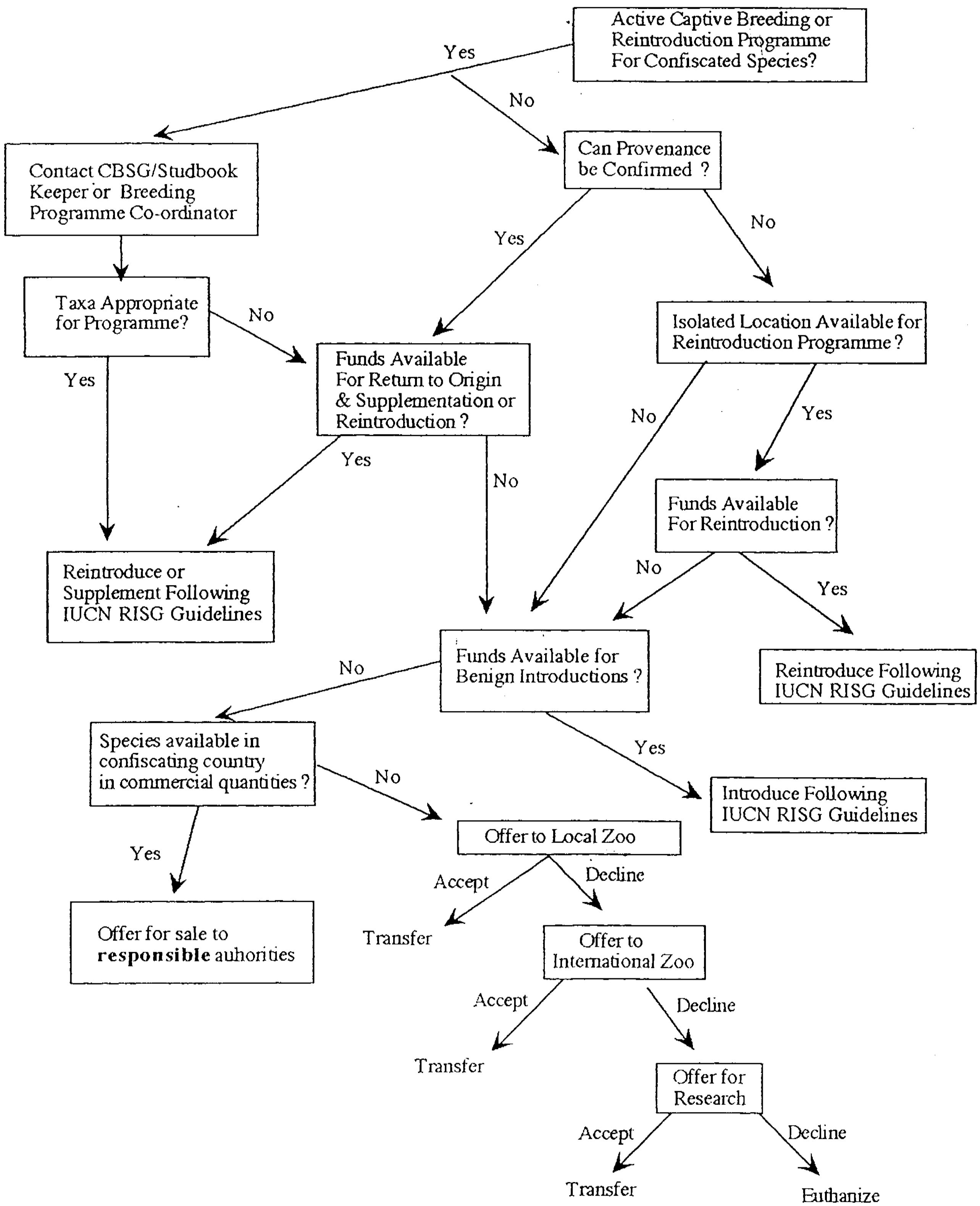
Rijksen, H.D. & Rijksen-Graatsma, A. (1979). Rehabilitation, a new approach is needed. Tigerpaper 6: 16-18.

Seal, U. S. & Foose, T. (1992). Captive Animal Management Program (CAMP) Summaly Report. (IUCN-CBSG, Apple Valley, Minm: USA).

Seal, U. S., E. T. Thorne, M. A. Bogan, and S. H. Anderson. (1989). Conservation biology and the black-footedferret. (Yale University Press, New Haven: USA).

Stanley Price, M. R. (1989). Animal reintroduction: the Arabian oryx in Oman. Cambridge studies in applied ecology and resource management. (Cambridge University Press. Cambridge: England).

Flow Chart for the Disposition Of Confiscated Animals



Approved by the 27th Meeting of the IUCN Council

IUCN POLICY STATEMENT ON RESEARCH INVOLVING SPECIES AT RISK OF EXTINCTION

PROLOGUE

IUCN holds that all research on or affecting a threatened species carries a moral responsibility for the preservation or enhancement of the survival of that species. Conservation of the research resource is clearly in the interest of the researchers.

IUCN recognizes that the taking and trading of specimens of threatened species are covered by international agreements and are normally included in national legislation which provides authorized exemptions for the purpose of scientific research.

Basic and applied research is critically needed on many aspects of the biology of animal and plant species at risk of extinction (e g. those listed by IUCN as Vulnerable, Rare, Endangered, or indeterminate) to provide knowledge vital to their conservation.

Other scientific interests may involve the use of threatened species in a wide variety of studies. Taking into account the importance of many kinds of research, as well as potential threats such species could be subject to in such activities, IUCN, after careful consideration, adopts the following statements as policy.

POLICY

IUCN encourages basic and applied research on threatened species that contributes to the likelihood of survival of those species.

When a choice is available among captive-bred or propagated, wild-caught or taken, or free-living stock for research not detrimental to the survival of a threatened species, IUCN recommends the option contributing most positively to sustaining wild populations of the species.

IUCN recommends that research programmes on threatened species that do not directly contribute to conservation of the species should acknowledge an obligation to the species by devoting monetary or other substantial resources to their conservation, preferably to sustaining populations in the natural environment.

Whether animals involved are captive-bred, wild-caught, or free living, or whether plants involved are propagated, taken from the wild, or in their natural habitat, IUCN opposes research that directly or indirectly impairs the survival of threatened species and urges that such research not be undertaken.

PROTOCOLS

In this context IUCN urges researchers to accept a personal obligation to satisfy themselves that the processes by which research specimens are acquired (including transportation) conform scrupulously to procedures and regulations adopted under international legal agreements. Further, researchers should adopt applicable professional standards for humane treatment of animal specimens, including their capture and use in research.

IUCN urges that any research on threatened species be conducted in conformity with all applicable laws, regulations and veterinary professional standards governing animal acquisition, health and welfare, and with all applicable agricultural and genetic resource laws and regulations governing acquisition, transport, and management of plants.

小群体生物学

前言

濒危物种，就其定义而言，是有灭绝危险的物种。恢复这类物种的主要目标是要把其灭绝的危险程度降低，减少到某一种可以接受的水平，也就是尽可能减少到与其背景近似，即一切物种的正常的灭绝危险程度。

危险一词的概念用以确定恢复的对象，同时用于明确恢复本身的含义。危险情况是濒危物种管理的中心问题，这毫不奇怪。然而，遗憾的是，有充分理由认为，作为人类的我们，天生来不善于评估已经危险到什么程度了。在这一方面，如果我们的工作能够进一步做好，物种的恢复就会进一步成功。为了帮助管理人员处理危险情况，迫切需要有一些工具。我们需要改进对危险情况的估计，需要对不同的潜在管理方案带来的危险进一步排列出其先后次序，需要在评估危险的时候进一步客观，同时，(通过内部先后一致的检查办法)，对于整个程序加以质量控制。在所要评估的危险当中，有灭绝和基因多样性。

最近几年来，这方面的工具，从数量上来说，增加了。野生生物管理和群体生物学之间的一些空白已经为保护生物学这门应用科学所填补。泛泛称为「群体生存分析」的一整套办法问世了。

这类技术的威力足以改进危险情况的辨认工作，排列出相关的危险的轻重缓急，以及评估各种可供选择的方案。另外的一个优点是可以把一部分决策过程，从无法向其提出挑战的主观见解变成为在数量上相当多的基本理论，(因而也就可以受到挑战)。

在下列几段，乔恩·巴卢，汤姆·富斯和鲍勃·莱希分别介绍「群体生存分析」(PVA)的不同方面。文章是根据其他有关「群体生存分析」著作改写的，(即乔恩·巴卢等人以及鲍勃·莱希等人在一九八九年分别发表的「群体生存分析」)，概括介绍构成「群体生存分析」基础的一些群体生物学概念。每一位在这方面有贡献的人，都根据自己的经验和专长来谈这个问题，因此内容和看法会有所不同，其中也会有一些重复的地方，不过，这只不过是用不同的词句来重复某

一点而已，因此对初接触这方面问题的人会有所帮助。一般介绍以后，将介绍野生的和饲养的大熊猫和小熊猫群体的情况，并在此基础上详细介绍「群体生存分析」，同时还要对增加这类物种恢复的可能性，提出一些建议。

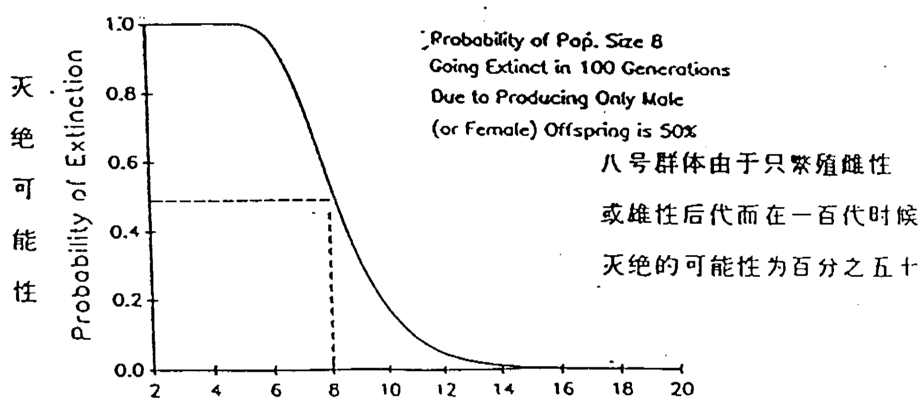
小群体概况

巴卢

单一物种保护计划的基本目标是降低群体灭绝的危险性。在这方面，第一步工作是认清有可能造成群体灭绝的因素。基本威胁自然是群体数量下降。如果一个群体在数量上减少，而又不采取行动来扭转，灭绝自然不可避免。即便一个小群体在数量上没有减少，即便实际上还有所增加，然而这个群体也仍然是前途未卜的。小群体受到许多因素的挑战，而这些因素可以增加这个群体灭绝的可能性，其简单原因，不外是这个群体是个小群体。

对小群体的挑战

小群体受到的挑战，就其分类，可以说是内在的，(在不涉及环境情况下，群体内部基因和数量上的偶然变化)，也可以是外部的，(环境作用于群体的基因和数量)。在最基本的单位方面，也就是在个体方面，群体受到的内在挑战为数量上的变化。数量上的变化，是群体内死亡和生育率以及性别比例受群体中个体的偶然变化而发生的正常变化。群体大小方面的波动可以单纯是由于个体繁殖，或者存亡的偶然差异而引起的。这种偶然的波动可以严重到使群体灭绝。举例来说，对于十分小的群体的关注是这个群体在一代中繁殖的所有个体都是一个性别的话，



图一(Fig.1)说明统计数量上的差异:一代只繁殖一个性别后代，一百代时灭绝的可能性。

群体大小 Population Size

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

其结果是这个群体会灭绝。图一说明，在不同大小的群体中，在一百代的时候发生的这种可能性。八号群体在这期间的某一个时间由于单一的性别比例而灭绝的机会是百分之五十。

死亡率高，或者是繁殖率低的巧合作用，也可能引起同样后果。然而，在大的群体中，这种危险基本上微不足道。一般来说，一个个体在大群体中对群体总趋势的影响小于在小群体中的影响。其结果是，除了极小群体之外(少于二十隻动物)，数量上的差异，相对来说，是一个比较小的挑战。

对于小群体来说，比较显著的一个外部威胁是环境变化。环境条件的变化显然对于群体繁殖和生存的能力有影响。就群体大小而言，对环境变化敏感的群体比不敏感的群体在群体大小问题上容易波动，增加了灭绝的危险。举例来说，濒危的佛罗里达州螺鸢直接受水位的影响，因为水位决定食物(螺)的多寡;在水位低的年分，孵化成功率可减少百分之八十。群体非常不稳定。(贝辛格著，一九八六年)。

对于小群体来说，另外一种威胁是灾难，如传染病。灾难和环境变化的其他形式有相似之处，这就自在于全都是外部条件。尽管如此，还是要单独列出，因为影响大，预测灾害的发生也困难。灾难也可以视为对群体的大部分产生灾难性后果的因素，然而相对来说，是很少发生的事情。传染病对于一个群体可以有直接或者是间接影响。举例来说，在一九八五年，野生啮齿动物鼠疫使黑足貂的基本捕获对象草原松鼠数量减少，结果对仅剩下的黑足貂产生了严重的间接影响。同年晚一些时候，犬瘟热使野生群体中的大部分死亡，结果只好把余下的六隻全部人工饲养起来。(索恩与别利茨基著，一九八九年)。

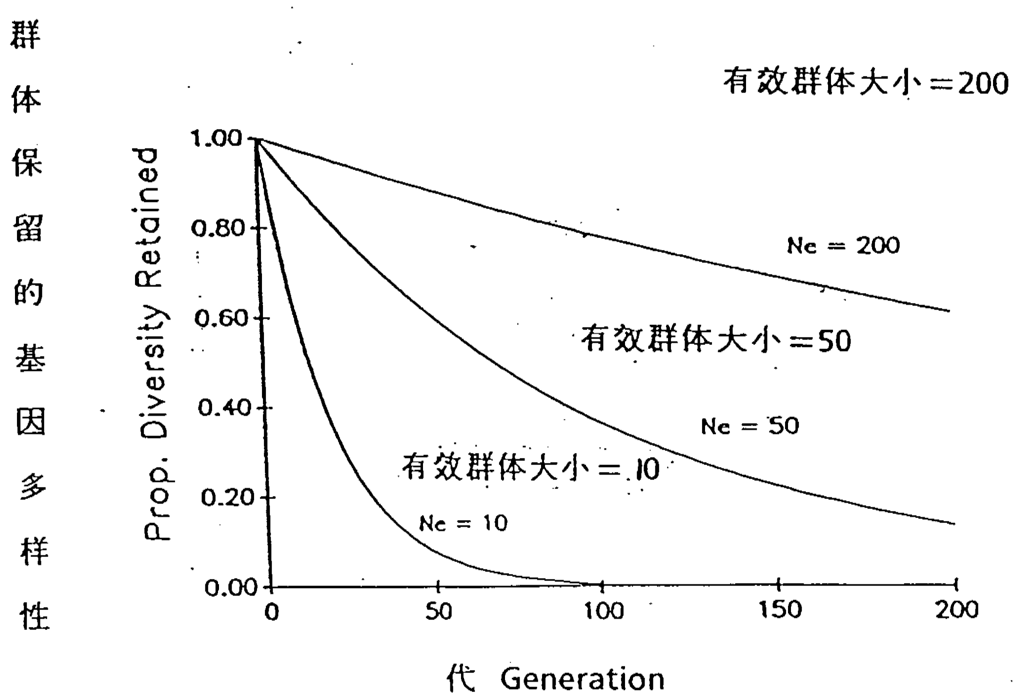
灾难是难得发生一次的，然而却能够使群体中个体大批减少。灾难性事件有自然方面的，(水灾，火灾，飓风)，或者是人为方面的(砍伐森林，或者是破坏生境的其他行为)。群体，不论其大小，都受灾难影响。当前，影响物种灭绝率最严重的，莫过于砍伐热带森林。对于热带物种的灭绝率，到本世纪末的时候有各种不同估计，在百分之二十到百分之五十之间(卢戈著，一九八八年)。

小群体也容易受基因方面的挑战。在基因方面的基本考虑是基因变异方面的损失。在每一代中，遗传给下一代的基因都是亲体的随机基因样。在小群体当中，随机基因样很小，只代表亲体基因十分微小的一部分。亲体中的基因变异偶然也可能没有传给下一代。在这种情况下，群体就失去了这部分基因。这个过程叫做遗传漂移，因为，随着时间的转移，群体的基因特点可

能漂移，或者变化。在小群体中，遗传漂移可以使基因多样性迅速损失掉。群体越小，损失速度越快。

保护计划内容以保留基因多样性为基本目标，其理由有几个。物种如果要能够长期生存下去，则必须保留住适应变化中的环境的能力(演变)。自然选择过程需要有基因变异，因此，保护策略中必须有为物种长期存在所需要的基因变异。除了要有长期演变考虑之外，已经证明，基因多样性对于维护群体的健康也十分重要。有越来越多的研究显示，基因多样性和许多涉及繁殖，生存和抗病等方面特点有一般的，然而却不是普遍的相互关系(阿伦多夫和利里合著，一九八六年)。基因变异水平低的个体比基因变异大的个体容易有较高死亡率和较低繁殖率。

近姻交配(在有血缘关系的个体之间)也会使群体失去基因多样性。小群体中的所有的动物相互之间会迅速都有血缘关系。有血缘关系的亲体繁殖的后代由于是近亲交配而从雌雄亲体那里得到等位基因。近亲交配的个体比非近亲交配的个体更容易有同型基因;这类个体的基因多样性小于没有血缘关系的亲体繁殖的后代。

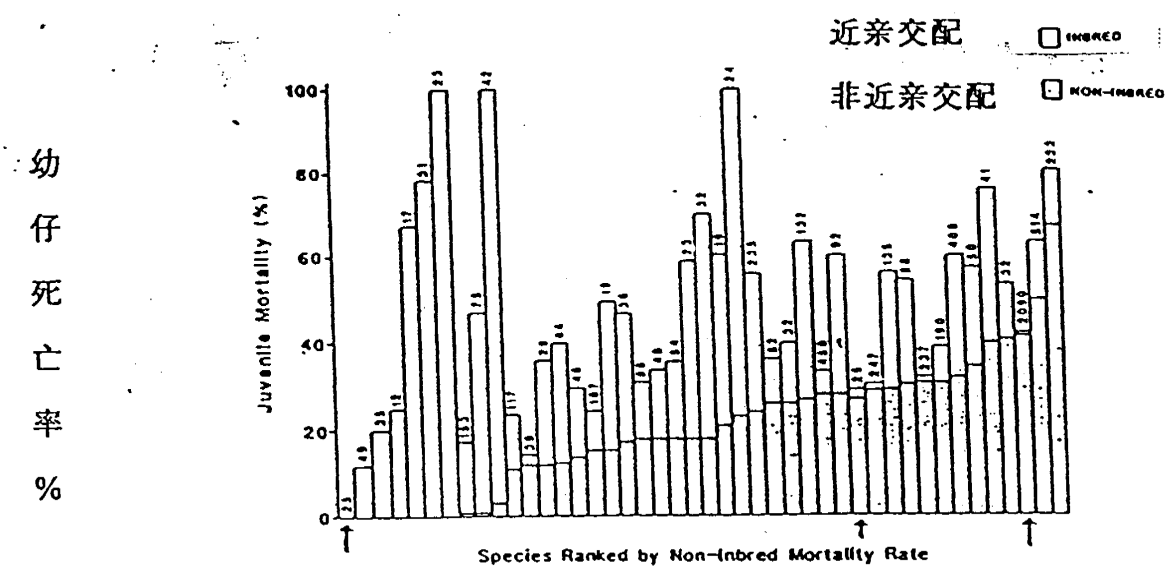


图二(Fig.2)。不同有效群体大小的群体在二百代的时候丧失的基因多样性(Ne).

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

图二说明不同大小的群体丧失基因多样性的情况。基因多样性丧失率是群体有效大小的一个功能(Ne为群体有效大小。每一代损失的多样性为1/2Ne。)从技术上来说，一个有效群体的大小应与真实群体有同样的基因多样性丧失率。这是理想群体的大小。现在已经有很多文献说明如何去估计一个有效群体的大小(兰德与巴罗克拉夫合著，一九八七年);然而，也可以用每一代对基因库有贡献的动物头数作为对群体有效大小的粗略估计。有效群体的大小，因此比群体中的实际头数，要小的多。进行过的一些估计暗示，有效大小往往只是群体总头数的百分之十到百分之三十。

对于外来物种近亲交配的影响所积累的数据，也说明了保持基因多样性的重要性。许许多多研究结果都表明，在很多野生生物中，近亲繁殖能够显著影响繁殖和生存(罗尔斯与巴卢合著，一九八三年，以及怀尔德等合著，一九八七年，图三)。造成近交衰退的，有两方面原因，其一，同型基因的增加使基因组中的有害隐性等位基因表露出来了;其二，在异型结合组只单纯因为有两个等位基因而比同型结合组更适合的情况下，近亲交配会降低近亲交配繁殖出来的后代的健康水平，使之不能够在群体中占优势。在这两种情况下，近亲交配造成基因多样性的丧失，对于群体的生存，都有着有害影响。

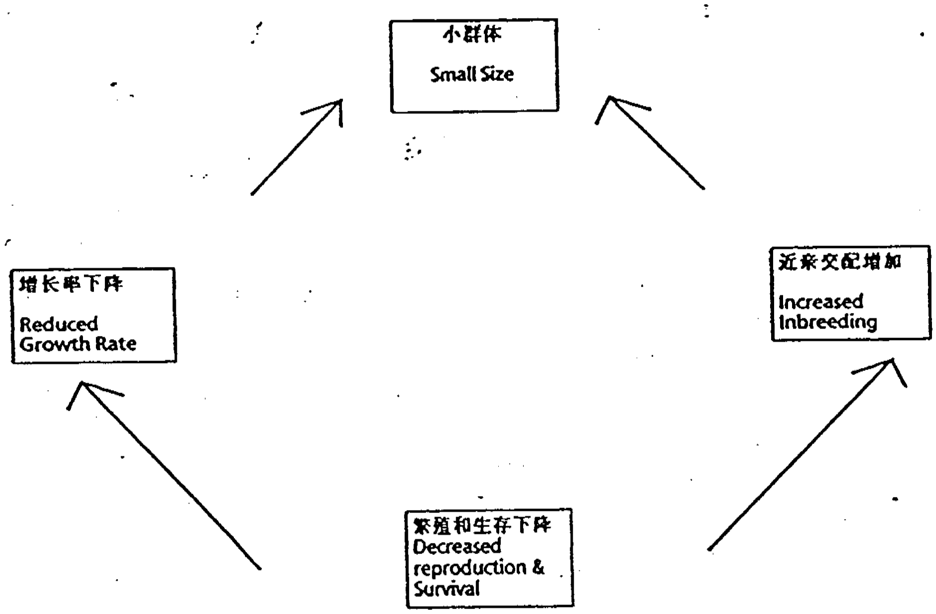


图三。(Fig.3)在四十五种饲养动物群体中近亲交配造成的幼仔死亡情况(摘自罗尔斯与巴卢合著一九八七年)

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

小的，孤立的群体，在没有得到来自其他群体的迁移的情况下，会丧失基因多样性，同时，随着时间的转移而近亲交配现象严重，从两方面危及这类群体的长期生存，因为这类群体，不但会失去演变所需要的基因多样性，而且，其近期生存，也会因为近亲交配对生存和繁殖的有害影响而受到威胁。

上面谈到的基因和数量两方面的挑战，在小群体中，显然并非独立起作用。一个小群体，近亲交配情况越来越多以后，生存与繁殖的可能性就越来越小，群体结果会缩小。近亲交配率上升使群体变小，而群体变小又引起更多的近亲交配现象，其结果不但是容易在数量上发生变化，而且，在疾病和严重的环境变化方面，也容易受影响。每一种挑战都会加深另外的一些挑战，结果造成负反馈作用。这种作用称之为「灭绝漩窝」(吉尔平与苏莱合著，一九八六年」。长此下去，群体越来越小，越容易灭绝。图四。



图四(Fig.4)小群体近亲交配造成负反馈作用形成的「灭绝漩窝」。

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

「群体生存分析」

小群体面对的挑战多数都是随机发生的，是无法预测的偶然性事件造成的，其中有很多，一般来说，都可以减少群体长期生存的可能性。不过，由于这些都是随时发生的，所以对于群体的

灭绝和基因多样性的保存，究竟有什么样的确切影响，尚难準确预测。举例来说，尽管近亲交配是普遍现象，然而其影响，因物种不同而异(图三)，不可能準确预测某一个群体对于近亲交配会有什么反应。

尽管如此，仍然要发展和执行一些保护策略来解决这些无法预测的灭绝问题和基因多样性丧失问题。近年来发展出来的一个用以评估灭绝可能性与基因多样性丧失问题的程序叫做「群体生存分析」(PVA;苏莱著，一九八七年)。「群体生存分析」的定义是系统评估使群体陷入危险情况的各种因素的相对重要性，设法辨明那些对于群体生存有重要意义的因素。在某一些情况下，这可能容易做到 ---- 对于大多数濒危物种来说，生境破坏往往是一个关键因素。但是，在另外一些时候，个别因素的影响，以及因素之间相互作用的影响，估计起来，就比较困难了。为了进一步了解这些因素的影响，目前已经发展出一些计算机模型，通过分析与模拟技术的结合使用，可以模拟出群体在一定时期的情况，估计出一个群体灭绝的可能性以及基因多样性的丧失情况。首先，要往模型中输入群体生活史特点的信息，其中包括首次繁殖的年龄，一窝幼仔的多少和分布情况，成活率，交配结构，年龄分布，以及和这里每一个变数有关系的变化估计情况，另外，还要考虑使用的是什么样的模型。此外，也可以考虑许多不同的外部因素，其中可能有环境变化水平，容纳量的变化，和近交衰退的严重程度。有一些模型还可以顾及到群体面临的一些威胁，如发生灾难的可能性，栖息地损失情况，以及疾病传染情况。(图五。)

「群体生存分析」

对于灭绝危险有影响的相互作用着的因素的评估过程

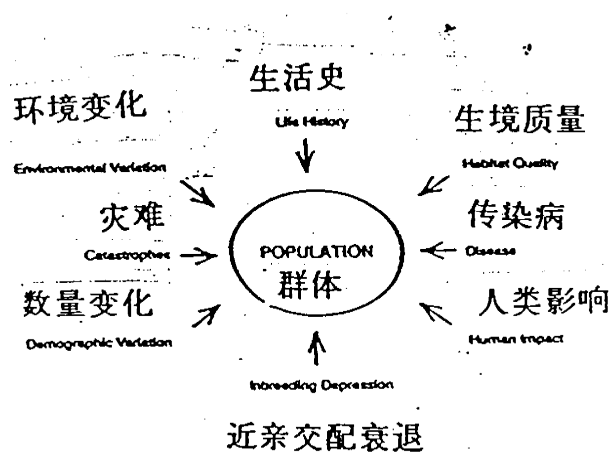
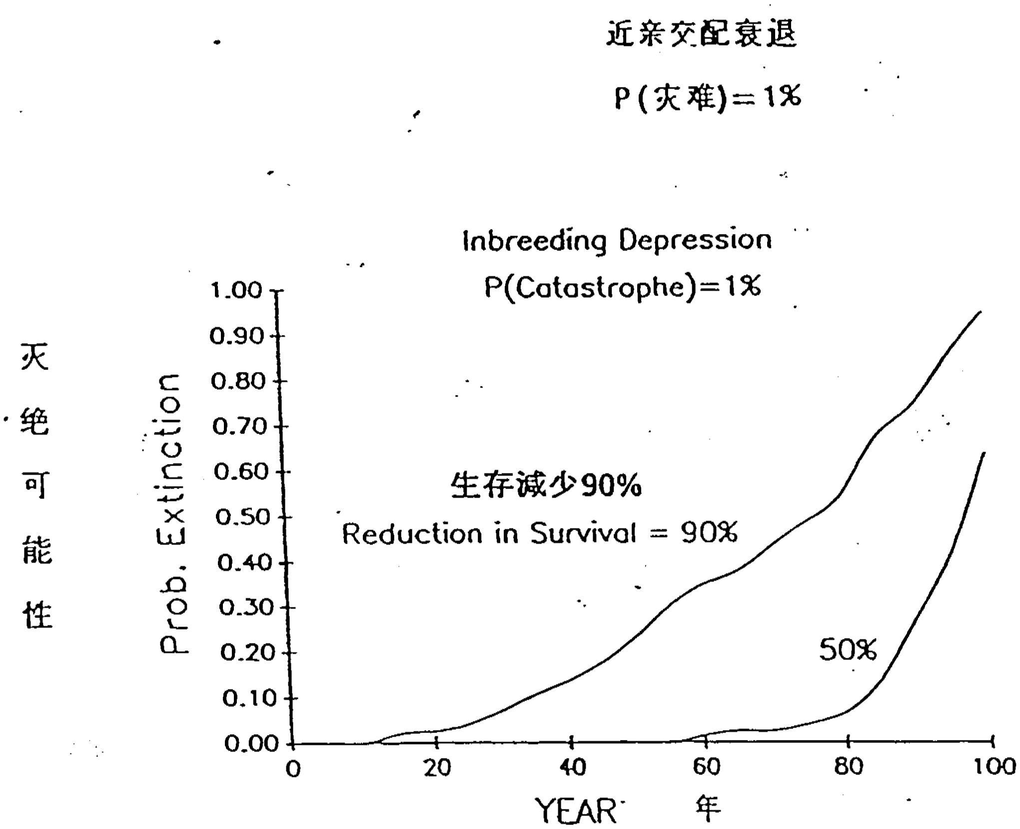


Figure 5. Population Viability Analyses (PVA) model the effects of different life-history, environmental and threat factors on the extinction and retention of genetic diversity in single populations.

图五。(Fig.5)「群体生存分析」模拟不同生活史，环境和威胁因素对一个群体的灭绝与保存基因多样性的影响。

这些模型使用生活史变数，外部因素以及潜在的威胁等来预见一个群体的前景，测量出随着时间的推移而保留住基因变异的程度，同时，如果发生灭绝现象(群体大小等于零)，也能够把灭绝的时间记录下来。模拟要重复进行，有的时候，重复几千次;这样才能够估计出和模拟结果有关系的各种数据的变数的作用。得出任取的一段时间的灭绝可能性所使用的方法，是取群体灭绝模拟的次数，然后再除以模拟总次数。(图六)。用以记录保留的基因变异水平的形式，是群体在特定点的原始异型结合的百分比，以及保留的原始等位基因的数量。



图六。(Fig.6.)漩窝「群体生存分析」模型得出的假想群体灭绝例子。本模型中有近亲交配的负作用以及1%的灾难可能性。随着时间的转移而灭绝的可能性，根据灾难严重的程度而有两种水平，即生存减少90%和50%。

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.

目前已经发展出来不少「群体生存分析」模型。国际保护自然资源和生物资源联合会(IUCN)的人工饲养专家小组(Captive Breeding Specialist Group)所使用的，是漩窝模型，是芝加哥动物

协会的罗伯特·莱希搞出来的，广泛用于发展不少物种的保护措施，其中有黑足貂，佛罗里达豹，波哥亚马孙鹦鹉，爪哇犀牛和四种不同的狮猴。

模型的真正价值不在于同时研究群体所有变数的影响。这许多因素相互之间的作用，过于复杂，不适合于以许多而不是几种考虑为出发点去研究群体预测的结果。在一定时间内只研究一，两个因素的时候，对于群体动态的了解，会更透彻，尤其是在选择了那些我们认为对群体有影响的因素，而放弃那些没有影响的因素的时候。

模型在发展保护策略时候的基本用途是可以把模型用于进行「万一」分析。举例来说，如果有了流行性传染病，野外群体生存的可能性，万一减少，这对群体的灭绝和对基因多样性的保存，会有什么影响呢?这种「万一」分析，也可以用于评价管理方面推荐的方案。举例来说，如果动物保护区的容纳量增加了百分之十，群体灭绝方面的可能变化，又是什么呢?

然而，模型并没有研究所有促成灭绝的潜在因素，因而往往低估了一个群体灭绝的可能性。有必要强调「群体生存分析」的目的，不是确切评估出灭绝的可能性，而在于辨认出考虑中的许多因素的相对重要性，同时也在于评估出，一系列管理方面的建议对于群体生存的影响。

「群体生存分析」对于管理目标的作用

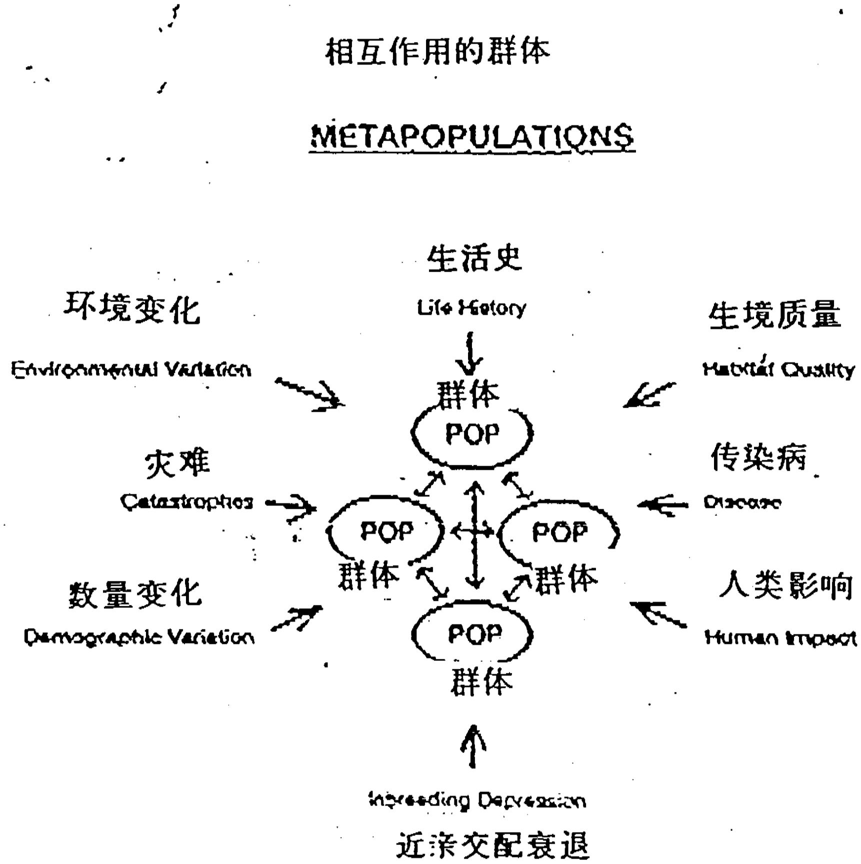
群体灭绝和基因多样性损失的概念，不是基于肯定，而是基于可能。「群体生存分析」模型提供的结果，能够使我们在对一个群体从现状和生物学的角度做出一些假设以后，了解到一些情况，不过，其结果是，我们在预测，或者是保证群体今后情况的时候，没有绝对的把握。

在我们试图发展保护计划来减少群体灭绝危险的时候，这样说，有其强烈含义。我们必须能够认识到，我们并不可能制定出和执行能够保证群体生存下去的建议方案，而只能够制定出和执行在一定期间内减少群体灭绝可能性的建议方案。

一个普通办法是发展出一些管理策略，以便使群体有百分之九十五的机会来生存一百年，并在同一期间，保存其基因变异的百分之九十。(谢福，一九八七年著;苏莱等一九八六年著)。这样就可以保证有极大的生存可能性，同时，也可以使群体在环境变化时保留住其基因方面的适应力的大部分，因而也可以演变。通过这种办法来实现这样的管理目标，就要有最低限度生存能力的群体(MVP).要全面评估管理策略，就必须对管理有确定的程度和时间构架，这些都必须具体化。

相互作用的群体

到目前为止所讨论的问题都涉及一个群体的灭绝和基因动态，然而，管理人员面对的问题常常牵涉到分布在几个相互作用的群体中的物种。这种情况，再加上动物在群体之间移动频繁(迁移)，多到一个群体的动态(灭绝或者是基因)可以影响到附近群体的动态的程度，我们就称这一组群体为相互作用的群体(图七)。在发展保护策略过程中，了解相互作用的群体的动态，有越来越大的重要性。



图七(Fig.7)群体中的所谓「片」"patch"的相互作用，形成相互作用的群体结构。保护策略必须要考虑到「片」的分布情况，也要考虑到，这对于「片」与「片」在灭绝方面的相互关系，以及群体在再恢复方面的相互关系。

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.

相互作用的群体的管理焦点在于群体的分布情况，以及这对于整个系统在基因和数量动态方面的影响。相互作用的群体可以视为群体(即「片」)的组合)，而这些「片」在大小和彼此之间的距离上，均有所不同，其中有一些「片」定期灭绝，要由其他「片」移殖过来的个体重新给予生机。在保护问题上，要考虑到的最重要的一点是单个「片」的灭绝率，以及「片」与「片」之间的移殖率。(吉尔平著，一九八七年)。

正如上面所讨论到的那样，任何一个「片」的灭绝动态都会受到许多因素的影响，其中包括群体的大小，以及在群体中的个体减少以后，群体的复元率等。从相互作用的群体的角度来看，在「片」与「片」的灭绝率彼此没有关系的时候，也就是任何一个「片」的灭绝同另外一个「片」没有关系的时候，这时候的水平是最简单的。环境的变迁和灾难的发生能够增加「片」之间的灭绝关系，而这又会引起整个相互作用的群体灭绝的可能姓。正是因为会有这种情况，所以，在发展保护策略的时候，一个重要的组成部分是考虑「片」与「片」之间的距离，以及不同的「片」，在环境发生变化和发生灾难的情况下，在反应上，会有什么样的相似之处。

但是，从另外一方面来说，「片」与「片」之间距离越近，一个「片」在灭绝以后的再恢复率越高，因为会有邻近「片」的个体加入这个「片」。

「片」的灭绝和再恢复对于相互作用的群体保住基因多样性也有关系。孤立的，支离破碎的小群体很快就会失去基因的多样性。然而，在「片」与「片」之间如果有迁移，「片」与「片」的基因流动会加强，而相互作用的群体的有效大小也会显著加大。可是，在群体灭绝之后的再恢复情况再三涉及到十分有限的几个个体的时候(一对，或者是一个可以生育的雌性)，则这个群体的基因没有变异，因为建立者的作用是循环发生的。

群体再恢复有利方面的相互作用，以及相互有关系的「片」灭绝的负作用，使我们对于相互作用的群体在基因与数量方面的了解复杂化了。遗憾的是，能够把上面提到的单一群体灭绝同基因考虑这两方面的因素与相互作用的群体方面的理论结合起来的计算机模型，还没有发展出来，目前还不能够用于发展管理策略。

尽管这样，管理人员应当认识到，相互作用的群体有其复杂性。从长远角度看问题，一般来说，分布在几个地点的群体比仅仅留在一个地点的一个群体更牢靠一些，尤其是在「片」与「片」之间有基因流动(不论这是自然发生的，还是通过管理而发生的)，而不同的「片」又不

会受到同一种灾难的威胁的情况下。在许多情况下，饲养的群体可以是牢靠的群体，可以用饲养群体作为其他「片」的再恢复的源泉和多样化基因库，方法是把饲养群体引入其他群体。

野生和饲养小群体的相互管理作用

傅斯

前言

濒危物种的保护策略必须基于有生存能力的群体。保护现场的濒危物种固然需要，然而却还远远不够，因而也必须管理起来。

必须管理的原因是，在生境恶化与非持久性开发的情况下，能够长期维持下去的群体，从物种方面来说，并不多，也就是说，可能是几十，或者几百，(在某些情况下，也可能有几千)。这取决于是什么物种。在这种情况下，这些群体受到许多环境，数量和基因问题的威胁，而这些威胁都是随时可能发生的，引致灭绝。

小的群体可以在一场灾难(天气方面的灾难，疾病的流行，以至于开发)发生以后受到严重损失，如黑足貂，波哥亚马孙鹦鹉。波动并不十分严重的环境变化，也可以使小群体中的个体数量减少。从数量上来说，小群体可以受到生存和繁殖的偶然波动的干扰，而从基因上来说，会失去健康存在和适应变化所需要的基因多样性。

有最低限度生存能力的群体

在谈到所有这些问题的时候，可以说，群体越小，而个体数量少的时间拖的越长，危险性也就越大，灭绝的可能性增加。其结果是，为数量上少，而有可能长期无法增加个体数量的物种制定保护策略的时候，其基础必须是能够长期维持住一个有最低限度生存能力的群体(即MVP)，也就是说，要有一个尽管遇到基因，数量和环境问题，然而其大小却足以使其能够长期坚持下去的群体。

有最低限度生存能力的群体的大小，不能够用一个万能数字来概括所有的物种，更不能够在一切时间都内适用于一个物种。有最低限度生存能力的群体取决于一个方案要实现的基因和数量目标，以及引起关注的群体或者是分类群的生物学特征。另外，在确定有最低限度生存能力的群体的时候，还有一个复杂考虑，这就是当前的基因因素和数量因素需要分别考虑，尽管这两个因素相互作用着。再者，评估有关群体大小的科学模型尚在发展中，尽管是在快速发展着。虽然有这些问题，然而科学分析所要考虑的，既有一个方案的基因和数量目标，也有一个群体的生物学特点，因而有可能提示出，群体究竟应该有多大的各种幅度，才足以应付随时发生的问题，同时还可以有一定的保障。

对于有最低限度生存能力的群体有重要意义的基因和数量目标

希望群体能够达到的生存可能性的百分比(也就是50%或者是90%);

保存下来的基因多样性的百分比(90%，95%等等);

维持数量安全和基因多样性的时间长短(五十年，二百年等等)。

就数量同基因问题而言，可能希望有95%的生存可能性，并维持二百年。现在已经出现一些模型，预测不同大小的群体遭到上述威胁的时候可以维持多长时间。或者，就基因问题而言，也许希望在二百年间保持住平均异型结合的95%。在这方面也已经有模型。但是，要认识到，生存能力，恢复，自体持久性和持久力，只有在制定出众多的基因和数量目标以后才能够确定，其中还要有实施的方案持续进行的时间和预期一个群体存留的时间。

对于有最低限度生存能力的群体有重要意义的生物学特点。

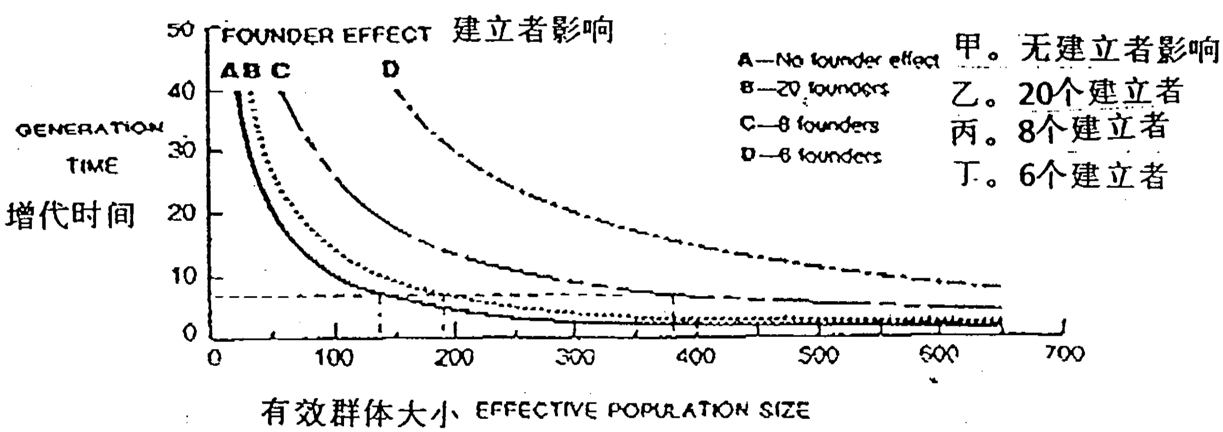
增代时间。基因多样性是一代代，而不是一年年损失的。因此，在同一个方案的特定时间内，繁殖期长的物种丧失基因多样性的机会要少一些。结果是，为了实现同一种基因目标，就繁殖期长的物种来说，有最低限度生存能力的群体就可以小一点。所谓增代时间，也就是，从质上来讲，是动物繁殖后代的平均年龄，而从量上来讲，是群体中，特定年龄的生存和能育性功能。这些可以自然发生变化，也可以通过管理来改变，也就是延长增代时间。

建立者的数量。所谓建立者，是来自于群体源(例如野生群)的一个动物，由它衍生出来一个群体，比如说，经过人工饲养而移殖到另外一个新地点，再不然，就是在强化管理方案最初执行的时候的个体。为了能够发挥作用，一个建立者必须有能力繁殖后代，同时在现存的群体中有其后代。从技术上来说，一个动物，要想成为一个全面的建立者，应当同群体源中的其他代表没有关系，同时也并非是近亲交配出来的。

基本上，建立者越多越好，也就是说，基因库的这个取样的代表性要强，同时，为基因目标而需要的有最低限度生存能力的群体要小。这里还有建立者数量影响的问题:建立者数量越多，数量随机情况引起的灭绝的可能性越小。但是，对于大的脊椎动物来说，到了某一点，就会有收获减少的现象(图八。)，起码就基因而言，有这种现象。由此说来，在建立一个群体的时候，一般都要有二十到三十个有效的建立者。如果满足不了这种要求，也就只好有多少算多少了。如果在阿拉斯加的冻土地带发现有一只怀胎的雌性猛犸象，自然值得为这个物种设法发展出一个恢复方案，而不去考虑成功率低的问题。不过，一个方案如果坚持要有最适合的条件，这确实会提高成功率。

把原始基因多样性的百分之九十保留二百年

PRESERVATION OF 90% OF ORIGINAL GENETIC DIVERSITY FOR 200 YEARS



图八(Fig.8)建立者数量，物种增代时间和把原始基因多样性的百分之九十保留二百年所需要的群体有效大小。

Figure 8. 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.

有效群体的大小。另外还有一个十分重要的考虑。这就是有效群体的大小，用Ne来代表。Ne与种群普查大小N不相同。Ne用以计量群体成员相互交配，以便把基因传给下一代的情况，通常小于N。以灰熊为例，Ne/N比例估计大约为0.25。(哈里斯与阿伦多夫合著，一九八九年)。其结果是，如果基因模型要求Ne为五百，才能够实现一套基因目标，有最低限度生存能力的群体有可能要多达两千。

生长率。生长率越高，群体由小恢复到大的速度越快，数量增加的结果可以减少数量上的危险，同时，也可以使所谓瓶颈效应时候损失的基因多样性，在量的方面减少。重要的一点是，要把有最低限度生存能力的群体同瓶颈大小区分开。

「群体生存分析」

由于考虑到许多因素，也就是有一系列目标和特点，而得出有最低限度生存能力的群体大小的过程，称之为「群体生存分析」，又称群体易受伤害分析。要想通过「群体生存分析」得出可以应用的结果，则需要有群体生物学家，管理人员和科研工作者相互作用的一个过程。「群体生存分析」已经应用于不少物种(即派克与使密斯合著，一九八八年;希尔等合著，一九八九年;巴卢等合著，一九八九年;莱希等合著，一九八九年;莱希与克拉克合著，付印)。

正如前边提到的，「群体生存分析」模型对基因和数量往往分别进行估计。基因模型显示，要想把基因库十分高的百分比维持几个世纪的话，则需要有几百个，乃至几千个群体。近来出现的一些模型已经可以同时对数量，环境的不稳定和基因的不稳定进行考虑。

对付数量和环境的随机性的最低限度生存能力的群体数量可能要高于保存住基因多样性的有最低限度生存能力的群体，尤其是希望在相当长的一段时间里有相当高的存活率的话。举例来说，百分之九十五的生存率有可能实际上需要有一个大群体，而且，这个群体所要持续维持的时间，可能会比要求有百分之五十生存可能性的群体持续的时间，大上二十倍;百分之九十生存率的时候，则只大十倍。从另外一种前景的角度来看，可以预期，在计算出来的等分时间来到之前，实际群体有百分之五十以上，有可能早已灭绝了。

大一些的脊椎动物物种的群体大小，几乎可以肯定需要有几百，乃至数千头，才有可能生存下去。就随机问题而言，多总比少好。

相互作用的群体和区域的最低限度

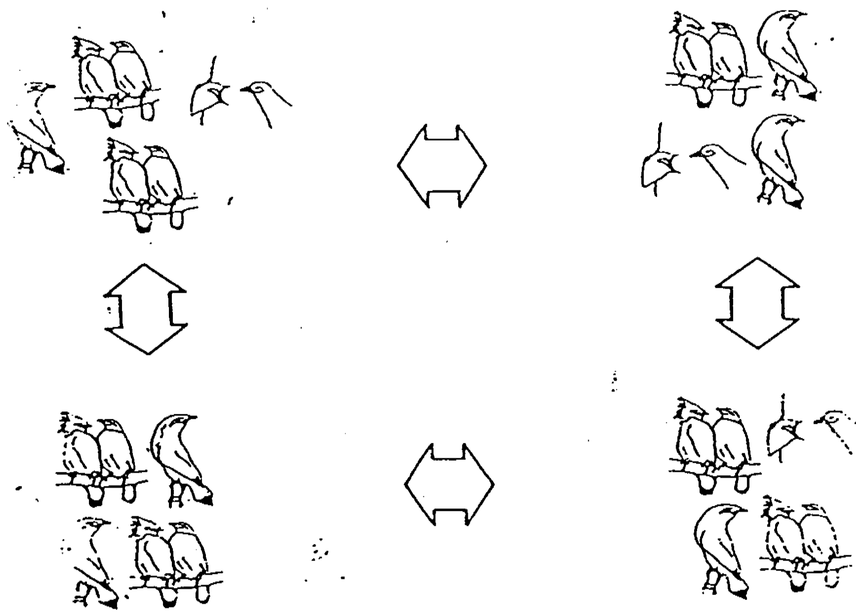
有最低限度生存能力的群体暗示，最低限度的，有关键意义的自然栖息地有可能难以，或者完全没有可能养活生存下去所需要的单一的，有连续性的群体中的数千个个体。

但是，如果把小一点的群体和保护地当做一个单一的，较大的群体(即相互作用的群体)来管理，而这些群体和保护地加起来等于一个有最低限度生存能力的群体(图九)，则小一点的群体也有可能生存下去，而小一点的保护地也会有养活群体的能力。实际上，把动物分到许多「亚群」之内，也有可能增加群体的有效大小，足以提高群体经受随机问题的能力。任何一个「亚群」都有可能因为发生这方面问题而灭绝，或者是几乎灭绝，然而通过其他「亚群」的再恢复，或者是补充，一个相互作用的群体就可以生存下去了。在自然界中，经常看到这种相互作用的群体，这种群体有其地方特色，也常常发生「亚群」的再恢复。

遗憾的是，野生群体支离破碎以后，再恢复所需要的迁移现象，有可能不会发生。因此，管理相互作用的群体的时候，要使动物移动，以纠正基因和数量方面发生的问题。(图十。)如此，在管理迁移的过程中，重要的一点是必须注意到迁移个体在基因和数量方面的情况。

相互作用的群体

METAPOPULATION



图九(Fig.9)以许多「亚群」做为基础来管理相互作用的群体，以便使一个物种在野外可以生存下去。

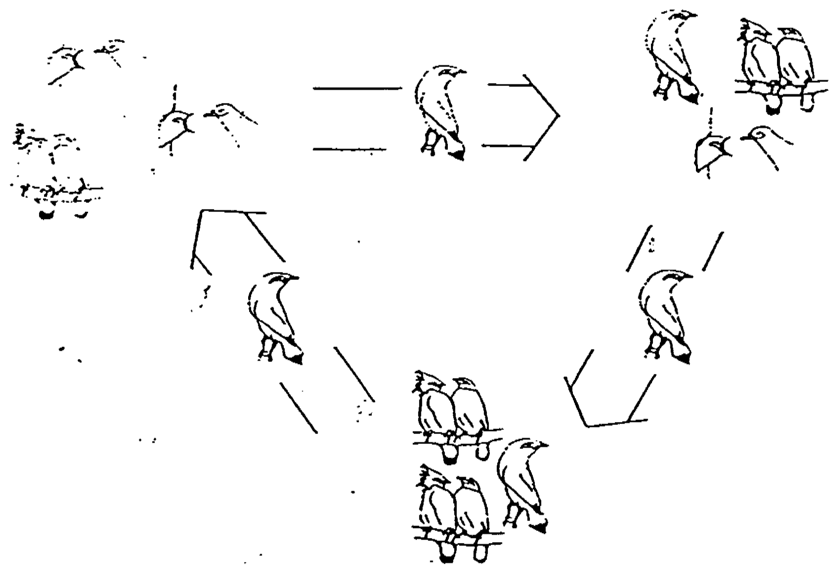
Figure 9. Multiple subpopulations as a basis for management of a metapopulation for survival of a species in the wild.

有管理的迁移仅仅是许多种加强管理和保护办法当中的一个。这些办法是保持群体在自然界生存下去所必须的和可取的。有最低限度生存能力的群体，从严格方面来讲，实际上暗示，这是一种善意的忽略。对于某一套要实现的目标来说，可以缩小有最低限度生存能力的群体的大小，再不然，如果是从另外一个角度来考虑问题，也可以延长特定大小的群体的持久时间，不过，在这种情况下，基因和数量问题，一经发生，马上就要通过管理上的介入而加以纠正。实质上，在这些措施当中，有 许多都有助于增加实际维持住的动物数量的Ne.

就狼而言，这种动物已经受到管理介入。野生个体为数有限，由于受到人的打扰，要保护有生存能力的狼群体，十分困难，尤其是在人类发展已经使狼的潜在栖息地支离破碎的情况下，因

此计划把饲养的狼放回到大自然去。这种介入证明，在自然保护地和在这些地方生活的群体缩小的情况下，这些地方以及群体实际上是在变化成为一个特大动物园，因此，在基因和数量集中管理的问题上，要和管理饲养的群体一样。

对巴里灰掠鸟群体的迁移管理



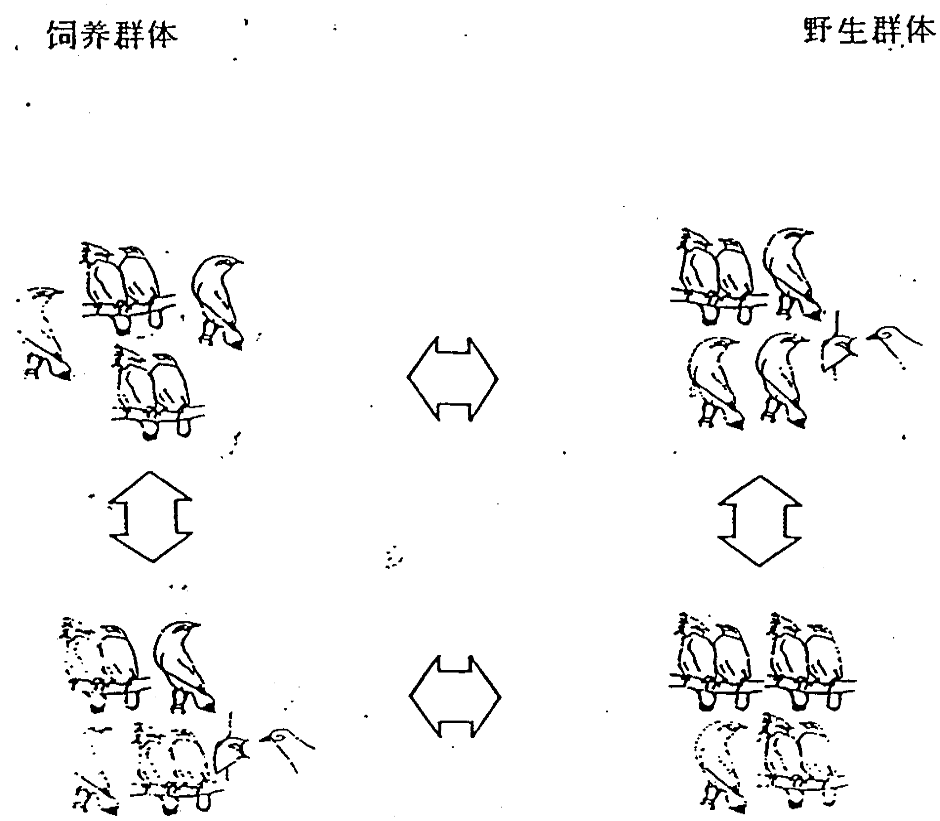
图十(Fig.10)管理亚群以维持相互作用的群体的基因流。

Figure 10. Managed migration among subpopulations to sustain gene flow in a metapopulation.

人工繁殖

增加物种生存能力的另外一种办法是用人工繁殖方法来增强野生群体。具体来说，人工繁殖有许多优点，其中有免受无法持久的开发利用，也就是没有偷猎问题；还有可以至少为群体的一部分缓解环境变化的影响；加强基因管理，从而增进对基因库的保护；加速群体向所需要的有最低限度生存能力的群体过渡的速度；可以加速把动物引入到新的地区，以及增加所要维持的动物的数量。

不过，这里要强调的一点是，人工繁殖的目的是强化而不是取代野外生存的群体。饲养的群体和动物园的作用必须是基因库和数量库的作用，定期向自然生境输送新的血液，以便重建灭绝的群体，或者是给因基因和数量问题而虚弱的群体以生机。



图十一。(Fig.11)利用饲养群体作为相互作用的群体的一个组成部分来扩大和保护一个物种的基因库。

Figure 11. The use of captive populations as part of a metapopulation to expand and protect the gene pool of a species.

大批濒危物种的生存会要依赖饲养群体的帮助，而且数量会越来越大。看来，理想的情况，同时又是不可避免的情况是，为物种制定保护策略的时候，要把野生及饲养群体结合进去，而这两种群体都处于相互作用的管理之下，以便能够彼此支援，都能够生存下去。(图十一)。饲养群体可以是对基因与数量材料具有关键性的一个库。野生群体，如果够大的话，可以使物种继

续受自然淘汰。国际保护自然与自然资源联合会已经采纳了这种总体战略。联合会目前建议，一个分类群，在数量上减少到一千以下，都要采取人工饲养办法。(国际保护自然与自然资源联合会，一九八八年)

物种生存计划

实际上有许多地区的动物园都在制定科学管理及高度协调着的项目来进行人工饲养，以补充野生群体。在北美地区，在美国动物园和水族馆协会(AAZPA)主持下，已经开展了这方面的努力，由国际保护自然与自然资源联合会的物种生存委员会的人工繁殖专家组配合工作(IUCN SSC CBSG)，称之为物种生存计划。(SSP)

饲养群体可以发挥帮助作用，然而前提是饲养群体的基础必须是有生存能力的群体。这也就是说，需要有尽可能多的建立者，尽快把群体正常发展到有几百个个体，同时，在基因和数量上，十分注意管理。这就是物种生存总计划的目的。也可以利用饲养项目来进行科学研究工作，以利管理饲养和野生群体，并使二者之间有相互作用。

饲养/野生策略的一个典型例子是美国鱼和野生生物管理局恢复计划/物种生存总计划共同搞的红狼项目。饲养的红狼大部分都是在华盛顿州的一个特殊场所繁殖的，然而，现在，有越来越多的动物园为红狼人为创造了自然生境，特别是那些历来是野生红狼出没的地方。

另外的一个把饲养同野生群体结合管理的突出的保护与恢复策略是用在黑足貂上的策略。显然，这个物种目前只有在饲养条件下才能够生存下去。由于建立饲养群体的决定，迟迟没有做出，这个物种的处境已经危险到，把所有的黑足貂都饲养起来，看来才是唯一出路。加利福尼亚州秃鹰也是这样。如果早一点采取行动来建立饲养群体，或许还可以有另外的选择办法。在波哥亚马孙鹦鹉和普通的鸽子的问题上，就有另外的选择办法。考虑到生存规律已经显示，黑足貂幼仔死亡率高，这暗示，在野外会死亡的那些幼仔从群体中移出以后，对群体不会有影响，或者只稍微有一点影响。对于许多动物和鸟类来说，情况都是这样。美国动物园和水族馆协会以及国际保护自然与自然资源联合会的物种生存委员会目前在世界各地都参加这种项目和策略。

「群体生存分析」

莱希

在仅剩下的一些自然区域，保护地，以及甚至在动物园里，一度十分大，有连续性和多样性的野生群体，现在都已经缩小到孤立的，支离破碎的小群体了。举例来说，黑犀牛过去有几十万，分布在非洲撒哈拉沙漠以南地区，如今，只有几千头生活在很少的几个公园和保护地上，每一个地区只能够养活几头，最多几百头。波哥亚马孙鹦鹉也是这样。这种鹦鹉是波多黎哥特有的，过去遍布整个岛屿，隻数也许不下一百万。到了一九七二年，仅剩下了二十隻(其中有四隻是饲养的)。大力下工夫的结果是这种鹦鹉稳健恢复，到了一九八八年年底，野生的，有三十四隻，而饲养的，有四十六隻。可是，在一九八九年，野生波哥亚马孙鹦鹉的生境和饲养群体所在的卢基约森林严重遭到飓风的破坏，看来，野生鹦鹉有一半遇难，它们筑巢的树木，大部分被毁掉，食物来源大量减少，因此，目前的野生群体是否有生存能力，值得怀疑。

群体变小，同时又与同类的其他群体隔绝的时候，这个群体则面对着许多不利于生存的基因和数量问题，尤其是偶然性问题，例如传染病的发生和发生的时间，所繁殖的后代的性别比例有偶然性的波动等，即使是孟德尔基因传递的偶然性，这时也可能比其他问题，例如群体是否有够大的栖息地，是否已经完全适应于这种生境，以及平均出生率大于中间死亡率等更重要。一个群体变小，陷于孤立的时候，基因和数量程序就会相互发生作用，形成令人情绪颓丧的，然而取名妥当的灭绝漩窝。近交衰退引起的基因问题以及对生境不适应的问题会使小群体变得更小，使寻找配偶和繁殖后代的不稳定性进一步加剧，结果是数量再减少，近亲交配现象增加，基因多样性减少。这样，群体就会加速走向灭亡。群体的大小若小于有可能使其被卷入灭绝漩窝的时候，，则把这种群体的大小称之为有最低限度生存能力的群体。

一个群体的最终灭绝通常是概论的，可能是遭到一，两年坏运气的后果，尽管最初的衰落是捕猎过渡和栖息地被破坏。近来发展的一些技术允许我们系统研究使小型孤立的群体受到威胁的数量和基因程序。把分析技术同模拟技术结合在一起以后，可以估计出一个群体生存到将来某一个时间的可能性。这个程序称之为「群体生存分析」(苏莱著，一九八七年)。如今，我们仍

然没有能够把所有的因素都输入分析与模拟模型(而同时也不了解我们所忽略的因素究竟有多重要，「群体生存分析」的结果，几乎可以肯定说是低估了群体灭绝的真正可能性。

「群体生存分析」的真正价值不在于粗略估计灭绝的可能性，而在于辨认清楚使群体受到威胁的各种因素的重要性，同时评估出，各种有可能采取的管理行动的价值(就提高群体坚持下去的可能性。公认为濒危物种中有少数物种已经恢复到足以不再被列为濒危物种;然而，也有一些，尽管受到保护，进行了恢复群体的努力，然而仍旧灭绝。这说明小群体受到的威胁的严重程度，同时也说明，有必要有一种更集中的，更系统化的恢复计划，动用一切可以利用的人力资源，分析资源，生物学资源以及经济资源。

支离破碎小群体的基因程序

在一个繁殖群体的数量为几十，或者是几百(而不是几千，或者更多)的时候，偶然事件会对基因和演变情况起主导作用。在没有选择的情况下，每一代都是上一代的偶然基因样品。在这种样品小的情况之下，基因变异(等位基因)的频数，由于偶然性机会，可以使下一代与上一代明显不同，一个群体也可能完全丧失变异。这个过程就叫做基因漂变。基因漂变是累积性的。等位基因频数没有恢复到原来状态的趋势(然而偶然也有这种可能性)，因此，一个变异祇要失去，便不可能复得，除非是通过突变，或者是从其他群体的迁移而重新引进。突变十分少见(不论对什么基因来说，都是百万分之一的机会)，以至于在小群体中，在人们所关注的时间范围内，基本上，无足轻重(莱希著，一九八七年)。通过迁移而恢复的变异，也只有在有其他群体，而这些群体又有可能作为基因材料来源的时候才有可能发生。

基因漂变(遗传漂变)，由于是随机过程，同样，也是非适应性质的。在少于一百个繁殖个体的群体中间，漂变可以淹没最强选择以外的一切影响:适应性质的等位基因可以因为漂变而丧失，结果群体中留下了有害的基因方差(也就是基因缺陷)。举例来说，佛罗里达豹有可能是群体中间一个十分有害的基因，从偶然性转变成为普遍性而造成的结果;尾巴上有一个结，恐怕是佛罗里达豹一个不十分有害的(至多是中性的)，然而却几乎已经完全固定下来的一个特征了。

在小群体中，基因漂变伴随着近亲交配而出现。这就是有基因关系的个体的相互交配。当交配的个体少的时候，近亲交配在所难免，成为普遍现象。近亲交配的动物有先天性缺陷的比率高，生长缓慢，死亡率大，生殖力低(近交衰退)。关于实验室使用的动物，家畜，(福尔克纳著，一九八一年)动物园饲养的动物(罗尔斯等著，一九七九年，罗尔斯，巴卢合著，一九八三年，以及罗尔斯等著，一九八八年)以及一些野生群体的近交衰退情况，已经有大量文献了。佛罗里达群岛鹿的幼鹿多半是雄性的，也有可能是近亲交配的结果，很少有一胎两仔，也可能是这原因。

近交衰退基本上可能是稀有的有害等位基因造成的，是稀有的有害等位基因的表现形式。许多群体都有一部分隐性有害等位基因(也就是群体的基因负担)。这种基因的影响往往是掩盖起来的，因为在任选的一个有繁殖力的群体中，总会有几个个体接受一个有害等位基因的两个相同的遗传基因。由于亲体在血缘上有关系，共有一些基因，因此，近因交配的动物有稀有等位基因的可能性就大一些，有同型结合体现象。如果经过选择而有效去掉小群体中间的有害倾向，逐步繁殖的群体就会去掉基因负担，即使再近一步近亲交配，也不会有多大问题。在十分小的群体当中，偶然性的漂变比选择性要强的多，因此，那些肯定是有害的倾向会普遍化(佛罗里达豹的隐结和群岛鹿多是一个性别的幼仔)，最终结果是使一个群体灭绝。

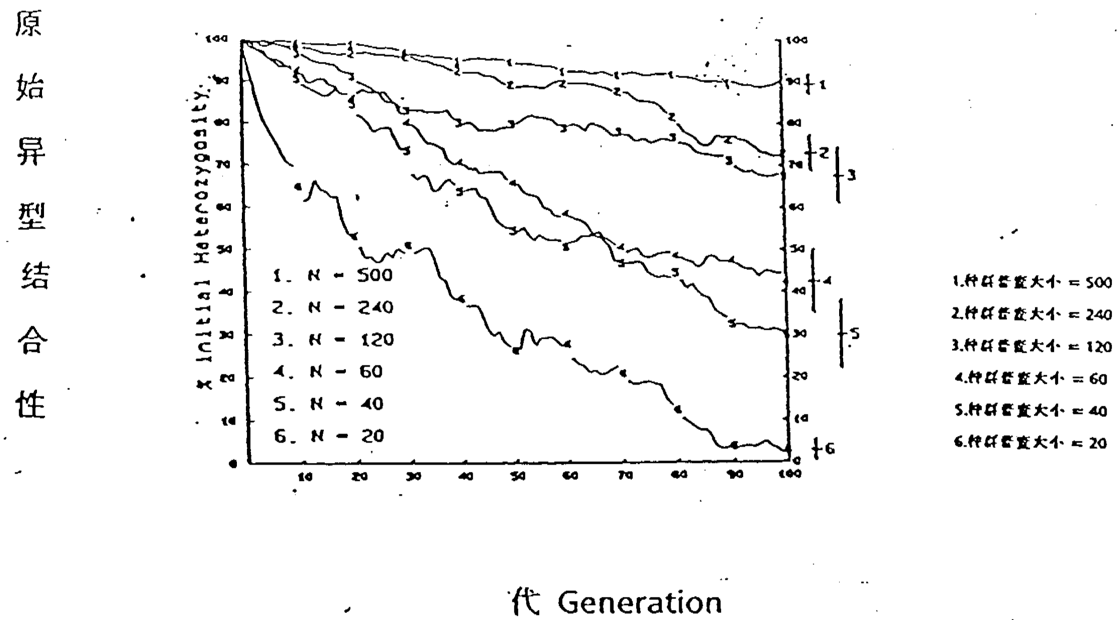
由于基因漂变而损失以基因方差形式出现的基因多样性，还有其他长期后果。一个群体越来越同一性质，就会越来越容易受到疾病，新的天敌，变化着的气候，以及其他环境变化的影响。当一切都是一样的时候，当适应能力不足的时候，即使是选择，也不能够再对适应力较强的群体发挥有利作用了。从某一种意义来说，每一种灭绝都是一个群体不能够对变化中的环境迅速适应的结果。

为了避免发生近亲交配的近期影响和基因变异的长期损失，一个群体必须是大群体，或者，至少要在一代，或者几代的时间内，渡过数量小的阶段(瓶颈)。波哥亚马孙鹦鹉增代时间长，所以目前的瓶颈，只存在于一，两代时间，希望能够在另外的一代时间结束之前，在进一步的基因衰退发生之前，能够摆脱这种情况。群岛鹿看来几千年一来都处在瓶颈当中，或许已经有两到三千代了。尽管我们还不能够预测，任何一个群体会损失什么基因变异(也就是基因漂变的性质)，然而我们却能够使预期的平均损失率具体化。图十二说明不同大小的任选繁殖群体的基因变异的中间数字。丧失基因变异的平均率(以异型结合性，数量倾向的加性变化，或者是等位基因频变的二项式方差来测量)可以因漂变而下降：

$$V_g(t)=V_g(o)x(1-1/(2Ne))^T$$

其中V_g是t代的基因方差，Ne是有效群体大小(如下)，或者大约是任选的一个繁殖群体中有繁殖力的个体的数量。图十三说明基因损失方差在不同群体有很大差异;有一些群体有可能(偶然机会)高于，或者低于图十二的平均数。在我们所关注的群体当中，可以接受的基因变异损失率取决于群体健康同基因变异的关系，健康水平下降的程度是否可以接受，以及人类对于保护野生群体的自然变异所寄于的价值等。就近期而言，已经观察出，基因变异(异型结合)减少百分之一，---这相当于近亲交配变异悉数百分之一的增长---使健康的某一些方面(生殖力和生存力)下降百分之一到二。这是在一些不同的群体中观察到的(福尔克纳著，一九八一年)。通常，饲养家畜的人可以接受每一代低于百分之一的近亲交配，认为这不会引起严重退化。在不同物种和一个物种的不同群体中，健康同近亲交配的关系，十分不同，有一些近亲交配程度很大的群体，不但能够生存，而且繁殖也很好(如海象，欧洲野牛和四不像)，而对其他许多群体的近亲交配努力，却使近亲交配的个体大部分，或者全部死亡(福尔克纳著，一九八一年)。
丧失基因适应性引起的关注又引出了这样一个建议，那就是对于濒危分类群的管理计划，必须争取做到保持原始群体的基因变异的百分之九十(福斯等著，一九八六年)。一个群体对于选择的适应性反应同选择出来的特性的基因变异成比例，因此，争取保留住百分之九十，就可以保住一个群体有原始群体百分之九十的适应能力。这样，就一百年期限来说，一个中等大小，增代时间为五年的脊椎动物，每一代的基因变异损失平均是百分之零点五，换言之，任选的一个群体要大约有一百个有繁殖能力的个体。

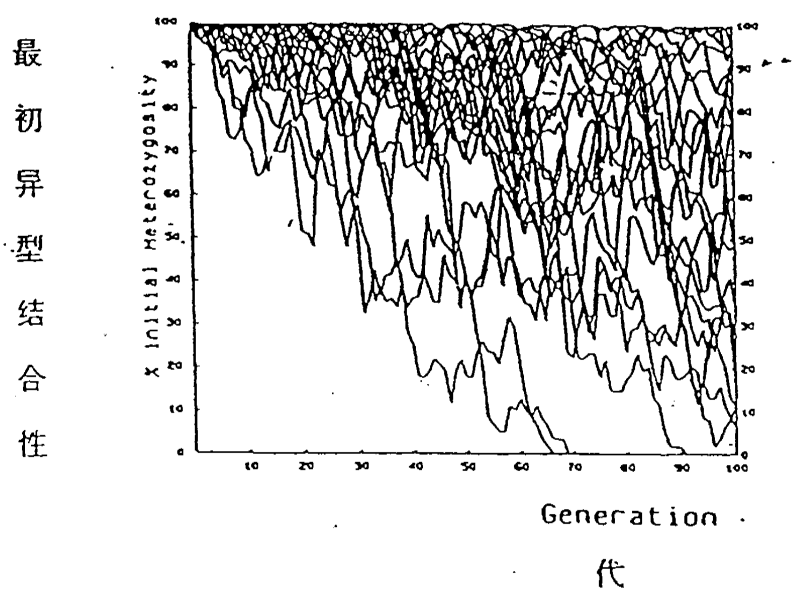
群体大小相比较



图十二(Fig. 12).基因漂变引起的基因变异平均损失(以异型结合，或者是基因变异加性来测量)。这是二十五个计算机模型模拟出有二十，五十，一百，二百五十和五百个任选的繁殖个体的群体情况。此图取自莱希所著，一九八七年。

Figure 12. 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.

基因漂变 ----- 过程中的变化



图十三(Fig.13).有任选的一百二十个繁殖个体的二十五个群体在基因位点上的异型结合损失情况，由计算机模拟出。莱希所著，一九八七年

Figure 13. The losses of heterozygosity at a genetic locus in 25 populations of 120 randomly breeding individuals, simulated by computer. Figure from Lacy 1987a.

大部分群体，不论是自然的，重新引进的，还是饲养的，都是由少数个体建立的，一般都比最终的遗传载体数量要少的多。在「瓶颈效应」(建立者影响)最初发生的时候，基因漂变速度可以特别快。群体小的时候就是这样。为了最大限度减少建立者影响造成的基因损失，管理下的群体，最初要有二十到三十个建立者，同时群体要尽可能扩大，达到最终的遗传载体量。(福斯等著，一九八六年，以及莱希所著，一九八八年及一九八九年)。一个最初的群体，有了二十个有繁殖能力的建立者以后，这个群体大约就可以有建立者来自的群体源的百分之九十七点五的基因变异。随着群体中个体的增加，每一代有百分之二点五的损失率，还可以降低。在建立者「瓶颈效应」发生的时候，基因变异损失十分快，因此，一个管理下的群体的最终的遗传载体数量有可能要比上边所说的一百个有繁殖能力的个体还要多得多，才可能使基因损失总数维持在百分之九十以下(或者是订出的其他指标)。

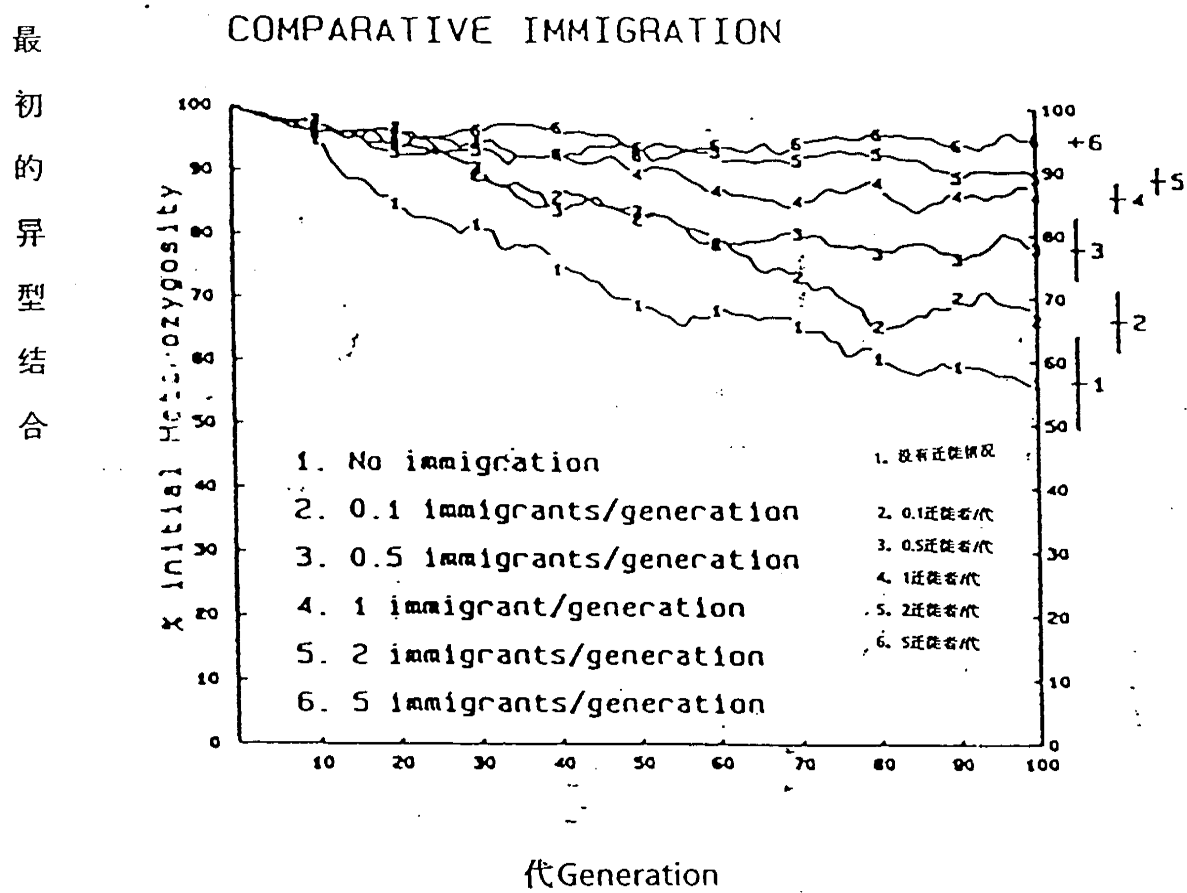
上述等式，图表以及计算结果的根据都是群体随机繁殖，然而，在自然群体中，如果有随机繁殖，那也十分罕见。所谓有效群体大小，指的是一个随机繁殖的群体的大小(这个群体的配子聚合是任意的)，而这个群体由于基因漂变而损失的基因变异率同所关注的那个群体完全一样。如果繁殖个体在性别比例上不平等的话，大于一生中的繁殖过程的随机变化时，或者是群体数量波动时，变异的损失率则会大于一个随机繁殖的群体，使群体的有效大小缩小。如果相关的变数可以衡量的话，那么，每一个因素对于Ne的影响，则可以用标準群体基因公式计算出来。(克劳同木村合著，一九七〇年，兰格同巴罗克拉夫合著，一九八七年)。对于许多脊椎动物来说，进入生殖年龄，转入生殖群体以后的那些个体，繁殖情况大体上是随机的，因此，初步概算的时候，可以把每一代中有繁殖能力的个体总数看成为群体的有效大小。在饲养的群体中(死亡率相对低，而数量稳定)，群体的有效大小往往是普查群体大小的二分之一，或者是四分之一。在野生群体中，(在这种群体中，许多动物在没有到达繁殖年龄之前就会死去)Ne/N的比例，难得超出这个幅度，经常低于这个比例。

为了使中等大小的一个动物的基因损失减少到最低限度，群体的大小，可以按照上边提到的计算，使Ne等于一百，而N为二百到四百。一个群体的生活史特点，在建立者瓶颈效应发生时候预期的损失，管理计划在基因方面要实现的目标，以及管理期的长短，这些能够，而且也应该使我们可以取得并确定一个引起关注的饲养群体的一些较精确的估计数字。

尽管，任意一个小群体在一定的代数的时候都有可能灭绝，然而，群体不见得完全隔绝于同种。大部分物种的分布都可以用相互作用的群体来形容，也就是说，有许多半孤立状态的群

体，而每一个群体中都会有随机交配。群体分散可以放慢基因漂变引起的基因损失，也可以在群体缩小以后再变大，再者，还可以在当地群体灭绝的情况下，重新恢复生境中的这种物种。

比较迁徙情况

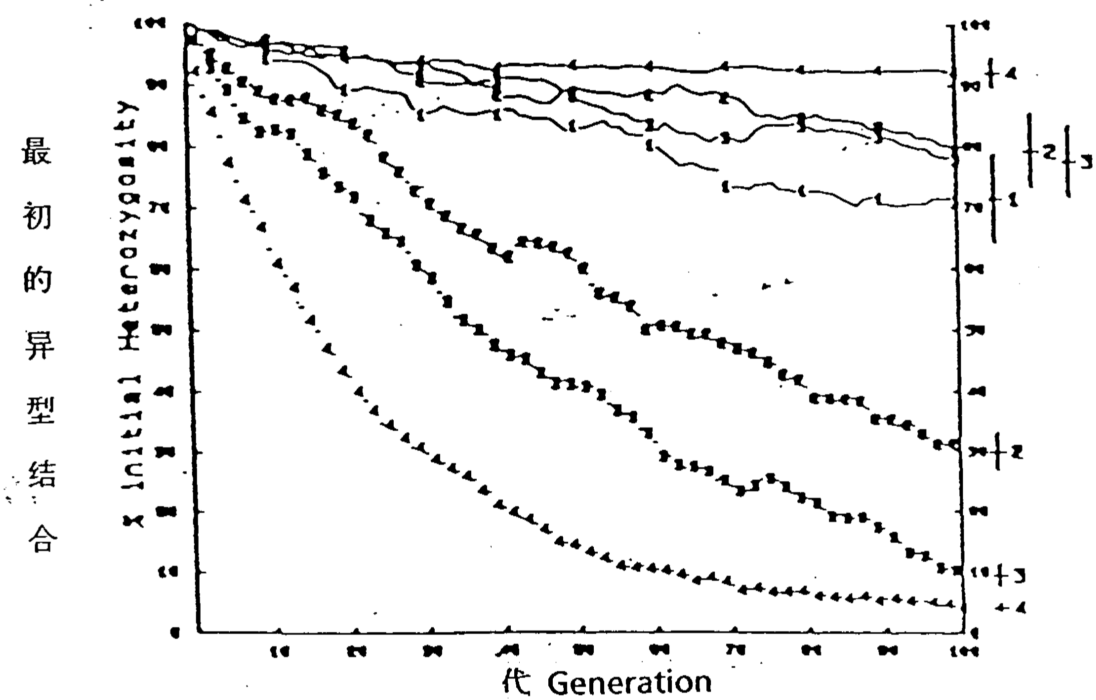


图十四。(Fig.14).大型群体源对于有一百二十个繁殖个体的群体所起的迁入作用。每一条线都代表二十五个计算机模拟的群体的中间异型结合情况(相当于一个群体中二十五个非联系着的基因位点的中间异型结合情况)。右边是标準误差线。取自莱希，一九八七年。

Figure 14. 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.

如果有一个十分大的群体，可以连续作为一个小的，孤立的群体的基因来源的话，那么，即使是偶然才发生迁徙一次(一代只有一个个体)，也可以避免使这个孤立的亚群损失相当数量的基因多样性(图十四)。通常的情况是，一个作为基因来源的群体的大小不足以防止基因漂变现象，而另外一个普遍现象是相互作用的群体被分割为许多小的，孤立的群体，而每一个都受随机力量的影响。每一个亚群内部都会损失基因多样性，然而，由于不同的变异是亚群偶然损失掉的，所以整个相互作用的群体还会保留住最初基因多样性的大部分。(图十五)。亚群中间，即使只有一点交流(每一代只有一个迁移者)，然而这也会使每一个亚群都能够保住基因的多样性。这是因为重新引进了基因漂变的时候损失掉的基因变异。(图十六)。即使迁移量十分小，然而这仍然也能够抵销基因漂变的影响，因此，一个小群体如果绝对孤立，则这会对这个群体的基因多样性有十分大的影响(同时，也会对群体的数量稳定有十分大的影响)。群体基因理论已经阐明，任何一个完全孤立的小群体都不可能长久存在下去。

绝对性的再划分

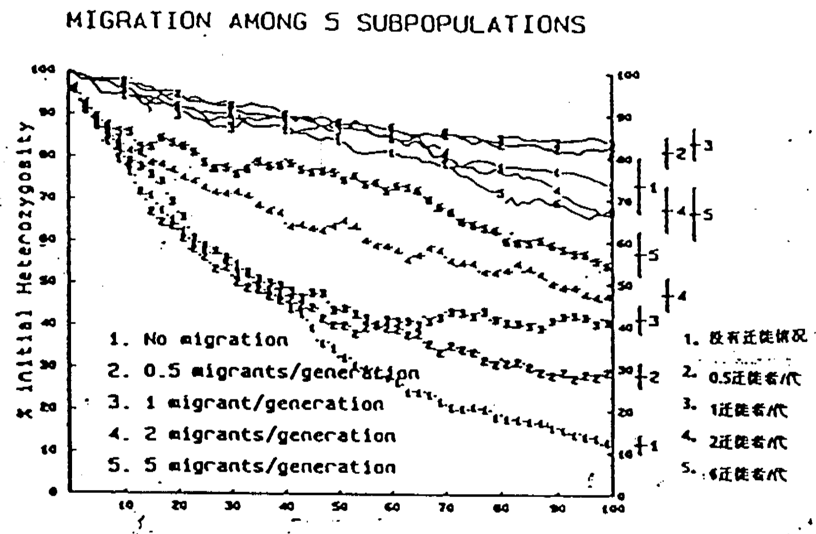


图十五。(Fig.15).把一个有一百二十个有繁殖能力的个体的群体分成为一个，三个，五个，或十个孤立的亚群造成的影响。虚线(数字)说明二十五个计算机模型模拟出来的亚群内的异型结合的中间数字。线代表模拟相互作用的群体中的全部基因多样性。取自莱西著，一九八七年。

Figure 15. 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.

五个亚群之间的迁移情况

最初的异型结合



代 Generation

图十六。(Fig.16)在有一百二十个有繁殖能力个体的群体当中，五个亚群相互迁移以后的影响。虚线(数字)表明二十五个计算机模型模拟出来亚群中间的异型结合的中间数字。线代表相互作用的群体的基因多样性总情况。取自莱希著，一九八七年。

Figure 16. 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.

参考著作

「基因漂变与等位基因损失同异型结合相比」，F.W.阿伦多夫著，一九八六年.动物园生物学5:181-190

「佛罗里达豹的群体生存分析」，向美国鱼和野生生物管理局提出的报告。J.D.巴卢，T.J.福斯，R.C莱希合著，一九八九年。美国明尼苏达州，艾波谷，国际保护自然和自然资源联合会物种生存委员会饲养专家组。

「数量，环境不稳定与螺鸢配偶遗弃情况」，S.R.贝辛格著，一九八六年。生境67:1445-1459

「群体基因理论入门」，J.F.克劳同M.三村合著，一九七〇年，纽约哈珀与罗出版社。

「数量基因入门」，D.S.福尔科纳著，一九八一年。纽约朗曼出版社，第二版。

「繁殖计划」，T.J.福斯，R.弗莱斯涅斯，N.R.拉勃同B.李德合著，一九八六年。动物园生物学5:139146

「小群体的演变」，I.R.福兰克林，一九八〇年，苏莱同威尔克斯序。保护生物学第135至150页。

「在管理下小群体中对于保护等位基因同基因异型结合的考虑」，P.A.福尔斯特与T.丸山合著；一九八六年，动物园生物学5:171-180

[空间结构和群体易受伤害性」，M.E.吉尔平，一九八七年。有生存能力的群体的保护，麻萨诸塞州，坎布里奇，坎布里奇出版社，第125至139页。

「有最低限度生存能力的群体:物种灭绝过程」M.E.吉尔平与M.E.吉苏莱合著，一九八六年。保护生物学。:稀有同多样性的科学。麻萨诸塞州桑德兰，第19至34页。

[偶然性灭绝的统计学」D.古特曼，一九八七年。有生存能力的群体的保护，麻萨诸塞州，坎布里奇，坎布里奇出版社，第11至34页。

[生态学:小群体动物模拟模型」，J.W.格里尔，一九八零年。创造性计算出版社。6:116-322

「白头海雕群体活力的模拟办法」，J.W.格里尔，一九八零年。野生生物协会通告，8:316-322

「通过再引进而建立起来的建立者群体的活力」，J.W.格里尔与J.H.巴尔克莱合著，一九八八年。迁徙隼群体。爱达荷州博伊斯，迁徙隼基金会，第698至700页。

「大型哺乳动物在基因上的有效群体的大小:对估计量的评估」，R..里斯与F.W.阿伦多夫合著，一九八九年。保护生物学，付印。

「国际保护自然和自然资源联合会关于人工饲养的声明」。国际保护自然和自然资源联合会，一九八八年。

「管理下的群体的基因多样性损失:基因漂变，突变，迁徙和亚群的相互作用」，R.C 莱希著，一九八七年。保护生物学，1:143-158.

「进一步分析犀牛小群体的基因同数量」，R.C 莱希著，一九八七年。厚皮动物，9:16-19

「饲养动物群的基因变异:评估过去的损失，目前的现状，以及未来的瞻望」R.C 莱希著，一九八八年。美国动物园与水族馆协会年度刊物，113-121

[对谱系中建立者代表的分析:相当于建立者与建立者基因组」，R.C 莱希著，一九八九年。动物园生物学，8:111-124

「对于波哥亚马孙鹦鹉的群体生存分析与建议」，R.C 莱希，U.S.希尔同N.R.弗莱斯涅斯合著，一九八九年。向美国鱼和野生生物管理局提出的报告。美国明尼苏达州，艾波谷，国际保护自然和自然资源联合会物种生存委员会饲养专家组。

「东部条文害鼠的群体生存分析」，R.C 莱希同T.W.克拉克，一九八七年。小群体的管理与保护，芝加哥，芝加哥动物协会(付印)

「群体有效大小，基因变异以及在群体管理中的应用」，R.兰德同G.F..巴尔克劳合著，一九八七年。有生存能力的群体的保护，麻萨诸塞州，坎布里奇，坎布里奇出版社，第187至223页。

「对热带森林物种多样性减少的估计」，A.E.卢格著，一九八八年。生物多样性。华盛顿特区，全国学院出版社，第58至70页。

「分子演变基因」，M.内著，一九八七年。纽约，哥伦比亚大学出版社。

「自然群体中间基因多样化同传染病的相互作用」，S.J.奥拜恩同J.F.埃弗曼合著，一九八八年。生态与演变动态，3:254-259

「美国鱼和野生生物管理局恢复计划/物种生存计划为红狼制定的总计划草案」，W.派克同R.史密斯，一九八八年。生物多样性。华盛顿特区，全国学院出版社，第58至70页。

「灭绝:动物园的教训」，K.罗尔斯同J.D.巴卢合著，一九八三年。基因与保护，加洲门罗园，第164至184页。

「对致命等量的估计和哺乳动物近亲交配的代价」，K.罗尔斯，A.R.坦普尔顿同J.D.巴卢合著，一九八八年。保护生物学2:185-193

「有蹄类小群体的近亲交配与幼仔死亡率」，K.罗尔斯，E.T.佐恩同J.巴卢合著 ，一九七九年，科学，206:1101-1103

「保护生物学与黑足貂」，U.S.希尔，E.T.佐恩，M.A.伯甘同S.H.安德森合著，一九八九年，纽黑文，耶鲁大学出版社。

「物种保护的最小限度群体大小」，M.L.谢弗尔，一九八一年，生物科学，31:131-134

「有最低限度生存能力的群体:应付不测问题」，M.L.谢弗尔，一九八七年。有生存能力的群体的保护，麻萨诸塞州，坎布里奇，坎布里奇出版社，第69至86页。

「千年方舟:航行时间要多久，客仓要有多少间，旅客要有多少?」，M.苏莱，M.E.吉尔平，W.康威，同T.福斯合著，一九八六年。动物园生物学5:101-114

「把基因组全部传给一千代的可能性」，E.汤普森，群体生存分」和管理的分析方法，(準备付印)

「怀厄明州黑足貂人工繁殖努力」，E.T.佐恩同别利茨基合著，一九八九年，保护生物学与黑足貂，，纽黑文，耶鲁大学出版社。

「建立孤立的狮子群体的繁殖与基因后果」，D.E.维尔特，M.布什，K.L.古德罗，C.派科，A.E.普瑟，J.L.布朗，P.乔斯林同S.L.奥部赖恩合著一九八七年。自然，329:328-331

基因词汇

脱氧核糖核酸

脱氧核糖核酸;含有通常称为核苷酸单位的分子链。这是把从一个细胞，或者是生物体遗传下来的信息，保存和传递给下一个的材料。脱氧核糖核酸在细胞核的染色体上;另外一部分在立线体中，这部分虽然少一点，然而却也有相当数量。

基因

脱氧核糖核酸中构成有遗传功能的单位的那一节。

位点(基因)

即基因在脱氧核糖核酸中占据的那一部分。基因和位点经常可以替换使用。

等位基因

基因的交替形式。严格说来，等位基因指的是一个基因中可以决定交替特点的不同的表现形式。然而，从广义来说，指的是一个基因的两个不同板样，也就是每一个二倍生物体在每一个位点上的基因的两个板样。

等位基因或者是基因频数(频率)

一个群体中所有代表着一个特殊等位基因样的比例。

基因型

一个个体作为一个基因的两个板样所有的各种等位基因，举例来说，如果在一个位点可能有两个等位基因(A,a)，则就有可能有三个基因型，AA,Aa同aa.

异型结合

一个群体中，在一个位点上有异型结合的个体的比例(也就是说，有不同作用的，不同的等位基因)。

哈迪 -- 温伯格平衡

这是群体基因的一个原则，以等位基因的频数为基础来预测基因型的频数，前提是假设这个群体随机交配时间至少已经有一代了。在最简单的情况下，在一个位点上有两个等

位基因(A,a)，而这类等位基因的频数为P_A与P_a，则根据哈迪--温伯格平衡可以预测，在一代随纪交配以后，基因型的频数将是$AA=P_A^2$; $Aa=2P_AP_a$; $aa=P_a^2$.

预期的异型结合

这就是一个群体如果保持哈迪--温伯格平衡，预期会有的异型结合。预期的异型结合是由等位基因频数计算出来的，是随机交配预期在后代会出现的异型结合。1-SUM p_i's,而p_i=等位基因频数i。

基因多样性 = 建立者等位基因多样性

目前的群体预期会有的异型结合，而这个群体同建立者来源于的那个野生群体有关系。基因多样性有的时候可以用P来代表。$P=H_t/H_o$ 而H_t与H_o在t时与o的预期异型结合。如此，群体保留的基因多样性则是野生群体的一小部分。

基因组

一个个体的全套基因(等位基因)。

基因漂变

这一代同下一代由于等位基因实际上由亲体随机传给后代而在等位基因频数上发生变化。这种随机变化在群体传到下一代而数量变少的情况下，也就是基因样变少的情况下，会加大。

瓶颈

建立者传下来的系谱中有一代只繁殖一个，或者几个后代，因此建立者的等位基因没有全部传给下一代。

建立者

一个取自群体源(野生)而可以实际繁殖后代的个体，并在现存的，衍生群体中(饲养群体)有其后代。

建立者代表

从某一个建立者衍生出来的群体，在任取时间的基因比例，或者是部分。

现有代表

群体中现有的建立者代表的比例。

目标代表

希望达到的建立者代表的百分比，或者是作为目标而要达到的百分比。目标数字和群体中生存下来的每一个建立者的基因组部分成比例。能够实现这类目标代表价值，则可以最大限度保存基因多样性。

原始建立者等位基因

建立者在每一个位点的每一个基因的等位基因总数。原始建立者等位基因数量两倍于原始建立者基因组。

原始建立者基因组

一个建立者的全套基因，其总合则是建立者基因组。原始建立者基因组是原始建立者等位基因的二分之一。

建立者存留下来的等位基因

群体中每一个位点存留下来的等位基因数量，前提是假设每一个建立者在每一个位点上都把两个独特的等位基因带入衍生(饲养)群体。

建立者存留下来的基因组

群体中尚有的原始建立者基因组的数量。这种公制单位衡量群体谱系发生瓶颈效应而损失的原始多样性的多少。

建立者基因组等价体

为了维持目前饲养群体的基因多样性而需要从野外新捕获来的动物的数量。这种公制单位反映出发生的瓶颈效应和建立者代表不一致的时候所受到的损失。

建立者等价体

等价代表所要有的数量，以产生在现有群体中所观察到的同样的基因多样性。前提是承认瓶颈效应已经使建立者等位基因损失掉。建立者等价体用以衡量基因多样性的损失，而这类损失是现存群体中的建立者谱系的不均匀代表所引起的。

有效群体大小

这是发展出来的一种概念，用以反映出，在一个群体中，不见得所有的个体，在把基因材料传给下一代的时候，都有相等的贡献。或许有的还根本没有。有效群体大小用Ne来表示，其定义为，一个理想群体的大小应当和目前在考虑中的真正群体有同样的基因漂移(漂变)。一个理想群体为，可以有性繁殖;有随交配;有等量性别比例;有普瓦松家系大小，即一生中繁殖的后代;稳定的年龄分布与群体大小的稳定性，即数量上的稳定性。

亲缘悉数

从群体中一个个体任取的一个等位基因在第二个个体中由于有共同的祖先而出现的可能性。有同样情况的，是在两个个体中，由于两个个体都出自于同一个祖先而具有相同基因的比例。一个动物的近亲交配系数等于亲体亲缘关系的二分之一。

平均亲缘

一个动物以及现存的，衍生下来的群体中的所有动物(建立者除外)的中间，或者平均亲缘系数。中间亲缘系数两倍于同建立者有亲缘关系的衍生群体的基因丧失率，同时，也两倍于随机交配繁殖的后代的中间，或者是平均近亲交配的系数。

统计数量辞汇

年龄 以年计算的年龄分类

P_x 具体年龄生存

任取年龄的动物生存到下一个年龄分类的可能性。

L_x 活到某一具体年龄

新生幼仔活到任取的年龄分类的可能性。

M_x 具体年龄能育性

在一定的年龄分类中的动物繁殖的后代的平均数字(同亲体性别相同)也可以解释为有繁殖能力的动物的平均百分比。

r 即刻变化率

如果 $r<0$...........群体在减少

如果 $r=1$...........群体稳定(数量不变)

如果 $r>1$...........群体增加

希腊字母Λ 群体每年变化的百分比

如果希腊字母Λ <0...........群体在减少

如果希腊字母Λ =1...........群体稳定(数量不变)

如果希腊字母Λ >1...........群体增加

R_o. 净繁殖率

每一代的变化率

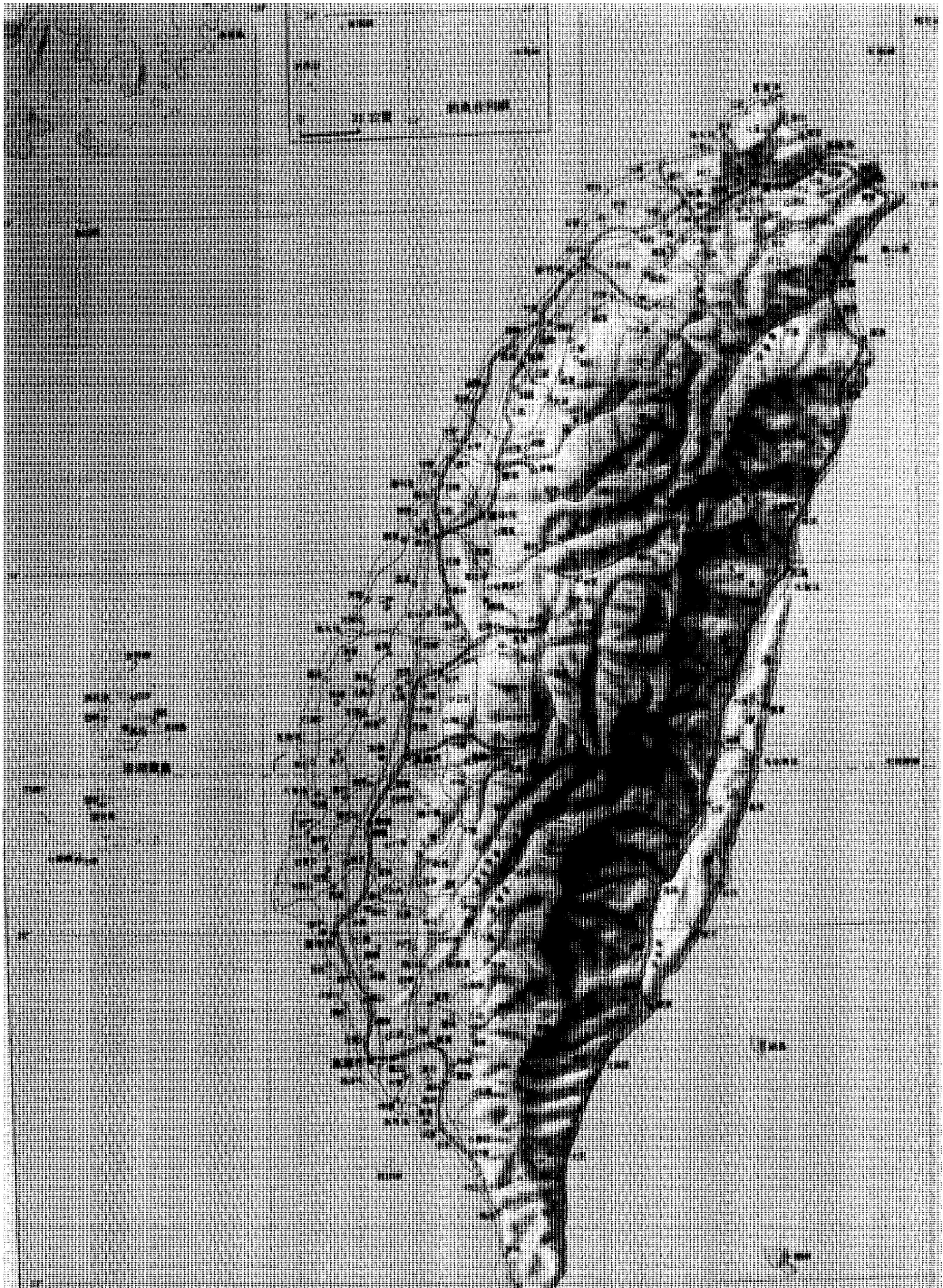
如果 $R_o < 0$..........群体在减少

如果 $R_o = 1$..........群体稳定(数量不变)

如果 $R_o > 1$..........群体增加

T 增代时间

亲体诞生时间同幼仔诞生时间的平均时间。(相等情况是动物繁殖后代的平均年龄)。


0 20 40 60 80 公里