ANOA SPECIES

Bubalus quarlesi & Bubalus depressicornis

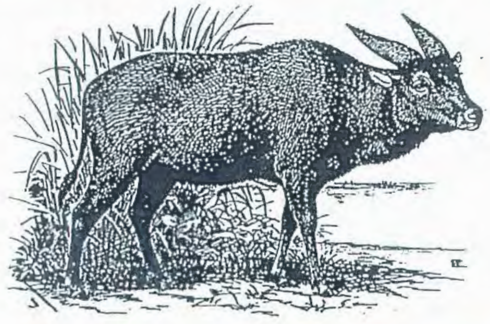
Population and Habitat Viability Assessment Workshop

Report

22 –26 July 1996

Taman Safari Indonesia

Cisuara, Indonesia



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Asian Wild Cattle Specialist Group (IUCN/SSC/AWCSG)
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Bubalus quarlesi & Bubalus depressicornis

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

22 - 26 July 1996

Taman Safari Indonesia
Cisuara, Indonesia

REPORT

Jansen Manansang, Simon Hedges, Dwiatmo Siswomartono,
Phillip Miller and Ulysses Seal (Editors)

Sponsored By:

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In Collaboration With

Asian Wild Cattle Specialist Group IUCN/SSC
Conservation Breeding Specialist Group IUCN/SSC/CBSG

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

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Additional copies of *Population and Habitat Viability Assessment Workshop for the Anoa* (Bubalus depressicornis and Bubalus quarlesi) *Report* can be ordered through the IUCN/SSC Conservation Breeding Specialist Group, 12101 Johnny Cake Ridge Road, Apple Valley, MN 55124.
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14 August 1996

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OFFICIAL INVITATION

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Jakarta, 29 March 1996

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No : 218/ VI-Sek / BKff /96

To : ULLYSES SEAL,
IUCN/SSC Conservation Breeding Specialist Group (CBSG)
Johnny Cake Road , Apple Valley , MN 55124, U S A

Fax : 1-612-432-2757

From : Ir Soekadji
for Director General of PHPA
Ministry of Forestry Indonesia

Subject : Babirusa/ Anoa PHVA Workshop

We would like to request the assistance of CBSG to coordinate a PHVA Workshop for the Babirusa and the Anoa in Sulawesi , Indonesia.
The best time would be sometimes in July 1996. Please contact Mr Jansen Manangsang at Taman Safari Indonesia about the details of the workshop as he might be able to organize the venue of the workshop.

As for the last workshops, we would appreciate the support of about 20 PHPA staff to attend the Babirusa and Anoa Workshop so that we can learn from the experience and be part of the process in developing a conservation action plan for Babirusa and Anoa.

Your assistance in this very important issue in Indonesia is very much appreciated, and we look forward to hearing your reply.

Yours sincerely,

Soekadji
Secretary of the Directorate General of PHPA

cc:
Mr Jansen Manangsang,
Director of Taman Safari Indonesia.

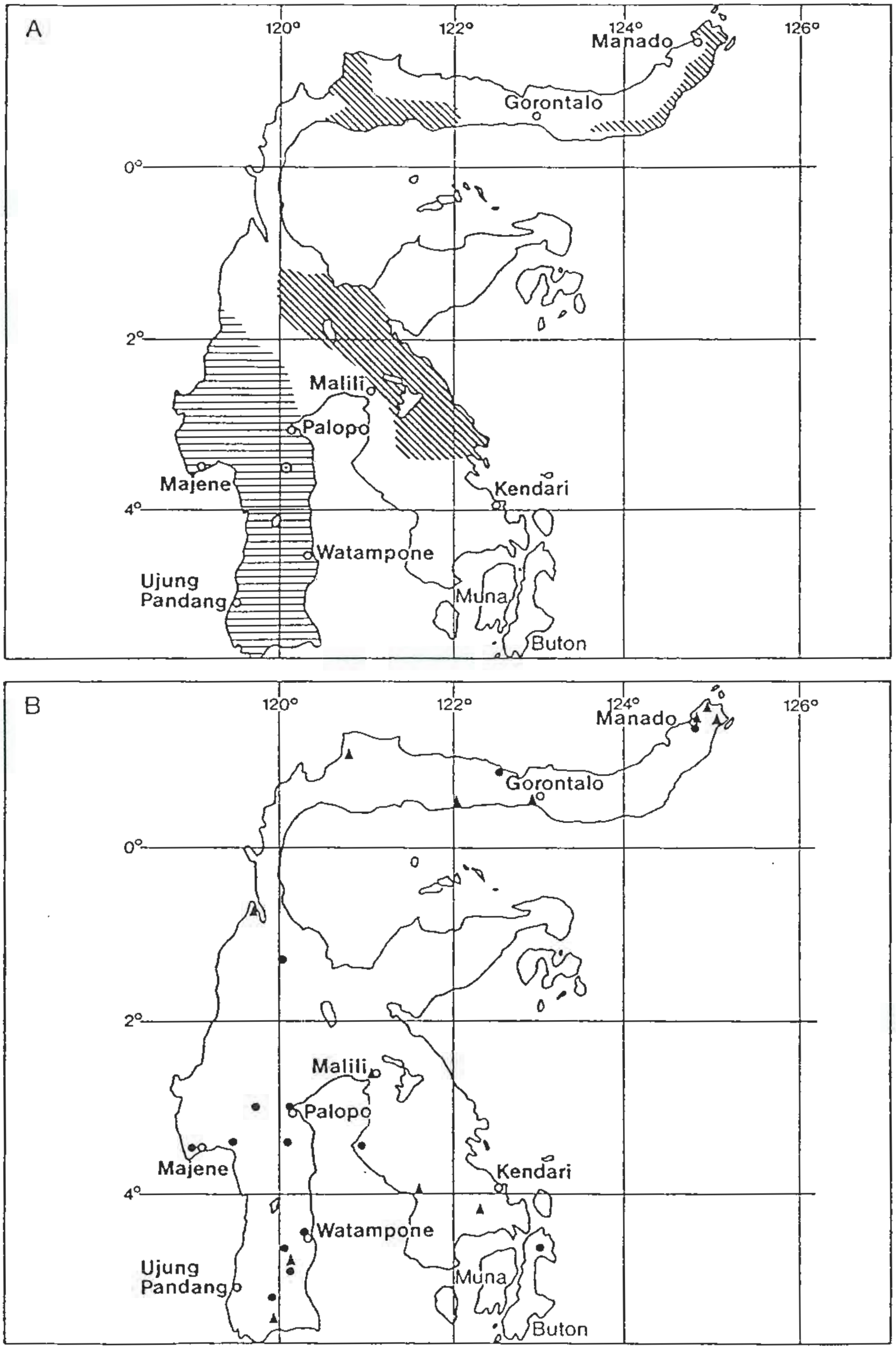

Figure 4. Distribution of anoa in historical times

A. E. MOHR (1921) ⧅: *B. depressicornis* ≡: *B. quarlesi*

B. C. GROVES (1969) ▲ : *B. depressicornis* • : *B. quarlesi*

EXECUTIVE SUMMARY

Anoa are small buffalo-like animals endemic to the Indonesian island of Sulawesi. Traditionally two species are recognized: the lowland anoa (*Bubalus depressicornis*) and the mountain anoa (*Bubalus quarlesi*). However, the classification of these animals has remained something of a puzzle ever since they were first described by Western biologists and it has been suggested that there may in fact be more than two species; it has also been suggested that there may only be one highly variable species (which may or may not be divided into a number of subspecies). In addition to the taxonomic uncertainties surrounding the anoas very little is known about the ecology, behavior, or general biology of these animals. Both species of anoa are listed as Endangered in the 1994 IUCN Red List (Groombridge, 1993) and both are included in CITES Appendix I.

Too few data exist to quantify the status of the anoas but they still appear to be widely distributed on Sulawesi. However, there is little doubt that they have been in decline since the beginning of the twentieth century; and no doubt that they have declined over the 1970-1995 period, precipitously in some areas. Hunting and habitat loss have been, and continue to be the major causes of the decline; with hunting the more serious factor in most areas. The current status of the anoas is thus a matter for serious concern with populations in small reserves such as Gunung Tangkoko - Dua Saudara NR and Tanjung Amolengu GR threatened with local extinction, and even the populations in large protected areas and other large forest blocks reported to be in decline as a result of heavy hunting pressure.

This species is vulnerable due to its restricted range and the possibility of extinction from several threats including hunting, habitat loss, and possible natural catastrophes. The management and conservation objective is to maintain genetically viable, self-sustaining, free-living Anoa population(s). In order to achieve this goal, it is necessary to understand the risk factors that affect survival of the anoas. Risk characterization is a major concern in endangered species management and a goal is to reduce the risk of extinction to an acceptable level by risk management. A set of software tools to assist simulation and quantitative evaluation of risk of extinction is available and was used as part of Population and Habitat Viability Assessment Workshop. This technique can improve identification and ranking of risks and can assist assessment of management options.

The Workshop was opened by PHPA Director General Soekadji with about 62 people present on the first day. Thirty-seven of the biologists, managers, and decision makers participated in the next 3 days of the Population and Habitat Viability Assessment (PHVA) Workshop in Cisuara, Indonesia at the Safari Garden Hotel on July 22-26, 1996 to apply the recently developed procedures for risk assessment and formulation and testing of management scenarios to the Anoa. The workshop was proposed by the PHPA and was a collaborative effort of the PHPA, TSI/PKBSI, and the Conservation Breeding Specialist Group (CBSG) and the Asian Wild Cattle Specialist Group of the Species Survival Commission/World Conservation Union (SSC/IUCN). The purpose was to review data from the wild and captive populations as a basis for assessing extinction risks, assessing different management scenarios, evaluating the effects of removals by hunting from the populations, evaluating available information on the taxonomy, and developing stochastic population simulation models. These models estimate risk of extinction and rates of genetic loss from the interactions of demographic, genetic, and environmental factors as a tool for ongoing management of the subspecies. Other goals included determination of habitat and capacity requirements, role of captive propagation, and prioritized research needs.

The first day consisted of a series of presentations summarizing data from the wild and captive populations. After a presentation on small population biology and the PHVA process, the participants formed three working groups (wild population, captive population, and population biology and modeling) to review in detail current information, to hear all ideas, and to develop management scenarios and recommendations. Stochastic population simulation models were developed and initialized with ranges of values for the key variables to estimate the viability of the wild population using the VORTEX software modeling package. Using data compiled from the literature and by consultation with workshop participants, a series of agreed baseline population values for the parameters required by the Vortex program were developed. These were then used to model several size populations .

This workshop report includes a set of recommendations for management and critical genetic and survey research on the wild and captive populations as well as sections on the history of the population, the population biology and simulation modeling of the population, and presentations made at the workshop.

RECOMMENDATIONS

Wild Population Group Priorities

1A and 1B are joint top priorities

1A. Protect anoas from hunting by enforcing existing laws. This enforcement should be combined with a community development program and a public awareness campaign.

1B. Do an island-wide survey to determine the status of anoas on Sulawesi. This survey should focus on determining how many types (taxa) of anoa exist in the wild on Sulawesi and mapping their distribution; as well assessing their current status (estimates of population sizes and assessment of threats to those populations).

   I) Conduct surveys to determine the presence/absence of anoas in all areas where they were reported in the 1980s (or 1970s) but not in 1990s (these were listed earlier in this report). Identify blocks of likely anoa habitat for which no reports exist and conduct presence/absence surveys in those blocks.

ii) Confirm the presence of anoas in all areas where they were reported in the 1990s and assess their relative abundance in the following key areas: Nani Wartabone (= Dumoga Bone), Panua, Nantu, Morowali, Lore Lindu, Pompangeo Mtns., Rawa Aopa - Watumohai, Amolengo / Peropa Unit, Batikolo, Buton Utara, Faruhumpenai, Latimojong.

iii) During the survey work samples should be collected for genetic and morphological analysis. The place of origin of all samples collected or photographed should be given as precisely as possible (giving longitude and latitude wherever possible).

2. Recommendations relating to the capture and release of anoas.

2A. No new founders should be collected from the wild until the survey work has provided a clearer idea of the number taxa and their distribution on Sulawesi and an evaluation of the need for new founders has been conducted.

2B. The group does not recommend reintroducing anoa to the wild at the present time.

3. The creation of a protected area in the Nantu forest area of North Sulawesi is strongly endorsed.

4. Once survey data has been collected the need for, and the possibility of creating additional protected areas should be established.

5. A field study of the ecology and behavior of anoa in the wild should be initiated as soon as possible (the study will require at least three years of field work).

6. A Sulawesi Endemic Wildlife Information and Study Center should be established.

Captive Population Group Priorities

1. A study should be undertaken immediately to investigate the issue of whether or not there are multiple taxa of anoa and how many taxa there are.

2. An Indonesian anoa management group for the captive anoa population in Indonesia should be formed within one year.

3. Every captive anoa should be permanently, individually identified by at least two methods such as ear tattoo, ear tag, and transponder.

4. Rigorous standards of record keeping which uses the SPARKS database as a minimum standard should be adopted and completed immediately for anoa currently in captivity.

5. Applied research in anoa reproductive physiology and assisted reproduction should be initiated as soon as possible in order to develop additional tools to be utilized in the conservation of the species.

6. A field survey to determine the status of the entire anoa population in the wild should be undertaken as soon as possible.

7. Anoa confiscated by PHPA should be added to the current captive population in Indonesia.

8. A program may be required to move animals from the wild population to the captive population in order to establish a genetically viable conservation population in captivity. The need for this program should be assessed in the light of genetic studies underway and a plan developed that is based on the results of those studies.

Modeling Group Priorities

1. The Anoa population may have population growth rate of only 1.5 - 2% per year. Sensitivity analyses indicate that the age of first reproduction and the proportion of females breeding per year have the greatest impact on anoa population dynamics. Estimates of these parameters in field studies are needed for management of the wild population.

2. Estimates of anoa density across Sulawesi are needed as a guide to trends and management.

3. Hunting of anoa for food appears to be the major factor in the decline of anoa populations. If hunting removes an additional 15% of individuals annually (over natural mortality) the simulated populations decline 17 - 18% per year and are at near 100% risk of extinction within about 50 years. With the current life-table parameter estimates, anoa populations may only be able to survive a hunting rate of 2-3% of the total population number each year. This defines an initial minimum management goal to reduce hunting pressure for survival and recovery of the anoa.

ANOA

Bubalus quarlesi & Bubalus depressicornis

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WILD POPULATIONS STATUS AND MANAGEMENT

WILD ANOA POPULATIONS STATUS AND MANAGEMENT

Introduction

Anoa are small buffalo-like animals endemic to the Indonesian island of Sulawesi. Traditionally two species are recognized: the lowland anoa (*Bubalus depressicornis*) and the mountain anoa (*Bubalus quarlesi*). However, the classification of these animals has remained something of a puzzle ever since they were first described by Western biologists and it has been suggested that there may in fact be more than two species; it has also been suggested that there may only be one highly variable species (which may or may not be divided into a number of subspecies). Recent research on the genetics of captive anoa which has been conducted in Indonesia, Europe, and Japan has also cast doubt on the traditional classification of these animals. Unfortunately this research proved inconclusive because of uncertainties about the provenance of many of the animals sampled and the possibility that hybridization between the two putative species may have occurred in several zoos. Further research using samples from wild anoa (e.g. dry skin samples obtained from hunters) is urgently needed. For the purposes of this PHVA workshop the wild anoa working group decided to avoid classifying the anoas into different species; instead the group decided to identify those areas which still contain anoa populations in the 1990s and simply note which areas have been reported to contain more than one type of anoa (Table W1).

In addition to the taxonomic uncertainties surrounding the anoas very little is known about the ecology, behavior, or general biology of these animals. (The little that is known has been summarized by Hedges (1996)).

Status

Both species of anoa are listed as Endangered in the 1994 IUCN Red List (Groombridge, 1993) and both are included in CITES Appendix I.

Too few data exist to quantify the status of the anoas but they still appear to be widely distributed on Sulawesi (see Table W1). However, there is little doubt that they have been in decline since the beginning of the twentieth century; and no doubt that they have declined over the 1970-1995 period, precipitously in some areas. Hunting and habitat loss have been, and continue to be the major causes of the decline; with hunting the more serious factor in most areas (see discussion below and Table W2). The current status of the anoas is thus a matter for serious concern with populations in small reserves such as Gunung Tangkoko - Dua Saudara NR and Tanjung Amolengu GR threatened with local extinction, and even the populations in large protected areas and other large forest blocks reported to be in decline as a result of heavy hunting pressure.

Threats

Hunting

Hunting (mainly for meat) and the loss of suitable habitat are the major threats, and recent reports indicate that hunting is by far the more serious of the two. For example, in and around Lore Lindu NP (Central Sulawesi) local hunters report that 10-20 years ago anoa could be found in areas adjacent to forest gardens but nowadays a hunting party has to walk for between one and three days in order to reach areas affording good anoa hunting, despite the fact that large areas of good forest remain (S. Hedges unpublished observations, 1994). Similarly in Tangkoko - Dua Saudara NR (North Sulawesi) hunting - not habitat loss or degradation - is thought to have been the main cause of the estimated 90% decline in lowland anoa numbers which occurred between 1978/79 an 1993/94 (O'Brien & Kinnaird, 1996).

Hunting pressure is also reported to be heavy in Mayoa area in Central Sulawesi (Schreiber & Nötzold, 1995); the Tanjung Amolengu WR area in South-East Sulawesi (Abdul Haris Mustari, 1995); and the Rawa Aopa - Watumohai NP area also in South-East Sulawesi, where an estimated 100 animals are being taken (mainly snared) every year from the park and surrounding areas (B. Lees pers. comm., 1996).

Anoa hunters generally use snares or hunt using spears and dogs (Whitten *et al.*, 1987b; S. Hedges unpub. obs., 1989 & 1994; Abdul Haris Mustari, 1995; Schreiber & Nötzold, 1995; B. Lees pers. comm., 1996). Hunters also set fires to attract and make the hunting of anoas easier (Whitten *et al.*, 1987b).

In rural areas there appears to be little awareness of the protected status of the anoas and villagers in Central Sulawesi readily recounted their experiences to Schreiber and Nötzold (1995), even inviting them to participate in a hunting trip. In towns, however, (some) shop-keepers selling anoa trophies are aware that this is illegal and are consequently reluctant to reveal the origins of the specimens (Schreiber & Nötzold, 1995), although Melisch (1995b) was able to obtain information about the trophies he found for sale in Rantepao.

Loss of suitable habitat

Although hunting is currently the most serious threat to the anoas the importance of the threat posed by loss of habitat must not be forgotten. Many anoa populations are becoming isolated as the forest around the protected areas is cleared or converted to plantations. For example, Tangkoko - Dua Saudara NR was formerly the core of a large block of forest that included Wiau Protection Forest and was contiguous with the forests of Gunung Klabat; but today much of the Wiau forest has been converted to coconut plantations and only a small patch of forest remains at the summit of Gunung Klabat. Tangkoko - Dua Saudara is thus effectively isolated

(O'Brian & Kinnaird, 1996). Similarly the anoa population in the small Tanjung Amolengu NR is isolated because anoas are no longer able to move between Tj. Amolengu and the nearby Tanjung Peropa NR because of an increase in the size of the human settlements between the two areas (Abdul Haris Mustari, 1995).

Loss of suitable habitat within protected areas is a problem too: for example the expansion of agricultural and/or settled areas, logging, mining, and fires are problems in many areas. However assessing the scale of the threat posed to the anoas by shifting agriculture, fires, etc. is hampered by our ignorance of their habitat requirements.

Trade

There have been occasional reports of illegal trade in live animals in the past, for example Anon (1976b) reported that an animal trader in south-east Asia was selling a pair of lowland anoa at US$3000 each. However, no significant international trade in either live animals or body parts has been reported in recent years.

The main reason for the widespread hunting of anoas is to obtain meat for local consumption (Thornback, 1983; Schreiber & Nötzold, 1995). Anoa skulls and horns do not seem to be particularly valued as trophies by the hunters themselves; for example, Schreiber and Nötzold report seeing 'hastily prepared' horns attached to partial skulls which they were offered as presents after only a few minutes of showing their interest. Souvenir shops in Toraja Land (e.g. in Rantepao and Makale) do, however, sell anoa horns and skulls, and the occasional mounted head; but these trophies are also poorly prepared and some are carbonized (hunters generally singe the hairs off carcasses before butchering them) and while quantitative data is unavailable the trade in trophies does not appear to pose a serious threat to the anoas (S. Hedges unpub. obs. 1989; Schreiber & Nötzold, 1995). Nevertheless Melisch (1995b) suggests that the presence of anoa trophies in tourist shops is a worrying development.

Other threats

In addition to hunting and the loss of suitable habitat, Grzimek (1990) suggested that diseases may have been partly responsible for the decline of the two species; and the presence of domestic or feral livestock, as well as introduced deer populations, obviously presents a risk to the anoas in those areas where they co-occur.

Table W1. AREAS WHERE WILD ANOA HAVE BEEN REPORTED TO OCCUR IN THE 1990s

Area	Type	Year	Evidence
NORTH SULAWESI PROVINCE			
Tangkoko	1 ?	1994	dung & tracks
Manembo-nembo	1 ?	1994	local informants' reports, dung & tracks
Nani-Wartabone	2 ?	1996	photographed by PHPA
Paguyaman/Gorontalo		1994 92/93	PHPA Rangers' reports reports of hunting
Gunung Ambang	1 ?	1992	An animal killed by hunters
Panua	1 ?	1993	Sightings by PHPA
Nantu	1 ?	1993	Snared animals and photographs
CENTRAL SULAWESI PROVINCE			
Lore Lindu	2 ?	90-94 1996	animals killed by hunters, photos karyotypic data, PHPA Rangers' reports
Gunung Pompangeo	2 ?	1990	Photograph, karyotypic data, specimens from hunters
Mayoa Area/ Faruhumpenai (South Sulawesi)	1 ?	1994	Report from hunters
Morowali	1 ?	1995	Hunters
Pagimana	1?	1994	Skulls, reports from hunters
Toli-toli (Pinjan/Tj. Matab)	1 ?	1992	Local people's reports

SOUTH SULAWESI PROVINCE

Toraja Land

1. Makale area	1 ?	1994	Captive animal
2. Latimojong	1 ?	1993	Skulls/horns

SOUTH EAST SULAWESI PROVINCE

Tj. Polewali	1 ?	1994	PHPA Report
Rawa Aopa-Watumohai	1 ?	1990s	Reports from hunters
Tj. Peropa	1 ?	1994	Skull & tracks
Tj. Amolengu	1 ?	1995	Field study
Tj. Batikolo	1 ?	1994	Skulls, photographs of live animals
Kolaka Utara	1 ?	1994	Animal caught
Toronipa	1 ?	1994	Foot prints

BUTON ISLAND

Buton Utara	1 ?	1995	Captive animal

Table W2. THREATS TO ANOAS

(* = the most important threat)

Area	Threat
NORTH	
Tangkoko	* Hunting, habitat loss, disturbance by tourists
Manembo-nembo	* Hunting
Nani - Wartabone Paguyaman/Gorontalo	* Hunting, habitat loss
Gunung Ambang	* Hunting, habitat loss (concessions)
Panua	* Hunting, habitat loss
Nantu	* Habitat loss (forest concessions and sugar plantations)
CENTRAL	
Lore Lindu	* Hunting, disease risk from domestic animals (buffalo)
Pompangeo Mtns	* Hunting
Mayoa Area/ Faruhumpenai	* Hunting
Morowii	Hunting (?), shifting cultivation (?)
Pagimanan	* Hunting
Toli-toli (Pinjan/Tj. Matab)	* Hunting, habitat loss (transmigrants)
SOUTH	
Toraja Land	
1. Makale area	* Hunting
2. Latimojong	* Hunting

Table W2 continued:

Area	Threat
SOUTH EAST	
TJ. Polewali	* Habitat loss (agricultural encroachment), hunting
Rawa Aopa	* Hunting
TJ. Peropa	* Forest cutting (kayu-besi), hunting
Tj. Amolengu	* Habitat loss (from 800 - 500 Ha), (wood gathering & encroachment), hunting
TJ. Batikolo	* Forest cutting (kayu-besi), pearl farm (leads to isolation of population), hunting
Kolaka Utara	* Habitat loss, hunting
Toronipa	* Hunting, habitat loss
BUTON ISLAND	
Buton Utara	* Habitat loss, hunting

Anoa Population Densities

It is very difficult to estimate the size of the remaining anoa populations because so few data exist. However for the purposes of modeling anoa population trends several crude estimates were made based on research conducted in Tangkoko - Dua Saudara NR in North Sulawesi and Tanjung Amolengu GR in South-East Sulawesi.

Tj Amolenggo GR: area = 5 km^2. In 1995 an estimated 8 to 12 anoa occurred in the reserve giving a crude population density of between 1.6 anoa/km^2 to 2.4 anoa/km^2 (the anoa were being hunted) (Abdul Haris Mustari, 1995).

Tangkoko - Dua Saudara NR: area = 89 km^2. In 1978/1979 the crude population density was estimated to be approximately 0.56 anoa/km^2 (and it was suggested that the population may have been at carrying capacity); and in 1993/1994 it was estimated to be 0.07 anoa/km^2 (the anoa were being hunted) (O'Brien & Kinnaird, 1996).

Thus we have a range of crude population densities of 0.07 anoa/km^2 to 2.4 anoa/km^2.

In the absence of any information about the extent of anoa habitat in these areas it was necessary to use these crude density figures to produce the 'guesstimates' of likely anoa population sizes needed for the modeling exercise. North Sulawesi was chosen for inclusion in the model and Table W3 shows the anoa population sizes used in the model (only areas where anoa have been reported in the 1990s were included).

Table W3. Estimated population sizes in North Sulawesi

Site	km^2	Estimated Population Size Low	Medium	High
Tangkoko	89	6	(6)	(6)
Manembo-nembo	65	4	36	104
Dumoga Bone	3,000	210	1,680	4,800
Gn. Ambang	86	6	48	138
Panua	455	31	255	728
Nantu	1,500	105	840	2,400
Total	5,195	362	2,859	8,170

Low estimate based on:	0.07 anoa / km^2
Medium estimate based on:	0.56 anoa / km^2
High estimate based on:	1.60 anoa / km^2

The highest crude density estimate (2.4 anoa / km^2) was not used because the group thought that the resulting estimate for the number of anoa in North Sulawesi (> 12,000) was impossibly high; indeed the group thought that the estimate based on 1.6 anoa / km^2 was also far too high.

For most models it was assumed that only one taxa of anoa existed in North Sulawesi but in a number of models two taxa were assumed to exist. Since Dumoga Bone is the only area from where two taxa have been reported in the 1990s it was assumed that the two taxa occurred in approximately the following proportions:

'Lowland anoa': 75 %
'Mountain anoa': 25 %

This was based on the assumption that (1) Dumoga Bone NP represents about 58% of the total anoa habitat in North Sulawesi and (2) within Dumoga Bone there were approximately equal numbers of the two taxa.

Recommended Priorities for Anoa Conservation

1A and 1B are joint top priorities

1A. Protect anoas from hunting by enforcing existing laws. This enforcement should be combined with a community development program and a public awareness campaign.

Enforcement strategies: Frequent patrols of key protected areas during which all snares found are destroyed and any poachers encountered caught or chased out of the area. Impose fines for people selling live anoas, anoa meat, horns, or other parts. Impose fines for people keeping pet anoas.

The public awareness campaign should stress that anoas are unique to Sulawesi and are in danger of being lost forever.

1B. An island-wide survey to determine the status of anoas on Sulawesi. This survey should focus on determining how many types (taxa) of anoa exist in the wild on Sulawesi and mapping their distribution; as well assessing their current status (estimates of population sizes and assessment of threats to those populations). Surveys should be carried out in collaboration with LIPI, PHPA, and other researchers, NGOs, etc. Indonesian laboratories must be given access to all samples collected for genetic and morphological analysis but foreign institutions will be invited to cooperate. It is estimated that three years will be required and the survey should be started as soon as possible (and no-later than the end of 1996). The proposed island-wide survey has three components (which should be conducted simultaneously):

I) Conduct surveys to determine the presence/absence of anoas in all areas where they were reported in the 1980s (or 1970s) but not in 1990s (these were listed earlier in this report). Identify blocks of likely anoa habitat for which no reports exist and conduct presence/absence surveys in those blocks.

ii) Confirm the presence of anoas in all areas where they were reported in the 1990s and assess their relative abundance in the following key areas: Nani Wartabone (= Dumoga Bone), Panua, Nantu, Morowali, Lore Lindu, Pompangeo Mtns., Rawa Aopa - Watumohai, Amolengo / Peropa Unit, Batikolo, Buton Utara, Faruhumpenai, Latimojong.

iii) During the survey work samples (i.e. dry skin, horns, skulls; and wherever possible fresh tissue samples) should be collected for genetic and morphological analysis. However fresh tissue samples should only be collected from pet (or other captive) animals. Any animals seen (in captivity, at salt licks, etc.) should be photographed and described; any skulls, horns, etc. seen in peoples houses or in shops and not collected (for whatever reason) should also be photographed and described. The place of origin of all samples collected or photographed should be given as precisely as possible (giving longitude and latitude wherever possible).

2. Recommendations relating to the capture and release of anoas.

   2A. No new founders should be collected from the wild until the survey work has provided a clearer idea of the number taxa and their distribution on Sulawesi and an evaluation of the need for new founders has been conducted.

   2C. The group does not recommend reintroducing anoa to the wild at the present time: protecting the wild population should be seen as the number one priority. However, if in the future the reintroduction of captive anoas to the wild is thought to be necessary and desirable it is essential that the following precautions are taken:

      1) An evaluation of the need for such a program must be conducted first.

      ii) Any reintroduction program should follow internationally recognized guidelines; and in particular there should be no reintroductions until there is clear evidence that hunting has been brought under control.

      iii) Any animal descended from the existing captive stock should be very carefully screened to determine its suitability for inclusion in a reintroduction program because of (1) the genetic problems (inbreeding, hybridization, etc.) affecting these animals; and (2) the place of origin of most if not all of these animals is unknown.

3. The creation of a protected area in the Nantu forest area of North Sulawesi is strongly endorsed.

4. Once survey data has been collected the need for, and possibility of creating additional protected areas should be established.

5. A field study of the ecology and behavior of anoa in the wild should be initiated as soon as possible (the study will require at least three years of field work).

6. A Sulawesi Endemic Wildlife Information and Study Center should be established.

Annex W1. Areas where anoas were reported to occur in the 1980s and 1970s but not the 1990s

Gunung Klabat NR	(53 km^2).
Pulau Dolongan (in the Buol Toli-toli area).	
Gunung Sojol proposed NR	(500 km^2).
Tanjung Api NR	(42 km^2).
Masupu Proposed GR	(25 km^2).
Mamasa area and Mambuliling Proposed GR	(100 km^2).
Lampuko-Mampie	(20 km^2).
Bulusaraung NR	(57 km^2).
Lasolo-Sampara Proposed NR	(450 km^2).
Lambu Sango Proposed NR	(200 km^2).

ANOA

Bubalus quarlesi & Bubalus depressicornis

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

22 - 26 July 1996
Taman Safari Indonesia
Cisuara, Indonesia

REPORT

Population Biology and Modeling

POPULATION BIOLOGY AND MODELING OF THE ANOA

Unique to Indonesian island of Sulawesi and a few small surrounding islands, the anoa (*Bubalus depressicornis*, *Bubalus quarlesi*) is the smallest of the extant Asian wild cattle species. The species are listed as Endangered under the 1994 IUCN Red List categories and are listed in Appendix I of CITES. While very few data exist on the population biology and general conservation status of the anoa, these animals are thought to be under severe threat from hunting pressure by the local human inhabitants in addition to habitat loss. Field observations in Northern Sulawesi have suggested considerable rates of decline of local anoa populations, resulting almost assuredly from these threats.

The need for and consequences of intensive management strategies can be modeled to suggest which practices may be the most effective in conserving the anoa of Sulawesi. VORTEX, a simulation software package written for population viability analysis, was used as a tool to study the interaction of a number of life history and population parameters treated stochastically, to explore which demographic parameters may be the most sensitive to alternative management practices, and to test the effects of a suite of possible management scenarios.

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

VORTEX is not intended to give absolute answers, since it is projecting stochastically the interactions of the many parameters which enter into the model and because of the random processes involved in nature. Interpretation of the output depends upon our knowledge of the biology of the anoa, the conditions affecting the population as well as possible changes in the future. What little data exists on the population biology of anoa was utilized for this analysis.

Input Parameters for Simulations

Mating System: Assumed to be polygynous. Anoas have been studied in the wild very little and there are few published data from captive animals. However, polygyny is the normal strategy adopted by ungulates and all wild bovines including Asian buffalo (*Bubalus bubalis*) and the tamaraw (*B. mindorensis*) are thought to be polygynous.

Age of First Reproduction: VORTEX precisely defines breeding as the time at which offspring are born, not simply the age of sexual maturity. In addition, the program uses the mean (or median) age rather than the earliest recorded age of calf production. Captive anoa females reportedly reach sexual maturity in their second year, so given a gestation period of between 275 and 315 days, a female could probably have her first calf at about three years of age. Considering the additional stresses present in the wild, the baseline anoa model was constructed with an age of first reproduction in females set at 4 years. The male age of first reproduction was set at 5 years to reflect the effects of competition with older and larger males (cf. *Bubalus bubalis*). Because of considerable uncertainty in this parameter, alternative models were developed with these ages reduced to three and four years, respectively, for females and males (see results below).

Age of Reproductive Senescence: VORTEX assumes that animals can breed (at the normal rate) throughout their adult life. The typical life span of captive Anoas is reported to be 20-30 years, although a male anoa kept at San Diego Zoo was 36 years old when it died (Nötzold, 1995). Unfortunately almost nothing is known about the longevity of wild anoa (which in any case is likely to be affected by such parameters as the rate of dental wear which can vary dramatically with the silica content of the animals' forage). Taking the ratio between age of death of wild/feral and captive Bubalus bubalis, as well as the anoas' smaller size in account, we estimated that the maximum age of wild anoa would likely be about 13 years. While this parameter was not varied in subsequent sensitivity analyses at this workshop, additional anoa population simulation modelling exploring this parameter in detail would be warranted.

Sex Ratio at Birth: Assumed to be even in the absence of data to the contrary.

Maximum Number of Offspring: Anoas generally have only a single calf but twins have been reported from Planckendael Zoo.

Offspring Production: For the purposes of modeling anoa population dynamics, we defined "reproduction" for a given female as the successful birth of a calf. By comparison with wild/feral buffalo populations we thought that most female anoas would probably raise calves only every other year. The sex ratio of calves (proportion of males) produced in a given year was set at 0.500 based on the assumed equal sex ratio at birth. In captivity, most anoa females produce only one calf, with twins only very rarely born (see above). We therefore assume that the litter size distribution in a given year will be the following:

Litter Size	% of females at breeding age in a given year
0	50
1	49
2	1

Sensitivity analysis was used to explore the impact of changes in the proportional female reproductive success on population dynamics. To accomplish this, alternative models were developed in which either 40% or 60% of adult females (on average) failed to reproduce in a given year. In these different cases, the relative proportions of females producing the specified numbers of calves remained constant.

Annual variation in female reproduction is modeled in VORTEX by entering a standard deviation (SD) for the proportion of females that do not reproduce in a given year. Since no appropriate data were available for anoa, we set this variation to approximately 25% of the mean value. VORTEX then determines the proportion of females breeding each year of the simulation by sampling from a binomial distribution with the specified mean (e.g., 50%) and standard deviation (e.g., 12%).

Male Breeding Pool: Although no data are available for this parameter, competition for access to estrous females makes it very unlikely that all adult males will be available to breed in a given year. For the purposes of developing the baseline model, it was assumed that only 35% of the adult males will be capable of siring offspring in a given year.

Mortality: Again, data are lacking on the mortality of specific age-sex classes of anoa but we have made the following assumptions.

In the wild, the juvenile age class (0-1) is likely to be the class where predation plays the largest role since the only natural predators of the anoas on Sulawesi are pythons and the three species of civet (Sulawesi palm civet (*Paradoxurus musschenbroeckii*), Malayan civet (*Viverra tangalunga*), and the Common palm civet (*Paradoxurus hermaphroditus*)). These predators, especially the civets, are more likely to take the juvenile animals rather than the large ones. We estimated the juvenile mortality in the wild to be 30%. There is no reason to assume a difference in survival rate for juvenile males and females, so it was taken to be equal for both sexes.. Predator pressure is likely to drop significantly from the age of one year onwards because of the larger size of the individuals. We estimated the mortality of the subadult animals (males and females) to be only 5%. Fully grown adult animals are likely to have a very low mortality which may be slightly higher for the females than the males because of the inherent risks of gestation, parturition and lactation. Values of 3% mortality for males and 4% for females were used.

As with the environmental variation set for female reproduction, we set the annual variation in mortality to be approximately 25% of the mean rates.

Catastrophes: Catastrophes are singular environmental events that are outside the bounds of normal environmental variation affecting reproduction and/or survival. Natural catastrophes can be tornadoes, floods, droughts, disease, or similar events. These events are modeled in VORTEX by assigning a probability of occurrence and a severity factor ranging from 0.0 (maximum or absolute effect) to 1.0 (no effect).

The Indo-Pacific is a tectonically active area with many volcanoes situated near the tectonic plate margins. Quite a number of volcanoes are found in North Sulawesi, the main ones being Tangkoko, Dua Saudara, Batuangus, Manadotua, Lokon, Klabat and Una Una on Una Una island of the Togian island group. Colleagues at the workshop with knowledge on Sulawesi estimated that a significant volcanic eruption in the immediate region of Sulawesi would take place every 50 years which gives a probability of occurrence of 2% annually. It was assumed that falling ash and toxic gases that accompany these events would take a toll on the anoa. In addition, the alteration of the landscape following an eruption would also result in a lowered frequency of successful reproduction in the year an eruption occurred. We estimated a 15% decrease in female reproduction and 15% extra female mortality (severity factors = 0.85).

The tectonic activity also causes earthquakes. It was estimated that a fairly large earthquake takes place every 5 years giving a probability of occurrence of 20% annually. We estimated 15% extra female mortality as a result of the earthquake. We assumed that earthquakes would not take such a large toll on the environment as a volcanic eruption. Therefore, if a female survives the eruption she is likely to still reproduce that year.

Initial Population Size: Information made available at the workshop indicated that anoa populations vary widely in size across Sulawesi, from perhaps less than 10 animals to maybe as many as about 2500. These estimates are highly dependent on the initial assumption of anoa density within the habitats studied. In order to investigate the fates of a number of different types of anoa populations of differing sizes, a set of models were developed with initial population sizes equal to 25, 100, 360, 1500, and 2860 individuals. For a more detailed discussion of the information used to arrive at these general estimates, see the section of wild anoa populations elsewhere in this report.

Carrying Capacity: The carrying capacity, K, for a given habitat patch defines an upper limit for the population size, above which additional mortality is imposed across all age classes in order to return the population to the value set for K. VORTEX, therefore, uses K to impose density-dependence on survival rates. The program also has the capability of imposing density-dependent effects on reproduction that change as a function of K, but since no such data are available for babirusa populations, we chose not to include density-dependent reproduction in our models.

No information is available on the carrying capacities of the different regions of Sulawesi where anoa occur. Considering the high hunting pressure on the species, especially in northern Sulawesi, we can assume that the initial population size to be below carrying capacity. We have therefore arbitrarily set the carrying capacity at twice the initial population size so that it could be graphically shown whether or not the population has a potential for growth

Iterations and Years of Projection: All scenarios were simulated 100 times, with population projections extending for 100 years. Output results were summarized at 10-year intervals for use in some of the figures that follow. All simulations were conducted using VORTEX version 7.2 (June 1996).

Results from Simulation Modeling

The Baseline Model

The demographic and environmental parameters discussed above were assembled in the VORTEX model to assess the status of an anoa population free from any human-mediated threats to its persistence. We call this the baseline anoa population model.

The first row of Tables 1 through 5 give the results of the baseline model for each of the initial starting population size conditions. Inspection of these results shows that, under the conditions modeled using the parameters agreed upon by the workshop participants, anoa populations have the capacity to increase in size at a rate of 1-2% annually (r_s = 0.011 - 0.018). Interestingly, this variation in stochastic growth rate is a result of the different starting population sizes. The smaller populations, starting with just 25 individuals, show a lower growth rate because of their greater susceptibility to random fluctuations in demographic parameters. In fact, this greater susceptibility directly translates into an increased risk of population extinction over the 100-year time frame of the simulations. Populations initiated with just 25 individuals have a 14% risk of extinction within 100 years while all larger populations have little or no risk. In other words, small populations are in danger of becoming extinct simply by being small. If they can remain reasonably large, i.e., at least 50-100 individuals, anoa populations are capable of reasonable growth if left undisturbed by humans.

As might be expected, the extent of heterozygosity retained in each of the simulated populations is also directly related to their initial size. If N_0 = 25, only 68.2% of the original heterozygosity is retained within the population after 100 years. However, those populations initiated with at least 1500 individuals retain essentially all of their heterozygosity throughout the duration of the simulation.

Alternative Models and Sensitivity Analysis

Since many of the demographic parameters for the simulated anoa populations are based on educated guesses from limited field data, it is instructive to use the simulation modelling approach in an investigation of the relative sensitivities of the populations to changes in different demographic parameters. In other words, we can determine which parameters are more influential in determining the future viability of anoa populations and utilize this information to help prioritize the collection of additional population data.

As discussed earlier, three demographic variables were chosen for investigation in this sensitivity analysis: the age of first reproduction, the proportional female reproductive success, and the extent of polygyny. Age of fist reproduction was decreased by one year for both females and males to 3 and 4, respectively. The baseline level of female reproductive success, with 50% of the adult females expected to reproduce in a given year, was altered to 40% and 60%. Finally, the extent of polygyny was deceased to 50%, i.e., 50% of the adult males are in the pool of available breeders, an increase from the baseline value of just 35%.

Tables 1 through 5 are organized so that the effects of changing these parameters relative to the baseline value can be assessed within a given initial population size. For each of the initial population sizes, it is apparent that a decrease in the age of first reproduction can have a significant effect on the dynamics of anoa populations. Reducing the age of first breeding by just one year doubles the stochastic growth rate under baseline modeling conditions. In fact, under the smallest population size modeled (N_0=25), the stochastic growth rate tripled from r_s = 0.011 under baseline conditions to r_s = 0.034 under the more favorable breeding conditions. The age of first breeding can also be very important under less favorable conditions of female reproductive success. For example, if only 40% of adult females are expected to reproduce in a given year, the reduction in the age of first reproduction can result in a change from population decline to population growth (Table 2: age = 4/5, r_s = -0.012; age = 3/4, r_s = 0.006).

In addition to the age of first reproduction, the extent of proportional female reproductive success appears to also play an important role in shaping anoa population growth dynamics. Under all initial population sizes studied, a reduction in the proportion of adult females expected to reproduce in a given year results in a sharp decrease in the stochastic population growth rate. For example, if N_0 = 100, the baseline growth rate is r_s = 0.016. If the female reproductive success if reduced to just 40% adult females reproducing in a given year, r_s drops to -0.012. A change in this one parameter changes the population from one that grows at a rate of nearly 2% per year to one that declines at more than 1% per year. If the reproductive success is increased to 60%, the population growth rate can essentially double. Under the most favorable of population conditions — early age of first reproduction and high proportional female reproductive success — anoa populations can grow at a rate exceeding 6% per year.

Finally, an investigation into the effects that changes in the extent of polygyny may have on anoa population dynamics reveals that, given the polygynous nature of the species' breeding system, the extent of polygyny has little impact on the demographic characteristics of the population but may serve to slightly increase the retention of heterozygosity. This is a result of the fact that more males are actively participating in breeding and, consequently, a greater proportion of the male genome is being transmitted from parent to offspring.

A summary of this sensitivity analysis is presented graphically in Figure 1. It is clear that the age of first reproduction and the degree of female reproductive success are the dominant factors emerging from this analysis. Figure 2 shows in more detail the relationship between female reproductive success and population extinction risk. Interestingly, an analysis of the role played by initial population size shows that, for the most part, populations of at least 100 individuals have equivalent stochastic growth rates and, as shown by the results in the Tables, a very low risk of extinction.

The Effects of Hunting on Anoa Population Viability

Numerous discussions at this workshop indicated that hunting of anoa by local human populations for subsistence as well as the meat and pet trade is perhaps the primary threat facing the species. To explore the impact that various levels of hunting may have on the future characteristics of anoa populations on Sulawesi, VORTEX models were developed that simulated additional anoa mortality brought about by hunting pressure. Instead of simulating hunting through the harvest of a constant number of animals annually, using the Harvest module in VORTEX, we simulated this pressure by increasing age-specific mortalities to more closely mimic the density-dependent nature of this type of population threat.

More specifically, hunting pressures were quantified based on observed rates of anoa population declines in North Sulawesi. For example, in Tangkoko - Dua Saudara NR, hunting is believed to be the cause of an estimated 90% decline in anoa population numbers over approximately 15 years (O'Brien and Kinnaird 1996). This translates into an annual rate of decline of about 15%. This can be modeled in VORTEX by adding 15% annual mortality to each age-sex class thought to be susceptible to this threat. Because of the unselective nature of snares, which are the predominant method of anoa hunting in Sulawesi, all age-sex classes were thought to be susceptible. Alternative models were also developed that looked at simulated 15-year population declines of 70% and 50%. These scenarios translate into annual rates of decline through hunting of 8% and 4%, respectively.

Table 6 shows the results of these hunting models on simulated populations with an initial size, N_0 of 1500 individuals and a carrying capacity, K, of 3000. Under the highest hunting pressure, corresponding to a 15% annual addition to baseline mortality, the rate of population decline is 17-18% per year and extinction of all populations, regardless of initial size, is certain and rapid. It is clear from these results that high levels of hunting of anoa have disastrous consequences for future population viability.

If the extent of hunting is reduced to 8% additional mortality above baseline levels, extinction is certain for all but the largest populations and is a very high probability for the largest populations (Table 6). Medium-sized populations, with N_0 = 100 or 360, become extinct within 60 years under this level of hunting pressure. Even if a larger population does not become extinct within the timeframe of the simulation, the final population sizes are so small—in the range of just 5-10 animals—that the populations are practically extinct soon after 100 years. If the level of hunting is again reduced to just 4% above baseline levels (Table 6), the stochastic population growth rate remains negative at 3-4% decline annually. Under these relatively optimistic hunting conditions, the smallest populations remain under considerable risk of extinction within 100 years. The largest populations have no measurable extinction risk from the simulations, but the final size of these populations after 100 years is significantly reduced from their initial values. For example, if N_0 = 2860, the size of this population after 100 years (N_{100}) is just 232, or more than 90% smaller than at the beginning of the simulation.

These results show quite dramatically that anoa populations, under the conditions modeled by VORTEX during this workshop, are extremely sensitive to additional mortality across age-sex classes brought about through hunting by the local human inhabitants. This conclusion is graphically summarized in Figure 3 which plots risk of population extinction under alternative hunting pressures for each population size investigated. As can be clearly seen from the graphic, the risk of extinction rises dramatically as the hunting pressure is increased, until extinction is virtually assured when just 8-10% of the total number of individuals within a population are removed annually by hunting. Stated in a slightly different way, these analyses suggest that anoa populations on Sulawesi are unable to survive hunting pressures greater than just 2-3% annually. The breeding biology of the species, in which a female usually produces just one calf every other year, plays a major role in determining this sensitivity.

Finally, it is instructive to look at the influence of sex-biased removal of anoas through hunting. Because of polygynous nature of anoa breeding biology, one might expect that removal of only females might carry a greater cost than an equivalent removal of only males, since the number of females is the limiting factor influecing population growth. This prediction is realized when alternative models are developed with N_0 = 1500 and an additional 8% hunting pressure assigned to the baseline model (Table 6, bottom). When only females are removed, the population behaves as in the earlier model with both sexes removed: the stochastic growth rate is r_s = -0.076 and the extinction risk is very high. Alternatively, if only males are removed, the population shows considerable stochastic growth (r_s = 0.017) and the risk of extinction is minimal. Consequently, anoa populations appear to be more tolerant of removal of males that of removal of females.

Conclusions and Recommendations: Anoa Population Modeling Group

1. The baseline VORTEX model for anoa developed during the workshop results in a projected population growth rate, in the absence of significant human interference, of about 1.5 - 2% per year. Furthermore, simple sensitivity analyses indicate that anoa population dynamics is most heavily influenced by the age of first reproduction and the proportional reproductive success of females (proportion of females breeding per year). However, very little is known about anoa population biology. In order to better assess the future of viability of fragmented populations of the anoa on Sulawesi, detailed long-term longitudinal studies of wild anoa are necessary. Parameters such as age-specific mortality rates, reproductive success, and reproductive life span can be quantified with more precision than is currently available.

2. Further field work is necessary in order to more firmly establish consensus estimates of anoa density across Sulawesi. Consensus must be reached as to the preferred methods to be used in such work.

3. Models were developed that explore the effects of hunting of anoa for food on the viability of populations subjected to this pressure. Proportional additions to mortality were used to simulate this pressure, based on estimates of anoa population declines observed in North Sulawesi. Results from these models suggest that if hunting removes an additional 15% of individuals annually from a simulated population, that population exhibits an annual rate of population decline of 17 - 18% and is expected to become extinct within about 50 years. Further models indicate that, with the current life-table parameter estimates, anoa populations may only be able to survive if the hunting rate does not exceed 2-3% of the total population number each year. Therefore, hunting of anoa for food by the local human population is seen as a major factor in estimating the future viability of anoa populations in Sulawesi. Studies must continue in their efforts to quantify the extent of hunting of anoa throughout the island.

Table 1. Anoa Population Viability. Initial population size is 25 and the carrying capacity, K, is 50. r_s is the stochastic population growth rate calculated from the simulation, P(E) is the probability of population extinction within 100 years, N_{100} is the size of the simulated population at the end of the 100-year simulation, and H_{100} is the population heterozygosity at 100 years.

Age of First Breeding	Breeding Success	r_s	P(E)	T(E)	N_{100}	H_{100}
35% Polygyny						
4,5	50	0.011	0.14	60	39	0.682
3,4	50	0.034	0.01	80	45	0.706
4,5	60	0.037	0.00	—	47	0.739
3,4	60	0.058	0.00	—	48	0.760
4,5	40	-0.023	0.67	56	22	0.502
3,4	40	-0.002	0.32	63	32	0.664
50% Polygyny						
4,5	50	0.010	0.13	58	39	0.680
3,4	50	0.032	0.02	59	46	0.722
4,5	60	0.037	0.00	—	47	0.744
3,4	60	0.058	0.00	—	48	0.764
4,5	40	-0.020	0.57	56	20	0.583
3,4	40	-0.002	0.19	56	31	0.660

Table 2. Anoa Population Viability. Initial population size is 100 and the carrying capacity, K, is 200. r_s is the stochastic population growth rate calculated from the simulation, P(E) is the probability of population extinction within 100 years, N_{100} is the size of the simulated population at the end of the 100-year simulation, and H_{100} is the population heterozygosity at 100 years.

Age of First Breeding	Breeding Success	r_s	P(E)	T(E)	N_{100}	H_{100}
35% Polygyny						
4,5	50	0.016	0.00	—	178	0.929
3,4	50	0.037	0.00	—	191	0.929
4,5	60	0.039	0.00	—	196	0.936
3,4	60	0.063	0.00	—	197	0.931
4,5	40	-0.012	0.11	83	55	0.805
3,4	40	0.006	0.00	—	138	0.888
50% Polygyny						
4,5	50	0.017	0.00	—	179	0.929
3,4	50	0.037	0.00	—	195	0.933
4,5	60	0.040	0.00	—	196	0.942
3,4	60	0.064	0.00	—	198	0.937
4,5	40	-0.012	0.05	83	52	0.812
3,4	40	0.006	0.02	53	133	0.899

Table 3. Anoa Population Viability. Initial population size is 360 and the carrying capacity, K, is 720. r_s is the stochastic population growth rate calculated from the simulation, P(E) is the probability of population extinction within 100 years, N_{100} is the size of the simulated population at the end of the 100-year simulation, and H_{100} is the population heterozygosity at 100 years.

Age of First Breeding	Breeding Success	r_s	P(E)	T(E)	N_{100}	H_{100}
35% Polygyny						
4,5	50	0.018	0.00	—	657	0.981
3,4	50	0.039	0.00	—	706	0.981
4,5	60	0.040	0.00	—	704	0.982
3,4	60	0.063	0.00	—	714	0.981
4,5	40	-0.010	0.01	97	173	0.938
3,4	40	0.006	0.00	—	487	0.968
50% Polygyny						
4,5	50	0.018	0.00	—	661	0.982
3,4	50	0.038	0.00	—	706	0.982
4,5	60	0.040	0.00	—	708	0.983
3,4	60	0.064	0.00	—	711	0.982
4,5	40	-0.010	0.00	—	174	0.946
3,4	40	0.008	0.00	—	545	0.974

Table 4. Anoa Population Viability. Initial population size is 1500 and the carrying capacity, K, is 3000. r_s is the stochastic population growth rate calculated from the simulation, P(E) is the probability of population extinction within 100 years, N_{100} is the size of the simulated population at the end of the 100-year simulation, and H_{100} is the population heterozygosity at 100 years.

Age of First Breeding	Breeding Success	r_s	P(E)	T(E)	N_{100}	H_{100}
35% Polygyny						
4,5	50	0.017	0.00	—	2775	0.995
3,4	50	0.038	0.00	—	2925	0.995
4,5	60	0.040	0.00	—	2949	0.996
3,4	60	0.063	0.00	—	2987	0.995
4,5	40	-0.009	0.00	—	766	0.987
3,4	40	0.007	0.00	—	2283	0.993
50% Polygyny						
4,5	50	0.018	0.00	—	2841	0.996
3,4	50	0.037	0.00	—	2952	0.996
4,5	60	0.040	0.00	—	2976	0.996
3,4	60	0.065	0.00	—	2978	0.996
4,5	40	-0.009	0.00	—	736	0.987
3,4	40	0.008	0.00	—	2278	0.994

Table 5. Anoa Population Viability. Initial population size is 2860 and the carrying capacity, K, is 5720. r_s is the stochastic population growth rate calculated from the simulation, P(E) is the probability of population extinction within 100 years, N_{100} is the size of the simulated population at the end of the 100-year simulation, and H_{100} is the population heterozygosity at 100 years.

Age of First Breeding	Breeding Success	r_s	P(E)	T(E)	N_{100}	H_{100}
35% Polygyny						
4,5	50	0.018	0.00	—	5332	0.998
3,4	50	0.037	0.00	—	5601	0.998
4,5	60	0.040	0.00	—	5621	0.998
3,4	60	0.063	0.00	—	5663	0.998
4,5	40	-0.010	0.00	—	1399	0.992
3,4	40	0.007	0.00	—	4211	0.997
50% Polygyny						
4,5	50	0.017	0.00	—	5358	0.998
3,4	50	0.039	0.00	—	5640	0.998
4,5	60	0.041	0.00	—	5642	0.998
3,4	60	0.064	0.00	—	5674	0.998
4,5	40	-0.008	0.00	—	1526	0.994
3,4	40	0.008	0.00	—	4456	0.997

Table 6. The effects of hunting on anoa population viability. See Table 1 legend for table definitions, and see text for further discussion of the quantification of population hunting pressue.

Hunting Pressure	N_0	r_s	P(E)	T(E)	N_{100}	H_{100}
15%	25	-0.188	1.00	14	—	—
	100	-0.176	1.00	23	—	—
	360	-0.177	1.00	30	—	—
	1500	-0.177	1.00	38	—	—
	2860	-0.172	1.00	43	—	—
8%	25	-0.104	1.00	25	—	—
	100	-0.092	1.00	44	—	—
	360	-0.086	1.00	61	—	—
	1500	-0.082	0.93	79	6	0.558
	2860	-0.083	0.83	84	7	0.618
4%	25	-0.040	0.89	48	14	0.518
	100	-0.035	0.56	72	19	0.654
	360	-0.033	0.16	84	30	0.821
	1500	-0.029	0.00	—	124	0.945
	2860	-0.028	0.00	—	232	0.974
8%, ♀♀ only	1500	-0.076	0.82	76	9	0.662
8%, ♂♂ only	1500	0.017	0.00	—	2760	0.994

Figure Legends

Figure 1. Effects of changes in anoa population demographic parameters on the stochastic population growth rate, r_s. Each bar represents the average growth rate across all simulation models using the specified demographic parameter with associated standard deviations (SD). The parameters include the age of first reproduction of females and males; the extent of female reproductive success, defined as the average proportion of adult females that produce offspring in a given year; the extent of polygyny, defined as the proportion of adult males in the available beeding pool in a given year; and the initial population size.

Figure 2. Impact of increasing proportional female reproductive success on the probability of population extinction for each of the simulated population sizes.

Figure 3. Impact of hunting on the probability of extinction of anoa populations.

Figure 1.
Anoa Population Viability:
Sensitivity Analysis

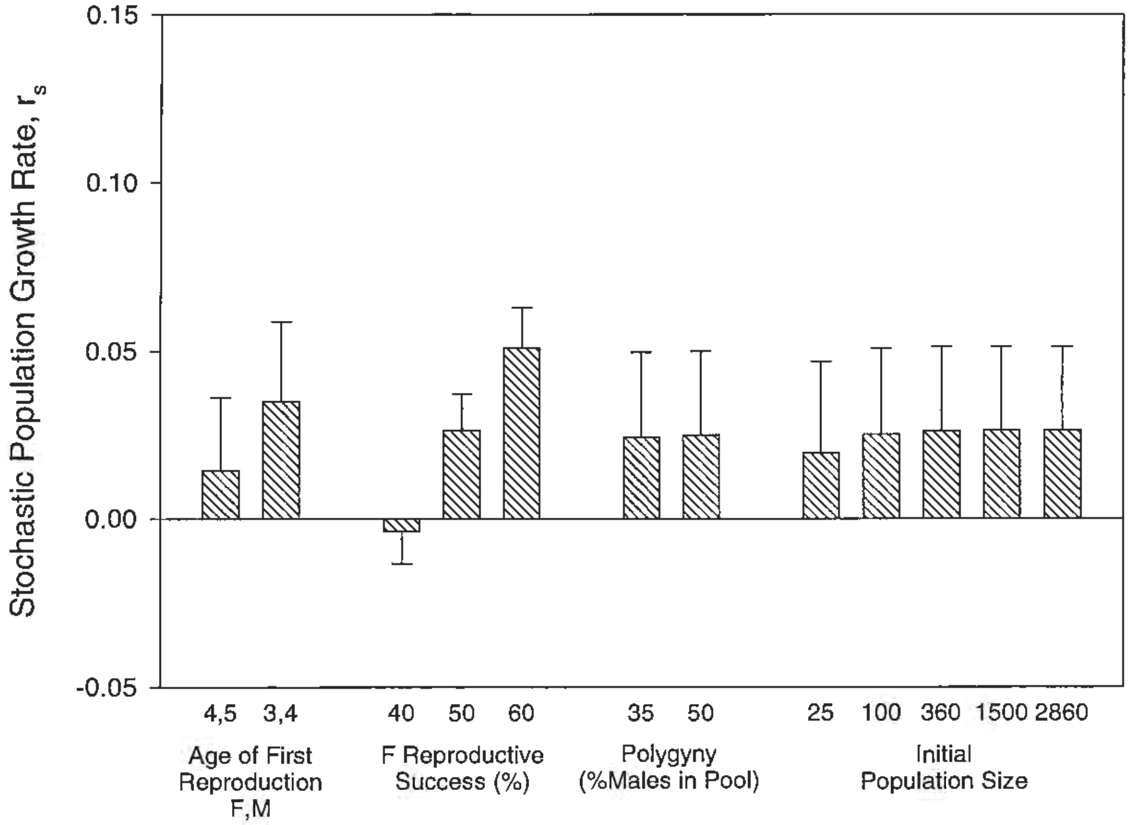


Figure 2.
Anoa Population Viability:
Female Reproductive Success
and Population Persistence

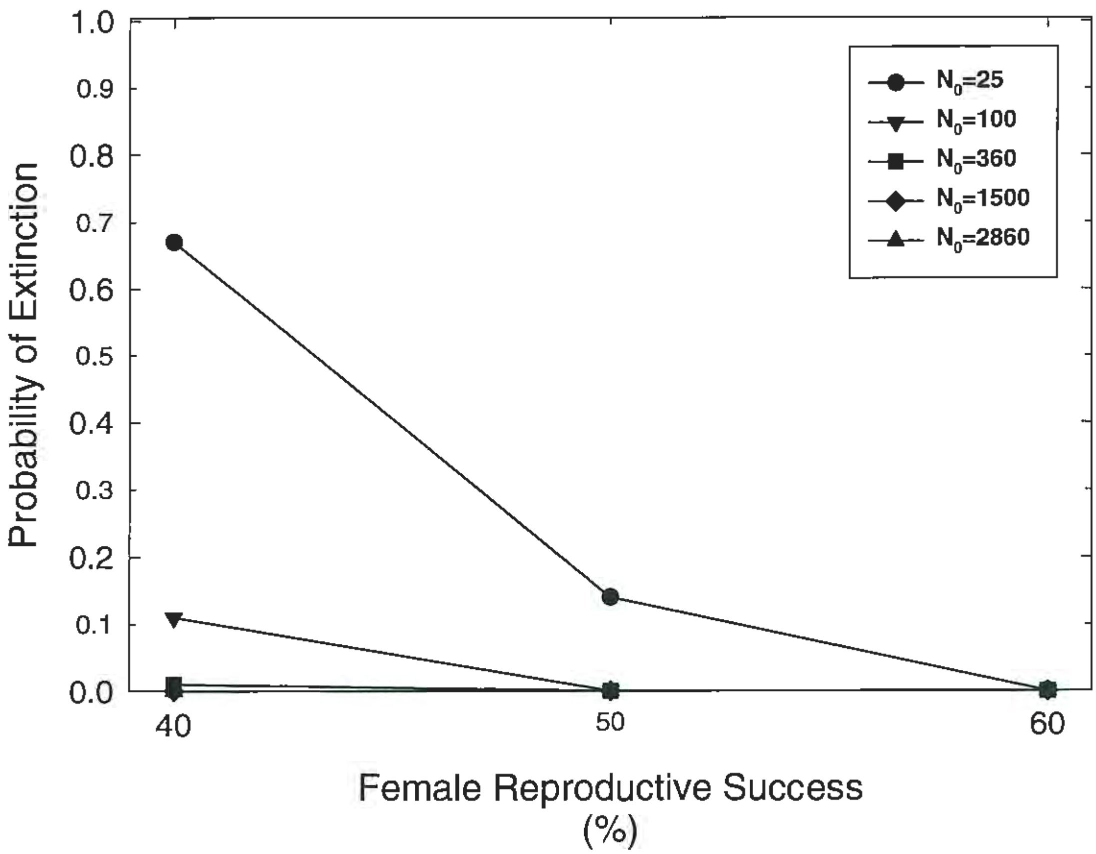
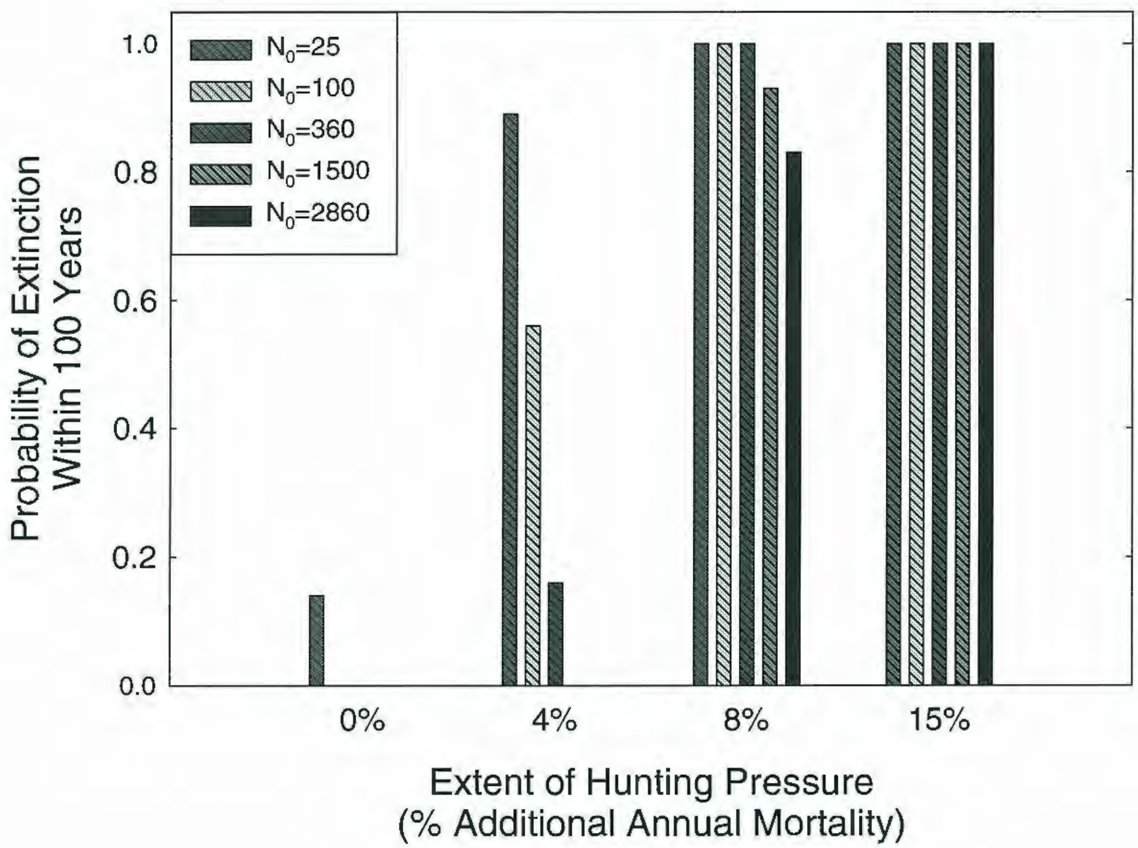


Figure 3.
Anoa Population Viability:
Hunting Pressure and Extinction Probability



Sample VORTEX Input File

```
ANOA_171.OUT     ***Output Filename***
Y     ***Graphing Files?***
N     ***Each Iteration?***
Y     ***Screen display of graphs?***
100     ***Simulations***
100     ***Years***
10     ***Reporting Interval***
1     ***Populations***
N     ***Inbreeding Depression?***
Y     ***EV correlation?***
2     ***Types Of Catastrophes***
P     ***Monogamous, Polygynous, or Hermaphroditic***
4     ***Female Breeding Age***
5     ***Male Breeding Age***
13     ***Maximum Age***
0.500000     ***Sex Ratio***
2     ***Maximum Litter Size***
N     ***Density Dependent Breeding?***
50.000000     ***Population 1: Percent Litter Size 0***
49.000000     ***Population 1: Percent Litter Size 1***
1.000000     ***Population 1: Percent Litter Size 2***
12.500000     ***EV--Reproduction***
34.000000     ***Female Mortality At Age 0***
8.500000     ***EV--FemaleMortality***
9.000000     ***Female Mortality At Age 1***
2.250000     ***EV--FemaleMortality***
9.000000     ***Female Mortality At Age 2***
2.250000     ***EV--FemaleMortality***
9.000000     ***Female Mortality At Age 3***
2.250000     ***EV--FemaleMortality***
8.000000     ***Adult Female Mortality***
2.000000     ***EV--AdultFemaleMortality***
34.000000     ***Male Mortality At Age 0***
9.500000     ***EV--MaleMortality***
9.000000     ***Male Mortality At Age 1***
2.250000     ***EV--MaleMortality***
9.000000     ***Male Mortality At Age 2***
2.250000     ***EV--MaleMortality***
9.000000     ***Male Mortality At Age 3***
2.250000     ***EV--MaleMortality***
9.000000     ***Male Mortality At Age 4***
```

2.250000 ***EV--MaleMortality***
7.000000 ***Adult Male Mortality***
1.750000 ***EV--AdultMaleMortality***
2.000000 ***Probability Of Catastrophe 1***
0.850000 ***Severity--Reproduction***
0.850000 ***Severity--Survival***
20.00000 ***Probability Of Catastrophe 2***
1.000000 ***Severity--Reproduction***
0.950000 ***Severity--Survival***
N ***All Males Breeders?***
Y ***Answer--A--Known?***
35.000000 ***Percent Males In Breeding Pool***
Y ***Start At Stable Age Distribution?***
25 ***Initial Population Size***
50 ***K***
0.000000 ***EV--K***
N ***Trend In K?***
N ***Harvest?***
N ***Supplement?***
Y ***AnotherSimulation?***

Sample VORTEX Output File

VORTEX -- simulation of genetic and demographic stochasticity

ANOA_171.OUT
Fri Jul 26 09:42:05 1996

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

No inbreeding depression

First age of reproduction for females: 4 for males: 5
Age of senescence (death): 13
Sex ratio at birth (proportion males): 0.50000

Population 1:

Polygynous mating;
35.00 percent of adult males in the breeding pool.

Reproduction is assumed to be density independent.

50.00 (EV = 12.50 SD) percent of adult females produce litters of size 0
49.00 percent of adult females produce litters of size 1
1.00 percent of adult females produce litters of size 2

34.00 (EV = 8.50 SD) percent mortality of females between ages 0 and 1
9.00 (EV = 2.25 SD) percent mortality of females between ages 1 and 2
9.00 (EV = 2.25 SD) percent mortality of females between ages 2 and 3
9.00 (EV = 2.25 SD) percent mortality of females between ages 3 and 4
8.00 (EV = 2.00 SD) percent annual mortality of adult females (4<=age<=13)
34.00 (EV = 9.47 SD) percent mortality of males between ages 0 and 1
9.00 (EV = 2.25 SD) percent mortality of males between ages 1 and 2
9.00 (EV = 2.25 SD) percent mortality of males between ages 2 and 3
9.00 (EV = 2.25 SD) percent mortality of males between ages 3 and 4
9.00 (EV = 2.25 SD) percent mortality of males between ages 4 and 5
7.00 (EV = 1.75 SD) percent annual mortality of adult males (5<=age<=13)
EVs may have been adjusted to closest values
possible for binomial distribution.
EV in reproduction and mortality will be correlated.

Frequency of type 1 catastrophes: 2.000 percent
with 0.850 multiplicative effect on reproduction
and 0.850 multiplicative effect on survival

Frequency of type 2 catastrophes: 20.000 percent
with 1.000 multiplicative effect on reproduction
and 0.950 multiplicative effect on survival

Initial size of Population 1:

(set to reflect stable age distribution)

Age 1	2	3	4	5	6	7	8	9	10	11	12	13	Total	
1	2	1	1	1	1	1	1	1	1	0	1	1	13	Males
1	2	1	1	1	1	1	1	1	0	1	1	0	12	Females

Carrying capacity = 50 (EV = 0.00 SD)

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

r = -0.027 lambda = 0.973 R0 = 0.808
Generation time for: females = 7.83 males = 8.52

Stable age distribution:

Age class	females	males
0	0.073	0.073
1	0.049	0.049
2	0.045	0.045
3	0.042	0.042
4	0.038	0.038
5	0.036	0.036
6	0.034	0.034
7	0.031	0.032
8	0.029	0.030
9	0.027	0.028
10	0.025	0.027
11	0.024	0.025
12	0.022	0.024
13	0.021	0.022

Ratio of adult (>= 5) males to adult (>= 4) females: 0.891

Population 1

Year 10
N[Extinct] = 0, P[E] = 0.000
N[Surviving] = 100, P[S] = 1.000
Population size = 18.66 (0.72 SE, 7.16 SD)
Expected heterozygosity = 0.923 (0.003 SE, 0.025 SD)
Observed heterozygosity = 0.993 (0.002 SE, 0.021 SD)
Number of extant alleles = 18.82 (0.53 SE, 5.28 SD)

Year 20
N[Extinct] = 8, P[E] = 0.080
N[Surviving] = 92, P[S] = 0.920
Population size = 16.67 (0.97 SE, 9.28 SD)
Expected heterozygosity = 0.848 (0.009 SE, 0.084 SD)
Observed heterozygosity = 0.937 (0.010 SE, 0.099 SD)
Number of extant alleles = 11.20 (0.47 SE, 4.54 SD)

Year 30
N[Extinct] = 18, P[E] = 0.180
N[Surviving] = 82, P[S] = 0.820
Population size = 15.12 (1.07 SE, 9.68 SD)
Expected heterozygosity = 0.781 (0.014 SE, 0.123 SD)
Observed heterozygosity = 0.885 (0.015 SE, 0.135 SD)
Number of extant alleles = 8.06 (0.38 SE, 3.40 SD)

Year 40
N[Extinct] = 37, P[E] = 0.370
N[Surviving] = 63, P[S] = 0.630
Population size = 15.56 (1.35 SE, 10.74 SD)
Expected heterozygosity = 0.737 (0.012 SE, 0.098 SD)
Observed heterozygosity = 0.850 (0.017 SE, 0.136 SD)
Number of extant alleles = 6.52 (0.34 SE, 2.67 SD)

Year 50
N[Extinct] = 55, P[E] = 0.550
N[Surviving] = 45, P[S] = 0.450
Population size = 14.78 (1.40 SE, 9.36 SD)
Expected heterozygosity = 0.669 (0.025 SE, 0.169 SD)
Observed heterozygosity = 0.731 (0.034 SE, 0.231 SD)
Number of extant alleles = 5.49 (0.36 SE, 2.40 SD)

Year 60
N[Extinct] = 66, P[E] = 0.660
N[Surviving] = 34, P[S] = 0.340
Population size = 14.44 (1.53 SE, 8.91 SD)
Expected heterozygosity = 0.660 (0.028 SE, 0.163 SD)
Observed heterozygosity = 0.754 (0.034 SE, 0.201 SD)
Number of extant alleles = 4.79 (0.37 SE, 2.19 SD)

Year 70
N[Extinct] = 71, P[E] = 0.710
N[Surviving] = 29, P[S] = 0.290
Population size = 14.55 (1.72 SE, 9.28 SD)
Expected heterozygosity = 0.605 (0.035 SE, 0.187 SD)
Observed heterozygosity = 0.705 (0.044 SE, 0.236 SD)
Number of extant alleles = 4.24 (0.39 SE, 2.08 SD)

Year 80
N[Extinct] = 80, P[E] = 0.800
N[Surviving] = 20, P[S] = 0.200
Population size = 14.00 (2.04 SE, 9.12 SD)
Expected heterozygosity = 0.538 (0.047 SE, 0.212 SD)
Observed heterozygosity = 0.583 (0.058 SE, 0.260 SD)
Number of extant alleles = 3.65 (0.42 SE, 1.90 SD)

Year 90
N[Extinct] = 85, P[E] = 0.850
N[Surviving] = 15, P[S] = 0.150
Population size = 15.07 (2.34 SE, 9.07 SD)

Expected heterozygosity = 0.493 (0.055 SE, 0.212 SD)
Observed heterozygosity = 0.567 (0.061 SE, 0.236 SD)
Number of extant alleles = 3.47 (0.49 SE, 1.88 SD)

Year 100
N[Extinct] = 89, P[E] = 0.890
N[Surviving] = 11, P[S] = 0.110
Population size = 14.45 (2.82 SE, 9.36 SD)
Expected heterozygosity = 0.518 (0.065 SE, 0.216 SD)
Observed heterozygosity = 0.571 (0.066 SE, 0.220 SD)
Number of extant alleles = 3.36 (0.43 SE, 1.43 SD)

In 100 simulations of Population 1 for 100 years:
89 went extinct and 11 survived.

This gives a probability of extinction of 0.8900 (0.0313 SE),
or a probability of success of 0.1100 (0.0313 SE).

89 simulations went extinct at least once.
Median time to first extinction was 49 years.
Of those going extinct,
mean time to first extinction was 48.27 years (2.30 SE, 21.74 SD).

No recolonizations.

Mean final population for successful cases was 14.45 (2.82 SE, 9.36 SD)

Age 1	2	3	4	Adults	Total	
0.45	1.27	1.00	1.27	3.36	7.36	Males
1.00	0.45	0.73		4.91	7.09	Females

Without harvest/supplementation, prior to carrying capacity truncation,
mean growth rate (r) was -0.0403 (0.0022 SE, 0.1651 SD)

Final expected heterozygosity was 0.5179 (0.0651 SE, 0.2158 SD)
Final observed heterozygosity was 0.5706 (0.0662 SE, 0.2197 SD)
Final number of alleles was 3.36 (0.43 SE, 1.43 SD)
****

ANOA

Bubalus quarlesi & Bubalus depressicornis

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

22 - 26 July 1996
Taman Safari Indonesia
Cisuara, Indonesia

REPORT

CAPTIVE POPULATION

ANOA CAPTIVE POPULATION STATUS AND MANAGEMENT

Jansen Manansang, Bambang Purwantara, V. Harwono Gepak, Ida Y. Masnur, Sutarman, Kuno Bleyenberg, Ravi Varadarajulu, Hiroshi Hori, Dedy Duryadi, Douglas Armstrong

Introduction

The wild populations of anoa are in decline due to hunting and habitat loss. These problems are exacerbated by a lack of information about the wild population. Based on the World Zoo Conservation Strategy published by the IUDZG, a captive population can contribute to the conservation of the species through providing a protected genetic reservoir for the species diversity, providing a base of physiological of information, to serve as a focus for a public education program and eventually could provide animals for a reintroduction program if it is required.

Program Goal

The primary goal of the captive anoa population is to reduce the risk of extinction of the species by managing a genetically sound captive population in a protected environment where the animals are not subject to the same risks and hazards as that faced by the wild population. Secondary goals of the captive population are to serve as a resource for investigations of the biology of the species and to provide animals for public exhibition and education. Eventually the captive population may provide animals for reintroduction but at the present time this is neither necessary or probable.

Population Management

The primary goal of the captive anoa population is to reduce the risk of extinction of the species. In order to accomplish this goal several objectives must be defined for this population and implementation steps identified and carried out. The parameters that apply to the captive population for this goal are:

1. The population would primarily be managed in Indonesia with all wild caught and F1 animals remaining in Indonesia.

2, The population will be managed to retain 90% of the wild populations heterozygosity or genetic variation for 100 years. In order to accomplish this goal it may require that animals be removed from the wild population to the captive population so that the captive population initially represents greater than 90% of the heterozygosity of the wild population.

3. The population will use the minimum number of wild caught founder animals necessary to accomplish the goal and will use current captive, wild caught stock as founders.

4. The population will be managed to maintain the minimum population size necessary to accomplish the goal.

5. The issue of how many genetic units (taxa or subspecies) of anoa exist and therefor may need to be managed in captivity needs to be resolved so that appropriate planning may be instituted.

Captive anoa population inventory in Indonesia on 23-07-96

Place	Species	Male	Femal e	Origin
Ragunan Zoo	Lowland Highland	1 1 1 0	2 0 1 1	wild caught captive bred wild caught captive bred
Surabaya	Lowland unknown	0 2 0	1 0 1	wild caught (Sulawesi Tenggara) captive bred captive bred
Taman Safari Taman Safari	Lowland Highland	5 1	3 0	wild caught: Noy- from Poso, Bovie- from Luwuk, Manis L- from Palu, Manis B- from Luwuk, Unyil- from Luwuk, Jacky- from Luwuk, Mencong- from Poso, Ibing- from Menado captive bred
Gembira Loka	Highland	1	0	wild caught from Gorontalo??
Sulawesi	?	?	?	?

Zoos currently holding wild caught anoa will attempt to identify very specific original capture locations and dates for those animals.

Total captive anoa population in Java:

Lowland-	wild caught	6.6
	captive bred	3.0
Highland-	wild caught	2.1
	captive bred	1.1

Current global studbook population for anoa:

Europe	27.23 at 13 institutions
Asia	18.16 at 7 institutions
USA	12.11 at 7 institutions

(Highland anoa outside Indonesia: 5.3 at Krefeld Zoo, Germany)

Estimated holding capacity for anoa.

Indonesian zoos that currently hold anoa and plan to participate in the management program can provide the following space for a captive anoa population managed for conservation purposes. It is probable that other institutions in Indonesia will choose to provide additional spaces but these are not yet identified.

Ragunan Zoo	70
Surabaya	20
Taman Safari	70
Gembira Loka	10
Total Capacity	170

Global holding capacity. There are additional spaces for anoa in institutions outside of Indonesia that would be available to hold animals in support of the primary captive conservation population in Indonesia. Currently this space is estimated based on anoa currently held in Europe, North

America and Asia outside of Indonesia. There is a realistic allowance for some expansion of the population size in support of a sound conservation management program.

Estimated holding capacity outside Indonesia- 125 spaces at 27 institutions

Total space likely to be available for a globally managed conservation population of captive anoa is 295 animals.

Captive program development

The captive management program for anoa in Indonesia will implement the following steps in order to establish a genetically sound, well managed captive anoa population in Indonesia for conservation purposes.

> Participate in studies to determine the genetic groupings of anoa.
>
> Establish a management group for anoa in Indonesia, appoint a species coordinator and a studbook keeper for the population and develop a master plan for population management. This should be accomplished within one year.
>
> Identify additional institutions within and outside Indonesia that might want to participate in the anoa program. These institutions must commit to the program in writing and appoint a representative to the management group.

The anoa management group that is formed will develop a plan for the captive population of anoa in Indonesia. This plan will be based on the genetic determinations made with regard to this species but in general the following parameters will apply. These are based on modeling this species requirements using the biological information available about the species.

> Approximately 10 pairs (20 animals) of founders will be needed for each species of anoa identified and for which a captive conservation population will be established.
>
> A well thought out plan based on the genetic distribution of the animals on Sulawesi must be developed before any captures are initiated. In general founders should be captured from widely dispersed groups in the population in order to provide as broad a representation of the wild population as possible.
>
> Wild caught founders will be distributed to a minimum of three participating institutions in order to minimize the risk of catastrophic loss of founders, increase the rate of learning about the species and to increase the base off support for the program.
>
> The captive population will probably have a target of 200 individuals for each species of anoa maintained in captivity.

Husbandry and Medical Guidelines and Standards

The management group formed will distribute husbandry guidelines for this species. A number of items can be defined at this time and a great deal of information concerning current husbandry practices is available. This information, outlined below , serves as a basis for the husbandry guidelines of the management group.

Individual animal identification

Every anoa must be permanently identified by ear tattoo in the right side for males and left side for females and by ***Trovan*** transponder placed at the base of the right ear. Animals that are newly arrived either by birth or animal transfer must be immediately temporarily identified until permanent identification numbers are assigned. All identifications applied to the animal whether temporary or permanent must be permanently recorded in the individuals permanent animal record and submitted to the regional studbook keeper. The permanent identification numbering system and code will be decided by each institution and the regional studbook keeper or population management committee.

Record keeping

Individual animal records must consist at a minimum of :

- Place of origin if wild caught (specific capture site)
- Date of capture
- Date of arrival at the institution
- Date of birth if captive born
- Sire and dam by local institution number and by studbook number
- Institution where birth occurred
- All permanent and temporary identification methods applied
- All location transfers within and between institutions

Facility design- enclosures, exhibit, holding area, quarantine, management or handling system

Exhibits should be as natural possible to reflect the animals natural habitat including appropriate tree and plant species as well as pools with attention to shelter availability, feeding equipment, drinking sources, good drainage, sanitation, and lighting. A separate off exhibit holding area should be provided for each animal with attention given to the items listed above for this area as well. This area will be used as an animal monitoring area and as an animal shift area for safety reasons to take anoa out of the exhibit while keepers work in that area.

Minimum space requirements for one pair of anoa is a 200 square meter area divided by a partition that can be opened or closed from outside the enclosure. The enclosure should be constructed of a double fence of galvanized mesh fencing material 1.5 meters in height or a dry moat, sloped on the animal side, 1.5 meters deep and 1 meter in width.

Nutrition

Natural diet:	anoa are browsers- leaves, grass, branches, fruits, roots and aquatic plants

Captive diet:

leaves-	nangka, banana, cassava, others
grass-	Juicena repens
fruits-	banana, nangka, papaya, guava, others
vegetables-	kangkung, cabbage, carrot, sweet potato, cassava
concentrate-	based on beef cattle concentrate
lick stone-	salt lick?.

Group composition

One group consists of one male and one female. Mature males fight with each other. In general when females deliver calves the mother and calf are kept separate from the males however it is possible to put sire, dam and offspring together for 1-2 hours daily if they are observed during this time for aggression by the male.

Introduction technique

New animals must be kept in separate cages and their social interaction with adjacent anoa observed for compatibility.

Breeding and reproduction

The onset of puberty in male anoa is 3 years of age and in females is 2-3 years of age.

The estrous cycle is 21-23 days in length and estrous has a duration of about 24 hours. Estrous behavior is characterized by increased running activity and a highly specific, characteristic vocalization by the female. The vulva of the female becomes swollen with the red mucosa of the vagina visible and a clear discharge present. The male pursues the female during this time with a characteristic behavior of smelling and licking the female's vulva and a flehmen response. The duration of copulation is 7-10 seconds.

The gestation period is normally 275-315 days. Anoa usually produce a single calf which is weaned at 6-9 months of age. Males will commonly attack calves.

Diseases- observed in captive population in Indonesia

Viral disease	akabane viral abortion (mosquito transmitted)
Bacterial diseases	tuberculosis, streptococcus, staphylococcus, brucellosis
Parasitic diseases	strongylus, Ascaris, balantidium, ticks, mites
Mycotic diseases	Aspergillus

Preventative parasite management consists of deworming every 2-3 months and ectoparasites with ectoparasiticides.

Anoa are probably susceptible to all cattle diseases, some of which could have a devastating impact on captive and wild populations such as foot and mouth disease and rinderpest. Consider serologic surveys of captive and free ranging animals. Disease outbreaks in herbivores near anoa may precipitate prophylactic vaccination of anoa for the diseases of concern.

Physiology of in-situ and ex-situ populations from blood samples

Hemograms of anoas from Sulawesi (from The Diversity and Hematology of Anoa from Sulawesi by Nawangsari Sugiri and Nur Hidayat). All values are means ± SD.

Source of samples	**Ragunan Zoo**	**Surabaya Zoo**	**Central Sulawesi**	**Central Sulawesi**
Number of samples	5 adults	4 adults	3 adults	2 juveniles
Hemoglobin (g%)	13.4 ± 1.6	13 + 2	12.9 + 0.6	13.9, 14.1
P.C.V.	46 + 3.7	41 + 6.6	42.8 + 6.3	42, 51
RBC (10^6/ul)	9.91 + 2.4	7.58 + 1.15	6.8 + 0.9	7.2, 7.4
WBC (10^3/ul)	3.38 + 0.92	6.9 + 3.17	7.11 + 0.63	3.35, 4.15
Neutrophil %	13.2 + 6.5		10.3 + 8.5	9, 11
Lymphocyte %	45.4 + 17.6	28.5 + 15.2	64.5 + 18.3	68, 77
Monocyte %	15.6 + 9.6	18.3 + 6.3		5, 6
Eosinophil %	17.4 + 8.1	13.7 + 5.5	4.7 + 3.8	4, 10
Basophil %	8.4 + 1.7	5 + 2.2		5

Hematology and Serum Chemistry Values Reported from Anoa at Two Institutions

		Taman Safari Indonesia	Kanazawa Zoological Gardens of Yokohoma
Hematology	Units	15 samples	15 samples
Hemoglobin	g/100 ml	12.4	15.43
Hematocrit	%	40.7	41.6
Red Blood Cell Count	million per ul	6.2	1.215
White Blood Cell Count	per ul	5586.9	2849.3
MCV	*calc	68.0	36.46

MCH	*calc	21.0	14.23
MCHC	*calc	30.5	38.77
Basophils	%	0	-
Eosinophils	%	0.7	2.25
Bands	%	0.6	-
Segmented Neutrophils	%	48.8	-
Lymphocytes	%	44.0	51.83
Monocytes	%	5.8	3.97
Chemistries			
Glucose	mg/dl	52.4	121.31
Total Protein	mg/dl	6.8	6.37
Albumin	mg/dl	3.9	3.7
Globulin	mg/dl	2.9	2.52
Total Bilirubin	mg/dl	0.5	0.85
Direct Bilirubin	mg/dl	0.1	-
Indirect Bilirubin	*calc	0.3	-
SGOT	IU	176.5	126.15
SGPT	IU	39.5	24
Alkaline Phosphatase	IU	124.3	398.62
BUN	mg/dl	41.0	29.82
Creatinine	mg/dl	1.4	2.2
Uric Acid	mg/dl	0.6	0.3
Sodium	mg/dl	-	138.69
Potassium	mg/dl	-	4.2
Chloride	mg/dl	-	95.15
Calcium	mg/dl	9.7	9.37
Phosphorous	mg/dl	9.2	-
Magnesium	mg/dl	3.9	2.05
Iron	mcg/dl	-	0177.69

Research

Several aspects of anoa biology require further investigation and data collection. The following areas are of importance to the species and require further work.

Genetic

The issue of the number of genetically distinct groups of anoa that exist is one that overshadows most aspects of anoa conservation. This issue is of great importance. A project to accomplish part of the work that needs to be done is attached as an addendum to this report.

Immobilization

The safe immobilization of animals in captivity is important for most management programs for purposes of physical examination. Diagnosis, animal transfer and research projects as well as other reasons. Safe and effective immobilization techniques may also be important for investigations of the wild population if radio collars are applied or samples collected from free ranging animals. At the present time there is not a consensus on techniques for immobilization of anoa that can meet these needs. This subject requires further investigation.

Artificial reproductive techniques

Assisted reproductive techniques would be of great value in managing the captive population and helping to conserve genetic diversity. The primary areas to investigate initially would be:

Electro ejaculation techniques for semen collection
Cryopreservation methods for long term storage of semen
Methods of artificial insemination of females

Technology Transfer and Training

Techniques have been developed for many species of wild and domestic animals that would have application in the conservation of anoa. These include techniques and information concerning field studies of wild populations, genetics, nutrition, captive husbandry and medicine. Resources are available within Indonesia and in other countries to apply this expertise to the conservation of anoa. Programs to transfer this information and technology to the professionals working with the wild and captive populations of anoa should be strongly supported and undertaken whenever possible.

Anoa Captive Breeding Group Recommendations

1. A study should be undertaken immediately to investigate the issue of whether or not there are multiple taxa of anoa and how many taxa there are. This investigation should

utilize all resources available to apply to this question and should, in addition, result in a useable method of identifying individual animals according to the genetic group they are part of.

2. An Indonesian anoa management group for the captive anoa population in Indonesia should be formed within one year. This group will appoint a studbook keeper for the anoa population, establish a master plan for management of the population, develop husbandry standard recommendations and distribute a husbandry manual for anoa. This management group may consider appointing subcommittees to deal with specific issues such as a research subgroup.

3. Every captive anoa should be permanently, individually identified by at least two methods such as ear tattoo, ear tag, and transponder.

4. Rigorous standards of record keeping which uses the SPARKS database as a minimum standard should be adopted and completed immediately for anoa currently in captivity.

5. Applied research in anoa reproductive physiology and assisted reproduction should be initiated as soon as possible in order to develop additional tools to be utilized in the conservation of the species.

6. A field survey to determine the status of the entire anoa population in the wild should be undertaken as soon as possible.

7. Anoa confiscated by PHPA should be added to the current captive population in Indonesia.

8. A program may be required to move animals from the wild population to the captive population in order to establish a genetically viable conservation population in captivity. The need for this program should be assessed in the light of genetic studies underway and a plan developed that is based on the results of those studies.

Genetic Analyses to Resolve the Issue of Subspecies in Anoa

A study proposal

Anoa Population and Habitat Viability Assessment
Taman Safari Indonesia
July 22-26, 1996

The question of the number of species or subspecies of anoa and a reliable method for identifying the group to which individual animals belong is not yet fully resolved. This issue is of great importance for both wild population conservation programs and for captive population management programs to be able to progress effectively. Resolution of this issue in as short a time as possible is a high priority. Successful resolution of the issue may require the participation of multiple institutions working collaboratively in sample collection and genetic and morphologic analysis in multiple laboratories. This proposal outlines a framework to initiate and accomplish this task.

Summary

This project would be accomplished in stages reflecting escalating levels of difficulty in sample acquisition, complexities of laboratory analyses, and identification of funding sources to meet higher cost levels for each stage.

Stage 1- the captive wild caught animals in Indonesian zoos represent a limited population that can provide valuable preliminary data for this issue. Samples can be readily obtained and the small sample size limits expenses. Samples for genetic analysis will be collected from all wild caught anoa in Indonesian zoos within the next 3 months (by November 1,1996). The samples will be submitted for genetic analysis to laboratories in Indonesia and collaborating laboratories outside Indonesia that agree to work within the parameters and time frames of this proposal. Results of analyses and interpretation of results will be reported back to the Indonesian project coordinator by July 1, 1997. The Indonesian project coordinator will freely distribute all results and interpretations to the PHPA, PKBSI, all zoos that contributed samples, all laboratories that processed samples and all other interested parties. Results may provide a basis for initial population master planning for the Indonesian captive anoa population.

Supportive information on each animal would greatly enhance the value of this study. Each zoo should provide the following material to the project coordinator:

1. Accurate original capture information including:
   specific capture site location- name of nearest village and kabupatan and kecamatan
   specific date of capture
   estimated age at capture

2. Description of each individual animal sampled including:

coat color and texture
details of any markings
standard measurements including shoulder height, nose to anus length, tail length, girth, notch to tip ear length, horn length along the outer curve and basal girth of the horn

3. Color photographs or slides of each animal individually identified for each animal:

side view of entire animal
side view of head
front view of head
close up of horns

Stage 2. A second sample set is represented by material such as skulls and hides owned by local people on Sulawesi, artifacts held by laboratories or other institutions in Indonesia and elsewhere, and by living, privately held, wild caught individual animals on Sulawesi. This sample set is larger but these samples will take more time to collect and analyze and funding for some aspects may need to be obtained. Laboratory work may be more problematic with samples of dried skin, hair or bone marrow due to difficulties associated with working with these samples. The parameters for laboratory participation and reporting of results will be the same as above with a modified time line.

Stage 3. The free ranging wild population of anoa on Sulawesi represents the definitive set of samples to resolve the taxonomic issue. The need for a study of this population should be assessed after stage1 and stage 2 are completed. If it is determined that a study involving the free ranging population is needed, then that project should be designed utilizing the least intrusive technology that will provide adequate samples and carried out according the highest professional standards. Samples will need to be collected from a wide number of locations with multiple samples at each site. This project will be able to provide the largest set of ideal samples for laboratory analysis but will be the most complex logistically and have the highest cost, for which funding will need to be identified. Consequently, this project has the longest probable time frame.

Parameters for Participation

All institutions that participate must agree to meet time frames for work completion and reporting and to the unrestricted distribution of information within the time frames described. In the case of participating zoos this implies that the zoo will collect samples from all wild caught anoa for all participating laboratories. Samples to be collected may include multiple blood samples (100 ml could safely be collected from an anoa at one time) and skin biopsies such as were collected from the Sumatran tigers. The zoos will also be responsible to arrange to get the samples to either the laboratory in Indonesia or to a central collection point for distribution to the laboratories. The laboratories that receive samples will complete the laboratory procedures within the specified time frame and will freely report back descriptions of methodology used, results of analyses, and interpretations of results within the specified time frames.

Distribution of results- All data will be distributed to PHPA, PKBSI, all participating zoos and laboratories and all others that may request this data.

Publication rights- No laboratory can retain exclusive publication rights from data produced from these samples. **In no case can the reporting of results to the project coordinator be delayed to permit a laboratory to publish results.** Publication of results in a refereed journal must be a shared undertaking of the pooled data with details to be negotiated between participants.

Costs-

Stage 1: The zoos will absorb any costs for animal handling, sample collection, and transport of samples to laboratories in Indonesia or a central distribution point for samples going to laboratories outside Indonesia. Laboratories will absorb all costs for sample processing and analysis and provide any unusual sample collection equipment or supplies. Laboratories outside Indonesia must provide funds to cover the costs of shipping samples from Indonesia. No support funds are available.

Stage2 and 3: The significantly higher costs associated with these studies will require development of proposals, submission of budgets and identification of funds to meet the costs involved.

Time Frame Requirements

Stage 1-

August 15,1996- Laboratories in and outside country must be contacted to determine interest in collaboration on this project. Written confirmation from appropriate authorities that permits will be issued for sample shipment to all laboratories.

September 1, 1996- Response from laboratories required including written agreement to the parameters of the project, a brief description of the laboratory analyses to be done on the samples, detailed protocols for sample collection and handling, unusual sample collection supplies provided, and funds to cover shipping costs if required

.

September 15,1996- Coordination of sample collection dates and procedures between the zoos established and agreement to the parameters of the project.

October 15,1996- All sample collection in zoos completed and samples submitted to laboratories in Indonesia or the central collection site.

November 1, 1996- Sample distribution to all laboratories in and out of Indonesia complete.

(time frame requirements continued)

March 1,1997- Written preliminary status report from all laboratories.

July 1,1997- All laboratory analyses complete and reports submitted to project coordinator.

July 30, 1997- Complete reports from all laboratories distributed by the project coordinator to PHPA, PKBSI, all zoos that contributed samples, and all laboratories that provided results.

Stage 2 and 3- Time frames to be defined as projects are developed

Project Coordination

Stage 1

Overall Project Coordination- Jansen Manansang, Taman Safari Indonesia
Supervision of the general progress of the project, coordination with PHPA and PKBSI, coordinate issuance of required permits, receipt and distribution of reports

Coordination with Indonesian laboratories- Bambang Purwantara and Dedy Duryadi
Contact with Indonesian genetics laboratories, obtain written agreements to project parameters, coordinate sample collection with zoo contact, and periodically monitor progress in the laboratories

Coordination with laboratories outside Indonesia- Ida Y. Masnur, Nuria Agustin, Sharmy Prastiti
Contact identified laboratories outside Indonesia and obtain agreement to project parameters, protocols and materials for sample collection, act as central collection point for samples for outside laboratories and ship samples to these laboratories.

Coordination of sample collection with zoos- Ida Y. Masnur, Nuria Agustin, Sharmy Prastiti

Contact all participating zoos in Indonesia and obtain written agreement to project parameters, coordinate distribution of sample collection supplies, coordinate sample collection times, receive samples for distribution to laboratories

Stage 2 and 3- To be determined as projects are developed

Initiation of project development- Zoos holding anoa, PHPA, PKBSI

Sample Population (Wild Caught Anoa Only)

Gembira Loka	1.0 mountain
Ragunan Zoo	1.2 lowland and 1.1 mountain
Surabaya	0.1 lowland
Taman Safari Indonesia	5.3 lowland

Samples requested by laboratories should be reasonable in type of sample and volume requested. For example it is reasonable for each laboratory to request 10 ml of whole blood or serum or to request full thickness skin biopsies(6mm diameter). Sample collection will be coordinated so that each animal only has to be handled one time and all samples are collected at that time. This may mean that up to 100 ml of blood may be drawn and multiple biopsies collected from each animal. It is safe to draw that volume of blood on an animal of this size. In general 10% of blood volume can be safely collected from any animal. The circulating blood volume of most animals is about 7% of body weight. An anoa of 50 kg body weight would have a blood volume of 3.5 kg or 3,500 ml. A collection of 350 ml of blood could safely be taken from that animal. Most anoa are larger than 50 kg and a collection of 100 ml of blood from any anoa should be safe.

Laboratories In Country

Dr. Ir. Dedy Duryadi
Institut Pertanian Bogor
Fakultas MIPA
Jl. Raya Pajajaran, Bogor, 16144
Phone: (0251) 323582
Fax : (0251) 312708
Technique to be used- random primers on mitochondrial DNA, microsatellites applied to nuclear DNA may be used if probes can be obtained

Dra.Noviar Andayani, MSc.
Universitas Indonesia
Fakultas MIPA - Biologi
Depok
Phone: (021) 7863431
Fax : (021) 7863431
Technique- ?

Prof. Dr. Amitaba
Universitas Airlangga
Jalan Dharmawangsa
Surabaya
Phone: Fax :
Technique- ?

Prof. Dr. Nawangsari Sugiri
Institut Pertanian Bogor
Lab. Biologi Hewan PAU- Ilmu Hayati
Darmaga - Bogor
Phone: Fax :
Technique- starch gel electrophoresis of mitochondrial DNA and polyacrylamide gel electrophoresis of serum proteins, karyotyping

Outside Laboratories

Edward Louis, DVM, PH.D.
Henry Doorly Zoo
3701 S. 10th
Omaha, NE, USA 68107-0200
Phone: 001-402-733-8401 Fax : 001-402-733-0490
Technique- bovine specific microsatellite probes applied to nuclear DNA

Dr. Arnd Schreiber
Zoologisches Institut
Universitat Heidelberg
Im Neuenheimer Feld 230
D-69120 Heidelberg, Germany
Phone: (06221) 54-5655 or (06221) 54-5656 Fax : (06221) 54-6162
Technique- mitochondrial DNA, protein polymorphisms

Contact for laboratory in Japan
Dr. Yoshiro Yamamoto
Chief Veterinarian
Kanazawa Zoological Gardens of Yokohoma
5-15-1 Kamariya Higashi
Kanazawa-Ku.
Yokohoma 236 Japan
Phone: 81-45-783-5060 Fax : 81-45-782-9972
Technique- ?

Laboratory Agreement to Collaborate with Genetic Analyses to Resolve the Issue of Subspecies in Anoa

The question of the number of taxa of anoa and a reliable method for placing individual animals in the appropriate group are issues that remain unresolved at this time. These issues overshadow and may significantly influence most aspects of conservation planning and management for this species. The Indonesian zoos that currently hold anoa have undertaken a project to produce initial information that will begin to address these questions and produce preliminary data in support of further projects to resolve these issues. Wild caught anoa currently held in Indonesian zoos represent a sample set that can be readily accessed to provide material for laboratory analysis. Samples from these animals can be provided for evaluation to laboratories that are willing to help resolve this issue for conservation purposes.

The urgent nature of this project in the context of the conservation needs of this endangered species and the need to generate preliminary data for projects that are designed to collect more comprehensive sample sets for this species necessitates that laboratories which want to participate in this project and receive samples from these animals agree to the parameters of the project. These parameters include the time frame established for completion of work and reporting of results and the free distribution of all results to all parties involved including the PHPA, PKBSI, all zoos that contribute samples, all laboratories that evaluate samples and any other parties to whom the information may be useful in the conservation of the species.

If the parameters of participation detailed in the project proposal entitled Genetic Analyses to Resolve the Issue of Subspecies in Anoa which accompanies this agreement are acceptable to you then we welcome your valued participation in this project. Please indicate your agreement to the conditions for participation described by signing and returning this form to the project coordinator.

__________________________(name) agrees to fulfill the parameters of participation for this project as outlined in the proposal including arranging for all permits required to import samples to your laboratory, the time frames described, the distribution of results as described, and the assumption of costs involved as described. I will act in good faith to fulfill these commitments.

____

signature

Zoo Agreement to Collaborate
with
Genetic Analyses to Resolve the Issue of Subspecies in Anoa

The question of the number of taxa of anoa and the lack of a reliable method of determining the appropriate grouping for individual animals are significant issues. These issues profoundly effect conservation planning for this species and at the present time effectively preclude the development of a valid conservation based captive breeding program for the anoa. A great deal of further work is needed to provide the information to fully resolve these issues. The Indonesian zoos that currently hold wild caught anoa are in a position to provide valuable samples from this group of animals which may help answer some of these questions. Work done on these samples cannot fully solve the issues but can provide valuable preliminary data and may provide sufficient information to develop an initial conservation master plan for the animals that are sampled.

In order to generate as much useful information as quickly as possible participating zoos will provide samples which will be distributed to multiple laboratories which have agreed to work on the project and to fulfill the parameters of participation as described in the accompanying project proposal. In order to provide as complete a sample set as possible, the participation of all zoos holding wild caught anoa is sought. The urgent need for this information in the conservation of this endangered species requires that the zoo animal sample collection phase of the project be completed in a very limited time frame as described in the accompanying proposal. This project requires that the zoos accept the responsibility for the costs associated with the sample collection and the laboratories will accept responsibility for the costs they incur in analyzing the samples. The project may require the collection of samples that seem relatively large but no request will be made for samples that is considered to be a significant risk to the animal. Please review the accompanying proposal.

If the project description and parameters of participation detailed in the proposal are acceptable to you then we welcome your participation in this project to benefit anoa. Please indicate your agreement to participate in the project by signing and returning this form to the project coordinator.

__________________________(name) agrees to fulfill the parameters of participation in this project as outlined in the proposal including the collection of samples from wild caught anoa at the ________________________________ zoo within the time frames described and the assumption of costs associated with the sample collection. I will act in good faith to fulfill this commitment.

____
signature

Sample Letter

Dr. Jansen Manansang
Taman Safari Indonesia
Jl. Raya Puncak
Cisaura, Bogor, 16750
Indonesia

Edward Louis, DVM, Ph.d.
Henry Doorly Zoo
3701 South 10^{th}
Omaha, NE, 68107-0200
USA

Dear Dr. Louis,

The zoos of Indonesia are establishing a conservation based captive breeding program for the endangered anoa. As you are aware, significant questions are associated with this species concerning whether or not there are multiple taxa or subspecies of anoa and if there are, how to determine which group individual animals fit into. These questions profoundly effect the captive population management program as well as conservation programs for the wild population on Sulawesi.

The Indonesian zoos that currently hold anoa are initiating a project to generate some of the data to help resolve these issues through genetic evaluation of samples collected from wild caught anoa currently held in Indonesian zoos. You have expressed interest in working with samples from anoa in your laboratory. We would like to invite you to consider participation in this project and to contribute to the information base for this species.

This project is limited in scope and is intended as an initial step in a series of up to three projects that increase in scope and definition. We are carrying this project out within a limited time frame and with no supporting funds. We have placed very specific information reporting requirements on those who receive samples in this project. We want to assure the free flow of information and to assure that results are received, distributed and applied as quickly as possible.

Please review the enclosed protocol and consider participation in this project under the terms described. If you are able to work within those parameters and would like to receive samples from anoa, please return the signed agreement to collaborate to me no later than September 1, 1996.

You will also need to provide any specialized sample supplies, storage solutions and shipping containers. It will be necessary for you to arrange all permits required in your country to receive the samples and to arrange some method of providing funds for shipping costs. The contact person for these aspects of the project is Dr. Ida Y. Masnur who may be contacted at the same address and fax listed above.

Thank you for considering this proposal. I hope you are able to work with us on this project to benefit the anoa. I look forward to your response.

Sincerely,

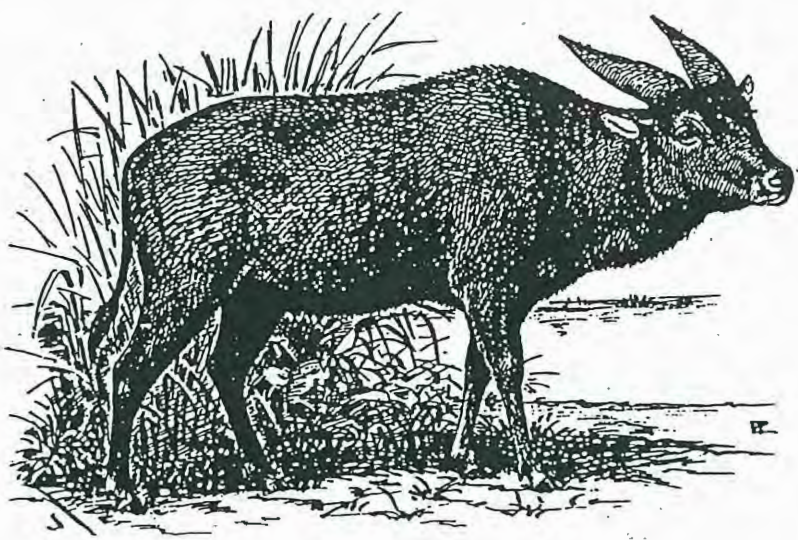
ANOA

Bubalus quarlesi & Bubalus depressicornis

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

22 - 26 July 1996

Taman Safari Indonesia
Cisuara, Indonesia



REPORT

The Anoas

Asian Wild Cattle SG Action Plan Chapter

The Anoas

Lowland anoa (*Bubalus depressicornis*)

Mountain anoa (*Bubalus quarlesi*)

Review of their biology, distribution, and status

Extracted from Chapter 15 in: Hedges, S. (1996). *Asian Wild Cattle and Buffaloes: Status Report and Conservation Action Plan.* [Final Draft] IUCN/SSC Asian Wild Cattle Specialist Group, Gland, Switzerland.

15. The Anoas

Lowland anoa (*Bubalus depressicornis*)

Mountain anoa (*Bubalus quarlesi*)

Biological Profile

Nomenclature and Systematics

Local names include: *anoa* or *anoang* (= *anoeang*) and *sapi-utan* (= *sapi oetan* = *sapi hutan*) for anoas in general, and *anoa dataran rendah* and *anoa gunung* for lowland and mountain anoas respectively (Indonesian); *buulu tutu* and *bandogo tutu* (in the Gorontalo area), *dangko* and *dangkon* (in the Manado area), and *langkau* (Tumbulu and the Minahasa area). In Southeast Sulawesi the lowland species is referred to as *anoa* or *kadue* and the mountain species is called *anoa perak*. In South Sulawesi the mountain species is called *soko* (by Bugis people) and *anoewang matjetjo* (by Toraja people).

The taxonomic status of the anoas has been a source of much confusion ever since the first specimens were brought to the attention of Western scientists. Despite the close similarity between the anoas and the Asian water buffalo (*Bubalus bubalis*) several authors have placed them in their own genus, *Anoa* H. Smith, 1827. Dolan (1965), however, considered *Anoa* to be a subgenus within *Bubalus*, while Bohlken (1958) did not consider *Anoa* to be a valid name even at the subgeneric level.

That the anoas are in fact significantly similar to the other *Bubalus* species and should be classified with them was demonstrated by Groves (1969) who considered the following features to be the most significant: horn structure, the morphology of the skull and spine, the growth form of the hair, hoof structure, and the general appearance of the animals. Several differences were also noted by Groves: these differences are again related to the shape and growth form of the horns and the structure of the skull, as well as certain features of the dentition, but as he points out these differences are relatively minor. Groves concluded that the anoas show all the specialized characters of *Bubalus* and few significant or absolute differences and he advocates allocation to that genus. However he recommended employing *Anoa* H. Smith, 1827 as a subgenus in order to better indicate the relationship between the anoas, Asian water buffalo, *Bubalus (Bubalus) bubalis*, and the tamaraw, *B. (B.) mindorensis*.

How many kinds of anoa are there?

The question which has most vexed biologists is that of how many species of anoa to recognize. Most classifications accept the existence of two forms, mountain anoas and lowland anoas, and many authorities have treated these forms as two species, *Bubalus depressicornis* and *B. quarlesi*, with or without additional subspecies (e.g. Harper, 1945; Groves 1969; Honacki *et al.*, 1982; Corbet & Hill, 1992). Others only recognize a single species with either two or three subspecies: *Bubalus depressicornis depressicornis*, *B. d. quarlesi*, and *B. d. fergusoni* (e.g.

Dolan, 1965; Frädrich, 1973; Weise, 1979). It has also been suggested that there may be more than two species (N. Sugiri *in litt.* to Schreiber *et al.*, 1993).

Groves (1969) gives detailed descriptions of the two forms, drawing attention to differences in size, horn structure, tail length, and markings (see below for descriptions). He was of the opinion that there were no intermediate forms linking the two types and he concluded that the two forms should be regarded as separate species, with the smaller form being characterized by a paedomorphic phenotype. Both forms were found all over Sulawesi but the locality records which were available for the specimens examined by Groves implied that the large form was found in lowland areas and the smaller form at higher elevations (but see below).

Groves shows that the first scientific description of the larger, or lowland anoa species was that of Smith (1827) who named it *Antilope depressicornis* and included it in a specially created subgenus: *Anoa*. The later names *Oreas platyceros* Temminck, 1853 and *Probubalus celebensis* Rutimeyer, 1865 are effectively substitute names for *depressicornis*, while Lydekker's (1905b) *Bos depressicornis fergusoni* is shown to be a synonym of *Bubalus (Anoa) depressicornis*. The smaller form was first described by Ouwens in 1910 who, recognizing it as a new species, gave it the name *Anoa quarlesi*; consequently the smaller anoa species (the so-called mountain anoa) should be referred to as *Bubalus (Anoa) quarlesi* (Ouwens, 1910).

Doubts have subsequently been raised over the validity of these two species. Weise (1979) studied anoa skins and skulls and the results of his multivariate analysis, which are summarized by Schreiber *et al.* (1993), showed no biometric differences between lowland and mountain anoas which could not be explained as a result of allometric transformations due to the smaller size of the mountain anoa. Horn shape did provide some diagnostic information but was considered ambiguous. (Wind and Amir (1978) have suggested that differences in horn shape may simply be a function of age.) Weise concluded that a two-species concept could not be supported, although he had to accept that the intraspecific variation could not be understood on the basis of the available materials (Schreiber *et al.*, 1993).

Field biologists who have worked in Sulawesi have also questioned the existence of two species. Thornback (1983) cites correspondence with Watling wherein he suggests that the differences between anoas may simply be the result of clinal variation. However, the distribution of the so-called lowland and mountain anoas does not suggest a geographical cline, if anything a mosaic pattern is suggested. Neither would there appear to be an altitudinal cline for, as we shall see below, both forms of anoa have been recorded from sea-level to elevations of more than 1500 metres. Finally, one would expect to encounter intermediate forms but Groves (1969) was of the opinion that such intermediates did not exist, although his sample size was admittedly rather small.

Keepers of captive anoa have cast doubt on the validity of conventional classifications too. Schreiber *et al.* (1993) recount that animals descended from the same founder stock were reported to them as both lowland and mountain anoa by different zoological gardens. Furthermore, apparently intermediate forms exist in some collections; this would, at first, seem to lend weight to the suggestion that there may be only a single, if rather variable species. However the possibility that these animal might be hybrids has to be considered because Schreiber *et al.* suggest that crossbreeding may have taken place between anoas of markedly different appearance in at least one Indonesian zoo and the ancestors of most anoas in Western zoos were imported from Java.

Schreiber and colleagues have recently conducted a detailed genetic study of captive anoas and they concluded that the coincidence of differences encountered in karyotypes[1], polymorphic genes, body size, hair texture, and other phenotypic

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1 Anoas in European zoos have been found to have four different karyotypes (44, 45, 47, and 48 chromosomes) (Schreiber *et al.*, 1993).

characters (including horn shape) indicated that the anoas comprise genetically differentiated taxa, but these taxa are less distinct than is typical for bovine species. The genetic distances between mountain and lowland anoas fell within the range of allozyme distances generally encountered between geographical races or subspecies. However, they cautioned that the taxonomic relevance of these genetic distances was open to question because the allele frequencies will have been affected by the bottle-necks inherent in establishing captive populations and by incest breeding in the captive mountain anoa population (the possibility that one or more of the founders were themselves hybrids should not be forgotten either). Furthermore, as they point out, the biological meaning of chromosomal and phenotypic variation between anoa populations needs to be investigated before appropriate taxonomic revisions can be suggested (Schreiber *et al.*, 1993).

However, another more recent study of mitochondrial DNA sequences revealed clear differences between captive animals thought to be mountain anoas (the *quarlesi* phenotype maintained at Krefeld Zoo, see below) and those from Leipzig and other European zoos which were thought to be lowland anoa (i.e. *depressicornis* phenotypes) (Schreiber *et al.*, in prep.). These differences were as large as those found between some valid bovine species (in contrast to the low allozyme distances reported by Schreiber *et al.* (1993) and discussed above). There are two possible explanations for these results. Firstly, mountain and lowland anoa *are* well-separated species but hybridization in the captive population caused the observed pattern of protein variation (which was based on allele frequencies averaged over all zoo-living specimens) reported in the earlier study whereas the maternally inherited mitochondrial gene sequenced in the second study reflects only the genotype of the founder females. Alternatively, the differences in the mitochondrial DNA sequences is a chance effect caused by the sole female founder of the *quarlesi* phenotype belonging to another mitochondrial lineage. Such polymorphism would have no taxonomic implications but would merely indicate the presence of very deep mitochondrial lineages and testify to the great age of the taxon as a whole (the anoas are widely held to be the most primitive member of tribe Bovini). Recent studies of well-differentiated hameoglobin sequences are in accordance with the second possibility (Schreiber *et al.*, in prep.). Nevertheless in the absence of any overwhelming evidence to suggest that the systematic position of the anoas presented by Groves (1969) and adopted by Honacki *et al.* (1982), Corbet and Hill (1992), and Wilson and Reeder (1993) is incorrect the two species, *Bubalus depressicornis* and *Bubalus quarlesi*, are accepted as valid taxa here. Further work is clearly needed, however, and should include molecular and chromosomal studies of wild-caught anoas.

Turning now to the possibility that the two species of anoa can be split into subspecies we see that the situation is also far from clear. Van Bemmel (cited in Hooijer, 1950) thought that *B. quarlesi* may have valid geographical races. Heller (1889) also postulates the existence of additional taxa. Dolan (1965) talks of three subspecies of anoa: the 'Lowland Anoa', *Bubalus depressicornis depressicornis* (H. Smith, 1827); the 'Mountain Anoa', *B. d. fergusoni* (Lydekker, 1905b); and 'Quarles' Anoa', *B. d. quarlesi* (Ouwens, 1911 [sic]) giving descriptions of all three. However, from these descriptions it seems likely that *B. d. depressicornis* and probably *B. d. fergusoni* are in fact *B. depressicornis* and 'Quarles' Anoa' is in fact *B. quarlesi*. Groves (1969) discussed the possibility of subspeciation within the anoas and concluded that while there did appear to be some geographically determined size differences the number of specimens available was insufficient to assess the significance of this variation. Bartikova and Dobroruka (1973) suggested that both species of anoa are polytypic with at least two subspecies and Nazir Foead (1992) quotes correspondence with Groves wherein the latter states that he now expects there to be two subspecies of *Bubalus quarlesi*, a black coloured one and a brown one.

It has also been suggested that there may be two races of lowland anoa because there are a few skulls of lowland-type anoa in Bogor Zoological Museum, labelled as originating from the north tip of the Minahassa Peninsula (close to

Tangkoko - Dua Saudara NR), which 'in absolute dimensions [look] larger than several "Lowland anoa" skulls from the southeastern peninsula' being rather 'buffalo-like' in appearance (Schreiber & Nötzold, 1995:422). Furthermore, Schreiber and Nötzold thought that lowland anoa filmed recently (by M. Patry) in the Gorontalo area also differed from these 'buffalo-like' anoa (although the differences were less marked in fully-grown individuals) and they speculate that the anoa of northeastern Minahassa might form a distinctive population. Nevertheless the present lack of formally described subspecies based on adequate sample sizes recommends against the adoption of subspecific names here.

In conclusion, then, it seems more than likely that revisions will need to be made within the subgenus *Anoa*. Since conservation needs a firm taxonomic foundation Schreiber and colleagues' urgent recommendation for field studies and further genetic research is strongly endorsed (see Schreiber *et al.*, 1993 and Schreiber & Nötzold, 1995).

Summary

Two species of anoa are recognized (*viz.* lowland anoa and mountain anoa). None of the described subspecies are regarded as valid but the observed variation in phenotype is recognized as likely to be significant. Further morphological, chromosomal, and molecular research is urgently required.

Lowland anoa

Valid name. *Bubalus depressicornis* (H. Smith, 1827).

Synonyms. *Antilope depressicornis, Bos bubalus anoa, Bos depressicornis fergusoni, Oreas platyceros, Probubalus celebensis.*

Holotype. Skin and nearly complete skull with horns from a juvenile female (with the second molars in the process of eruption); in the British Museum (Natural History), London (B.M. 0.5.26.16).

Type locality. Sulawesi, Indonesia.

Paratype. Skull from an unsexed subadult (third molars erupted but unworn); in the British Museum (Natural History), London (B.M. 8.12.23.1).

Mountain anoa

Valid name. *Bubalus quarlesi* (Ouwens, 1910).

Synonyms. *Anoa quarlesi, Anoa anoa, Bubalus depressicornis quarlesi.*

Syntypes. Three specimens in the Amsterdam Museum are labelled as syntypes: skin and skull from a juvenile (first molar present) (a male?) (ZMA 9288); skin and skull from an older juvenile (second molar present) (a female?) (ZMA 9289); the third, an infant skull (ZMA 9295), is considered by Groves (1969) to be erroneously labelled as a type because Ouwens only refers to three animals in his paper.

Type locality. Mountains of Central Toradja district, Sulawesi, Indonesia.

Comments. Both species were placed in subgenus *Anoa* by Groves (1969).

Description

Anoas are the smallest of the extant wild cattle species. They are stocky, short limbed, and thick necked. Young anoas are generally reported to have a thick covering of yellowish brown woolly hair but there is much variation; new born calves in zoos have also been brown or black. Adults are also variable in colour but are predominantly brown or black. Males are usually darker than females. Both male and female anoas have horns (as in all other extant Bovini). Anoas are reputed to have an exceptionally thick hide. The following descriptions of the two (putative) species should be regarded as a guide only given the apparently high levels of individual variation shown by these animals and the uncertainty which remains about their taxonomic status.

Lowland anoa can weigh up to 300 kg, measure 80-100 cm at the shoulder and have a body length of between 170-188 cm. Their horns are short (males 27-37 cm; females 18-26 cm), straight, triangular in cross-section, with obvious transverse ridges and a marked external keel. The tail is relatively long compared to that of *B. quarlesi*. Lowland anoa are further distinguished from the mountain species by their colouration: the adults are predominantly black but the forelegs are always white or yellowish-white from the knees to the hooves with a black line down the front and another crossing this over the fetlocks; the hind legs have conspicuous white spots above the hooves; the groin is pale, sometimes white, and there is often a white crescent on the throat. The lowland species has sparse straight hair (Dolan, 1965; Groves, 1969; Walker *et al.*, 1975; Grzimek, 1990).

Mountain anoa can weigh up to 150 kg, stand up to 75 cm at the shoulder and have a body length of between 122-153 cm. Their horns are shorter than *B. depressicornis* (15-20 cm in both sexes), conical, round in cross-section and have no marked external keel or transverse ridges. The tail is shorter than that of the lowland species. The coat remains thick and somewhat woolly in adults, especially the females. Adults vary in colour from dark brown to black. The legs sometimes have whitish or yellowish spots above the hoofs but these markings are often inconspicuous. Although a recent review (National Research Council, 1983) states that the entire lower limbs of *B. quarlesi* are creamy white all other published descriptions have emphasized the generally dark-coloured legs of mountain anoa. The groin is lighter than the surrounding coat but not white and the mountain species does not have the white crescent on the throat (Dolan, 1965; Groves, 1969; Walker *et al.*, 1975; Grzimek, 1990).

Schreiber *et al.* (1993) concluded that the phenotypic characters that are conventionally used to distinguish lowland and mountain anoas including horn cross-section, shoulder height, markings, and hair characteristics are ambiguous, particularly if only a few animals are available for comparison. However, their conclusions were based on an examination of animals in zoological collections and as mentioned above doubts have been raised about the parentage of these animals.

Distribution

The anoas are endemic to the Indonesian island of Sulawesi (plus several small off-shore islands) and both types were apparently found all over the island in historical times. Mohr (1921) provides a distribution map but it is now rather dated and is in any case somewhat lacking in detail. Groves (1969) gives a much more detailed map of the anoas' historical distribution (reproduced below) but the taxonomic attribution of some of the specimens examined by Groves has been challenged by Weise (1979).

Fossil and subfossil remains of anoas have been found in two areas. *Bubalus depressicornis* have been recorded among the so-called Cabenge fauna which was uncovered from sedimentary deposits some 100 km north-east of Ujung Pandang (South Sulawesi) and is believed to date from the Late Pliocene (i.e. more than 1 million years ago); and in the various caves near Maros which have yielded the so-called Toalian fauna (which is of far more recent origin, dating from perhaps 30,000 years ago). *Bubalus quarlesi* remains were also found in the second of these areas suggesting that the two species may have occurred sympatrically (Hooijer, 1950; Sartono, 1979; Whitten *et al.*, 1987b).

Groves states that all the locality records which he was able to find (either in the literature or on the labels of specimens) indicated that the small form of the anoa (i.e. *Bubalus quarlesi*) occured in mountainous areas, and the large form (i.e. *Bubalus depressicornis*) occured in the lowlands. Furthermore in some cases both species were recorded as coming from the same locality. Indonesian Forestry Department staff who spoke with Schreiber and Nötzold in September 1994 were also of the opinion that both species of anoa inhabited the same areas but occurred at different altitudes (G. Nötzold *in litt.*, 1995). However, MacKinnon (cited in Thornback, 1983) reports that within any region there tends to be only one species of anoa, suggesting an allopatric, or at least parapatric distribution. Remarks made to Hedges by forestry service staff and villagers (including hunters) in South and Central Sulawesi in 1989 and 1994 were generally in aggreement with MacKinnon's observations (although in Lore Lindu NP the presence of both species was reported by park rangers). Furthermore, despite the common names given to the two species their altitudinal ranges appear little different. MacKinnon remarks that in mountainous areas one tends to find *Bubalus quarlesi*, but within a *quarlesi* region this animal can be found at sea level as well as at higher elevations. Indeed Bartikova and Dobroruka (1973) collected a specimen of mountain anoa from a mere 100 metres above sea level. Meanwhile in *B. depressicornis* areas this supposedly lowland form ranges up to at least 1500 metres (e.g. in the Gunung Tangkoko and Gunung Ambang areas).

It is also worth noting that anoa are excellent swimmers and that they have been reported to swim quite considerable distances to reach off-shore islands. In the past anoa in SE Sulawesi apparently often swam across the Bay of Kolono which is about 5 km wide (Abdul Haris Mustari, 1995).

Given the taxonomic problems discussed at the beginning of this chapter it is not really surprising that there should be so much uncertainty about the distribution of these little known animals. Nevertheless despite these problems it is useful to reassess what we know about the present-day distribution of the anoas (see Table 15.1 and the summary at the end of this section also).

Mountain anoa

There have been several reliable reports of the presence of mountain anoa in recent years, these include: a captive female anoa reportedly originating from the Makale area in Toraja Land (= Tanatoraja), which was examined in 1994 by Schreiber and Nötzold; and mountain anoa horns thought to originate from Toraja Land which were seen for sale in Rantepao and Makale in 1993 and 1994 (Melisch, 1995b; Schreiber & Nötzold, 1995). An anoa of the mountain type was also recently obtained from from Mount Nokilalaki (in the Lore Lindu area) by Prof. Nawangsari Sugiri (of Institut Pertanian Bogor, Java) (and interestingly, since the putative mountain anoa at Krefeld zoo have 44 or 45 chromosomes, the specimen was found to have 44 chromosomes); and Hedges saw horns from mountain anoa which had been killed by local hunters in Lore Lindu NP (S. Hedges unpub. obs., 1994). In addition, Schreiber and Nötzold examined specimens of mountain anoa which had been killed by hunters in the Mayoa area (south-east of Lake Poso). These reports all suggest that typical mountain anoa occur in the central highlands from the Quarles Mountains and adjacent mountain ranges of Toraja Land, northwards to Lore Lindu NP, and eastwards to Lake Poso. There have been no recent reports of mountain anoa south of Toraja Land.

East of Lake Poso the picture becomes less clear. A specimen obtained from the Pompangeo mountains was karyotyped by Nawangsari Sugiri and found to have 46 chromosomes, suggesting that it may have been of the mountain type[2]. However, photographs of the specimen do not resemble the typical dark coloured and woolly-haired mountain anoa of Toraja Land (or Krefeld zoo), instead they show a pale-brown coloured animal (Schreiber & Nötzold, 1995). [But cf. the photograph of an anoa identified as being of the mountain type photographed on Buton island by Abdul Harls Mustari (1995:6).]

Mountain anoa have also been reported from Morowali NR (in the eastern peninsula) (WCMC, 1991 citing the reserve's management plan which was produced in 1980) but it is not known what criteria were used to classify the anoa.

Abdul Haris Mustari (1995) reports the occurrence of both mountain and lowland anoa on the south-eastern peninsula but he does not present any evidence to support the occurrence of mountain anoa on the mainland; however, a captive adult female anoa on Buton island was identified as being of the mountain type and photographed by him.

The occurrence of mountain anoa on the Minahassa Peninsula of North Sulawesi seems quite likely since park rangers in Nani-Wartabone (formerly Dumoga-Bone) National Park report the occurrence of both mountain and lowland anoa and showed Schreiber and Nötzold skulls from ('possibly adult') anoa which had the rounded horns typical of the mountain type (however, despite these skulls Schreiber and Nötzold apparently remained uncertain that mountain anoa actually occur in the area, although they do not explain why). Intriguingly a wall-painting in Nani-Wartabone also depicted animals with characters supposedly diagnostic of mountain anoa but, as Schreiber and Nötzold note, such paintings do not necessarily depict animals living nearby.

Lowland anoa

Lowland anoa are known to occur on the south-eastern peninsula: specimens (carcasses and skulls/horns) have been collected and live animals photographed by Abdul Haris Mustari (1995). In addition they may be present on Buton Island because they were reported to occur in Buton Utara NR in 1982 (FAO, 1982a) (although the criteria used to classify them are unknown). Anoa of the lowland type are also known to occur on the Minahassa Peninsula (North Sulawesi): they have been seen by biologists working in Tangkoko - Dua Saudara NR (O'Brien & Kinnaird, 1996); filmed in the Gorontalo district by Maurice Patry (pers. comm. to Schreiber & Nötzold, 1995) (the animals he filmed resembled the Leipzig zoo animals); and skulls with horns having the triangular cross-section characteristic of lowland anoa were shown to Schreiber & Nötzold by rangers in Nani-Wartabone NP. Specimens of lowland-type anoa have also been obtained from the Minahassa Peninsula by Prof. Nawangsari Sugiri (the animals, which again resembled the Leipzig zoo animals, had 48 chromosomes[3]) (Schreiber & Nötzold, 1995).

Both mountain and lowland anoa have been reported by park rangers in Lore Lindu NP in the central highlands (S. Hedges unpub. obs., 1994; Schreiber & Nötzold, 1995); but the rangers' descriptions were vague and the reports appear to be based largely on habitat utilization rather then any obvious difference in the animals' appearance (S. Hedges unpub. obs., 1994). The presence of mountain anoa has been confirmed by other means (see above) but it remains unknown whether lowland anoa also occur in the central highlands.

There appear to be no recent reports of lowland anoa from Toraja Land or

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2 Mountain anoas from Krefeld Zoo have 44 or 45 chromosomes and these numbers are thought to be part of a Robertsonian-type translocation polymorphism of 44-46 chromosomes. The karyotype recorded in the Gunung Pompangeo specimen could therefore be indicative of the same polymorphic system found in the mountain anoa at Krefeld but more detailed study is required (Schreiber & Nötzold, 1995).

3 All putative lowand anoa in western zoos have been found to have 48 chromosomes, with one exception which had 47 chromosomes (Schreiber & Nötzold, 1995).

further south on the southern peninsula.

Summary (see Table 15.1 also)

Region	Lowland anoa	Mountain anoa
Northern peninsula	yes	yes?
Central highlands	?	yes
Eastern peninsula (east of Tomori Bay)	?	?
Toraja Land (= Tanatoraja)	?	yes
Southern peninsula (south of Toraja Land)	?	?
South-eastern peninsula	yes	?
Buton (= Butung) Island	?	yes

Habitat

Very little is actually known about the habitat preferences of these little studied animals. Anoas reportedly have more of a requirement for undisturbed forest than the other species of wild cattle in South and Southeast Asia (Whitten *et al.*, 1987b), although they are known to use selectively logged forest - probably attracted by the regeneration which follows logging activities (Watling *in litt.* to Thornback, 1983). Lowland anoa are reported to inhabit lowland forests including secondary formations and swampy areas, and were reportedly common along coasts in the past; mountain anoa are reported to occur in montane forest up to 2000 m above sea level (National Research Council, 1983; Jahja, 1987; Abdul Haris Mustari, 1995). Nevertheless the mountain anoa is sometimes found at sea level and the lowland species is sometimes found at high elevations in mountainous areas (Bartikova & Dobroruka, 1973; MacKinnon & MacKinnon cited in Thornback, 1983). Like other wild buffalo the anoas wallow and bathe in pools of water and/or mud but it is not known whether such activities are essential to their well-being (cf. *Bubalus bubalis*). It is probable that mineral springs or licks are also required; although anoa are reported to drink seawater which might fulfill their mineral needs in areas without licks or springs (Whitten *et al.*, 1987b; Abdul Haris Musrai, 1995).

Mountain (?) anoa in Lore Lindu National Park have been reported to prefer well drained and rugged areas without dense undergrowth when feedlng, and relatively open and dry ridge-top areas when resting and ruminating (Wirawan, 1981). However, Nazir Foead (1992) thinks that mountain anoa prefer dense forest over more open subalpine vegetation; he also reports that within regions of similar elevation and forest type they prefer the more vegetationally diverse areas. Sugiharta, who like Nazir Foead and Wirawan also worked in Lore Lindu NP, reports that mountain anoa select hilly landscapes (within montane rainforests) with a relatively low density of trees and a high density of understorey vegetation, abundant water sources, open areas, and no (or at least) infrequent human activity (Sugiharta, 1994).

Ranging Behaviour

Nothing is known.

Diet and Feeding Behaviour

Anoas have a varied diet and are known to eat grasses and other herbs, aquatic plants, the leaves of shrubs and young trees, bark, and fruit. Around cultivated areas anoas are reported to favour latex bearing plants such as cassava (Whitten *et al.*, 1987b).

Abdul Haris Mustari (1995) examined feeding traces of lowland anoa in Tanjung Amolengu Wildlife Reserve in South-East Sulawesi and compiled a list of 33 species, including eight grass species, which had been eaten by the anoa. His observations showed that *Petunga microcarpa*, *Bambusa* sp., and *Hibiscus tiliaceus* were particularly frequently consumed; the mangrove species *Sonneratia alba* was also eaten. Wirawan (1981) lists a number of plant species known to be eaten by (mountain?) anoa in Lore Lindu National Park in Central Sulawesi and Whitten *et al.* (1987b) mention that anoa eat the seeds of *Lithocarpus* spp., *Castanopsis* spp., and *Leptospermum* species - the latter are apparently particularly favoured. *Ficus* spp., *Eugenia* spp., *Palaquium* spp., *Antidesma* spp., young banana trees, bamboo shoots, and rattan sprouts are also known to be eaten by anoas (Anon, 1977 & 1980b). Many of the food species listed in these last two reports are found in secondary or disturbed forest (Jahja, 1987).

Analysis of anoa dung from Mount Rantemario in South Sulawesi confirmed that they are primarily browsers and that graminaceous species form a relatively unimportant part of their diet (Whitten *et al.*, 1987b). Similar results were obtained by Nazir Foead (1992) from his analysis of (mountain?) anoa dung collected in Lore Lindu NP. They do appear to be attracted to areas of newly shooting grass however, and this fact has been used to advantage by hunters who burn areas into which they wish to attract anoas. Faecal analysis has also revealed significant amounts of moss in anoa dung, confirming the suspicions of Van Balgooy and Tantra (1986) who had seen anoas apparently eating mosses in Lore Lindu NP. It has been suggested that anoas may eat mosses as much for their water content as for their nutritive value (Whitten *et al.*, 1987b).

Anoas have been reported to require a mineral rich diet (National Research Council, 1983), but it is unclear exactly what is meant by this claim since many large herbivores need to supplement the small quantities of sodium present in most plants by licking rocks or eating soil that contains relatively high concentrations of sodium salts. Anoa have been observed at mineral licks (M. Patry pers. comm. to Schreiber & Nötzold, 1995) and they have also been seen licking at 'semi-dry mangrove soil' (Abdul Haris Mustari, 1995). It is also interesting to note that surveys carried out in Central Sulawesi failed to find any evidence that mineral licks were used by anoas even though the animals were apparently quite common in the surrounding areas (and the licks were used by deer and pigs); anoa tracks were, however, frequently seen around springs and chemical analysis of water from these springs showed that some of them had high sodium concentrations (Anon, 1979; Wirawan, 1981; Whitten *et al.*, 1987b). Anoa are also known to drink seawater (Whitten *et al.*, 1987b; Abdul Haris Musrai, 1995).

Social Organization and General Behaviour

Very little is known, and much of what has been reported is anecdotal.

Grouping. Most reported sightings of anoas are of lone animals or pairs although a group of five ran past an expedition climbing Mount Nokilalaki in Central Sulawesi (Meijer, 1983). Abdul Haris Mustari (1995) reports 40 observations of which 21 were of single adult males, 3 were of single adult females, 9 were of an adult male with an adult female, 5 were of adult females with infants, and 2 were of an adult female, a subadult male, and an infant; no groups larger than three were encountered (however the estimated population size in his study area was only 8-12 animals).

Anoas appear to live at low density and it has been suggested that the frequent use of mineral springs (inferred from tracks) is of importance socially as well as nutritionally since the springs act as focal points for the animals in the region and this helps bulls locate oestrous females (Watling cited in Whitten *et al.*, 1987b). Hunters also take advantage of this frequent use of springs.

Mating, dominance, aggression, and territorial behaviour. It has been reported that (lowland) anoa are monogamous (Abdul Haris Mustari, 1995). This surprising conclusion - monogamy is a strategy very rarely adopted by ungulates - was based on the belief that adult males did not consort with more than one adult female during the breeding season; however the animals which were studied could only be observed for a small proportion of each month and then only in the more open vegetation types and consequently the observations may well not reflect the real situation. Moreover the same author concluded that anoa were not territorial (see below) giving the doubly unlikely combination of a monogamous but non-territorial ungulate.

Little is known about intraspecific aggression in the anoas. During a year's field study of lowland anoa Abdul Haris Mustari (1995) did not observe any fights although he states that male-male, female-female, and male-female fights do occur, and furthermore 'fighting between individuals frequently takes place.' Anoas have a reputation for aggression towards humans and their 'ferocity and unpredictable behaviour is attested to by villagers and scientists who have spent long periods in the forest, and some of them bear the scars made by the sharp, stout horns' (Whitten *et al.*, 1987b). Young bulls or cows with young are considered especially dangerous (Dolan, 1965; Grzimek, 1990).

There is no evidence that anoa are territorial according to Abdul Haris Mustari (1995); although he did suggest that the soil-scratching behaviour which adult male anoa sometimes exhibit after urinating and defecating, as well as their horning of trees, might indicate territoriality and should be studied further.

Activity patterns. Jahja (1987) states that anoas are shy and largely nocturnal, hiding in dense undergrowth during the day; although such behaviour may be a response to disturbance by humans, particularly hunting, as suggested by Sungkawa (1975). Abdul Haris Mustari (1995) notes that lowland anoa 'spend most of their time in the deep forest' but are active both during the day and the night. The lowland anoa he studied in SE Sulawesi were generally most active in the morning between 0600 and 0900h and in the afternoon after 1600h, spending the period in between these activity-peaks resting and ruminating in the forest. The animals foraged in cropland around the reserve at night.

Like other members of their genus they frequently wallow in mud and water.

Reproductive Biology and Demographic Characteristics

Little is known, and almost all the data refer to captive animals kept in European or North American zoos.

Breeding season and reproductive physiology. Sexual maturity is reportedly attained in the second year for female anoa, and at the beginning of the third year for male anoa (of unspecified type) (Jahja, 1987). It is unclear whether breeding is seasonal in the wild: during a year-long field study in South-East Sulawesi two (lowland) anoa calves were observed, one was estimated to be 3-4 months old in September, the other was 1-2 weeks old in November (Abdul Haris Mustari, 1995). Mating in captive animals does not seem to be restricted to a certain period, although a slight increase in the number of births in March has been reported (Grzimek, 1972). Females are in oestrous for about 24 hours every 22-30 days. The gestation period is reported to be between 275-315 days and generally only a single calf is born (National Research Council, 1983; Jahja, 1987); however twins were born at Planckendael Zoo in 1994 (and they were still alive in June 1995) (G. Nötzold *in litt.*, 1995).

Longevity. The typical life span in captivity is reported to be 20-30 years (Walker *et al.*, 1975; National Research Council, 1983; Grzimek, 1990); although a male anoa kept in San Diego Zoo was 36 years old when it died in 1988 (G. Nötzold *in litt.*, 1995).

Population structure and dynamics. The only available information appears to Abdul Haris Mustari's data from Tanjung Amolengu WR. He estimated that at least 8 (and possibly 12) lowland anoa occurred in the 5 km² reserve; the 8 animals comprised 2 adult males, 3 adult females, 1 young adult male, and 2 infants. Unfortunately the small (and unknown) size of the anoa population occupying this tiny patch of forest and the fact that hunting was known to be taking place in the area during the study (as well as the undefined age-classes) reduce the utility of the data.

Interactions with Domestic Livestock

Anoas are thought to be intolerant of domestic livestock which tend to drive them to higher ground (McNeely, 1978).

Interactions with Other Species

Predators (other than humans). The only potential natural predators are the pythons (*Python reticulatus* and *P. molurus*) and possibly the endemic civet (*Macrogalidia musschembroekii*) which might occasionally prey upon infant anoa (Whitten *et al.*, 1987b).

Potential competitors. Wallace (1869) thought that anoas never occurred in areas where there were deer and while surveys conducted in Central Sulawesi would seem to cast doubt on his suggestion they did reveal that anoas do not appear to use mineral licks which were frequented by deer and pigs (Whitten *et al.*, 1987b). With the present almost total lack of information on the behaviour and ecology of anoas in the wild it is not possible to assess the significance of these findings; however, it is worth noting that lowland anoa and the introduced deer species (*Cervus timorensis*) coexist in the 5 km² Tanjung Amolengu WR in South-East Sulawesi (Abdul Haris Mustari, 1995).

Domestication and Economic and Cultural Importance

Anoas have never been domesticated but they are frequently hunted for their meat (National Research Council, 1983; Jahja, 1987; Schreiber & Nötzold, 1995). It is less clear how valuable their horns and hide are because while the first two references listed above state that these are valued throughout Sulawesi, Schreiber and Nötzold were of the opinion that neither anoa hides nor horns had much commercial value (see the Trade section below). They generally tend to avoid settlements and other frequently used areas and consequently damage caused by them is minimal.

Despite their aggressive and nervous temperament it has been suggested that anoas might make potentially valuable livestock animals. It has also been suggested that the offspring of an anoa x water buffalo cross could produce a useful stock animal. Jahja (1987) reports that captured anoas are often kept as pets and that young anoas are sometimes reared by domestic water buffalo. However, Whitten *et al.* (1987b) remark that while anoas were caught by the Toraja people, who attempted to breed them for meat, their aggressive nature even after several years in captivity meant that they were not used as domestic animals. And Abdul Haris Mustari (1995) interviewed two villagers in Southeast Sulawesi who had tried to domesticate the lowland anoa and who reported that the aggressiveness of the animals had forced them to cut the sharp tips of the horns many times.

Conservation

Population Trend and Current Status

1994 IUCN Red List (Groombridge, 1993): both species are listed as Endangered
CITES: both species are listed in Appendix I
Action Plan Categories: both species are classified as Endangered

Current status: an overview

Too few data exist to quantify the current abundance of either mountain or lowland anoa. Nevertheless they still appear to be relatively widely distributed within (what we know of) their historical range on Sulawesi (see Distribution section, Map 15.1, Table 15.1, & Table 15.2). However there is little doubt that they have been in decline (i.e. there has been a decrease in their range and abundance) since the turn of the century; and no doubt that they have declined over the 1970-1995 period, precipitously in some areas. Hunting and habitat loss have been, and continue to be, the major causes of the decline; with hunting the more serious factor in most, if not all areas (see Threats section & Table 15.3). The current status of both species is consequently a matter for serious concern with anoa populations in small reserves (e.g. Gunung Tangkoko - Dua Saudara NR and Tanjung Amolengu WR) and other forest fragments threatened with local extinction; and even the populations in large protected areas (e.g. Lore Lindu NP or Rawa Aopa - Watumohai NP) and other large forest blocks reportedly in decline as a result of heavy hunting pressure.

Table 15.2 lists all the areas where anoas have been reported to occur in the 1990s; while Table 15.3 provides more details about those areas, as well as listing all the other protected areas (and other sites) in Sulawesi which have previously been reported to contain anoas.

Review of earlier reports

Both lowland and mountain anoa were thought to be quite common at the end of the nineteenth century (Jahja, 1987), although Harper (1945) reported that by the beginning of the twentieth century the anoas were retreating into the interior of the island, abandoning coastal areas where they had previously been numerous. Nevertheless until 1940 both species were still thought to be locally abundant (but probably declining).

Anoas were 'quite numerous' in the eastern peninsula between Luwuk and Poso according to Hanbury-Tenison who visited the area in 1974 (Thornback, 1983).

In the late-1970s and early-1980s anoas were reportedly still widely distributed, and in undisturbed areas of favourable habitat still locally common, occurring in all the remaining forest blocks which had been surveyed. Nevertheless the trend was believed to be downwards due to hunting and habitat loss. In 1979 John MacKinnon reported that lowland anoa had disappeared from, or reached low numbers in many places, particularly near towns and villages where they were heavily hunted. Mountain anoa were also reported to be very rare (MacKinnon, 1979; J. & K. MacKinnon, & R. Watling *in litt.* to J. Thornback, 1979 - 1983).

In 1982 John MacKinnon thought it was probable that each species numbered a few thousand but these figures were, of necessity, little more than guesses (cited in Thornback, 1983).

The authors of a 1983 National Research Council report suggested that the forested areas of the island's central highlands and northern, eastern, and south-eastern peninsulas still contained anoas. They listed a number of nature reserves, Gunung Tangkoko Batuangus - Dua Saudara NR, Gunung Manembo-Nembo GR, 'Panna' [presumably Panua NR?], 'Lobi Mojong' [presumably Pegunungan Latimojong Protection Forest?] and the former Dumoga-Bone NP (now Nani-Wartabone NP), which they suggested could provide refugia for anoas and they concluded that both species were relatively abundant and in no immediate danger.

There have few attempts to assess the status of the anoas since the early-1980s although MacKinnon and MacKinnon (1986) stated that the lowland anoa was the more endangered of the two species; and Jahja (1987) reported that the lowland anoa was restricted to isolated areas of swamp forest, and despite legal protection both species were in decline as a result of hunting and habitat loss.

According to Dolan (1965) anoas were rarely hunted 'prior to the introduction of firearms' because of their reputation as a dangerous quarry but the fact that in the 1990s hunters frequently use snares or hunt with spears and dogs rather suggests that Dolan's assertion is incorrect.

Number of anoas currently in captivity

A total of 89 (47,42) anoas were in reported to be in captivity on 31 December 1992. These animals were held in 19 institutions: seven in Europe, three in North America, and nine in Asia. Of these 89 animals it is thought that 18 (10,8) were born in the wild. All 89 animals were listed as *Bubalus (Anoa) depressicornis* although 8 (6,2) were recorded as representatives of a putative *quarlesi* subspecies (Nötzold *in litt.*, 1993).

Read *et al.* (1994) cite ISIS data which indicate that 50 (27,23) lowland anoa are held in captivity (with three recognized phenotypes designated A, B, and C); and 6 (4,2) mountain anoa (again apparently representing three phenotypes designated A, B, and C).

An international studbook is maintained, the keeper is: Gerd Nötzold, Zoologischer Garten Leipzig, Pfaffendorfer Strasse 29, D-04105 Leipzig, Germany.

The status of the captive breeding programme is reviewed below.

Threats

Hunting

Hunting (mainly for meat) and the loss of suitable habitat are the major threats, and recent reports indicate that hunting is by far the more serious of the two. For example, in and around Lore Lindu NP (Central Sulawesi) local hunters report that 10-20 years ago anoa could be found in areas adjacent to forest gardens but nowadays a hunting party has to walk for between one and three days in order to reach areas affording good anoa hunting, despite the fact that large areas of good forest remain (S. Hedges unpub. observations, 1994). Similarly in Tangkoko - Dua Saudara NR (North Sulawesi) hunting - not habitat loss or degradation - is thought to have been the main cause of the estimated 90% decline in lowland anoa numbers which occurred between 1978/79 an 1993/94 (O'Brien & Kinnaird, 1996).

Hunting pressure is also reported to be heavy in Mayoa area in Central Sulawesi (Schreiber & Nötzold, 1995); the Tanjung Amolengu WR area in South-East Sulawesi (Abdul Haris Mustari, 1995); and the Rawa Aopa - Watumohai NP area also in South-East Sulawesi, where an estimated 100 animals are being taken (mainly snared) every year from the park and surrounding areas (B. Lees pers. comm., 1996).

Anoa hunters generally use snares or hunt using spears and dogs (Whitten *et al.*, 1987b; S. Hedges unpub. obs., 1989 & 1994; Abdul Haris Mustari, 1995; Schreiber & Nötzold, 1995; B. Lees pers. comm., 1996). Hunters also set fires to attract and make the hunting of anoas easier (Whitten *et al.*, 1987b).

In rural areas there appears to be little awareness of the protected status of the anoas and villagers in Central Sulawesi readily recounted their experiences to Schreiber and Nötzold (1995), even inviting themn to participate in a hunting trip. In towns, however, (some) shop-keepers selling anoa trophies are aware that this is illegal and are consequently reluctant to reveal the origins of the specimens (Schreiber & Nötzold, 1995), although Melisch (1995b) was able to obtain information about the trophies he found for sale in Rantepao.

Loss of suitable habitat

Although hunting is currently the most serious threat to the anoas the imoportance of the threat posed by loss of habitat must not be forgotten. Many anoa populations are becoming isolated as the forest around the protected areas is cleared or converted to plantations. For example, Tangkoko - Dua Saudara NR was formerly the core of a large block of forest that included Wiau Protection Forest and was contiguous with the forests of Gunung Klabat; but today much of the Wiau forest has been converted to coconut plantations and only a small patch of forest remains at the summit of Gunung Klabat. Tangkoko - Dua Saudara is thus effectively isolated (O'Brian & Kinnaird, 1996). Similarly the anoa population in the small Tanjung Amolengu NR is isolated because anoas are no longer able to move between Tj. Amolengu and the nearby Tanjung Peropa NR because of an increase in the size of the human settlements between the two areas (Abdul Haris Mustari, 1995).

Loss of suitable habitat within protected areas is a problem too: for example the expansion of agricultural and/or settled areas, logging, mining, and fires are problems in many areas (see Table 15.3). However assessing the scale of the threat posed to the anoas by shifting agriculture, fires, etc. is hampered by our ignorance of their habitat requirements (see Habitat section).

Trade

There have been occasional reports of illegal trade in live animals in the past, for example Anon (1976b) reported that an animal trader in south-east Asia was selling a pair of lowland anoa at US$3000 each. However, no significant international trade in either live animals or body parts has been reported in recent years.

The main reason for the widespread hunting of anoas is to obtain meat for local consumption (Thornback, 1983; Schreiber & Nötzold, 1995). Anoa skulls and horns do not seem to be particularly valued as trophies by the hunters themselves; for example, Schreiber and Nötzold report seeing 'hastily prepared' horns attached to partial skulls which they were offered as presents after only a few minutes of showing their interest. Souvenir shops in Toraja Land (e.g. in Rantepao and Makale) do, however, sell anoa horns and skulls, and the occasional mounted head; but these trophies are also poorly prepared and some are carbonized (hunters generally singe the hairs off carcasses before butchering them) and while quantitative data is unavailable the trade in trophies does not appear to pose a serious threat to the anoas (S. Hedges unpub. obs. 1989; Schreiber & Nötzold, 1995). Nevertheless Melisch (1995b) suggests that the

Table 15.1 Present-day distribution of wild anoas (see text for further details)

Region	Province	Occurs?	Evidence
		Lowland anoa	
Northern peninsula (= Minahassa Peninsula)	North Sulawesi	Yes	- Skulls/horns (from Nani-Wartabone NP) examined recently (1994) - Recent (1990s?) film of wild anoa (in the Gorontalo area) - Karyotype data (from specimens obtained in the 1990s?) - Historical presence demonstrated by Groves
Central highlands: Donggala area (*ca.* 45 km NNW of Lore Lindu)	Central Sulawesi	Possibly	- Historical presence demonstrated by Groves
Central highlands: Lore Lindu NP	Central Sulawesi	Possibly	- Reports from park rangers (in 1994)
Southern peninsula: south of Toraja Land	South Sulawesi	Possibly	- Historical presence demonstrated by Groves
Northern end of SE peninsula: Malili area (*ca.* 120 km SE of Lore Lindu)	South Sulawesi	Possibly	- Historical presence demonstrated by Groves
South-eastern peninsula	South-East Sulawesi	Yes	- Carcasses and skulls/horns examined recently (1994 & 1995) - 1994/95 photographs of wild anoa (in Tanjung Amolengu WR) - Historical presence demonstrated by Groves
Buton (= Butung) Island	South-East Sulawesi	Possibly	- Listed in a 1982 report
		Mountain anoa	
Northern peninsula (= Minahassa Peninsula)	North Sulawesi	Yes?	- Skulls/horns (from Nani-Wartabone NP) examined recently (1994) - Historical presence demonstrated by Groves (and? by a wall-painting in Nani-Wartabone)
Central highlands: Lore Lindu NP	Central Sulawesi	Yes	- Recent (1990s?) specimen photographed and karyotyped - Historical presence demonstrated by Groves
Central highlands: Mayoa area (*ca.* 20 km SE of Lake Poso)	Central Sulawesi	Yes	- Specimens killed by hunters were examined recently (1994)
Central highlands: Pompangeo Mountains (*ca.* 40 km E of Lake Poso)	Central Sulawesi	Possibly	- Recent (1990s?) specimen photographed and karyotyped but phenotypically the animal did not appear to be a 'typical' mountain anoa
Eastern peninsula: Morowali NR	Central Sulawesi	Possibly	- Reported in the 1970s
Toraja Land (= Tanatoraja)	South Sulawesi	Yes	- A captive female (reportedly from the Makale area) examined in 1994 - Skulls/horns (in shops in Rantepao) examined recently (1993 & 1994) - Historical presence demonstrated by Groves
Southern peninsula: south of Toraja Land	South Sulawesi	Possibly	- Historical presence demonstrated by Groves
South-eastern peninsula	South-East Sulawesi	Possibly	- Recent (1990s?) reports of unknown origin and quality - Historical presence demonstrated by Groves
Buton (= Butung) Island	South-East Sulawesi	Yes	- A captive female was photographed in 1994 or 1995 - Historical presence demonstated by Groves

Table 15.2 Areas where anoas have been reported to occur in the 1990s

Area	Type	Year	Evidence
North Sulawesi Province			
Tangkoko - Dua Saudara NR	lowland	1994	sightings by biologists
Gunung Manembo-Nembo GR	unspecified	1994	reports from local informants
Nani-Wartabone (formerly Dumoga-Bone) NP	both?	1994	reports from park rangers
& the Paguyaman area west of the park	lowland	1992	reliable reports that anoas were being hunted
Gorontalo area	lowland	1990s	film of wild anoa
Central Sulawesi Province			
Lore Lindu NP	both?	1994	reports from park rangers
	unclear	1994	reports from local hunters (and horns from mountain anoa killed by them were seen)
	mountain	1990/91	field study
	mountain	1990s	specimen obtained, photographed, and karyotyped
Pompangeo Mountains (E of Lake Poso)	mountain?	1990s	specimen obtained, photographed, and karyotyped
Mayoa area (SE of Lake Poso, close to Pegunungan Peruhumpenai NR in South Sulawesi)	mountain	1994	reports from local hunters (hunting was reportedly intense) and specimens examined by biologists
South Sulawesi Province			
Toraja Land: generally	mountain	1994	mountain anoas reportedly widespread (based on information from local informants and the large number of skulls/horns (and a head) for sale in Rantepao). (1989 reports from local hunters also suggested that anoa of unspecified type were still widespread, if uncommon, in the Quarles Mountains between Mamasa and Rantepao.)
Toraja Land: Makale area	mountain	1994	a captive female reportedly originating from the area around Makale was examined by biologists
Toraja Land: Latimojong Mountains (SE of Rantepao)	mountain	1993	the reported place of origin of two mountain anoa trophies (frontals with horns) found for sale in Rantepao
South-East Sulawesi Province			
Rawa Aopa Watumohai NP & environs	unspecified	1990s	reports (from local informants) that anoa were being hunted (*ca.* 100 animals/year)
Tanjung Peropa WR	unspecified	1990s	reports of unknown quality
Tanjung Amolengu WR	lowland	1994 & 1995	field study/sightings by a biologist (photographs taken & skulls/horns collected)
Tanjung Batikolo WR	unspecified	1990s	reports of unknown quality
Kolaka Utara NR	unspecified	1990s	reports of unknown quality
Toronipa WR	unspecified	1990s	reports of unknown quality
Buton Utara NR (on Buton Island)	mountain	1994 or 1995	a captive adult female was examined and photographed by a biologist

presence of anoa trophies in tourist shops is a worrying development.

Other threats

In addition to hunting and the loss of suitable habitat, Grzimek (1990) suggested that diseases may have been partly responsible for the decline of the two species; and the presence of domestic or feral livestock, as well as introduced deer populations, in many areas obviously presents a risk to the anoas in those areas. Table 15.3 gives further information about this and other threats to the anoas and their habitat.

Table 15.3 Areas reported to contain anoas and the major threats to those areas

North Sulawesi Province

Gunung Klabat NR (53 km^2). Lowland anoa listed by FAO (1982a). Several other species of conservation importance occur in the area including *Macaca nigra*, the endemic Sulawesi civet (*Macrogalidia musschenbrockii*), and the endemic nightjar (*Eurostodus diabolicus*). The FAO report lists hunting, orchid collecting, firewood gathering, and agricultural encroachment as the main threats to the integrity of the area.

Gunung Tangkoko - Dua Saudara NR (89 km^2). The reserve contained a small population of lowland anoa according to FAO (1982a) and a recent (September 1994) report indicates that anoa 'very probably of the lowland type' still occur; however it was suggested that they may be confined to high altitudes, which if correct would mean that they have a very limited range in this small reserve (Schreiber & Nötzold, 1995). O'Brien and Kinnaird (1996) conducted surevys in the reserve between April 1993 and March 1994 and, comparing their results with the data collected by MacKinnon and MacKinnon in 1978/79, they concluded that the anoa population had declined by 90% and was on the verge of local extinction. Other mammal species of interest include *Babyrousa babirussa*, *Macaca nigra*, and *Phalanger ursinus*. Threats include agricultural encroachment, especially the establishment of coconut plantations; fires, and hunting which is heavy throughout the reserve (WCMC, 1991; Schreiber & Nötzold, 1995; O'Brien & Kinnaird, 1996).

Gunung Manembo-Nembo GR (65 km^2). Anoa were listed by FAO (1982a) and two independent informants mentioned that anoa still survived in the area in September 1994 (A. Schreiber & G. Nötzold *in litt.*, 1995). A small population of *Babyrousa babyrussa* was the main reason for establishing the reserve. FAO (1982a) listed agricultural encroachment, illegal clove plantations, and hunting as the main threats and considered the reserve a low priority area.

Gunung Ambang NR (86 km^2). Lowland anoa were relatively common in the more remote regions (WCMC, 1991; citing the 1979 management plan). Other notable mammals include the Celebes black macaque (*Macaca nigra*) and the Greater Sulawesi tarsier (*Tarsius spectrum*). Several endemic bird species also occur in the reserve.

Nani-Wartabone NP (formerly Dumoga-Bone NP) (3000 km^2). Both lowland and mountain anoas are reported to occur by park rangers, and lowland anoa have recently been filmed in the nearby Gorontalo area (Schreiber & Nötzold, 1995). The park was reported to have the largest anoa population on Sulawesi by MacKinnon and MacKinnon (1986): but it is unclear what evidence this statement was based on. This very important protected area has also been reported to be the main stronghold of *Babyrousa babyrussa*; and contains many other mammals of interest including *Macaca nigra*, *M. tonkeana*, *Tarsius spectrum*, *Phalanger ursinus*, and *P. celebensis* (MacKinnon & MacKinnon, 1986). The most important threat to the park is illegal gold-mining, with groups of up to 300 gold-diggers living in semi-permanent camps deep within the park. The forest has been destroyed or seriously degraded in a wide area around these camps and wild animals are hunted for food by the gold-seekers. The mining activities reportedly occur throughout the park, with a concentration around the Toraut area in the east. The newly established Wallacea research institute in North Sulawesi has called for international protests (Anon, 1994b). Other threats to the park include the encroachment of shifting cultivation, particularly on the western boundary; rattan collecting, and hunting (WCMC, 1991; Anon, 1994b). In addition the possibility that copper may be mined in the Bone River catchment poses serious problems for environmental management in the area. Other potential threats include road development, logging of adjacent forest blocks, and the collection of produce within the park by local people (Wells, 1989; WCMC, 1991).

Gorontalo area (to the west of Nani-Wartabone NP). Lowland anoa were filmed recently by Maurice Patry (Schreiber & Nötzold, 1995).

Paguyaman area (to the west of Nani-Wartabone NP). Lowland anoa still occur (and are hunted) according to recent reports (K. MacKinnon, pers. comm. 1992).

Marisa Complex (940 km^2). **1) Panua NR** (15 km^2): a small nature reserve which was established to protect an important maleo (*Macrocephalon maleo*) nesting area; lowland anoa were listed in 1982 along with babirusa and *Macaca tonkeana*. Threats to the area included cattle grazing and the establishment of coconut plantations. The reserve is bisected by a public road (FAO, 1982a). **2) Randangan Proposed NR**: anoa are not listed. **3) Tanjung Panjang Proposed NR** (30 km^2): the area is/was important for the conservation of endemic species as well as for the protection of an important catchment but anoa are not mentioned in the FAO conservation plan for Sulawesi (FAO, 1982a).

Central Sulawesi Province

Pulau Dolongan (in the Buol Toli-toli area). The Sulawesi section of the National Conservation Plan for Indonesia (FAO, 1982a) reported that the island provided a refuge for anoa, babirusa, maleos, and other wildlife; and listed human disturbance as the major threat.

Gunung Sojol proposed NR (500 km^2). In 1982 the area contained undisturbed montane forests with an abundance of wildlife including anoa and babirusa. There were reportedly few threats (FAO, 1982a).

Lore Lindu NP (2310 km^2). Both mountain and lowland anoa occur according to PHPA reports and park rangers (Nazir Foead, 1992; S. Hedges unpub. observations, 1994; Schreiber & Nötzold, 1995). That mountain anoa occur is certain: Prof. Nawangsari Sugiri (Institut Pertanian Bogor, Java) recently (1990s?) obtained, photographed, and karyotyped a specimen of mountain anoa (Schreiber & Nötzold, 1995); and in 1994 Hedges examined horns from mountain anoa killed by local hunters; in addition Meijer (1983) reported seeing a group of five mountain anoa. There have also been at least two recent field studies of mountain anoa (Nazir Foead, 1992; Sugiharta, 1994). The presence of the lowland type is more doubtful, however, because the descriptions given by park rangers were rather vague and their belief that both types of anoa occur seemed to be based largely on habitat utilization rather than any obvious difference in the animals' appearance (S. Hedges unpub. observations, 1994). Local hunters also reported the presence of anoa of unspecified type (but mountain anoa horns were seen in locals' houses); furthermore the hunters were of the opinion that anoa numbers had declined because 10-20 years ago anoa could be found in areas adjacent to forest gardens but nowadays they have to walk for between one and three days in order to reach areas affording good anoa hunting (S. Hedges unpub. observations, 1994). According to Whitten *et al.* (1987b) frequent reports had suggested that anoa dung could often be seen along the logging road on Mount Roroka but when they visited the area very few signs of anoa were found. They speculate that this might represent a seasonal phenomenon, but the fact that many traps and snares which had been set for anoa were found and destroyed does not encourage optimism. They also suggest that the death of a PHPA ranger in the park was in some way connected with anoa poaching in the area. In addition to hunting the integrity of the park is potentially threatened by a planned hydroelectric development in the Lake Lindu area (WCMC, 1991). Apart from the anoas other notable mammals known to occur within this large and valuable national park include *Macaca tonkeana*, *Tarsius dianae*, *Babyrousa babyrussa*, and the two phalangers *Phalanger ursinus* and *P. celebensis* (WCMC, 1991).

The **Bada valley** to the south of Lore Lindu NP still contained anoa (of unspecified type) in 1989 according to local villagers (S. Hedges unpub. observations, 1989); and a stew containing minced anoa meat was offered to Melisch in 1993 (Melisch, 1995).

Mayoa area (SE of Lake Poso and close to Pegunungan Peruhumpenai NR in South Sulawesi). Mountain anoa specimens killed by local hunters were examined in 1994 by Schreiber and Nötzold (1995); and hunting was reportedly intense.

Pompangeo Mountains (east of Lake Poso and west of Morowali NR). A specimen was obtained, photographed, and karyotyped by Prof. Nawangsari Sugiri (Institut Pertanian Bogor, Java) in the 1990s (?). Phenotypically the animal did not resemble the dark coloured and woolly-haired mountain anoa of Toraja Land (South Sulawesi) but the animal's karyotype suggested that it was probably a mountain anoa (Schreiber & Nötzold, 1995; see Distribution section).

Morowali NR (2250 km^2). Mountain anoa were reported to occur (WCMC, 1991 citing 1980 management plan). Other notable mammal species include babirusa, both phalanger species, *Macaca tonkeana*, and *Tarsius spectrum*. The reserve also has important hydrological protection value. The chief threats to the area stem from the over-exploitation of forest products including rattan, resin, and maleo eggs. Potential problems include logging since much of the lowland area has been granted as a forestry concession (WCMC, 1991).

Tanjung Api NR (42 km^2). Anoa were listed along with *Sus celebensis*, *Babyrousa babyrussa*, *Phalanger ursinus*, and *Macaca tonkeana* (FAO, 1982a). Threats listed by FAO included agricultural activities and timber extraction on the southern border and an enclave on the northern coast.

South Sulawesi Province

Pegunungan Peruhumpenai NR (900 km^2). In 1982 the area was reported to have extensive forests containing a wealth of wildlife including anoa, babirusa, megapodes, and *Macaca tonkeana*. Mountain anoa probably still occur because in 1994 specimens killed by local hunters were examined in Mayoa (to the north of the reserve) (Schreiber & Nötzold, 1995). The authors of the FAO report recommended surveying the area, writing a management plan, and improving the guarding. Threats included hunting and clearing of lowland forest along the river valleys (FAO, 1982a).

Masupu Proposed GR (25 km^2). Mountain anoa were reported but the area was threatened by shifting agriculture and hunting (FAO, 1982a). The area originally proposed was too small (2500 ha) to have any real conservation value and FAO recommended either increasing the area to be included in the reserve or dropping the proposal.

Mamasa area and Mambuliling Proposed GR (100 km^2). The montane forests above the Mamasa river were reportedly inhabited by anoa in the early 1980s (FAO, 1982a); and reports from local villagers (including hunters) suggested that anoa were still widespread, if uncommon, in the mountains between Rantepao and Mamasa in 1989 (S. Hedges unpub. observations, 1989). Threats included shifting agriculture and hunting (FAO, 1982a). Although the authors of the FAO report did not consider the area to have high conservation value they suggested that if surveys revealed a good population of anoa the proposed reserve could be extended to join the large area of Protection Forest on the adjacent plateau.

Lampuko-Mampie (20 km^2). Anoa were reported to occur in this low-lying swampy area in the early 1980s (FAO, 1982a); but according to a more recent report the majority of the area has been converted into fishponds, and anoa are not mentioned (Scott, 1989).

Makale area. In 1994 a confiscated female mountain anoa was examined in the town of Makale where it was kept in a swampy meadow by the 'mayor' [= *bupati*?], the animal was reported to have come from the area around Makale (which lies *ca.* 16 km NW of the Pegunungan Latimojong Protection Forest) (Schreiber & Nötzold, 1995).

Pegunungan Latimojong Protection Forest (580 km^2). A National Research Council report (1983) suggests that the area could provide a refuge for anoa and Whitten *et al.* (1987b) report that the Mount Rantemario area still contained anoa. Two mountain anoa trophies on sale in Rantepao in 1993 reportedly came from animals killed in the Latimojong Mountains (Melisch, 1995b).

Bulusaraung NR (57 km^2). Anoa and *Macaca maura* were reported to occur in this small and isolated patch of mountain-top forest. Most of the reserve is covered in secondary and heavily disturbed forest, and grasslands (but it still had hydrological protection value in 1982). The primary threat was deforestation resulting from shifting cultivation. According to FAO (1982a) 'the reserve has very little conservation value and does not warrant any expensive development.'

South-East Sulawesi Province

Lasolo-Sampara Proposed NR (450 km^2). Anoa were reported to occur in the forests surrounding the cultivated lowland areas in the Lawe Solo river valley. The integrity of the area was threatened by hunting, logging, and shifting cultivation (FAO, 1982a). The FAO team recommended redesigning the proposed reserve to exclude the human settlements and disturbed forest areas.

Rawa Aopa - Watumohai NP (2000 km^2) (comprises Rawa Aopa Proposed GR (1500 km^2) and Gunung Watumohai HR (500 km^2)). Lowland anoa were reported to occur in the Rawa Aopa area but they were apparently not very common (Anon, 1984; Petocz, 1989a; WCMC, 1991). Mountain anoa were also reported to occur in montane forests close to Rawa Aopa (Zwahlen, 1992 citing 1978 & 1983 PPA reports). Anoa of unspecified type still occured in the mid-1990s but hunting pressure was reportedly high, with an estimated 100 animals being taken (mainly snared) every year from the park and surrounding areas (B. Lees pers comm., 1996). Earlier reports have also mentioned anoa hunting in the area; other threats include fires, forest clearance, and rattan harvesting (FAO, 1982a; Whitten *et al.*, 1987b; Petocz, 1989a; Scott, 1989; Zwahlen, 1992). Introduced deer (*Cervus timorensis*) and feral water buffalo (*Bubalus bubalis*) also occur in the area, posing a possible disease risk to the anoas. It has been suggested that the deer population be managed as a sustainable resource for the local population (Petocz, 1989a). There were plans, several years ago, to mine and burn the peat from the Rawa Aopa peatswamp to generate electricity but so far investors have been more attracted by the much larger peat deposits in Sumatra and Kalimantan (Whitten *et al.*, 1987b). The area's major attractions are reported to include fishing and traditional horseback deer hunts (Anon, 1985a), but the authors of the FAO report recommended changing the status of the area since it was considered too important a site for hunting to be allowed (the current legal status of the area is unknown). The Rawa Aopa peatswamp already forms much of the northern part of the Rawa Aopa - Watumohai NP but expansion of the park to include a greater proportion of the swamp has been proposed (Zwahlen, 1992).

Polewali (Tenggara) Proposed GR (80 km^2). Although much of the proposed reserve had already been destroyed by 1982 there were still some good patches of lowland forest and mangroves remaining and a reportedly wide variety of wildlife including anoa. Threats included land clearance and shifting agriculture (FAO, 1982a). The FAO team recommended redrawing the borders of the reserve to include only the relatively undisturbed western part.

Tanjung Peropa GR (390 km^2). Anoa are reported by Abdul Haris Mustari (1995) citing unspecified [presumably PHPA?] reports.

Tanjung Amolengu GR (5 km^2). An estimated 8-12 lowland anoa occurred in this very small reserve in 1995; the estimate was based on a combination of concentration counts, transects, and footprint counts. Hunting (especially the use of snares) is a significant problem in the reserve: both anoa and deer (introduced *Cervus timorensis*) are taken. During a year-long stay in the area 13 anoa skulls were collected; of these 13 animals, 10 had been snared, 2 had been killed by people while swimming at sea, 1 was speared, and 1 was found after a natural death. The reserve is also exploited by local people as a source of timber, fire-wood, rattan, bamboo, honey, etc. Furthermore the reserve is becoming increasingly isolated as a result of the expansion of surrounding villages and cultivated areas and anoa may no longer be able to move between this area and the Tanjung Peropa GR to the north (Abduk Haris Mustari, 1995).

Tanjung Batikolo GR (55 km²). Reported to be rich in wildlife including anoa, booted macaque (*Macaca ochreata*), hornbills, and maleo birds in the 1970s; the area was threatened by land clearance (FAO, 1982a). Anoa reportedly still occur (Abdul Haris Mustari, 1995 citing unspecified [presumably PHPA?] reports).

Kolaka Utara NR (7 km²). Anoa are reported by Abdul Haris Mustari (1995) citing unspecified [presumably PHPA?] reports.

Toronipa NR (20 ? km²). Anoa are reported by Abdul Haris Mustari (1995) citing unspecified [presumably PHPA?] reports.

<u>Buton (= Butung) Island (SE Sulawesi Province)</u>

Buton Utara GR (820 km). Lowland anoa were reported to occur by FAO (1982a). A captive adult female mountain anoa [originating from this reserve?] was examined and photographed in 1994 or 1995 by Abdul Haris Mustari (1995). In addition to anoas the reserve was reported to be rich in wildlife including *Macaca ochreata* and maleo birds; coastal clearance was the chief reported threat (FAO, 1982a). The FAO team recommended that a survey be made so that a detailed management plan could be written and that this 'very valuable reserve' be well guarded.

Lambu Sango Proposed NR (200 km²). This proposed reserve was reported to contain anoa and babirusa but the integrity of the area was threatened by fires (of human origin) and hunting. The FAO team recommended carrying out a feasibility study before the area was processed further (FAO, 1982a).

<u>Abbreviations</u>. Protected area status codes: GR = game reserve, HR = hunting reserve, NP = national park, NR = nature reserve. Other: PHPA = Directorate General of Forest Protection and Nature Conservation (of the Ministry of Forestry, Government of Indonesia). PPA = Directorate of Nature Conservation and Wildlife (the predecessor to PHPA).

<u>Sources</u>. Protected area status and size: WCMC (1991) and Abdul Haris Mustari (1995).

Conservation Measures Taken

Legislation

Indonesia. Anoas (unspecified species) have been legally protected in Indonesia since 1931 (Jahja, 1987). Information from IUCN suggests that while *Bubalus quarlesi* receives total protection under Indonesian law the status of *B. depressicornis* requires clarification (IUCN-ELC *in litt.*, 1991).

International. *Bubalus quarlesi* and *Bubalus depressicornis* are both included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); the listing includes the generic synonym *Anoa* (Source: CITES Appendix I as adopted by the Ninth Meeting of the Conference of the Parties, and valid from 16 February 1995).

Protection of anoas and their habitat

Sulawesi boasts an impressive number of protected areas, many of which are believed to contain anoas (Tables 15.3 & 15.4); unfortunately however, most of these areas are poorly managed and in practice provide little protection for their wildlife (MacKinnon & MacKinnon, 1986).

Captive Breeding

Schreiber *et al.* (1993) review the status and history of the captive anoa population and much of the following information is drawn from their paper. The captive population (89 animals, 8 of which are listed as *quarlesi*, as of 31 December 1992 (Nötzold *in litt.*, 1993) is reported to be descended from fifteen founders. These animals were imported from zoos in Indonesia or Malaysia, or from animal dealers, by Antwerp, (West) Berlin and Leipzig zoos (in Germany); Namegawa Island zoo (in Japan); and Rotterdam zoo (in the Netherlands). Their places of origin within Sulawesi are unknown.

Studbook recommendations have, of necessity, been rather general because of the uncertainty surrounding the taxonomic affiliations of the captive animals. Biometric and photographic assessment of the founders of the Antwerp, Rotterdam, and Leipzig lines have indicated their phenotypic similarity; these populations have subsequently been hybridized. The anoa imported by the Berlin and Namegawa Island zoos have been bred in isolation and the surviving groups remain small. Offspring of the Namegawa Island and Antwerp/Leipzig/Rotterdam lines appear to have been crossed at San Diego Zoo. The anoa at Krefeld zoo, descendants of animals originally imported by Berlin Zoo, have been listed as mountain anoa: at present only one breeding pair remains and these are brother and sister. Of the eight animals listed as mountain anoa only two are female. The breeding programme has been greatly hindered by the difficulties of assigning captive anoa to appropriate taxa. In addition the anoas do not appear to be easy animals to breed in captivity. Grzimek (1990) emphasizes the difficulties and reports that they are very vulnerable to 'feeding errors', infectious diseases, and endoparasites. Their aggressiveness poses problems too, not least by increasing the space required to maintain adequate numbers. Certainly neither species can be considered well established and the status of the mountain anoa is particularly unsatisfactory. However the survival rate of the calves is reportedly good and adults have a long reproductive life (in captivity at least) so there is perhaps room for cautious optimism. Further information can be found in Dolan (1965), Pournelle (1965), Seifert *et al.* (1974), Seifert, (1984), Thomas *et al.* (1986), Jahja (1987), Seifert and Nötzold (1988), Schreiber *et al.* (1993), and Schreiber and Nötzold (1995).

ANOA

Bubalus quarlesi & Bubalus depressicornis

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

22 - 26 July 1996

Taman Safari Indonesia
Cisuara, Indonesia

REPORT

APPENDIX I

CBSG PROCESSES
GLOSSARY
IUCN REINTRODUCTION GUIDELINES

CBSG **Population and Habitat Viability Assessment (PHVA) Processes**

Information on Capabilities of Conservation Breeding Specialist Group (CBSG/SSC/IUCN)

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, on the characterization of their risk of extinction, on the effects of management interventions, and the possible effects of future events.

The Conservation Breeding Specialist Group (CBSG) of IUCN's Species Survival Commission (SSC) has developed and applied a series of scientifically-based tools and processes to expedite species management. 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 workshop environment and a neutral facilitation process that supports sharing of available information, reaching agreement on the issues and available information, and then making useful and practical management recommendations for the taxon and habitat system under consideration. The process has been remarkably successful in unearthing and integrating previously unpublished information; its proven heuristic value and constant refinement and expansion have made it 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 humans living within the range of the threatened species as well as established international interests. There are characteristic patterns of human behavior that appear cross-disciplinary and cross-cultural: 1) in the acquisition, sharing, and analysis of information; 2) in the perception and analysis of risk; 3) in the development of trust among individuals; and, 4) in 'territoriality' (personal, 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 consensus on needed conservation actions.

Frequently, needed management actions have been identified by local management agencies, consultants, and local experts. An isolated approach, however, seems to have little effect on the needed political and social changes (social learning) for effective management and conservation of 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. One goal in all workshops is to reach a common understanding of the state of scientific knowledge available and its possible application to needed management actions. We have found the workshop process with stochastic simulation modelling, risk assessment, and scenario testing to be a powerful tool in extracting, assembling, and exploring this information and developing a shared understanding across wide boundaries of training and expertise. This tool also supports consensus and instills ownership and pride during the workshop process. As participants appreciate the complexity of the problems as a group, they have a tendency to take more ownership of the process as well as the ultimate recommendations to achieve solutions. This is essential if the management recommendations generated by the workshops are to succeed.

CBSG has learned a host of lessons in its more than 100 workshop experiences. Our traditional approaches have tended to emphasize our lack of information and the need for additional research. This has been coupled with a hesitancy to make risk assessments of species status and a reluctance to make immediate or non-traditional management recommendations. The result has been long delays in preparing action plans 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. Modelling is an important tool as part of the process and to provide a continuing test of assumptions, data consistency, and of scenarios. It recognizes 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 programs on the basis of sound science while allowing new information (that eventually becomes available) to be used to adjust and further refine management practices.

Workshop Processes and Multiple Stakeholders

Experience: The Chairman and Program Officers of CBSG have conducted and facilitated more than 100 species and ecosystem Workshops in 35 countries including the USA during the past 5 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) and have assisted in the development of national conservation strategies for other taxa (e.g., 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 experienced in such workshops. These facilitator's training workshops have proven very popular with 3-4 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. *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 at one and 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 and management processes. *We will apply the same scientific study tools to the workshops in this program and provide an analysis of the results after each workshop.*

Stochastic Simulation Modelling

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 for internal consistency. Timely reports from the workshop are necessary to have 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 events at the local 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 during the course of this project 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 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, of course, 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 solutions.
- Population modeling forces discussion on biological and physical aspects 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), management, and monitoring. This not only influences assumptions, but also the group's goals.
- Population modelling 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 consensus 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.

Modelling Tools: At the present time, our preferred model for use in the population simulation modelling process is called 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 models, but presently they have some limitations such as failing to measure genetic effects, being difficult to use, or failing to model individuals. VORTEX has been successfully used in more than 70 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 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 modelling tools. More than 2000 copies of VORTEX are in circulation and it is being used as a teaching tool in university courses.

It is our plan to use this model and the experience we have with it as a central tool for the population dynamic aspects of this project. Additional modules building on other simulation modelling tools for 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 will be developed to provide input into the salmon population model whose outputs can then be used to evaluate possible effects of different management scenarios. No such composite models are available. There is a lack of general acceptance among stakeholders of the available salmon population models.

CBSG Resources as Unique Asset

Expertise and Costs: The problems and threats to salmon are complex and interactive with a need for 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 local stake, and for active transfer of wanted 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 will call upon individual experts to assist in all phases of this project.

Indirect cost contributions to support: Although not detailed in the proposal, use of CBSG resources and the contribution of participating experts will provide a documentable matching contribution more than equaling the proposed budget request for the project. We also have not requested indirect costs for overhead.

Manuals and Reports: We have manuals available which provide guidance on the goals, objectives, and preparations needed for our workshops. These will reduce startup time and costs and allow us to begin work on organizing the 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 will also be prepared on the mini-workshops (working groups) that will be conducted in information gathering exercises with small groups of experts and stakeholders. We can print reports within 24-48 hours of preparation of final copy. We also have CD-ROM preparation facilities, software and experience.

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.

ANOA

Bubalus quarlesi & Bubalus depressicornis

POPULATION AND HABITAT VIABILITY ASSESSMENT WORKSHOP

22 - 26 July 1996

Taman Safari Indonesia
Cisuara, Indonesia

REPORT

APPENDIX II

PRESENTATIONS

DEPARTEMEN KEHUTANAN
DIREKTORAT JENDERAL PERLINDUNGAN HUTAN DAN PELESTARIAN ALAM
TAMAN NASIONAL DUMOGA - BONE
Jln. AKD, Telp. (0434) 22548 Fax 22547 Kotak Pos 106 Kotamobagu 95716
SULAWESI UTARA

PENYEBARAN ANOA DAN BABIRUSA DI TAMAN NASIONAL BOGANI NANI WARTABONE

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H

SRI WINENANG*

KOTAMOBAGU, JULI, 1996

* Staf Taman Nasional Bogani Nani Wartabone

THE DISTRIBUTION OF ANOA AND BABIRUSA IN BOGANI NANI WARTABONE NATIONAL PARK AREA

I. INTRODUCTION

A. BACKGROUND

Anoa and babirusa are the two of the unique and endemic animals which are relatively easy found in Bogani nani Wartabone National Park area. There are 2 species of anoas live in this Park namely lowland anoa (Bubalus depressicornis) and mountain anoa (B. quarlessi). For babirusa, we have only one species, Babyroussa babirussa.

Bogani Nani Wartabone National Park is much considered as the most important conservation area in North Sulawesi Province. As a matter of fact, this Park, with its large about 287.115 ha (almost 10 % of the Province area), is the largest conservation area in North Sulawesi of which this primary forest stretches out from Bolaang Mongondow Regency to Gorontalo Regency. This virgin forest still contains a lot of nature biodiversity and natural resources.

That enormous natural resources might be caused by its unique location of the island. We have already known that Sulawesi island iis located on the transition zone of the two important biogeographic zones, Asian and Australian. This area is more welknown as Wallacea Area.

As the transition zone, this island contains both of those two biogeographic diversities. That is more obvious and significant when we take a look at the fauna species found there. Besides that, there are a lot of endemic animals, it might be caused by the hybridization process of the two fauna types.

B. HISTORY OF THE NATIONAL PARK ESTABLISHMENT

This Park is located in North Sulawesi Province, about 4 hours by plane from Jakarta.

At the first time, the name of Dumoga Bone National Park was announced by the Ministry of Agriculture with his decree No. 736/Mentan/X/1982 dated on October 14, 1982, at the third World National Park Congress in Bali. That chosen area included three conservation areas established before namely Dumoga Sanctuary Zone, Bone Sanctuary Zone, and Bulawa Nature Protection. This united area was also named as Dumoga Bone National Park area by the decree of the Ministry of Forestry No. 731/Kpts-II/91 dated on October 19, 1991.

So, there was no different between the name of organization and its area at that time.

But then, the local government of North Sulawesi Province asked the Ministry of Forestry to change that later name to Nani Wartabone National Park. The Ministry of Forestry agreed to change only the area name by his Decree No. 1068/Kpts-II/1[illegible] dated on November 19, 1992. This name was no longer exist, because again, the local government suggested to change the later name to Bogani nani Wartabone National Park. And the Ministry of Forestry also agreed about this by his Decree No. 1127/Kpts-II/1992 dated on December 19, 1992.

The organization name still remains unchange namely Dumoga Bone National Park

ANIMAL DISTRIBUTION

In this Park, the actual distribution of these two species, anoa and babirusa, has not known precisely yet. Even there is a very little available data of these animals. I think this might be caused by their unique characters and limited populations and not many people, especially scientists, do not much interest in this matter. And the writer has not seen any scientist conduct the research on this kind of problems in the Park thus far.

Therefore, some information about characters of these animals presented here mainly comes from the experience oof the writer and his staffs while living in the Park area.

This is our information.

In general, we can say that these animals can be found relatively easy in the whole Park area, scattered out from Bolaang Mongondow Regency to Gorontalo Regency. This is possibly caused by the large primary forest exists there or by their large home ranges.

In particular, anoa is very often found in Poniki Mountain (1.817 m) and its surrounding, Sinombayuga Mountain (1.970 m), Gambuta Mountain (1.954 m), Bulawa hills, Sula Mountain (1.710 m), Kabela Mountain, Padang Mountain, and Ambang Mountain.

Meanwhile babirusa is often seen in Poniki Mountain, along Kosinggolan River, Toraut area, Taludaa, Tambun, Lonuo, Tulabolo, Gambuta Mountain and Bakidaa.

Those animals are usually seen along the bank of river and top of the hills. Anoa is rarely found in group, it is almost always seen lonely (soliter). While babirusa is almost always found in a small group of 4 - 5 individuals.

At the early 1980, these animals were relatively much easy to see them inside the Park area. The Park staffs were often seen them in the forest close to the boundary, and even confiscated them from the illegal hunters.

At that time the Park managers ever kept these animals for several months because those confiscated animals were heavily wounded by the hunters.

B. ANIMAL BIOLOGY AND ECOLOGY

According to the experience of the writers and staffs, it can be shown some difference characters between the two species of anoa. Those data was shown on the table belows:

	B. depressicornis	B. quarlessi
-Body size	relatively bigger and higher, 70-80cm.	smaller, 60-70 cm.
-Leg	front legs are shorter than hind one.	front and hind legs have the same length.
-Skin/body hair	redish color. subtle.	darker color. rough.
-Horn composition	parallel.	more open.

C. DIET

Anoa usually eats young leaves of shrubs such as rumput tepus, sintrong, etc.

In the captivity, anoa also consumes rumput australia and young corn leaves.
There is no much data on the diet of babirusa. But we met them outside the forest, they consume ubi kayu (cassava), ubi jalar, and some species of worms. We think that the diet of babirusa i much alike with the usual wild pig.

III. RECENT CONDITION

A. HABITAT DESTRUCTION

As we said above that recently the population of these animals is decreasing drastically. We know about this from the confiscated animals found from time to time, and not many people can see them often, even inside the forest.

The main problems arise now are habitat destruction and illegal hunting.
Habitat destruction is caused by illegal activities done in the park such as wood/rattan collection, encroachment and illegal gold mining (inside the Park area).

Illegal hunting also becomes a very serious problem because most North Sulawesi people consume the wild pig and babirusa as their daily food. This hunter usuallay doesn't select the species of animals they want to catch. In the pig catching activity, hunters usually make a trap, but unfortunately, this trap becomes a serious problem for anoa. And the wounded anoa (by this trap) sometimes becomes a very dangerous to the people living in surrounding the Park area. There were several people were wounded even death because of this problem.

B. PATROLLING ACTIVITIES

As we said before that there is no people have a special interest to study ecology and biology of these two animals in the Bogani nani Wartabone National Park area. Therefore, there is not much available data on this subject. The Park managers have always something to do to protect the habitat and population of these species. So, patrolling activities and other operations have always conducted from time to time.

IV. SUGGESTION

1. Bogani nani Wartabone National Park absolutely needs the scientists to conduct their research on the biology and ecology subject of anoa and babirusa.

2. It needs more patrolling activities done in the Park to protect the habitat and population of these species.

3. It needs ecological monitoring research for these species.

SEAL

THE DIVERSITY AND HEMATOLOGY OF *ANOA* FROM SULAWESI

by

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ABSTRACT

The diversity and hematology of 14 anoas respectively 5 from the Ragunan Zoo, 4 from the Surabaya Zoo and 5 from Central Sulawesi were studied.

All anoas from Ragunan Zoo were identified as *A. quarlesi*, from Surabaya Zoo as *A. depressicornis*, while those from Central Sulawesi have conical horn like *A. quarlesi*, but with different head form. The head and the smooth brown hair of this group resemble those of the Bali Cattle but the chromosome number is the same as *A. quarlesi* which is 23 pairs (2n=46), with different karyotype. One adult anoa has white head and a brownish sheep's wool, the head is like a sheep and the chromosome number is 22 pairs (2n=44). It is concluded that those from Central Sulawesi cannot be classified as *A. quarlesi* or *A. depressicornis*.

The range of hemograms of the anoas consists of hemoglobin (10,0-15,3%); PCV (32,0-52.5%); Red blood cells (5.87-13.8x10^6/ul and white blood cells 3.15 - 6.55x10^3/ul).

The paper is presented at the workshop of PHPA on *Anoa* and *Babyrousa*, at Taman Safari, from the 22^{nd} - 26^{th} of July, 1996.

SEAL

INTRODUCTION

Anoa is a awarf buffalo which endemic to the island of Sulawesi, the central part of Indonesia. On the island exist two species of anoas, the *Bubalus* (Anoa) *depressicornis* H. Smith, 1827 of the lowland and *Bubalus* (Anoa) *quarlesi* Owens, 1910 of montainous region (Groves, 1969). The lowland anoa is bigger than the mountain anoa.

The range of body length of the lowland anoa is 1700-1884 mm, the shoulder height is 757-860 mm, while the horn length is 271-300 mm (Jahja, 1986). The range of body length of the mountain anoa is 1220-1584 mm, the shoulder height is 623-690 mm, while the horn length is 146-199 mm.

The mountain anoa differs from the lowland in having (1) conical horn with no external keel; (2) dark brown until black woolly hairs in adult; (3) whitish or yellowish spots above the hoofs which are often inconspicuous or absent; (4) light groin but not white; (5) no white crescent on the throut (Groves, 1969).

According to Groves (1969), the distribution of the mountain anoas in Central Sulawesi is Lake Lindu and Tuwulu, while that of the lowland is Donggala. The anoas protected by law in Indonesia 1931 and on the list of Red Data book 1972, as endangered species. Until now no research on the hematology of healthy anoa have been done which are important as a basic for the verinarian and for the conservation.

SYSTEMATICS, MORPHOLOGY AND DISTRIBUTION

As stated by Groves (1969) that on the island of Sulawesi exist two species of anoa, the *Bubalus* (Anoa) *depressicornis* of the lowland and *Bubalus* (Anoa) *quarlesi* of the mountainous region, while on Mindoro island one species the *Bubalus* (Bubalus) mindorensis.

Walker (1964), Fisher V.H. Holm (1973) regarded the Tamarô of Mindoro island (Phillipines) as a member of the genus *Anoa*, the *Anoa mindorensis*. *Anoa mindorensis* is separated from the close related species, the *A. depressicornis*. Several authors believed that the anoa belongs to the genus *Anoa* H. Smith 1827. (Mohr, 1921; Pilgrim, 1939; Hooijer, 1948, 1950). Lydekker (1905) stated the anoa as belonging to the genus *Bos* and called it *Bos depressicornis fergusoni* while Groves (1969) regarded it as the subgenus Anoa, genus *Bubalus*.

According to Hooijer (1948) there is only one species of anoa on the Island of Sulawesi, i.e. *Anoa depressinornis* Smith and based on the structure and size of the teeth, it consists of two subspecies, *A.d. fergusoni* Lydekker , from the Southern part of Sulawesi. Unfortunately the latter has not the exact type locality and type specimen.

According to Groves, *A.d. fergusoni* is a synonym of *B.* (Anoa) *depressicornis*, because the type specimen in not clear. Based on the measurements of the skull at the museum in the Netherlands and in Germany, Heller was convinced that there are no differences between the two subspecies.

The anoa resemble the Asiatic buffalo in having (1) hollow horns, unbranched triangular with keel; (2) in mature animals the hair tends to be scare; (3) broad hoofs; (4) nearly straight back and (5) thick pallatum fused with vomer (Groves, 1969).

The anoa is related to the Asian swamp buffalo, *Bubalus bubalis* and the Tamarao, *Bubalus* (Bubalus) *mindorensis* which is found on the island of Mindoro (Phillipines). Several authors classified the Tamarao into the genus *Anoa* (Walker, 1969; Fisher and Hohn, 1973). There are several differences between the Tamarao and *Bubalus* a.o.: (1) smaller and more straight; (2) has shorter and bigger horn; (3) the distal digits of the legs are shorter; (4) the general structure of the horns faces a bit outward.

Groves (1969) described and classified the anoa as follows (1969) : *Bubalus* (Anoa) *depressicornis*. Localities (1) Northern peninsula: Minahasa, Menado, Bambulan, Gorontalo. Likupang, Lempias, coast near Limbe, forest between Langowan and Panku, Paybi, Tolitoli (Heller, 1889). (1) Central Celebes; Donggala. (3) Southestern peninsula: north slope of Boro-Boro, Mts. Kampung Mowita: Malili, Kolka (Ouwens, 1910) (4) Southwestern peninsula: cave north of Tjani "very recent", Panganrejang Tudeja "before 1300 A.D." (Hooijer, 1950).

Description: color of adult black, the hair being sparse and the woolly brown juvenile coat lost about the time $M^3/3$ erupting. Legs are always white or yellowish-white, except for a black line down the front and across the patterns. Groin light to white; often a white crescent on throat. Tail length 19.8-25.8% of total length (9 skins). Adult horns triangular in section flattened, with marked transverse ridges and marked external keel; index of least to greatest (i.e. antero-posterior to bilateral) basal horn breadth, 57.9-80.0 in adult, 66.0-91.7 in juvenile, the marked expansion of the external angle occuring about the time of eruption of $M^3/3$. Skull length of male 298-322 mm, female 290-300 mm. Horn length of male 271-373 mm, female 183-260 mm. Toothrow length of both sexes 82-98 mm.

Bubalus (Anoa) *quarlesi*.

Localities (1) Northern peninsula: Besoa, Menado (2) Central Celebes; Lake Lindu, Tuwulu (3) Southeastern peninsula: Buton island (4) Southwestern peninsula: Latimojong, Watampone, Madjene, mountains island from Makassar at 2.000 m; Toradja.

Upper Binuwang, Palopa (Ouwens, 1910); Mandar Mts (Mohr, 1921): Bola Batu "before 17th century", caves north of Tjani "very recent" - probably (Hooijer, 1950).

Description: color of adult dark brown to black, the hair sometimes still thick and woolly well into adulthood, especially in females and even when the wooly coat is shed, hair is never as sparse as in *B. (Anoa) depressicornis*. Legs have only whitish or yellowish spots above the hoofs, and even these are often very inconspicuos or absent. Groin light but not write; never any white crescent on throat. Tail length 14.6-17.8% of total length (5 skins). Adults horns short and conical, rounded in section, just as in juveniles, with no marked ridges or external keel; index of least of both sexes 244-290 mm. Horn length of both sexes 146-199 mm. Toothrow length of both sexes 65-80 mm.

Groves (1989) stated that, there are 5 stages of development in anoa: the infant stage (no permanent teeth) of both species have golden brown hair; the juvenile I (M1/1 present) *B. (Anoa) depressicornis* has drab-brown hair, while *B. (Anoa) quarlesi* is golden to red hair; the juvenile II (M2/2) of *B. (Anoa) depressicornis* has medium brown hair, and *B. (Anoa) quarlesi* is dark brown color; young adult (all permanent teeth) and adult of both species have brown to black hair and black hair respectively.

BEHAVIOR AND REPRODUCTION

There was some information, that anoa is dangerous and has been known to attack and wound people. Balen J.H., reported is at the regions of Menado, someone was suddenly attacked by his own tame anoa. During pregnancy, anoa is very aggressive and sensitive. Sexual maturity is about two years, and the life span ranges from 25-30 years (Siregar A.B., *et al.*), and gestation period range from 275-314 days.

CHROMOSOMES

The chromosome number of *A. depressicornis* is 48 (2n) consisting of 1 pair of metacentric, 5 pairs of submetacentric and 17 pairs of acrocentric autosomes and 1 pair of acrocentric sexual chromosomes (Hsu and Bernischke, 1974).

Anoa mindorensis which is endemic on the Island of Mindoro (Phillipines) has a chromosome number of 46 (2n) consisting of 6 pairs metacentric and submetacentric, 16 pairs of acrocentric autosomes and 1 pair acrocentric sexual of chromosome (Fisher, M and H. Hohn, 1973).

The chromosome number of *A. quarlesi* is 46 (2n), consisting of 7 pairs submetacentric and 15 pairs acrocentric autosomes and 1 pair of acrocentric sexual chromosome.

MATERIALS AND METHODS

Five anoas (mountain type) of the Ragunan Zoo; 4 anoas (lowland type) of the Surabaya Zoo and 5 mountain anoas of Central Sulawesi were used.

External morphology, hair and color pattern and horn form were observed. The habitat were studied. Blood samples were collected aseptically from the jugular vein into 5 ml plastic disposable and the syringe tip was sealed. The blood sample were kept in a thermos containing dry ice. Cultures were made within 24 hours, by transferring 0.75 ml of whole blood in a medium consisting of 5 ml TC 199, 0.8 serum and 0.8 FHA (Phytohe- maglutinin). The cultures were incubated at 37°C for 72 hours. Two hours before harvesting, 0.1 ml of cholchicine solution (3 mg%) was added to each culture. The sediment was obtained by centrifuging the culture at 800 rpm for 10 minutes. The stained metaphase spreads were photographed. From each animal Giemsa stained metaphase were analyzed.

And for the hematology blood samples of the anoas were taken from the Ragunan Zoo, Surabaya zoo and from Central Sulawesi, while 17 blood samples of swamp buffaloes were taken in the vicinity of Bogor.

The blood samples each of 10 ml were collected aseptically from the jugular vein into 15 ml heparinized disposable venoject, after injected with rompun 0,25 ml/50 kg body weight intramuscularly. The blood samples were put in the thermos containing dry ice cubes and were brought to the Laboratory of Zoology, Department of Biology, Faculty of Natural Sciences.

Blood smears were prepared, and were stained with Giemsa. At the Laboratory examination were done on the number of blood cells i.e. erythrocytes leucocytes, hemoglobin concentration and PCV. The differential examination was done from the blood smears by counting the number of lymphocytes monocytes, neutrophils, eosinophils and basophils.

RESULTS AND DISCUSSION

The characteristics of anoa from the Ragunan Zoo are as follow :

(1) Horn conical, short sharp, directed backward.
(2) Hair brown to black, thick and woolly.
(3) Head like as cattle head.
(4) Inner ear is white.
(5) Anoa with one white spot on head is 20%, and with two spot on head is 40%.
(6) Anoa with white big spot on throat is 40%, and with small spot is 20%.

(7) anoa with crecent white spot on throat is 20%, (see table 1).
(8) The head is lake the cattle head.

The characteristics of anoa from Surabaya Zoo are as follows:
(1) Horn, short and flattened.
(2) Hair brown, yellow to black, and mostly sparse.
(3) On cheeks, there are one, two or more white spots.
(4) Anoa with crecent white spots on throat is 25% (see table 2).
(5) The head is like the buffaloes head.

The characteristics of anoa from Central Sulawesi are as follows :
(1) Horn conical, short and sharp directed caudad.
(2) Hair thick, brown, black or red brown and woolly.
(3) 60% have white spots on cheeks and on throat (see table 3).
(4) 20% have one white spot on throat (see table 3).
(5) Anoa which head resemble the Bali Cattle, has shoulder height 60-75 cm.
(6) One individual which head resemble sheeps head has shoulder height of 60 cm.

DISTRIBUTION AND HABITAT

Anoa which head resemble the head of the Bali cattle exists in the vicinity on mountain range of Pompangeo, in the south-eastern part of Poso (near Lake Poso), with an altitude of 2865 m above sea level; while the anoas which head resemble sheep head exist around mountain Nokilalaki, at an altitude of 2355 m above sea level.

From the field studies of anoas in Central of Sulawesi, there is an indication that anoas live in the vicinity of either fresh or salted water pool surrounded with vegatation.

Anoas usually hide in big holes either under stones or logs. It inhabit also bushes of 2 m height, forest of dicotyledones and rattans. From the track studies, it can be concluded, that anoas live in a group of 2 or 3, or bigger. According to the inhabitants of Central Sulawesi, anoa is a dangerous animal and often attack people and inflicts severe wounds.

KARYOTYPE

The chromosome number of anoa from Central Sulawesi which head resemble the Bali cattle is 23 pairs (2n=46) just, like the mountain anoa and the Tamarao. However the karyotype is different (see table 4).

Anoa from Central Sulawesi which head resemble the sheep head, with white head and white body, has 22 pairs (2n=44) of chromosome. It can be concluded that in the mountainous region of Central Sulawesi, beside *A. quarlesi* there are 2 mutants which can be regarded as 2 new different species. But this still need further research. From the studies of the karyotype, it can be concluded that the relation between A. depressicornis and the swamp buffalo is closer, than the relation between the Tamarao and the swamp buffalo.

Since the name Anoa has been used by the neolithic race in Asia for all anoa or dwarf buffalo, we proposed that the dwarf buffalo be classified as genus *Anoa*.

HEMATOLOGY

There is a considerable variation of blood composition between the anoas from the Ragunan Zoo, Surabaya Zoo and from Central Sulawesi. Individually there's also a variation in blood composition. The blood composition of the anoas from the Ragunan Zoo consists of erythrocyte 6.9 - 13.08 x 10^6/ml (x= 9.91 ± 2.4), leucocyte 3.15 - 4.175 x 10^3/ml (x= 3.38 ± 0.92. The concentration of hemoglobin is 12 - 15.3 g% (x= 13.4 ± 1.6) and PVC is 43 - 52.5% (x= 46 ± 3.67).

The blood composition of the anoas from the Surabaya Zoo consists of erythrocyte 6.54 - 9.2 x 10^6/ml (x= 7.58 ± 1.5), leucocyte 4.9 - 11.65 x 10^3/ml. The concentration of hemoglobin is 10 - 13 gr% (x= 13.2 ± 2), and PVC is 32 - 40% (x= 41 ± 6.6).

The blood composition of the buffaloes from bogor consists of erythrocyte 4.2 - 9.58 x 10^6/ml (x= 6.07 ± 6), leucocyte 3.6 - 9.8 x 10^3/ml (x= 7.32 ± 1.83).

The concentration of hemoglobin is 10.3 - 18.2 gr% (x= 14 ± 2), and PVC is 31 - 55 (x= 4.19 ± 6). Thus the blood composition of the buffaloes from Bogor is different from that of the egyptian buffaloes reported by Havez and Anwar (1954).

The older anoas showed a decrease of erythrocytes, hemoglobin, PCV, neutrophil, lymphocytes, eosinophil and basophil, and an increase of leucocytes and monocyte. The blood composition of the anoas differs from that of the buffaloes.

CONCLUSION

(1) The variation of colour pattern found in anoas is only a variation and not a specific feature of a species.
(2) Based on the morphology, karyotype and the protein serum, there are in the mountaineous region of Central Sulawesi at least are more than one species of anoa.

(3) Based on the karyotype, the relation between *A. depressicornis* and the swamp buffalo if closer than the relation between the Tamarao and the swamp buffalo.
(4) There is considerable variation of hemograms of the anoas from different zoos and region.

RECOMMENDATION

Further research has to be carried out every aspect of anoa such as physiology, reproduction, management and breeding.

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Table 1 : The characteristics of anoa from Ragunan Zoo (RZ)

No.	Name/Sex	Hair color & Condition of hair	Head type	Horn type	White spots pattern				
					inner ear	head			
						cheek	throat	neck A/B	Above leg
1.	Nuri, ♀	dark-brown,red blackish and thick hair	like cattle	conical sharp	+	++	+ (big)	B (sickle)	+
2.	Bravo, ♂	black, thick		conical sharp	+	++	+ (big)	-	+
3.	Nona 1, ♀	blackish, thick and thin		conical sharp	+	-	-	-	+
4.	Nona 2, ♂	blackish, thick and thin		conical sharp	+	+	+ (small)	-	-
5.	X, ♂	black, thin		conical sharp	+	-	-	-	-

A = upper; B = below

Table 2 : The characteristics of anoa from Surabaya Zoo (SZ)

No.	Name/Sex	Hair color & Condition of hair	Head type	Horn type	White spots pattern				
					inner ear	head			
						cheek	throat	neck A/B	Above leg
1.	Katijah, ♀	black, sparse	like buffalo	flattened	+	++	+	+	+
2.	Slamet, ♂	black, sparse		flattened	+	+	+	-	+
3.	Nonik, ♀	dark-brown, yellowish, like young buffalo		flattened	+	-	+	-	+
4.	Roni, ♂	dark-brown blackish		sharp, long and flattened	+	many spots	+	-	+

A = upper; B = below

Table 3: The characteristics of anoa from Central Sulawesi (CS)

No. Code/Sex	Age (Y/M)	Origin	Hair color & Condition of hair	Head type	Horn type	White spots pattern				
						inner ear	head			
							cheek	throat	neck A/B	Above leg
1. 1089, ♀	3 Y	Gintu	red and thick hair	cattle	conical sharp	+	+	+	-	+
2. 2089, ♀	2 Y	Nokilalaki mountain	blackand white like wool	sheep	conical sharp	+	+	+	+	+
3. 10P89, ♀	3 Y	Pompangeo mpuntain	black, thick	cattle	conical sharp	+	+	+	-	+
4. 11P89, ♀	4 M	Pompangeo mountain	black and reddish	cattle	conical sharp	+	-	-	-	+
5.12P89, ♀	4 M	Pompangeo mountain	black and reddish, thick		conical sharp	+	-	-	-	+

A = upper; B = below

Table 4 : The Karyotype of Anoa and Buffalo

Name of Species	M (ps)	SM (ps)	A (ps)	Sex chromosome (ps)
A. quarlesi (2n=46)	-	7	15	1
A. windorensis (2n=46)	1	5	16	1
A. depressicornis (2n=48)	1	5	17	1
B. Bubalus	1	4	18	1
Anoa which head resembling sheep head (2n=44)	1		could not be identified	
Anoa which head resembling cow's head (2n=46)	1	6	15	1

M = metacentric; SM = submetacentric; A = acrocentric

Table 5 : Hemograms of anoas from Sulawesi and Buffaloes from Bogor (West Java)

Nama of species	Number (M)	RANGE								
		Hb (g%)	PCV (%)	RBC (10^6/ul)	WBC (10^3/ul)	N	L	M	E	B
						(%)				
Anoa :										
From the Ragunan Zoo	5	12-15.3 (x = 13.4±1.6)	43-52.5 (x= 46±3.67)	6.9-13.08 (x= 9.91±2.4)	3.15-4.175 (x= 3.36±0.92)	4-20 (x= 13.2±6.5)	23-66 (x= 45.4±17.6)	2-28 (x= 15.6±9.6)	8-22 (x= 17.4±6.1)	7-11 (x= 9.4±1.7)
From the Surabaya Zoo	4	10-13 (x= 13±2)	32-40 (x= 41±6.6)	6.54-9.2 (x= 7.58±1.15)	4.9-11.65 (x= 6.9±3.17)	8-26 (x= 34.5±21.5)	14-50 (x= 28.5±15.2)	11-26 (x= 18.3±6.3)	9-19 (x= 13.7±5.5)	3-8 (x= 5±2.2)
From Central Sulawesi	3 adults (♀)	12.5-13.6 (x= 12.9±0.6)	35.8-48 (x= 42.8±6.3)	5.87-7.67 (x= 6.8±0.9)	6.55-7.8 (x= 7.11±0,63)	2.0-19 (x= 10.3±8.5)	58-85 (x= 64.3±18.3)	17-21 (x= 15.3±6.7)	2-9 (x= 4.7±3.8)	2-4 (x= 5.3±4.2)
	2 juvenils (♀)	13.9-14.1	42-51	7.2-7.4	3.35-4.15	9-11	68-77	5-6	4-10	5
Buffalo :										
From Bogor	17	10.3-18.2 (x= 14.7±2)	31-55 (x= 41.9±6)	4.2-9.58 (x= 6.07±6)	3.6-9.8 (x= 7.32±1.83)	3-54 (x= 18.6±12.5)	16-67 (x= 52±15.8)	13.6-24 (x= 15.7±3.96)	1-18 (x= 7.1±5.9)	1-16 (x= 6.5±4.8)

Hb = Hemoglobin
PCV = Packed cell volume
N = Neutrophils
L = Lymphocytes
B = Basophils
E = Eosinophils
RBC = Red blood cells
WBC = White blood cells
M= Monocytes

SCAU

SOCIO-ECOLOGICAL BEHAVIOUR OF LOWLAND ANOA (*Bubalus depressicornis* Smith) IN TANJUNG AMOLENGU WILDLIFE RESERVE SOUTHEAST SULAWESI

By

Abdul Haris Mustari [1]

ABSTRACT

Tanjung Amolengu Wildlife Reserve is situated in the southeast tip of Sulawesi mainland. It covers 500 ha of forested area, consisting of primary, secondary, transitional, and mangrove forests.

The behavioural data of the lowland anoas were collected by combination of direct and indirect observations. This study reveals that the animals are solitary, mostly found single or in pairs. The animals are monogamous during the rutting season. The breeding season is estimated to occur in June-October, and the mating season is estimated to occur in October-January. The animals were found dipping and wallowing in the transitional-mangrove forest, and swimming in the seashore. The anoas use some species of trees for scouring and/or for sharpening their horns. The preferred tree is *Evodia* sp. of the Rutacea family. The animals scratch the soils nearby their faeces along their trails. The horn-scouring trees and the soils scratching nearby their faeces tend to indicate the 'scent-marking' as an expression of their territoriality. But these must be observed in more detail to conclude what the biological sense od these behaviours are. The anoas are active diurnally and nocturnally. At night, some individuals leave the reserve looking for food in the garden close to the reserve border.

Key words : Anoa, *Bubalus depressicornis*, soliter, conservation

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INTRODUCTION

The medium sized ruminant anoas are are endemic to Sulawesi, Indonesia. According to Groves (1969), there are two species of anoa, lowland anoa (*Bubalus depressicornis*) and mountain anoa (*Bubalus quarlesi*). Lowland anoa has white fore-legs, a long tail, the hair being sparse in adult individuals. Males are generally darker than females; often they have a white crescent at the throat. Horns are triangular in section, flattened and wrinkled, 271-373 mm length in males, 183-260 mm length in females. The skull length is 298-322 mm in males, 290-300 mm in females. The mountain anoa has legs that are generally of the same colour as the body. The hair is dark brown to black. It has more hair than the lowland anoa does and never white crescent on throat. The tail is short, horns are rounded in section, nonwrinkled, 146-199 mm length in both sexes. Skull length of both sexes is 244-290 mm.

The anoa was cought by Toraja people in the northern part of South Sulawesi in attemps to breed it for meat production. Its aggressiveness lasted even after several years in captivity and this prevented it from being used directly as a domestic animal (Whitten et.al., 1987). In the Southeast of Sulawesi, I interviewed two villagers who tried to domesticate the lowland anoa. But again, the aggressiveness of the animals forced them to cut the sharp tip of the horns many times, since the animals turned on them.

Generally they are seen alone or in pairs (Dolan, 1965). Except when the females are to give birth, anoas apparently associate in pairs rather than in herds. Some individuals enjoy water and wallowing in mud. In the morning, members of this genus feed alone and in the afternoon they gather and seek refuge in the shade (Whitten et.al., 1987).

Little is known about the ecological behaviour of this animal due its secretive habits, wary nature, secluded environment and restricted range. This study was conducted to reveal the socio-ecological behaviour of the lowland anoa in their natural habitat in Tanjung Amolengu Wildlife Reserve, Southeast Sulawesi. The data presented here are based on a field study conducted in the reserve from August 20,1994 to March 8, 1995.

STUDY AREA

Tanjung Amolengu Wildlife Reserve is situated in the Southeast of Sulawesi. The forested area stretches from 122° - 123° east and 4° - 5° south. This area was declared as wildlife reserve in 1974. It covers 500 ha of forested area including 75 ha of primary forest, 225 ha of secondary forest, 50 ha of transitional forest, and 150 ha of mangrove forest.

The topography is relatively flat with rugged slopes in the middlewest and in the transitional forest; elevation reaches from 0 to 50 meter above sea level.

In Southeast Sulawesi, the rainy season extends from January through July with rainfall from 1,600 - 1,621 mm, and the dry season for the rest of the year. During the dry season (September 1994 - February 1995), the average daily temperature was approximately 30.8°C; the average daily relative air humidity was approximately 70.8% (at 12.00).

Mammals species that could be found in the reserve are lowland anoa (*Bubalus depressicornis*), Rusa-deer (*Cervus timorensis*), wild boar (*Sus celebensis*), squirrel (*Callosciurus sp.*), and the tail-less black macaque (*Macaca ochreata*). Of the bird species, the Red-knobbed Horn-bill (*Rhyticeros cassidix*) is common in this reserve. The other birds are Pied Imperial Pigeon (*Ducula bicolor*), Green Imperial Pigeon (*Ducula aenea*), Celebes Hanging Parrot (*Loriculus stigmatus*), Parrot (*Tanygnathus* sp.), Black-naped Oriole (*Oriolus chinensis*), Celebes Scop Owl (*Otus manadensis*), and Red Jungle Fowl (*Gallus gallus*).

METHODS

The behavioural data were collected by direct and indirect observations. The observations were partly undertaken in the feeding grounds and in the wallowimg sites. The observations were conducted twice a week from 06.00 to 18.00 pm, especially when the feeding grounds were still inundated with water from the end of August through early of October 1994. In the dry season, the observations were mainly undertaken in the wallowing sites. Social behaviour, wallowing and dipping and were observed. Defaecation, urination, and the horn scouring tress were observed in the feeding ground, along the trails and in the 12 vegetational line transects. Additional informations could be taken from the villagers who have seen anoa or the tracks of these animals in their gardens. Valuable informations were also recorded from the fisherman who have seen anoa in the seashore.

Home ranges were estimated based on the regular trails in the forest, particularly in the edges of the feeding grounds, water holes, riverbanks, and in the mangrove forest during low tide. The trails of the animals in the gardens were also observed.

RESULTS AND DISCUSSION

Social characteristics

In the reserve, the anoas were observed mostly single or in pairs. I did not observe more than three individuals in a group. Two or more adult males and two or more adult females were not found to form a group. Of 40 observations, 21 (50.5%) were a single adult males, 3 (7.5 %) were single adult females, 9 (22.5%) were adult females with infants. Only 2 (5%) observation showed a small group consisting of adult female, sub adult male, and infant.

I have observed that four anoas were drinking and feeding in the feeding ground on August 22, 1994 at 05.25 pm. Three animals formed a small group consisting of an adult female, a sub adult male, and an infant. Another was a solitary adult male.

The anoas form small groups and develop solitary social behaviour. The small groups and/or solitary behaviour seem closely related to their habitat characteristics of this animals ,dense forest. It is difficult for the animals to form a big group under the thick tall forest within their home range. Halder (1973) stated that the ungulates that living in highly structured habitats with a localized supply of the resources tend to be solitary and form small groups.

The anoas are monogamous during the mating season. Adult males could not be recorded to consort with more than one adult female during the breeding season, althought it may choose another in a subsequent breeding season. There were two females with infants and two adult males, but I did not observed the two females after delivery form group with the males.

Kuehn (1986) stated that the social behaviour of the tamaraw (*Bubalus mindorensis*) in the Philippines is closely related to that of anoas. However, anoas are more solitary than tamaraw. Habitats of the tamaraw are 90% covered with grassland, instead of approximately 95% dense forest in the habitat of the lowland anoas. An aggregation of 6 individuals, including an adult bull, cow and calf, and three bulls more than 3.5 years old has been obseved by Kuehn (1986). I have not observed an aggregation of anoa like these bovids. These descriptions impressed that anoa are more solitary than other bovines.

Breeding

Two calves of anoa could be observed during my field study. The first calf was estimated to be 3-4 months old in September 1994, and the second was 1-2 weeks old in November 1994. Morphological characteristics of the second calf were as follows : the hair colour was blackbrownish, body weight 8 kg, head-body length 66 cm, shoulder height 48 cm, tail length 14 cm, and ear length 7 cm.

The time of deliveries seems to be at the end of the rainy season. If the gestation period is 276-315 days (Dolan, 1965); the mating season occur during the dry month from October-January. I could observe a bull and a cow always together from September 1994 to March 1995. I supposed that they were in rutting season.

Agonistic behaviour

No fights between anoa were observed during this study. One adult male was pursuing another adult male for about 15 min under the thick forest in the south edge of Pera 1 feeding ground on September 7, 1994 at 04.15 pm. These males came there for drinking. At the same time, however, there was one adult female in the area pursuing. The reason for the observed might have been the presence of the female they competed for.

Fierceness and wariness

When wounded or when a female is giving birth, anoa can attack fiercely. The sideways and upwards stab of their straight sharp horns can be dangerous. An old man was injuried from an attacking anoa at the riverbank of Batu Mati, Rumba Rumba, it is situated 3 km in the north of Tanjung Amolengu Wildlife Reserve on November 21, 1994. After the attack, the man jumped up and climbed tree branches. Then the anoa swiftly ran away.

In 199?, a wounded anoa bull was killed in the village when it came out of the forest. A tip of bamboo pieces was found to be nested in its foreleg. A seriously wounded anoa seems to keep close to the water for easy drinking, dipping, and wallowing.

The anoa is fierce especially when wounded but normally the animals are very shy and wary. Their auditory and olfactory senses are well-developed and help the animals to detect early the presence of people and other signs of danger. When observing this animal, one has to place him/herself throughly against the direction from where the breeze comes and the anoa is expects one to be. One subadult male anoa, for example approached me up to about 5 m distance under the *Acrosticum aureum* vegetation in Baturempe, on Feberuary 13, 1995, at 11.20 am. Then this animal disappeared after I observed it for about 8 min at the distance.

Defaecation and urination

The faecal matter of anoa looks like the faeces of water buffalo, but it is smaller in size. During the dry season, the faeces are relatively hard compared with those in the rainy season. I suppose this is the effect of the difference in the food/water content. During rainy season, foliages contain more water.

Most of the faeces were found in along of the anoa trails in the transitional forest, in the reserve patrols, and in the feeding ground. From 87 faeces I found, 42 (48.3%) were with soil-scratching nearby. However, not all of the soil-scratching were with faeces nearby. All the dunghills with soil-scratching were in along the anoas trails. The manure heaps in the feeding ground, however, showed no scraped soil nearby.

Swimming

The anoas is an excelent swimmer. It is reported from different locations, that these ungulates cross the sea to reach an island or vice versa. In the past, specimens of the anoa population in Tanjung Batikolo and Tanjung Amolengu Wildlife Reserve also often crossed the Bay of Kolono, which is about 5 km wide. In 1987, however, a pearl company settled in the seashore. Since that year, it is riskly for the animals to swim accross the bay. One animal was killed by fisherman in 1984. Another, adult male was killed by a speed boat driver on August 31, 1994 at 07.00 am (pers.observation).

Wallowing and dipping

From 40 personal observations of the anoas, 6 were while wallowing and/or dipping. In the rainy season, the wallowing sites were mainly in the feeding ground and in Baturempe (in the transitional mangrove forest). The animals use the latter site both in the dry and rainy season. I found 5 wallowing sites frequently used by the animals. These sites were connected to each other by trails under the rumpio herb (*Acrosticum aureum*). Circle and oval was the common shape of the sites, the diameter between 1.5 and 5 m, and the depth between 0.4 and 0.6 m. These sites are slightly affected by the low and high tide.

Table 1. The wallowing times of the lowland anoas in Tanjung Amolengu Wildlife Reserve

Date	Time	Location	N	Sex
07.09.94	15.30	Pera 1	1	young adult male
05.12.94	08.30	Baturempe	1	Unidentified
12.01.95	08.30	Baturempe	2	adult male,adult female
19.01.95	08.00	Baturempe	1	adult male
20.01.95	16.30	Baturempe	2	adult male,adult female
09.02.95	11.30	Baturempe	1	adult male

Horn-scouring trees

The anoas use the trunks of trees for scouring their horns as shown by the bark damage on the trees. Not all tree species were used for this. Plant species and diameter of the trees seem to be important factors for the animals when choosing one. A total of 147 individuals of plants were recorded to be used for this activity. About two-thirds (68.7%) of the trees are *Evodia* sp. This pioneer species belongs to the Rutaceae family.

The animals preferred trees with a diameter between 2 and 6 cm (61.90%, n=147). The bark damage was found between 0 and 125 cm, mainly between 60 and 100 cm above the ground.

Based on the diameter of the trees, it corresponds to the base-distances of the animals horns. For the hypothesis, I measured the base-distance and the tip-distance of the horns of 23 skulls of anoa (13 were the skulls I collected from the villagers near the reserve, and 10 were the skulls in Bogor Zoology Museum). The base-distance of the horns is 30-65 mm (μ=51.13 mm) and the tip-distance is 80-235 mm (μ =152.30 mm). It seems that the animals preferred the trees with a diameter in the range of their horns base-distance, 3-6.5 cm. When scouring their horns, the tree is in between the two horns.

The trees were mainly in the southern and eastern parts of the Pera I feeding ground and along the trails. It appears that animals were scouring their horns or rubbing their heads on the trees while resting nearby the feeding ground. The death of trees due to these activities could be observed, particularly the trees with smaller diameters, where the bark was completely peeled off. The trees with larger diameters might be used many times for this activity.

The distribution of the trees along their trails indicates that the animals may use them for "scent-marking" as an expression of their territoriality. But this must be observed in more detail to conclude what the biological sense of this behaviour is.

Anoa bulls compete over cows during the rutting season. The horns are impotant weapon for the bulls for fighting in the sexual competition. The fighting is not only between the males, but also between females, and between males and females. They are solitary animals and a small group have to be maintained for a certain period, thus the fighting between individuals frequently takes places.

Table 2. The horn-scouring/sharpening trees of the lowland anoas

Species	Family	N	N (%)
Uvaria celebica	Annonaceae	1	0.68
Xylopia malayana	Annonaceae	1	0.68
Macaranga sp.	Euphorbiaceae	2	1.36
Trigonopleura malayana	Euphorbiaceae	3	2.64
Homalium foetidum	Flacourtiaceae	9	6.12
Cryptocarya sp.	Lauraceae	1	0.68
Dehaasia caesia	Lauraceae	2	1.36
Barringtonia racemosa	Lecythidaceae	4	2.72
Syzygium lineatum	Myrtaceae	3	2.04
Syzygium sp.	Myrtaceae	4	2.72
S.cf.zollingerianum	Myrtaceae	1	0.68
Plectronia horrida	Rubiaceae	5	3.40
Evodia sp.	Rutaceae	101	68.71
Ellatostachys verrucosa	Sapindaceae	1	0.68
Euphorianthus obtusatus	Sapindaceae	8	5.44
"Kaeo"	?	1	0.68
Total		147	

Home range

Anoas use their home range to get all of their needs, including food, water, cover, wallowing and dipping sites, and for social interaction. The animals use the trails regularly in their home range, connecting the resources one another.

Distribution of the anoa was different in the rainy and in the dry season. During the wet season, the animals were evenly distributed all over the reserve, since water was not a limiting factor. At that time water is available in the feeding grounds, the water holes, the courses, and even in the plants, the animals get water.

In the peak of the rainy season in April and May, the water level in the feeding ground is nearly 0.8 m. These area are completely e.q. anoa, deer, and wild bear dried out at the beginning of October. Thus, the big mammals compete for water at the beginning of the dry season. The shortage of water in the reserve occurs from October through January.

After 10.00 am, the animals could rarely be observed in the secondary and primary forests. They visited the feeding grounds at night and in the early morning. The animals fed on the dewed grasses.

The anoa and the deer have different home ranges. Anoa are more shy and secretive than deer. The animals spend most of the time in the deep forest, from the middle part of the primary forest to the south in the transitional and mangrove forests. The deer spend most of the time in the secondary forest.

During daytime the deers were observed at Pera 1 feeding ground (16 observations), at Pera 2 (7 observations). There were 4 observations of anoa at Pera 1 feeding ground and no observation at Pera 2. The shy animal, anoa, has a high risk if it appears at Pera 2 during the daytime, since it is too close to the settlement.

Individual home ranges of the lowland anoas overlapped each other. There was no indication of territorial behaviour of the animals, except the horn-scouring trees and the soil-scratching after defaecation and urination. However these marks should be studied in more detail, whether they indicate the territoriality or not.

The anoa home range includes the primary, secondary, and transitional forests. The animals use the mangrove forest as a home range only during the low tide. Since the animals come out from the reserve to the gardens nearby in the night, it could be concluded that the daily individual home ranges were more than the present area of the reserve, 500 hectares.

The anoas are diurnal and nocturnal animals. They are active in the morning from 06.00 to 09.00 am, and in the afternoon after 16.00 pm. Between these periods, the animals rest and ruminate in the shade of trees, preferably in the transitional forest. At night, some individuals come out from the reserve to the gardens looking for food. Footprints and fresh faeces could be found in the gardens close to the forest in the morning.

CONCLUSION

The lowland anoa are solitary animals, form small group with more than three individuals in a group. They are mostly found single or in pairs. The animals are monogamous during the mating season. The mating season is estimated to occur in October-January and the breeding season is in June-October. The anoas were found dipping, swimming and wallowing. They use some species of trees to scour and/or to sharp their horns. The animals also found to scratch the soils nearby their faeces along their trails. Observations in their natural habitat revealed that the animals are active diurnally and nocturnally. In the daytime, the animals are active mainly in the morning between 06.00-09.00 am, and in the afternoon after 16.00 pm.

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SERU.

ECOLOGY AND CONSERVATION OF LOWLAND ANOA (*Bubalus depressicornis* Smith) IN TANJUNG AMOLENGU WILDLIFE RESERVE SOUTHEAST SULAWESI

By

Abdul Haris Mustari [1)]

ABSTRACT

Tanjung Amolengu Wildlife Reserve is one of the habitats of lowland anoa in Sulawesi. It is situated in the southeast tip of Sulawesi mainland. It covers 500 ha of forested area, consisting of primary, secondary, transitional, and mangrove forests.

In the primary forest the dominant trees are "nguru" (*Tarrietia riedeliana*), "rao" (*Dracontomelon mangiferum*), and "kolasa" (*Parinari corymbosa*). In the secondary forest the dominant trees are "agel" (*Corypha* sp.), "bolongita" (*Tetrameles nudiflora*), "osee" (*Evodia celebica*), "ondolea" (*Canangium odoratum*), and "kalengka" (*Anthocephalus macrophyllus*). In the transitional forest the dominant trees are "dungun" (*Heritiera littoralis*), "buta-buta" (*Exoecaria agallocha*), and "agel" (*Corypha* sp.). In the mangrove forest the dominant trees are "tongke (*Bruguiera gymnorrhiza*), "bakau" (*Rhizophora apiculata*), and "tangir"(*B. caryophylloides*).

The anoa population in the reserve was 8-12 individuals. This estimation was based on the combination of concentration count (8 individuals), line transect count (11 and 12 individuals) and footprint count method (10 individuals). Composition and age structure of the herd was as follows : 2 adult males, 3 adult females, 1 young adult male, and 2 infants. The sex ratio was 1:1. Ratio of juvenile:sub adult: adult was 2:1:5. Population density was 1.6 individuals per square kilometer.

The illegal cutting of trees and poaching are threatening both habitat and population of the lowland anoas. Therefore, more intensive management and protection is urgently needed.

Key words : Anoa, *Bubalus depressicornis*, conservation

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INTRODUCTION

The medium sized ruminant anoa are endemic to Sulawesi, Indonesia. They are classified as endangered species by the Red Data Book of the International Union for Conservation of Nature and Natural Resources (IUCN), and are on Appendix I of the Convention of International Trade of Endangered Spesies of Wild Flora and Fauna (CITES). In Indonesia, the animals have been protected by law since 1931.

Habitats of the anoas are now under cultivation, illegal cutting, and lumbering of the Forest Concession Rights. They have very restricted ranges and the protected areas for these animals are too small compared to its distribution; the areas are scattered into pocket systems. They are hunted illegally for their meat, hides and horns. The horns are famous as a trophy for the local people of the island.

In the Southeast of Sulawesi, both the lowland and the mountain species inhabit some of the protected areas in the province, such as in the Rawa Aopa National Park, Kolaka Utara National Reserve, Tanjung Amolengu Wildlife Reserve (this study), Tanjung Batikolo Wildlife Reserve, and Buton Utara Wildlife Reserve.

The people of Sulawesi kow the anoa well. It is called a fierce but otherwise very shy animal. The government of the Southeast of Sulawesi has declared the lowland anoa as fauna mascot of the province. One of this policy aims is to give a special attention to the species and the people of the province have a special pride; they will conserve this endemic species.

Most of the authors on anoa have focussed their observations on the systematic of the animals, based on the materials from zoos and museums. Biology, ecology, and behaviour of this species in their natural habitat have remained untouched, while habitat destruction and populaion depletion are still going on.

This study was conducted to reveal habitat, population and to identify the conservation problems of the lowland anoa in Tanjung Amolengu Wildlife Reserve, Southeast Sulawesi.

METHODS

Vegetational data collection

The quadrat method was applied for vegetational analysis. The plots were distributed on a regular grid pattern along the 17 line transects, covered the primary, secondary, transitional, and mangrove forests. The distance between plots was 100 m in the primary and secondary forests, and 50 m in the transitional and mangrove forests. The plants were classified as tree, pole, sapling, and seedling. Herbs and grasses were recorded in the seedling plots. The plants species in the reserve were recorded. Plant species and plant parts (vegetative:leaves, shoots, buds, baks, etc., and generative : flower, fruits, seeds, etc.) which were possibly used by the anoas as food sources were determined. The food choice of the animals was assessed by direct and indirect observations on the feeding traces along the trails and in the vegetational transects.

Population

The anoa population was estimated by combination of the concentration count, line transect count, and footprint count methods. The concentration count was applied in the feeding grounds and in the wallowing sites. These observations were conducted from 06.00 to 09.00 am and from 16.00 to 18.00 pm. In the dry season observations were focussed in the wallowing sites. The line transect count was applied in the 12 transects, 200 m apart, their length varying from 0.4 to 2.2 km. This method was conducted twice, on January 12 and 19, 1995. The footprint count was undertaken along the trails of the animals where their footprints could be well recognized.

In the concentration count and line transect count methods, sex, number, age estimation, individual characteristics, solitary or in pairs and time of encountering were recorded. In the footprint count method, lenght, width (in mm) and shape of the footprints were recorded.

RESULTS AND DISCUSSION

Habitat

Tanjung Amolengu Wildlife Reserve is one of the habitats of lowland anoa in Sulawesi. The anoas had inhabited this area before the human population settled in the vicinity of the reserve. From 1940 to 1970, about two-thirds of the forest area was cleared for cultivation. The only undisturbed forest during that period was in the center part, which I shall consider to be primary forest. The small pocket of forest was the main refuge for the animals during that period. This is why this species is still found in this area; otherwise, it would have undergone local exticntion.

Composition and structure of vegetation in the reserve as can be observed today are the results of the successional vegetation and the influence of the local people on the forest in the past. In this study, at least 101 of plants (trees) species in 38 families were recorded. The shrubs consist of 13 species in 11 families; herbs were 15 species in 11 families. The recorded grasses were 10 species in 12 families.

In the primary forest the dominant trees are "nguru" (*Tarrietia riedeliana*), "rao" (*Dracontomelon mangiferum*), and "kolasa" (*Parinari corymbosa*). In the secondary forest the dominant trees are "agel" (*Corypha* sp.), "bolongita" (*Tetrameles nudiflora*), "osee" (*Evodia celebica*), "ondolea" (*Canangium odoratum*), and "kalengka" (*Anthocephalus macrophyllus*). In the transitional forest the dominant trees are "dungun" (*Heritiera littoralis*), "buta-buta" (*Exoecaria agallocha*), and "agel" (*Corypha* sp.). In the mangrove forest the dominant trees are "tongke (*Bruguiera gymnorrhiza*), "bakau" (*Rhizophora apiculata*), and "tangir"(*B. caryophylloides*).

Food items in the reserve

I recorded 33 plants species had been browsed by the anoas. They belonged to 18 families, consisting of woody plants, shrubs, herbs and grasses. Of the 33 species, 27 species were eaten with leaves (including young leaves and shoots), 5 species were eaten with fruit and 1 species was eaten with its tuber. There was a marked preference for three species, with over 65 % of all accounted for by *Petunga microcarpa*, *bambusa* sp. and *Hibiscus tiliaceus*.

The grass species eaten by the animals are *Oplismenus burmannii*, *Paspalum conjugatum*, *Panicum repens*, *Cyperus haspan*, *Cyperus* sp., *Scleria lithosperma*, *Centotheca lappacea* and *Oryza meyeriana*.

I recorded 6 species of the crops eaten by anoa. Among them are *Zea mays*, *Manihot esculenta*, *Musa* sp. and *Artocarpus integra*.

Population

In the concentration count method, as the study progressed it was possible to identify the animals individually through the individual characteristics such as age (juvenile, sub adult, and adult), sex, horn shape, horn length, tail length, hair colour, live in solitary or in a small group. I recorded 8 anoas based on this method. Based on the line transect count method, 11 and 12 anoas were recorded on January 12 and 19, 1995 respectively. During the field observation, I measured 70 footprints of anoa. The hoof length varies from 38-60 mm (μ=53.8 mm); the width is 18-30 mm (μ=25 mm). After classifying them, I estimated that these footprints belonged to 10 individuals of anoa. Based on the combination of these methods, the anoa population in the reserve was 8-12 individuals.

It was difficult to determine the sex of the animals based on the line transect count method due to the visual limitations when observing the animals in the dense forest. The same problem was also found in the footprint count method. The sex of the animals could not be determine based on their footprints.

Due to these difficulties, I estimated that the 8 individuals of the concentration count method were the reliable number of lowland anoa in the reserve. Composition and structure of the herd was as follow : 2 adult males, 3 adult females, 1 young adult male, and 2 infants. The sex ratio was 3 : 3 for the reproductive individuals, and 4 : 4 for the all age-classes. Ratio of juvenile : subadult : adult was 2 : 1 : 5. Population density was 1.6 individuals per km^2.

In the field study, I observed a small group consisting of 3 individuals, including the adult female, a subadult male, and one infant. This group was observed two times in the feeding ground. During my first observation on August 22/1994 at 17.00 pm, these animals were drinking and feeding. At the second sighting on September 8, 1994 at 15.00 pm, the animals were drinking. The infant was estimated to be 3 months old at that time.

One female infant was captured by a fisherman in between the transitional and mangrove forest of Peosoa on November 5, 1994 at 11.00 am. It was estimated to be 2 weeks old. I measured and tagged it, then I released it to the point where it was captured at the first time. The infant was observed again with its mother on December 1, 1994 at 10.45 am.

There is no natural predator of the animals in this reserve except the reticulated python (*Python reticulatus*), but it is very rare in this area. The only native predator in Sulawesi is the Sulawesi Palm Civet (*Macrogalidia musschembroeki*), but it is absent from this reserve. During the field observation, I found only one anoa's skull, adult male, within the reserve. It was about one-half kilometer into the southern part of the feeding ground. La Ondu (pers. comm.) during his 13 years dedication as a forest ranger in the reserve failed to found one anoa's skull within the reserve. This description might give a first impression about the present population of lowland anoas in this area.

The two anoa calves which were sighted during the field study give the impression that they are moderately able to produce offspring. Morphologically, the anoas are in good condition, although it is still in question, whether this small herd can exist in future and produce further fit generations. The small herd is faced with genetic degradation due to inbreeding between the individuals. These circumstances are negatively influenced by the increasing human population surrounding the reserve. In 1994, there were 2,700 people inhabiting three villages in the northern part of the reserve. This number will increase considerably within a short time.

Formerly, the anoas often crossed from one to the other and changed their home ranges. Anoas from Tanjung Amolengu crossed to Tanjung Peropa Wildlife Reserve, and oppositely, crossed the place of the settlement located between the two reserves. There are no corridors available for the animals movements and individuals changes between the reserves.

Illegal cutting and poaching

The forest has provided resources to the human population, such as wood for houses, fire wood, and the non-wood forest products, e.g. be honey, rattan, and bamboos, etc. The increasing human population will enlarge the need for the natural resources. In the mangrove forest, the trees usually cut are tangir (*Bruguiera caryophylloides*), and bakau (*Rhizophora apiculata*). In the primary forest, the preferred trees are fafa (*Vitex cofassus*), cendrana (*Pterocarpus indicus*), and saru (*Dehaasia caesia*).

The anoas are occasionally killed within the reserve, in the gardens and in the reserve-garden borders, especially at the beginning of the dry season when the water becomes the limiting factor. Poachers set snares surrounding the feeding grounds and along the animal's trails. Some of the snares are established along the reserve-garden borders. The snares are mainly constructed to catch deer and anoa.

From thirteen anoa skulls I collected during my stay there, ten were snared, 2 were killed when the animals swimming in the seashore, one was speared, and one was found after normal death. Ten of these specimens are males and three are females.

CONCLUSION

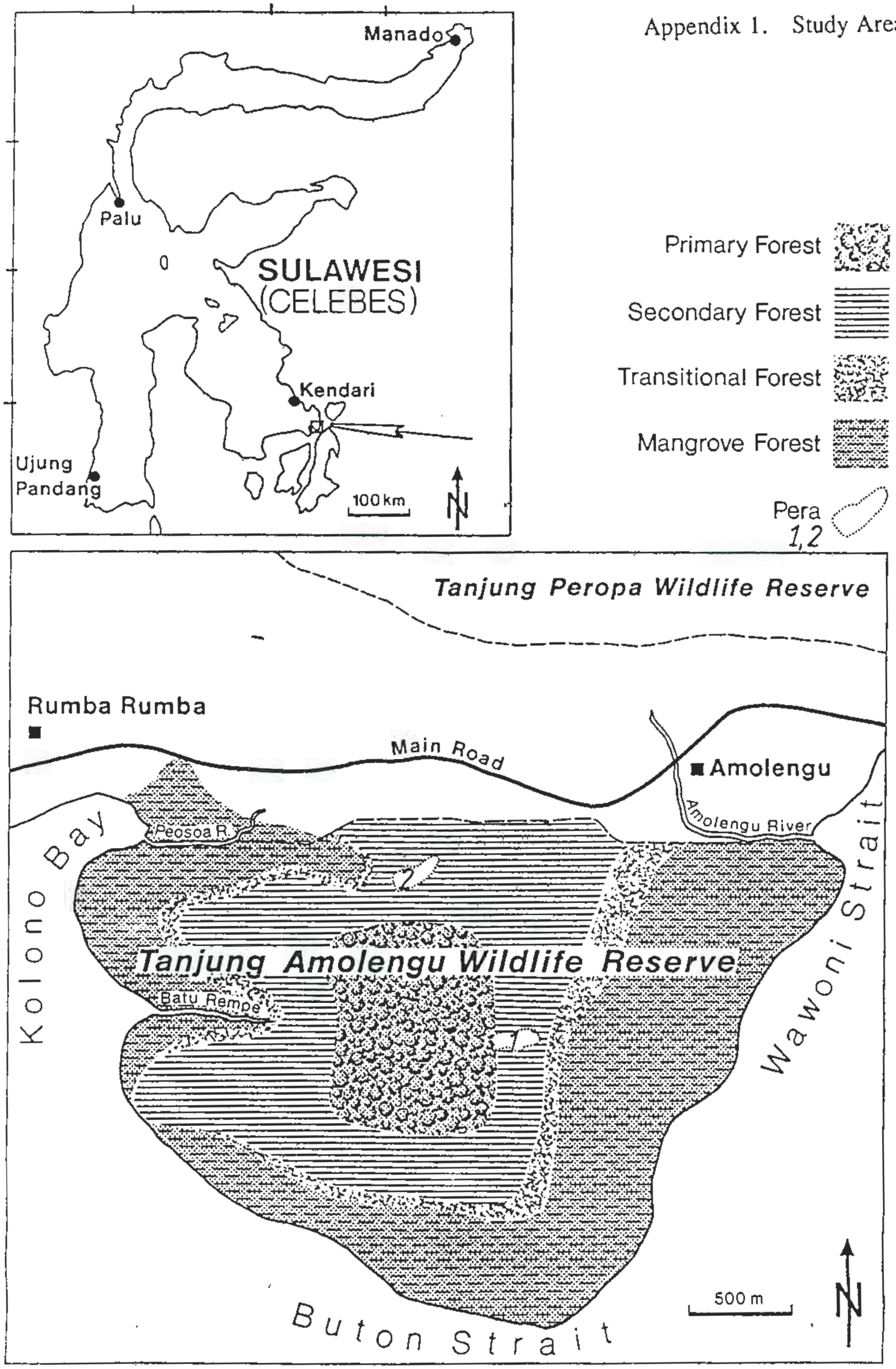
The lowland rainforest of Tanjung Amolengu Wildlife Reserve is one of lowland anoa habitats in Southeast Sulawesi. This refuge plays undoubtedly an important role in the protection of the anoa herd and different other wild animals. The small herd is faced genetic degradation due to inbreeding between the individuals. Corridors should be established for the anoas which provide access for the individuals change between the anoa herd form Tanjung Amolengu Wildlife Reserve to Tanjung Peropa Wildlife Reserve and vice versa.

The illegal cutting of trees and poaching are threatening both habitat and population of the lowland anoas. Therefore, more intensive management and protection is urgently needed.

RECOMMENDATIONS

1. Define the reserve borders immediately. A renovation of the initial border is urgently needed to clarify the position of the reserve.
2. Establish corridors for the anoas which provide access for the individuals change between the anoa herd from Tanjung Amolengu Wildlife Reserve to Tanjung Peropa Wildlife Reserve and vice versa.
3. The lower part of Amolengu River and its banks should be included into the reserve area, since no fresh water for the animals is available during dry season, 4-7 months.
4. Set up notice boards with conservation themes. The attention and awareness of the local people to conserve their environment will be encouraged by such boards.
5. Gain public support through public education and information. The information media, such as slide films, leaflet, booklet, and other audiovisual instruments are among the most effective methods.
6. The floating constructions of the industrial pearl production in the bay must be reorganized to give a quarantee of free water ways for the swimming anoas.

Appendix 1. Study Area



Appendix 2. The five most important plant species in each of the forest formations

Forest Formation	Herbs	Trees
Primary forest	*Tetracera scandens* *Psychotria sp.* *Pandanus tectorius* *Lygodium circinatum* *Calamus spp.*	*Tarrietia riedeliana* *Dracontomelon mangiferum* *Corypha sp.* *Parinari corymbosa* *Pterospermum celebicum*
Secondary forest	*Tetracera scandens* *Lygodium circinatum* *Psychotria sp.* *Pandanus tectorius* *Dioscorea hispida*	*Corypha sp.* *Tetrameles nudiflora* *Tarrietia riedeliana* *Pterocarpus indicus* *Pterospermum celebicum*
Transitional forest	*Acrosticum aureum* *Acanthus ilicifolius* *Pandanus tectorius* *Oplismenus burmannii* *Cyperus haspan*	*Heritiera littoralis* *Exoecaria agallocha* *Corypha sp.* *Dolichandrone spathacea* *Pterocarpus indicus*
Mangrove forest	*Acrosticum aureum* *Acanthus ilicifolius* *Derris heterophylla* *Pandanus tectorius*	*Bruguiera gymnorrhiza* *Rhizophora apiculata* *Bruguiera sexangula* *B. caryophylloides* *Xylocarpus sp.*

Appendix 3 Floristic composition in Tanjung Amolengu Wildlife Reserve

No	Local Name	Botanical Name	Family
1	Rao	*Dracontomelon mangiferum*	Anacardiaceae
2	Gholo	*Spondias pinnata*	Anacardiaceae
3	Ondolea	*Canangium odoratum*	Annonaceae
4	Kaeo berkayu	*Uvaria celebica*	Annonaceae
5	Welagho	*Xylopia malayana*	Annonaceae
6	Tongkoya	*Alstonia sp.*	Apocinaceae
7	-	*Cerbera manghas*	Apocinaceae
8	Mande mandea	*Oroxylon indicum*	Bignoniaceae
9	Bambaelo	*Dolichandrone spathacea*	Bignoniaceae
10	Kapuk	*Ceiba pentandra*	Bombacaceae
11	Kapuk hutan, Olele	*Gossampinus malabarica*	Bombacaceae
12	Onula, Wonula	*Cordia mixa*	Boraginaceae
13	Damar, Bindari	*Canarium sp.*	Burseraceae
14	Berru, Oris, Wou	*Garuga floribunda*	Burseraceae
15	Kalemo lemo	*Capparis micrantha*	Capparidae
16	Kokoleo	*Terminalia sp.*	Combretaceae
17	Bolongita	*Tetrameles nudiflora*	Datiscaceae
18	Kalaero	*Diospyros macrophylla*	Ebenaceae
19	Gito gito	*Diospyros pilosanthera*	Ebenaceae
20	Holea	*Cleistanthus sumatranus*	Euphorbiaceae
21	Rogo	*Croton sp.*	Euphorbiaceae
22	Kubuli buli	*Glochidion arborescens*	Euphorbiaceae
23	Mangko mangko	*Macaranga sp.*	Euphorbiaceae
24	Tofa	*Mallotus philippinensis*	Euphorbiaceae
25	Salahota	*Mallotus malaccensis*	Euphorbiaceae
26	-	*Mallotus resinosus*	Euphorbiaceae
27	Lapingkabu	*Melanolepis multiglandulosa*	Euphorbiaceae
28	Kasampalu	*Trigonopleura malayana*	Euphorbiaceae
29	Welalombalo	*Albizia saponaria*	Fabaceae
30	Sauntiri	*Albizia procera*	Fabaceae
31	Taloe	*Cynometra ramiflora*	Fabaceae
32	Welagho riri	*Dialium sp.*	Fabaceae
33	Asam berduri	*Parkia sp.*	Fabaceae
34	Kalapi	*Kalappia celebica*	Fabaceae
35	Karu	*Casearia grewiaefolia*	Flacourtiaceae
36	Hi, Ohia	*Homalium foetidum*	Flacourtiaceae
37	-	*Xylosma sp.*	Flacourtiaceae
38	-	*Salacia sp.*	Hippocratiaceae
39	-	*Beilschmiedia gemmiflora*	Lauraceae

Appendix 3 (continued)

No	Local Name	Botanical Name	Family
40	Saru, Karematu	*Dehaasia caesia*	Lauraceae
41	Ponto	*Litsea firma*	Lauraceae
42	-	*Litsea glutinosa*	Lauraceae
43	-	*Cryptocarya crassinervis*	Lauraceae
44	-	*Cryptocarya sp.*	Lauraceae
45	Putat	*Barringtonia racemosa*	Lecythidaceae
46	Saru robine	*Planchonia valida*	Lecythidaceae
47	Paratongko	*Leea indica*	Leeaceae
48	Sosorea	*Leea cf. aculata*	Leeaceae
49	-	*Hyptage benghalensis*	Malphigiaceae
50	Waru, Bontu	*Hibiscus tiliaceus*	Malvaceae
51	Harendong	*Melastoma malabathricum*	Melastomaceae
52	-	*Aglaia argentea*	Meliaceae
53	Kontawu	*Xylocarpus sp.*	Meliaceae
54	Sangi, Rombo	*Broussenatia papyrifera*	Moraceae
55	Bakekoko	*Ficus sp.1*	Moraceae
56	Rerano	*Ficus sp.2*	Moraceae
57	Bakengkanini	*Ficus benjamina*	Moraceae
58	Nkea nkea	*Ficus variegata*	Moraceae
59	Rarantulu	*Allaeanthus glabra*	Moraceae
60	Lempeni	*Ardisia humilis*	Myrsinaceae
61	Tembeuwa	*Kjellbergiodendron celebicum*	Myrtaceae
62	Saulembi	*Rhodamnia mulleri*	Myrtaceae
63	-	*Rhodamnia cinerea*	Myrtaceae
64	Nduwo	*Syzygium zollingerianum*	Myrtaceae
65	Mbebele	*Syzygium cf.zollingerianum*	Myrtaceae
66	-	*Syzygium lineatum*	Myrtaceae
67	Katolo tolobe	*Syzygium sp.1*	Myrtaceae
68	-	*Syzygium sp.2*	Myrtaceae
69	Aren, Enau	*Arenga pinnata*	Palmae
70	Kelapa	*Cocos nucifera*	Palmae
71	Agel	*Corypha sp.*	Palmae
72	Kombungo	*Livistonia rotundifolia*	Palmae
73	Sagu	*Metroxylon sagu*	Palmae
74	Tangir	*Bruguiera caryophylloides*	Rhizophoraceae
75	Tongke	*Bruguiera gymnorrhiza*	Rhizophoraceae
76	Kukuni	*Bruguiera sexangula*	Rhizophoraceae
77	Soliti	*Carallia brachiata*	Rhizophoraceae
78	-	*Ceriops sp.*	Rhizophoraceae

Appendix 3 (continued)

No	Local Name	Botanical Name	Family
79	Bakau	*Rhizophora apiculata*	Rhizophoraceae
80	Kolasa	*Parinari corymbosa*	Rosaceae
81	-	*Atuna racemosa*	Rosaceae
82	Kalengka, Kokabu	*Anthocephalus macrophyllus*	Rubiaceae
83	Longkida	*Nauclea orientalis*	Rubiaceae
84	-	*Petunga microcarpa*	Rubiaceae
85	Bidara	*Plectronia horrida*	Rubiaceae
86	-	*Randia oppositifolia*	Rubiaceae
87	Osee	*Evodia celebica*	Rutaceae
88	Sio	*Evodia sp.*	Rutaceae
89	-	*Exocarpus latifolius*	Santalaceae
90	Korope	*Ellatostachys verrucosa*	Sapindaceae
91	Taha	*Erioglossum rubiginosum*	Sapindaceae
92	Korope robine	*Euphorianthus obtusatus*	Sapindaceae
93	Korope	*Mischocarpus sundaicus*	Sapindaceae
94	Tanjung	*Mimusops elengi*	Sapotaceae
95	Tahimanu	*Palaquium obtusifolium*	Sapotaceae
96	-	*Planchonella obovata*	Sapotaceae
97	Peropa	*Sonneratia alba*	Sonneratiaceae
98	Dungun	*Heritiera littoralis*	Sterculiaceae
99	Kabangka bangka	*Pterocymbium tinctorium*	Sterculiaceae
100	Rumbei	*Pterospermum celebicum*	Sterculiaceae
101	Kepuh	*Sterculia foetida*	Sterculiaceae
102	Nguru	*Tarrietia riedeliana*	Sterculiaceae
103	Api api	*Avicennia alba*	Verbenaceae
104	Pattiwala	*Lantana camara*	Verbenaceae
105	Bitti, Fafa	*Vitex cofassus*	Verbenaceae
106	Bitti komba	*Vitex sp.*	Verbenaceae
	Unidentified :		
107	Ewu, Wewu		
108	Maracope		
109	Koba		
110	Kasta		
111	Kanini		
112	Biringponiki		

Appendix 3 (continued)

No	Local Name	Botanical Name	Family
	<u>Herbs</u> :		
113	Santi santi	*Acanthus ilicifolius*	Acanthaceae
114	Tatabako	*Pseudelephantopus spicatus*	Asteraceae
115	Wonta	*Cyperus haspan*	Cyperaceae
116	Wonta	*Cyperus sp.*	Cyperaceae
117	Hilanggoku	*Scleria lithosperma*	Cyperaceae
118	Kaopi	*Tetracera scandens*	Dilleniaceae
121	Katone tone	*Calathea sp.*	Maranthaceae
122	Onena	*Donax cannaeformis*	Maranthaceae
123	Kaeo kuning	*Arcangelisia flava*	Menispermaceae
124	Rotan	*Calamus spp.*	Palmae
125	Ghorindi	*Pigafetta filaris*	Palmae
126	Pandan	*Pandanus tectorius*	Palmae
127	-	*Centotheca lappacea*	Poaceae
128	Karewu rewu	*Oplismenus burmannii*	Poaceae
129	Hulu mata karabau	*Oryza meyeriana*	Poaceae
130	Acembigare	*Paspalum conjugatum*	Poaceae
131	Rumput Pera 1	*Panicum repens*	Poaceae
132	Bambu	*Bambusa sp.1*	Poaceae
133	Bulu	*Bambusa sp.2*	Poaceae
134	Alang alang	*Imperata cylindrica*	Poaceae
135	Komea	*Rubus moluccanus*	Rosaceae
136	-	*Nauclea exelsa*	Rutaceae
137	Onentu	*Lygodium circinatum*	Schizaeaceae
138	-	*Stenochlaena palustris*	Poaceae
139	Rumpio	*Acrosticum aureum*	Poaceae
140	Komba komba	*Euphatorium odoratum*	

Appendix 4 Food items of lowland anoas in Tanjung Amolengu Wildlife Reserve

No	Species	Local Name	Family	Parts of plant browsed
	<u>*Trees* :</u>			
1	*Dracontomelon mangiferum*	Rao	Anacardiaceae	fruits
2	*Canangium odoratum*	Ondolea	Annonaceae	shoots, leaves
3	*Tetrameles nudiflora*	Bolongita	Datiscaceae	shoots, leaves
4	*Cleistanthus sumatranus*	Holea	Euphorbiaceae	shoots, leaves
5	*Trigonopleura malayana*	Kasampalu	Euphorbiaceae	shoots, leaves
6	*Barringtonia racemosa*	Puta	Lecythidaceae	shoots, leaves
7	*Planchonia valida*	Saru robine	Lecythidaceae	shoots, leaves
8	*Hibiscus tiliaceus*	Waru, Bontu	Malvaceae	shoots, leaves
9	*Artocarpus dasyphyllus*	Kulingka	Moraceae	fruits
10	*Ficus sp*	Bakekoko	Moraceae	fruits
11	*Ficus benjamina*	Bakengkanini	Moraceae	fruits
12	*Ardisia humilis*	Lempeni	Myrsinaceae	shoots, leaves
13	*Petunga microcarpa*	-	Rubiaceae	shoots, leaves
14	*Ellatostachys verrucosa*	Korope	Sapindaceae	shoots
15	*Sonneratia alba*	Perop[illegible]	Sonneratiaceae	shoots, leaves
16	-	Moniwang	Fabaceae	fruits
17	-	Wewu	-	shoots, leaves
	<u>*Herbs*:</u>			
1	*Cyperus haspan*	Wonta	Cyperaceae	leaves
2	*Cyperus sp.*	Wonta	Cyperaceae	leaves
3	*Scleria lithosperma*	Hilanggoku	Cyperaceae	leaves
4	*Dioscorea hispida*	Kolope	Dioscoreaceae	tubers
5	*Leea indica*	Paratongko	Leeaceae	shoots, leaves
6	*Calamus spp.*	Rotan	Palmae	shoots
7	*Bambusa sp.1*	Bambu	Poaceae	shoots, leaves
8	*Bambusa sp.2*	Bulu	Poaceae	shoots, leaves
9	*Centotheca lappacea*	-	Poaceae	leaves
10	*Panicum repens*	Rumput Pera 1	Poaceae	leaves
11	*Imperata cylindrica*	Alang-alang	Poaceae	leaves
12	*Oplismenus burmannii*	Karewu-rewu	Poaceae	leaves
13	*Oryza meyeriana*	Hulu mata karabau	Poaceae	leaves
14	*Paspalum conjugatum*	Acembigare	Poaceae	leaves
15	*Acrostichum aureum*	Rumpio		shoots, leaves
16	-	Rotan monyet		shoots, leaves