TAMARAW

(*Bubalus mindorensis*)

15-17 MAY 1996
Population and Habitat Viability Assessment

REPORT

SPECIES SURVIVAL COMMISSION

TAMARAW

(*Bubalus mindorensis*)

Population and Habitat Viability Assessment

University of the Philippines Los Baños
College, Laguna, Philippines

15-17 May 1996

REPORT

J. de Leon, N. Lawas, R. Escalada, P. Ong, R. Callo, S. Hedges,
J. Ballou, D. Armstrong, U.S. Seal (Editors)

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A Collaborative Workshop

Department of Environment and Natural Resources
University of The Philippines Los Baños Foundation, Inc.
Asian Wild Cattle Specialist Group SSC/IUCN
Conservation Breeding Specialist Group SSC/IUCN

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

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Population and Habitat Viability Assessment

University of The Philippines Los Baños
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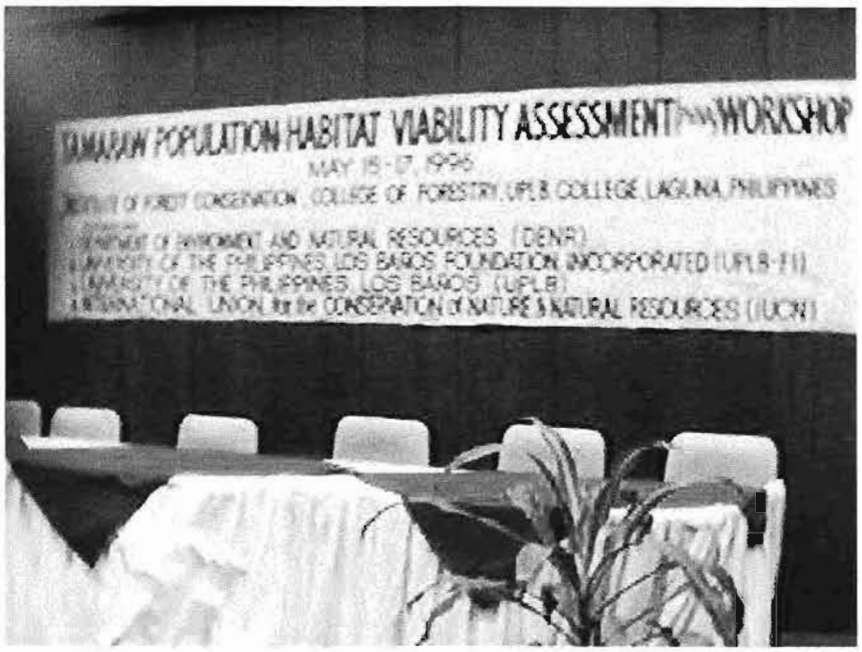

15-17 May 1996

Report

SECTION 1

Executive Summary

EXECUTIVE SUMMARY

The endangered tamaraw (*Bubalus mindorensis*) is endemic to Mindoro Island in the Philippines. Historically, the population may have numbered 10,000 in 1900 but has since declined to 100-400 animals as the result of habitat loss, hunting, and disease. They may be fragmented into several subpopulations with no opportunity for natural exchange. Efforts to establish a practical conservation management and research program for this species have been hampered by conflicting recommendations from outside organizations and multiple changes in supervising authority which have resulted in altered priorities, unreliable funding, and suspension of activities. A Population and Habitat Viability Assessment (PHVA) for the Tamaraw was recommended by the Asian Wild Cattle Specialist Group (SSC/IUCN) at a Asian Wild Cattle CAMP Workshop in Thailand in June of 1995. Participants included Ruben Callo and Mary June Maypa of the Philippines Department of Environment and Natural Resources (DENR).

CBSG was officially invited by Delpfin J. Ganapin, Jr., Undersecretary for Environment and Programs Development of the DENR to conduct a PHVA for the species in the Philippines, 15-17 May of 1996. The workshop was endorsed by the Wilfrido S. Pollisco, the Director of PAWB and arrangements included Dr. Ruben L. Villareal, Chancellor of the University of the Philippines at Los Baños, Hon. Josephine Sato Governor, Occ. Mindoro, and Hon. Victor A. Ramos, Secretary DENR as well as Philippine biologists, researchers, and wildlife managers. The objectives of the course and workshop are to assist local managers and policy makers to: 1) formulate priorities for a practical management program for survival and recovery of the species in wild habitat, 2) develop a risk analysis and simulation population model for the species which can be used to guide and evaluate management and research activities, 3) identify and initiate useful technology transfer and training, and 4) identify and recruit potential collaborators for the conservation program.

A briefing book was distributed to participants. A draft report was prepared during the course with all recommendations reviewed and agreed by the participants. More than 40 Filipino scientists, biologists, managers, and NGO members participated in the workshop. Foreign CBSG team participants included Doug Armstrong, DVM from the Omaha Zoo, Jon Ballou from the Smithsonian Institution, Ulysses S. Seal Chairman of CBSG, Simon Hedges and S. Sompoad co-chairmen of the Asian Wild Cattle Specialist Group, Harri Vredenberg and Francis Westley, from Universities in Canada. After opening welcomes, a series of short presentations were made summarizing recent history and current knowledge of the threats, biology, and management of the tamaraw in the wild and in captivity. These presentations are included in the report. Much unpublished information was made available for the workshop and the many gaps in our knowledge of the species were clearly identified.

The participants were formed into 4 working groups reflecting their expertise, interests and the key problems for tamaraw conservation and most of the work over the three days was done by these groups. The groups were; Wild Population, Captive Population, Population Biology and Modeling, and People Participation. Each group developed an outline of its tasks and then developed key areas with extensive review of available information and discussion of needed actions. Each group presented the results of their work in three plenary sessions to

assure that everyone had an opportunity to contribute to the work of the other groups and to assure that all issues were careful reviewed and discussed by all workshop participants. This process allowed for a full review of all of the recommendations that are a part of this executive summary and for agreement and acceptance by all participants. The discussions were intense but orderly with the result that many contentious issues were openly discussed. It is clear that there has not been sufficient communication among all of the stakeholders in the conservation of this species to reach working resolution of problems and misunderstandings that have arisen over the years. The following recommendations, however, do represent a consensus of the workshop participants.

The management and research recommendations for the wild and captive populations are very specific and capable of implementation. Of particular note is the need for a program for the scientific survey and census of the tamaraw populations. This can be implemented through a training course designed for the needs of the tamaraw taking into account the difficult habitat, their low numbers, and their dispersed distribution. A suggested carefully designed program was prepared by the Wild Population group and is included in this document. It needs to be started not later that December 1996 - January 1997 to allow initiation of the surveys early in the dry season. The two specialist groups (Asian Wild Cattle - Hedges and Sompoad and CBSG - Seal and Armstrong) are prepared to assist in this process if DENR and the government of the Philippines wish to begin this process and if there are people who can undertake the commitment to the training and the actual field work.

A second project that can be implemented immediately, involving international collaboration and partnership, is the work on establishing a genome resource bank with semen collection from the current male tamaraws in captivity. They represent a valuable genetic resource that is not likely to be effectively utilized for a natural breeding program because of their age and the shortage of females. Collection and storage of their semen would allow this material to be used at a later time since with proper technique semen can be stored indefinitely (at least 40 years). A participant in the workshop, Dr. Doug Armstrong of the Omaha zoo has extensive experience with reproductive biology techniques in wild cattle species. He is highly skilled in their husbandry, drug immobilization, and clinical management as well so that he could share a range of experience. He is interested in undertaking such a project and would have some support from his institution.

It is clear from the history of this species and from the reviews and analyses conducted in this workshop that the survival and recovery of a viable population of the tamaraw is going to be a long process requiring a sustained effort and collaboration among all stakeholders. A process to assist this endeavor was undertaken in this PHVA Workshop. We have found that a continuation of this process based on a friendly but neutral and objective review of the programs, coupled with analysis of information and experience gained in the program, by all stakeholders can be of assistance and can contribute to stronger collaborative efforts. We recommend that there be another such workshop in late 1997 after some information is gathered in the proposed surveys. CBSG is interested in continuing this collaboration with our Philippine colleagues and would be willing to again assist if it is desired.

RECOMMENDATIONS

I. Wild Population (1 and 2A-C are equal top priorities)

1. Protect the known Tamaraw populations in Iglit Ranges and Aruyan by creating a dedicated tamaraw protection force (TPF). *This force should be created, equipped, and deployed as soon as possible.*

2. Organize a training course to demonstrate appropriate survey methods and initiate a tamaraw survey. This course should start December 1996 - January 1997.

2A. Organize a training course in survey methods to be followed with an island-wide presence / absence survey plus a more extensive survey in the Iglit ranges to determine minimum population size in the area.

2B. Conduct more extensive surveys / censuses in areas identified as important in Part 1 above.

2C. Initiate follow-up monitoring of population status and threats in all areas with major tamaraw populations.

[This complete program should be initiated as soon as possible and will probably require about 2 years]

3. Assess the need for habitat management (e.g. burning + possible reforestation) and possible experimental treatments (should include training of habitat management personnel).

4. Monitor all populations (population status and threats).

5. Develop management plans for all important areas.

6. Recommend that any areas containing major tamaraw populations be declared as protected areas (if they are not already included).

7. Enforcement of existing legislation is needed.

8. Initiate a long-term study (3-5 yrs minimum) of ecology and behavior of the tamaraw in the wild.

9. Collection of hair samples, horns, skulls (plus any other required material) from any carcasses / other remains found plus any animals taken by hunters.

10. Conduct an independent evaluation of the TCP2 program annually.

II. Population Modeling

1. *It is imperative that more accurate estimates of population size of the Mount Iglit Baco tamaraw population and all potential populations be obtained.* Accurate estimates will be essential to establish time-frames for further management action and convey the degree of urgency in implementing these management actions.

2. *Initiate long-term field studies to determine base-line values of those life-history parameters shown to most significantly affect population viability.* These are: female reproductive rate, age of female first reproduction, calf mortality rate, and reproductive longevity.

3. Quantify the annual loss of tamaraw due to hunting and other threats.

4. Studies are needed to evaluate historical levels of genetic variation in tamaraw to determine if the observed low variation is a recent characteristic of this island species. Samples from the current wild population(s) should be collected when there is an opportunity.

5. "Explicit goals need to be formulated for the captive population that address the issues of genetic diversity to retain, and the captive population sizes and numbers of founders needed for this to be achieved."

III. Captive Population

High Priority:

1. Implement substantial, comprehensive improvement of the captive management program (see Captive Population Management Plan, addendum 2).

2. Transfer the existing Gene Pool site to a more accessible area and develop a biodiversity conservation and research center with tamaraw as the flagship.

3. Establish a program of routine semen collection and genome resource banking from the males currently held at the Gene Pool as soon as possible.

Essential Actions:

4. The veterinary professionals working with the Tamaraw Conservation Program will make a written recommendation within one month to the Philippine Department of Agriculture to establish more stringent requirements for the transfer of domestic

ruminants and swine to Mindoro. These requirements are intended to prevent the transmission of disease to the island which helps protect both the local ranchers and the tamaraw population. Testing requirements should include negative tests for Foot and Mouth Disease and brucellosis.

5. Establish a protocol for sample collection and health assessment of tamaraw currently in captivity and for animals that may come into captivity in the future (addendum 3).

6. Within six months the TCP veterinarians will perform a serologic survey of cattle in the vicinity of the current captive population location to detect potential disease threats in proximity to the captive population. Cattle will be surveyed for exposure to:
   1. Foot and Mouth Disease
   2. Hemorrhagic Septicemia
   3. Leptospirosis
   4. Brucellosis
   5. Bluetongue
   6. Pseudorabies
   7. *Mycobacteria paratuberculosis* (Johne's disease)

7. The existing Tamaraw Conservation Program Operations Manual will be thoroughly reviewed and updated within six months.

Contingent Priorities: (Dependent upon results of field surveys and actions taken on Priorities 1-3 above).

8. Increase the captive population of tamaraw by preferential capture of females from the wild. Numbers will depend on the recommendation of the population geneticists but an additional six founder males and ten founder females may be sufficient. A complete review of all options available for capture will be completed and a plan developed using the best capture method prior to beginning the capture program.

9. The capture of tamaraws from the wild should come from different sites to insure genetic diversity in the captive population.

10. Establish two separate fall-back populations, one on Mindoro Island but located far from tamaraw habitat and cattle ranches. The initial population base will be animals currently held in captivity and relocated to the new site on Mindoro. When the time is appropriate, additional animals may be added to this population to establish a core captive population. A second population should be located outside of Mindoro Island as protection against an island wide catastrophic event. The second herd could be established from first generation (F1) offspring of the wild caught founder animal core herd on Mindoro.

IV. People Participation

A. Short term

1. *IEC - plug the program on tamaraw conservation.* (Coordinators: TCP Implementor & KMFI; Partners: LGU, DENR, DECS, DSWD and other concerned agencies/NGOs/POs). Use as many means of information as possible including:
    a. mass media
    b. disseminate popularized reading materials
    c. resource awareness at the barangay level via interpersonal communication.
    d. training seminars
    e. curriculum integration

2. *Law Enforcement.* (Coordinator: LGU & DENR; Partners: KMFI, TCP, PNP)
    a. Increase level of awareness re: laws on tamaraw conservation.
    b. Recommend hiring wildlife wardens and forest rangers to enforce laws.
    c. LGU to appoint barangay guards/wardens to regularly report to DENR/PNP.

3. *Livelihood and technology transfer:*
    a. training
    b. demo farms
    c. clinics in following areas:
        1) food production in home gardens (crops, poultry, livestock);
        2) improve farming system;
        3) cottage/home industries with minimum extraction & harvesting.

B. Medium term. (Coordinators: TCP; Partners: DTI, DENR, etc.).

1. Continue/sustain implementation of educational campaigns and law enforcement.

2. Continue livelihood and technology transfer.

3. Encourage investors in cottage industries.

4. Develop marketing systems for farm products/handicrafts.

5. Continue lobbying for CADC and AD.

C. Long term. (Coordinators: LGU, DOST, DTI; Partners: DENR-ISF, DSWD, DA, TCP, KMFI, etc.).

1. Improve access to communities.
2. Total community development.

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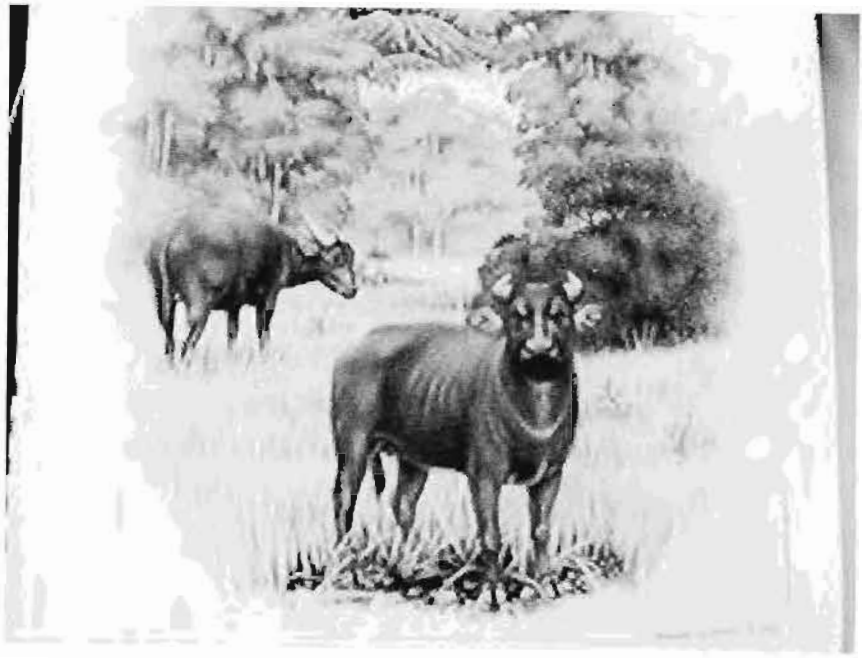


15-17 May 1996

Report

SECTION 2

Introduction

Republic of the Philippines
Department of Environment and Natural Resources
Visayas Avenue, Diliman, Quezon City, 1100
Tel. Nos: (632) 97-66-26 to 36; (632) 97-70-41 to 43

NOV 0 3 1995

Dr. Ulysses S. Seal
Chairman, Conservation Breeding
Specialist Group
12101 Johnny Cake Ridge Road
Apple Valley MN 55124-8151,USA
Fax: 1-612-432-2757

Dear Dr. Seal,

In pursuit of the recommendation reached during the Asian Wild Cattle Conservation Assessment and Management Plan Workshop held in Thailand in July 1995 which was participated in by our representatives Ruben Callo and Mary June Maypa, we are pleased to confirm the holding of the Population and Habitat Viability Assessment (PHVA) Workshop for the Tamaraw on 18-20 March 1996. The workshop will be held at the University of the Philippines Los Banos, College, Laguna.

We understand that the Captive Breeding Specialist Group is willing to co-sponsor the activity by providing the free services of 3-4 experts/resource persons and shouldering all the incidental expenses relative to their attendance, as well as the production (pre- and post-) of technical reports/proceedings.

Relative thereto, we would appreciate receiving your confirmation to co-sponsor the activity as soon as possible.

From our end, we have set aside an amount of two hundred thousand pesos (P 200,000.00) for the workshop.

Attached is the tentative program of activities and the proposed topics for presentation, for your information.

Thank you and warm regards.

Very truly yours,

DELFIN J. GANAPIN, JR
Undersecretary for Environment
and Programs Development

\letphva

CalEnergy Joins Effort to Protect Endangered Species

CalEnergy and Kiewit Construction Company *(a subsidiary of Peter Kiewit Sons', Inc.)*, in collaboration with the Conservation Breeding Specialist Group (CBSG), have joined forces to sponsor Population and Habitat Viability Assessments (PHVA) for two endangered species — one in the Philippines and one in Indonesia.

CBSG is an international conservation organization dedicated to protecting the world's plant and animal species. Its mission is to conserve and establish populations of threatened species through captive breeding programs and through intensive protection and management of various plant and animal populations in the wild.

"Because of our involvement in the Philippines and Indonesia, we felt this was a perfect opportunity to assist these countries with their conservation efforts," said David L. Sokol, Chairman and Chief Executive Officer.

The Philippine and Indonesian wildlife and government officials have invited the CBSG to conduct these two assessments. CBSG uses numerous processes and tools it has developed to carry out its globally recognized program. More important, decisions are then made by the Philippine and Indonesian wildlife officials allowing practical and expedient implementation of a resulting management program.

As the word of CBSG's successful work has spread, so has the demand for its services. To meet this growing demand, CBSG has begun to train scientists worldwide. The PHVA workshops they have developed bring together biologists and other professionals to assess the extinction risk and develop better management strategies for particular endangered species. Their goal is to share knowledge and permit ongoing evaluation of the conservation of plants and animals.

Two such endangered species identified by the CBSG are the **Javan Hawk-Eagle** from Indonesia and the **Tamaraw** from the Philippines.

The **Javan Hawk-Eagle**, a member of the eagle species, is found in the western part of Java. It is considered an endangered species due to the large decrease in the forests and the increase in human population in Java.

The **Tamaraw**, a member of the wild Asian buffalo species is located on the Mindoro Island in the Philippines. Because of the increased cattle ranching, poor nutrition, and a decrease in their habitat the Tamaraw is now in danger of becoming extinct.

The PHVA workshops will assist local Philippine and Indonesian managers and policy makers in:

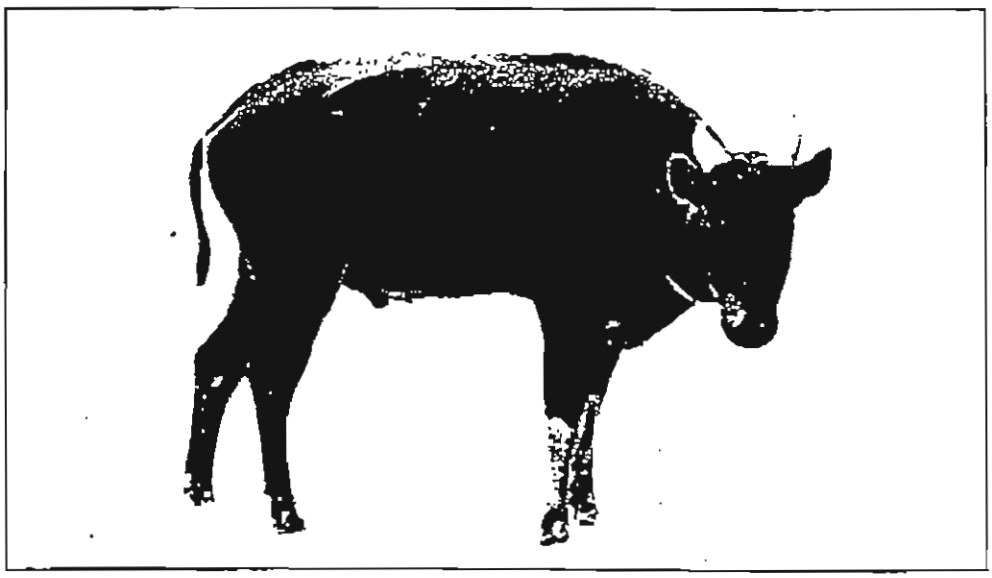
- *formulating priorities for practical management programs for survival and recovery*
- *developing risk analysis and simulated population models which can be used to guide and evaluate management and research activities*
- *identifying and initiating useful technology transfer and training*

An in-depth analysis of each species will assess their:

life history, population dynamics, ecology, demographics, genetics, environmental factors, risk of extinction, and perceived threats

Both the **Tamaraw** and **Javan Hawk-Eagle** PHVA workshops are scheduled to be held in May.

Javan Hawk-Eagle, an endangered species of the eagle, can be found in Indonesia.



The Tamaraw, an endangered species of the wild Asian buffalo, can be found in the Philippines.

Keynote Speech

Victor O. Ramos
Secretary, Department Environment and Natural Resources

Honorable Congressman Jose Villarosa of Occidental Mindoro; UPLBFI Executive Director, Dr. Virgilio Fernandez; Conservation Breeding Specialist Group Chairman, Dr. Ulysses Seal and company; our guests from Nagoya University, Japan; our partners in environmental conservation from the various sectors; colleagues in government service; ladies and gentlemen!

When I speak of our tamaraw, I am reminded of the American bison. A bulky, bearded buffalo, also of the bovine family, that once thundered its millions presence in the plains of the United States. Hunted almost to near extinction, from a high of 30 million head in the early 1800s, its population sank to almost a thousand in 1889.

With it comes the subjugation of the Plains Indians by the U. S. Army. The drama was so heart-rending that it was succinctly described by an American colonel with the following words:

> "Ten years ago the Plains Indians had an ample supply of food ... now everything is gone and they are reduced to the condition of paupers, without food, shelter, clothing, or any of those necessaries of life which came from the buffalo ..."

Essential to Plains Indians' religion and lore, the bison is honored as a life giver. its virtual eradication by white men helped crush their tribes' fight for land and freedom.

But the bison has thundered back from its sad past. Helped by the present generation of American's sense of responsibility toward their natural heritage, its population has soared back to an amazing 200,000 head by 1994. Its continued thundering existence in the plains seems to be bright in the American horizon.

And we are here today for the existence of our tamaraw, nowhere to be found anywhere in the world except in the mountains of Mindoro. Indeed a national treasure ... yet an endangered one! Much like the bison, the tamaraw has been hunted for food and trophy, its habitat destroyed through kaingin and illegal logging. From a high of an estimated 10,000 individuals in the early 1900s, it is presently estimated to be more than a hundred. God forbade, it may stop decreasing.

And it should be! I am confident that just like the present generation of Americans that brought back the bison in their plains, the Filipinos of today can do the same for their tamaraw.

It has been said that a captive tamaraw spent a daily average of only 9.41% of its time sleeping, the rest covering 94.59% on walking, running, lying down, ruminating and feeding.

From here, can we surmise that the tamaraw is sending us a clear signal that a large part of its time is spent for its survival? Perhaps, and for that, we can do no less.

As we contemplate in this workshop a holistic way of saving the tamaraw and its habitat, let us include in our approach the return to our roots - our indigenous roots.

And one of our indigenous ways is sharing or Pakikipagkapwa-tao. We share everything we have - material things and emotions - to our kin, family and visitors. As the German wife of Kidlat Tahimik, a noted Filipino artist, would put it:

> "This sharing, it occurred to me, was basic to the Filipino life. Sharing is basic and sharing is humane"

Let us, therefore, extend our Pakikipagkapwa-tao to our treasured yet endangered tamaraw and elevate it to Pakikipagkapwa-nilalang or respect for all life-forms.

This has been practiced by our forebears, including the venerable Mangyans, and their time, before the colonization, tell of a dignified civilization which was at peace with nature.

In retrospect, allow me to share with you a portion of a prayer a 10-year old boy delivered during the celebration of earth day at the DENR in Quezon City, which says:

> "At higit sa lahat, kami'y nananalanging: makitang magiliw na gumagapang patungong dagat ang laksa-laksang pawikan kasing-cute ni Pong Pagong!
>
> Maaninag sa kalawakan ang kapangyarihan ng pakpak ng sanlibong mabagsik na agilang pag-asa!
>
> Mahalina sa mala-sirenang paglangoy ng mapang-akina Mariang dugong!
>
> Mayanig sa mga yabag ni Juan tamaraw sa kanyang muling pamamayagpag sa mga talahiban ng bundok ng Mindoro!
>
> At sa lahat naming mga kapatid na hayop at nilalang sa kagubatan, parang at karagatan - nawa'y patuloy silang mabuhay ng mapayapa at masagana!"

Let us not fail the boy's prayer ...

Maraming Salamat Po!

Opening Remarks

Wilfredo S. Pollisco
Director of Protected Areas and Wildlife Bureaau

Honorable DENR Assistant Secretary for Legal and Legislative Affairs, Dewaldo Lorenzo; Honorable Congressman, Jose Villarosa of Occidental Mindoro; Dr. Ulysses S. Seal and company of the Conservation Breeding Specialist Group; UPBLFI Executive Director, Dr. Virgilio A. Fernandez; our guests from Nagoya University, Japan; scientists and participants from the various sectors; colleagues; ladies and gentlemen; Good Morning to All of You!

It is my honor and privilege to address this distinguished group of wildlife experts and enthusiasts who are in the noble task of wildlife conservation. Your presence in this workshop signifies the importance of the tamaraw not only to the Filipino people but to the international communities as well.

This workshop is a very welcome opportunity. It is significant not only because we were able to bring together all groups responsible for saving and managing the species, as well as the experts who can assist us in rescuing the species, but more so, is the objective output which will be generated from this activity.

As what I understand, we are here to undertake in-depth analyses of existing information on the tamaraw and evaluate current management scenarios and perceived threats to the species. This scientific exercise will lead us to the identification of gaps; and assist us in the formulation of management alternatives and new strategies to best address the factors that continue to contribute to its population decline.

For three consecutive days, we will be working together towards these objectives. With the presence of all the tamaraw experts, managers, and able legislators in this workshop, I have all the reasons to conclude that this international undertaking will be a successful one. It is hoped, however, that this occasion will serve just be the formal beginning of a more concerted, collaborative and aggressive efforts toward our ultimate objective of saving the tamaraw from extinction. More challenges needing everyone's support and assistance are before us.

Thank you and I welcome you all to this international workshop!

Welcome Address

Dr. Virgilio A. Fernandez
Executive Director
University of the Philippines
Los Baños Foundation, Inc.

The Honorable Congressman, Jose Villarosa of Occidental Mindoro, the Director of PAWB, Atty. Wilfrido S. Pollisco, the Assistant Director of PAWB, Celestlno B. Ulep, Professor Lawas, distinguished experts and scientists both national and international, friends, Good Morning!

Let me first welcome you all to this workshop and also to the University of the Philippines Los Baños. The Chancellor is supposed to be here to welcome you himself, but due to an important commitment outside the country, he cannot make it this morning. Now to those who are here for the first time, I'd like to say a few words about this place.

We are currently located at the foot of the legendary Mt. Makiling the home of Maria Makiling, a beautiful lady who is supposed to be guarding this mountain. This mountain used to be dominated by grasses during the early part of the century. Reforestation started when the University was established in 1909. There were tree planting activities every year by the students and staff of the University. You can now see the effect of the reforestation starting from 1909 to 1996. It is now very rich in biodiversity. From some studies, it is now the habitat of at least 50,000 species of plants and animals. It is a success story in reforestation, with the stakeholders who are mainly the University constituents, seeing the need to develop and protect the resources.

The University, as mentioned earlier, started with the establishment of the College of Forestry and Agriculture. For more than 60 years, there were only two colleges in the University- colleges of Forestry and Agriculture. In 1972, it became an autonomous University. More Colleges were added. Today we have eight (8) colleges in the campus. In addition to the College of Agriculture and Forestry, we have the College of Economics and Management, College of Engineering and Agricultural Technology, College of Arts and Sciences, College of Human Ecology, College of Veterinary Medicine and we have a Graduate School.

In addition to these colleges there are more than 30 centers and institutions. Right now, it has the highest concentration of scientists and experts in Agriculture, Forestry and related sciences in the South East Asian Region if not in the whole of Asia. It is also the home of a number of national, regional and international organizations like the International Rice Research Institute (IAMBI), Southeast Asian Regional Center for Graduate Study in Agriculture (SEARCA), Forest Products Research and Development Institute of DOST, the

Philippine council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), and the Fisheries Council of DOST and some other organizations in the Campus. So we have international organizations in this part of the country.

This Workshop on the Population and Habitat Viability Assessment for the tamaraw is very significant to us. It is about time, if not long overdue to pause and analyze our strategies for the Conservation of tamaraw. Are we on the right track? Is there a light at the end of the tunnel? Are we leading to our objectives? These are very serious questions which need accurate answers. Have we reached an irreversible decline in the population? Is there a need to train the tamaraws now to get used to the present situation because these conditions are here to stay? Or do we need to start documenting for posterity the tamaraws for future generations of earthling to know that once upon a time the tamaraw existed.

We have with us today a rich composition of national and international experts to diagnose the tamaraw. We hope we'll come up with the right prescription. At this stage of the game we cannot afford to fail. For the University of the Philippines Los Baños Foundation Inc., we have already been very supportive to this project. I hope everybody will do their share for the sake of tamaraw.

Again, welcome to everybody. I hope you will have a pleasant stay.

Thank you.

CAMP TAXON REPORT

SPECIES: Bubalus mindorensis (tamaraw)
STATUS:

IUCN: Endangered

Criteria based on: Extent of occurrence (B1, B2c), Number of mature individuals (D1), Population estimates (C).

CITES: Appendix I

OTHER: USDI - endangered

TAXONOMIC STATUS: This is a recognized species of wild Asian buffalo.
CURRENT DISTRIBUTION: Found on higher elevation of Mindoro Island, Philippines. Can also be found in areas of low elevation without established human activities.
HISTORICAL DISTRIBUTION: Observed in the lowlands of Mindoro Island prior to urbanization. Now found at higher elevations of the Island where there is insignificant human interference.
EXTENT OF OCCURRENCE: B, 101-5,000 km2; approximately 255,725 hectares (25% of the island).
AREA OCCUPIED: C, Approximately 230,000 hectares are protected but area occupied by tamaraw is very probably 501-2,000 km2. Found in 4 separate conservation areas namely Calavite Game Refuge and Bird Sanctuary (17,000 ha.), F.B. Harrison Game Refuge and Bird Sanctuary (123,000), Mts. Iglit-Baco National Park (75,445 ha.), Mt. Halcon - Eagle Pass (15,000 ha).
NUMBER OF LOCATIONS: 4 locations separated by local communities and areas developed by them for sources of livelihood such as agricultural farms and commercial cattle ranches.
POPULATION TRENDS- % CHANGE IN YEARS OR GENERATIONS: Stable for the past 10 years because of the concerted efforts of conservation groups.
TREND OVER PAST 100 YEARS: Declining. 10,000 estimated in 1900 (Harrison, 1969) declined to 1000 in 1949 (Manuel, 1957; Harrison, 1969). 200 in 1981 (PCARRD, 1981) and approximately 200-300 in 1993 (TCP 1993).
GENERATION TIME: 6-8 years
WORLD POPULATION: Upper end of the 300-400 range.
REGIONAL POPULATION(S): Calavite Game Refuge and Bird Sanctuary (25 individuals), F.B. Harrison Game Refuge and Bird Sanctuary (75 individuals), Mts. Iglit and Baco (182 wild and 7 captive individuals), Mt. Halcon - Eagle Pass (85 individuals).

DATA QUALITY: Reliable census information; This information is estimated separately from 3 sources: 1) 1981 and 1991 field census of Mts. Iglit-Baco National Park; 2) the Asian wild cattle specialist group action plan estimates 356 in 1987 (based on incidental observations of local villagers); and 3) Collado reported a 1993 estimate of upper end of the 300-400 range based on field studies conducted by TCP-UPLBFI and NGOs.

RECENT FIELD STUDIES: 1) Tamaraw census in Mts. Iglit-Baco National Park, Occ. Mindoro and gene pool farm (Callo and Lustria, 1992); 2) Tamaraw habitat ecology (Callo, 1983); 3) Parasites of the captive tamaraw (Anunciado et al., 1995, in press); 4) Characteristics of tamaraw range (Rubio and Castillo, 1993); 5) The skull of the tamaraw (Masangkay et al., 1991); 7) Other ongoing research/field studies being undertaken by the ICP-UPLBFI.

THREATS: Human interference, loss of habitat due to cattle ranching, habitat fragmentation and hunting for food and trophies, disease. Nutrition and disease are threats to the captive population.

TRADE: None reported for the past 20 years.

COMMENTS: Human interference is still the biggest setback towards conservation efforts. Fragmentation of existing known population makes it difficult to protect and manage the tamaraw.

RECOMMENDATIONS:

RESEARCH MANAGEMENT: Monitoring, habitat management, limiting factors research and life history studies. In addition, a field study should be conducted to document the biology and behavior of this species in the wild. Reproductive biology studies should be conducted on both wild and captive populations.

PHVA: Yes

CAPTIVE PROGRAM RECOMMENDATION: Level 1

LEVEL OF DIFFICULTY: Level 1

EXISTING CAPTIVE POPULATION (DENR): 4.2

SOURCES: 1) Field reports, DENR-RIV-B, 1994-1995; 2) Tamaraw Conservation Program Terminal Report, 1991-1993, UPLB Foundation, Inc.; 3) Callo, R.A., 1983, Ecological evaluation on the habitat of the Tamaraw in Mts. Iglit-Baco National Park, Occ. Mindoro, Master of Science Thesis UPLB, College, Laguna, Philippines; 4) Callo, R.A. and U.M. Lustria, 1992, Tamaraw census in Mt. Iglit, Occidental Mindoro and gene pool farm. Sylvatrop 2 (1):81-90; 5) PCARRD. 1981. State of the art - Tamaraw; 6) Kuehn, D.W. 1976. A field study of the Tamaraw. Pterocarpus 2(1):26-35; 7) DENR. 1993. Tamaraw evaluation report, DENR S.O. No. 93 series of 1993; 8) Harrison, T. 1969. The tamaraw and its survival. IUCN bull. 2(11):85-86; 9) Hedges, S. 1995, IUCN/SSC Asian Wild Cattle and Buffaloes Draft Action Plan.

COMPILERS: Working Group 4

MAMMALIAN SPECIES No. 520, pp. 1–5, 3 figs.

Bubalus mindorensis.

By Carlo C. Custodio, Myrissa V. Lepiten, and Lawrence R. Heaney

Published 17 May 1996 by the American Society of Mammalogists

Bubalus mindorensis Heude, 1888

Tamaraw

Bubalus mindorensis Heude, 1888:4, 50. Type locality "Mindoro," Philippines.

Anoa mindorensis Steere (*in* Sclater, 1889:364). Type locality above Calapan, Catuiran River, Mindoro, Philippines. Type specimen designated by Hooper (1941).

CONTEXT AND CONTENT. Order Artiodactyla, Superfamily Bovoidea, Family Bovidae, Subfamily Bovinae. The genus *Bubalus* includes two subgenera, *Anoa* and *Bubalus*. The subgenus *Anoa* includes the two species on the island of Sulawesi, the lowland anoa (*Anoa depressicornis*) and the mountain anoa (*Anoa quarlesi*). The subgenus *Bubalus* includes the Asiatic water buffalo (*Bubalus bubalis*), and the Mindoro buffalo or tamaraw (*Bubalus mindorensis*—Groves, 1969; Grubb, 1993). There are no subspecies recognized. Heude (1888) and Steere (1889) described the species independently, coincidentally giving it the same specific name.

DIAGNOSIS. The tamaraw superficially resembles the anoas because of the whitish markings on its face, neck, and legs (Fig. 1), but is larger than either species of *Anoa*. It is recognized as a member of subgenus *Bubalus* largely because of the shape of the horns, which are short and thick with an outward initial direction (Fig. 1), as opposed to the closely approximated and backwardly directed horns of anoas; molars that are short and high with square crowns (Fig. 2); broad ribs; forwardly directed hair on the anterior part of the back; and comparatively small ears. *B. mindorensis* differs from the Asiatic water buffalo (*B. bubalis*) by being smaller and more robust. Compared with *B. bubalis*, *B. mindorensis* has short, stocky limbs, has more hair on its body, and is dark brown to grayish black in color instead of pale gray (Fig. 1). Its horns are stout and short and grow in a "V" form instead of a wide "C" as in the water buffalo, with the base in a roughly triangular form as opposed to the rectangular form in domestic water buffalos. In comparison with the water buffalo, the adult tamaraw has a reduced parietal bone and a narrow occipital bone (Alcasid, 1977; Groves, 1969; Hollister, 1911; Popenoe, 1983).

GENERAL CHARACTERS. *Bubalus mindorensis* is a small buffalo; females have been estimated to weigh approximately 300 kg (Talbot and Talbot, 1966) and 180–220 kg (Roth and Montemayor-Taca, 1971). The dental formula is: i 0/3, c 0/1, p 3/3, m 3/3, total 32 (Rabor, 1986). Measurements (in cm) of the lectotype of *Anoa mindorensis* Steere are as follows: length of head and body, 220; length of tail, 60; length of hind foot from hock to distal hoof tip, 44.5; height at shoulder, 94.5; height at hindquarters, 98.3; girth behind shoulders, 165.5; and approximate length of ear from notch, 13.5. Skull measurements (in mm) are: greatest length of skull, 380; basal length, 354; palatal length, 237; breadth across zygomata, 162; breadth across mastoids, 185; distance from anterior border of orbit to tip of rostrum, 202; width of skull across lateral alveolar border of M2, 108; alveolar length of upper cheek-teeth, 101; and alveolar length of lower cheek-teeth, 114. Horn measurements (in mm) are: circumference of base of left horn, 335; length of left horn on outside curve, 420; and distance between tips of horn cores, 271 (Hooper, 1941).

Comparison of a single adult female and single adult male (Heller, 1889; Jentink, 1894) revealed that in the female the horn cores are inclined backwards with respect to the frontal bones; frontal bones are concave in the female and convex in the male; and nasal bones measure 155 mm in the female and 144 mm in the male. The bony palate ends at the last molars in the male, but extends beyond that in the female; the vomer is more prominent and twice as large in the female as in the male; and posterior palatine foramina are located more posteriorly in the female than in the male. In the female, coronoid processes are more curved, and incisors are more anteriorly inclined. In addition, bulls have a thicker neck than cows (Steere, 1890).

In bulls, the triangular horns tend to be longer, thicker, more flattened, and closer together at the base than in cows, and thus may be used for determining the sex of skulls (Kuehn, 1976; Steere, 1889). The horns are directed downward and straight backward, turning slightly toward each other at the tips (Fig. 1). They are short (35.5, 38, 40, and 43 cm—Sclater, 1889; Steere, 1891; Taylor, 1934) and stout with deep, irregular, transverse grooves and pits on the anterior, lateral, and posterior surfaces; the inner surface is very rough. Horns are black in color (Lydekker, 1898; Rabor, 1977, 1986; Steere, 1889; Taylor, 1934).

The vertebral column consists of 13 T (which have spinous processes with enlarged tips that diminish in size towards the lumbar vertebrae), 7 C, 6 L 5 S, and 18 or 19 Ca, total 49–50. Ribs are attached to all thoracic vertebrae, and in the female, the first lumbar vertebra has a movable, well-developed rib on the left side. The ribs are broad, measuring 55 mm at the widest portion. The sternum consists of seven bones ending in a sickle-shaped xiphisternum (Jentink, 1894). Limb proportions relative to metacarpal length are: humerus 1.9, radius 1.8, femur 2.3, tibia 2.1, and metatarsal 1.2. The metacarpal is 45.8 mm in length, metatarsal 32.0 mm, and humerus 253.5 mm. Body size and limb proportions in adults are not sexually dimorphic (Heller, 1889). The skeleton has been described in detail by Sumulong (1931).

Pelage of adult tamaraws is dark brown to grayish black in both sexes. A gray-white stripe runs from the inner corner of the eye toward (but does not reach) the base of the horn. Gray-white or white patches are found above the hooves, on the insides of the lower forelegs, on each side of the lower jaw and lip, and on the throat and inner surfaces of the ears. The skin and hair of the groin are white, and the bare skin of the nose and lips is black (Lydekker, 1898; Steere, 1889, 1890). At birth, calves are reddish-brown, becoming brown in a few weeks, turning slate-colored in about 3 years, and finally attaining adult coloration in about 5 years (Kuehn, 1976).

The hair is short and dense with hairs on the dorsum somewhat longer and more closely set. Like domestic water buffalos, the hair of tamaraws is directed forward from the neck to the hind-

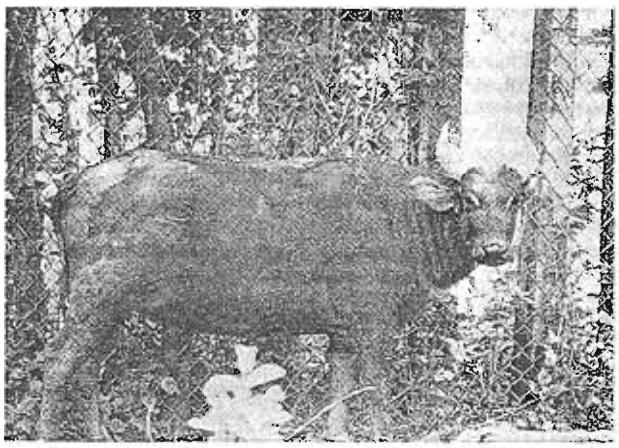


FIG. 1. Photograph of a female tamaraw, taken in 1992 at the tamaraw captive breeding center in Mt. Iglit-Baco National Park, Mindoro by V. G. Momongan.

quarters instead of backward (toward the tail). Hairs in posterior parts are directed forward, downward, and backward, resulting in whorls (Jentink, 1894; Lydekker, 1903).

DISTRIBUTION. The tamaraw is restricted to Mindoro Island in the Philippines (Fig. 3; Bourns and Worcester, 1894; Heaney et al., 1987; Steere, 1889), an island of 9,735 km² that is a distinct faunal region with at least 43% endemism among its indigenous non-volant mammals (Heaney, 1986). The tamaraw was formerly numerous and widespread on Mindoro (Meyer, 1896), but at present is restricted to three areas designated as reserves for this species: Mt. Iglit/Mt. Baco (75,450 ha), Mt. Calavite (35,000 ha), and the Mt. Mitchell (Sablayan) area (100,000 ha), all in Occidental Mindoro Province (Alcasid, 1977; Popenoe, 1983; Sitwell, 1975; the last of these does not have mapped boundaries; Fig. 3).

FOSSIL RECORD. Beyer (1957) referred several fossilized bovid teeth from surface accumulations in Novaliches Municipality and Pangasinan Province, Luzon, to *B. mindorensis*, suggesting that tamaraw occurred on Luzon as well as Mindoro during the Pleistocene. However, there has been no critical examination of these specimens, some of which are on display (in 1994) at the Philippine National Museum.

ONTOGENY AND REPRODUCTION. Tamaraws breed early in Mindoro's 6-month dry season (December–May) and cows bear their single calves in the rainy season (June–November) when vegetation is lush and weather is cool (Kuehn, 1976, 1986; Talbot and Talbot, 1966). Gestation is from 276 to 315 days (MacDonald, 1984). A cow tamaraw usually bears calves once every 2 years and young separate from their mother between the ages of 2–4 years (Nowak, 1991; Rabor, 1986). Tamaraws have bred successfully only once in captivity (Harrisson, 1969a; Oliver, 1993; World Conservation Monitoring Centre, 1994).

ECOLOGY. In the 1890s, the tamaraw was moderately common in virgin forests that covered most of Mindoro (Thomas, 1898). It occurred from sea level to nearly 2,000 m, near rivers, marshes, in bamboo thickets of secondary growth, and in grasslands (Alcasid, 1977; Grzimek, 1972; Lydekker, 1898; Rabor, 1977, 1986; World Conservation Monitoring Centre, 1994).

Current populations are confined primarily to Mt. Iglit-Baco National Park, an area of rugged topography with mountain peaks rising to about 1,000 m. The original lowland dipterocarp forest vegetation has largely been cleared by logging and fire, as has occurred throughout Mindoro (Fig. 3); three common grassland types now cover 90% of the Mt. Iglit reserve area. A tall, coarse grass called talahib (*Saccharum spontaneum*) dominates the wettest areas, and cogon (*Imperata cylindrica*) dominates the dryer areas. Shorter grasses, including *Themeda* spp., *Paspalum* spp., and *Alloteropsis semialata*, are common along the upper slopes of the ridges. Bamboo (*Dinochloa* spp. and *Schizostachyum* spp.) and secondary dipterocarp forest occur along the rivers and in small pockets along limestone ridges. There are both permanent and seasonal streams. The Mt. Iglit area has a dry season from December through May and a rainy season from June through November. Rainfall averages 300 cm annually (Kuehn, 1986; Talbot and Talbot, 1966).

Transformation of the Mt. Iglit area from forest to grassland has been attributed partially to agricultural practices of the Batangans, a tribal group that engages in shifting agriculture. Because fields are fertile for only a few years, the Batangans have opened up large areas of forest. Burning grassland prevents tree reproduction and promotes grass (Talbot and Talbot, 1966). Sitwell (1975) believed that the transformation from forest to grassland, which took place prior to 1970, was not necessarily disadvantageous to the tamaraw because young grass that covers the burned area provides food for grazing, and longer grass (which can grow to >4 m) provides cover during daylight. Tamaraws reportedly feed on *Cynodon arcuatus, Digitaria sanguinalis, Eleusine indica, Sorghum nitid-*

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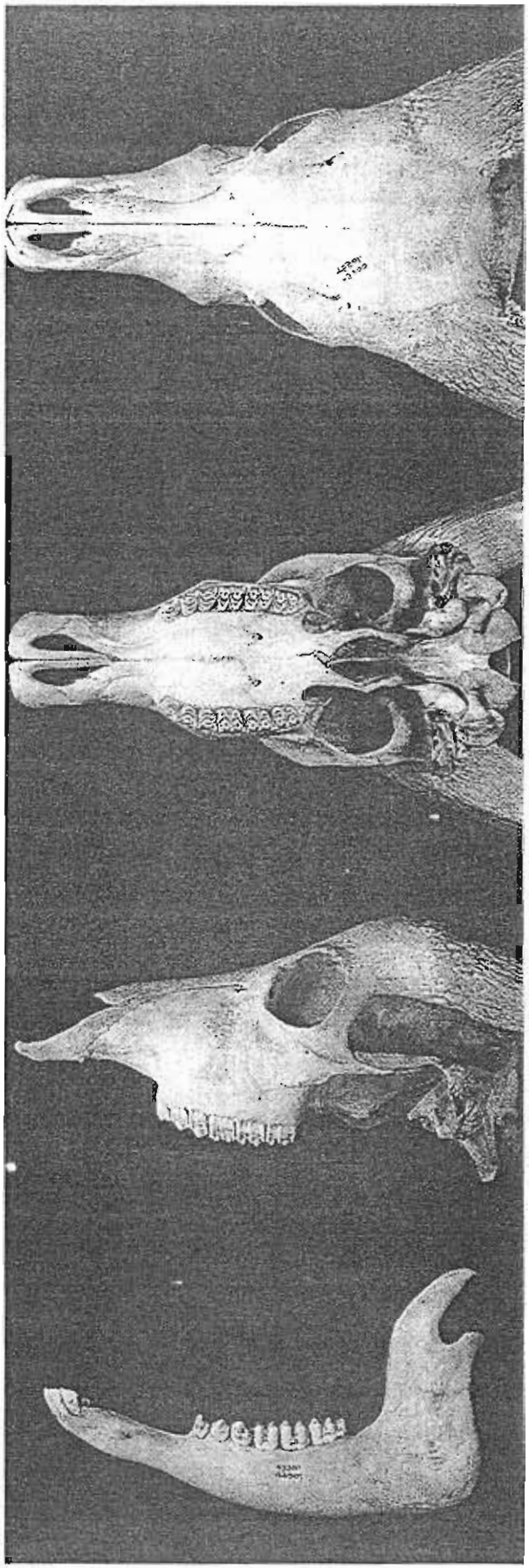

FIG. 2. Dorsal, ventral and lateral view of the skull and lateral view of the mandible of *Bubalus mindorensis*; (43300 in The Field Museum, Chicago, taken in 1935 at an unknown locality on Mindoro). Length of upper left toothrow is 102 mm.

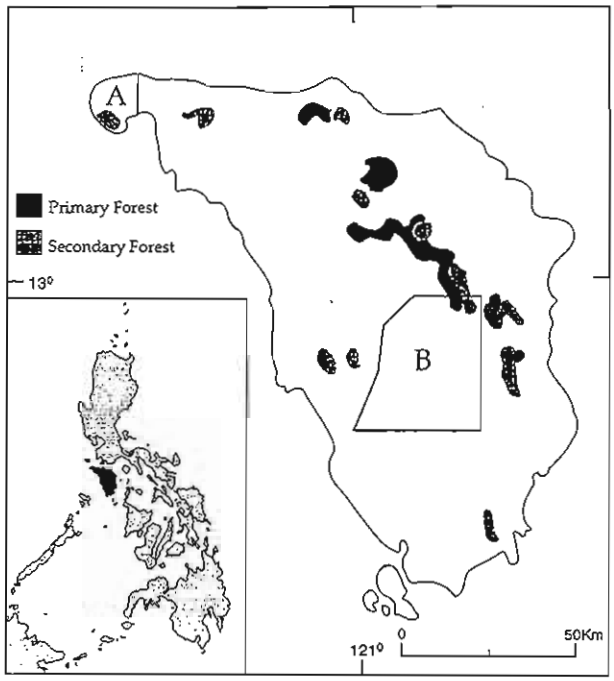

FIG. 3. Map of Mindoro Island, Philippines, showing the locations of Mt. Calavite Tamaraw Reserve (A) and Mt. Iglit-Baco National Park (B). Forest cover estimates from National Mapping and Resource Information Authority, 1988.

um, Paspalum scrobilatum, Alloteropsis semialata, and *Vetiveria zizanoides.* During the wet season, tamaraws feed on new shoots of climbing bamboo (*Schizostachyum* spp.—Talbot and Talbot, 1966). Several authors have inferred that the tamaraw's preferred habitat would be on the forest edge where safe cover, open pasture, and water to drink and wallow in are close together (Popenoe, 1983; Talbot and Talbot, 1966).

Many tamaraws fell victim to a rinderpest epidemic that swept Mindoro around 1930 (Harper, 1945; Parker, 1990). Life expectancy for tamaraw is reported to be 20 years (World Conservation Monitoring Centre, 1994).

The tamaraw is listed in Appendix I of the Convention on International Trade of Endangered Species of Fauna and Flora (World Conservation Monitoring Centre, 1994). Its population has declined from an estimated 10,000 in 1900 (Harrisson, 1969b), to 1,000 in 1949 (Manuel, 1957), 244 in 1953 (Manuel, 1957), 100 in 1969 (Harrisson, 1969b), 100 in 1970 (Alvarez, 1970), 148 in 1971 (Popenoe, 1983), 125 in 1975 (Sitwell, 1975), and 150–200 in 1983 (Popenoe, 1983). A 1987 estimate of 356 individuals is said to be "of questionable reliability" (Oliver, 1993:139). A reported decline in tamaraw populations at the end of the last century was primarily attributed to sport-hunters and a few professional hunters (Thomas, 1898). During the American colonial period in the early 1900s, a bag limit of one male tamaraw per hunter per year was set and Calavite Mountain was declared a reserve where no hunting of tamaraw was allowed. Commonwealth Act No. 73, enacted in 1936 and still in effect (La Vina, 1991), provides for complete protection of both sexes, except for protection of human life and property or for scientific purposes, with proper authorization from the Secretary of Agriculture and Commerce (Grzimek, 1972; Harper, 1945; Kuehn, 1976; World Conservation Monitoring Centre, 1994).

As the population declined from 1940 to 1975, sport hunting, logging, poaching for food, and settlement of a large part of its range were identified as main causes of depletion (Harper, 1945; Kuehn, 1976; Talbot and Talbot, 1966). Soaring human populations, logging, and ranching have devastated habitats up to 1,000 m on Mindoro (Harrisson, 1969*a*, 1969*b*; Kuehn, 1976; Talbot and Talbot, 1966). As recently as the 1960s, farmers and ranchers on Mindoro regularly hunted tamaraws (Grzimek, 1972; Talbot and Talbot, 1966). Hunts using helicopters were also reported in 1968 (Harrisson, 1969*b*). In the 1960s and 1970s, poaching was aggravated by availability of firearms (Popenoe, 1983; Sitwell, 1975; Talbot and Talbot, 1966).

In 1969, the International Union for the Conservation of Nature and Natural Resources, World Wildlife Fund, and Philippine government developed a plan to protect the tamaraw (Alcasid, 1977; Harrisson, 1969*a*, 1969*b*). Although the population in the Mt. Iglit area appeared to have increased substantially during the early 1970s due to active protection efforts (Kuehn, 1976, 1986), success declined in the late 1970s. Popenoe (1983) and Oliver (1993) described a project begun in 1979 that established a small semi-captive population in an enclosed 400-ha area in the Mt. Iglit refuge that could be guarded, studied, and managed. Nearly all 20 animals captured for this project had died by 1993, and the project was declared a failure (Oliver, 1993). Current evidence indicates that the tamaraw population continues to decline (Heaney and Utzurrum, 1991; Oliver, 1993).

BEHAVIOR. Tamaraws are traditionally described as ferocious and aggressive (Alcasid, 1977; Bureau of Insular Affairs, 1903; Harrisson, 1969*b*; Kuehn, 1976; Lydekker, 1898; Rabor, 1986; Sitwell, 1975; Steere, 1889; Talbot and Talbot, 1966; Worcester, 1914). Although some reports state that aboriginal people of Mindoro never attacked tamaraws (Bureau of Insular Affairs, 1903; Thomas, 1898), other reports describe natives capturing them by means of rope snares suspended from trees, corral traps, and pitfalls (Harper, 1945). Hunting tamaraws with firearms is described as difficult and dangerous (Bureau of Insular Affairs, 1903).

Adult tamaraws are largely solitary; 82% of 218 observations of adult bulls were of lone individuals, and 66% of 107 observations of adult cows were of individuals alone or with calves (Kuehn, 1986). The largest aggregation seen during the most intensive study consisted of an adult bull, three subadult bulls, an adult cow, and a calf (Kuehn, 1986); Talbot and Talbot (1966) reported a grouping of 11 animals. A bull and a cow may be seen together any time of year, but the association is casual and frequently breaks up within hours except during breeding. Adult females have been seen accompanied by three young of different ages (Kuehn, 1976, 1986). Groups of juvenile tamaraw sometimes persist for a year or longer, but as animals grow older they become less social, especially after they reach adulthood at about 6 years (Bureau of Insular Affairs, 1903; Kuehn, 1976, 1986; Rabor, 1986; Talbot and Talbot, 1966).

Although fights between bulls have not been observed, agonistic behavior between bulls is commonly associated with breeding, with habitat reduction caused by annual fires, and with range expansion by juvenile bulls (Kuehn, 1986). Tamaraws have not been seen to use earth-tossing or vertical head movements as threats, as do water buffalo. Cow tamaraws threaten conspecifics by lowering their heads until their horns are nearly vertical and then shaking the horns laterally, a behavior similar to that of domestic cattle (Kuehn, 1986). Male tamaraws older than 3 years and female tamaraws older than 4.5 years were not observed in family groups; individuals of either sex older than these ages apparently are driven off (Kuehn, 1986). The observation of a tamaraw cow grazing 50 m from her neonate, which lay stretched out along the ground, suggests that calves behave as typical "hider" species (Kuehn, 1986).

Traditional descriptions of tamaraws emphasize their aggressive and suspicious behavior toward humans. For example, they are often said to turn about and face back down their own trail before lying down to sleep (Bureau of Insular Affairs, 1903; Worcester, 1914). Worcester (1914:826, 827) further reported that tamaraws circle back on their trail "before lying down, so that while one is still a mile or two from it by the line which it followed, it may in reality be not more than fifty or hundred yards away." When being pursued, a tamaraw "will almost invariably back off at right angles to its own trail, waiting for pursuers to come up, and charge them, giving them no time to fire."

Most authors state that tamaraws sleep during the day in dense vegetation, feed at night, and visit nearby water courses before morning in order to drink (Bureau of Insular Affairs, 1903; MacDonald, 1984; Talbot and Talbot, 1966; Worcester, 1914). Steere (1889), however, stated that they may feed and move about during both day and night. Ranchers on Mt. Iglit reported that when ranches were first established in the early 1960s, tamaraws were relatively tame and could be seen grazing in the open during daylight. With continued hunting, they became more secretive and aggressive in their habits (Talbot and Talbot, 1966).

Tamaraws wallow in mud like water buffalos (Lydekker, 1898;

Steere, 1889), and mud wallows are often present within tamaraw habitat (Talbot and Talbot, 1966). Captive individuals feed most frequently from 06:00 to 10:00 and 18:00 to 22:00; feeding and rumination occupy 24 and 26% of the day, respectively. Wallowing is more frequent during the day than during the night; running and pawing dirt are most often observed during the night (Momongan and Walde, 1993).

GENETICS. A female tamaraw had a karyotype of 2n = 46; this differs from the karyotype of *Bubalus (Anoa) depressicornis*, which has 2n = 48, by the lack of one acrocentric pair (Fischer and Hohn, 1976).

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TAMARAW
(*Bubalus mindorensis*)

Population and Habitat Viability Assessment

University of The Philippines Los Baños
College, Laguna, Philippines

15-17 May 1996

Report

SECTION 3

Wild Population Status and Management

GROUP I. WILD POPULATION MANAGEMENT

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I. History of Wild Population

The Twentieth century has seen a dramatic decline in the number of tamaraw. Many died during an outbreak of rinderpest in or around 1930 (Grzimek, 1990); and despite being legally protected since 1936 Harper (1945) warned that the species was threatened with extinction if habitat loss and illegal hunting were not controlled.

Harper's warning proved prophetic. The numbers of tamaraw declined precipitously in the years following World War II as a result of hunting (using high-powered rifles and automatic weapons in addition to the more traditional spears and pit-traps) and the continued loss of suitable habitat due to logging activities, ranching, and an increase in the local human population (Rabor, 1961; Talbot & Talbot, 1966; National Research Council, 1983). From a total population of perhaps 10,000 individuals in 1900 (Harrisson, 1969a), tamaraw numbers had decreased to about 1000 by 1949. In 1953 there was an estimated population of only 244 (Manuel, 1957). Hediger (1965) estimated that there were not more than 200-250 left on the island and in the late 1960's there were reports that hunting had intensified - even helicopters were being used. By 1969 it was thought that only about 100 survived (Harrison, 1969b; Alvarez, 1970). In 1971 it was estimated that about 150 - 200 tamaraw remained, including about 80 in the Mount Iglit Game Refuge (Kuehn, 1975, 1976, & 1977; National Research Council, 1983); while in 1982 the Presidential Committee for the conservation of the Tamaraw (PCCT) estimated that a maximum of 250 tamaraw remained on the island.

In 1987 the Conservation and Resource Management Foundation (CRMF) estimated that there were 356 wild tamaraw on Mindoro (Petocz, 1989b). These animals were believed to be distributed as follows:

Mount Calavite Tamaraw Reservation	45
Mount Halcon - Eagle Pass	65
Santa Cruz - Pinagturilan	20
Mount Iglit-Baco NP (Mangyan Heritage Park)	145
Aruyan - Mapad Valley	41
Victoria - Bansud - Bongabong - Mansalay	40

At first glance these figures are encouraging since they suggest that there has been an increase in the tamaraw population in Mindoro since 1982. Unfortunately, the CRMF survey was based almost entirely on information obtained from local people in a few villages, along with some incidental observations of tamaraw tracks (Cox & Woodford, 1990); and as a consequence the results are potentially very misleading.

Since the CRMF survey there have been a number of other estimates of the number of tamaraw on Mindoro: Callo (no date b) estimated that the total number was probably more than 500 in 1990, he also suggested that the population was increasing; however Read *et al* (1994) mentioned an estimated population of about 250 individuals and the population was thought to be declining.

Unfortunately all of the figures referred to above are in reality little more than guesses. There has never been a systematic survey of tamaraw using acceptable methods. The working group formulated some guidelines for improving tamaraw surveys which are included in an Appendix to this section.

II. Current Status

During the course of the PHVA workshop we attempted to compile the most recent reports of tamaraw sightings in order to determine whether we could list those areas where tamaraw definitely still existed in the wild in 1996. We also listed the most recent 'guesstimates' for the size of those populations. The results of this process are shown in table WILD1. It will be seen from the table that in 1996 we can only say with confidence that tamaraw still exist in 2 areas: Iglit-Baco NP and the Aruyan area; it also appears that the Iglit population is larger than the Aruyan population. The only other area on Mindoro where tamaraw have been confirmed in the 1990s is Mount Calavite Tamaraw Reservation (1 animal was seen in 1994).

III. Threats to the Wild Population

The decline of tamaraw populations on Mindoro has been largely due to habitat loss and hunting. Both these factors remain as serious threats today but the group identified hunting as the most serious threat. Table WILD2 lists those areas where tamaraw are either known to occur or are suspected to occur based on the CRMF survey and indicates the major threats to tamaraw in those areas. Suggested responses are also listed.

CENSUS AND DISTRIBUTION				
MOST RECENT REPORTS OF TAMARAW				
AREA	YEAR	PRESENCE / ABSENCE	ESTIMATE OF POPULATION SIZE	METHOD / COMMENTS
	1995/		175 (TCP)	extrapolation
1. Iglit-Baco NP	1996	present	> 45 (TCP)	total count
1.a. Iglit Ranges (2700 ha)			< 20 (KMFI)	total count
1.b. Elsewhere in park	1995	?		doubtful reports from locals
2. Mapad Valley	1987	reported present by CRMF		
		disputed by KMFI	?	
3. Aruyan	1994/1995	present	14 (KMFI) 1994 / 30 (TCP)	total count
	1996	present	unknown numbers (KMFI)	field visit
Note: Iglit-Baco (Iglit Ranges) and Aruyan are the only two areas in Mindoro				
where we know there are tamaraws in 1996				
4. Eastern Mindoro (Victoria -	1987	present	~ 40 (CRMF)	interviews / field visits
Bansud - Bongabong -				
Mansalay)				
5. Santa Cruz - Pinagturilan	1987	present	~ 20 (CRMF)	interviews / field visits
	1996	doubtful	0 ? (KMFI)	now villages
6. Mt. Halcon - Eagle Pass	1987	present	~ 65 (CRMFI)	interviews / field visits
7. Mt. Calavite	1987	present	~ 45 (CRMF)	interviews / field visits
	1994	present	> 1 (KMFI)	field visit
Summary: Only 3 areas have been confirmed as having tamaraw populations in the 1990s; and only 2				
are known to remain in 1996. The 2 areas are the Iglit ranges and Aruyan but unfortunately we have				
very few data on population sizes in either site. Estimates for the Iglit ranges vary from < 20 to				
~ 175, and figures of between 14 to 30 have been suggested for Aruyan.				

GROUP I. WILD POPULATION MANAGEMENT: WILD2

THREATS	RESPONSE				AREA						
	a	b	c	d	1*	2	3	4	5*	6	7*
Hunting	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ranching	Y	Y	Y	Y	Y	x	x	Y	Y	x	Y
Shifting Agriculture	Y	Y	Y	x	Y	Y	Y	Y	Y	Y	Y
Burning	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Logging	Y	Y	Y	Y	Y	x	Y	Y	Y	x	Y
Diseases	Y	x	Y	x	Y	?	?	Y	Y	x	Y
Squatters / Transmigrants	Y	Y	Y	Y	Y	Y	Y	Y	Y	x	Y
Captive Breeding	Y	x	Y	x	Y	P	Y	P	P	P	P
Capture for Commerce (smuggling)	Y	Y	Y	Y	P	P	P	P	P	P	P
Permanent Agriculture and Expansion	Y	Y	Y	Y	Y	x	Y	Y	Y	x	Y
Ancestral Domain Claims	Y	x	Y	x	Y	Y	Y	Y	Y	Y	Y

Legend:

Area
1. Iglit-Baco NP
2. Mapad Valley
3. Aruyan
4. Eastern Mindoro
5. Santa Cruz - Pinagturilan
6. Mt. Halcon - Eagle Pass
7. Mt. Calavite

P = potential
Y = with threat
x = no threat
* = tamaraw conservation area
? = uncertain

Response
a. community-based management
b. implementation of laws (i.e. enforcement)
c. IEC (information, education, communication)
d. protection (permanent ranger force)

IV. Carrying Capacity

The working group was asked to come up with an estimate for the tamaraw carrying capacity of the Iglit Ranges area in Iglit-Baco NP (this estimate was required by the population modeling working group). After much discussion of the theoretical and practical difficulties of measuring carrying capacity it was decided that too few data existed to produce a meaningful estimate of the

tamaraw carrying capacity for the Iglit ranges area. However to facilitate the modeling process the group decided to recommend using the following range

3 --> 10 animals / sq. km.

(These figures are based on Lustria and Callo's work and KMFI's observations in Iglit-Baco NP as well as data from wild buffalo populations elsewhere in Asia.)

V. Management Needs

1 and 2A-C are equal top priorities

1. Increase protection for Iglit ranges & Aruyan areas (i.e. establish ranger posts & provide resources for rangers and local volunteers).

2A. Training course in survey / census methodology + development of acceptable standard techniques for tamaraw.

2B. Survey to confirm presence / suspected absence in all areas where tamaraw have been reported plus all other areas of potential tamaraw habitat.

2C. Select high priority areas for more thorough surveys & censuses if possible.

3. Assess the need for habitat management such as burning + possible reforestation and include training of habitat management personnel.

4. Monitor all populations (population status and threats).

5. Development of management plans for all important areas.

6. Recommend that any areas which contain major tamaraw populations be declared as protected areas (if they are not yet included).

7. Enforcement of existing legislation.

VI. Research Needs

8. Initiate a long-term study (3-5 yrs minimum) of ecology and behavior of tamaraw in the wild; the study should include an investigation of:

    a. habitat requirements

b. response to habitat management (linking to management needs)
c. response to disturbance
d. social organization
e. population dynamics

VII. Genetic Needs

9. Collection of hair samples, horns, skulls (plus any other required material) from any carcasses / other remains found plus any animals taken by hunters.

VIII. Wild Group Concerns About the Captive Program

While the group recognized the good intentions of the captive management team the wild population working group still had the following concerns:

1. We recommended that no animals should be caught until the program had demonstrated its capability over a 3-year period by:

i) closing the gene pool and moving all the tamaraw (successfully) to a new site on Mindoro. (We further recommended though that the site should be converted to a guard post.) and

ii) by establishing the highest possible standards of animal husbandry.

Furthermore,

i) there should be an independent evaluation of the program before any decision to catch new founders is taken; and

ii) the status of wild tamaraw on the island needs to be assessed before any new founders are caught

2) Captive breeding is expensive and may detract from conservation of wild tamaraw and wider biodiversity conservation in Mindoro, therefore international support for captive program should be looked-for (limited Philippine Government money should not be used unless essential).

3) A clear statement of the aims of the captive program is required and recognition that conservation of tamaraw takes precedence over experimental hybridizations, etc.

IX. Recommendations

Top Priorities (1=2 joint top)

1. Protect the known populations in Iglit Ranges and Aruyan by creating a dedicated tamaraw protection force (TPF). This force should be created, equipped, and deployed as soon as possible.

a. This TPF requires 20 rangers + support staff as shown below (the TPF should include the existing TCP Tamaraw Survey Team personnel):

Iglit: 5 teams of 2 rangers, plus 2 support staff = 12 people
Aruyan: 2 teams of 3 people (2 local rangers + 1 indigenous person) + 2 support staff = 8 people

b. The existing guard post in the Iglit ranges area should be rehabilitated.

c. Each team needs a radio, there should also be a base camp radio; each team will need 2 pairs of binoculars.

d. The protection force will also need 2 motorbikes and 1 four-wheeled vehicle plus 8 horses (disease risk needs to be considered).

Notes:

1. The group was divided over the need for guns
2. A local NGO (KMFI) agreed that such a strategy would help their efforts to protect tamaraw
3. All rangers should be local residents.
4. A permanent presence of the group must be maintained in Aruyan / Mapad and Iglit ranges
5. The Rangers must be deputized by DENR to give them police powers.

2. Organize a training course to demonstrate appropriate survey methods and initiate a tamaraw survey. This should start as soon as possible.

Part 1. Organize a training course in survey methods to be followed with an island-wide presence / absence survey plus a more extensive survey in the Iglit ranges to determine minimum population size in the area.

Part 2. Conduct more extensive surveys / censuses in areas identified as important in Part 1 above.

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Part 3. Initiate follow-up monitoring of population status and threats in all areas with major tamaraw populations.

[This complete program should be initiated as soon as possible and will probably require about 2 years]

3) Conduct an independent evaluation of TCP accomplishments annually.

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CENSUS, SURVEY, AND MONITORING TECHNIQUES

Introduction

At the present time we know very little about how many tamaraw remain and all of the counts which have been conducted have been brief and rather crude. Counts using robust and reliable techniques are urgently needed.

Before starting an animal count the goals of the project must be well defined (i.e. what is the information needed for?). A major consideration is whether absolute numbers are ever required. In almost all cases indices of relative abundance combined with information on population trend is adequate for wildlife managers and conservation planners. However in the case of the tamaraw there is a need to try and obtain figures for minimum size in all key areas in order to facilitate planning. Careful thought must be given to the level of confidence required, and the time, resources, and number of interested and dedicated people available.

Definitions

For the purpose of this report we will use the following definitions:

Survey: Attempt to produce an index of relative abundance.

Census: Attempt to estimate the absolute number of animals in an area.

Monitoring: Attempt to assess population trends over time through repeated surveys or censuses.

Below is a list of potential techniques which can be used for censussing, surveying, and monitoring wild bovid populations; their suitability for tamaraw is assessed in the 'Discussion' section.

Techniques

Faecal Techniques

Advantages: relatively cheap (time and money required are low); good for estimating relative abundance. Better than sightings for low density populations. Major problems: confusion will arise if > 1 species produce similar faeces, needs good quality data on decay rate, cannot be used for census unless information is available on defecation rate (very limited data are usually available), provides no information on population structure, and many animals defecate in a non-random fashion thus requiring a large sample size. Rainy season rapid decay rates in the tropics frequently make this technique unsuitable except in areas of high population density. There are two major ways of recording faecal abundance: line transects and plots.

1. Line transects. This includes any technique in which a known line is patrolled, and the perpendicular distance from the line to the faecal piles is recorded. Advantages: can provide good quality data with confidence limits, a widely used technique; it is frequently more efficient, as more time is spent collecting data; allows for quantitative compensation for samples of unknown origin (i.e. dung from unknown species).

2. Plots. This involves any technique in which plots are designated on the ground and dung piles are counted within them. Advantages: in areas of very high abundance sampling is easier; more effective than line transects in areas of poor visibility such as tall grass; and easier in rough terrain.

Sighting Techniques

Advantages: can get information on population structure and animal condition, there is usually no problem of identifying species. Disadvantages: requires good visibility.

1. Line transects. Advantages include the fact that this method can provide good quality data with confidence limits, and that it is a widely-used and hence well-known technique. Difficult to do in areas of rough terrain or poor visibility; can't be used effectively along roads, rivers, or cut transects [for statistical reasons], therefore, walking a known line and recording distances is difficult; for herding animals, results are expressed in density of groups (possibly reducing the utility of the data); can be very time consuming, especially in areas of low density.

2. Drive counts: This technique involves having many people walking systematically through a known area and counting animals that are flushed. Requires many people, a good organizer, good visibility, and large animals. Even in the best conducted drive counts some animals will be missed leading to under estimation of density.

3. Count/recount known animals. This technique is based on the same idea as capture/mark/recapture. Requires individual identification of a sufficient number of animals in the population, and good visibility so that re-sightings are frequent.

4. Concentration counts. Any simultaneous count made at points where animals may congregate, such as water holes, mineral licks, etc. This method is generally only suitable for crude monitoring within an area but if sufficient people are available for well-planned and well-coordinated intensive counts they can be useful.

5. Automatic camera "traps": Any set-up involving the use of cameras with automatic trigger systems (e.g. trip wires), such that an animal may be photographed as it moves through the area. This method may be justified for very rare species in which sufficient funding is available. Most useful for determining presence/absence. Possibly allows for the identification of individuals.

6. Aerial surveys: Very expensive, appropriate in areas that are large and at least seasonally open.

7. Block searches: Predefined blocks are systematically searched ideally using teams of people. All animals sighted are recorded. Advantages: Produces detailed information on habitat, behavior and ecology in addition to numbers. Disadvantages: Requires much careful organization and preparation, and lots of people, time, and money.

Track Counts

For large herding animals the technique is only of use for determining presence/absence of a species in an area, provided there are no other similar species or domestic forms in the area.

Discussion and Identification of Suitable Methods for Wild Tamaraw

The issue of which techniques to use for various purposes is complex, and depends on factors such as available resources (financial, time, and manpower), environmental conditions, size of the area to be surveyed, number of similar species in the area, and behavior of the animal in question. We recommend that prior to the start of any census or survey advice is sought from people with experience of counting large terrestrial herbivores in similar environments.

Tamaraw are small, rather solitary animals which live in areas of rough and mountainous terrain which is often densely vegetated (i.e. the areas are covered with tall grasses, bamboo thickets, etc.). Visibility is therefore very poor for most if not all of the year within tamaraw habitat. Furthermore tamaraw now appear to live at low population density. Given these factors it is extremely difficult to survey tamaraw populations and probably impossible to census them.

Methods <u>Not</u> Recommended:

Track Counts: Track counts can only be used for determining presence or producing very crude indices of relative abundance. However there is the problem of distinguishing tamaraw tracks from water buffalo (carabao) tracks. Local people say they can tell the difference but this would require rigorous testing (by blind-tests) before the method could be used.

Faecal Techniques: Not recommended because: 1) The problems of distinguishing dung from domestic and/or feral buffalo and cattle (again local people say that they can tell the difference but this would require rigorous testing). 2) The problems of determining dung decay rate and tamaraw defecation rate. Both are required for censuses; defecation rate is not necessarily required for surveys but decay rate is, and obtaining sufficient decay rate data might still present problems (particularly if the rate proved to be highly variable spatially and/or temporally). 3) Because tamaraw population density is now likely to be very low, design of an appropriate sampling strategy would be difficult.

Sighting Transects: Not recommended because a combination of poor visibility and low tamaraw density will mean too few animals will be seen for censuses (confidence limits from line-transects would be too large); and even for surveys the encounter rates would render the method very inefficient. In any case the practical difficulties of moving through tamaraw habitat and watching for tamaraw at the same time suggest that sighting transects would never be useful techniques. Furthermore tamaraw have been reported to be largely nocturnal/crepuscular in many areas.

Aerial Surveys, Count/Recounts of Known Animals, Block Searches: Similar problems of visibility, low density, and the animal's largely nocturnal behavior recommend against these techniques.

Drive Counts: The poor visibility and difficulty of walking through areas of tall and densely growing grass in mountainous areas suggest that this technique would not be suitable because too many animals would remain uncounted (and because one cannot assume a constant proportion of animals go uncounted in different areas or at different times, the method is not suitable even for surveys and monitoring).

Methods Which Could be Used:

Automatic Camera "Traps". Could be used to confirm presence but cannot be used for surveys unless individual animals can be recognized and large numbers of cameras are available. (Obviously an expensive technique and cameras may be stolen!)

Recommended Method:

Intensive Concentration Counts (i.e. Simultaneous Multi-vantage Point Counts). If good maps (1:50,000 or 1:25,000) and sufficient numbers of well-prepared keen observers equipped with compasses and binoculars and/or spotting telescopes can be made available it is recommended that this survey technique is assessed in the field (because it seems to be the only potentially suitable method). The basic idea is to:

1) Divide the area to be surveyed into relatively small blocks (the size of the blocks will depend on the terrain and the number of observers); and then select a large number of areas where tamaraw feed and/or drink and which can be seen from (mapped) vantage points within each block.
2) Station pairs of observers at all these points simultaneously so that they can count all tamaraw using those areas, noting time, the bearing from the vantage point, and the age and sex of the animals.
3) Map the sightings and analyze the resulting data to produce a figure for the minimum number of tamaraw living in an area. 4) Repeat the counts several times in order to maximize the number of animals seen (taking sex and age composition into account). This technique requires a great deal of organization and coordination to be successful. At least one orientation/preparation visit to the area to be surveyed will be required.

TAMARAW
(*Bubalus mindorensis*)

Population and Habitat Viability Assessment

University of The Philippines Los Baños
College, Laguna, Philippines

15-17 May 1996

Report

SECTION 4

Population Biology and Modeling

Population Biology and Simulation Modeling

Group Members: Perry Ong, Annabelle Sarabia, Maximo Quimbo, Manuel Bravo, Roberto Rubio, Kazuaki Tanaka, Chester Solis, Lorilie Rizaldo, Jonathan Ballou.

The task of this group is to: a) determine what is known of basic life-history data of the tamaraw; b) use simulation population modeling to identifying those life-history parameters which are not known but of critical importance to evaluating the viability of wild tamaraw populations; 3) use population modeling to evaluate the effect that various threats and possible management actions might have on wild population viability; and 4) explore the implications of different captive population goals on captive population sizes needed and numbers of new founders needed to achieve those goals. We used the VORTEX (Version 7.2) stochastic simulation model (Lacy 1995) for these projections.

LIFE HISTORY PARAMETERS

Data on tamaraw were taken from the reports of Kuehn (1986), Callo (1983), Lustria and Callo (1992 and this workshop), and field surveys conducted in 1995 and 1996 (Quimbo, report at the PHVA workshop). These data were very useful in providing information on number of females observed with calves and sex ratios of adults. Otherwise, very little is known about the life-history of tamaraw. To a large extent, life-history parameters were extrapolated from what is known of other buffalo species, in particular other *Bubalus* species.

Age of first female calving: Age of female at first calving is unknown. In one case in captivity, estimated first calving occurred at age 6. In other buffalo, females can calf as early as 3. We initially used age 5 in the model. The effect of varying the age of female first calving was examined in the section on Model Sensitivity, below.

Age of male calving: Again very little is known, but it was generally agreed to be age 4-5. We used age 5.

Breeding System: Breeding system is unknown, but assumed to be polygynous as in other *Bubalus*. Observations taken of groups in the wild in 1995/96 indicate that tamaraw are seen as solitary animals in 30/43 times (70%; 32% solitary males, 38% solitary females with or without young), male/female pairs in 9/43 (21%) pairs, and single males with more than one female in 4/43 (9%) groups. Single males with more than one female were the minority of observations. This led Callo (report at this workshop) to speculate that tamaraw might be monogamous. However, these observations were not taken during breeding season. In addition, monogamy in bovids would be extremely unusual. Based on the biology of other *Bubalus* species, which are known to be monogamous, we assumed that tamaraw were also monogamous. Nevertheless, we examined the effect of assuming monogamy vs. polygyny and various degrees of polygyny (as measured by # females bred by each male).

Maximum age of reproduction: Again, nothing is known. A male in captivity is currently 17 years old, but it is not known if he is still reproductively capable. From data on water buffalo, it was thought that maximum age might be between age 17 to 25. Initially we used age 23, but this was varied in the model below.

Sex ratio at birth: Assumed to be 50/50.

Proportion of females reproducing: In captivity, two cases show an inter-calf interval of 712 days (about 2 years). In water buffalo, birthing interval is also 2 years (Camoens 1976). Kuehn (1986) observed ten females with a total of 8 calves (0 to 2 years of age) for a ratio of .8 calves/adult female for a two year period. Based on the Quimbo's July 1995 to April 1996 field observations, there were a total of 26 adult females and 17 calves (age 0 to between 1 and 2 years old) observed, for a calf/female ratio of .65. These rates are over periods of two years because calves are aged 0 to 2, therefore they need to be divided in two to give annual reproductive rates. Also, these ratios are after early calf mortality, so these estimates need to be adjusted upwards by early mortality to give calf/female ratios at time of calving. Using the calf mortality of 20% for the first year and 5% for the second year (see mortality below), survival through age 1 is 76%:

From Kuehn (1986):

Proportion of females calving = (Proportion females with calves)/(2-year survival) = .8/.76 = 1.05

Annual reproductive rate of females = 1.05/2 = .50

From Quimbo (report this workshop):

Proportion of females calving = (Proportion females with calves)/(2-year survival) = .65/.76 = .8

Annual reproductive rate of females = .8/2 = .40

However, if we assume that calving age of females is 5, then some proportion (11% based on stable age distribution) of the females in the above observations will be subadults. If we remove this proportion from the total adult females, we get the following estimates of % females producing:

Kuehn (1986) 8 calves/9 females = .88/.76 = 1.17/2=.58
Quimbo(this workshop) 17 calves/23 females = .74/.76=.97/2=.48

Under these two scenarios, annual reproductive rates varied from .4 to .6. We used .5 in the model. This is lower than the rates observed in African buffalo (about .7; Sinclair 1977). We will examine various rates of female productivity in the modeling.

Mortality: Mortality rates in tamaraw are unknown. Examples of estimates for other species is 18% for domestic populations of Water buffalo (Camoens 1976), and 33% for African buffalo (Sinclair 1977). We used these values as guidelines and examined a range from 18% to 33%. We assumed that post-calf mortality was constant (ages 2 through longevity). In water buffalo, annual mortality is 4.6% (Camoens 1976), and in African buffalo, we estimated 6% for females and 8% for males (from data in Sinclair 1977). We used 5% in our initial models, but examined the effect of increasing these rates on population viability. Lacking data to the contrary, we assumed mortality rates of males and females were the same. Observations by Kuehn (1986), Lustria and Callo (1991) and the Quimbo (report this workshop) show a variety of sex ratios of adults, none of which are statistical different from equal sex ratio (using chi-square, $p > 0.05$; but sample sizes are quite small):

Sex ratios observed:

Study	Adult Males	Adult Females	Males:Females
Kuehn 1986	20	15	1:0.75
Lustria & Callo (1991)	8	10	1:1.25
Callo (1983)	7.3	8.9	1:1.22
Quimbo (this workshop)	28	36	1:1.27

Estimates of Standard Deviations on All Parameters: Data to estimate standard deviations on life-history parameters for tamaraw are not available for any parameters. Some limited variance estimates are available for water buffalo: standard deviation in adult mortality across seven regions was 0.02, or about 40% of the mean; standard deviation in calf mortality across 25 herds was 18%, or about 100% of the mean (Camoens 1976). However, differences among herds and regions are magnified by differences in management practices. We used a conservation standard deviation of 30% for all parameters, but tested the effects of higher variance in the sensitivity analysis below.

THE BASELINE MODEL

The above rates were used in the VORTEX model. This Baseline Model was used to represent life-history characteristics in good conditions and in the absence of any threats.

The resulting deterministic growth rate (r) was 0.055, with a generation length of 11 years (which may be a bit high). Ratio of calves (ages 0 to 2) to adults from the stable age structure was .25. This corresponded well with field observations:

Study	Calves	Adults	Ratio
Kuehn (1986)	10	41	.20
Lustria & Callo (1991)	7	19	.27
Callo (1983)	7.6	16.7	.31
Quimbo (this workshop)	17	64	.21

Additionally, the growth rate corresponded well with potential population growth rates in African buffalo (5 to 7%; Sinclair 1977).

Below we examine both the effect of changing the assumptions we made about some of the life-history parameters on population viability and growth rate, as well as the effects of various risk factors in tamaraw populations of different sizes.

SENSITIVITY ANALYSIS OF LIFE-HISTORY PARAMETERS

Baseline data: The Baseline Model was applied to populations of two sizes: N=175 and N=20, to reflect a range of possible population sizes in tamaraw and because effects of parameter values may be more important in smaller populations than larger populations. A population size of 175 was selected using the average density of tamaraw per km^2 (which ranged from 3 to 10) provided by the group discussing the wild population. The size of 20 was the lowest estimate provided for the Mt. Iglit-Baco population.

The following measures of population viability were recorded from the VORTEX outputs: r (stochastic intrinsic rates of increase), standard deviation of r, probability of extinction by 100 years [P(E)], population size at year 100 (N, and its standard deviation), and % heterozygosity remaining at 100 years (Het). Population projection simulations were run 200 times.

The Baseline Model gave the following results:

	r	SD(r)	P(E)	N	SD(N)	Het
N=175	0.051	0.062	0	172.22	5.3	94.63
N=20	0.044	0.103	0.035	18.37	2.74	58.36

A) Maximum age of reproduction:

We varied maximum age of reproduction from 15 to 25 years of age (baseline model maximum age was 23 years). The results are as follows:

Scenario	r	SD(r)	P(E)	N	SD(N)	Het
N=175						
Max age=15	0.026	0.064	0	167.24	11.49	93.84
Max age=25	0.053	0.061	0	172.35	6.1	94.68
N=20						
Max age=15	0.014	0.123	0.27	15.45	4.82	52.36
Max age=25	0.047	0.101	0.035	18.54	2.62	61.14

Interpretation: although decreasing maximum age of reproduction to age 15 does decrease r values to at most one-half the base values, this appears not to affect population viability in the large population. In the small population (N=20) decreasing age to 15 increases the probability extinction almost nine-fold (from 3.5% to 27%).

B) First year mortality. We decreased first-year mortality to 10% and increased it to 35% (baseline model was 20%):

File	Scenario	r	SD(r)	P(E)	N	SD(N)	Het
111	N=175						
	10% Mort	0.06	0.061	0	173.92	4.83	94.51
112	35% Mort	0.035	0.065	0	170.98	8.50	94.88
211	N=20						
	10% Mort	0.054	0.101	0.025	18.6	2.59	58.92
212	35% Mort	0.029	0.108	0.095	17.11	3.80	58.52

Interpretation: Increasing mortality to 35% reduced r about 2%. Again, this did not affect survival of a large population, but did triple probability of extinction in the small population.

C) Post-calf mortality (two years or greater). We decreased post-calf mortality to 2% and increased it to 8% (baseline is 5%):

File	Scenario	r	SD(r)	P(E)	N	SD(N)	Het
113	N=175						
	Mort=2%	0.089	0.052	0	174.9	4.35	94.54
114	Mort=8%	0.030	0.070	0	168.32	9.99	94.25
213	N=20						
	Mort=2%	0.085	0.085	0.005	19.52	1.58	60.5
214	Mort=8%	0.023	0.124	0.17	15.89	4.01	50.27

Interpretation: life-history parameters were extremely susceptible to annual mortality rates. Increasing post-calf mortality resulted in an almost five-fold increase in probability of extinction in the small population.

D) Variation in age of sire and dam at time of calf drop. We varied this from 3 years to 6 years (baseline was 5):

File	Scenario	r	SD(r)	P(E)	N	SD(N)	Het
102	N=175						
	Age=3	0.076	0.068	0	174.24	4.5	93.5
103	Age=4	0.062	0.065	0	173.68	4.88	94.08
104	Age=6	0.041	0.059	0	171.88	5.78	94.96
202	N=20						
	Age=3	0.069	0.106	0.02	18.87	2.15	54.62
203	Age=4	0.055	0.105	0.04	18.38	2.79	57.67
204	Age=6	0.035	0.102	0.05	17.52	3.48	60.78

Interpretation: decreasing age of first calving to age 3 or 4 did result in an increase in population growth rate and a decrease in the probability of extinction in the small population from about 4% in the standard to 2%. Delaying age of calving likewise increased prob. extinction by about 2%.

E) Degree of Polygyny. We varied the degree of polygyny in terms of the number of females bred, on average by each breeding male. This is similar to varying herd size. All adult males were considered available for breeding. We examined a monogamous breeding system as well as the male:female ratios of: 1:2, 1:4, 1:8 and 1:18. The extreme value of 1:18 was explored because this has been observed in unmanaged water buffalo populations.

File	Scenario	r	SD(r)	P(E)	N	SD(N)	Het
137	N=175						
	Monogamy	0.052	0.061	0	172.97	5.36	95.32
107	1:4	0.051	0.062	0	173.39	4.87	93.28
108	1:8	0.052	0.062	0	173.24	4.59	90.61
118	1:18	0.051	0.061	0	172.32	5.76	88.36
138	N=20						
	Monogamy	0.038	0.097	0	18.06	3.04	62.64
207	1:4	0.043	0.103	0.025	17.83	3.3	61.01
208	1:8	0.044	0.103	0.030	18.36	2.88	55.77
209	1:18	0.042	0.104	0.010	18.28	2.97	55.37

Interpretation: the degree of polygyny had no effect on population growth rates. There was also only minor effects on increased loss of heterozygosity due to polygyny. Determining the degree of polygyny is not considered of primary importance with regards to population viability.

F) Increased Environmental Variation: We examined the effect of increasing the standard deviation of life-history characters (survival and reproductive rates) from 30% of mean values to 50% and 100%. These standard deviations were not applied to carrying capacity limitations.

File	Scenario	r	SD(r)	P(E)	N	SD(N)	Het
110	N=175						
	SD=50% Mean	0.053	0.087	0	169.81	8.09	94.35
140	SD=100% Mean	0.058	0.186	0	152.42	29.64	93.12
210	N=20						
	SD=50% Mean	0.047	0.119	0.03	17.96	3.07	59.65
141	SD=100% Mean	0.047	0.200	0.165	15.77	4.68	53.31

Interpretation: increasing standard deviations to 50% did not decrease viability in either populations. Increasing standard deviation to 100% of the mean significantly impacted viability in the small population (to 16.5% from 3.5% P(E) in the baseline model). Standard deviation in r and population size at 100 years also was substantially higher.

G) Variation in proportion of females breeding (i.e., producing a calf during any given year). We varied this from .3 to .7 (baseline was .45):

File	Scenario	r	SD(r)	P(E)	N	SD(N)	Het
115	N=175						
	Rate=.3	0.025	0.053	0	170.06	7.72	94.64
116	Rate=.7	0.104	0.055	0	174.82	4.00	93.84
215	N=20						
	Rate=.3	0.018	0.104	0.09	15.84	4.38	57.89
216	Rate=.7	0.095	0.095	0.01	19.33	1.84	56.2

Interpretation: The model was extremely sensitive to variation in proportion of females breeding. In particular, a rate of 0.3 in a small population decreased r to 0.018 and increased extinction probabilities almost three-fold.

SUMMARY OF SENSITIVITY ANALYSIS:

Population viability was highly sensitive to parameters that potentially have a strong effect on population growth rate. The parameters that were examined which substantially increased or decreased population growth rates, and the proportional change in r resulting from the sensitivity analysis, are shown in the SENSITIVITY figure.

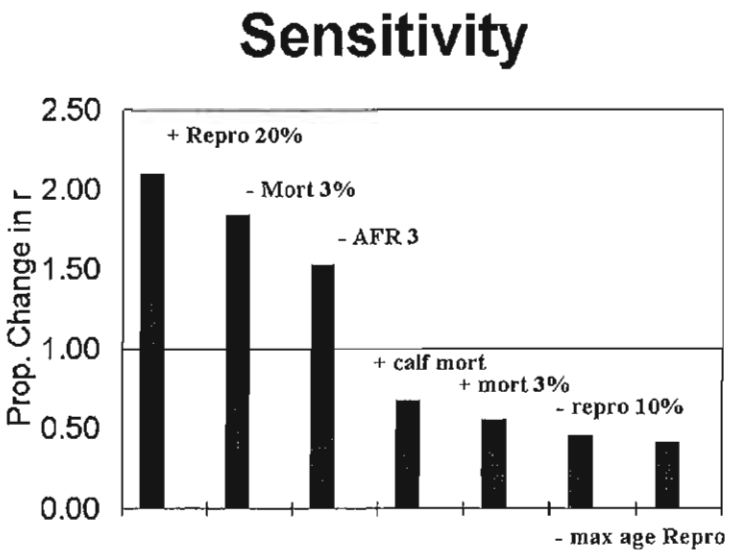


Figure legend: proportional change in r from the Baseline Model (r=.055) resulting from changes in life-history parameters. Bars above the horizontal line indicate proportional increases in r, those below the line indicate proportional decreases. "+ Repro 20%" = Increasing female reproductive rate by 20%; "- Mort 3%" = decrease non-calf mortality by 3%, "- AFC 3" = decrease age of first reproduction to age 3; "+ calf mort" = increase calf mortality to 35%; "- mort 3%" = decrease non-calf mortality by 3%; "- Repro 15%" = decrease female reproductive rate by 15%; "- max age repro" = decrease maximum age of reproduction to age 15.

Population viability is also threatened if there are extreme fluctuations in reproductive and survival rates from one year to the next. In our modeling, population viability in the small population was threatened when the standard deviation of parameters was increased to 100% of the mean. This models the situation when in approximately one out of every three years (34% of the time), survival for any particular age class and/or reproduction, drops to zero. In other words, each year there is a one in three chance that there will be no births and/or that all the animals in any particular age class will die. This is indeed a substantial level of year-to-year variation and it is not surprising that it has a direct impact on population viability.

The most highly sensitive parameters are:

- Rate of female reproduction (% females breeding each breeding cycle)
- Maximum age of female reproduction
- Age of first calving in females
- Calf mortality rates
- Annual mortality rates

None of these values are known for the tamaraw nor is anything known of how much they might vary from year-to-year.

A SUB-OPTIMAL BUT REALISTIC MODEL

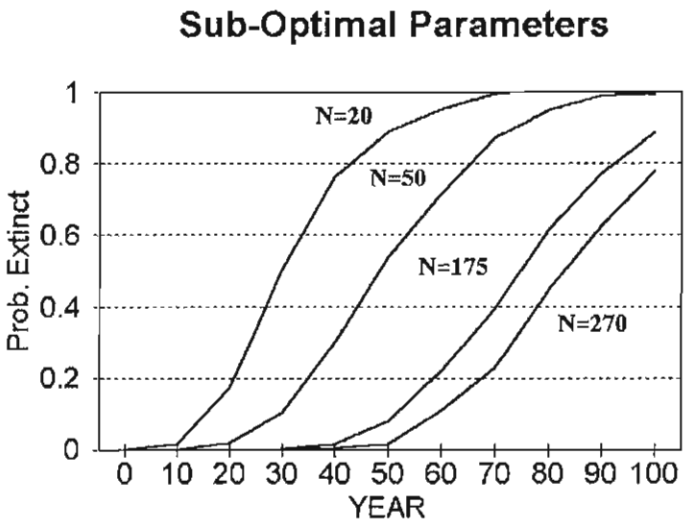
The sensitivity analysis above examined the effect of changing the parameters one at a time within the context of the Baseline Model. To examine the potential cumulative effect of a number of sub-optimal life-history parameters acting together, we developed a "sub-optimal" model. The parameters used in this model were selected to be low but not unrealistically so. The following parameters were used and applied to populations of 20, 50, 175 and 270. The population size of 270 was based on the maximum potential population size in the Mt. Iglit-Baco area using the density estimate of 10 tamaraw/km^2 (see report from group discussing the wild populations).

Age of first calving	6
Age of maximum reproduction	15
Standard Deviation of all parameters	50% of the mean
Calf mortality	30%
Annual non-calf mortality	8%
Reproductive rate of females	40% each year
Inbreeding Depression:	3.14 Lethal Equivalents (This is the level typical of mammalian species; Ralls et al., 1988)

Each male mates with as many as 18 females

The "sub-optimal" results in a population decline of about 4%/annum. Consequently, none of the populations are safe from extinction and the extinction results are shown in the following figure "SUB-OPTIMAL PARAMETERS".

Figure Legend: Probability of extinction over 100 years using "sub-optimal" life-history values in populations of size 20, 50, 175 and 270.



There was some debate among participants that using age 6 as the first age of calving was overly pessimistic. There was also some concern that non-calf mortality rates were underestimated. We therefore modeled three more sub-optimal scenarios using age 4 and 5 as the first age of calving as well using age 4 but increasing non-calf mortality to 10%. This model was applied to the population of 175 and 270. Population growth was still negative even when age of first calving was decreased to age 4 and adult mortality kept at 8%. Thus all populations declined towards extinction, with the larger populations simply lasting longer than the small ones before going extinct. The results for populations sizes of 175 and 270 are shown in the figures 4 and 5, respectively, below.

Figure Legend: Probability of extinction in population of size 175 when age of first calving (AFC) decreased to age 5, age 4 and age 4 with 10% annual non-calf mortality.

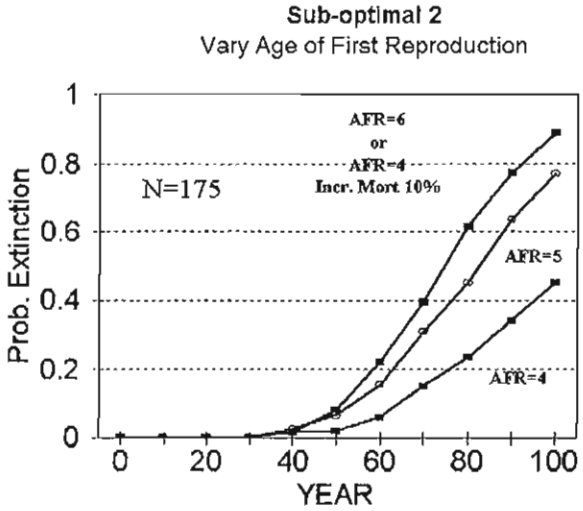
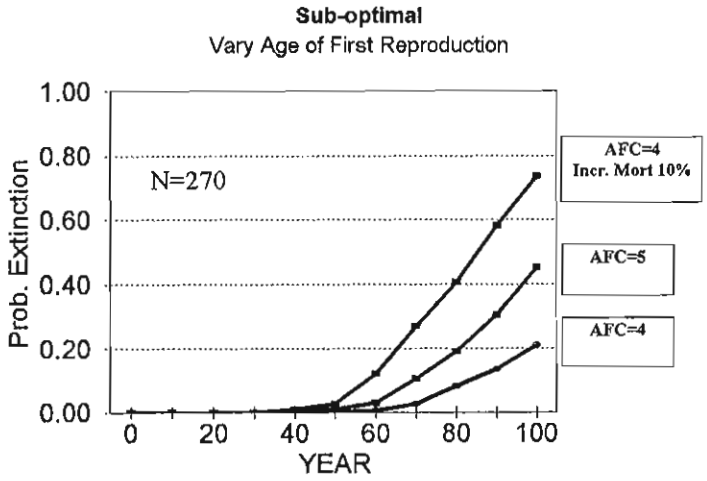


Figure Legend: Probability of extinction in population of size 270 when age of first calving (AFC) decreased to age 5, age 4 and age 4 with 10% annual non-calf mortality.

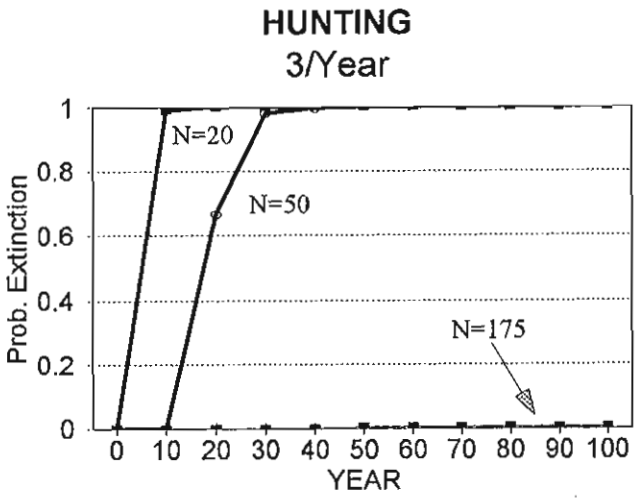


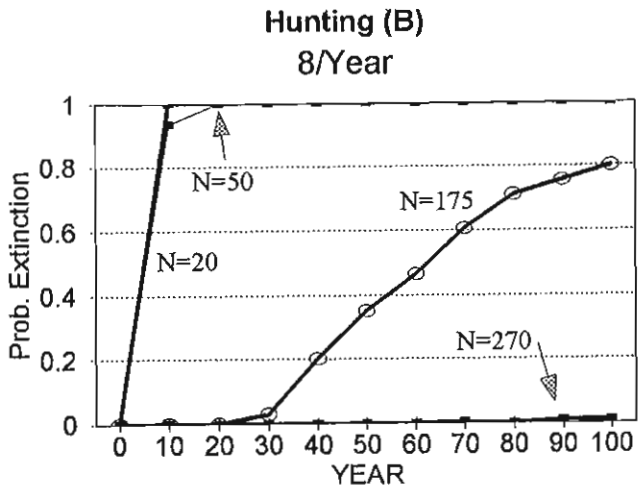
THE EFFECT OF HUNTING ON TAMARAW POPULATIONS

Hunting was identified as the primary threat to tamaraw populations by the group discussing wild populations. We modeled three hunting scenarios provided to us by that group: removal of 3 animals/year, removal of 8/year, and removal of 22/year. These hunting rates were applied to the Base Model described above. This was done in populations of size 20, 50, 175, and 270 to reflect the full range of estimates provided for the Mt. Iglit population. In the model, we used the Harvest routine to remove adult animals of equal sex ratio for each of these scenarios (for removal of 3 animals/year we removed 1 male and 2 females. The results are shown in the following table:

Scenario	r	SD(r)	P(E)	Median Time to Extinction
3/year				
N=20	-0.281	0.235	1	7
N=50	-0.095	0.129	1	18
N=175	0.026	0.061	0.005	0
N=270	0.036	0.059	0	0
8/Year				
N=20	-0.576	0.309	1	5
N=50	-0.384	0.341	1	9
N=175	-0.047	0.164	0.80	63
N=270	0.018	0.064	0.03	86
22/Year				
N=175	-0.373	0.370	1	12
N=270	-0.231	0.320	1	20

Interpretation: In smaller populations, e.g., 20 or 50, with removal rates of 3/Year, r is negative and the probability of extinction [P(E)] is 100% within at least 18 years. In the larger populations, r remains positive with very low P(E): the reproductive potential of populations this size is sufficient to allow removal of 3 animals/year but still maintain population growth. With higher hunting rates, 8/year, r is negative in all but the largest population size and sufficient to cause extinction of the population of size 175 in 12 years, on average. However, even the largest population will be vulnerable to hunting rates of 22/year. The most important finding is that even low levels of hunting can have significant impacts on population survival of small populations. Extinction probabilities over time for these three scenarios are shown in figures Hunting (A), Hunting (B) and Hunting (C).





Genetics of Tamaraw and Population Viability

Analysis of protein allozymes and the cytochrome b region of the mitochondrial DNA show very little genetic variation in the 7 captive (gene pool) tamaraw (transferrin was the only polymorphic loci of 20 examined) (Solis, this workshop; Tanaka, this workshop). Such low levels of genetic diversity are potential indicators of genetic problems. The modeling shows that even if small populations (e.g., N=20) don't go extinct, they will rapidly lose what little variation is remaining over time and become increasingly inbred (see the % heterozygosity remaining in the sensitivity analysis of breeding systems above).

The low levels of genetic variation do not imply lack of susceptibility to inbreeding depression (e.g., Brewer et al. 1986). We examined the potential effects of inbreeding depression in populations of size 20 and 50. Three levels of inbreeding depression were modeled: 1.5, 3.14 and 4.5 lethal equivalents (see Ralls et al,. 1988).

None of the levels of inbreeding depression were sufficient to cause growth rates to become negative (the lowest was r = 0.012 for 4.5 lethal equivalents in the population of size 20). However, this was low enough that when combined with the levels of demographic and environmental variation in the baseline model, the probability of extinction was significantly increased in populations of size 20 (see figure below). No extinctions were recorded when N=50.

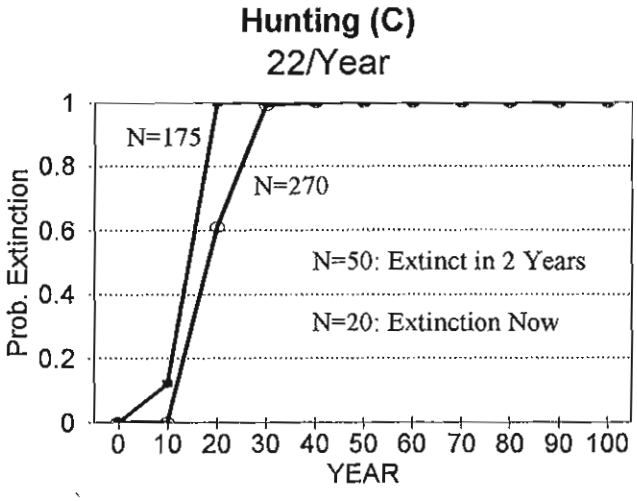
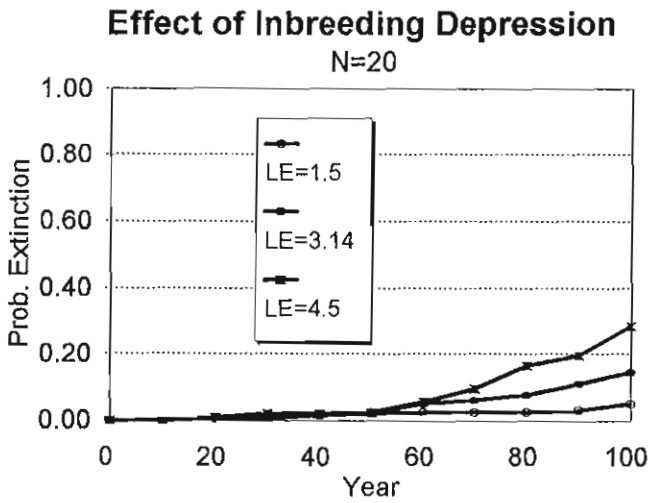


Figure legend: Effect of different levels of inbreeding depression in a population of size 20 starting with the baseline model. LE = lethal equivalents.



Goals of the Captive Population: Founder Numbers and Population Size

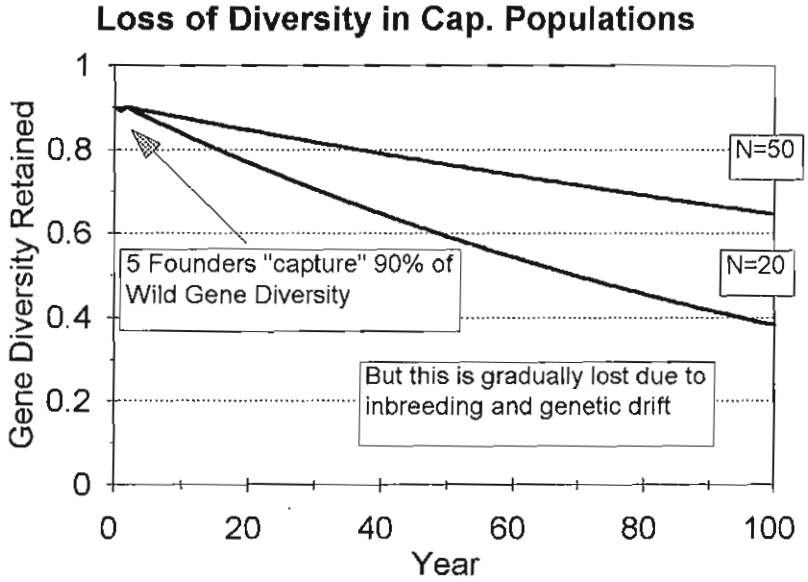
The goal of the captive population has been stated as maintenance of genetic diversity of the wild population. The capability of the captive population to retain genetic diversity depends on a number of important factors:

- the number of initial founders used to establish the captive population;
- the size of the captive population;
- how well it is genetically and demographically managed; and
- the potential availability of periodic addition of new founders from the wild population.

All of these factors need to be considered in determining the goals of the captive population. In considering these issues, it is useful to understand what happens to genetic diversity in captive populations.

The captive population starts out with the genetic diversity brought into the population by the wild-caught founders. Only a few number of founders are needed to capture a large proportion of the genetic diversity of the wild-population (e.g., 5 founders capture 90%, 10 founders capture 95%, and 25 founders capture 98% of the gene diversity from the wild-population).

Figure Legend: Five founders "capture" 90% of the wild population's gene diversity. But this is lost over time. The rate of loss is more rapid in small populations (N=20) than in a large population (N=50).



Even though a high level of gene diversity may be "captured," over time, from one generation to the next, this genetic diversity is lost due to inbreeding and genetic drift. Also, all of the wild-caught founders might not reproduce, and of those that do, some may bred less than others. This causes further loss of genetic diversity. So the amount of gene diversity originally brought into the captive population is gradually eroded away.

The rate at which it is lost depends of the size of the population (small populations lose it faster) and how well it is managed (selecting male/female pairings based on pedigree analysis is best for maintaining genetic diversity). Figure 10 shows how an initial level of genetic diversity is lost gradually over time.

To better understand the implications of the loss of genetic diversity, consider that retaining 90% gene diversity implies that 10% of the wild genetic diversity has been lost. This means that the level of inbreeding in the population is about 10% so on the average individuals in the population are related at a level of almost half-siblings. If only 75% of the gene diversity is retained, 25% has been lost and the average relationship among animals is 25%, or equivalent to the level of half-siblings. Basically the population is one big family. This is very highly inbred.

Conservation geneticists recommend that captive populations try to maintain at least 90% of the gene diversity. Why not try to maintain all the genetic diversity? This would be preferable, but the size of populations and number of founders needed would, in most cases, be prohibitively large. Much more loss than 90% compromises the genetic conservation value and evolutionary potential of the population (ability for evolutionary adaptation is a directly dependent of genetic variation). In addition, many studies have shown that even at this level of relatedness, inbreeding depression (higher mortality, lower reproduction) can be a problem.

The only way to increase the level of genetic variation in the population is by adding wild-caught founders. This can be accomplished through importing more founders or, if the technology is available, through artificial reproductive techniques (e.g., artificial insemination). Periodic import of new animals will boost genetic diversity:

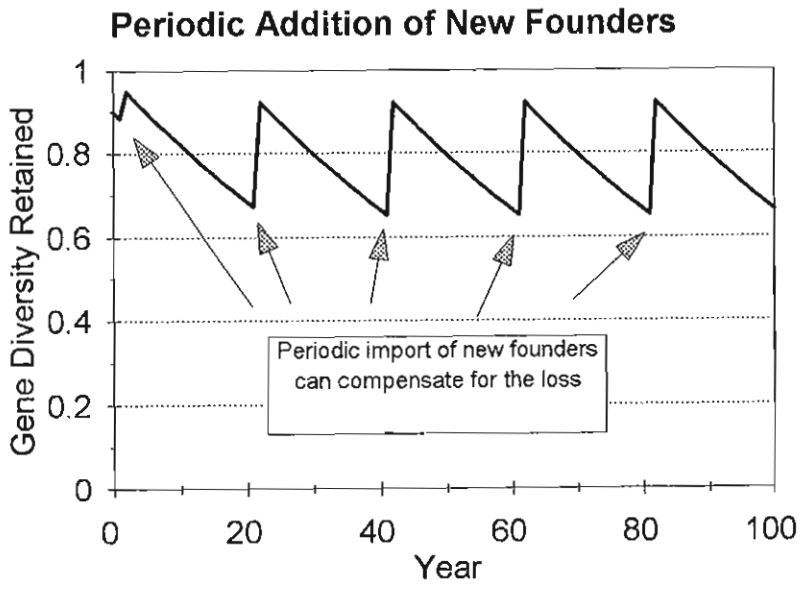


Figure legend: periodic import of new founders (here 10 every 20 years) can add new genetic diversity and maintain higher levels in the captive population.

The goals of captive breeding programs depend of the interactions of these various factors: the number of original founders, the population size and the potential of bring in new founders if they are available. We will next consider various options for the goals of the captive population. A spreadsheet model was used to explore these options; the particulars of the model are presented below. We optimistically assume that the 5 male and 2 female tamaraw in the captive population will reproduce and that the potential maximum growth rate of the population is 13% per year.

[Details of the model: Population growth rate is 5% per year for the first 5 years, after which the maximum growth rate of 13% increase is achieved. Effective size is assumed to be 30% of census size. Generation length assumed to be 10 years. Loss of genetic diversity per year is $H(t) = H(t-1)*[1-1/2Ne]^{(1/T)}$ where T is the generation length, Ne is effective population size and H(t-1) is heterozygosity in year (t-1).]

Options for the Goals of the Captive Population

1) The "Standard" Objectives:

The most common genetic goal for captive breeding programs is to maintain 90% of the wild population's gene diversity for a period of 100 years. The intent is to establish a long-term, self-sufficient captive gene pool for the species. This strategy assumes that no founders will be added to the population but attempts to preserve as best as possible the current levels of gene diversity.

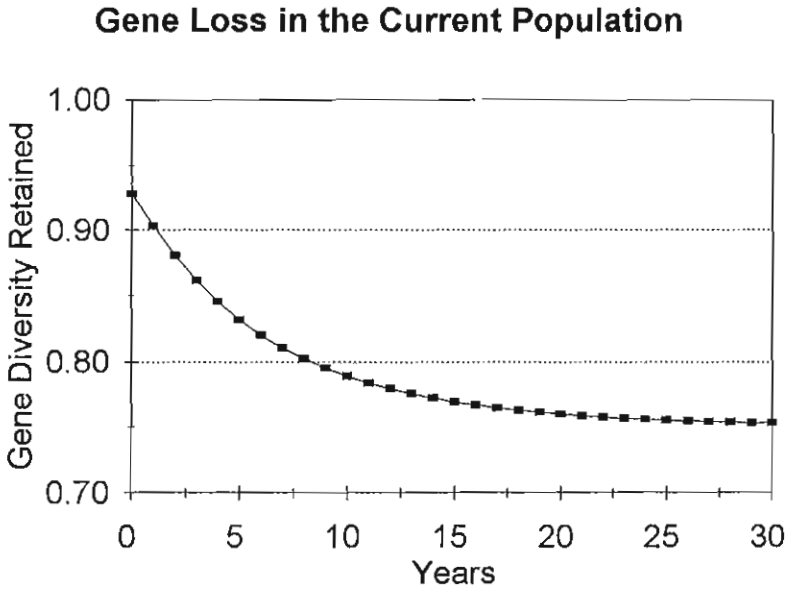


Figure legend: Loss of genetic diversity over the a 30-year period in the captive tamaraw population without the addition of new founders (and assuming that all tamaraw in the captive population are capable of reproduction).

As the captive population of tamaraw now stands (that is, without adding new founders), this objective is not possible: the population can not grow fast enough to achieve a population size sufficient to retain 90% for 100 years. In fact, it is not possible to retain even 75% over a 100 year period. The following graph shows that 25% will be lost (75% retained) within 20 years.

How much genetic diversity can be retained without adding new founders? The following table gives us some idea. The best that can be done is a little over 70%. This is a highly inbred population that has lost 30% of its evolutionary adaptive potential.

Captive Population Size	Gene Diversity Retained
50	58%
100	66%
200	71%
300	72%
400	73%

2) The Effect of Immediately Adding New Founders

An alternative strategy is to increase the current gene diversity by adding new founders now, but not in the future. The intent is still to establish a long-term self-sustaining genetic reservoir. To examine this situation we need to consider at least two factors: what effect will removal of additional founders have on the wild population, and how well will these founders contribute to the captive gene pool?

Let us first consider the second question: how well will new founders contribute to the genetics of the captive population? In captive populations, we think of "ideal" founders: those founders who are able to reproduce sufficiently well to pass on all their genes to descendants in the population and in equal proportion to all the other founders (e.g., theoretically a pair of founders needs to produce about 12 viable offspring to insure with almost 100% certainly that all their genes are represented in the descendant generation - this may not be possible given the potential reproductive life-time of tamaraw). These founders are said to have a "founder genome equivalent," or fge of 1.0. Founders producing fewer offspring have a fge less than 1.0.

We measure the genetic effectiveness of new founders by their fge. To date, captive tamaraw have failed to produce any viable offspring so estimating a fge for tamaraw is impossible. So we examined 2 values: fge of 0.2 (20% efficiency), and fge of .5 (50% efficiency). It is not unusual for some proportion of wild-caught founders to fail to produce at all, so these estimated are not unreasonable low. We examined the effect of adding various numbers of new founders on the population's ability to retain genetic diversity over time. We looked at two population capacities: a captive population capacity of 50 and 200:

Percent Diversity Maintained for 100 Years in a captive population with capacity of 50.

No. New Founders	fge = 0.2	fge = 0.5
2	60%	60%
5	61%	62%
10	63%	64%
20	65%	66%

Percent Diversity Maintained for 100 Years in a captive population with capacity of 200.

No. New Founders	fge = 0.2	fge = 0.5
2	73%	73%
5	75%	76%
10	78%	79%
20	81%	82%

For a captive population that can't grow beyond 50, addition of even 20 new founders will not increase levels of gene diversity to acceptable levels. However, for a population of 200, levels approach and exceed 80%. Two points:

- Even with unlimited captive capacity, it is not possible to retain 90%; and

- Even with unlimited number of imports in a captive population as large as 200, it is just barely possible to retain about 90% for 100 years.

The second consideration is the effect of removing animals on the wild population. For small population sizes, removal of 10 to 20 will clearly have an impact. However, if the populations really are that small, and hunting is a threat that can not be controlled, the populations are already highly vulnerable. Managers are faced with the alternatives of either letting the population go extinct or rescuing the animals for a captive breeding program.

3) Periodic Import of Founders: the Metapopulation Approach

The previous scenarios assume that the captive population would be an independent and self-sufficient repository of the genetic diversity of tamaraw: it does not depend of the wild population beyond any initial or immediate imports of wild-caught founders. An alternative scenario is to consider the captive population as part of a larger metapopulation, with the wild population(s) action as other member populations of the metapopulation. The genetic objective would to be maintain higher levels of gene diversity in the captive population at all times through periodic import (addition) of new founders from the wild population(s). Unlike the

previous strategies which managed for 100 years, the intent of this strategy is to continuously maintain a larger proportion (e.g., 95% or 98%) of the gene diversity of the species in the captive population at all times. If the wild population goes extinct, then much of its diversity is preserved, and through reintroduction, the wild populations can be subsequently re-colonized (after the immediate cause of extinction is removed) with much of its gene diversity intact. This strategy has been termed with "Nucleus Population" strategy (Foose et al., 1995).

But how many founders need to be added, and at what frequency? This depends on how much gene diversity it to be retained in the captive population. As much as 95% or 98% has been recommended (Foose et al., 1995). Again using the fge ratios of 0.2 and 0.5, we can estimate the number of periodic imports needed every 5 years to continuously maintain 90% and 95% gene diversity in the captive population. We limited our analysis to a captive capacities of 100. This table shows the number of founders that needed to be added, and when:

Numbers of wild-caught founders that need to be added to the captive population under different goals (levels of gene diversity to be continuously maintained) and assumptions (fge contribution of each founder). Captive capacity is 100 tamaraw.

	Continuously Maintain 90% Gene Diversity		Continuously Maintain 95% Gene Diversity		Continuously Maintain 98 Gene Diversity	
	fge=0.2	fge=0.5	fge=0.2	fge=0.5	fge=0.2	fge=0.5
First 5 Years:	0	0	15	12	90	36
Year 5-10:	9	4	27	7	82	35
Years 10-15:	6	3	14	4	39	20
Every 5 years after that:	2-3	1-2	7	2-3	36	15

Retaining very high levels of gene diversity (e.g., 98%) requires substantial numbers of founders.

Again, these strategies need to evaluate the effect of these levels of removal on the wild population. Furthermore, the strategy assumes we want to achieve the specified level of genetic diversity immediately. This means that a large number of founders need to be added within the first few (5) years (15+27 in the case of retaining 95% diversity). An alternative is to reach the objective more gradually (say over a 20 year period). However, the cost of doing this is that there is a delay in getting the wild-population's gene diversity into the captive population, during which time the gene diversity in the captive population will be below desired levels. If the wild population goes extinct, a lower proportion of the gene diversity will be preserved.

SUMMARY OF CAPTIVE POPULATION GOALS

This analysis is intended to help define a number of questions that need to be addressed when considering the future goals of the captive population rather than provide exact estimates of the numbers needed to reach certain objectives. The calculations are based on numerous assumptions which need to be verified and examined in more detail.

However, it seems from this preliminary analysis that the goal often adopted by the captive community (90% retained for 100 years) is not possible under the current situation, and not even possible with large number of imports. Lower levels of genetic diversity (80%) can be maintained with large number of imports, but only when captive capacity is large (about 200 animals).

The alternative is the metapopulation strategy. In this case 90% or 95% could be maintained if the wild population were of sufficient size to supply the number of founders needed; the larger the capacity, and the more effectively wild-caught animals can be bred in captivity, the fewer number of founders are needed. Here reproductive technology can be of assistance. Semen storage and artificial insemination can be used to improve fge values for founders (to capture genetic contribution of non-reproducing males) as well as extend their reproductive life-time for as long as stored samples last. Both will help reduce the number of imports needed to retain genetic diversity.

In light of the above, the following questions need to be seriously considered with regards to establishing the captive population, and its objectives:

1) What is the goal for the captive population in terms of levels of gene diversity to retain? And for how long?

2) What strategy should be used to retain this level? A large captive capacity (perhaps more than 200) with large numbers of immediate imports (10 to 20) or a metapopulation strategy of periodic importation from the wild?

3) If a periodic import strategy is selected, the existence of a large viable population now (if there is one) does not insure the continued existence of a viable population. What are the implications of changes in the status of the wild population on the strategy/goals of the captive population? If the wild population can no longer sustain periodic removal of founders at the levels required, what are the alternatives for the captive population? What does that mean about the viability of the wild population?

RECOMMENDATIONS:

1. The most significant factor contributing to population extinction is population size. Size estimates of the largest know population (Mt. Iglit-Baco) range from less than 20 to approximately 270. It is imperative that more accurate estimates of this and all potential populations be obtained. Accurate estimates will be essential to establish time-frames for further management action and convey the degree of urgency in implementing these management actions.

2. Initiate long-term field studies to determine base-line values of those life-history parameters shown to most significantly affect population viability. These are:

   - female reproductive rate
   - age of first reproduction
   - calf mortality rate
   - reproductive longevity

This will require longitudinal studies of know-aged animals.

3. Quantify the annual loss due to hunting and other threats. This can perhaps best be accomplished by conducting periodic monitoring (twice a year during dry and wet seasons would be ideal) of existing populations to determine changes in population size that reflect the effect of significant threats (e.g., hunting) acting on the populations. Monitoring efforts should be of sufficient level of accuracy to discount the effect of sampling errors accounting for changes in population size.

4. Studies are needed to evaluate historical levels of genetic variation in tamaraw to determine if the observed low variation is a recent characteristic of this island species. This can be accomplished by collecting DNA samples from museum specimens and trophies with known date of collection. Samples from the current population(s) should collected when there is an opportunity (e.g., during handling of wild-animals for other reasons or from animals found dead).

5. Explicit goals need to be formulated for the captive population that address the issues of levels of genetic diversity to retain, and the captive population sizes and numbers of founders needed to for this to be achieved.

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APPENDIX A

Group Composition from Field Observations of Tamaraws from July 1995 to April 1996 at the Mount Iglit Range (from Quimbo's report)

	Frequency					
Group	**July**	**Aug**	**Sep**	**Mar**	**Apr**	**Total**
1 Male	3	2	2	5	2	14
1 Female	2	3	1	2	2	10
1M 1F	1	1	1	1	1	5
1M 2F						
1M 1F 1C			1	1	1	3
1M 2F 2C				1		1
1M 3F 2C					1	1
1M 1F 1U					1	1
1M 2F 2U				1		1
1F 1C	2		1		1	4
2F 2C				2		2
2M 2F 2C		1				1
Total	**8**	**7**	**6**	**13**	**9**	**43**

Summary Statistics From Table

# of calves seen = 17
# of Females seen = 26
Ratio of calves to Females = 0.65 after early mortality

% Solitary = 70% (32% M, 38% F)
% Pairs = 21%
% Polygynous = 9%

Adult Sex Ratio= 28M: 36F
Calf/Adult Ratio= 17/81 or 21%

APPENDIX B: Model to Determine Genetic Effect of Adding New Founders to a Captive Population (J. Ballou)

A model was constructed to measure the effect of adding founders on the maintenance of gene diversity in captive populations. It requires a number of parameters that can be calculated for any captive population. The model was developed using QUATRO-PRO spreadsheet software.

Model Structure

The model calculates the change in gene diversity from one year to the next, and covers a period of 100 years (although this can be easily modified). Each year, some gene diversity is lost due to genetic drift and inbreeding but gene diversity can also be increased through the addition of new founders.

Gene Diversity of Founders

We have to make some assumptions about how much each founder might increase gene diversity. The model measures this in terms of founder genome equivalents (fge). The ideal case is when all of a founder's genes become incorporated in the population, and at a frequency equal to all other founders. Here fge = 1.0. Usually founders have an average value less than 1 because some founders fail to breed and those that do are not likely to contribute equally. Furthermore, the effect of importing a new founder, regardless of its fge, will not be immediate. It will take several years for a founder's genes to be incorporated. Therefore the model allows the user to specify both the fge value for each founder (which will range from 0 to 1), and the time frame and frequency with which the fge becomes incorporated into the population.

Estimates of fge values per founders have be estimated for only one species (the golden-headed lion tamarin, Mansour and Ballou, in preparation). Studies of the GHLT population show that the average founder after a period of 7 years achieved an fge of about 0.40. Others have suggested that the fge value be 0.5. In the tamaraw, we use values of 0.2 and 0.5 to encompass a range of potential values..

The model uses the following set of formulas to measure change of gene diversity from one year to the next. It starts with the loss of gene diversity caused by inbreeding and drift, which is a function of the population's effective size:

$$GD'_t = GD_{t-1}\left(1-\frac{1}{2N_{e(t-1)}}\right)^{1/T} \quad \textbf{(1)}$$

where GD'_t is gene diversity at year t before the addition of new founders, GD_{t-1} is the gene diversity last year after the addition of founders, T is the generation length in years, and $N_{e,t-1}$ is the effective size of the population last year (t-1).

To incorporate the effect of founders, we convert the GD'_t to fge'_t using:

$$GD = 1 - \frac{1}{2fge} \quad (2)$$

To add new founders, we then add the fge resulting from the addition of new founders (fge^{new}) to the fge'_t to get the fge at the end of the year (fge_t):

$$fge'_t + fge^{new} = fge_t \quad (3)$$

where

$$fge^{new} = \sum_{i=1}^{6} fnd_{(t+1-i)} a_i \quad (4)$$

The $fnd_{(t+1-l)}$ are the number of founders added to the population t+1-l years ago, scaled by a_l to give their fge contribution in year t. In tamaraw we used 0.2 and 0.5 for a_1 and 0 for all other ai values (thus we assumed that tamaraw were able to make their full contributions during the first year. This is certainly not true, but this value can and should be modified as this tamaraw model is refined further).

Gene diversity for year t (GD_t) is then calculated from fge_t using formula (2).

Calculating Number of Imports Required.

The Quatro-Pro solution solver function and optimizer were used to determine exactly how many founders were required to achieve specific objectives (e.g. 95% in 10 years). The number of founders required to keep the population at an objective was determined by calculating the number of founders that if added to the population every five years, would minimize the sum of the squared differences between the target levels of gene diversity and the level in the population.

Other Model Assumptions

Starting GD:	Gene diversity in 1996 assumed to be .928 (fge = 7). This assumes that all living tamaraw in captivity are potential founders..
Starting N:	N in 1996 is 7.
Population growth:	For first 5 years potential growth lambda is 1.05, after that potential lambda 1.15.
Carrying Capacity:	Population was not allowed to exceed limit, exponential growth to limit.
Effective size:	Assumed to be 30% of actual size
Generation length:	Assumed to be 10

Any of these values can be changed in the model.

TAMARAW
(*Bubalus mindorensis*)

Population and Habitat Viability Assessment

University of The Philippines Los Baños
College, Laguna, Philippines

15-17 May 1996

Report

SECTION 5

Captive Population and Management

Tamaraw Captive Population

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The tamaraw population has been declining since 1900 from about 10,000 to about 100-400 head at present. If this trend continues, the tamaraw population will become extinct in a few years time. A need exists for a deliberate human intervention through protection of the tamaraw in the wild, protection of its habitat and captive breeding is imperative.

The wild tamaraw population is at significant risk of extinction. A captive tamaraw population should serve the purpose of preserving the genetic diversity of the wild population in a more protected environment that is not subject to the same threats as the wild population. Secondarily over time the captive population may serve the purpose of providing animals for a reintroduction program to the wild and for investigations of tamaraw biology.

Current Population and Management

Initially the Gene Pool population was established to provide a protected but minimally controlled environment in which Tamaraw could propagate through natural breeding in a random fashion based on the animals that were released into a 281 hectare enclosure. This program requires significant reevaluation since it has not succeeded in its original goal and because the initial goal and method require reassessment in the light of current information concerning basic animal husbandry, genetic management of animal populations for conservation purposes and the current status of the tamaraw.

Thirteen tamaraws have been released into the large enclosure at the Gene Pool site since 1982. Mortality in the large enclosure population has been significant and reproduction in this population remains largely unknown but minimal with no known living offspring. Three other animals have been held in small pens at the Gene Pool site but not released into the large enclosure and one animal was held off site at San Jose. During the period from late 1990 to 1993 a program was instituted to recapture animals in the large enclosure and transfer them to manageable holding pens. (See attached capture summary, addendum 1).

At the present time five male and two female adult tamaraws are confined in individual enclosures at the Gene Pool site. One of the females is pregnant. All animals are considered to be original wild caught animals. There are two other animals still free ranging in the Gene Pool site, one of which is a male and the other of unknown sex. There is not currently any plan to catch these two animals. The female formerly held at the Manilla Zoo is reported dead. No other tamaraws are known to be held in captivity in the Philippines.

The animals are currently held in individual chain link enclosures of about 450 m^2 with dirt substrates. There is a 1 meter separation between pens. The pens are located at a site away from and above the level of the river. The animals are fed fresh forage 4-5 times daily consisting primarily of Napier grass with some paragrass. The grass is cultivated and collected from a 2-hectare site nearby where it is grown specifically for the tamaraw. The tamaraws are also provided with bangkal leaves seasonally as it is available. Bangkal is a tree in the area. Some fruits such as cashews are seasonally available to the animals as they fall into enclosures. Animals consume approximately 1.8% of their body weight daily on a dry matter basis with males consuming 5.55 kg and females 5.25 kg of dry matter per day. Mineral salt blocks are provided for each animal and these are utilized by the animals. Drinking water is provided from a spring which is impounded in a storage tank and then fed by gravity to each animal. Water is free flowing all the time and flows into a water trough in each animals pen. Contaminants such as rat hair are occasionally found in the water.

Routine medical prophylactic treatments currently consist of anthelminthic treatment with albendazol at the label dose per kg. for cattle. Albendazol is provided in rice bran so that the tamaraw will eat it. All animals are treated every three months. Rice bran is also used as a nutritional supplement for animals recovering from disease. Fecal analysis is performed on a monthly basis to monitor the parasite load of each animal.

Some tamaraws in this facility have been conditioned to restraint in a cattle chute with a head gate and in some cases to permit handling and minor procedures such as rectal palpation.

Mortalities and threats to the captive population

Mortalities prior to confinement of the animals in management pens were largely indeterminate with regard to cause. Since controlled management of the animals was instituted, one animal death was associated with an excessive parasite load. This led directly to the routine parasite prevention program currently in place. One other death was attributed to bacterial pneumonia on gross necropsy and two deaths have been attributed to chronic hepatitis on gross necropsy possibly related to toxicity. A possibly related incidence of clinical disease in another tamaraw was diagnosed as selenium toxicity based on clinical symptoms with support of laboratory data indicating elevated SGOT and SGPT as well as selenium levels of 5.9 ppm in the forage being fed to that animal and 1.9 ppm in the soil where the forage was raised. However this is not a clear-cut issue because other animals were receiving the same forage at that time with no evidence of disease. Conversely the affected animal did respond to treatment and recovered. Forage has continued to be raised on that site since with no adverse responses. (Ranchers in the area report a condition in their cattle called hard liver in which the liver is firm and pale). Follow up or routine analyses of feeds might detect ongoing abnormalities in the feed.

Potential threats to the population of tamaraw in captivity include parasitism but this is currently managed on a preventive basis. Foot-and-Mouth disease is present on Luzon as well as hemorrhagic septicemia. These diseases could be transferred to the estimated 2500-3000 cattle immediately adjacent to the Gene Pool. No testing is currently required before domestic ruminants are transferred to Mindoro, only a permit is required.

Summary points

1. The basic premise for the captive population is to serve as a protected genetic reservoir to back up the wild population in case there is a catastrophic event and the wild population is lost or diminished in size or diversity. In order to fulfill this objective the captive population would have to increase with a larger number of females and should also include more males and females from diverse sites and subpopulations in order to conserve as much diversity of the current wild tamaraw population as possible.

2. The captive population at the Gene Pool has not fulfilled its original objective which was to provide a protected reservoir of animals to propagate by natural breeding to reinforce the wild population.

3. The original plan to achieve that objective is inappropriate in the light of current information regarding conservation of biodiversity, genetic management of populations, and the current status of the tamaraw.

4. The minimal management or hands-off approach to management of the captive population did not work. It is currently being demonstrated that tamaraw can be managed in a more intensive manner consistent with accepted animal care principles.

5. The current captive population at the Gene Pool cannot make any significant contribution to tamaraw propagation due to low numbers of females. The greatest value of this population is as a research population.

A. With no change in objective or plan the population will provide information only concerning disease processes in aging tamaraw.

B. The predominance of males in this population makes it possible to initiate a limited research program with regard to semen cryopreservation and long term storage of genetic material in a Genome Resource Bank. This bank could preserve a portion of the genetic diversity of tamaraw.

6. If a captive population is to fulfill the role of serving as a genetic reservoir or safety net against catastrophic changes in the wild population then it may not be wise to hold the entire captive population in a single location adjacent to the wild herd where it is subject to the same events as the wild herd.

Recommendations (1-3 are highest immediate priority)

High Priority:

1. Implement substantial, comprehensive improvement of the captive management program (see Captive Population Management Plan, addendum 2).

2. Transfer the existing Gene Pool site to a more accessible area and develop a biodiversity conservation and research center with tamaraw as the flagship.

3. Establish a program of routine semen collection and genome resource banking from the males currently held at the Gene Pool as soon as possible.

Essential Actions:

4. The veterinary professionals working with the Tamaraw Conservation Program will make a written recommendation within one month to the Philippine Department of Agriculture to establish more stringent requirements for the transfer of domestic ruminants and swine to Mindoro. These requirements are intended to prevent the transmission of disease to the island which helps protect both the local ranchers and the tamaraw population. Testing requirements should include negative tests for Foot and Mouth Disease and brucellosis.

5. Establish a protocol for sample collection and health assessment of tamaraw currently in captivity and for animals that may come into captivity in the future (addendum 3).

6. Within six months the TCP veterinarians will perform a serologic survey of cattle in the vicinity of the current captive population location to detect potential disease threats in proximity to the captive population. Cattle will be surveyed for exposure to:
   1. Foot and Mouth Disease
   2. Hemorrhagic Septicemia
   3. Leptospirosis
   4. Brucellosis
   5. Bluetongue
   6. Pseudorabies
   7. *Mycobacteria paratuberculosis* (Johne's disease)

7. The existing Tamaraw Conservation Program Operations Manual will be thoroughly reviewed and updated within six months.

Contingent Priorities: (Dependent upon results of field surveys and actions taken on Priorities 1-3 above).

8. Increase the captive population of tamaraw by preferential capture of females from the wild. Numbers will depend on the recommendation of the population geneticists but an additional six founder males and ten founder females may be sufficient. A complete review of all options available for capture will be completed and a plan developed using the best capture method prior to beginning the capture program.

9. The capture of tamaraws from the wild should come from different sites to insure genetic diversity in the captive population.

10. Establish two separate fall-back populations, one on Mindoro Island but located far from tamaraw habitat and cattle ranches. The initial population base will be animals currently held in captivity and relocated to the new site on Mindoro. When the time is appropriate, additional animals may be added to this population to establish a core captive population. A second population should be located outside of Mindoro Island as protection against an island wide catastrophic event. The second herd could be established from first generation (F1) offspring of the wild caught founder animal core herd on Mindoro.

Addendum 1

Tamaraw Capture Data - Aruyan Site Primarily
(from Roberto Escalada, DVM, Tamaraw Conservation Program)

Capture Date dd-mm-yy	Sex	Estimated Age at Capture	Initial Identification	Remarks
14-02-82	♀	Adult	Valentina	
14-02-82	♂	Adult	Valentino	Died 17-02-82
15-03-82	♂	3 years	Macho	
04-04-82	♂	2 years	Kuba	Died 05-09-88
23-04-82	♂	2-3 years	Bruce White	
11-05-82	♂	2 years	Pedro	
16-12-85	♀	Adult		Died 00-02-86
13-03-86	♀	Adult	Pingas	
27-04-86	♂	Adult	Big Boy	Died 30-04-86
13-03-87	♀	Adult	White Nose	
13-03-87	♀	6-8 weeks	Anoa	Died 00-00-87
18-03-87	♀	3-4 years	Eliza	
12-04-87	♂	4-5 years	Pusog	Died 06-04-93
17-03-89	♂	Adult	Pingas Lalaki	
09-04-89	♂	5-6 years	Pogi	Died 08-06-89
26-04-89	♂	Adult		Released from pit trap
26-10-89	♂	1.5-2 years	Tammy	Died 11-05-93
16-02-93	♀	2-3 years	Mimi	
22-06-86	♂	Adult		Died 25-06-86
22-06-86	♀	Adult		Died 25-06-86

Most of tamaraw listed on the capture chart that do not have a date of death listed are assumed to be still alive and to be the animals that have been recaptured from the Gene Pool large pen. However no method of permanent identification was applied to the tamaraw when they were placed into the Gene Pool so it is not possible to positively identify animals as they are recaptured. Consequently as animals were recaptured and moved to smaller management pens they were assigned new names. Some animals such as Eliza were not released into the large group pen but were held in individual pens so that positive identification is possible for those animals. The current plan is to apply permanent identification methods to each individual to permit positive identification throughout the life of the animal. Identification systems may include some combination of ear tags, tattoos and transponders.

Current Captive Population Held at the Gene Pool Site
(from Roberto Escalada, DVM, Tamaraw Conservation Program

Name	Sex	Date of Recapture	Date of Birth	Body Weight kg Nov 1993	Date of Death
Eliza	♀			249.5	
Pusog	♂				06-04-93
Noble	♂	12-10-90		290	
Dabu	♂	13-10-90		290	
Gene Boy	♂		18-10-90		19-10-91
Donny	♂	09-11-90		294	
Sadam	♂	16-01-91			02-09-91
Saipan	♂	08-12-91		284	
Charlie	♂	22-03-91		268	
Tammy	♂	26-10-89			11-05-93
Mimi (Nayang)	♀	16-02-93	00-05-90 Estimate	121.5	
	♂		29-09-92 twin		29-09-92 Stillbirth
	♀		29-09-92 twin		29-09-92 Stillbirth
	♀		16-06-94		16-06-94 Abortion

Tamaraw Birth Record at Gene Pool
(from Roberto Escalada DVM, Tamaraw Conservation Program)

Name	Sire	Dam	Gestation-Days	Date of Birth	Date of Death
Gene Boy	Pusog	Eliza	317	18-10-90	19-10-91
Male	Pusog	Eliza	319?	29-09-92	29-09-92
Female	Pusog	Eliza	319?	29-09-92	29-09-92
Female	Dabu	Eliza	180?	16-06-94	16-06-94

Addendum 2

CAPTIVE POPULATION MANAGEMENT PLAN

The management plan for the present population of tamaraws raised in captivity will include the following:

I. Build up of Credibility with the Present Situation

Since the past programs for the conservation have not been very successful in meeting their original objectives, many questions or issues were raised by different sectors (government and private) concerning the viability of current efforts to conserve the tamaraw. The management personnel of the conservation programs have been changed and their contributions recognized, but at the same time also criticized. It is high time therefore to make efforts to build up the credibility of the people behind all the accomplishments of the above programs. Such efforts hope to gain more support from wildlife lovers from the local and international scene. The following methods are proposed:

A. Better Management Strategies

The management procedures being practiced by tamaraw conservationists are considered optimum for the current situation. In the light of technological advances, more understanding of the tamaraw physiology through researches and expert contributions from experienced foreign consultants, the management practices could be improved. Specifically these include the fields of nutrition, animal health and record keeping.

1. Nutrition

This will involve the continuous monitoring of feed quality requirements of the tamaraw. The nutritional content of the forage, concentrates and other supplements given shall be determined and analyzed at the Institute of Animal Science, UPLB. Their actual effects will be determined by continuous monitoring of the body condition scores and weights of the animals. All reports will be analyzed by nutrition experts and discussed with field personnel. A more effective nutritional program could then be developed.

2. Health

High mortalities have plagued the captive population. Most of these fatalities were diagnosed to be due to diseases of livestock. There is therefore a need to review these experiences and develop a program for disease prevention. Initially this could be done by veterinarians and animal health personnel who shall strictly implement the animal health protocols. Specifically these include the following methods:

a. Regular monitoring of the parasite load of the animals
b. Regular monitoring of health status of animals near the site
c. Biosecurity-quarantine observance

It has been observed that drugs, particularly for emergency or life-threatening situations, were not readily available in the gene pool area and even in nearby San Jose. There is therefore a need to have an adequate supply of drugs kept in the office. In addition, a minimum laboratory which has basic diagnostic capability (hematology, urinalysis, and fecalysis) would be a great help in maintaining the health status of the animals.

3. Record keeping/data base

Conflicting reports about the tamaraws have created confusion and controversies among personnel concerned with tamaraw conservation. These could be resolved by concrete data for anybody to examine. A more systematic and permanent method of recording will therefore be devised.

B. Research Capabilities

There are ongoing researches being conducted by different agencies. Research results contribute to more knowledge on the needs of the tamaraw. They also generate recommendations. Moreover, more published researches will strengthen the support of local and international funding agencies, which in turn will make conservation of the tamaraw more viable. The following research topics are proposed, and more may be added.

1. Reproduction

Semen collection is the main activity for research. The primary purpose is to provide a gene bank depository to preserve the genetic material of the males collected for future conservation applications in the preservation of the species. In addition, after sufficient semen is cryopreserved for conservation purposes, semen will be made available for research projects to benefit tamaraw conservation such as the investigation of hybridization with carabao.

All adult males will be considered as donors. Two methods of collection are used. One is the artificial vagina method, which requires training of the bulls. The other involves the use of an electroejaculator, which requires a chemical restraint agent. In the latter method, different chemical restraint agents will be tested and the most suitable one will eventually be used for future semen collections.

Semen is collected and then repeated after two weeks. The procedure is done only twice a year for each male. The semen samples are processed within the gene pool area and the stored in the same area and other research institutions. Researches will be conducted to explore the possibility of hybridization with buffaloes. The purpose of the hybridization is to test the species compatibility. The future plan is to identify which animal species could be used as surrogate mothers in case embryo transfer is resorted to as an alternative method of reproduction for rapid expansion of the tamaraw population.

2. More data collection of the following:

a. Genetics
   1. Population survey of genetic variability
   2. Blood proteins
   3. Isozymes
   4. Mitochondrial DNA (cytochrome b, D loop, etc.)
   5. Chromosomal variation (karyotype analysis, fluorescence *in situ* hybridization (FISH))
   6. Isolation of DNA markers (satellite DNA sequences, repetitive DNA elements)
   7. Genetic screening with microsatellite DNA markers (polymorphism in wild population, identification of individuals: parent-offspring relationship)

b. General anatomy (gross and microscopic)

c. Pathology
   1. Serological data (cross-infection of tamaraw with livestock)
   2. Hematology (blood chemistry values, complete blood count)
   3. Urinalysis

II. Transfer of the present facility to a new site within Mindoro

The captive site (Gene Pool) at present has received many complaints. Among these complaints are: it is surrounded by cattle ranches, inaccessible during rainy weather and no electricity. It is therefore recommended to transfer it to a new site with the following requirements:

Accessible by land transportation all year round.
Presence of amenities for communication and power.
Away from both tamaraw wild habitat and livestock.
At least 20 hectares.

III. Make plans for the capture of wild tamaraws from different sites to be used as founder animals

Continue pit- and surface trapping but explore the feasibility of alternate methods (e.g., dart method). Training for this kind of method will be provided by foreign specialists. The goal is to increase the effective population size to prevent inbreeding depression.

IV. Linkaging and networking with local NGO's.

This aims to integrate local NGO's for cooperative work to conserve the tamaraw.

V. Make plans for reintroduction of the tamaraw to the wild.

It is the intention of the group to reintroduce the tamaraw to its natural habitat after an adequate population is bred in captivity and a suitable habitat is present.

VI. Resources List

A. Facilities
   1. Feed analysis laboratory
   2. Semen storage equipment
   3. Diagnostic laboratory

B. Support Agencies
   1. Nagoya University - for genetics research
   2. Omaha Henry Doorly Zoo - for training of two individuals on semen collection and immobilization
   3. Feed analysis could be done by the Institute of Animal Science, UPLB
   4. Basic diagnostic facilities to be provided by TCP at Mindoro

Schedule of implementation:

	Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Year 6*
IA1	----------	----------	----------	----------	----------	--------->
IA2	----------	----------	----------	----------	----------	--------->
IA3	----------	----------	----------	----------	----------	--------->
IB1						
*	--------->					
**	--------->					
***		----------	----------	----------	----------	--------->
****		----------	----------	----------	----------	--------->
*****		----------	----------	----------	----------	--------->
IB2a	----------	----------	----------	--------->		
IB2b	----------	----------	--------->			
IB2c	----------	--------->				
III	- - - - - - -	- - - - - - -	- - - - - - -	--------->		
IV	----------	----------	----------	----------	----------	--------->
V	- - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - >
VIB1	- ----------	----------	----------	----------	----------	--------->
VIB2	--------->					
VIB3	----------	----------	----------	----------	----------	--------->
VIB4	----------	--------->				

* procurement of reagents and equipment
** training
*** collection and processing
**** storage
***** research

Addendum 3

Protocol for sample collection and processing of Tamaraw

This protocol initially applies to processing of currently captive tamaraw in order to establish the baseline for handling procedures and biologic values. Eventually these procedures and values could be applied to wild caught animals.

Procedures

1) Permanent identification by at least two of the following methods:
   - Ear tag
   - Tattoo
   - Transponder

2) Morphologic measurements
   - Muzzle Print
   - Body Measurements(need specific delineation of measurements to make)
   - Body Weight
   - Dentition Pattern

3) Sample Collection
   - Ectoparasite collection

   Blood collection

   Whole blood for RBC, WBC, hematocrit, and differential WBC

   Serum chemistry values for calcium, phosphorous, glucose, blood urea nitrogen, uric acid, cholesterol, bilirubin, alkaline phosphatase, creatinine, sodium, potassium, chloride, magnesium, LDH, SGOT, SGPT, albumin and total protein.

   5-10 ml whole blood in heparin for genetic evaluation and 10 ml serum for genetic work.

   Serum for serologic evaluation for: Foot and Mouth Disease, Hemorrhagic septicemia, Leptospirosis, Brucellosis, Bluetongue, Pseudorabies, Johne's disease.

   Fecal sample for parasite analysis

   Additional samples and tests may include urinalysis, preputial wash, vaginal flora exam, hair sample for genetic work and semen for cryopreservation.

TAMARAW
(*Bubalus mindorensis*)

Population and Habitat Viability Assessment

University of The Philippines Los Baños
College, Laguna, Philippines

15-17 May 1996

Report

SECTION 6

People Programs

People-Participatory Management in Tamaraw Conservation and Information, Education and Communication Program Group

Group Members: Nestor Lawas, Marlynn Mendoza, Victorio Capitan, Edgardo Jimenez, Conrado Fontanilla, Mercedes Garcia, Josefina de Leon, Harry Vredenburg,

I. PAST AND PRESENT SCENARIOS:

A. People Involvement in TCP

The involvement of people outside the government service in the implementation of the Tamaraw Conservation Program (TCP) was effected in 1985 when the then Ministry of Agriculture and Food (MAF) contracted the services of a non-government organization, the Conservation and Resource Management Foundation, Inc. (CRMFI), to handle the operational management of the TCP. Following the termination of the CRMFI services in 1989, another NGO, the University of the Philippines Los Baños Foundation, Inc. (UPLBFI), started to implement the Program in 1990 until 1993. In 1995, the DENR tapped again the services of the UPLBFI in the operational management of the TCP. The said foundation still manages the TCP to date.

In recognition of the importance of involving other groups of varied disciplines in conserving the tamaraw, the DENR thru the TCP, established a strong linkage with the Local Government Units of Occ. Mindoro that resulted to the creation of the Mindoro Tamaraw Conservation Council (MTCC) in 1990; deputized the Kalikasan Mindoro Foundation, Inc. (KMFI) as tamaraw and habitat protectors from July 1993 to December 1994; and started involving communities near and/or within the Mts. Iglit-Baco Natural Park/Tamaraw Reservation in protecting and rehabilitating the said reservation in 1995. Negotiation for the possible complementation of activities on tamaraw conservation with the interim Protected Area Management Board (PAMB) of Mt. Iglit-Baco Natural Park and implementors of specific National Integrated Protected Area Projects (EU-NIPAP and ADB-TA) has also been initiated. However, as per initial consultation made by the EU, ADB, and DENR representatives with some tribal members on the proposed NIPAS projects, the said IPs manifested a lack of interest.

B. Project Activities

Although the TCP years from 1979 to 1993 were marked with changing hands in management and supervision, a review of the activities undertaken during the period showed that the thrust and direction earlier set, i.e. captive propagation and habitat protection, with complementary IEC activities were maintained. However, it was only in 1990 when specific and basic studies on tamaraws in captivity were initiated. Also, earlier attempts to determine the population status of the wild tamaraw population were fragmented and without continuity.

Evaluation of previous activities and accomplishments also revealed insignificant results as evidenced by failure to produce captive-bred tamaraws, unabated degradation of tamaraw habitats, and continuous decline in the wild tamaraw population. These findings indicate the need for stronger functional linkages, support services, networking and cooperation.

While community participation is crucial to TCP especially in habitat protection, and communities within or adjacent to the tamaraw habitat can be the best protectors of the tamaraw, this, however, can be brought about if: 1) they understand their role in it; 2) alternative sources of livelihood for their basic needs are provided and sustained by the government; 3) values and commitments to conserve the tamaraws are developed within themselves; and 4) their capabilities are enhanced and developed.

Toward this end, initial efforts were undertaken starting in 1995. These efforts include: 1) value formation training and information dissemination on the importance of the tamaraw to the environment and to the people, thru various media; 2) community resource assessment, profiling, and organizing with the ultimate objective of developing them as TCP partners; and 3) pilot-testing of a livelihood project. Based on the information provided by the UPLBFI-TCP Program Manager, 4 communities were already organized. However, these are lowland communities. No tribal community is yet organized. Also, mushroom culture as a livelihood project was abandoned due to non-viability.

C. Legislation, Policies and Their Enforcement

Long before the initiation of the TCP, the Philippine Government has paid attention to the protection of the tamaraw thru policies and Legislation. These policies and Legislation include the following:

1. Commonwealth Act No. 73 of 1936, as amended by Republic Act No. 1086 of 1954 - prohibits the killing, wounding, or taking away of the tamaraw and providing penalties in violation thereof;

2. Proclamation No. 557 of 1969 and Republic Act No. 6148 of 1970 - declaring Mts. Iglit-Baco as a Game Refuge and Bird Sanctuary and as a National Park, respectively;

3. Accession of the Philippine Government as a member-country to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1983, a treaty which regulates the international trade of wildlife species;

4. DENR Administrative Order No. 48, S. of 1991 - establishing the national list of threatened Philippine wildlife, which includes the tamaraw, for priority concern for protection and conservation; and,

5. Republic Act 7586 otherwise known as the NIPAS ACT of 1992 - establishing the National Integrated Protected Areas System and providing measures to develop, conserve, and manage protected areas.

Although adequate laws and policies governing the protection and conservation of the species are existing and violations specifically against tamaraw hunting and killing are reported, no record indicates that a violator was apprehended nor case was filed before the proper courts to date.

D. Indigenous People in Mindoro in Relation to TCP

The Mindoro province is inhabited by diverse indigenous/tribal/sub-tribal groups with varying cultures, beliefs, and customary traditions, such as Mangyans, Batangans, Alangan, and Iraya, among others. Though the current generation of these tribal groups has gradually adopted to the "civilized" way of life, they are still bound to observe traditional laws (written or unwritten) imposed by their recognized respected elders (chieftains). Per reports, these groups are connected with and strongly influenced by missionaries / Catholic groups.

These tribal groups are mostly dependent on natural resources for subsistence. They practice traditional wildlife hunting and slash-and-burn agriculture (kaingin) without regard or paying less attention to the possible adverse consequences of such practice to the ecosystem. These led to the destruction of major portions of the tamaraw habitats and depletion of wildlife resources.

Under Republic Act No. 6148, the tribal groups are allocated an area of 1,000 hectares inside the Mts. Iglit-Baco National Park for tenancy/occupation. Likewise, the NIPAS Act provides tenurial rights to local people who have been occupying an area inside a protected area for a certain period of time as indicated in the said Act. These groups are now compelling the proper authorities to award to them the areas they are presently occupying.

As far as the NIPAS Act is concerned, granting of tenurial rights requires a lengthy process and conduct of several activities which include Protected Area Suitability Assessment (PASA), community censussing, actual demarcation or delineation of the area, and establishment of buffer zones, among other things. As of date, the actual demarcation of Mts. Iglit-Baco National Park is yet to be carried out, hence, hampering the immediate granting of tenurial rights to concerned tribal members.

II. PROPOSED ACTION PLAN

A. Guiding Principles

Several factors were considered in the formulation of the proposed action plan. They are the current programs being implemented by various groups to benefit different communities (target groups or beneficiaries), issues and problems, and identified corresponding solutions (Table I). The Plan's major thrusts focused on measures to address the issues and problems enumerated below.

1. Shifting agriculture (kaingin-making) by the tribal and upland communities.

2. Dependence of the IPs and local people on nature-based resources due to cultural influences and poverty attributed by the lack of alternative source of livelihood and/or unemployment and capital, inadequate technology, and inadequate public services.

3. Hunting or poaching of wildlife could be attributed to insufficient knowledge of the people on their ecological importance and long term benefits that can be derived from the resource.

4. Lack of proper coordination, transparency, and exchange of information among the various groups implementing activities directly or indirectly aimed at conserving the tamaraw and its habitat.

5. Lack of interest of IPs to cooperate with the government in implementing NIPAS prjects could be associated with problems on tenancy and ancestral domain claims, disinformation, and cultural differences.

B. Recommendations

Based upon the aforementioned problems and issues, the following recommendations are made.

1. Intensify information, education, and communication campaigns.

2. Pursue a higher level of law enforcement.

3. Intensify tamaraw and habitat protection thru people's participation.

4. Provide adequate attention to the ancestral domain claims of concerned communities.

5. Expand community organizing and development activities with the IPs and upland communities as the priority target communities.

6. Continue the development of alternative livelihood projects based on the needs of and acceptability by the target communities.

C. Strategies and Schedule of Implementation

The proposed Action Plan, covering a period of five (5) years, is divided into three major components as follows. Strategies and specific activities are presented in Table 2.

1. Information, Education, and Communication (IEC).

2. Livelihood and Technology Transfer.

3. Law Enforcement.

III. DETAILED RECOMMENDATIONS

Table 1.

A. Short term

1. *IEC - plug the program on tamaraw conservation.* (Coordinators: TCP Implementor & KMFI; Partners: LGU, DENR, DECS, DSWD and other concerned agencies/NGOs/POs). Use as many means of information as possible including:
    a. mass media
    b. disseminate popularized reading materials
    c. resource awareness at the barangay level via interpersonal communication.
    d. training seminars
    e. curriculum integration

2. *Law Enforcement.* (Coordinator: LGU & DEN; Partners: KMFI, TCP, PNP)
    a. Increase level of awareness re: laws on tamaraw conservation.
    b. Recommend hiring wildlife wardens and forest rangers to enforce laws.
    c. LGU to appoint barangay guards/wardens to regularly report to DENR/PNP.

3. *Livelihood and technology transfer:*
    a. training
    b. demo farms
    c. clinics in following areas:
        1) food production in home gardens (crops, poultry, livestock);
        2) improve farming system;
        3) cottage/home industries with minimum extraction & harvesting.

B. **Medium term.** (Coordinators: TCP; Partners: DTI, DENR, etc.).

1. Continue/sustain implementation of educational campaigns and law enforcement.
2. Continue livelihood and technology transfer.
3. Encourage investors in cottage industries.
4. Develop marketing systems for farm products/handicrafts.
5. Continue lobbying for CADC and AD.

C. **Long term**. (Coordinators: LGU, DOST, DTI; Partners: DENR-ISF, DSWD, DA, TCP, KMFI, etc.).

1. Improve access to communities.
2. Total community development.

Table 2.
ACTION PLAN I
CADC Facilitation

1. Consultation
2. Produce map
3. Legislation - ICC Ancestral Domain Bill
4. Award CADC

Livelihood Projects

1. Expansion of community organizing
2. Identification of projects
3. Training
4. Support projects

Technology Transfer

1. AIDA (attention, interest, desire, action/adoption)
2. Gradual phase-out and turnover of TCP to local community
3. Impact assessment

Law Enforcement / Policy

1. Public awareness
2. Apprehension
3. Court litigation
4. Correctional

ACTION PLAN II

Land Reform

1. Adjudication
2. Award of certificates of land ownership
3. Form credit and other infrastructures

Investments

1. Invite investors
2. Encourage local entrepreneurs
3. Improve investment climate e.g. fax incentives

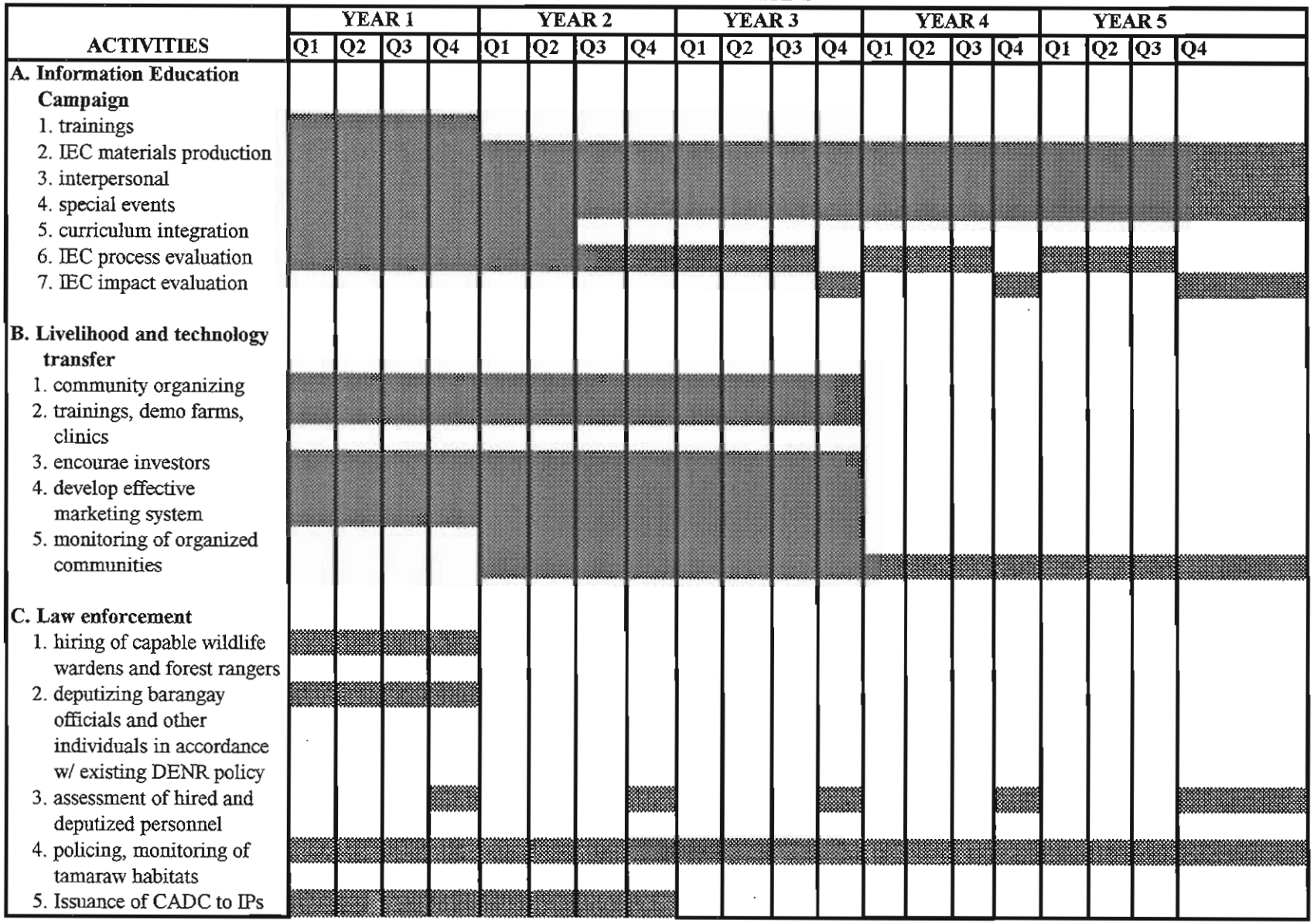
IEC

1. Information
2. Education
3. Communication

Linkaging

1. Among local groups
2. Among international groups
3. Networking

SCHEDULE OF ACTIVITIES



PEOPLE-BASED CONSERVATION AND RESOURCE MANAGEMENT PROGRAM

TARGET GROUPS	INFLUENCE GROUPS				Problems Issues	Solutions	ACTION PLAN			PLAYERS*	
	NGOs	Govt.	Int'l	Church			Short Term	Medium	Long	Lead	Partners
1. ICCs/IPs											
a. Batangans	UPLBFI * CO/CD * Research's Development	DENR * TCP * NIPAS	EU-NIPAP ADB-TA ILO Others		- Kaingin - Delineation of AD - Poverty	* IEC * Livelihood * Technology transfer * CADC (lobbying)	Continuing activity ——>; Continuing activity ——>; X; X			1 and 5 1 1 1 & 2	2,3,4 & 10 7, 8 & 9 9 10
	KMFI * IE Campaign * Community Development * Enforcement of forest and wildlife laws * Deputized as ENRO	MTCC									
b. Iraya	No information	OSCC * livelihood * IEC		Protestants * livelihood	- Kaingin - Delineation of AD - Poverty	* IEC * Livelihood	Continuing activity ——>	X		1 and 5 1	2,3,4 & 10 7, 8 & 9
c. Alangan	No information			Catholic * CADC * livelihood	- Kaingin - Delineation of AD - Poverty	* CADC (lobbying) Livelihood	X	X		1 & 2 1	10 7,8 & 9

* Players: 1- TCP; 2 -DENR; 3-DECS; 4 - DSWD; 5 -KMFI; 6 - PNP; 7-DTI; 8- DA; 9- DOST; 10-LGU

PEOPLE-BASED CONSERVATION AND RESOURCE MANAGEMENT PROGRAM

TARGET GROUPS	INFLUENCE GROUPS				Problems Issues	Solutions	ACTION PLAN			PLAYERS*	
	NGOs	Govt.	Int'l	Church			Short Term	Medium	Long	Lead	Partners
2. Upland Communities	UPLBFI * CO/CD * Research and Dev't. KMFI * CO/CD * Volunteer program * Information gathering * Law Enforcement * Biodiversity Conservation	DSWD DENR DA DAR	Possible implementation of ADB-TA		- Hunting/ Trapping - Kaingin - Tenancy - Poverty - Low technical capability	* IEC * Livelihood * Technology transfer * CADC * Law Enforcement * Land Reform	Continuing activity ———	———	———>	1 and 5 1 1 & 2 2 & 10 1 & 8	2,3,4 & 10 9 10 1,5 & 6 2 & 10
							X X X X				
3. Cattle Ranchers	- Cattle Ranching Association - UPLBFI	DENR * TLA Monitoring			Hunting Forest fires	* Law Enforcemen IEC	X X			2 & 10 1 and 5	1,5 & 6 2,3,4 & 10
4. Students/ Teachers	UPBLFI * value formation * CEIC * Curriculum integration	DECS			Low level of awareness	IEC linkaging	X			1 and 5	2,3,4 & 10

* Players: 1- TCP; 2 -DENR; 3-DECS; 4 - DSWD; 5 -KMFI; 6 - PNP; 7-DTI; 8- DA; 9- DOST; 10-LGU

PEOPLE-BASED CONSERVATION AND RESOURCE MANAGEMENT PROGRAM

TARGET GROUPS	INFLUENCE GROUPS				Problems Issues	Solutions	ACTION PLAN			PLAYERS*	
	NGOs	Govt.	Int'l	Church			Short Term	Medium	Long	Lead	Partners
	KMFI-YEAR * Volunteers * Training * Advocacy										
5. General Public (Mindoro)	UPLBFI * mass media	LGU DND-PNP DAR			Hunting Poaching Low level of	Policy/Law Enforcement Investments	X	X		2 & 10 7,9, & 1	1,5 & 6 1,2,4,5 & 8
	KMFI * volunteers				awareness Poverty Communication	Land Reform IEC	X		X	1 & 8 1 and 5	2 & 10 2,3,4 & 10

* Players: 1- TCP; 2 -DENR; 3-DECS; 4 - DSWD; 5 -KMFI; 6 - PNP; 7-DTI; 8- DA; 9- DOST; 10-LGU

APPENDIX A

GROUPS AND AGENCIES CURRENTLY IMPLEMENTING ACTIVITIES RELATIVE TO THE CONSERVATION OF THE TAMARAW, ISSUES AND PROBLEMS ENCOUNTERED, AND PROPOSED SOLUTIONS

GROUPS AND AGENCIES/ ACTIVITES				CLIENTELE	PROBLEMS/	SOLUTIONS
NGOs	GOVT.	INT'L.	CHURCH	GROUPS	ISSUES	
UPLBFI * CO/CD * Research's Development	DENR * TCP *NIPAS(CADC)	EU and ADB consultations for possible implementation of NIPAS projects		1. ICCs/IPs a. Batangans	- Kaingin - Delineation of AD - Poverty	* IEC * Livelihood * Technology transfer * CADC (issuance)
KMFI * IE Campaign * Community Development * Enforcement of forest and wildlife laws * Deputized as ENRO	MTCC * Fund sourcing * Local ordinance implementation	ILO * Livelihood Others: IUCN *workshop				
	OSCC * livelihood * IEC		Protestants * livelihood	b. Iraya	- Kaingin - Delineation of AD - Poverty	* IEC * Livelihood
	DENR *NIPAS(CADC)		Catholic * CADC	c. Alangan	- Kaingin - Delineation	CADC
UPLBFI * CO/CD * Research and Dev't. KMFI * CO/CD * Volunteer program * Information gathering * Law Enforcement * Biodiversity Conservation	DSWD DENR DA DAR			2. Upland Communities	- Hunting/ Trapping - Kaingin - Tenancy - Poverty - Low technical capability	* IEC * Livelihood * Technology transfer * Law Enforcement * Land reform

APPENDIX A

GROUPS AND AGENCIES CURRENTLY IMPLEMENTING ACTIVITIES RELATIVE TO THE CONSERVATION OF THE TAMARAW, ISSUES AND PROBLEMS ENCOUNTERED, AND PROPOSED SOLUTIONS

GROUPS AND AGENCIES/ ACTIVITES				CLIENTELE	PROBLEMS/	SOLUTIONS
NGOs	GOVT.	INT'L.	CHURCH	GROUPS	ISSUES	
- Cattle Ranching Association - UPLBFI	DENR * TLA Monitoring			3. Cattle Ranchers	- Hunting - Forest fires	* Law Enforcement * IEC
UPBLFI * value formation * CEIC * Curriculum integration KMFI-YEAR * Volunteers * Training * Advocacy	DECS			4. Students/ Teachers	- Low level of awareness	* IEC * Curriculum Integration
UPLBFI * mass media KMFI * volunteers	LGU DND-PNP DAR			5. General Public (Mindoro)	- Hunting - Poaching - Low level of awareness - Poverty - Communication gap	

TAMARAW
(*Bubalus mindorensis*)

Population and Habitat Viability Assessment

University of The Philippines Los Baños
College, Laguna, Philippines

15-17 May 1996

Report

SECTION 7

Participants

TAMARAW POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP
MAY 15-17, 1996
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SECTION 8

Contributed Papers

THE TAMARAW CONSERVATION PROGRAM: PAST, PRESENT AND FUTURE THRUSTS AND DIRECTION[1]

Nestor R. Lawas[2] and Josefina de Leon[3]

[1]. Paper presented at the PHVA Workshop held on May 15-17, 1996 at IFC, UPLB-CF.
[2]. Assistant Professor of Agronomy, UPLB College of Agriculture and Program Director, TCP 1996. [3]. Officer-In-Charge, Wildlife Management Section, DENR-PAWB

Introduction

The Tamaraw Conservation Program (TCP) is the effort of the Government of the Republic of the Philippines, particularly by the Department of Environment and Natural Resources (DENR), to prevent the extinction of the tamaraws (Bubalus mindorensis) which is considered as a rare Philippine treasure that is found only in the island of Mindoro. As conceptualized, TCP consists of strategies and activities that are focused on the preservation of the ruminant's natural habitat and on the application of knowledge on their basic biology to possibly multiply a certain captive number and lead to an increase in the tamaraw population.

Such was the Program (TCP) when it was initiated in 1979. However, throughout its sixteen (16) years of implementation which saw management and supervision changed hands involving at most nine (9) government and non-government organizations, the program has been saddled with issues and problems that, expectedly, lead to varying priorities and thrusts as well as shifts in direction. Thus, it can be said that maybe up to now and the ha future, TCP's thrusts and direction are not yet as firmly established as they should be although present management in coordination with the Protected Areas and Wildlife Bureau (PAWB)of DENR has set these as a primary concern.

The conduct, therefore, of this Tamaraw Population and Habitat Viability Assessment (PHVA) Workshop is a very much timely and strategic exercise, the results of which could be very vital to our present concern of charting and determining TCP's thrusts and direction. We do recognize though that there have been earlier attempts and efforts by the previous and also the present management to set and establish a sustainable program and these are precisely what this paper would try to present. Hopefully, this presentation could serve as a helpful input to the workshop and with the results benefitting the concerns and interests of both the workshop organizers and TCP.

The Pre-TCP Efforts

Even long before the initiation of TCP in 1979, the State has paid attention to the protection of the tamaraw though policies and legislation, such as commonwealth Act No. 73

of 1936 which prohibited the killing, hunting, wounding or taking away of the tamaraw other than for the protection of person or property or for scientific purposes (TCP 1995). This was followed by amendments in 1954.

Meantime, efforts were also made to estimate or ascertain the tamaraw population. From an estimate of 10,000 heads in 1900, it was reported in 1949 to have rapidly declined to about 1000 heads. Estimates made in the early '9Os saw a further decline to only about 200 heads. This very rapid rate of population decline of the tamaraw elicited grave concern not only nationally but up to international levels, such as during the 1965 Bangkok Conference of the International Union for the Conservation of Nature and Natural Resources (lUCN). Subsequently, then President Marcos issued Proclamation No. 557 proclaiming Mts. Iglit-Baco and its vicinities as Game Refuge and Bird Sanctuary in 1969 as a measure to protect the area and the tamaraws. In 1970, the same area was declared a National Park by virtue of Republic Act 6148. And then, in 1979, President Marcos issued EO 544 creating a Presidential Committee for the Conservation of the Tamaraw (PCCT) with the task of implementing a program to conserve the tamaraw and its habitat. This is what is officially recognized now as the start of TCP.

It is evident from these pre-TCP events that the program is a reaction by government to the concern raised over the declining population of the tamaraws. And if we consider the population decline rate, we can say it was a delayed reaction. In fact, it was only in 1991, through DAO 48, that the tamaraw was included in the list of Endangered species of animals where Endangered means that the population are in danger of extinction and whose survival is unlikely if the causal factors continue operating.

Nevertheless, we can see in this apparently delayed reaction that even early on, the thrust was protection of the tamaraw and the habitat.

The TCP From 1979 to 1995

With the general mandate of preventing the extinction of the tamaraw, TCP started to operate under PCCT with its focus on establishing first the known habitats of tamaraws. However, in 1980, a new strategy was formulated which was to make a sudden shift in thrust and program implementation priority, i.e. - captive propagation and establishment of a gene-pool. With this strategy, it was necessary to capture tamaraws in the wild and for them to by brought to the gene-pool area - a 280-hectare facility located in the southern part of the proclaimed National Park - and there, their behavior can be studied and hopefully, the stock can multiply naturally.

The management of TCP by PCCT lasted up to 1984 with captive propagation and habitat as its main thrusts. However, these TCP years also was marked by changes in the government agency tasked to supervise the program - first the Ministry of Natural Resources in 1979, then

the Presidential Assistance for National Minorities (PANAMIN) in 1981 and the office of Muslim Affairs and Cultural Communities (OMACC) in 1984. In 1985, the PCCT was dissolved and replaced by the Conservation and Resource Management Foundation, Inc. (CRMFI). Supervision of the program was then placed under the Ministry of Agriculture and Food (MAF) until 1987. Later, in the same year, supervision was placed under the DENR with management (CRMFI) executing a Memorandum of Agreement. CRMFI's management lasted up to November 1989 and following a brief transition period up to April 1990, tile TCP was contracted to the University of the Philippines Los Baños Foundation, inc. (UPLBFI) starting in May 1990 up to December 1993.

Although the TCP years from 1979 to 1993 were marked by changing hands in management and supervision, a review of the activities undertaken during the period will show that the thrusts and direction earlier set, i.e. captive propagation and habitat protection, were maintained. Perhaps, they differed only in the strategies and approaches, as well as priorities, but these exacted heavily on TCP's integrity and continuity.

It was, however towards 1993, with the TCP still under UPLBFI that dramatic events will ensue and mark a drastic shift in TCP's direction. With still captive propagation and habitat protection as its general objectives, UPLBFI specifically proposed to establish and maintain an alternate breeding herd of tamaraws at UPLB in Laguna and with such, conduct researches in the areas of breeding and reproduction, genetics, nutrition, health and management in captivity. This proposal elicited opposition from the Mindorenses and as we know, it did not materialize. UPLBFI, however, in accepting this response to its proposal, raised some issues and problems (TCP 1993) that put to task the question of who is really responsible for habitat protection and whether captive breeding of the tamaraw is a necessary evil? The position of UPLBFI on these two issues are - 1) that habitat protection is the responsibility of DENR and 2) even with a reforestation and rehabilitation program for the tamaraw habitat, it would take time to succeed so, in the meantime, tamaraws can be bred in captivity where they can be given the proper care and attention.

In June 1993 the DENR decided to redirect the programs thrust from captive breeding to tamaraw protection and rehabilitation of its habitats. UPLBFI then expressed reservations about some of the proposed activities which it felt were not within the scope of their expertise and thus terminated its management contract effective December, 1993.

In December 1994, a three-day review and planning workshop was held in San Jose, Occidental Mindoro with the objective of formulating a new TCP plan of action. The result was a strategic plan with six (6) major component thrusts: habitat protection, protected areas community development, conservation education and information, applied research, captive species management and support activities.

With the strategic plan serving as the new operational framework for TCP, the management of TCP for 1995 was again awarded to UPLBFI, but this time with a different set

of managers and implementors. TCP 1995 used as its program conceptual framework the three elements - tamaraw, habitat, people - and their interaction to see the interrelationships of the six (6) major component thrusts spelled out in the strategic plan and to base its detailed work plan. As reported by TCP, 1995 the major highlight of its implementation is the recognition of the vital role of local community participation and the need to involve a broader cross-section of Mindoro for a sustainable TCP.

The Present TCP

In recognition of UPLBFI's manpower and expertise which enabled it to implement TCP 1995 to the satisfaction of DENR, DENR-PAWB has renewed the contract of May 1995 to extend up to December 1996, for UPLBFI to again manage the TCP. The work and financial plan of TCP for CY 1996 basically is a continuation of TCP 1995 with the same major component thrusts. The plan however reflects a new perspective in terms of priorities and concerns that are to be addressed, i.e. highest priority for fund allocation going to protection and law enforcement, and engagement of local people in such activities; involvement of sectoral groups / organizations of good standing in Mindoro, with UPLBFI building their technical capabilities through training and establishing strong linkages and close coordination; and for the gene pool and the captive breeding project to be assessed comprehensively for its viability and make recommendations on its fate in the near future.

UPLBFI, in its 1996 contract, also is obliged to prepare a long-term conservation and management plan for the tamaraw and its habitat, as well as a scheme for the eventual phase-out from program management and its turn-over to the local community.

Aside from these, TCP 1996 is closely coordinating with two (2) projects which have started also this year in the same area, i.e. the National Integrated Protected Area Program - European Union (NIPAP-EU) and the Buffer Zone Management under the ADB-TA project. The areas for coordination include: a) delineation of the Iglit-Baco Protected Area viz. Tamaraw National Park; b) assessment of gene pool area and other tamaraw habitats as part of the protected area; c) protection and law enforcement.

Amidst all these issues and concerns that are intricately meshing with TCP's operational framework, the program during its year-end pluming review held on January, 1996 (TCP 1995) managed to come up with the following vision:

"We envision a stable tamaraw population in a habitat that is protected and managed by well-informed and well-trained local people in harmonious partnership with the national and local government, NGO's, academe and private sector for the benefit of present and future generations."

The question, however, of what a stable tamaraw population is has not been resolved yet and probably, this workshop could give us the answer.

TCP in the Future

The immediate concern of TCP that it hopes will create a strong impact on its future is how to operationalize the "tamaraw x habitat x people framework" in the context of local participation, partnership and co-operation. TCP 1996 is now slowly working on the Mindoro Tamaraw Conservation Council (MTCC) to assume the role of catalyst of this new order. The indications, however, are that the MTCC itself needs to be vitalized and strengthened if it is to play this major role.

A policy paper developed through TCP 1995 envisions the creation of a broader body and mechanism - the Mindoro Biodiversity Conservation Council (MBCC) - as a long-term strategy to address all issues and concerns, including those presented in this paper. TCP then is seen as a component of MBCC and would still continue its conservation efforts for the tamaraw. The difference with this set-up, is that TCP can coordinate its activities through MBCC which can then serve to provide support and do effective coordination such as to allow TCP to direct its thrusts, which could then include: Community development in protected areas; 2) conservation education, information and communication; 3)establishment of a Biodiversity Center, probably in Murtha, 4)Developing the gene pool area for wild ranging tamaraws and ecotourism; 5) Gene pool as site for telemetry and R and D and 6) Networking and Linkaging.

Concluding Remarks

We believe that from the sixteen (16) years of TCP implementation, we have gained meaningful lessons that are more than enough to now allow us to firm up and pro-actively chart the programs thrusts and direction not only for the immediate future but for the longer tend as well. If there is one lesson that cries out to be learned and applied now, it is the setting aside of personal interests and putting the tamaraws' above. Who knows, the tamaraw may only be a symbol. It may be our own future - as a people and as a nation - that is really at stake here.

Tamaraw Habitat and Ecology

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In general the tamaraw (*Bubalus mindorensis* Heude) can be found in the lowland and upland habitats on the island of Mindoro. But because of the impact of urbanization, increased human population coupled with agricultural expansion to include crop production and cattle ranching, the endemic bovine was driven into the least accessible habitats which include forested and grassland areas.

There are tamaraw reservations established through Republic Acts primarily to prevent the endangered animal from extinction. The largest is the Mt. Iglit-Mt. Baco National Park situated in the hinterlands of Mindoro provinces and occupying approximately 75,445 ha. The vegetation composition is predominantly grassland with forest patches along some waterways. The climax grass cover can be attributed to annual occurrence of range fire initiated by either the native Mangyan tribes, the hunters or the ranchers. F. B. Harrison Tamaraw Refuge and Animal Sanctuary in the Municipality of Sablayan, Occidental Mindoro occupies an area of approximately 40,000 ha and the Mt. Calavite Tamaraw Refuge located in the northwestern tip of Mindoro occupies about 20,000 ha. The Aruyan-Lampawan in Ligaya, Sablayan population is outside the legislated tamaraw reservation.

Tamaraw Habitat and Feeding Ecology

Habitat and feeding ecology of the tamaraw was studied in the grassland and forested areas of Mts. Iglit-Baco National Park specifically within the former Mt. Iglit Game Refuge and Bird Sanctuary (Fig. 1). In terms of topography, the study site is practically rugged with high mountain peaks ranging from 1000 to 1205 m above sea level, and the general contour of this portion indicated an abrupt change in elevation for an even less than a hundred meter ground distance.

The 400-hectare censussing area (Fig. 2) is hilly, defined by gullies, creeks, ponds and rivers. It experiences an equal duration of dry (late November to mid-May) and wet (mid-May to early November) periods with relatively high annual precipitation. *Saccharum spontaneum* L., *Imperata cylindrica* (L.) Beauv., and *Themeda triandra* Forssk. are the dominant grass vegetation. The forested area is dominated by *Albizia procera* and *Lagerstroemia speciosa* species.

Identification of habitat range - In 1981, the area identified as tamaraw distribution was approximately 1880 ha within the northern portion of the Sanctuary (Fig. 3) and in 1991 it increased to about 2000 ha extending southward. Criteria for inclusion were actual sightings, presence of resting places with hoof marks, fecal droppings and feeding areas. The limit of tamaraw distribution can be attributed to the following: (1) nearness and accessibility to water sources - the bovine seasonally migrates to lower elevations where water is only available; (2) presence of domesticated cattle - not a single head of tamaraw was sighted nor reported from interviews with both the Batangans (a Mangyan subtribe) and the ranchers; and (3) the presence of local residents - tamaraws are never observed near the villages of the Batangans, however crop plantation away from the villages are intruded and fed upon during the lean months.

The vegetation pattern - From the censussing area identified, *Saccharum* stand occupies about 37%, found in areas with high sediment and water-logged during rainy months, *Saccharum* composing 80.96% of the total aerial biomass (ab) with an average height of 2.61 m. Mixed grass species occupies 25.75%, average height of 1.27 m, co-dominated by *Imperata, Themeda* and *Saccharum* with cumulated ab of 71%; *Imperata* occupies 21.25%, average height of 1.2, ab of 58.06% and *Themeda* occupies 16%, 1.22 m high found on marginal hilly areas. A forest nearby used as hiding and resting area is co-dominated by *Lagerstroemia speciosa* with importance value index (IV) of 86.84, *Albizia procera* (IV=44.67) and *Olax imbricata* (IV=29.51). Most of the remaining spots of forests are located near waterways and where annual fire seldom occurs.

Plant dry matter productivity - The average monthly dry weight of aerial biomass from the four grass vegetation classes was monitored just after the simulated annual burning commencing from April 1978 and ending in March 1978. *Saccharum* stand produce 1.5 kg/m2/y, *Themeda* stand with 0.91 kg/m2/y, *Imperata* stand with 0.966 kg/m2/y and mixed stand with 0.97 kg/m2/year.

Tamaraw food and cover - A total of 48 species belonging to 9 families were identified. Eleven species are considered preferred namely: *Scleria scrobiculata, Allopteropsis semialata, Capillipedium parviflorum, Imperata cylindrica, Ophiurus tongcaligii, Paspalum commersoni, P. conjugatum, Phragmites karka, Sorghum nitidum, Themeda trinandra* and *Ephigenia* sp. On the other hand three species were identified poisonous i.e. *Pteridium aquilinum, Chromolaena odorata,* and *Crotalaria incana.* Preferred food plants are those regularly eaten probably due to palatability and seasonal abundance. On many occasions, tamaraws were observed to actively graze one hour before sunset until early midnight and then resume grazing in early morning until one hour after sunrise (Table 1). After grazing before midnight the animals rest on top of hills as evidenced by lying areas with fresh droppings and observations during full moon. On many occasions, tamaraws seek refuge under tall vegetation nearby, tall objects and shaded areas. Tall objects include rocks while shaded areas include gullies, rivers and other places beside high mountain or hill formations.

Grazing pattern - Generally, the tamaraw graze on young and palatable forage. They return to grazed-over areas frequently. Just after the occurrence of range fire the animals graze on the unburned palatable shoots of some preferred food plants contrary to the belief that the animals feed on ashes. The fact that there is an abundance of palatable herbage one month after the occurrence of range fire, the animals have the very option to forage on most palatable species. The first occurring palatable re-growths are *Ephigenia, Sorghum, Apluda, Scleria, Paspalum, Allopteropsis, Capillipedium*, and *Ophiurus*. The bovine even digs the bulbs of *Ophiurus* just after the burning of the herbage. The repeated grazing by tamaraw on previously grazed over areas shows that the animals themselves have the vision of maintaining a continuous source of palatable herbage throughout.

The sporadic burning activities by the indigenous people in a way sustains the grazing areas of the tamaraw. The Batangans are aware of the Tamaraw Conservation Laws hence they hunt only on other wildlife species like deer, wild pigs, quail, snakes, etc. by circular burning, use of snares, etc.

Table and Figure Legends

Table 1. Average monthly dry weight of above-ground vegetation from the four classes of grass cover in Mt. Iglit GRBS (April 1978 - March 1979).

Table 2, List of identified tamaraw food plants at Mt. Iglit Game Refuge and Bird Sanctuary, Occidental Mindoro.

Table 3. Number of tamaraw sighted bt time within the 400-hectare study area at Mt. Iglit GRBS, Occidental Mindoro (April 1117-23, 1981).

Figure 1. Map of Mindoro Island, Philippines showing te relative locations of Mount Iglit - Mount Baco National Park and the study area.

Figure 2. Topographic map of the 8,956-hectare former Mount Iglit Game Refuge and Bird Sanctuary, Mindoro, Philippines showing the limit of tamaraw distribution in 1981.

Figure 3. Map of the identified tamaraw population distribution in the former Mount Iglit Game Refuge and Bird Sanctuary showing the 1981 rainy-season's water resources distribution.

Figure 4. Sketch of vegetation cover and sampling layout within the 400-hectare censusing area of Mount Iglit.

Table 1. Average monthly dry weight of above-ground vegetation from the four classes of grass cover in Mt. Iglit GRBS (April 1978-March 1979).

MONTH	DRY WEIGHT (GRAM PER SQUARE METER)			
	Themeda stand	Imperata stand	Mixed-grass stand	Saccharum stand
April	19.92	82.28	64.15	173.93
May	113.33	289.94	330.20	671.02
June	298.36	404.77	579.95	903.04
July	386.61	487.48	730.95	961.15
August	393.04	668.33	752.80	963.11
September	410.27	675.13	820.83	1132.83
October	572.33	730.63	836.65	1356.58
November	548.14	831.56	846.70	1381.37
December	551.66	847.17	860.69	1418.87
January	604.02	861.29	903.45	1429.67
February	744.44	894.78	916.24	1515.06
March	910.39	966.38	969.68	1518.74

For Themeda: $Y = 29.359 + 66.669\ (X)$ with $R = 0.963^{**}$

For Imperata: $Y = 174.343 + 72.405\ (X)$ with $R = 0.955^{**}$

For Mixed-grass: $Y = 298.466 + 64.496\ (X)$ with $R = 0.864^{**}$

For Saccharum: $Y = 440.535 + 104.346\ (X)$ with $R = 0.925^{**}$

where Y = monthly dry weight (grams/m2)
and X = coded times 1,2, ... , 12 for April 1978-March 1979, respectively

Table 2. List of identified tamaraw food plants at Mt. Iglit Game Refuge and Bird Santuary, Occidental Mindoro.

FAMILY / SPECIES	PREFERENCE		
	Preferred	Casual	Associated
COMPOSITAE			
1. *Ageratum conyzoides*		X	
2. *Erechtites valeria-naefolia*		X	
3. *Synedrella nodiflora*		X	
4. *Tridax procumbens*		X	
CYPERACEAE			
5. *Bulbostylis barbata*			X
6. *Cyperus rotundus*			X
7. *C. stoloniferus*			X
8. *Fimbristylis complanata*			X
9. *F. pauciflora*			X
10. *Scleria scrobiculata*	X		X
EQUISETACEAE			
11. *Equisetum* sp.		X	
GRAMINAE			
12. *Alloteropsis semialata*	X		
13. *Apluda mutica eu mutica*		X	
14. *Botriochloa* sp.		X	
15. *Brachypodium sylvaticum*			X
16. *Capillipedium parviflorum*	X		
17. *Chrysopogon aciculatus*		X	
18. *Dicanthium* sp.		X	
19. *Digitaria timoriensis*		X	
20. *Dinochloa scandens*		X	
21. *Echinochloa* sp.		X	
22. *Eleusine indica*		X	
23. *Imperata cylindrica*	X		
24. *Ophiurus tongcaligii*	X		
25. *Paspalum commersonii*	X		
26. *P. conjugatum*	X		
27. *Phragmites karka*	X		
28. *Pogonatherum paniceum*		X	
29. *Pseudopogonatherum contortum*		X	
30. *Saccharum spontaneum*		X	
31. *Setaria pallida*		X	
32. *Sorghum nitidum*	X		
33. *S. propinquum*		X	
34. *Themeda triandra*	X		
35. *T. arundinacea*		X	
LEGUMINOSAE			
36. *Aeschynomene inoica*		X	
37. *Calopogonium mucunoides*		X	
38. *Desmodium scorpiurus*		X	
39. *D. procumbens*		X	
40. *D. triquetrum*		X	
41. *Parkia roxburgii*		X	
42. *Uraria lagopodioides*		X	
LILIACEAE			
43. *Ephigenia* sp.	X		
MALVACEAE			
44. *Sida acuta*		X	
MYRTACEAE			
45. *Psidium guajava*		X	
RUBIACEAE			
46. *Mussaenda philippica*		X	

Table 13. Number of tamaraw sighted by time within the 400-hectare study area at Mt. Iglit GRBS, Occidental Mindoro (April 17-23, 1981).

TIME	TAMARAW HEAD COUNT								
	day 1	day 2	day 3	day 4	day 5	day 6	day 7	Total	Mean[1/]
Morning									
5:00 - 5:30	11	0	16	1	1	8	4	41	5.86[b/]
5:31 - 6:00	32	34	19	10	22	14	16	147	21.00[a/]
6:01 - 6:30	5	15	4	10	4	1	3	42	6.00[ab/]
6:31 - 7:00	0	1	3	13	0	0	1	18	2.57[b/]
7:01 - 7:30	1	1	2	1	1	5	2	13	1.86[b/]
Afternoon									
4:01 - 4:30	6	5	1	8	5	0	15	40	5.71[bc/]
4:31 - 5:00	0	11	6	8	9	1	13	48	6.86[ab]
5:01 - 5:30	3	12	6	7	20	10	14	72	10.29[ab]
5:31 - 6:00	12	18	9	6	36	19	20	129	17.14[a]
6:01 - 6:30	12	12	1-	15	35	6	23	119	17.00[a]
6:31 - 7:00	0	0	7	0	5	0	0	12	1.71[c]
Total	81	109	89	79	138	64	111	672	96.00

[1/] Mean values bearing similar superscript(s) are not significantly different ($P<0.05$) based on Tukey's test. Data were analyzed for the two sessions (morning and afternoon).

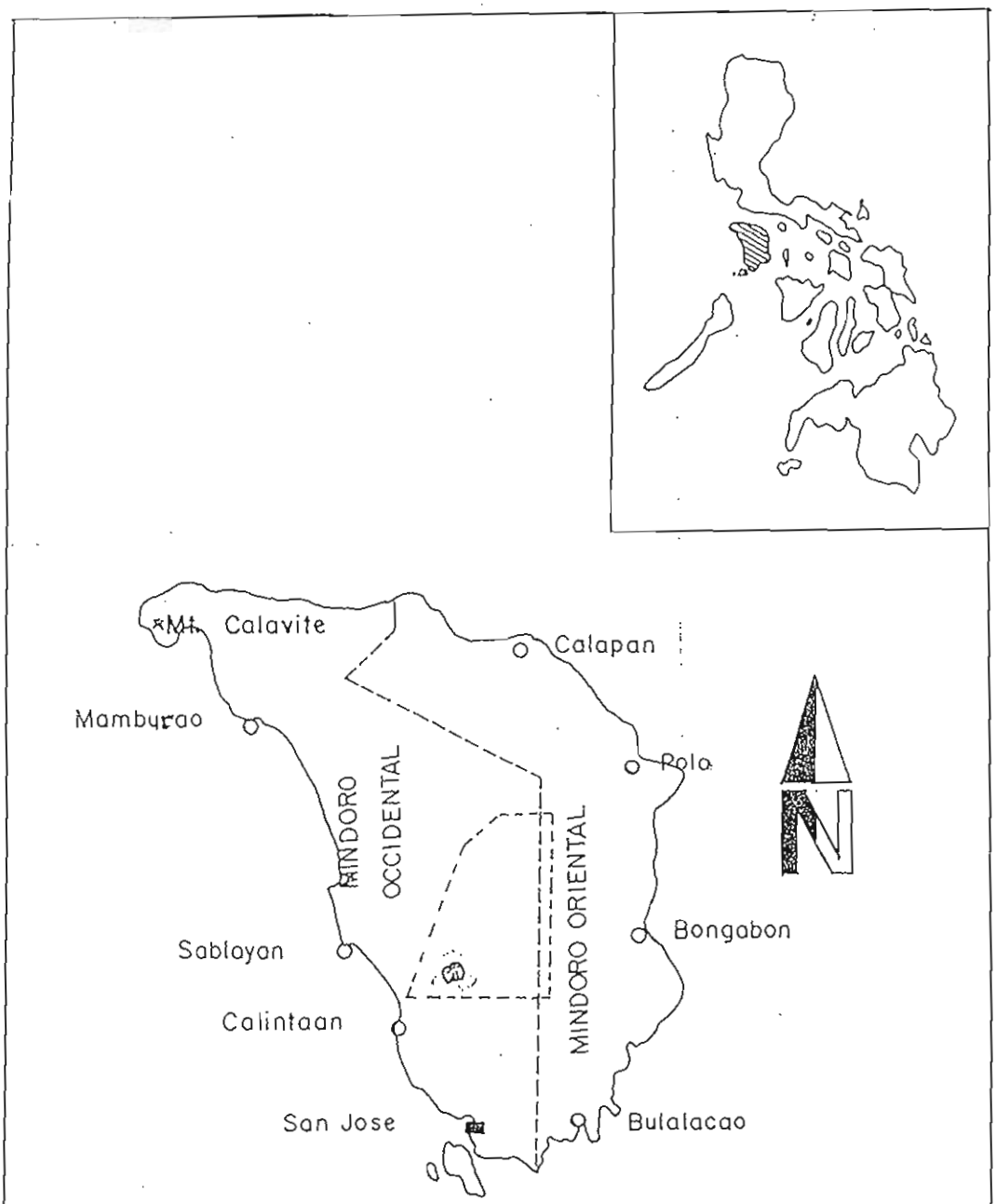
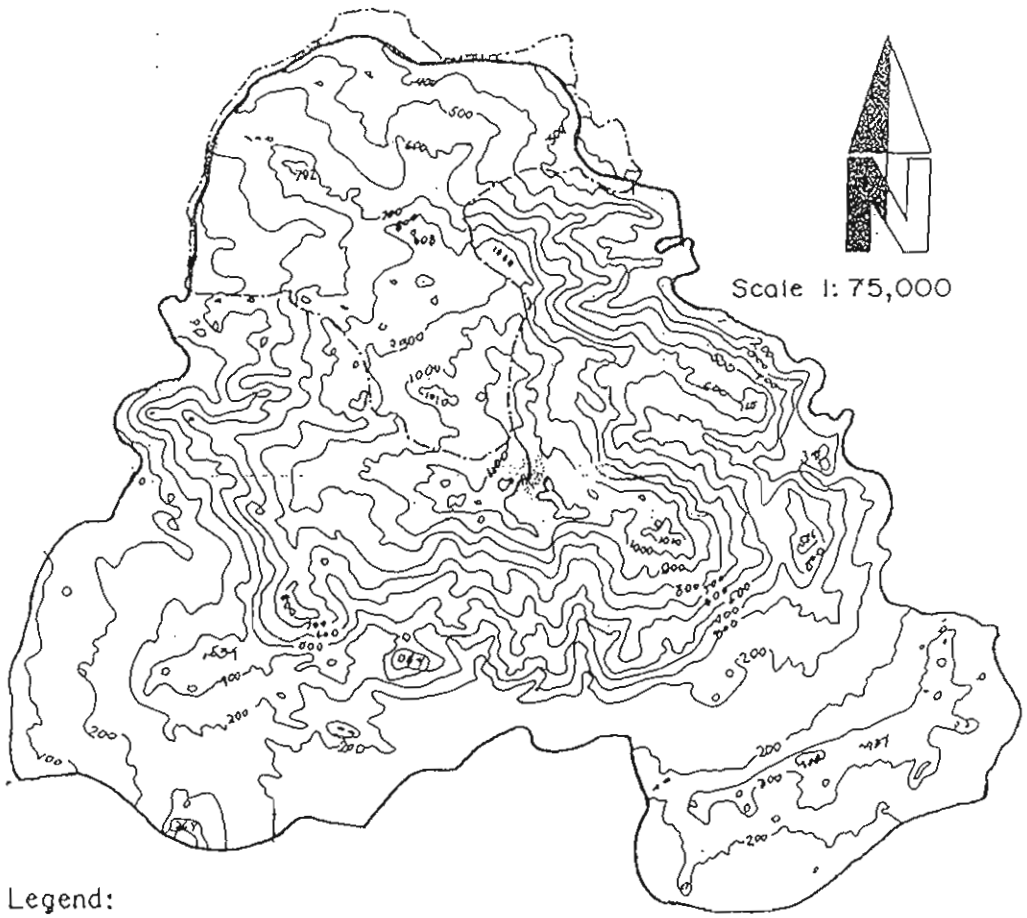


Fig. 1. Map of Mindoro Island, Philippines showing the relative locations of the Mount Iglit-Mount Baco National Park (uneven broken lines) and the study area (dotted)



Legend:

GRBS boundary

Contour line

Limit of tamaraw distribution

Fig. 2. Topographic map of the 8,956-hectare former Mount Iglit Game Refuge and Bird Sanctuary, Mindoro, Philippines showing the limit of tamaraw population distribution in 1981

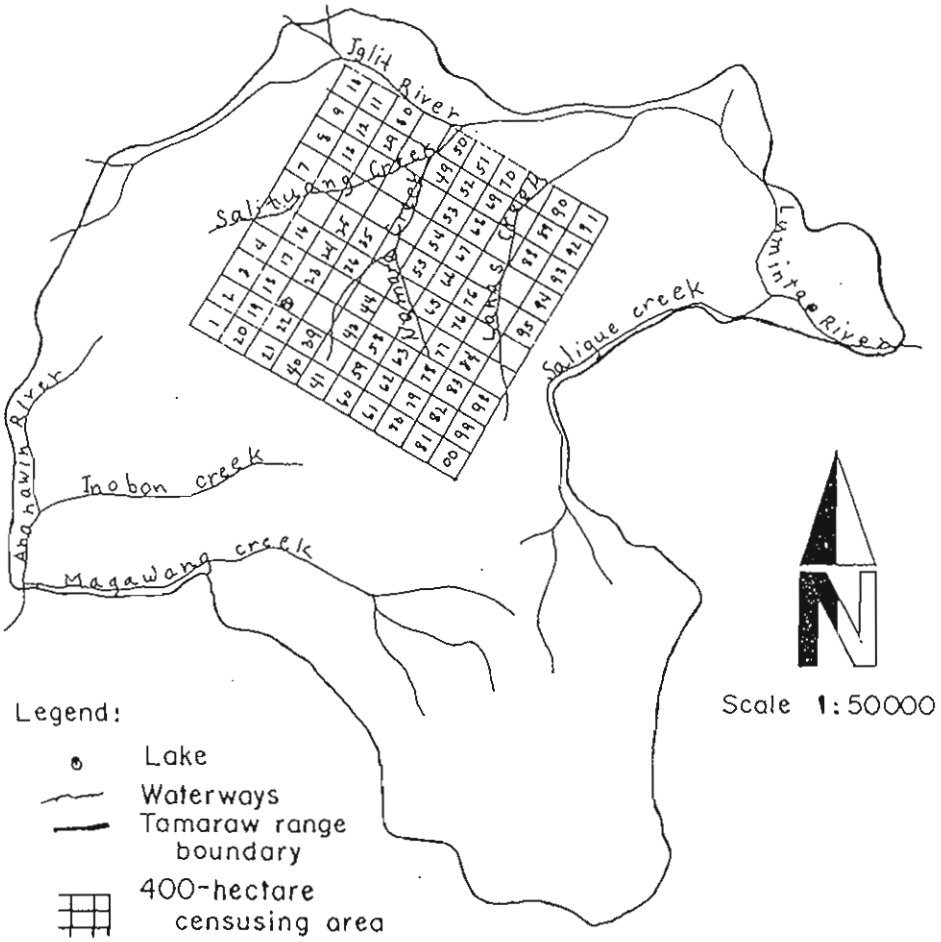


Fig. 3. Map of the identified tamaraw population distribution in the former Mount Iglit Game Refuge and Bird Sanctuary showing the 1981 rainy-season's water resources distribution

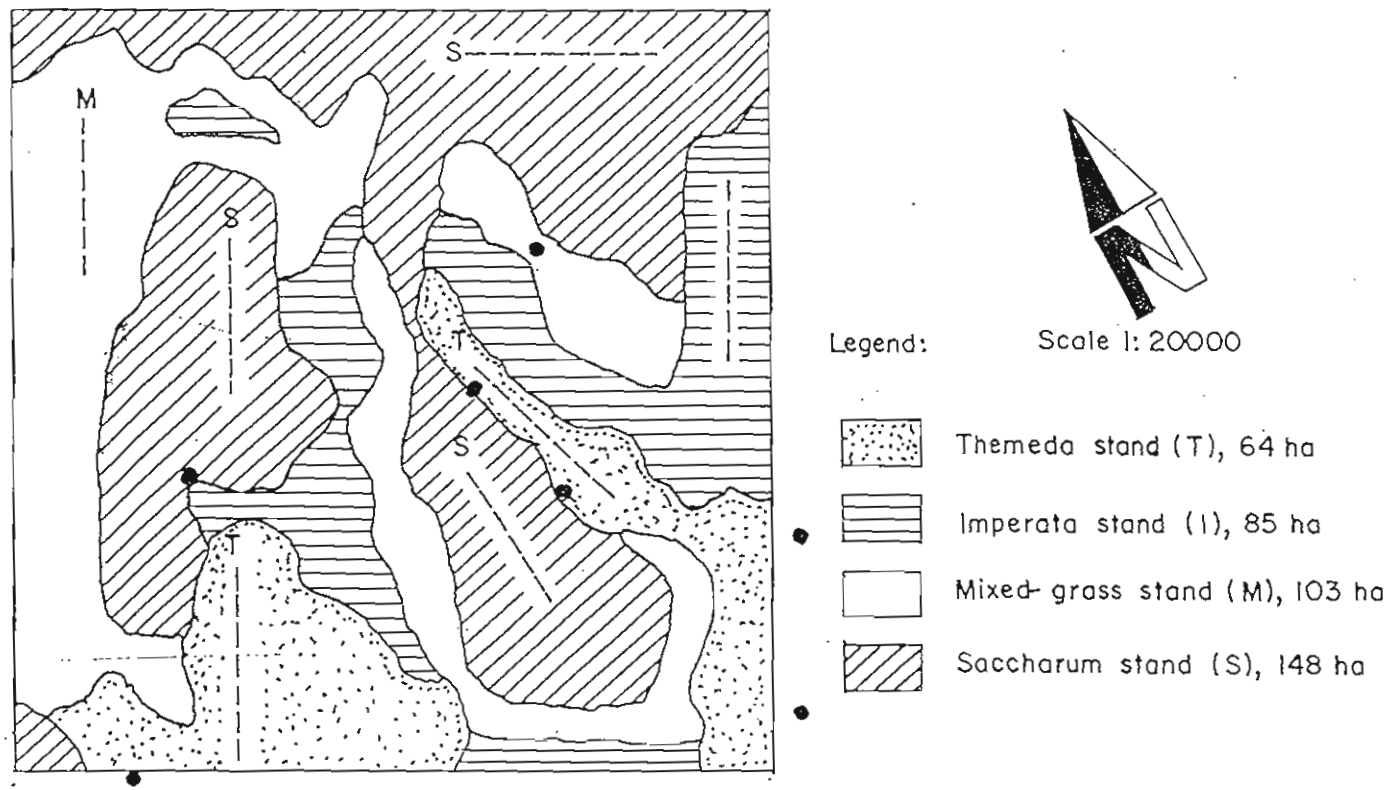


Fig. 4. Sketch of vegetation cover and sampling layout within the 400-hectare censusing area at Mount Iglit. Bold dots are censusing stations while broken lines represents transects

TAMARAW POPULATION: DISTRIBUTION AND STATUS[1]

MAXIMO A. QUIMBO
Field Operations Manager, Tamaraw Conservation Program

Introduction

The Tamaraw (*Bubalus mindorensis*) is considered by the World Conservation Union in 1994 as one of the most threatened land mammals in the world. It is typically a solitary but fierce animal with a very keen sense of smell. The Tamaraw has been known to detect the presence of a person even a kilometer away. For this reason, the tamaraw is very difficult to track down. This also explains the difficulty in trying to come up with an accurate accounting of its distribution and population. This lack of information hampers the government and non-government agencies' effort to protect and conserve these rare and endangered animal species.

Tamaraw Distribution

The Tamaraw is known to occur only in the island of Mindoro and nowhere else. It can be found specifically in the upper ranges of Mt. Iglit, Mt. Baco, Mt. Halcon and Mt. Calavite. In 1987, the Conservation and Resource Management Foundation, Inc. (CRMFI) estimated about 356 non-captive tamaraws in the island of Mindoro as shown in Table I.

Table 1. Distribution and Population of Tamaraws in Mindoro (CRMFI) 1987).

PLACE	NUMBER
Mt. Halcon - Eagle Pass	65
Mt. Cruz - Pinnagtuilan	20
Mt. Iglit - Baco National Park	145
Aruyan - Mapad Valley	41
Victoria - Bansud-Bongobong - Mansalay	40
Total	356

The typical habitat range and grazing ground was approximated by Rubio and Castillo (1992) to be between 100 to 600 meters above sea level. The tamaraw habitat is characterized by wide grasslands and patches of second growth forest. It requires dense vegetation for resting, water for drinking and wallowing and open land for grazing.

[1]Paper presented during the Tamaraw Population and Habitat Assessment Workshop held at the Institute of Forest conservation ,(IFC), UPLB, College, Laguna on May 15-17, 1995.

Population Status

The tamaraw has been known to proliferate in great numbers throughout Mindoro. In the mid-1900s, the tamaraw population was estimated to be around lO,OOO individuals (Harrison, 1969). From then on, the tamaraw population took a very dramatic decline so that in 1975, the number of tamaraws dropped to an estimated 150-200 heads (Kuehn, 1977). Alarmed at this dangerous development, the government initiated the Tamaraw Conservation Program in order to save the tamaraw from imminent extinction. In 1987 the tamaraw population managed to increase to 356 non- captive tamaraws in the island of Mindoro based on the CRMF report.

The most recent census of the tamaraw was conducted by Lustria and Callo in 1991 in a 1,880 hectare area of tamaraw habitat in Mts. Iglit-Baco National Park (MIBNP) as cited by Rubio and Castillo (1992). They recorded 133 heads of tamaraws .

Field Biology Study

The UPLBFI, a non-government organization tasked to manage the Tamaraw Conservation Program since 1995, conduct a continuing field biology study of tamaraws to determine its grazing, home range, distribution, migration pattern and movements. The study is being conducted in two known tamaraw habitats; Mt. Iglit ranges located within the MIBNP and Aruyan which is situated within the municipal boundary of Sablayan, west of the MIBNP. Actual field sightings of tamaraws are recorded by the patrol team who follow pre-determined routes. The information obtained will be used as a guide for subsequent patrolling, censussing and validation activities as well as other field research work of the Program.

Reports of Tamaraw Sightings in Arayan

An initial investigation in the form of interviews with resident Batangans to determine the possible presence, number and location of tamaraws in Mt. Aruyan was conducted by the TCP Patrol Team from April to early July, 1995. The place being referred to in the interview provided sighting information through memory-recall guided by questions from TCP staff. Validation of the said data was conducted by the same patrol team when they set out the second time from July 16-31, 1995. Below is the results of their interview with the resident Batangans.

Table 2. Sightings of tamaraws by some Batangans interviewed by the TCP Patrol Team from April to July 1995.

Month	Male	Fem	Sex?	Area where sighted	Interviewee
April		1		Kawayan Kinhawi area	Bingi
April		1	1	Maranog, near Inrubag, Low Malati	Dario
April			4	Salakan Creek	Batangan from Kinarawan
April			1	Upper Pusog River	Lito
May			4	Buwayan Creek that runs to Kinarawan River possibly a new discovery.	Anonymous
May		1		Kaingin area near Arnyan	Peding
May			3	Between the Penal Colony and Burihan	Anonymous
May			2	Bugsuron Katilad area	Anonymous
May		1		Katilad, observed going as far as Patag Malati	Anonymous
June		1		Kinarawan	Piding
June		1	1	1	Not indicated but was forested now cleared	Herminio and Lopez
June			2	4	Terrain thickly wooded with virgin forest	Banawi and Lopez
June				3	Observed grazing at kaingin area.	Anonymous
June	foot prints					Anonymous
					At thickly forested area of Malati river.	Anonymous

July	1	Malati river
July	3	Three locations in the mountain ranges near Bolo Creek Ingon and Pato Creek Anonymous
		Kawayan, Kinhawi, Aroyan area Burihan, probably the same group that had been seen before.

The information suggests that during the said period, approximately 35 Tamaraws were sighted in separate places within an area of around 3,000 hectares. Because of their familiarity with the tamaraws, the Batangans can readily tell the their sex. They also know by heart every corner of the mountain. However, the memory-recall method can cast doubt as to the actual number sighted due to probable lapses in memory. In addition, sightings in different areas at different times call give misleading information about the tamaraw population in the area.

On the second patrolling operations, actual sightings of tamaraws were recorded by the TCP Patrol Team from July 16 to 31. Table 3 shows the results of their observations.

Table 3. Number of Tamaraws actually sighted by TCP Patrol Team in Mt. Aruyan.

Male	Female	Unidentified	Place of Observation
	1	1 (calf)	Aruyan
1			Aruyan
1	1		Bulihan
		1	Bulihan

As shown in Table 3, a total of six Tamaraws were sighted in Mt. Aruyan area, with three in tile mountain, and three at lower elevation in Bulihan. Two males and two females were noted, while for the remaining two, the sex were not determined.

The patrol stayed in Mt. Aruyan for two weeks. During this period, foot patrolling was also done within the vicinities of So. Central (part of Sablayan Penal Farm). In this area, no tamaraws, nor footprints were observed. This could be due to extensive clearing as observed in the area for shifting cultivation.

The continued monitoring and census of tamaraws southeast of Salakan, Buayan area and its vicinities has resulted in the discovery of yet another herd of tamaraws. This particular area faces Mapad Valley and a portion of Mount Iglit is visible from the observation point.

From here, another pass was made on all places already mentioned and reported to make a more credible and realistic estimated head count. It was observed that there were only 12 to 16 heads in the entire area visited namely in: Aruyan, Bugsuron, Bulihan, Lampawan, Katilad, Inrugay, Salakan, Buayan, and Paglibuan. These are areas south and west of Madaldua, a vast range east of Aruyan with an estimated land area of 600 to 800 hectares.

In September, fresh footprints were found near Mataginting and at the foot of Lampawan. They belong to a lone tamaraw heading east along the general direction of Andala Creek in the Dangari area.

Massive footprints of what appeared to be a herd of three (3) tamaraws and footprints of a calf are found near Andala Creek, also in the Dangari area.

Two tamaraws were spotted at Katilad Salakan area, most probably ranging as far as Palbong up north near the boundary of Kinarawan-Mongpong Rivers and observed to be definitely not Aruyan tamaraws.

It was noticed that there is a new concentration of tamaraws in the area of Dangan, believed to be the group that vacated Aruyan because of the heavy trapping (Balatic and Binsik) and kaingin by the natives and Christians alike. Other places were visited for possible tamaraw presence.

In November 1-15, the patrol team spotted one young tamaraw at the Aruyan camp about 150 meters away near a cogon clearing. The animal was grazing and drinking water. It has been observed in the same place many times. Two heads were spotted at the Bugsuron area, while three tamaraws were seen at Paglibutan, a male, a female and a calf.

Reports of Tamaraw Sightings in Mt. Iglit

Initial field observations in Mt. Iglit was conducted in late July, 1995. A total of 9 tamaraws were physically sighted, particularly near the Bolo Creek and Pato Lake, some spots in Mt. Bayokbok and Loibpo Hill as shown in Table 4.

Table 4. Number of tamaraws actually sighted in Mt. Iglit for the month of July, 1995.

Date/Time Sighted	Sex M	F	?	Place of Observation	Behavior
l) 7-24/2030	1			Bolo Creek to Sablayan Hill	Wk
2) 7-25/1635		1	1	Mt. Bayokbok	G
3) 7-26/1715		1		Mt. Bayokbok going down	Wk,G

				Namara Creek	
4) 7-26/0530	1			Mt. Bayokbok, eastern side	G
5) 7-26/0540		1		Base of Mt. Bayokbok	G
6) 7-27/1030				Pato Lake	G
7) 7-27/1030			2	Loibpo Hill	Wk
Total	3	3	3 (1 calf)		

Wk- Walking; G- Grazing

Foot prints of two tamaraws were spotted possibly crossing the Anahawin River, from Sablayan Hill going to Tawilan Creek. Another footprint was spotted near the bank house at the Lawitan Area. A Batangan confirmed six tamaraws.

For the month of August, a total of 12 tamaraws were seen in different observation spots. These observation are shown in Table 5.

Table 5. Number of tamaraws actually sighted in Mt. Iglit for the month of August, 1995.

Date Sighted	Sex M	F	?	Place of Observation	Behavior
1) 8-10	2	2	2	Loibpo Hill	G
2) 8-10		1		Inobon Creek	Wk
3) 8-12	1			Forest near Tangle Creek	G
4) 8-12		1		Pato Lake	G,Wk
5) 8-15		1		Mt. Bayokbok	Wk
6) 8-15	1			Hill between Namara and Anyamo Creeks	G
7) 8-15	1	1		Namara Creek	Wk
Total	5	5	2 (calves)		

Wl - Wallowing

Aside from actual sightings, a skull was found near the junction of Iglit River and Namara creek.

The incidence of tamaraw sightings increased dramatically in September where a total of 29 tamaraws were sighted. These sightings are reflected in the table below.

Table 6. Number of tamaraws actually sighted in Mt. Iglit for the month of September, 1995.

Date/Time Sighted	Sex M	F	?	Place of Observation	Behavior
1) 9-10/1245			1	Salubang Creek	G
2) 9-10/1730		1	1	Inobon Creek	G
3) 9-10/1830				Mt. Bayokbok	Wk
4) 9-11/0545	1			SW of Mt. Bayokbok	G,Wk
5) 9-11/1645		1		Bolawo Creek	G,Wk
6) 9-11/1715	1			South of Mt. Magawang	Wl
7) 9-11/1715	1	1	1	East of Mt. Magawang	Wk
8) 9-11/1805			2	Hill adjacent to Mt Magawang	G
9) 9-12/0530		2	2	Mt. Magawang	G, Wk
10) 9-12/0545		1	3	Base of Mt. Saligi	Wk
11) 9-12/			5	Forested area of Baaras	G, Wk
12) 9-12/1000		2	2	Loibpo Hill	Wl
13) 9-25/		1		Punas forest	Resting
Total	3	9	17 (6 calves)		

Gathering of data on field sightings of tamaraw resumed in 1996. The patrol team revisited the areas already covered before to re-validate their initial sightings. The results of their observations are shown in Table 7.

Table 7. Number of Tamaraws actually sighted in Mt. Iglit for the month of March.

Date/Time Sighted	Sex M	F	?	Place of Observation	Behavior
1) 3-5/0610	1	2	2	Pato Lake to Tangle Creek	Wk
2) 3-5/0645			2	Hill to Namara Creek	G
3) 3-5/0650	1	1	1	Mt. Bayokbok	G
4) 3-6/	1			Side of mt. near Iglit River	G
5) 3-10/0530	1			West of Loibpo Hill	Wk
6) 3-22/1100	1			Side of Loibpo Hill	G, Wk
7) 3-22/0600		1		North of Pato Lake	G
8) 3-22/		2	2	Between Namara & Salubang Creek	R
9) 3-23/0515		1		Lanas Hill	Wk
10)3-24/0545	1	2	2	Ridge to Inobon Creek	Wk
11)3-25/0550		1		Namara Creek	Wk
12)3-25/0620		2	2	Medalla	G
13)3-25/0635	1			Mibluan to Bolo Creek	Wk
14)3-25/	1			Pakuan Lutukan Creek	Wk
15)3-25/0725	1			East of Libpo Hill	G
Total	9	13	11 (7 calves)		

For April 1996, the patrol team concentrated their observations on the Southern and Eastern part of Mt. Iglit, Mt. Tagnayan, Mt. Magawang and Tanas. Tamaraws sighted at Mt. Bayokbok, Loibpo Hill and Namara Creek (a total of 14 head), were not included to prevent duplication of sightings in the area. Indications of tamaraw presence such as footprints and feces were observed, however, only tamaraws actually sighted are presented in Table 8.

Table 8. Number of tamaraws actually sighted in Mt. Iglit for the month of April.

Date/Time Sighted	Sex M	F	?	Place of Observation	Behavior
1) 4-13/1830	1	1		Mt. Mibluan	G
2) 4-14/0800		1	1	Malibayong	G
3) 4-14/0830		1		Ridge of Mt. Tandugi	Wk
4) 4-14/0850	1			Southwest of Rocky Forest	G, Wk
5) 4-14/0850		1		Munat Creek	R
6) 4-15/0530	1	1	1	Side of Mt. Saligi	G, Wk
7) 4-15/0600	1	3	2	Between Mt. Magawang and Rocky Forest	G
8) 4-19/	1			Near Iyan Creek	G
9) 4-19/	1	1	1	Lanas Hill	Wk
Total	5	8	7 (4 calves)		

Observations

From the consolidated patrol reports, the tamaraws in Aruyan are increasingly being threatened by the increase in human activity in the area, more specifically the Batangan' practice of shifting cultivation and hunting activity from both Christians and Non-Christians. This has led herds of tamaraws to migrate to the lower Dangari area and other areas. Others may have eventually moved inside the Mt Iglit-Baco National Park.

The population of tamaraws in Mt. Iglit on the other hand seems to have been sustained and may even be increasing as indicated by the increase in frequency of sighting incidents and the healthy number of calves observed by the patrol team. Moreover, the tamaraws in Iglit have become more sedentary. The tamaraws observed before in a particular area were again seen within the vicinity during subsequent patrolling activity.

DISEASES OF TAMARAWS (*Bubalus mindorensis*) IN CAPTIVITY[1]

Joseph S. Masangkay[2], DVM, PhD, Manuel Bravo[3], DVM, MS, and Roberto F. Escalada4, DVM

The tamaraw (*Bubalus mindorensis*) is the only true wild population of bubaline in the world found only in the island of Mindoro, Philippines. Just like the common carabao (Bubalus bubalis) it belongs to subfamily Bovinae, Family Bovidae, Suborder Ruminantia and Order Artiodactyla.

It is an accepted fact that wild animals left alone do not suffer much from common diseases affecting their domestic counterparts. A good example of this disease is endoparasitism. Wild animals have their own designated places for defecating and another separate place for resting and sleeping. When these animals are confined in a small paddock the concentration of parasite ova increases and parasites with direct cycle can complete several generations in shorter time. The rate of infection increases. Because of this problem there is a need to regularly monitor the parasite load of confined wildlife. This can easily be done by fecalysis either by direct microscopic examination of feces or by quantitative analysis using the McMaster Flotation and Sedimentation techniques.

The tamaraws in captivity at the gene pool were examined for the presence of ectoparasites and endoparasites. The seven captive tamaraws were composed of five mature males and two females. Biweekly fecal analysis covering a period of 12 months were done and the following gastro-intestinal parasites were found: two species of trematodes *Calicophoron calicophorum* and *Fasciola* sp., three species of nematodes *Oesophagostomum radiatum, Mecistocirrus digitatus* and *Trichuris* sp. and one species of cestode *Monieza* sp. The external parasites found were: three species of ticks *Amblyoma* sp., *Boophilus microplus* and *Rhipicephalus sanguineus* and one species of louse *Haematopinus tuberculatus*. These parasites are common in domestic ruminants except for *Rhipicephalus sanguineus* which is a common parasite of domestic dogs while *Amblyoma* sp has been reported in a variety of wildlife in the Philippines.

To prevent this cross contamination between domestic animals and the captive tamaraws we instituted strict quarantine regulations in the gene pool. Only livestock owned by the program are allowed in the gene pool. At present we have one carabao and two horses. These animals are checked by the program veterinarian and together with the tamaraws they are also de-wormed accordingly. Dogs kept as guard in the gene pool are not allowed access to the tamaraw paddock and they are also immunized against rabies.

Aside from parasitic infestation we also observed cases of suspected poisoning. Two male tamaraws died of suspected selenium poisoning. The clinical signs were none-specific but the pathological findings of chronic toxic hepatitis were very much indicative of selenium poisoning. One young female tamaraw showed the classical signs of blind staggers indicative

of selenium poisoning. At first this animal showed anorexia and aimless wandering oftentimes bumping into objects. The gait was swaying and the pupil was dilated. No evasive response was elicited when objects were put in front of the animal. Fluid and supportive therapy were initiated which saved the animal. Blood examination showed high levels of SGPT and SGOT highly indicative of liver damage. In selenium poisoning the liver is the organ mostly affected which showed chronic centrilobular necrosis and replacement fibrosis. At present this animal is still alive and doing well. The source of the poison could have been the forage given to the animal grown in soil with high concentration of selenium.

Another suspected case of poisoning was reported in one male tamaraw. This time we suspected strychnine poisoning because of the characteristic opistothonus, tense muscle and dilated pupils unresponsive to direct light. The animal had been a downer for more than 18 hours and beginning signs of hypostatic pneumonia were seen. To avoid further pulmonary complications the animal was forcibly turned on the other side to relieve the hypostatic congestion after which fluid and supportive therapy were instituted. The animal recovered and is still under observation. The source of the poison could have been the strychnine group of plants trees and mushrooms found in the gene pool.

Other infectious diseases of viral and/or bacterial causes were not observed in the gene pool. The captive tamaraws were tested for the presence of antibodies to six selected pathogenic agents: bluetongue virus (BTV), pseudorabies virus, *Mycobacterium paratuberculosis*, *Brucella abortus*, *Pasteurella multocida* and *Leptospira* sp. Out of the six tested animals two were seropositive to *Leptospira* sp. while one animal reacted to both bluetongue virus and *Leptospira* sp. However no clinical signs of the diseases were observed in these animals. The source of the *Leptospira* sp. could have been carried by wild rodents contaminating the wallowing pools of the tamaraw while the bluetongue virus could have been introduced from neighboring ranches. These ranches imported cattle from Australia where the disease is prevalent.

Mindoro is a very clean island when it comes to diseases of livestock. It is one of the few islands in the country declared free from Foot and Mouth Disease (FMD). This disease affects all cloven-footed animals and ruminants, like the tamaraw, are very susceptible. To maintain this clean status the Bureau of Animal Industry must do its best to enforce strict animal quarantine regulations particularly in all ports of entry to Mindoro island. Even in the absence of an outbreak in any part of the country all the airports and piers in Mindoro must always be guarded.

In the gene pool we maintain strict quarantine regulation by coordinating all visits with the main office in San Jose. All vehicles entering the gene pool are disinfected particularly the tires. The paddocks where the tamaraws are kept are surrounded by filter fence to prevent direct access by visitors. Only authorized personnel are allowed to go near the tamaraws through designated entry points. Foot baths are installed in these entry points. The surrounding ranches were also asked to cooperate and coordinate with the program

veterinarian in any suspected cases of infectious diseases in their animals.

Aside from the threat of infectious diseases and poisoning one of the most difficult problems to solve in threatened and endangered species is its narrow genetic variability which can really lessen the chance of its recovery due to inbreeding depression. Preliminary findings based on genetic analysis of these captive tamaraws show this possibility.

[1]Paper presented at the Population and Habitat Viability Assessment (PHVA) Workshop for Tamaraw held on May 15-17, 1996 at University of the Philippines Los Baños, Institute of Forestry Conservation

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TAMARAW CAPTURE

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I. Introduction

During the late 1970's the Bureau of Forest Development(BFD) estimated the tamaraw population at 148 head and the Forest Research Institute (FORE reported about 200 in the same period. Thus, the Presidential Committee for the Conservation of the Tamaraw (PCCT) was created in 1979 through Executive Order No. 544, an organization with the primary aim of saving and propagating the tamaraws.

The creation of the committee led to the establishment of a 280-hectare gene pool farm at Sitio Lapuz, Bry. Manoot, Rizal in the province of Occidental Mindoro, intended for the purpose of captive breeding of the species. A former tamaraw habitat during the early days, the gene pool was entirely fenced off with interlinked wires, enclosed creeks, plains and forested hills within. Consequently, a capture operation was organized at Aruyan and Lampawan Hills at Ligaya, Sablayan in the said province.

Methods of Capture, Handling and Transport

A. The Capture

In the early summer of 1982, the Presidential Committee for the Conservation of the Tamaraw (FCCT), started its capture operation in the forests of Pusog, Lampawan and Aruyan Hills at Ligaya, Sablayan, Occ. Mindoro. These capture areas were identified and selected after surveys were made by a team headed by Mr. David Anthony Parkinson, a renowned wildlife conservationist who was then working with the project. Mr. Parkinson was also able to design and engineer the traps that were used to capture the animals.

Two types of traps were used in the capture operations. The pit trap (ordinary and all-weather) and the surface trap. The surface trap method, however, was discouraged since its construction required too large a volume of small round timbers. The all-weather pit trap, as the name implies, can be operational during the dry and the wet season, because it is provided with walling support and a drainage system so that water does not accumulate in it thus posing no danger to a possible catch. The traps were constructed at elevations ranging from 800-2000 m above sea level.

Every capture season, which is during the dry months of the year (December to April), an average of six (6) pit traps were activated. These are constructed along an identified

tamaraw trail, and each one measures 9 ft. x 3 ft. x 7 ft.. Excavated earth from the pits are deposited several meters away from the pit so as not to scare the animals of a new structure in the area. Controlled burning along the trail is also implemented; this is necessary to allow growth of new shoots of grasses which will entice the animal to go into the area and hence fall into the pit trap, and at the same time to remove any trace of human scent in the area which might ward off any prospective prey. A handful of salt which serves as bait, is spread on the center of the earth-covered lid of the trap. A two-foot thick cushion of dried grass is layered on the bottom of the pit to prevent injuring the animal upon falling. These traps are then monitored every morning to check any possible catch.

From 1982 to April of 1989, a total of 16 tamaraws - 10 males and 6 females were captured and airlifted from the capture site to the gene pool. It is strongly believed that these animals prefer this habitat because of its coronal plateaus (colon is *Imperata cylindrica*), abundant water supply, and availability of natural mineral clay licks.

In March 1986, another capture operation was established in Mount Halcon, Oriental Mindoro where a single pit trap was activated. The lone pit trap caught two tamaraws, a bull and a young female on June 22, 1986. It was the very first time that two tamaraws fell into a trap at the sane time. It was unfortunate however, that both died even before the capture team got to the site which was a 10-hour hike frown the nearest barrio The operation was finally discontinued in September 1987 due to weather and transportation problems.

B. Holding Pen

Once an animal falls into the pit trap, a holding pen measuring 12 feet x 8 feet was immediately constructed to temporarily confine the catch while waiting for the helicopter transport. Identified preferred forages such as colon grass (*Imperata cylindrica*) and young shoots of 'talahib' (*Saccharum spontaneum*) were given. Larger volume of forage was given at night time as it was observed that the animal feeds more during night time. Abundant supply of medicated drinking water was provided and the animal was given a bath twice a day to prevent heat stroke.

C. Crating and Transport

The animal is transferred from the holding pen into a crate through a chute. Sensing that it is now being crated, it would go very wild and attack the walls and ceilings of the crate. It has been observed that the behavior of the confined animal varies with sex and age. Bulls were observed to be more difficult to handle than the female and younger tamaraws.

A sedative is administered as soon as crate is secured. Rompun (xylazine) given at 0.22 mg/kg body weight was used to sedate the animal before it is airlifted. Sedation of the animal is a very important factor in reducing the stress on the animal during transport. Once signs of sedation are manifested by the captured tamaraw, airlift procedures are carried out

immediately. The airlifting techniques, wherein the crate is hung from a helicopter, plays a very important role in ensuring the safety of the animal. It should be carefully carried out to prevent the crate from rotating or revolving while hanging from the helicopter. The flight from the capture site usually takes about 20 to 25 minutes to the gene pool.

D . Releasing

The Tamaraw is given a bath to relieve it of excessive body heat before the crate is opened. The release area at the gene pool is also provided with an artificial wallowing pond where it can wallow upon release.

Upon leaving the crate , it usually moves in swaying gait which is the effect of the sedative and of the airlift. Although the animal shows incoordination, it may still attack any person in the immediate vicinity and even upon the crate itself. There was one incident that even the parked helicopter was almost charged upon by the newly released animal. Hence, to avoid any accident, and so as not to scare the tamaraw, presence of personnel should be minimized in the area during the release procedures.

The tamaraw will then proceed to investigate its new environment. Afterwards, it will seek refuge in the forest and is then closely monitored. Experienced personnel are assigned to locate and monitor the newly relocated animal.

E. Markings and Identification

In the absence of tagging device, every animal is given a name for the purpose of identification and monitoring. One animal is differentiated from another through their natural body markings such as notched ear, hence, the animal is named, "Pingas" - meaning "notched". White markings on the nostrils earned one the name of "White Nose". These are only example of the names given to two from the captive herd.

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ELECTROPHORETIC BLOOD PROTEIN VARIATION IN THE ENDANGERED TAMARAW (*BUBALUS (B.) MINDORENSIS*): GENETIC VARIABILITY AND RELATIONSHIP AMONG OTHER ASIAN BUFFALOES

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ABSTRACT.--Genetic variation based on 20 blood protein loci was examined electrophoretically from seven captive tamaraws (*Bubalus (B.) mindorensis*) and in comparison with the other related species under the Asian buffalo group: 2 lowland anoas (*B. (Anoa) depressicornis*), 9 mountain anoas (*B. (A.) quarlesi*), 5 river buffaloes and 15 swamp buffaloes to estimate genetic

RUNNING HEAD: Blood protein variation in Asian buffaloes

variability and phylogenetic relationships, and infer implications on conservation. The tamaraw has revealed its first protein variation, being yet known to be polymorphic at only one protein locus (Tf). Variations in these five subgroups were attributable to eight polymorphic loci (Hbβ, GPI, CA-II, SOD, ES, Alb, Tf and DBP) within the subgroups, and three variable loci (Hbα, ALP and PGM) in the Asian buffalo group. The mean $\hat{H}$ of the this group was relatively high (6.3%). The tamaraw was the lowest together with the lowland anoa (2.5%), high in the river buffalo (7.1%), and highest in both mountain anoa and swamp buffalo (9.7%). Genetic distance values showed that the tamaraw was the most distant subgroup, farthest from the river buffalo (0.372) followed by the mountain anoa (0.317), but slightly closer to the lowland anoa (0.218) and the swamp buffalo (0.273). Lowland anoa and mountain anoa were closely related to the swamp buffalo (0.187 and 0.205, respectively) than the river buffalo (0.246 and 0.265, respectively). Genetic distances between the two anoas (0.055) and between two types of water buffaloes (0.052) were the closest. The tamaraw exhibited genetic uniqueness and has apparently low genetic variation. The phylogenetic relationships of these Asian buffaloes and implications to the conservation of the tamaraw are discussed.

Endangered animals have always been given attention for the conservation of biodiversity, and because their genetic structure may also significantly contribute in the future animal breed development for various purposes. The tamaraw (Bubalus (B.) mindorensis) is a rare wild buffalo inhabiting only in the island of Mindoro, the Philippines, which in many ways related to the species belonging to the Asian buffalo group (Cockrill, 1984; Grubb, 1993; Mahadevan,

1992). Its number has steadily declined at a critical level where presently no more than 200-300 heads are left, and has been categorized as extremely endangered nearing to extinction (1990 IUCN Red List of Threatened Animals, World Conservation Monitoring Centre, UK; Nowak, 1991). Although it has been classified as a separate species in the Asian buffalo group, confusions still persist with regards to its exact systematics and relationship with the other member species. Various nomenclature including Bubalus arnee mindorensis (Klös and Wünschmann, 1972) and Anoa mindorensis (Fischer and Hohn, 1976) have been given to this rare buffalo since little is known about its basic genetics and biology.

The Asian buffalo group which all domestic and majority of the buffaloes in the world today are descended, presently embraces an intricate taxa with two subgenera and four species (Grubb, 1993; Nowak, 1991) comprising also the lowland anoa (B. (Anoa) depressicornis), mountain anoa (B. (A.) quarlesi) and the water buffalo (B. bubalis). Although these different subgroups of Asian buffaloes can be recognized based on several parameters including morphology, karyotype and geographical distribution (Cockrill, 1984; Mahadevan, 1992; Namikawa, et al., 1995), a definitive genetic characterization remains elusive. The anoas have also been suffering from complexities in description and classification of recognized types (Schreiber et al., 1993). Difficulties in the implementation of conservation programs arise when the exact taxonomy and genetic characters of rare species are unknown. The water buffaloes also despite has long been given one scientific name, there are still arguments regarding the systematic subdivision of the two types. Among the livestock and domestic animals worldwide, the buffalo has remained to be the least differentiated into breeds (Hall and Ruane, 1993).

Presently, research efforts for these buffaloes should initially

focus on the comprehensive characterization of this group to clarify genetic structure and phylogenetic relationships which offer opportunities for genetic improvement, selective breeding and conservation. Examination through blood protein electrophoresis at several loci has never been done in the tamaraw as well as in the complete species of the Asian buffalo group. The present study examines 20 blood proteins/enzymes employing various electrophoretic techniques to increase basic genetic and biological characterization of these buffaloes.

MATERIALS AND METHODS

Blood samples were collected in EDTA tubes from 7 captive tamaraws from Mindoro, the Philippines, 2 lowland anoas and 9 mountain anoas kept at Indonesian zoos, 5 river buffaloes and 15 swamp buffaloes from Indonesia and the Philippines. Whole blood was then separated into RBC and plasma fractions by centrifugation. Hemolysates and globin components were prepared for the hemoglobin and globin chains analyses according to Chernoff and Pettit (1964). A total of 20 blood protein loci were examined (Table 1).

Hbα, Hbβ and DBP were resolved on 0.2 mm-thick, while PGM on 0.4 mm-thick gels by polyacrylamide gel isoelectric focusing (PAGIF) according to the procedures of Pharmacia LKB Biotechnology System Handbook (1989), with some modifications, using Pharmalyte with pH gradients of 5-8 for Hbα, Hbβ and PGM, and pH 4.5-5.4 for DBP. The following proteins were typed employing starch gel electrophoresis: MDH, LDH-A, LDH-B, CA-II, SOD, and G6PD using buffer systems described by Shaw and Prassad (1970); ES, CP, LAP and ALP using LiOH system according to Fergusson and Wallace (1961); AK and ME using the method in Hillis and Moritz (1990); GPI using tris-citrate system by Shotake et al.(1977); Alb using a discontinuous system by Shotake (1979); and

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ACP by the method of Ishimoto (1972). Tf was typed by horizontal polyacrylamide gel electrophoresis (PAGE) according to the procedure of Gahne et al. (1977).

Assuming autosomal codominant genes, allele frequency of each protein locus was determined by simple gene counting. Genetic variability was estimated from the proportion of polymorphic loci (Ppoly) and average heterozygosity ($\hat{H}$) among the subgroups: tamaraw, lowland anoa, mountain anoa, river buffalo and swamp buffalo. Genetic distances were computed using Nei's formula (Nei, 1987). Dendrogram based on the genetic distance matrix of all subgroups was obtained by the unweighted pair-group method (UPGMA) of clustering. Principal component analysis (PCA) was carried out using the variance-covariance matrix of allele frequencies with angular transformation ($\theta = \sin^{-1}(P)^{0.5}$, where P is frequency of a gene) at polymorphic loci.

RESULTS

Protein Electrophoretic Phenotypes and Variations

Eight out of 20 blood protein loci examined were polymorphic within subgroups of Asian buffaloes (Table 2). Polymorphic loci detected for each subgroups were: one for the tamaraw and lowland anoa (Tf and Alb, respectively), six in mountain anoa (Hbβ, GPI, SOD, CA-II, Tf and DBP), three in river buffalo (Alb, Tf and DBP) and five in swamp buffalo (ES, CA-II, Alb, Tf and DBP). In addition, three loci (Hbα, ALP and PGM), although not polymorphic within the subgroups, have also shown to be variable among the Asian buffaloes.

The Hbα as described previously (Solis et al., 1995) differentiates the tamaraw by the evidently distinct α globin pattern ($Hb^{T\alpha}$) on PAGIF gel from the rest of the Asian buffaloes (Fig. 1a). Although the α globin bands of Asian buffaloes show relative affinity, this Hbα haplotype remains unclarified in these buffaloes since

constitutions at primary structural level are not yet established. Only the mountain anoas have shown variations in Hbβ with three alleles while the tamaraw settled for the common $Hb\beta^1$ with the rest of the buffaloes (Fig. 1a). GPI locus with a basic pattern of double bands in the starch gel was also polymorphic only to the mountain anoas with a variant anodal mobility. CA-II displayed extensive heterogeneity with four allozyme types on the starch gel. The tamaraw and lowland anoa revealed a monomorphic common $CA\text{-}II^b$ allele with a single intermediate band. Only the water buffaloes displayed the $CA\text{-}II^d$ allele, but the common $CA\text{-}II^b$ is not present in the river type. Mountain anoas have previously revealed two alleles (Amano et al., 1983; Schreiber et al., 1993), but a third allele ($CA\text{-}II^c$) with a more anodic mobility was newly found in this study. The SOD phenotypes were clearly identified using specific stains or detected accidentally while staining other enzymes using MTT-PMS reactions on the starch gel (Fig. 1b). Only the mountain anoas have shown SOD variants while the tamaraw and the rest have shown monomorphic SOD^a with a cathodic major band and an anodic minor band. The tamaraw revealed a single intermediate moving ES^b band between the two allozymes of swamp buffalo in which the slow moving one was similar with those of the anoas and river buffalo on starch gel using LiOH buffer system. A monomorphic Alb^A was detected in tamaraw, an allele which was not found only in the mountain anoa (only monomorphic Alb^X). Variations were detected on lowland anoa having predominant Alb^A, swamp buffalo with predominant Alb^X, and only the river buffalo had three alleles with the Alb^B at highest frequency (Fig. 1c). The remarkable polymorphism displayed by Tf locus on PAGE has been so far the first locus to unveil variants in the tamaraw (Tf^A and Tf^D) similar to the alleles of the swamp buffalo (Fig. 1d). The river buffalo showed the more cathodic alleles, Tf^D and Tf^E. Anoas' Tf phenotypes were the most

anodic. In addition, a new Tf variant was detected in mountain anoa through heterozygous individuals (Tf^{0x}) which has not been reported elsewhere. ALP variation in the present study revealed two alleles, a slow moving double broad bands of the wild tamaraw and anoas, and a fast moving for the domestic water buffaloes. Similarly, two PGM focusing patterns, one for the tamaraw and another for the other buffaloes, were resolved with a basic pattern consisting up to nine major bands on the IEF gel. Although the type of PGM isozyme and the number of expressed loci in these buffaloes have not been determined yet, the two zymogram patterns differing phenotypically at higher pI level suggest at least one locus difference is involved. No reports yet have clearly clarified the DBP patterns of Asian buffaloes on electrophoretic gels. We have detected for the first time DBP patterns in tamaraw and anoas. Variants were evident within mountain anoa and two types of water buffaloes bringing together four detectable DBP allozymes for the Asian buffaloes. Basic DBP phenotype patterns on the PAGIF gel shows two major bands of higher pI and a minor one with lower pI (Fig. 1e).

Genetic Variability among Subgroups of Asian Buffaloes

Table 3 presents the quantified genetic variability based on values for proportion of polymorphic loci (Ppoly) and average heterozygosity ($\hat{H}$) among the five subgroups of Asian buffaloes. Ppoly may sometimes be subjected to problems related to small sample size (n) and small number of loci examined, and therefore may not be a good measure of genetic variation than $\hat{H}$ (Nei, 1987). However, the values for Ppoly in this study correspond with those of $\hat{H}$. Mean heterozygosity for all these buffaloes revealed a relatively high values ($\hat{H}$= 0.063), but among the subgroups the tamaraw and lowland anoa were the lowest ($\hat{H}$= 0.025) compared to the above mean values of

the mountain anoa ($\hat{H}$= 0.097), river buffalo ($\hat{H}$= 0.071) and swamp buffalo ($\hat{H}$= 0.097).

Genetic Distances and Relationships in Asian Buffaloes

The tamaraw showed to be the most distant subgroup particularly to the river buffalo (0.372) and mountain anoa (0.317), slightly closer to the lowland anoa (0.218) and swamp buffalo (0.273). Lowland anoa and mountain anoa leaned more closer to the swamp buffalo (0.187 and 0.205, respectively) than with the river buffalo (0.246 and 0.265, respectively). Relationships between the types of water buffaloes (0.052) and between the two anoas (0.055) were very close. A dendrogram (Fig. 2a) was drawn based on genetic distance values showing the relationships among these Asian buffaloes.

The PCA diagram (Fig. 2b) constructed by the first and second component scores accounting the sum of 88.0% of all variations further elaborates their relationships and clearly show a triad of classes for the Asian buffalo group: the tamaraw, the anoas, and the water buffaloes. Each class occupied single quadrant where the corresponding types for the anoas and water buffaloes associated together.

DISCUSSION

Blood Protein Variation and Genetic Variability in Asian Buffaloes

Multi-locus blood protein variation is yet the first account to examine the tamaraw at several protein loci to provide an estimation of its population genetic structure, and also to allow genetic comparison and characterization among the complete species of the Asian buffalo group at protein level. The tamaraw has revealed its first protein variation, being yet known to be polymorphic at only one protein locus (Tf), while several other loci (Hbα, ES and PGM) have also provided evidences of its uniqueness despite its close

relationship among other Asian buffaloes. Genetic variability estimates (Table 3) show the mean amount of polymorphic loci in Asian buffaloes to be 16%, where the tamaraw and lowland anoa were the lowest (5%). These values correspond to average heterozygosity ($\hat{H}$) where the mean amount of heterozygotes in Asian buffaloes was 6.3% and again both subgroups scored very low (2.5%) compared to the above average values of the other subgroups. However, lowland anoa has been reported to be polymorphic in several other blood proteins (Amano et al., 1983; Schreiber et al., 1993), and its sample size (two individuals) may partly be accountable for its very low values. The Asian buffaloes harbored an average $\hat{H}$ value close to 6.7% ($\hat{H}$= 0.067 ± 0.005), an average for a collection of 172 mammalian species (May, 1995) indicating a fairly high variation in the group. Previous reports which also noted variations in several parameters in these Asian buffaloes, suggest that it is very likely that this group encompasses genetically diversified taxa which also extend to the variations of several genetic markers at molecular level.

Phylogenetic Relationships in the Asian Buffalo Group

The pattern of distribution of blood protein phenotypes and polymorphisms reflects the group's composition of well-differentiated members as also shown by the dendrogram based on genetic distance and the PCA (Fig. 2a and b), thus useful for the reconstruction of interspecific phylogeny of Asian buffaloes. The uniqueness of the tamaraw was augmented by the total predominance of alleles $Hb\alpha^{T\alpha}$, ES^{b} and PGM^{b}, while Hbα, Tf, ES and PGM loci in anoas, and Hbα, ALP and CA-II loci in water buffaloes contributed significantly to their respective distinction in the PCA. Alb may differentiate between the two anoas, while CA-II, Alb, Tf and DBP may distinguish between the two types of water buffaloes. Thus several of these protein loci have

demonstrated their potential application as biochemical markers to characterize and classify Asian buffaloes.

The evolutionary relationships inferred from the analyses show that the tamaraw is more distantly related compared between the anoas and the water buffaloes, while their respective types are the closest, as predicted. However, the tamaraw shows more affinity to the anoas and swamp buffalo, which are all endemic in the south-east Asian region, than the river buffalo common in south Asia. There seems to be a strong correlation between genetic relationships and geographical distribution among these buffaloes which may have been an important factor to their divergence. This is also apparent between similar types such as the notable geographical determined size differences between lowland and mountain anoas (Grove, 1969), and the differences in general conformation and habit between river buffalo of Indian subcontinent and swamp buffalo of south-east Asia (Cockrill, 1984).

Implications to the Conservation of the Tamaraw

The genetic uniqueness of the tamaraw may serve significance in the context of animal breed development and conservation of biological diversity. Much efforts have been devoted to the collection and preservation of unique genetic resources from which genetic utilization for future development of needed strains may prove advantageous, and this unique animal may be a valuable source of genetic materials which are economically and biologically important. However the present results also indicates that the tamaraw may have a low degree of genetic variability in its population. This has been observed to be common to most, although not all, rare and threatened species (Avise, 1994; May, 1995). Its population seemingly exhibits problem on survival, yet it remains to be confirmed whether it is related to the consequences of low variability as a result of e.g.,

inbreeding. But it is known that most small populations, whether captive or wild, are likely or tend to be inbred as a result of restricted choice of mate, and often associated with increasing mortality and decreasing reproduction that may further reduce the size of the population (Alderson and Bodò, 1992; Moore, et al., 1992).

The success of any conservation and breed development program rely upon several critical factors, but a sound theoretical understanding of the genetics aspect is of immense importance. Most discussions of genetics in conservation biology have focused on how best to preserve variability within rare and threatened populations, a common assumption being that higher heterozygosity enhances the probability of a population's survival over ecological or evolutionary time. Causal link between molecular heterozygosity and population viability may be elusive, but nevertheless management for heterozygosity remains an important consideration for the implementation of effective management and conservation of endangered species (Avise, 1994).

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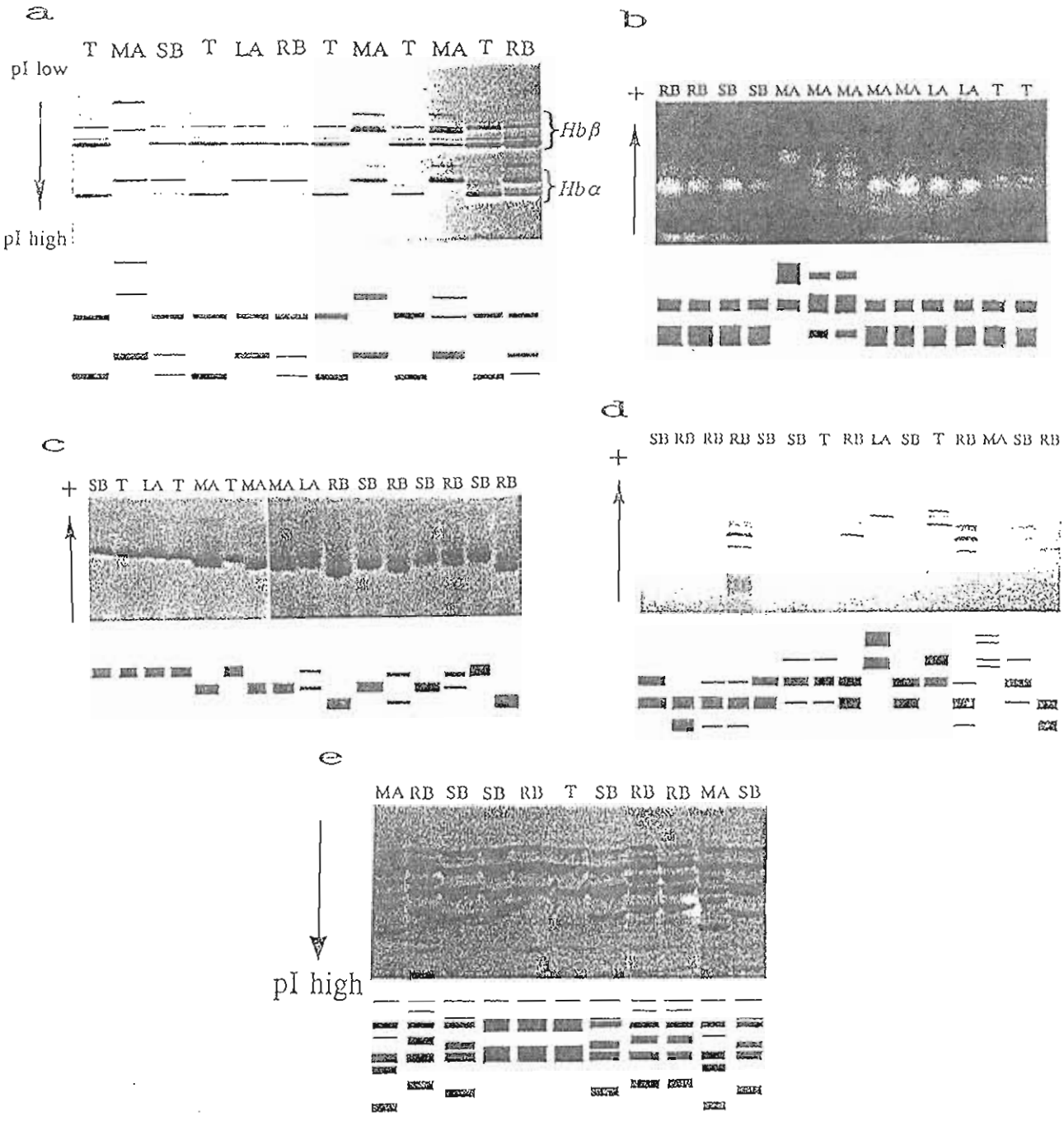
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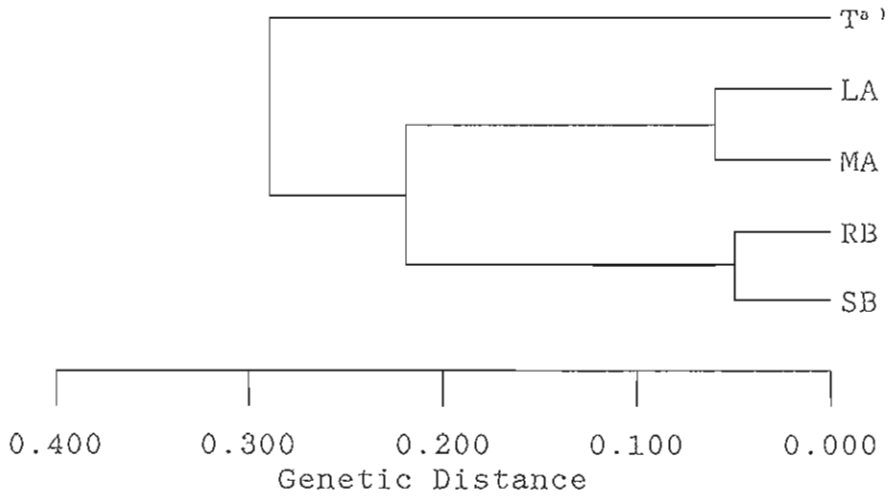

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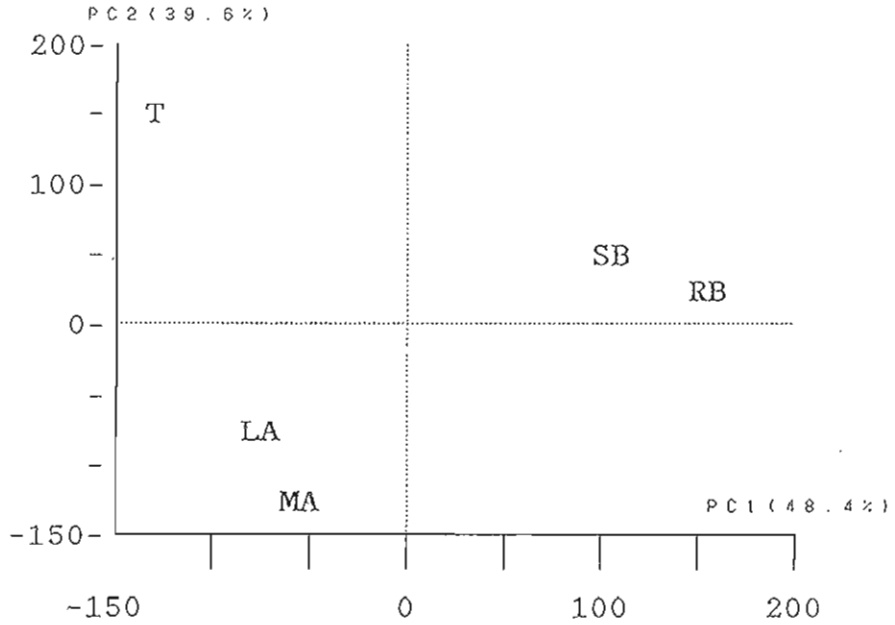
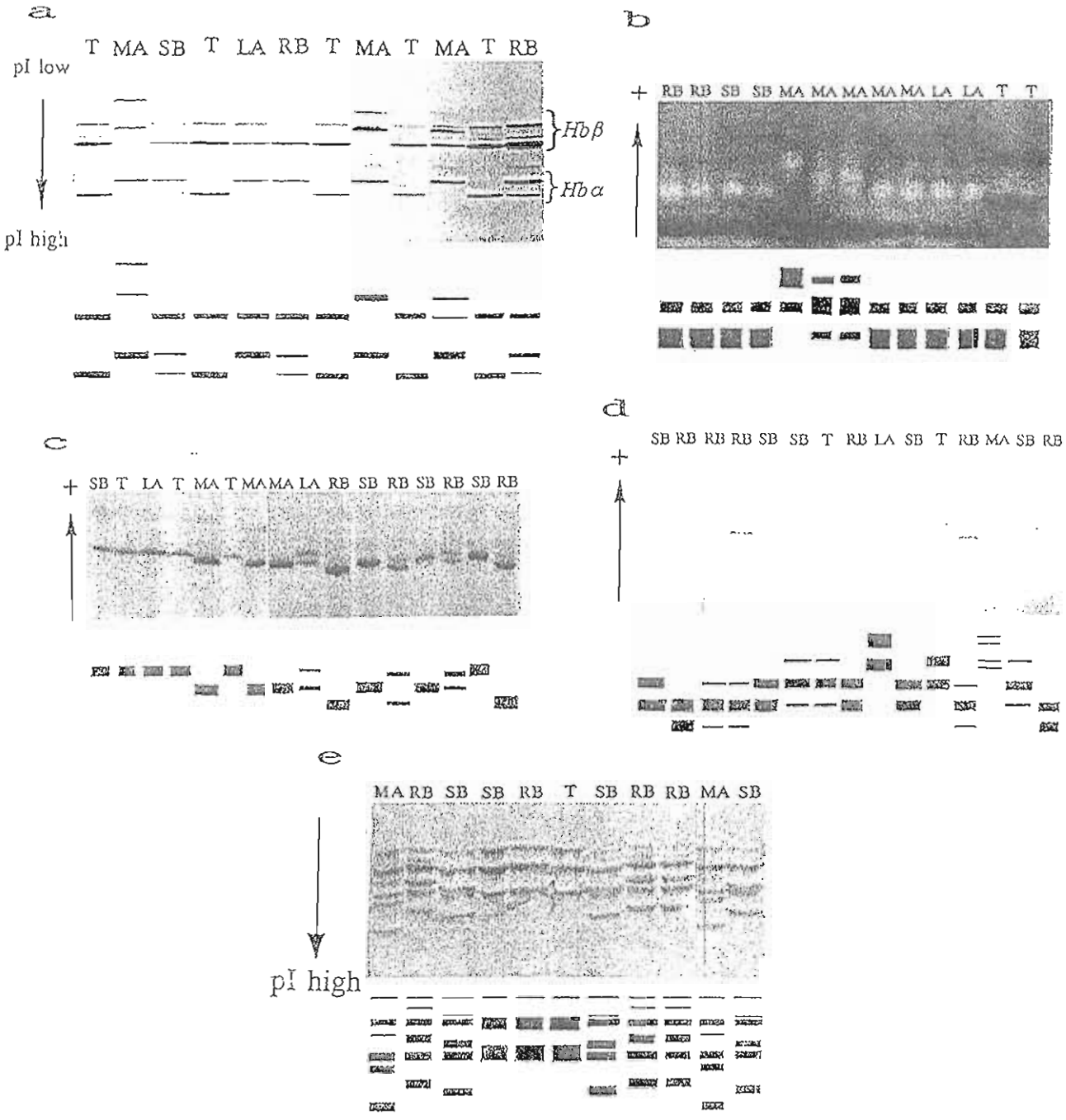


[a)] T= tamaraw, LA= lowland anoa, MA= mountain anoa, RB= river buffalo, SB= swamp buffalo)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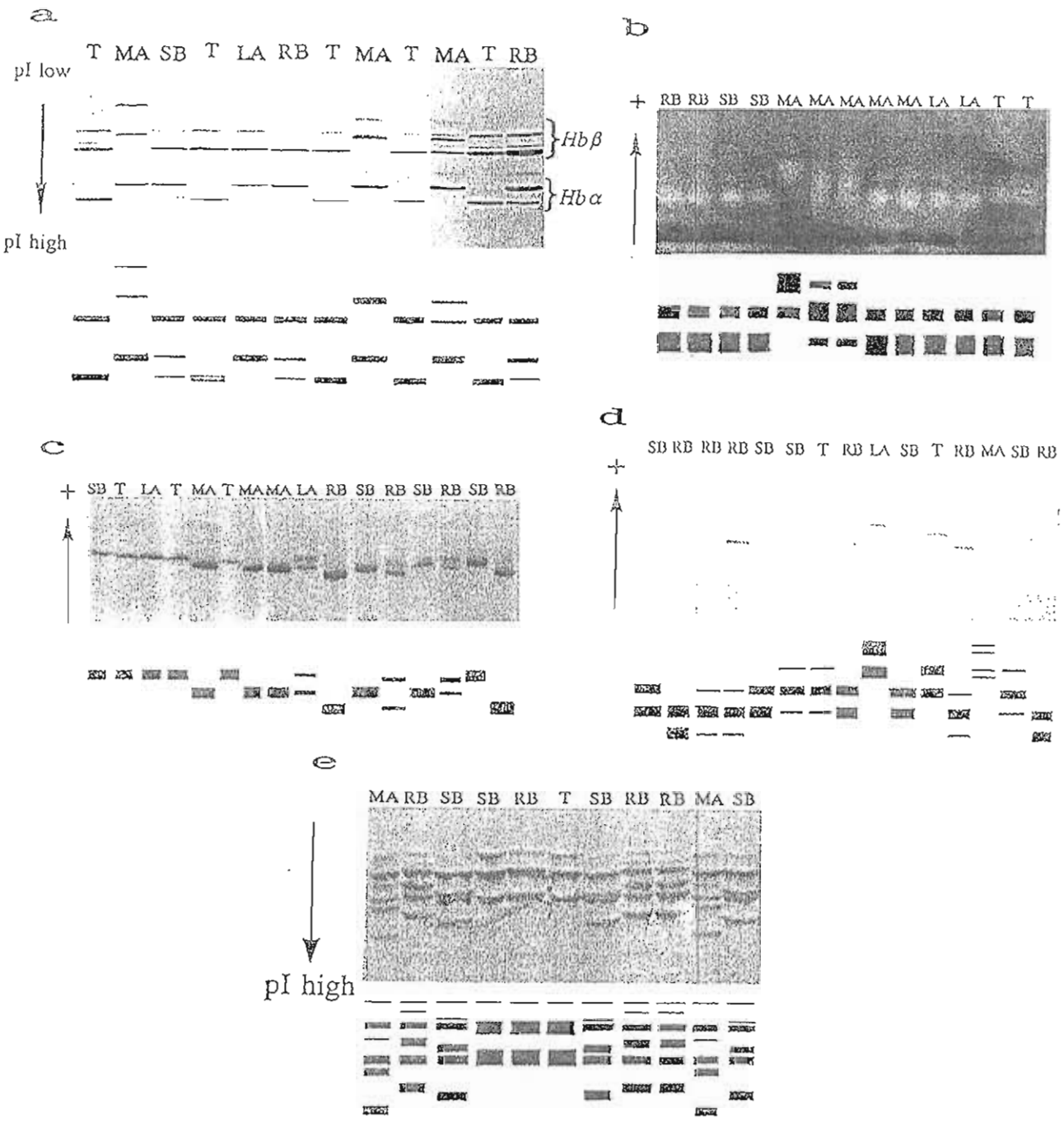
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THE BEHAVIORAL PATTERN AND SOME BASIC PHYSIOLOGICAL PARAMETERS OF TAMARAWS (*BUBALUS MINDORENSIS* HEUDE) IN CAPTIVITY DURING THE DRY AND WET SEASONS

G.I. Walde, V.G. Momongan and R.F. Escalada

Introduction

The tamaraw, (*Bubalus mindorensis* Heude) is an authentic treasure to Philippine wildlife. This rare mammal can be found nowhere except in the island of Mindoro, Philippines.

In early 1900s there were still 10,000 head of tamaraws and its population declined tremendously in 1949 to about 1,000 head. At present, the number of tamaraws has been reported to be about 200-300 only.

Several factors have been attributed to the slow extinction of the tamaraws. Indiscriminate logging and forest fires have destroyed the tamaraw's natural habitat. Poaching has driven also the tamaraws to the mountainous area. Likewise, the growing density of cattle ranches around their habitat has taken over the natural feeding range of tamaraws. Moreover, cattle bring communicable diseases which affect the tamaraws and thus aggravate the latter's plight.

To save the endangered tamaraws from becoming extinct the Department of Environment and Natural Resources (DENR) established the Tamaraw Conservation Program (TCP). This is a government effort to save the tamaraw from extinction. The TCP is not only concerned in

preserving the tamaraw's natural habitat but also in learning the basic biology of these mammals for proper captive management and to increase the tamaraw population.

Objectives

General Objective

To determine the behavioral pattern and some physiological parameters of the Tamaraws (*Bubalus mindorensis* Heude) for proper captive management to prevent its extinction.

Specific Objectives

1. To determine the length of time tamaraws spend in eating, ruminating, wallowing, idling, sleeping and other activities such as walking, running, scratching and pawing dirt in a 24-hour day period during dry and wet seasons;
2. To determine how frequent the tamaraws urinate, defecate and drink water within the 24-hour day period during dry and wet seasons;
3. To know the length of time spent for chewing regurgitated bolus, number of chews per bolus and the time interval between boluses being ruminated by the tamaraws; and
4. To determine the normal values of the body temperature, pulse rate and respiration rate of tamaraws.

Materials and Methods

Three mature male tamaraws and one mature female tamaraw were used as experimental animals. The tamaraws used in this study were placed in individual pens with areas ranging from 315.0 sq.m. to 450.76 sq.m. The animals were given fresh forage grasses throughout the day and night and rice bran between 6:00 p.m. to 7:00 p.m. daily. Drinking water and water wallows were available at all times. Fifteen 24-hour continuous observation for the dry season and ten 24-hour continuous observation for the wet season and data gathering were done by four regular watchers. The behavioral pattern of the tamaraws were observed throughout the day and night till the following morning. The 24-hour observation was divided into four-hour periods, i.e. from 6 a.m. to 10 a.m., 10 a.m. to 2 p.m., 2 p.m. to 6 p.m., 6 p.m. to 10 p.m., 10 p.m. to 2 a.m., and 2 a.m. to 6 a.m. of the next day. During the 24-hour observation, activities of each tamaraw were recorded on a continuous basis. Whenever a tamaraw changes activity the time was noted. The time periods spent in eating, ruminating, wallowing, idling and other activities like running, walking, scratching and pawing dirt was added up to 24 hours (86400 seconds or 1440 minutes). This allowed an accurate determination of the proportion of the time devoted to each activity. The time of occurrence, duration and the frequency of each activity were recorded. Pauses less than one minute in duration was not regarded as the end of the activity. The number of

times of urination, defecation and drinking were also noted.

To facilitate nighttime observations, flashlights and hurricane lamps were used. The parameters that were considered and how they were measured were the following:

1. Feeding time - This included the time spent during eating.
2. Rumination time - This included the total time spent in regurgitation, mastication, swallowing of ruminal ingesta and the time intervals between boluses either while standing, lying down or wallowing.
3. Wallowing time - This included the total time spent in plain wallowing and/or ruminating while wallowing.
4. Idling/resting time - This included the time spent on standing or lying down with no apparent locomotor activity.
5. Sleeping - This was the total time spent by the tamaraws in sleeping.
6. Other activities like walking, running, scratching and pawing dirt.
7. Urination, defecation and drinking - This included the number of times the animal urinated, defecated and drank. The time of the day when these activities occurred was also noted.

Some physiological parameters of the tamaraw were also determined like body temperature, pulse rate and respiration rate using standard procedures.

The pulse rate, respiration rate and body temperatures (PRT) of the animals were determined when the animals were sedated. This was done to facilitate ease of handling the animals since they were not docile and were still wary of people.

Data were collected after the behavioral pattern of tamaraws have been observed so as not to affect the bahavior of the animals. Other related data were recorded like the ambient temperature and relative humidity during the day of observation.

Time and Place of Study

The study was conducted at the Tamaraw Gene Pool Farm, Sitio Lapuz, Barangay Manoot, Municipality of Rizal, Occidental Mindoro from April to May, 1992 (dry season) and from June to July 1992 (wet season).

Statistical Analysis

The data gathered were analyzed using the Analysis of Variance (ANOVA) technique for Completely Randomized Design (CRD). Duncan's Multiple Range Test (DMRT) was used to further test the significance of treatment means.

The effects of season was tested using the T-test technique and descriptive statistics such as mean, standard deviation, minimum and maximum values were used for data on physiological parameters and rate and intensity of rumination.

Results and Discussion

Ambient Temperature, Relative Humidity and Rainfall Data at the Tamaraw Gene Pool Farm

Table 1 shows the meteorological data gathered at the experimental site. The mean ambient temperature in the experimental area during the day ranged from 25.16°C (6:00 a.m.) to 33.76°C (12:00 noon) with an average of 30.19°C during the dry season. During the wet season, the mean ambient temperature ranged from 25.13°C (6:00 a.m.) to 29.00°C (12:00 noon) with an average of 27.51°C. The mean relative humidity for the dry season was noted to range from 48.53% (6:00 p.m.) to 85.72% (6:00 a.m.) with an average of 61.74%. The mean relative humidity of

Table 1. Mean ambient temperature, relative humidity, amount of rainfall and number of rainy days in the experimental area (April-July, 1992)

	AMBIENT TEMPERATURE (°c)				RELATIVE HUMIDITY (%)				TOTAL RAINFALL (cm)	NO. OF RAINY DAYS
SEASON	6:00 a.m.	12:00 noon	6:00 p.m.	Ave.	6:00 a.m.	12:00 noon	6:00 p.m.	Ave.		
DRY (April to May)	25.16	33.76	31.66	30.19	85.72	50.97	48.53	61.74	0	0
WET (June to July)	25.13	29.00	28.40	27.51	93.32	76.60	81.70	83.87	161.50	14

the wet season on the other hand was also noted to range from 76.6% (12:00 noon) to 93.32% (6:00 a.m.) with an average of 83.87%. The total amount of rainfall (June and July) was observed to be 161.5 cm. with 14 rainy days. No rain ever occurred during the dry season (April and May).

Feeding

The average total time spent on feeding regardless of season, was 339.2 minutes per day or 23.55% of the 24-hour period, both for dry and wet seasons (Table 2). It should be noted that the animals were observed to feed more during the early morning time period (6 a.m. - 10 a.m.) and early evening time period (6 p.m. - 10 p.m.). This could be due to the low environmental temperature at this time of the day. Also, the feeding of concentrate (rice bran) to the tamaraws coincided

Table 2. Feeding pattern of tamaraws during the 24-hour observation period for the dry and wet seasons (in minutes).

	DAYTIME			NIGHTTIME			TOTAL					
SEASON	6 - 10	10 - 2	2 - 6	6 - 10	10 - 2	2 - 6	Daytime	%	Nighttime	%	GRAND TOTAL	PERCENT (in 24 hrs)
DRY	83.2	62.6	35.7	84.6	43.0	4.6	181.6	12.61	142.3	9.88	323.9	22.49
WET	76.6	65.4	40.9	99.0	42.6	30.0	182.8	12.70	171.6	11.92	354.4	24.61
Ave.	79.9	64.0	38.3	91.8	42.8	22.3	181.2	12.65	157.0	10.90	339.2	23.55

*Values on the same row followed by different letters are statistically different at 5% level of significance.

with the 6 p.m. to 10 p.m. feeding time. The least time spent on feeding was at 2 a.m. - 6 a.m. The findings generally agree with the observations of Callo (1983) who claimed that the tamaraws in their natural habitats tend to graze during the early morning and late in the afternoon. These observations are in agreement also with the study on Egyptian buffalo cows conducted by El-Kaschab et. al. (1991) who observed that although feed was always abundant and available in the mangers, the two major peaks of feeding were from 6:00 a.m. to 9:00 a.m. and from 6:00 p.m. to 9:00 p.m.

The average total time spent on feeding during the wet season (354.4 minutes) was slightly longer compared to that during the dry season (323.9 minutes), although they were not significantly different ($P > 0.05$) from each other (Table 2). Regardless of seasons, the feeding time during the day was slightly longer (181.2 minutes or 12.65 percent of the 24-hour observation period) as compared to that during nighttime (157.0 minutes or 10.90 percent of the 24-hour day period). However, there was no significant difference between nighttime and daytime feeding either during the dry season or during the wet season.

Rumination

Rumination was observed to follow after the end of each feeding period. Animals ruminated while standing, lying down in the open or under the shade and often while wallowing. The average total time

spent on rumination, regardless of season, was 381.2 minutes per day or 26.47 percent of the 24-hour day period (Table 3). Out of this total, 55.3 minutes per day or 3.84 percent of the 24-hour day period was spent ruminating while standing, 242.2 minutes per day or 16.82 percent of the 24-hour day period was spent while lying down and 83.7 minutes or 5.81 percent was spent ruminating while wallowing. Most rumination was done by the animal while lying down (63.54% of the rumination time); rumination while wallowing accounted 21.95% and rumination while standing used up 14.51% of the total rumination time. Other workers also observed that in dairy cow (Hancock, 1950), sheep (Sharafeldin and Shafie, 1965) and cattle (Herbel and Nelson, 1966) the greatest portion of ruminating time was spent by the animals while lying down.

Most of the rumination occurred at 2 p.m. - 6 p.m. during the daytime and 10 p.m. - 2 a.m. during the nighttime; whereas least rumination happened at 6 a.m. - 10 a.m. at daytime and 6 p.m. - 10 p.m. at nighttime. This is in agreement with El-Kaschab et. al. (1991) who reported that Egyptian buffalo cows had one peak period of rumination occurring at late evening between 9 p.m.-12 midnight. On the other hand, least rumination time occurred during the periods of 6:00 a.m.-9:00 a.m. and 6:00 p.m. - 9:00 p.m. which were observed to be the two peaks of eating time.

Table 3. Rumination pattern of tamaraws in captivity during the 24-hour observation period for the dry and wet seasons (in minutes).

ACTIVITY	SEASON	DAYTIME 6-10	DAYTIME 10 - 2	DAYTIME 2 - 6	NIGHTTIME 6 - 10	NIGHTTIME 10 - 2	NIGHTTIME 2-6	TOTAL Daytime	TOTAL Nighttime	GRAND TOTAL	PERCENT (in 24 hrs)	PERCENT (total rumination)
Rumination (standing)	Dry	16.9	7.6	13.4	4.1	2.6	2.4	37.9*	9.2	47.1	3.27	
	Wet	11.9	7.5	8.5	15.1	10.4	10.2	27.9	35.6	63.5	4.41	
	Ave.	14.4	7.6	11.0	9.6	6.5	6.3	32.9	22.4	55.3	3.84	14.51
Rumination (lying down)	Dry	20.5	29.8	24.3	43.9	64.4	54.9	74.6	163.1**	237.7	16.51	
	Wet	36.1	50.9	28.7	25.2	59.3	45.9	116.4	130.3	246.7	17.13	
	Ave.	28.7^{c}	40.4^{bc}	26.5^{c}	34.5^{bc}	61.8^{a}	50.4^{ab}	95.5	146.7	242.2	16.82	63.54
Rumination (while wallowing)	Dry	11.9	17.6	51.2	1.1	0.0	1.8	80.6**	2.8	83.5	5.80	
	Wet	18.8	8.8	40.6	6.8	0.1	8.8	68.2	15.7	83.9	5.82	
	Ave.	15.4^{b}	13.2^{b}	45.9^{a}	4.0^{bc}	0.1^{c}	5.3^{bc}	74.4*	9.3	83.7	5.81	21.95
Total Rumination	Dry	49.3	55.1	88.8	49.1	67.0	59.1	193.2	175.1	368.3	25.58	
	Wet	67.5	67.2	77.8	47.0	69.8	64.8	212.5	181.6	394.1	27.37	
	Ave.	58.4^{bc}	61.1^{bc}	83.3^{a}	48.0^{c}	68.4^{b}	61.9^{bc}	202.9	178.4	381.2	26.47	100.00

Values on the same row followed by different letters are statistically different at 5% level of significance.

*Significant at ($P < 0.05$) level

**Significant at ($P < 0.01$) level

There was no significant difference in the length of time spent by the animals ruminating while standing between the different time periods. However, rumination while lying down was observed to be longer during the late evening (10 p.m.-2 a.m.) and early dawn (2 a.m.-6 a.m.). On the other hand, rumination while wallowing was longer during the late afternoon (2 p.m. - 6 p.m.) and shortest during early evening (6 p.m.-10 p.m.) and late evening (10 p.m.- 2 a.m.). It was observed in general, regardless of season, that lesser time was spent by the animals on rumination during the peaks of feeding. This observation conforms with that made by Gonyou (1980) who claimed that rumination occurred primarily during the periods of reduced eating. It was then concluded by El-Kaschab (1991) that rumination in general showed the reverse of fluctuation to eating. This might be expected because the two behaviors are mutually exclusive and much time is spent on each one.

Although there was no significant difference in rumination time during the dry (363.3 minutes) and wet (394.1 minutes) seasons, it can be observed that the wet season rumination time was slightly longer than that of the dry season (Table 3). However, rumination while standing was significantly ($P < 0.05$) longer at nighttime during the wet season (35.6 minutes), than that during the dry season (9.2 minutes).

Regardless of season, tamaraws tend to ruminate longer while standing during the day (32.9 minutes) than at night (22.4 minutes); and while lying down, tamaraws ruminate longer during the night (146.7 minutes) than during the day (95.5 minutes) as shown in Table 3. However, these differences were not significant ($P > 0.05$). But when the animals were wallowing, they were observed to ruminate longer during the day (74.4 minutes) than at night (9.3 minutes), which was significant at 5% probability level.

If we consider rumination activity during the dry season only, daytime rumination while standing (37.9 minutes) was significantly ($P<0.05$) longer than the time spent for the same activity at night (9.2 minutes). It was also observed that rumination while lying down was significantly ($P<0.01$) longer during the night (163.1 minutes) than during the day (74.6 minutes) during the dry seasons.

During the wet season, there was no significant difference in the rumination time during the day and night, although more time was spent in rumination at night when the animal was ruminating while standing or lying down. On the other hand, more time was spent in ruminating during the day than at night when the animal was ruminating while wallowing.

In general, more rumination occurred during the daytime than during nighttime, regardless of seasons, although the difference in duration was not statistically significant.

The Rate and Intensity of Rumination

Considering the fact that the number of chews per bolus is a more accurate measure of rumination quantitatively than the rumination time (Gorden, 1958), the rate of rumination (length of time of chewing per bolus), intensity of rumination (chews per bolus) and the time interval between boluses were determined and recorded in Table 4.

Table 4. Length of time of chewing per bolus, number of chews per bolus and the time interval between boluses of ruminating tamaraws.

ANIMAL NO.	LENGTH OF CHEWING (seconds)	NUMBER OF CHEWS PER BOLUS	TIME INTERVAL BETWEEN BOLUSES (seconds)
1	46.40 ± 8.01	39.72 ± 7.64	4.43 ± 1.23
2	43.58 ± 8.95	35.72 ± 7.82	4.40 ± 1.52
3	44.54 ± 8.62	37.29 ± 8.33	4.15 ± 1.03
4	42.54 ± 6.63	36.36 ± 6.92	4.21 ± 1.04
Average	44.22 ± 8.05	37.19 ± 7.68	4.30 ± 1.20

The length of time it took the tamaraws to chew a single bolus ranged from 21.38 seconds to 69.16 seconds with an average of 44.22 ± 8.05 seconds. The coefficient of variation was 17.00%.

The number of chews per bolus ranged from 18.00 to 68.00 with an average of 37.19 ± 7.68 chews per bolus with a coefficient of variation of 20.67%. This is similar to the findings of Wagnon (1963) on beef cows wherein he observed that the average chews per cud ranged from 32 to 33 chews per cud when the forage was short and succulent and with increasing forage growth there was an increase in chews per cud to about 45 to 46 chews.

The time interval between boluses is the interval between the time of swallowing the previous bolus and the start of chewing of the next one. The time interval ranged from 1.00 second to 11.37 seconds with an average of 4.30 ± 1.20 seconds with a coefficient of variation of 27.99%.

Wallowing

The total time spent by the animals in the wallow, on the average, regardless of season, was 194.0 minutes or 13.47 percent of the 24-hour day period. Plain wallowing took up 7.66 percent of the 24-hour day period or 56.86 percent of the total wallowing time; whereas, wallowing while ruminating took up 5.81 percent of the 24-hour period or 43.14 percent of the total wallowing time (Table 5).

Wallowing was significantly longer ($P<0.05$) during the time period interval 2 p.m. - 6 p.m. during the daytime and shorter during the nighttime from 10 p.m. - 2 a.m. Very short periods of wallowing

Table 5. Wallowing pattern of tamaraws in captivity during the 24-hour observation period for the dry and wet seasons (in minutes).

ACTIVITY	SEASON	DAYTIME 6-10	DAYTIME 10-2	DAYTIME 2-6	NIGHTTIME 6-10	NIGHTTIME 10-2	NIGHTTIME 2-6	TOTAL Daytime	TOTAL Nighttime	GRAND TOTAL	PERCENT (in 24 hrs)	PERCENT (total wallowing)
Plain Wallowing	Dry	19.8	18.6	40.3	3.2	0.0	6.5	78.8**	9.7	88.5	6.15	
	Wet	27.6	16.4	60.6	10.4	0.1	17.1	104.6*	27.5	132.1	9.17	
	Ave.	23.7^{b}	17.5^{bc}	50.4^{a}	6.8^{cd}	0.0^{a}	11.8^{bcd}	91.7	18.6	110.3	7.66	56.9
While Ruminating	Dry	11.9	17.6	51.2	1.1	0.0	1.8	80.6**	2.8	83.5	5.80	
	Wet	18.3	8.8	40.6	6.8	0.1	8.8	68.2	15.7	83.9	5.82	
	Ave.	15.4^{b}	13.2^{b}	45.9^{a}	3.9^{bc}	0.1^{c}	5.3^{bc}	74.4*	9.3	83.7	5.81	43.1
Total Wallowing	Dry	31.8	36.2	91.5	4.3	0.0	8.3	159.4**	12.6	172.0	11.94	
	Wet	46.5	25.2	101.2	17.1	0.2	25.8	172.8*	43.2	216.0	15.00	
	Ave.	39.1^{b}	30.1^{bc}	96.3^{a}	10.7^{cd}	0.1^{d}	17.1^{bcd}	166.1	27.8	194.0	13.47	100.0

Values on the same row followed by different letters are statistically different at 5% level of significance.

*Significant at ($P < 0.05$) level

**Significant at ($P < 0.01$) level

occurred during 6 p.m. - 10 p.m. and 2 a.m. - 6 a.m. Most of the wallowing during the periods occurred between 6 p.m. - 7 p.m. and 5 a.m. - 6 a.m.

The tamaraws tended to wallow longer during the wet season (216.0 minutes) than during the dry season (172.0 minutes) although the difference was not significant ($P > 0.05$), as presented in Table 5.

The observations made by Viray and Momongan (1982) and Na Phuket (1974) on carabaos were in agreement with the result of this study with respect to longer wallowing time during the wet season. However, as observed by Na Phuket (1974) more time was spent wallowing during the wet season because the animals had their fill easily attained due to good forage availability. Viray and Momongan (1982) noted that the wallowing activity of carabaos was not directly influenced by temperature and relative humidity, but perhaps by the availability of wallowing ponds in the pasture during the rainy season. However, in this study, the wallowing pond was maintained in the tamaraw's holding pen throughout the experimental period, both during dry and wet seasons. Perhaps, the reason why the tamaraws spent more time wallowing during the rainy season could be attributed to the apparent presence of more insects during the wet season than during the dry season.

Regardless of season, the average time spent for wallowing during the day (166.1 minutes or 85.6% of total wallowing time) was longer than that observed during the night (27.8 minutes or 14.4% of the total wallowing time). Most of the wallowing occurred between 2-6 pm, which is 96.3 minutes or 49.7% of the total wallowing time (194.0 minutes) as shown in Table 5.

The tamaraws spent the least time for wallowing at 10 pm to 2 am with an average wallowing time of only 0.1 minutes or 0.05% of total wallowing time and at 6-10 pm with 10.7 minutes or 5.52% of total

wallowing time in a 24-hour day period. Thus, the time spent for wallowing between 6 pm to 2 am is only 5.57% of the total wallowing time in a 24 hour day period.

In an experiment with carabaos, Viray and Momongan (1982) also observed that carabaos spent minimal time for wallowing during the night. They postulated that the major reason for night wallowing was the desire of the carabaos to get rid of nocturnal biting insects so that they can rest.

Idling

The animal was considered idle when it did not show any apparent motor activity whether standing or lying down and either under shade or in the open. Tamaraws in captivity spent more time in idling than in any other activities. Of the 24 hour day period, the tamaraw spent 440.8 minutes or 30.61% of the time doing nothing or idling. Most of the idling time was spent during the period from 10 pm to 6 am with a total time of 191.9 minutes or 43.5% of the total idling time. About 62% of idling time was spent while lying down, and about 38%, while standing.

There is not much difference in the time spent for idling during the dry season and wet seasons (Table 6). However, the idling time spent at night during dry season (260.5 minutes) is significantly longer ($P<0.05$) than that spent at daytime (188.9 minutes). During the wet season, although idling at night time is longer than that at daytime, the difference was not significant ($P > 0.05$), perhaps due to

Table 6. Idling pattern of tamaraws in captivity during the 24-hour observation period for the dry and wet seasons (in minutes).

ACTIVITY	SEASON	DAYTIME 6-10	DAYTIME 10-2	DAYTIME 2-6	NIGHTTIME 6-10	NIGHTTIME 10-2	NIGHTTIME 2-6	TOTAL Daytime	%	TOTAL Nighttime	%	GRAND TOTAL	PERCENT (in 24 hrs)	PERCENT (total Id-ling)
Idling (standing)	Dry	54.7	41.6	27.2	34.2	25.7	36.6	123.5	8.58	96.6	6.71	220.1**	15.28	
	Wet	25.0	13.6	14.7	28.4	17.3	14.9	53.2	3.70	60.5	4.20	113.8	7.90	
	Ave.	39.9	27.6	20.9	31.3	21.5	25.7	88.4	6.14	78.5	5.45	116.9	11.59	37.86
Idling (lying down)	Dry	11.9	32.6	21.0	40.1	57.3	65.7	65.4	4.54	163.9**	11.38	229.3	15.92	
	Wet	31.7	59.1	33.4	30.5	82.6	82.8	122.5	8.51	195.9	13.61	318.5	22.12	
	Ave.	21.8^{c}	45.8^{b}	27.2^{bc}	35.3^{bc}	70.4^{a}	74.2^{a}	94.0	6.52	180.0	12.50	274.0	19.02	62.14
Total Idling	Dry	66.6	74.2	40.2	74.3	83.9	102.3	188.9	13.12	260.5*	18.08	449.4	31.20	
	Wet	55.1	72.7	48.0	59.0	99.9	97.6	175.8	12.21	256.5	17.81	432.2	30.02	
	Ave.	60.8^{bc}	73.4^{b}	48.1^{c}	66.6^{bc}	91.9^{a}	100.0^{a}	182.3	12.66	258.5	17.95	440.8	30.61	100.00

Values on the same row followed by different letters are statistically different at 5% level of significance.

* Significant at ($P < 0.05$) level

** Significant at ($P < 0.01$) level

wide variations among animals. Also, the idling time spent while standing during the dry season (220.1 minutes) was significantly longer ($P < 0.01$) than that spent during the wet season (113.8 minutes). On the other hand, the idling time spent while lying down during the wet season (318.5 minutes) was longer than that spent during the dry season

(229.3 minutes), although the difference was not statistically significant ($P > 0.05$).

In general, there was a tendency for the tamaraw to have more idling time at night (258.5 minutes) than at daytime (182.3 minutes), although the difference was not significant ($P > 0.05$).

Sleeping

It was observed that tamaraws sleep for very short periods. As shown on Table 7, the tamaraws were found to sleep, on the average, for 96.7 minutes or 6.73 percent of the 24 hour day period regardless of season. Most sleeping periods occurred during the night from 10 p.m. - 6 a.m., while they slept least during early mornings (6 a.m. - 10 a.m.).

The sleeping time of tamaraws during the dry season (135.5 minutes or 9.41 percent of the 24 hour day period) was observed to be significantly longer ($P<0.05$) than that of the wet season (57.9 minutes or 4.02 percent of the 24-hour day period).. This could be due to the fact that during the dry season the environmental temperature is relatively higher compared to that during the wet season and to avoid producing more heat, the animals were less likely to be more active and thus sleep longer during the dry season. It was also observed that the tamaraws slept significantly ($P < 0.05$) longer during the night, for both dry and wet seasons, than during the day (Table 7).

Table 7. Sleeping, Walking, Running, Scratching and Pawing Dirt pattern of tamaraws in captivity during the 24-hour observation period for the dry and wet seasons (in minutes).

		DAYTIME			NIGHTTIME			TOTAL		GRAND	
ACTIVITY	SEASON	6 - 10	10 - 2	2 - 6	6 - 10	10 - 2	2 - 6	Daytime	Nighttime	TOTAL	PERCENT
Sleeping	Dry	6.0	20.2	15.2	11.8	38.1	44.2	41.3	94.1*	135.5	9.41
	Wet	0.8	8.3	2.2	3.7	21.7	21.2	11.3	45.6*	57.9	4.02
	Ave.	3.4^{b}	14.2^{b}	8.7^{b}	7.7^{b}	29.9^{a}	32.7^{a}	26.4	70.3*	96.7	6.73
Walking	Dry	14.2	9.2	11.3	15.3	8.4	12.2	35.2	35.8	71.0	4.93
	Wet	11.0	9.6	9.5	17.6	5.4	8.9	30.2	32.0	62.1	4.31
	Ave.	12.9^{ab}	9.4^{bc}	10.4^{bc}	16.4^{a}	6.9^{c}	10.6^{bc}	32.7	33.9	66.6	4.62
Running	Dry	0.2	nil	0.3	0.6	nil	nil	0.5	0.6	1.1	0.08
	Wet	0.5	nil	0.6	0.9	0.1	nil	1.2	1.0	2.2	0.15
	Ave.	0.4^{ab}	nil^{b}	0.5^{a}	0.7^{a}	nil^{b}	nil^{b}	0.8	0.8	1.7	0.11
Scratching	Dry	0.1	0.2	0.1	1.2	0.4	0.1	0.4	1.8**	2.2	0.15
	Wet	0.8	0.4	0.5	2.4	0.4	0.3	1.6	3.2	4.8	0.33
	Ave.	0.4^{b}	0.3^{b}	0.3^{b}	1.8^{a}	0.4^{b}	0.2	1.0	2.5*	3.5	0.24
Pawing Dirt	Dry	nil	nil	nil	nil	nil	nil	nil	nil	nil	0.003
	Wet	nil	nil	nil	0.1	nil	nil	nil	0.1	0.1	0.009
	Ave.	nil	nil	nil	0.1	nil	nil	nil	0.1	0.1	0.006

Values on the same row followed by different letters are statistically different at 5% level of significance.

*Significant at ($P < 0.05$) level

**Significant at ($P<0.01$) level

Other Activities

Activities observed other than feeding, rumination, wallowing, idling and sleeping were lumped together as other activities. These included walking, running, scratching and pawing dirt.

A. Walking

Of all other activities, walking was noted to be the longest, occupying about 66.6 minutes or 4.62 percent of the 24-hour day period, for both dry and wet seasons. Walking was observed as the animals travelled from their resting place to the feeding chute, to the wallow and around the pen. It was also noted that the animals walked significantly for a longer time ($P<0.05$) periods during 6 a.m. - 10 a.m. and 6 p.m. - 10 p.m. These time periods coincided with the peaks of feeding of tamaraws since the animals walked to and from their feeding chutes frequently. As shown in Table 7, there was no significant difference between walking time during the day and night for both dry and wet seasons.

B. Running

Tamaraws would at times run around their pens especially when something agitates them like the presence of a carabao, people, and biting insects. It was noted that most of the running was done during the daytime (2 p.m. - 6 p.m.) and at early evening (6 p.m.-10 p.m.) which are significantly longer ($P<0.05$) than those performed during other time periods. On the average, tamaraws were observed to run for 1.7 minutes per day or 0.12 percent of the 24 hour observation period. As shown in Table 7, there was no significant difference in running time during the dry and wet season, and during daytime and nighttime.

C. Scratching and Pawing Dirt

The animals were observed to scratch and rub on rubbing devices like posts and fences significantly longer ($P<0.05$) during the night than during the day, and more during the wet season than during the dry season (Table 7). The animals were observed to scratch more ($P<0.05$) during the 6 p.m.to 10 p.m. time period for both dry and wet seasons. This might be due to the presence of more nocturnal biting insects like mosquitoes and blackflies (Leptoconops spinosefrons) or "niknik".

Pawing dirt was noted to be more frequent from 6 p.m. to 10 p.m. This appears to coincide with periods of longer scratching and standing times.

D. Urination, Defecation and Drinking

1. Number of urination, defecation and drinking of tamaraws per day. The average number of urinations of tamaraws during the dry season was 10.26 ± 2.71, defecation was 6.53 ± 1.17 and drinking water was 4.57 ± 1.44 times per day; while during the wet season, they urinated 7.15 ± 1.23 times, defecated 3.95 ± 0.81 times and drank water 0.95 ± 0.17 times per day (Table 8).

It can be observed that the animals urinated, defecated, and drank water more frequently during the dry season than during the wet season. This could be due to the relatively higher environmental temperature during the dry season compared to the wet season. Tamaraws could possibly lack sweat glands just like carabaos, and in order to regulate

Table 8. Average number of urination, defecation and drinking of tamaraws per day.

	DRY SEASON			WET SEASON ANIMAL		
NUMBER	Urination	Defecation	Drinking	Urination	Defecation	Drinking
1	13.73	7.27	4.33	7.80	4.40	1.10
2	9.87	7.53	3.67	8.40	4.80	1.00
3	7.13	4.93	3.60	5.60	3.60	0.70
4	10.33	6.40	6.67	6.80	3.00	1.00
AVE.	10.26±2.71	6.53±1.17	4.57±1.44	7.15±1.23	3.95±0.81	0.95±0.17

body temperature, these animals tend to drink, urinate and defecate more during the dry season than during the wet season. This is in agreement with the report of Hancock (1950) who claimed that the number of times an animal defecates, urinates and drinks in a day is partly determined by the weather. He also observed that all these functions, particularly the number of drinks, tend to increase when the daily temperature rises. This was also in agreement with the results reached by Waite et al. (1951) who reported that more water was drunk by dairy cows in hotter weather, but on days of persistent rain very little or none was drunk. The decrease in the frequency of drinking during the wet season could also be attributed to the amount of water in the grass eaten by the animals. It was observed that during the wet season, the grasses were more succulent and wet as compared to those of the dry season. This conforms with the findings of Waite et al. (1951) who

claimed that the grass eaten by dairy cows also furnished about 10 gallons of water, thus, fewer drinkings were observed during rainy days.

2. Time of day of urination, defecation and drinking. Figures 1, 2 and 3 shows the average frequency of urination, defecation, and drinking water of tamaraws, respectively during the dry and wet seasons. Figure 1 shows that the tamaraws, on the average, urinated more frequently during the morning (6 a.m. - 10 a.m.) during the dry and wet seasons, with more frequency during the dry seasons than during the wet season.

The tamaraws were observed to defecate more during the morning for both dry and wet seasons, with the highest frequency occuring between 6:00 a.m. to 10:00 a.m. for the dry season; and between 6:00 to 10:00 a.m. and 2:00 p.m. to 6:00 p.m. for the wet season (Figure 2). Fewer defecations were observed to occur during the night especially from 10:00 p.m. to to 6:00 a.m.

These observations conform with that made by El-Kaschab et.al. (1991) on Egyptian buffalo cows, wherein they observed that there were two major peaks for urinations and defecations i.e. 6:00 a.m. to 9:00 a.m., 9:00 a.m. to 12:00 p.m. for urination and 6:00 a.m. to 9:00 a.m. and 12:00 p.m. to 3:00 p.m. for defecations. They also observed that the minimum occurrence of both defecations and urinations was during the time period from 12:00 midnight to 3:00 a.m.

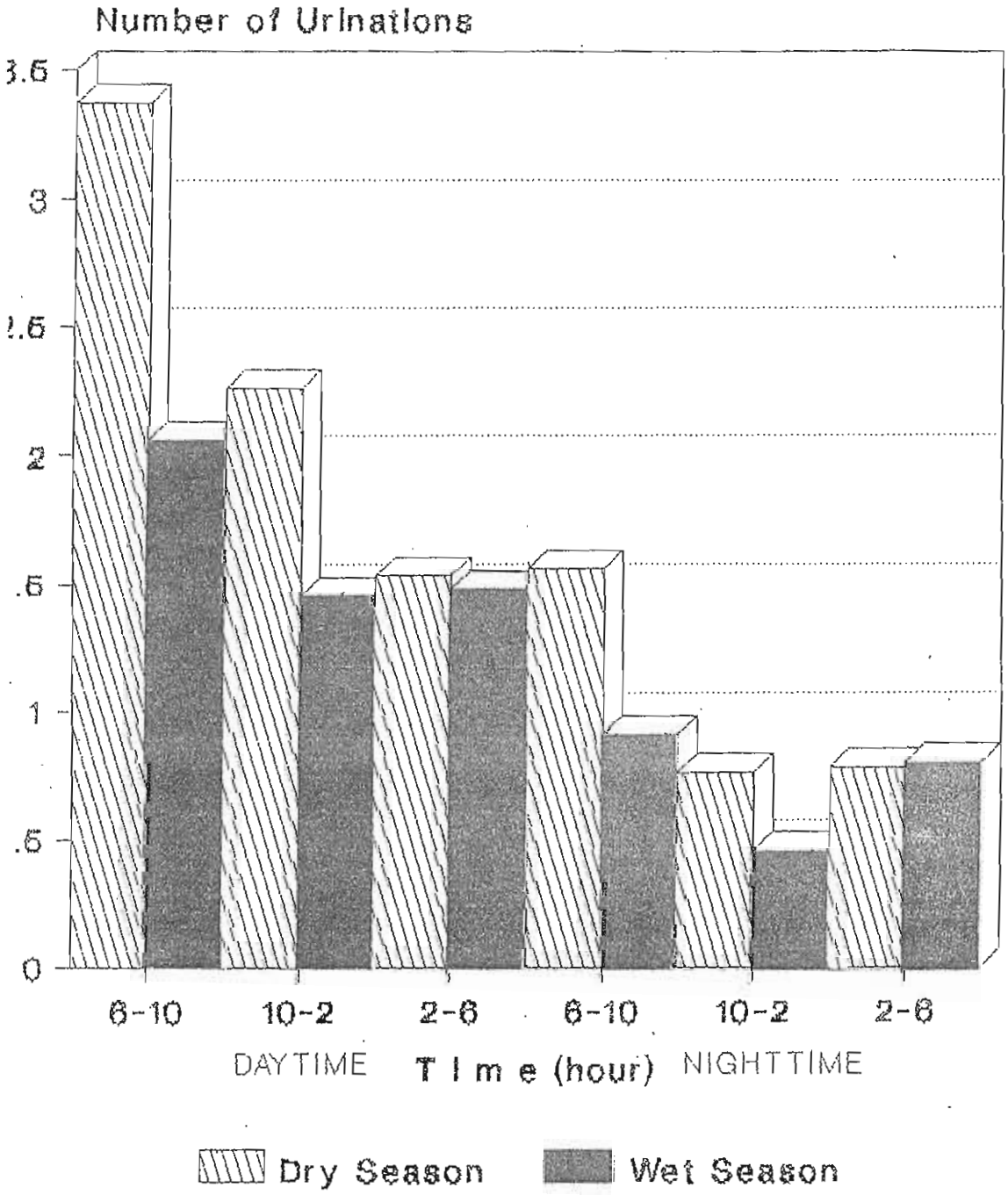


Figure 1. Average number of times of urination of tamaraws per day during the dry and wet seasons.

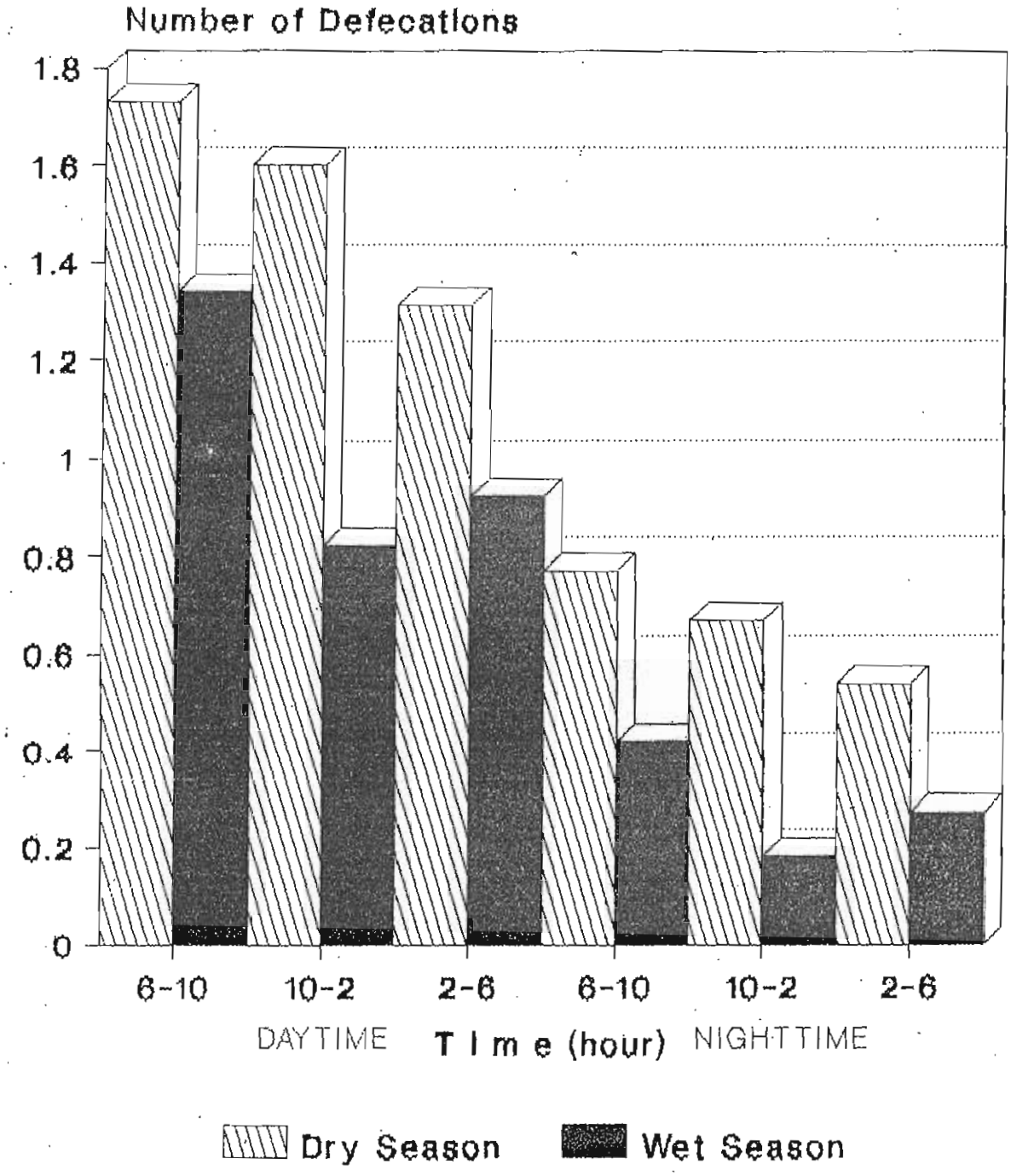


Figure 2. Average number of defecations of tamaraws per day during the dry and wet seasons.

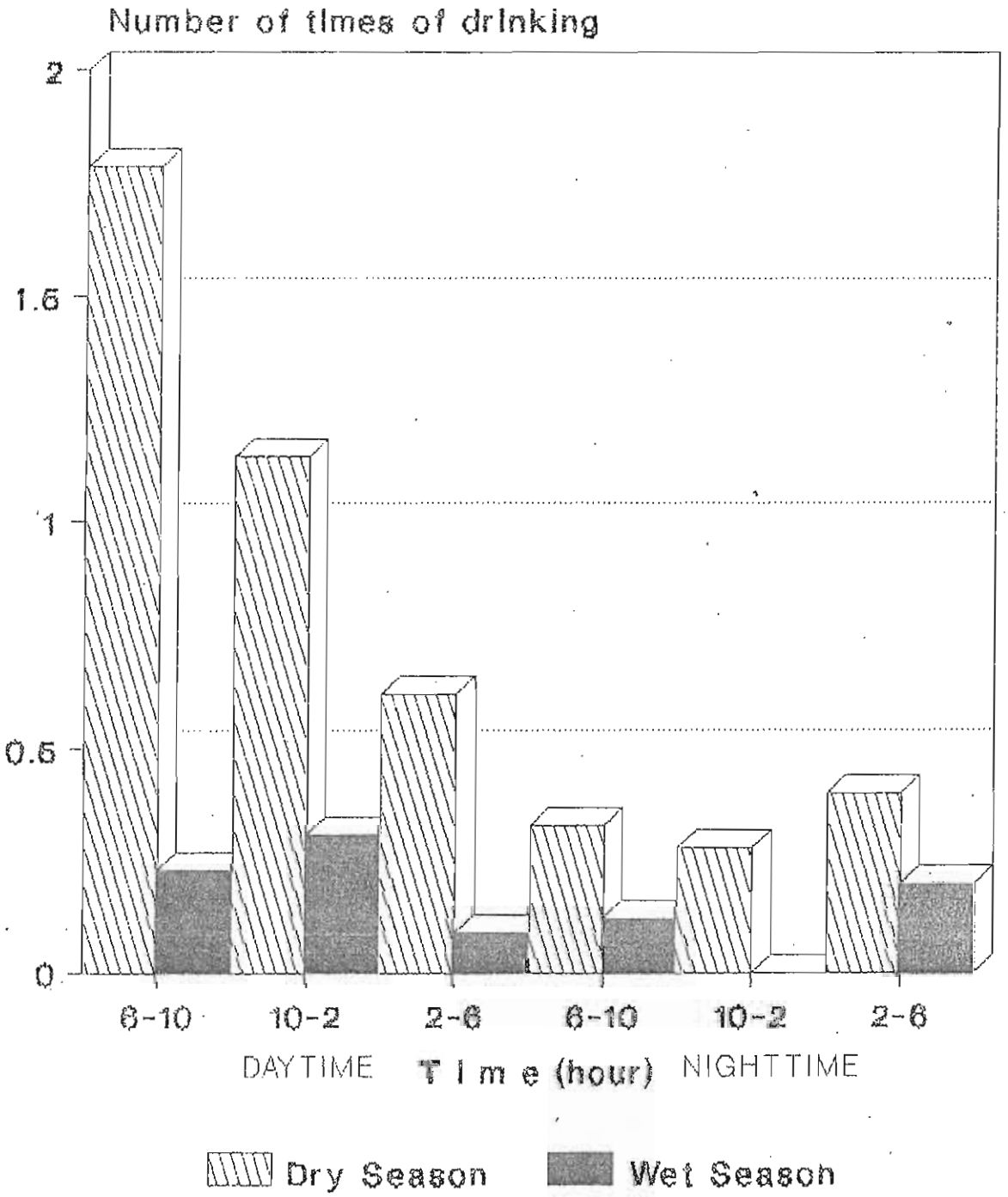


Figure 9. Average number of times of drinking of tamaraws for 24-hour period during the dry and wet seasons.

It was also noted that with the tamaraws, urinations or defecations or both invariably occurred immediately after getting up if the animal had been lying down for an appreciable length of time. This observation was also observed by Waite et al. (1951) on dairy cows and El-Kaschab et al. (1991) on Egyptian buffalo cows.

The tamaraws were noted to drink water more during the dry season, which occurred mostly at 6:00 to 10:00 a.m. period (Figure 3). During the wet season, drinking water invariably occurred from 6:00 a.m. to 2:00 p. m., with more frequency at the 10:00 am to 2:00 p.m. period. This higher frequency of water drinking during the dry season could be attributed to the possible effect of high environmental temperature on the animal which tends to cool itself by drinking more water.

Pulse Rate, Respiration Rate and Body Temperature of Tamaraws

As presented in Table 9, the average pulse rate of tamaraws was 52.80 $\pm$ 9.55 counts per minute. This was observed to be higher than the pulse rate of adult carabaos. The average respiration rate of tamaraws was observed to be 28.38 $\pm$ 6.28 counts per minute which was also higher than the respiration rate of carabaos. The body temperature was 40.31 $\pm$ 1.39 ^{o}C which was still higher than that of carabaos. A factor that could have possibly affected the differences in pulse rate, respiration rate and body temperature of tamaraws and carabaos was body size since tamaraws on the average just weigh around 250 kilograms while carabaos may weigh from 400-500 kilograms. The

Table 9. Comparison of Pulse Rate, Respiration Rate and Body Temperature of Mature Tamaraws and Mature Carabaos.

PHYSIOLOGIC PARAMETER	TAMARAWS (MEAN ± SD)	CARABAOS	
		(Garillo et.al.) (1985)	(Delos Santos and Momongan) (1987)
Pulse rate(cpm)	52.80 ± 9.55	33.50	38.16
Respiration rate (cpm)	28.38 ± 6.28	19.77	21.37
Body Temperature (^{o}C)	40.31 ± 1.39	37.77	41.09

excitement that the tamaraws experienced during the measurements of these parameters (PRT) could have contributed to the higher values of PRT in tamaraws than the observed values in carabaos.

Summary and Conclusion

Four captive tamaraws (one female and three males) were subjected to continuous 24-hour observation period during the dry and wet seasons to determine their behavioral pattern. The effects of season and time of day on the behavioral patterns of the tamaraws were determined. The pulse rate, respiration rate and body temperature of tamaraws were also determined. The major observations were the following:

1. Feeding was observed to be 23.55 percent of the 24-hour day period. Feeding time was significantly longer ($P < 0.01$) during 6 a.m.

to 10 a.m. and 6 p.m. to 10 p.m. than at any time of the 24-hour day period. There was no significant difference in the length of time spent on feeding during the dry and wet seasons, and between daytime and nighttime feeding. However, the feeding time during the wet season was slightly longer than that during the dry season; and daytime feeding was slightly longer than the nighttime feeding. Least feeding time was spent by the tamaraws from 10:00 p.m. to 6:00 a.m.

2. Rumination was observed to follow after the end of each feeding period. The time spent for rumination was 26.47 percent of the 24-hour day period. There was no significant difference between the time spent for rumination during the dry season and wet seasons, although the wet season rumination time was slightly longer. Most of the ruminations were observed during late afternoon (2 p.m. to 6 p.m.) when the animals were mostly wallowing and late at night (10 p.m. to 6 a.m.) when the tamaraws were mostly lying down. Less rumination was observed to occur during peaks of feeding. The rate and intensity of rumination was also determined since these provide a more accurate measure of rumination quantitatively than rumination time.

3. Tamaraws were observed to wallow more frequently during daytime than nighttime; and more often during the wet season than during the dry season. Most of the wallowings were observed between 2 p.m. to 6 p.m. There was very minimal wallowing at night and this was apparently performed just to get rid of nocturnal biting insects.

4. Idling was observed to be the most dominant preoccupation of tamaraws in captivity with 30.61 percent of the 24-hour day period. Most of the idling while standing was observed during the day, whereas, the idling while lying down was more frequent during the night.

5. Sleeping was noted to be very minimal and was longer during the nighttime than at daytime and significantly ($P<0.05$) longer during the dry season than during the wet season.

6. Walking was observed to be longer during peaks of feeding time, while running, scratching and pawing dirt were noted to be longer at night between 6 p.m. to 10 p.m. and more often during the wet season than during the dry season, apparently due to the presence of biting insects during the wet season.

7. Urination, defecation and drinking were observed to be more frequent during the dry season and during the day due to high environmental temperature. Most urinations, defecations and water drinking during the dry season occur during the 6:00 to 10:00 a.m. period. During the wet season, urination and defecation had the highest frequency at 6:00 to 10:00 a.m. period, but water drinking was highest at 10:00 a.m. to 2:00 p.m. period.

8. The pulse rate, respiration rate and body temperature of tamaraws were determined and observed to be higher than those of the carabaos.

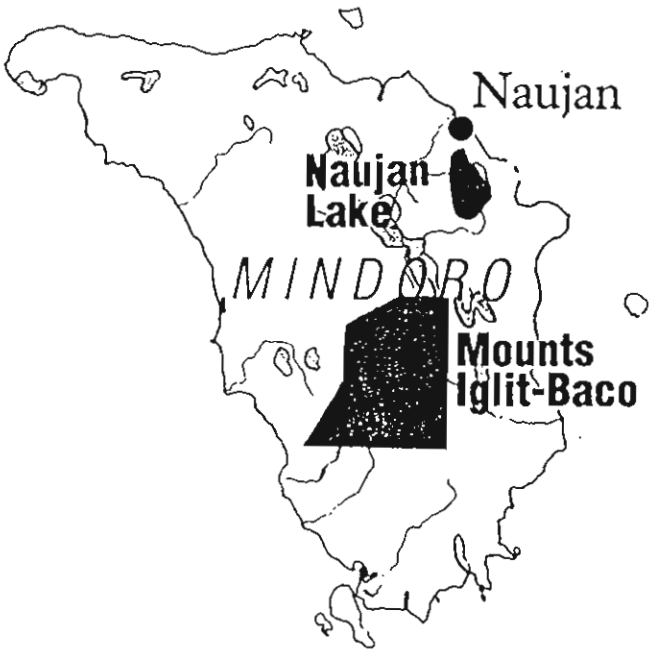
TAMARAW
(*Bubalus mindorensis*)

Population and Habitat Viability Assessment

University of The Philippines Los Baños
College, Laguna, Philippines

15-17 May 1996

Report



SECTION 9

Glossary
IUCN Policy Papers and Guidelines

GENETICS GLOSSARY

DNA

Deoxyribonucleic Acid; a chain of molecules contain units known as nucleotides. The material that stores and transmits information inherited from one cell or organisms to the next. The principle DNA is located on the chromosomes in the nucleus of cells. Lesser but still significant DNA is located in the mitochondria.

GENE

The segment of DNA that constitutes a functional unit of inheritance.

LOCUS

The section of the DNA occupied by the gene. Gene and locus (plural: loci) are often used interchangeably.

ALLELE

Alternative forms of a gene. Most strictly, allele refers to different forms of a gene that determine alternative characteristics. However, allele is used more broadly to refer to different copies of a gene, i.e. the 2 copies of each gene that every diploid organism carries for each locus.

ALLELE OR GENE FREQUENCY

The proportion of all copies of a gene in the population that represent a particular allele.

GENOTYPE

The kinds of alleles that an individual carries as its two copies of a gene. As an example, if there are two alleles (A, a) possible at a locus, there are then three genotypes possible: AA, Aa, and aa.

GENOTYPIC FREQUENCY

The proportion of individuals in the population that are of a particular genotype.

HETEROZYGOSITY

The proportion of individuals in the population that are heterozygous (i.e., carry functionally different alleles) at a locus.

HARDY-WEINBERG EQUILIBRIUM

A principle in population genetics that predicts frequencies of genotypes based on the frequencies of the alleles, assuming that the population has been randomly mating for at least one generation. In the simplest case, where there are two alleles (A, a) at a locus and these alleles occur in the frequency p_A and p_a, the Hardy-Weinberg law predicts that after one generation of random mating the frequencies of the genotypes will be: $AA = p_A^2$; $Aa = 2p_Ap_a$; $aa = p_a^2$.

EXPECTED HETEROZYGOSITY = GENE DIVERSITY

The heterozygosity expected in a population if the population were in Hardy-Weinberg equilibrium. Expected heterozygosity is calculated from allele frequencies, and is the heterozygosity expected in progeny produced by random mating. 1 - SUM p_i's, where p_i = the frequency of allele i.

GENOME

The complete set of genes (alleles) carried by an individual.

GENETIC DRIFT

The change in allelic frequencies from one generation to the next due to the randomness (chance) by which alleles are actually transmitted from parents to offspring. This random variation becomes greater as the population, and hence sample of genes, transmitted from one generation to the next, becomes smaller.

BOTTLENECK

A generation in the lineage from a founder when only one or a few offspring are produced so that not all of the founder's alleles may be transmitted onto the next generation.

FOUNDER

An animal from a source (e.g., wild) population that actually produce offspring and has descendants in the living derived (e.g., captive) population.

FOUNDER REPRESENTATION

The percentage or fraction of all the genes in the population at any given time that have derived from a particular founder.

EXISTING REPRESENTATION

The existing percentage representation of founders in the population.

TARGET REPRESENTATION

The desired or target percentage representation of founders. These target figures are proportional to the fraction of each founder genome that survived in the population. Achieving target representation will maximize preservation of genetic diversity.

ORIGINAL FOUNDER ALLELES

The total number of alleles (copies) of each gene carried at each locus by the founders. The number of original founder alleles is twice the number of original founder genomes.

ORIGINAL FOUNDER GENOMES

The set of all genes in a founder. The sum of all such sets are the founder genomes. The number of original founder genomes is half the number of original founder alleles.

FOUNDER ALLELES SURVIVING

The number of alleles still surviving at each locus in the population assuming that each founder carried two distinct alleles at each locus into the derived (captive) population.

FOUNDER GENOMES SURVIVING

The number of original founder genomes still surviving in the population. This metric measures loss of original diversity due to bottlenecks in the pedigree of the population.

FOUNDER GENOME EQUIVALENTS

The number of newly wild caught animals required to obtain the genetic diversity in the present captive population. This metric reflects loss due to both bottlenecks and disparities in founder representation.

FOUNDER EQUIVALENTS

The number of equally represented founders that would produce the same gene diversity as that observed in the surviving population, acknowledging the founder alleles that have already been lost due to bottlenecks. Founder equivalents measures the loss of genetic diversity due to the uneven representation of founder lineages in the surviving population.

EFFECTIVE POPULATION SIZE

A concept developed to reflect the fact that not all individuals in a population will contribute equally or at all to the transmission of genetic material to the next

generation. Effective population size is usually denoted by N_e and is defined as the size of an ideal population that would have the same rate of genetic drift and of inbreeding as is observed in the real population under consideration. An ideal population is defined by: sexual reproduction; random mating; equal sex ratio; Poisson distribution of family sizes, i.e. total lifetime production of offspring; stable age distribution and constant size, i.e. demographic stationariness.

COEFFICIENT OF RELATEDNESS

The probability that an allele selected at random from one individual in the population is present in a second individual because of inheritance of that allele from a common ancestor. Equivalently, the proportion of genes in two individuals that are the same because of common descent. The inbreeding coefficient of an animal is equal to 1/2 the relatedness of the parents.

AVERAGE RELATEDNESS

The average or mean coefficient of relatedness between an animal and all animals (including itself) in the living, descendant (i.e., excluding the founders) population. The mean relatedness is twice the proportional loss of gene diversity of the descendant population relative to the founders and is also twice the mean or average inbreeding coefficient of progeny produced by random mating.

DEMOGRAPHY GLOSSARY

Age Age class in years.

Px Age-specific survival.

Probability that an animal of age x will survive to next age class.

Lx Age-specific survivorship.

Probability of a newborn surviving to a age class x.

Mx Age-specific fertility.

Average number of offspring (of the same sex as the parent) produced by an animal in age class x. Can also be interpreted as average percentage of animals that will reproduce.

r Instantaneous rate of change.

If $r < 0$ ..... Population is declining

If $r = 0$ ..... Population is stationary (no change in number)

If $r > 0$ ..... Population is increasing

lambda Percent of population change per year.

If lambda < 1 ..... Population is declining

If lambda $= 1$ ..... Population is stationary

If lambda > 1 ..... Population is increasing

R_o Net reproductive rate. The rate of change per generation.

If $R_o < 1$ ..... Population is declining

If $R_o = 1$ ..... Population is stationary

If $R_o > 1$ ..... Population is increasing

G Generation Time.

Average length of time between the birth of a parent and the birth of its offspring. Equivalently, the average age at which an animal produces its offspring).

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.

THE IUCN POLICY STATEMENT ON OF 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, *Otyx leucoryx*).

RECOMMENDATION

IUCN urges that those national and international organizations and those individual institutions concerned with maintaining wild animals in captivity commit themselves to a general policy of developing demographically self-sustaining 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.

Approved by the 27th Meeting
of 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.

DRAFT

IUCN GUIDELINES FOR THE PLACEMENT OF CONFISCATED LIVE ANIMALS

Statement of Principle:

When live animals are confiscated by government authorities, these authorities have a responsibility to dispose of them appropriately. Within the confines of national and international law, the ultimate decision on disposition of confiscated animals must achieve three goals: 1) to maximise conservation value of the specimens without in any way endangering the health, behavioural repertoire, genetic characteristics, or conservation status of wild or captive populations of the species[1]; 2) to discourage further illegal or irregular[2] trade in the species; and 3) to provide a humane solution, whether this involves maintaining the animals in captivity, returning them to the wild, or employing euthanasia to destroy them.

Statement of Need:

Increased regulation of trade in wild plants and animals and enforcement of these regulations has resulted in an increase in the number of wildlife shipments intercepted by government authorities as a result of non-compliance with these regulations. In some instances, the interception is a result of patently illegal trade; in others, it is in response to other irregularities[2]. While in some cases the number of animals in a confiscated shipment is small, in many others the number is in the hundreds. Although in many countries confiscated animals have usually been donated to zoos or aquaria, this option is proving less viable with large numbers of animals and, increasingly, for common species. The international zoo community has recognized that placing animals of low conservation priority in limited cage space may benefit those individuals but may also detract from conservation efforts as a whole. They are, therefore, setting conservation priorities for cage space (IUDZG/CBSG 1993).

In light of these trends, there is an increasing demand -- and urgent need -- for information and advice to guide confiscating authorities in the disposition of live animals. Although specific guidelines have been formulated for certain groups of organisms, such as parrots (BirdLife International in prep.) and primates (Harcourt 1987), no general guidelines exist.

When disposing of confiscated animals, authorities must adhere to both national and international law. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) requires that confiscated individuals of species listed on the treaty's Appendices be returned to the "state of export...or to a rescue centre or such other place as the Management Authority

[1]Although this document refers to species, in the case of species with well-defined subspecies and races, the issues addressed will apply to lower taxonomic units.

[2]Irregular trade in a species refers to, for example, insufficient or incomplete paperwork from the exporting country or poor packing that has comprised the welfare of the live animals in the shipment.

deems appropriate and consistent with the purpose of the Convention" (Article VIII). However, the treaty does not elaborate on this requirement, and CITES Management Authorities must act according to their own interpretation, not only with respect to repatriation but also as regards what constitutes disposition that is "appropriate and consistent" with the treaty. Although the present guidelines are intended to assist CITES Management Authorities in making this assessment, they are designed to be of general applicability to all confiscated live animals.

The lack of specific guidelines has resulted in confiscated animals being disposed of in a variety of ways. In some cases, release of confiscated animals into existing wild populations has been made after careful evaluation and with due regard for existing general guidelines (IUCN 1987, IUCN 1995). In other cases, such releases have not been well planned and have been inconsistent with general conservation objectives and humane considerations, such as releasing animals in inappropriate habitat, dooming these individuals to starvation or certain death from other causes against which the animals are not equipped or adapted. Such releases may also have strong negative conservation value by threatening existing wild populations as a result of: 1) diseases and parasites acquired by the released animals while held in captivity spreading into existing wild populations; 2) individuals released into existing populations, or in areas near to existing populations, not being of the same race or sub-species as those in the wild population, resulting in mixing of distinct genetic lineages; 3) animals held in captivity, particularly juveniles and immatures, acquiring an inappropriate behavioural repertoire from individuals of other species, and/or either losing certain behaviours, or not developing the full behavioural repetoire, necessary for survival in the wild. Also, it is possible that release of these animals could result in inter-specific hybridisation.

Disposition of confiscated animals is not a simple process. Only on rare occasions will the optimum course to take be clear-cut or result in an action of conservation value. Options for disposition of confiscated animals have thus far been influenced by the public's perception that returning animals to the wild is the optimal solution in terms of both animal welfare and conservation. A growing body of scientific study of re-introduction of captive animals suggests that such actions may be among the least appropriate options for many reasons. This recognition requires that the options available to confiscating authorities for disposition be carefully reviewed.

Management Options:

In deciding on the disposition of confiscated animals, decision-makers must ensure both the humane treatment of the animals and the conservation and welfare of existing wild populations of the species involved. Options for disposition fall into three principal categories: 1) maintenance of the individual(s) in captivity; 2) returning the individual(s) in question to the wild; and 3) euthanasia.

Within a conservation perspective, by far the most important consideration in reviewing the options for disposition is the conservation status of the species concerned. Where the confiscated animals represent an endangered or threatened species, particular effort should be directed towards evaluating whether and how these animals might contribute to a conservation programme for the species. The decision as to which option to employ in the disposition of confiscated animals will

depend on various legal, social, economic and biological factors. The "Decision Tree" provided in the present guidelines is intended to facilitate consideration of these options. The tree has been written so that it may be used for both threatened and common species. However, it recognizes that the conservation status of the species will be the primary consideration affecting the options available for placement, particularly as the expense and difficulty of returning animals to the wild (see below) will often only be justified for threatened species. International networks of experts, such as the IUCN-Species Survival Commission Specialist Groups, should be able to assist confiscating authorities, and CITES Scientific and Management Authorities, in their deliberations as to the appropriate disposition of confiscated specimens.

Sending animals back automatically to the country from which they were shipped, the country in which they originated (if different), or another country in which the species exists, does not solve any problems. Repatriation to avoid addressing the question of disposition of confiscated animals is irresponsible as the authorities in these countries will face the same issues concerning placement as the authorities in the original confiscating country.

OPTION 1 – CAPTIVITY

Confiscated animals are already in captivity; there are numerous options for maintaining them in captivity. Depending on the circumstances, animals can be donated, loaned, or sold. Placement may be in zoos or other facilities, or with private individuals. Finally, placement may be 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. If animals are maintained in captivity, in preference to either being returned to the wild or euthanized, they must be afforded humane conditions and ensured proper care for their natural lives.

Zoos and aquaria are the captive facilities most commonly considered for disposition of animals, but a variety of captive situations exist where the primary aim of the institution or individuals involved is not the propagation and resale of wildlife. These include:

--- **Rescue centres**, established specifically to treat injured or confiscated animals, are sponsored by a number of humane organisations in many countries.

--- **Life-time care facilities** devoted to the care of confiscated animals have been built in a few countries.

--- **Specialist societies** or clubs devoted to the study and care of single taxa or species (e.g., reptiles, amphibians, birds) have, in some instances, provided an avenue for the disposition of confiscated animals without involving sale through intermediaries. Placement may be made directly to these organisations or to **individuals** who are members.

--- **Humane Societies** may be willing to ensure placement of confiscated specimens with private individuals who can provide humane life-time care.

--- **Research laboratories (either commercial or non-commercial, e.g. universities)** maintain collections of exotic animals for many kinds of research (e.g. behavioural, ecological, physiological, psychological, medical). Attitudes towards vivisection, or even towards the non-invasive use of animals in research laboratories as captive study populations, vary widely from country to country. Whether transfer of confiscated animals to research institutions is appropriate will therefore engender some debate. However, it should be noted that transfer to facilities involved in research conducted under humane conditions may offer an alternative -- and one which may eventually contribute information relevant to the species' conservation. In many cases, the lack of known provenance and the risk that the animal in question has been exposed to unknown pathogens will make transfer to a research institution an option that will be rarely exercised or desired.

CAPTIVITY - SALE, LOAN OR DONATION

Animals can be placed with an institution or individual in a number of ways. It is critical, however, that two issues be separated: the ownership of the animals and/or their progeny, and the payment of a fee by the institution/individual receiving the animals. Paying the confiscating authority, or the country of origin, does not necessarily give the person or institution making the payment any rights (these may rest with the confiscating authority). Similarly, ownership of an animal can be transferred without payment. Confiscating authorities and individuals or organizations participating in the placement of confiscated specimens must clarify ownership, both of the specimens being transferred and their progeny. Laws dictating right of ownership of wildlife differ between nations, in some countries ownership remains with the government, in others the owner of the land inhabited by the wildlife has automatic rights over the animals.

When drawing up the terms of transfer many items must be considered, including:

-- ownership of both the animals involved and their offspring (dictated by national law) must be specified as one of the terms and conditions of the transfer (it may be necessary to insist there is no breeding for particular species, eg. primates). Either the country of origin or the country of confiscation may wish to retain ownership of the animals and/or their progeny. Unless specific legal provisions apply, it is impossible to assure the welfare of the animals following a sale which includes a transfer of ownership.

-- sale or payment of a fee to obtain certain rights (e.g. ownership of offspring) can provide a means of placement that helps offset the costs of confiscation.

-- sale and transfer of ownership should only be considered in certain circumstances, such as where the animals in question are not threatened and not subject to a legal proscription on trade (e.g., CITES Appendix I) and there is no risk of stimulating further illegal or irregular trade.

-- sale to commercial captive breeders may contribute to reducing the demand for wild-caught individuals.

-- sale may risk creating a public perception of the confiscating State perpetuating or benefiting from illegal or irregular trade.

-- if ownership is transferred to an organization to achieve a welfare or conservation goal, the confiscating authority should stipulate what will happen to the specimens should the organization wish to sell/transfer the specimens to another organization or individual.

-- confiscating authorities should be prepared to make public the conditions under which conficated animals have been transferred and, where applicable, the basis for any payments involved.

CAPTIVITY– BENEFITS

The *benefits* of placing confiscated animals in a facility that will provide life-time care under humane conditions include:

a) educational value;
b) potential for captive breeding for eventual re-introduction;
c) possibility for the confiscating authority to recoup from sale costs of confiscation;
d) potential for captive bred individuals to replace wild-caught animals as a source for trade.

CAPTIVITY– CONCERNS

The *concerns* raised by placing animals in captivity include:

A) DISEASE. Confiscated animals may serve as vectors for disease. The potential consequences of the introduction of alien disease to a captive facility are more serious than those of introducing disease to wild populations (see discussion page 9); captive conditions might encourage disease spread to not only conspecifics. As many diseases can not be screened for, even the strictest quarantine and most extensive screening for disease can not ensure that an animal is disease-free. Where quarantine cannot adequately ensure that an individual is disease-free, isolation for an indefinite period, or euthanasia, must be carried out.

B) CAPTIVE ANIMALS MAINTAINED OUTSIDE THEIR RANGE CAN ESCAPE from captivity and become pests. Accidental introduction of exotic species can cause tremendous damage and in certain cases,

such as the escape of mink from fur farms in the United Kingdom, the introduction of exotics can result from importation of animals for captive rearing.

C) COST OF PLACEMENT. While any payment will place a value on an animal, there is no evidence that trade would be encouraged if the institution receiving a donation of confiscated animals were to reimburse the confiscating authority for costs of care and transport. However, payments should be explicitly for reimbursement of costs of confiscation and care, and, where possible, the facility receiving the animals should bear all such costs directly.

D) POTENTIAL TO ENCOURAGE UNDESIRED TRADE. Some (e.g., Harcourt 1987) have maintained that any transfer - whether commercial or non-commercial - of confiscated animals risks promoting a market for these species and creating a preception of the confiscating state being involved in illegal or irregular trade.

BirdLife International (in prep.) suggests that in certain circumstances sale of confiscated animals does not necessarily promote undesired trade. They offer the following requirements that must be met for permissible sale by the confiscating authority: 1) the species to be sold is already available for sale legally in the confiscating country in commercial quantities; and 2) wildlife traders under indictment for, or convicted of, crimes related to import of wildlife are prevented from purchasing the animals in question. However, experience in selling confiscated animals in the USA suggests that it is virtually impossible to ensure that commercial dealers suspected or implicated in illegal or irregular trade are excluded, directly or indirectly, in purchasing confiscated animals.

In certain circumstances sale or loan to commercial captive breeders may have a clearer potential for the conservation of the species, or welfare of the individuals, than non-commercial disposition or euthanasia. However, such breeding programmes must be carefully assessed as it may be difficult to determine the effects of these programmes on wild populations.

OPTION 2 – RETURN TO THE WILD

These guidelines suggest that return to the wild would be a desireable option in only a very small number of instances and under very specific circumstances. The rationale behind many of the decision options in this section are discussed in greater detail in the IUCN Re-introduction Guidelines (IUCN/SSC RSG 1995) which, it is important to note, make a clear distinction between the different options for returning animals to the wild. These are elaborated below.

> 1) **Re-introduction**: an attempt to establish a population in an area that was once part of the range of the species but from which it has become extirpated.
>
> Some of the best known re-introductions have been of species that had become extinct in the wild. Examples include: Père David's deer (*Elaphurus davidianus*) and the Arabian oryx (*Oryx leucoryx*). Other re-introduction programmes have involved species that exist in some parts of their historical range but have been eliminated from other areas; the aim of these

programmes is to re-establish a population in an area, or region, from which the species has disappeared. An example of this type of re-introduction is the recent re-introduction of the swift fox (*Vulpes velox*) in Canada.

2) **Reinforcement of an Existing Population**: the addition of individuals to an existing population of the same taxon.

Reinforcement can be a powerful conservation tool when natural populations are diminished by a process which, at least in theory, can be reversed. An example of a successful reinforcement project is the golden lion tamarin (*Leontopithecus rosalia*) project in Brazil. Habitat loss, coupled with capture of live animals for pets, resulted in a rapid decline of the golden lion tamarin. When reserves were expanded, and capture for the pet trade curbed, captive-bred golden lion tamarins were then used to supplement depleted wild populations.

Reinforcement has been most commonly pursued when individual animals injured by human activity have been provided with veterinary care and released. Such activities are common in many western countries, and specific programmes exist for species as diverse as hedgehogs and birds of prey. However common an activity, reinforcement carries with it the very grave risk that individuals held in captivity, even temporarily, are potential vectors for the introduction of disease into wild populations.

Because of inherent disease risks and potential behavioural abnormalities, reinforcement should only be employed in instances where there is a direct and measurable conservation benefit (demographically and/or genetically, and/or to enhance conservation in the public's eye), for example when reinforcement will significantly add to the viability of the wild population into which an individual is being placed.

3) **Conservation Introductions** (also referred to as Beneficial or Benign Introductions - IUCN 1995): an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within a suitable habitat in which a population can be established without predicted detriment to native species.

Extensive use of conservation introductions has been made in New Zealand, where endangered birds have been transferred to off-shore islands that were adjacent to, but not part of, the animals' original range. Conservation introductions can also be a component of a larger programme of re-introduction, an example being the breeding of red wolves on islands outside their natural range and subsequent transfer to mainland range areas (Smith 1990).

RETURN TO THE WILD – CONCERNS

Before return to the wild of confiscated animals is considered, several issues of concern must be considered in general terms: welfare, conservation value, cost, and disease.

a) WELFARE. While some consider return to the wild to be humane, ill-conceived projects may return animals to the wild which then die from starvation or suffer an inability to adapt to an unfamiliar or inappropriate environment. This is not humane. Humane considerations require that each effort to return confiscated animals to the wild be thoroughly researched and carefully planned. Such returns also require long-term commitment in terms of monitoring the fate of released individuals. Some (e.g., International Academy of Animal Welfare Sciences 1992) have advocated that the survival prospects for released animals must at least approximate those of wild animals of the same sex and age class in order for return to the wild to be seriously considered. While such demographic data on wild populations are, unfortunately, rarely available, the spirit of this suggestion should be respected -- there must be humane treatment of confiscated animals when attempting to return them to the wild.

b) CONSERVATION VALUE AND COST. In cases where returning confiscated animals to the wild appears to be the most humane option, such action can only be undertaken if it does not threaten existing populations of conspecifics or populations of other interacting species, or the ecological integrity of the area in which they live. The conservation of the species as a whole, and of other animals already living free, must take precedent over the welfare of individual animals that are already in captivity.

Before animals are used in programmes in which existing populations are reinforced, or new populations are established, it must be determined that returning these individuals to the wild will make a significant contribution to the conservation of the species, or populations of other interacting species. Based solely on demographic considerations, large populations are less likely to go extinct, and therefore reinforcing existing very small wild populations may reduce the probability of extinction. In very small populations a lack of males or females may result in reduced population growth or population decline and, therefore, reinforcing a very small population lacking animals of a particular sex may also improve prospects for survival of that population. However, genetic and behavioural considerations, as well as the possiblity of disease introduction, also play a fundamental role in determining the long term survival of a population.

The cost of returning animals to the wild in an appropriate manner can be prohibitive for all but the most endangered species (Stanley Price 1989; Seal et al. 1989). The species for which the conservation benefits clearly outweigh these costs represent a tiny proportion of the species which might, potentially, be confiscated. In the majority of cases, the costs of appropriate, responsible (re)introduction will preclude return to the wild. Poorly planned or executed (re-)introduction programmes are no better than dumping animals in the wild and should be vigorously opposed on both conservation and humane grounds.

c) FOUNDERS AND NUMBERS REQUIRED. Most re-introductions require large numbers of founders, usually released in smaller groups over a period of time. Hence, small groups of confiscated animals may be inappropriate for re-introduction programmes, and even larger groups will require careful management if they are to have any conservation value for re-introduction programmes. In reality, confiscated specimens will most often only be of potential value for reinforcing an existing population, despite the many potential problems this will entail.

c) SOURCE OF INDIVIDUALS. If the precise provenance of the animals is not known (they may be from several different provenances), or if there is any question of the source of animals, supplementation may lead to inadvertent pollution of distinct genetic races or sub-species. If particular local races or sub-species show specific adaptation to their local environments mixing in individuals from other races or sub-species may be damaging to the local population. Introducing an individual or individuals into the wrong habitat type may also doom that individual to death.

d) DISEASE. Animals held in captivity and/or transported, even for a very short time, 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. Even if there is a very small risk that confiscated animals have been infected by exotic pathogens, the potential effects of introduced diseases on wild populations are so great that this will often prevent returning confiscated animals to the wild (Woodford and Rossiter 1993, papers in *J. Zoo and Wildlife Medicine* 24(3), 1993).

Release of any animal into the wild which has been held in captivity is risky. Animals held in captivity are more likely to acquire diseases and parasites. While some of these diseases can be tested for, tests do not exist for many animal diseases. Furthermore, animals held in captivity are frequently exposed to diseases not usually encountered in their natural habitat. Veterinarians and quarantine officers, thinking that the species in question is only susceptible to certain diseases, may not test for the diseases picked up in captivity. It should be assumed that all diseases are potentially contagious.

Given that any release incurs some risk, the following "precautionary principle" must be adopted: ***if there is no conservation value in releasing confiscated specimens, the possibility of accidentally introducing a disease, or behavioural and genetic aberrations into the environment which are not already present, however unlikely, may rule out returning confiscated specimens to the wild as a placement option.***

RETURN TO THE WILD— BENEFITS

There are several *benefits* of returning animals to the wild, either through re-introduction for the establishment of a new population or reinforcement 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 as a whole, or of a local population of the species (e.g., golden lion tamarins).

b) Returning animals to the wild makes a strong political/educational statement concerning the fate of animals (e.g., orangutans (*Pongo pygmaeus*) and chimpanzees (*Pan troglodytes*) - Aveling & Mitchell 1982, but see Rijksen & Rijksen-Graatsma 1979) and may serve to promote local conservation values. However, as part of any education or public awareness programmes, the costs and difficulties associated with the return to the wild must be emphasized.

OPTION 3 – EUTHANASIA

Euthanasia -- the killing of animals carried out according to humane guidelines -- is unlikely to be a popular option amongst confiscating authorities for disposition of confiscated animals. However, it cannot be overstressed that euthanasia may frequently be the most feasible option available for economic, conservation and humane reasons. In many cases, authorities confiscating live animals will encounter the following situations:

a) Return to the wild in some manner is either unnecessary (e.g., in the case of a very common species), impossible, or prohibitively expensive as a result of the need to conform to biological (IUCN/SSC RSG 1995) and animal welfare guidelines (International Academy of Welfare Sciences 1992).

b) Placement in a captive facility is impossible, or there are serious concerns that sale will be problematic or controversial.

c) During transport, or while held in captivity, the animals have contracted a chronic disease that is incurable and, therefore, are a risk to any captive or wild population. In such situations, there may be no practical alternative to euthanasia.

EUTHANASIA –ADVANGATES:

a) From the point of view of conservation of the species involved, and of protection of existing captive and wild populations of animals, euthanasia carries far fewer risks (e.g. loss of any unique behavioural/genetic/ecological variations within an individual representing variation within the species) when compared to returning animals to the wild.

b) Euthanasia will also act to discourage the activities that gave rise to confiscation, be it smuggling or other patently illegal trade, incomplete or irregular paperwork, poor packing, or other problems, as the animals in question are removed entirely from trade.

c) Euthanasia may be in the best interest of the welfare of the confiscated animals. Release to the wild will carry enormous risks for existing wild populations and may pose severe challenges to

the survival prospects of the individual animals, who may, as a result, die of starvation, disease or predation.

d) Cost: euthanasia is cheap compared to other options. There is potential for diverting resources which might have been used for re-introduction or lifetime care to conservation of the species in the wild.

When animals are euthanized, or when they die a natural death while in captivity, the dead specimen should be placed in the collection of a natural history museum, or another reference collection in a university or research institute. Such reference collections are of great importance to studies of biodiversity. If such placement is impossible, carcasses should be incinerated to avoid illegal trade in animal parts or derivatives.

EUTHANASIA– RISKS

a) There is a risk of losing unique behavioural, genetic and ecological material within an individual or group of individuals that represents variation within a species.

DECISION TREE ANALYSIS

For decision trees dealing with "Return to the Wild" and "Captive Options," the confiscating party must first ask the question:

Question 1: Will "Return to the Wild" make a significant contribution to the conservation of the species?

The most important consideration in deciding on placement of confiscated specimens is the conservation of the species in question. Conservation interests are best served by ensuring the survival of as many individuals as possible. The release of confiscated animals therefore must improve the prospects for survival of the existing wild population. Returning an individual to the wild that has been held in captivity will always involve some level of risk to existing populations of the same or other species in the ecosystem to which the animal is returned because there can never be absolute certainty that a confiscated animal is disease- and parasite free. In most instances, the benefits of return to the wild will be outweighed by the costs and risks of such an action. If returning animals to the wild is not of conservation value, captive options pose fewer risks and may offer more humane alternatives.

Q1 Answer: **No:** Investigate "Captive Options".
Yes: Investigate "Return to the Wild" Options.

DECISION TREE ANALYSIS - CAPTIVITY

The decision to maintain confiscated animals in captivity involves a simpler set of considerations than that involving attempts to return confiscated animals to the wild.

Question 2: Have animals been subjected to a comprehensive veterinary screening and quarantine?

Animals that may be transferred to captive facilities must have a clean bill of health because of the risk of introducing disease to captive populations.

These animals must be placed in quarantine to determine if they are disease-free before being transferred to a captive-breeding facility.

Q2 Answer: Yes: Proceed to Question 3.
No: Quarantine and screen and move to Question 3

Question 3: Have animals been found to be disease-free by comprehensive veterinary screening and quarantine or can they be treated for any infectinon discovered?

If, during quarantine, the animals are found to harbour diseases that cannot reasonably be cured, they must be euthanized to prevent infection of other animals. If the animals are suspected to have come into contact with diseases for which screening is impossible, extended quarantine, donation to a research facility, or ethanasia must be considered.

Q3 Answer: Yes: Proceed to Question 4
No: If chronic and incurable infection, first offer animals to research institutions. If impossible to place in such institutions, euthanize.

Question 4: Are there grounds for concern that sale will stimulate further illegal or irregular trade?

Commercial sale of Appendix I species is not permitted under the Convention as it is undesireable to stimulate trade in these species. Species not listed in any CITES appendix, but which are nonetheless seriously threatened with extinction, should be afforded the same caution.

Sale of confiscated animals, where legally permitted, is a difficult option to consider. While the benefits of sale -- income and quick disposition -- are clear, there are many problems that may arise as a result of further commercial transactions of the specimens involved. Equally, it should be noted that there may be circumstances where such problems arise as a result of a non-commercial transaction or that, conversely, sale to commercial captive breeders may contribute to production of young offsetting the capture from the wild.

More often than not, sale of threatened species should not take place. Such sales or trade in threatened species may be legally proscribed in some countries, or by CITES. There may be rare cases where a commercial captive breeding operation may purchase or receive individuals for breeding, which may reduce pressure on wild populations subject to trade. In all circumstances, the confiscating authority should be satisfied that:

1) those involved in the illegal or irregular transaction that gave rise to confiscation cannot obtain the animals;
2) the sale does not compromise the objective of confiscation; and, finally,
3) the sale will not increase illegal, irregular or otherwise undesired trade in the species.

Previous experience with sale in some countries (e.g., the USA) has indicated that selling confiscated animals is beset by both logistic and political problems and that, in addition to being controversial, it may also be counter-productive to conservation objectives.

Answer: Yes: Proceed to Question 5a.
No: Proceed to Question 5b.

Question 5a: Is space available in a non-commercial captive facility (e.g., life-time care facility, zoo, rescue centre, specialist society, their members or private individuals)?

Question 5b: Is space available in a non-commercial captive facility (e.g., life-time care facility, zoo, rescue centre, specialist society, their members or private individuals) *or* is there a commercial facility breeding this species, and is the facility interested in the animals?

Transfer of animals to non-commercial captive-breeding facilities, if sale may stimulate further illegal or irregular trade, or commercial captive breeding facilities, an option only if sale will **not** stimulate further illegal or irregular trade, should generally provide a safe and acceptable means of disposition of confiscated animals. When a choice must be made between several such institutions, the paramount consideration should be which facility can:
1) offer the opportunity for the animals to participate in a captive breeding programme;
2) provide the most consistent care; and
3) ensure the welfare of the animals.

The terms and conditions of the transfer should be agreed between the confiscating authority and the recipient institution. Terms and conditions for such agreements should include:
1) a clear commitment to ensure life-time care or, in the event that this becomes impossible, transfer to another facility that can ensure life-time care, or euthanasia;
2) clear specification of ownership of the specimens concerned (as determined by national law) and, where breeding may occur, the offspring. Depending on the circumstances, ownership may be vested with the confiscating authority, the country of origin or export, or with the recipient facility.
3) clear specification of conditions under which the animal(s) or their progeny may be sold.

In the majority of instances, there will be no facilities or zoo or aquarium space available in the country in which animals are confiscated. Where this is the case other captive options should be investigated. This could include transfer to a captive facility outside the country of confiscation particularly in the country of origin, or, if transfer will not stimulate further illegal trade, placement in a commercial captive breeding facility. However, these breeding programmes must be carefully assessed and approached with caution. It may be difficult to monitor these programmes and such programmes may unintentionally, or intentionally, stimulate trade in wild animals. The conservation potential of this transfer, or breeding loan, must be carefully weighed against even the smallest risk of stimulating trade which would further endanger the wild population of the species.

In many countries, there are active specialist societies or clubs of individuals with considerable expertise in the husbandry and breeding of individual species or groups of species. Such societies can assist in finding homes for confiscated animals without involving sale through intermediaries. In this case, individuals receiving confiscated animals must have demonstrated expertise in the husbandry of the species concerned and must be provided with adequate information and advice by the club or society concerned. Transfer to specialist societies or individual members must be made

according to terms and conditions agreed with the confiscating authority. Such agreements may be the same or similar to those executed with Life-time Care facilities or zoos. Placement with these societies or members is an option if sale of the confiscated animals may or may not stimulate trade.

Answer: Yes: Execute agreement and sell.
No: Proceed to Question 6.

Question 6: Are institutions interested in animals for research under humane conditions?

Many research laboratories maintain collections of exotic animals for research conducted under humane conditions. If these animals are kept in conditions that ensure their welfare, transfer to such institutions may provide an acceptable alternative to other options, such as sale or euthanasia. As in the preceding instances, such transfer should be subject to terms and conditions agreed with the confiscating authority; in addition to those already suggested, it may be advisable to include terms that stipulate the types of research the confiscating authority considers permissible. If no placement is possible, the animals should be euthanized.

Answer: Yes: Execute Agreement and Transfer.
No: Euthanize.

DECISION TREE ANALYSIS -- RETURN TO THE WILD

Question 2: Have animals been subjected to a comprehensive veterinary screening and quarantine?

Because of the risk of introducing disease to wild populations, animals that may be released must have a clean bill of health. These animals must be placed in quarantine to determine if they are disease-free before being considered for released.

Q2 Answer: Yes: Proceed to Question 3.
No: Quarantine and screen and move to Question 3

Question 3: Have animals been found to be disease-free by comprehensive veterinary screening and quarantine or can they be treated for any infectinon discovered?

If, during quarantine, the animals are found to harbour diseases that cannot reasonably be cured, unless any institutions are interested in the animals for research under humane conditions, they must be euthanized to prevent infection of other animals. If the animals are suspected to have come into contact with diseases for which screening is impossible, extended quarantine, donation to a research facility, or ethanasia must be considered.

Q3 Answer: Yes: Proceed to Question 4
No: If chronic and incurable infection, first offer animals to research institutions. If impossible to place in such institutions, euthanize.

Question 4: Can country of origin and site of capture be confirmed?

The geographical location from which confiscated individuals have been removed from the wild must be determined if these individuals are to be re-introduced or used to supplement existing populations. In most cases, animals should only be returned to the population from which they were taken, or from populations which are known to have natural exchange of individuals with this population.

If provenance of the animals is not known, release for reinforcement may lead to inadvertent hybridisation of distinct genetic races or sub-species. Related species of animals that may live in sympatry in the wild and never hybridise have been known to hybridise when held in captivity or shipped in multi-species groups. This type of generalisation of species recognition under abnormal conditions can result in behavioural problems compromising the success of any future release and can also pose a threat to wild populations by artificially destroying reproductive isolation that is behaviourally mediated.

Q4 Answer: Yes: Proceed to Question 5.
No: Pursue 'Captive Options'.

Question 5: Do the animals exhibit behavioural abnormalities which might make them unsuitable for return to the wild?

Behavioural abnormalities as a result of captivity can result in animals which are not suitable for release into the wild. A wide variety of behavioural traits and specific behavioural skills are necessary for survival, in the short-term for the individual, and in the long-term for the population. Skills for hunting, avoiding predators, food selectivity etc. are necessary to ensure survival.

Q5 Answer: Yes: Pursue 'Captive Options'.
No: Proceed to Question 6.

Question 6: Can individuals be returned expeditiously to origin (specific location), and will benefits to conservation of the species outweigh any risks of such action?

Repatriation of the individual and reinforcement of the population will only be options under certain conditions and following the IUCN/RSG 1995 guidelines:
1) Appropriate habitat for such an operation still exists in the specific location that the individual was removed from; and
2) sufficient funds are available, or can be made available.

Q6 Answer: Yes: Repatriate and reinforce at origin (specific location) following IUCN guidelines.
No: Proceed to Question 7.

Question 7: **For the species in question, does a generally recognized programme exist whose aim is conservation of the species and eventual return to the wild of confiscated individuals and/or their progeny?** ***Contact IUCN/SSC, IUDZG, Studbook Keeper, or Breeding Programme Coordinator.***

In the case of species for which active captive breeding and/or re-introduction programmes exist, and for which further breeding stock/founders are required, confiscated animals should be transferred to such programmes after consultation with the appropriate scientific authorities. If the species in question is part of a captive breeding programme, but the taxon (sub-species or race) is not part of this programme (e.g. Maguire & Lacy 1990), other methods of disposition must be considered. Particular attention should be paid to genetic screening to avoid jeopardizing captive breeding programmes through inadvertent hybridisation.

Answer: Yes: Executer agreement and transfer to existing programme.
No: Proceed to Question 8.

Question 8: **Is there a need and is it feasible to establish a new re-introduction programme *following IUCN Guidelines*?**

In cases where individuals cannot be transferred to existing re-introduction programmes, return to the wild, following appropriate guidelines, will only be possible under the following circumstances: 1) appropriate habitat exists for such an operation; 2) sufficient funds are available, or can be made available, to support a programme over the many years that (re)introduction will require; and 3) either sufficient numbers of animals are available so that re-introduction efforts are potentially viable, or only reinforcement of existing populations is considered. In the majority of cases, at least one, if not all, of these requirements will fail to be met. In this instance, either conservation introductions outside the historical range of the species or other options for disposition of the animals must be considered.

It should be emphasized that if a particular species or taxon is confiscated with some frequency, consideration should be made as to whether to establish a re-introduction, reinforcement, or introduction programme. Animals should not be held by the confiscating authority indefinitely while such programmes are planned, but should be transferred to a holding facility after consultation with the organization which is estabishing the new programme.

Answer: Yes: Execute agreement and transfer to holding facility or new programme.
No: Pursue 'Captive Options'.

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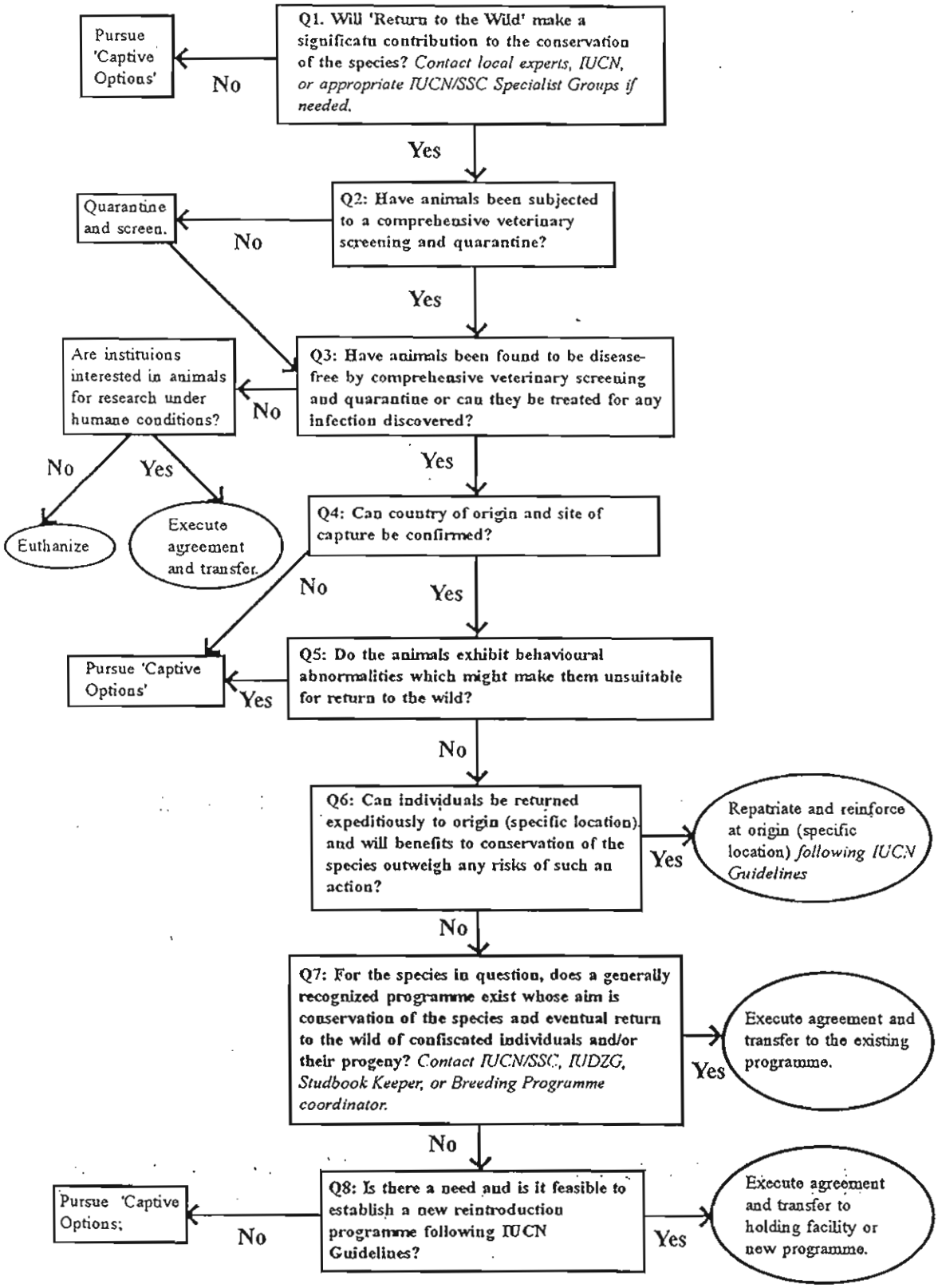
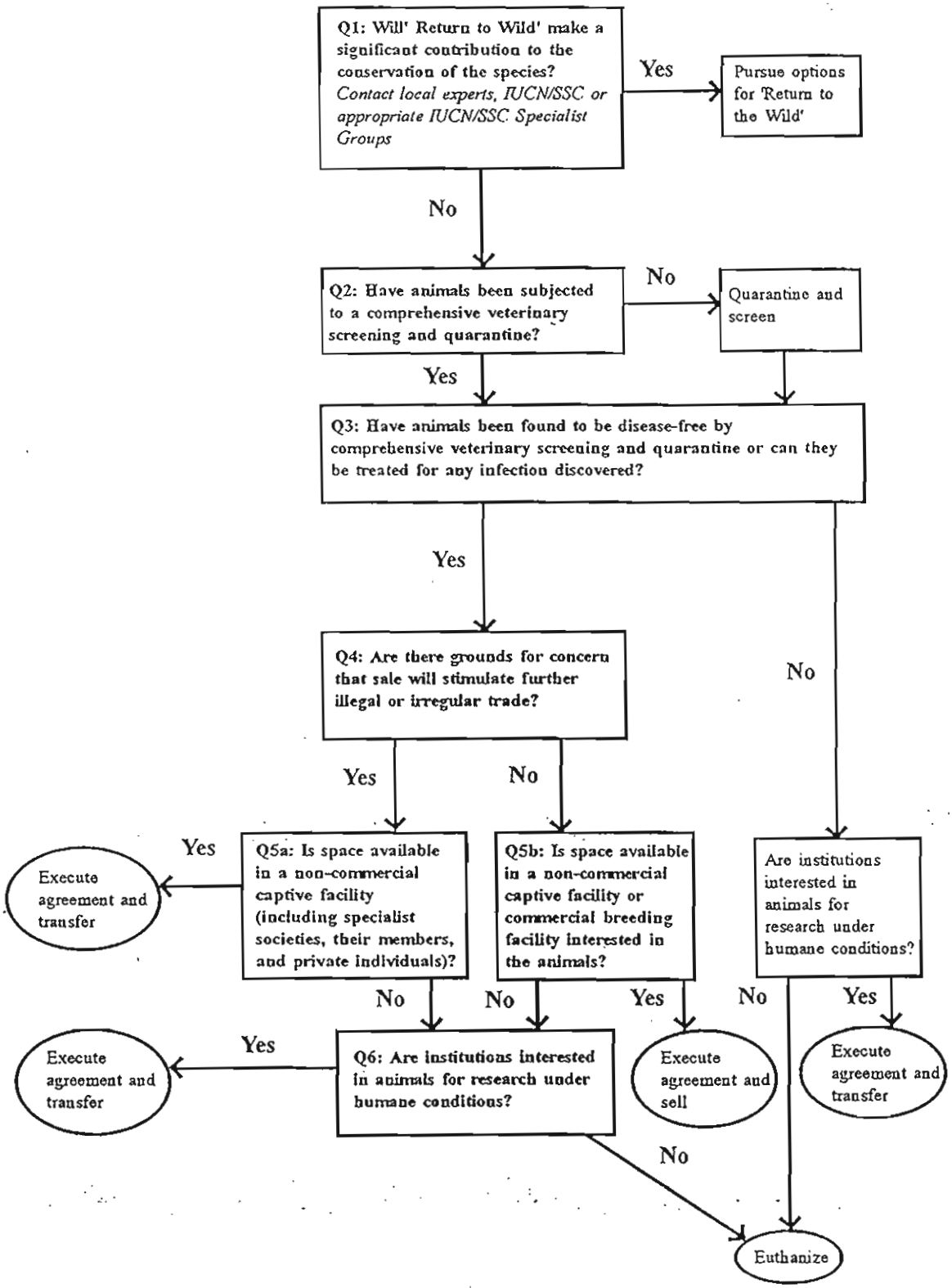
Decision Tree for Return to the Wild



Decision Tree for Captive Options



PREPROPOSAL FOR A COMBINED TRAINING COURSE IN APPROPRIATE SURVEY METHODS FOR TAMARAW AND TAMARAW STATUS SURVEY

(Preproposal written by: Simon Hedges, Co-Chair, IUCN/SSC Asian Wild Cattle Specialist Group; ref. no. tamaraw\sh960523.v1)

Background

Tamaraw (*Bubalus mindorensis*) are a seriously endangered species of buffalo. The total population is now thought to be fewer than 300 animals and their numbers are continuing to decline, mainly as a result of illegal hunting. They are endemic to the island of Mindoro in the Philippines and it has been suggested that they could act as the 'flagship species' for a Mindoran biodiversity conservation program. It has also been suggested that they could make valuable domestic animals and that they represent an important, but as yet untapped, resource for the livestock industry in the Philippines and the wider Asia-Pacific region. However these opportunities will be lost unless effective action is taken very soon.

The status of the species was reviewed during the May 1996 Tamaraw Population and Habitat Viability Analysis (PHVA) Workshop which was held at the University of the Philippines at Los Banos. The data presented during this workshop highlighted the pressing need for action since it would appear that only two small populations are *known* to exist in 1996. These two populations are located in the Iglit Ranges areas of Mount Iglit-Baco National Park (estimates range from fewer than 20 to approximately 175 animals) and the nearby Aruyan area (an unknown number of animals but thought to be fewer than 30). The presence of tamaraw was also confirmed in the Mount Calavite Tamaraw Reservation in 1994 (when one tamaraw was seen). There have been no other reports of tamaraw since a 1987 survey which reported their presence in about nine areas; however this survey has been criticized for relying too heavily on reports from local people. Thus the present state of knowledge regarding the status of tamaraw can be summarized as: 'an unknown number of animals in two locations with the possibility of further animals in an unknown number of other sites'.

This scarcity of information greatly hampers the development of an effective conservation strategy and assessing the status of tamaraw was identified as a very high priority during the PHVA workshop. Furthermore two major reasons for this lack of good or even reasonable quality data were identified during the workshop. Firstly, the scarcity of trained personnel; and secondly, the difficulties inherent in surveying an animal such as the tamaraw. It was therefore recommended that appropriate survey techniques for tamaraw be developed and training provided for Filipino wildlife conservation personnel.

Proposed training and status survey

Introduction.

The 1996 Tamaraw PHVA Workshop's participants recommended that appropriate survey methods for tamaraw should be developed and then used to assess the status of tamaraw on Mindoro. It was further recommended that the status survey should be divided into two phases (this preproposal covers Phase One only).

Phase One. Survey activities in Phase One can be divided into three parts: (1) development of appropriate survey techniques for tamaraw and training of survey personnel, (2) utilization of the techniques to obtain an assessment of the minimum number of tamaraw in the key Iglit Ranges area of Mount-Iglit Baco NP and if possible the Aruyan area too; and (3) a Mindoro-wide survey to determine presence/suspected absence of tamaraw in all areas where tamaraw have previously been reported to occur, plus any other areas of potentially suitable habitat. Information about tamaraw population structure (sex and age ratios) and threats to tamaraw and their habitat will also be collected during Phase One activities.

Phase Two. (Not covered by this preproposal.) Once appropriate techniques have been field-tested and a corp of tamaraw surveyors trained in their use further surveys (actually repeated minimum counts) will be conducted in all other areas where the presence of tamaraw was confirmed during Phase One.

Development of suitable techniques.

Problems. Tamaraw are difficult to count because they are small wary and largely solitary animals, and because they live at (apparently) low density in mountainous areas dominated by tall grasses and other concealing vegetation. Furthermore their dung can be confused with that of domestic and/or feral livestock, and their footprints can be confused with those of water buffalo (*Bubalus bubalis*). These problems hold true for both surveys (i.e. sample counts) and censuses (i.e. total counts).

What information is required? Unfortunately the status of the tamaraw is now too precarious for simple indices of relative abundance to suffice. Some assessment of the likely size of at least the major tamaraw populations is needed if an effective tamaraw conservation plan is to be initiated. For example, if only a small number of tamaraw are left in the wild and significant numbers are being taken by hunters (and hunting pressure was reported to be high in the Iglit Ranges area by local people who attended the recent PHVA) then it may be necessary to capture some of the remaining animals in order to safeguard the species against extinction. It was therefore decided to try and assess the minimum size of all remaining major tamaraw populations beginning with Iglit-Baco NP (other sites will be included during Phase Two, i.e. once a suitable technique has been field-tested and we have a better idea of the species's distribution on Mindoro). Data about the sex and age structure of the tamaraw populations will of course be collected at the same time and this information should allow major trends to be monitored in the future (provided a sufficiently large proportion of the animals in the population are seen).

The recommended technique: simultaneous observations from multiple vantage points. After discussion with people familiar with tamaraw and their habitat in the Iglit Ranges region (an area of about 27 km²) it was decided that the best way of calculating the minimum number of tamaraw in the area would be to have a large number of observers stationed at vantage points overlooking tamaraw grazing areas, wallows, and other water sources *at the same time*. Since it is unlikely that the whole 27 km² area can be covered simultaneously the area will be divided up into a number of blocks (the actual number will depend on topography and the number of observers available but obviously the smallest possible number of blocks will be used). It is proposed that a team of two observers is stationed at each vantage point and that each team has at least one pair of binoculars, a compass, and a watch. Whenever a tamaraw is seen the observers will record the time, location (including

the compass bearing and estimated distance from their vantage point), the number of tamaraw seen and their sex, age classes, and activities. The length of time they remain visible will also be noted as will major changes of location.

Tamaraw are reported to be mainly active in the early morning and at dusk so the observers will need to camp at the vantage points. The teams will probably need to stay at their vantage points for three nights to allow for two full-days of observations (three early morning counts and two dusk counts).

The best time to conduct the survey appears to be late in the November-to-March/April dry season (probably late-January or early-February) because the Iglit-Baco area is more accessible then and because the tamaraw should be concentrated around sources of water. Furthermore the indigenous people who live in Iglit-Baco NP normally burn large areas of the national park between November and February and it is hoped that this burning might prove advantageous since it normally results in a mosaic of newly burnt areas, patches of re-growing grasses of different heights, and unburnt areas. Thus visibility should be improved in a number of areas and since the tamaraw are likely to be attracted to the areas of new and thus short grasses they should be easier to see.

The opportunities for and desirability of conducting small-scale drive counts will also be assessed during the field work. (People familiar with the Iglit Ranges area report that patches of tall *Saccharum spontaneum* (wild sugar cane) occur in the wetter parts of the area and consequently it may be necessary, or at least desirable, to flush any tamaraw using these areas into the open.)

Presence/suspected absence survey.

It is anticipated that about ten graduate students associated with the Philippines Wildlife Conservation Society will conduct this part of Phase One activities. These students will visit all the areas where tamaraw have previously been reported, plus, it their is sufficient time, any other areas of potentially suitable habitat, and look for evidence of tamaraw. The emphasis will be on obtaining actual sightings and so enough time to achieve a reasonable chance of at least one sighting will be spent in area even if this means that the number of areas which can be covered is reduced. The survey team will collect information from local people knowledgeable about wildlife (including hunters if possible), indigenous people, local government staff (CENRO, PENRO, etc.), and any conservation NGO personnel or scientists active in the various areas. This information will then be used to select those areas where the chances of actually seeing tamaraw are greatest (e.g. frequently used wallows).

Other evidence of tamaraw will also be sought, i.e. any potential tamaraw faeces or footprints will be recorded (and the prints measured); and the presence of domestic and/or feral livestock will be recorded in order to help assess the usefulness of the footprint/faecal evidence.

In order to maximize their time in the field the students who conduct this survey will not attend the training sessions at the 'Gene Pool' (discussed below). However a separate briefing session will be organized prior to the survey.

Training.

A large part of the training component of Phase One will be accomplished during the actual tamaraw count in the Iglit Ranges area, i.e. the trainees will be 'learning by doing'. It is anticipated that the first days of counting in block one will be in effect a demonstration of the technique (and consequently the length of time spent in block one may be longer than that spent in other blocks - it may even be necessary to return to block one after the other blocks have been counted).

There will, however, be a number of training sessions before the actual tamaraw counts. These sessions will include:

1) General introduction. This will cover the need for reliable estimates; acceptable evidence of the presence of an animal (for presence/suspected absence surveys); the differences between censuses, surveys, and monitoring; designing and conducting wildlife surveys, and analyzing and presenting results; and classification of animals into different age and sex classes. The recommended technique will be introduced during these sessions. Drive counts will also be discussed.

2) An introduction to compass and map work. The accurate identification and recording of locations is an essential underpinning of much survey work (and is particularly important for the method of counting tamaraw which will be used in the Iglit Ranges area).

3) Interview and questionnaire surveys. How to maximize the usefulness of local informants including such important topics as how to interview hunters, foresters, villagers, etc. without asking leading questions; and the design of unbiased questionnaires.

Personnel

The presence/suspected absence survey will involve about ten graduate students. The training course and tamaraw count in the Iglit Ranges will involve about 30 trainees plus three instructors/coordinators.

The trainees will be the five Tamaraw Conservation Program (TCP) tamaraw survey team personnel, the four local CENRO staff (associated with Iglit-Baco NP and the Aruyan area), about ten KMFI volunteers (the KMFI is a local NGO involved in tamaraw conservation work), and about ten students from the Philippine Wildlife Conservation Society. It is emphasized that the intention is to involve those personnel who will be conducting future tamaraw surveys (in Phase Two), not office-bound administrators.

The instructors will be people with extensive experience of conducting mammal surveys in the Asian tropics. If possible all the instructors will be involved in the training course on a voluntary basis, i.e. although their expenses will be covered no consultancy fees will be paid.

Accommodation

It is proposed that the Tamaraw Conservation Program's premises at the Tamaraw 'Gene Pool' in Mount Iglit-Baco National

Park be used as a base during the pre-survey training and preparation phase. (This will need to be checked with the Program's veterinary staff in order to assess whether such a use of the premises would present a risk to any captive tamaraw which are being held there at the time of the survey.)

Timetable

The training course and preparation period will require about one week and will be followed immediately by the tamaraw count in the Iglit Ranges area (and the Aruyan area if there is sufficient time). The counting period will probably require two weeks. Thus about three weeks will be required. The Mindoro-wide presence/suspected absence survey will require a minimum of four weeks. The exact dates will be selected later when the availability of personnel is better known but for the reasons discussed above the training course and tamaraw count should be held in the late-January 1997 to February 1997 period. The Mindoro-wide survey will be conducted simultaneously.

Week 1	Day 1: one day briefing for Mindoro-wide survey teams (two teams of five graduate students) in Manila. Day 2: departure of these two teams for Mindoro. Day 3: start of Mindoro-wide survey.
Week 2	Day 1: instructors/coordinators and trainees/Iglit Ranges tamaraw count team leave San Jose for the 'Gene Pool'. Days 2-7: training and preparation.
Weeks 3/4	Tamaraw count in the Iglit Ranges area (plus the Aruyan a ea if there is time).
Week 5	Days 1 & 2: debriefing of tamaraw count team at the 'Gene Pool' and departure for San Jose; Mindoro-wide survey teams return to Manila. Day 4 or 5: debriefing meeting for Mindoro-wide survey teams in Manila.

An orientation visit by at least one of the instructors/coordinators prior to the training sessions and actual survey would clearly be advantageous and should be included if possible.

Budget

The precise budget is not yet known but approximately US$19,300 is likely to be required. This sum will cover:

	US$
Equipment	
maps of Mindoro (provided by PAWB)	free
detailed maps (1:50,000 or 1:25,000) of the Iglit-Baco NP and Aruyan areas (from PAWB)	free
15 sighting compasses @ $40	600
1 global positioning system device (GPS)	2500
20 binoculars @ $75	1500
20 sleeping bags @ $40	800
20 backpacks @ $68	1360
15 tents @ $120	1800
Accommodation	
Training course at 'Gene Pool'	free
Tamaraw count in Iglit Ranges (camping)	free
The 2 Mindoro-wide survey teams will stay with CENRO officials, village chiefs, etc. whenever possible but the budget allows for up to 10 nights in hotels (for both teams) @ $8/double room/night	480
Food	
Training course/tamaraw count team: 33 people for 23 days @ $4/person/day	3036
Mindoro-wide survey mobile teams: 10 people for 30 days @ $6/person/day	1800
Hire of 4 cooks/support staff for 'Gene Pool' based team @ $10/person/day (allow 2 weeks)	560
Transport	
Hire of Jeepneys between San Jose and the 'Gene Pool': 6 trips @ $40/one-way trip	240
Use of TCP pickup if possible	free
10 students by boat from Manila-San Jose-Manila @ $28/person	280
Estimate of cost which will be incurred by the 2 Mindoro-wide survey teams	1200
SUBTOTAL	16156
10% contingency	1616
Costs incurred by the 3 instructors/coordinators	
3 return flights (home/base-Manila-home/base): hopefully provided free of charge by Philippines Airlines	free
3 return flights (Manila-San Jose-Manila): hopefully provided free of charge too but included in budget	270
3 nights in cheap hotels @ $30/double room/night	180
TOTAL	18222
Possible orientation visit by 2 instructors/coordinators prior to course/survey	
2 return flights (home base-Manila-home base): as above	free
2 return flights (Manila-San Jose-Manila) hopefully provided free of charge too but included in budget	200
Hire of jeepney @ $40/San Jose-'Gene Pool' trip	80
Hire of 2 local guides @ $10/guide/day (allow up to 8 days)	160
Food @ $6/person/day (allow for 4 people for up to 8 days)	200
3 nights in cheap hotels @ $30/double room/night	90
Miscellaneous expenses (transport in Manila, communications, etc.)	270
TOTAL	1000
GRAND TOTAL	19222

[Note: all equipment purchased will be kept in the Philippines for use during Phase Two activities.]

Conservation Breeding Specialist Group

Species Survival Commission
IUCN -- The World Conservation Union

U.S. Seal, CBSG Chairman

CBSG Population and Habitat Viability Assessment (PHVA) Processes

Introduction

There is a lack of generally accepted tools to evaluate and integrate the interaction of biological, physical, and social factors on the population dynamics of the broad range of threatened species. There is a need for tools and processes to characterize the risk of species and habitat extinction, on the possible effects of future events, on the effects of management interventions, and on how to develop and sustain learning-based cross-institutional management programs.

The Conservation Breeding Specialist Group (CBSG) of IUCN's Species Survival Commission (SSC) has 10 years experience in developing, testing, and applying a series of scientifically-based tools and processes to assist risk characterization and species management decision making. These tools, based on small population and conservation biology (biological and physical factors), human demography, and the dynamics of social learning are used in intensive, problem-solving workshops to produce realistic and achievable recommendations for both *in situ* and *ex situ* population management.

Our Workshop processes provide an objective environment, expert knowledge, and a neutral facilitation process that supports sharing of available information across institutions and stakeholder groups, reaching agreement on the issues and available information, and then making useful and practical management recommendations for the taxon and habitat system under consideration. These processes have been remarkably successful in unearthing and integrating previously unpublished significant information for the decision-making process. Their proven heuristic value and constant refinement and expansion have made the PHVA process one of the most imaginative and productive organizing forces for species conservation today (Conway, 1995).

Integration of Science, Management, and Stakeholders

The CBSG PHVA Workshop process is based upon biological and sociological science. Effective conservation action is best built upon a synthesis of available biological information, but is dependent on actions of people living within the range of the threatened species as well

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as established national and international interests. There are characteristic patterns of human behavior that are cross-disciplinary and cross-cultural which affect the processes of communication, problem solving, and collaboration: 1) in the acquisition, sharing, and analysis of information; 2) in the perception and characterization of risk; 3) in the development of trust among individuals; and, 4) in 'territoriality' (personal, professional, institutional, local, national). Each of these has strong emotional components that shape our interactions. Recognition of these patterns has been essential in the development of processes to assist people in working groups to reach agreement on needed conservation actions, collaboration needed, and to establish new working relationships.

Frequently, management actions have been identified by local management agencies, external consultants, and local experts. However, an isolated narrow professional approach which focuses primarily on the perceived biological problem seems to have little effect on the needed political and social changes (social learning) for collaboration, effective management, and conservation of habitat fragments or protected areas and their species components. CBSG workshops are organized to bring together the full range of groups with a strong interest in conserving and managing the species in its habitat or the consequences of such management. One goal in all workshops is to reach a common understanding of the state of scientific knowledge available and its possible application to the decision-making process and needed management actions.. We have found that the decision-making driven workshop processes with risk characterization tools, stochastic simulation modeling, scenario testing, and deliberation among stakeholders are powerful tools for extracting, assembling, and exploring information. This process encourages developing a shared understanding across wide boundaries of training and expertise. These tools also support building of working agreements and instill local ownership of the problems, the decisions required, and their management during the workshop processes. As participants appreciate the complexity of the problems as a group, they take more ownership of the process as well as the ultimate recommendations made to achieve workable solutions. This is essential if the management recommendations generated by the workshops are to succeed.

CBSG participants have learned a host of lessons in more than 100 workshop experiences in 40 countries. Traditional approaches to endangered species problems have tended to emphasize our lack of information and the need for additional research. This has been coupled with a hesitancy to make explicit risk assessments of species and habitat status and a reluctance to make immediate or non-traditional management recommendations. The result has been long delays in preparing action plans, loss of momentum, dependency on crisis-driven actions or broad recommendations that do not provide useful guidance to the managers.

CBSG's interactive and participatory workshop approach produces positive effects on management decision-making and in generating political and social support for conservation actions by local people. Modeling is an important tool as part of the process and provides a continuing test of assumptions, data consistency, and of scenarios. CBSG participants recognize that the present science is imperfect and that management policies and actions need

to be designed as part of a biological and social learning process. The Workshop process essentially provides a means for designing management decisions and programs on the basis of sound science while allowing new information and unexpected events to be used for learning and to adjust management practices.

Workshop Processes and Multiple Stakeholders

Experience: The Chairman and 3 Program Officers of CBSG have conducted and facilitated more than 100 species and ecosystem Workshops in 40 countries including the USA during the past 6 years. *Reports from these workshops are available from the CBSG Office.* We have worked on a continuing basis with agencies on some taxa (e.g., Florida panther, Sumatran tiger) and have assisted in the development of national conservation strategies for other taxa (e.g., Sumatran elephant, Sumatran tiger, Indonesia). Our *Population Biology Program Officer (Dr. P. Miller)* received his doctoral training with Dr. P. Hedrick and is familiar with the genetic and demographic aspects of a range of vertebrate species. He has worked extensively with VORTEX and other population models.

Facilitator's Training and Manual: A manual has been prepared to assist CBSG workshop conveners, collaborators, and facilitators in the process of organizing, conducting, and completing a CBSG workshop. It was developed with the assistance of two management science professionals and 30 people from 11 countries with experience in CBSG workshops. These facilitator's training workshops have proven very popular with 2 per year planned for 1996 and 1997 in several countries including the USA. *Copies of the facilitator's manual are available from the CBSG Office.*

Scientific Studies of Workshop Process: The effectiveness of these workshops as tools for eliciting information, assisting the development of sustained networking among stakeholders, impact on attitudes of participants, and in achieving consensus on needed management actions and research has been extensively debated. We initiated a scientific study of the process and its long term aftermath three years ago in collaboration with an independent team of researchers (Vredenburg and Westley, 1995). A survey questionnaire is administered at the beginning and end of each workshop. They also have conducted extensive interviews with workshop participants in workshops in five countries. *Three manuscripts on CBSG Workshop processes and their effects are available from the team and the CBSG office.* The study also is undertaking follow up interviews about two years after each workshop to assess longer term effects. To the best of our knowledge there is no comparable systematic scientific study of conservation management processes. *We apply the same scientific study tools to all of the workshops in our programs and provide an analysis of the results after each workshop.*

CBSG Workshop Toolkit

Our basic set of tools for workshops include small group dynamics skills, explicit use in small groups of problem restatement, divergent thinking sessions, identification of the history and chronology of the problem, causal flow diagraming (elementary systems analysis), matrix methods for qualitative data and expert judgements, paired and weighted ranking for

making comparisons between sites, criteria, and options, utility analysis, stochastic simulation modeling for single populations and meta-population and deterministic and stochastic modeling of local human populations. Several computer packages are used to assist collection and analysis of information with these tools. We provide training in several of these tools in each workshop as well as intensive special training workshops for people wishing to organize their own workshops.

Stochastic Simulation Modeling

Integration of Biological, Physical and Social Factors: The Workshop process, as developed by CBSG, generates population and habitat viability assessments based upon in-depth analysis of information on the life history, population dynamics, ecology, and population history of the populations. Information on demography, genetics, and environmental factors pertinent to assessing population status and risk of extinction under current management scenarios and perceived threats are assembled in preparation for and during the workshops. Modeling and simulations provide a neutral externalization focus for assembly of information, identifying assumptions, projecting possible outcomes (risks), and examining the data for internal consistency. Timely reports from the workshop are necessary to have an impact on stakeholders and decision makers. Draft reports are distributed within 3 weeks of the workshop and final reports within 60 days.

Human Dimension: We have collaborated with human demographers in 4 CBSG workshops on endangered species and habitats. They have utilized computer models incorporating human population characteristics and events at the local village level in order to provide projections of the likely course of population growth and the utilization of local resources. This information was then incorporated into projections of the likely viability of the habitat of the threatened species and used as part of the population projections and risk assessments. We have prepared a draft manual on the human dimension of population and habitat viability assessment. It is our intention to further develop these tools and to utilize them as part of the scenario assessment process.

Risk Assessment and Scenario Evaluation: A stochastic population simulation model is a kind of model that attempts to incorporate the uncertainty, randomness or unpredictability of life-history and environmental events into the modeling process. Events whose occurrence is uncertain, unpredictable, and random are called stochastic. Most events in an animal's life have some level of uncertainty. Similarly, environmental factors, and their effect on the population process, are stochastic - they are not completely random, but their effects are only predictable within certain limits. Simulation solutions are usually needed for complex models including several stochastic parameters.

There are a host of reasons why simulation modeling is valuable for the workshop process and development of management tools. The primary advantage is to simulate scenarios and the impact of numerous variables on the population dynamics and potential for population extinction. Interestingly, not all advantages are related to generating useful management recommendations. The side-benefits are substantial.

- Population modeling supports consensus and instills ownership and pride during the workshop process. As groups begin to appreciate the complexity of the problems, they have a tendency to take more ownership of the process and the ultimate recommendations to achieve workable solutions.
- Population modeling forces discussion on biological and physical aspects of the problem and specification of assumptions, data, and goals. The lack of sufficient data of useable quality rapidly becomes apparent and identifies critical factors for further study (driving research and decision making), management, and monitoring. This not only influences assumptions, but also the group's goals.
- Population modeling generates credibility by using technology that non-biologically oriented groups can use to relate to population biology and the "real" problems. The acceptance of the computer as a tool for performing repetitive tasks has led to a common ground for persons of diverse backgrounds.
- Population modeling explicitly incorporates what we know about dynamics by allowing the simultaneous examination of multiple factors and interactions - more than can be considered in analytical models. The ability to alter these parameters in a systematic fashion allows testing a multitude of scenarios that can guide adaptive management strategies.
- Population modeling can be a neutral computer "game" that focuses attention while providing persons of diverse agendas the opportunity to reach agreements on difficult issues.
- Population modeling results can be of political value for people in governmental agencies by providing support for perceived population trends and the need for action. It helps managers to justify resource allocation for a program to their superiors and budgetary agencies as well as identify areas for intensifying program efforts.

Modeling Tools: At the present time, our preferred model for use in the population simulation modeling process is VORTEX. This model, developed by Lacy et al., is designed specifically for use in the stochastic simulation of the small population/extinction process. It has been developed in collaboration and cooperation with the CBSG PHVA process. The model simulates deterministic forces as well as demographic, environmental, and genetic events in relation to their probabilities. It includes modules for catastrophes, density dependence, metapopulation dynamics, and inbreeding effects. The VORTEX model analyzes a population in a stochastic and probabilistic fashion. It also makes predictions that are testable in a scientific manner, lending more credibility to the process of using population modeling tools.

There are other commercial population models, but presently they have some limitations such as failing to measure genetic effects, being difficult to use, expensive and so not readily available to all users, or failing to model individuals. VORTEX has been successfully used in more than 90 CBSG PHVA workshops in guiding management decisions. VORTEX is general enough for use when dealing with a broad range of species, but specific

enough to incorporate most of the important processes. It is continually evolving in conjunction with the PHVA process. VORTEX has, as do all models, its limitations which may restrict its utility. The VORTEX model analyzes a population in a stochastic and probabilistic fashion. It is now at Version 7.2 through the cooperative contributions of dozens of biologists. It has been the subject of a series of both published and in press validation studies and comparisons with other modeling tools. More than 2000 copies of VORTEX are in circulation and it is being used as a teaching tool in university courses.

We use this model and the experience we have with it as a central tool for the population dynamic aspects of our workshops. Additional modules, building on other simulation modeling tools for local human population dynamics (which we have used in 3 countries) with potential impacts on water usage, harvesting effects, and physical factors such as hydrology and water diversion need further development to provide input into the population and habitat models which can then be used to evaluate possible effects of different management scenarios. No such composite models are available.

CBSG Resources as Unique Asset

Expertise and Costs: The problems and threats to endangered species everywhere are complex and interactive with a need for information from diverse specialists. No agency or country encompasses all of the useful expert knowledge. Thus, there is a need to include a wide range of people as resources and analysts. It is important that the invited experts have reputations for expertise, objectivity, initial lack of a local stake, and for active transfer of needed skills. CBSG has a volunteer network of more than 700 experts with about 250 in the USA. More than 3,000 people from 400 organizations have assisted CBSG on projects and participated in workshops on a volunteer basis contributing tens of thousands of hours of time. We call upon individual experts to assist in all phases of each project.

Indirect cost contributions to support: Use of CBSG resources and the contribution of participating experts provide a matching contribution more than equaling proposed budget requests for projects.

Manuals and Reports: We have manuals available which provide guidance on the goals, objectives, and preparations needed for CBSG workshops. These help reduce startup time and costs and allow us to begin work on organizing a project immediately with proposed participants and stockholders. We have a process manual for use by local organizers which goes into detail on all aspects of organizing, conducting, and preparing reports from the workshops. Draft reports are prepared during the workshop so that there is agreement by participants on its content and recommendations. Reports are also prepared on the mini-workshops (working groups) that are conducted in information gathering and diagnostic exercises with small groups of experts and stakeholders. We can print reports within 24-48 hours of preparation of final copy. We have CD-ROM preparation facilities and experience.