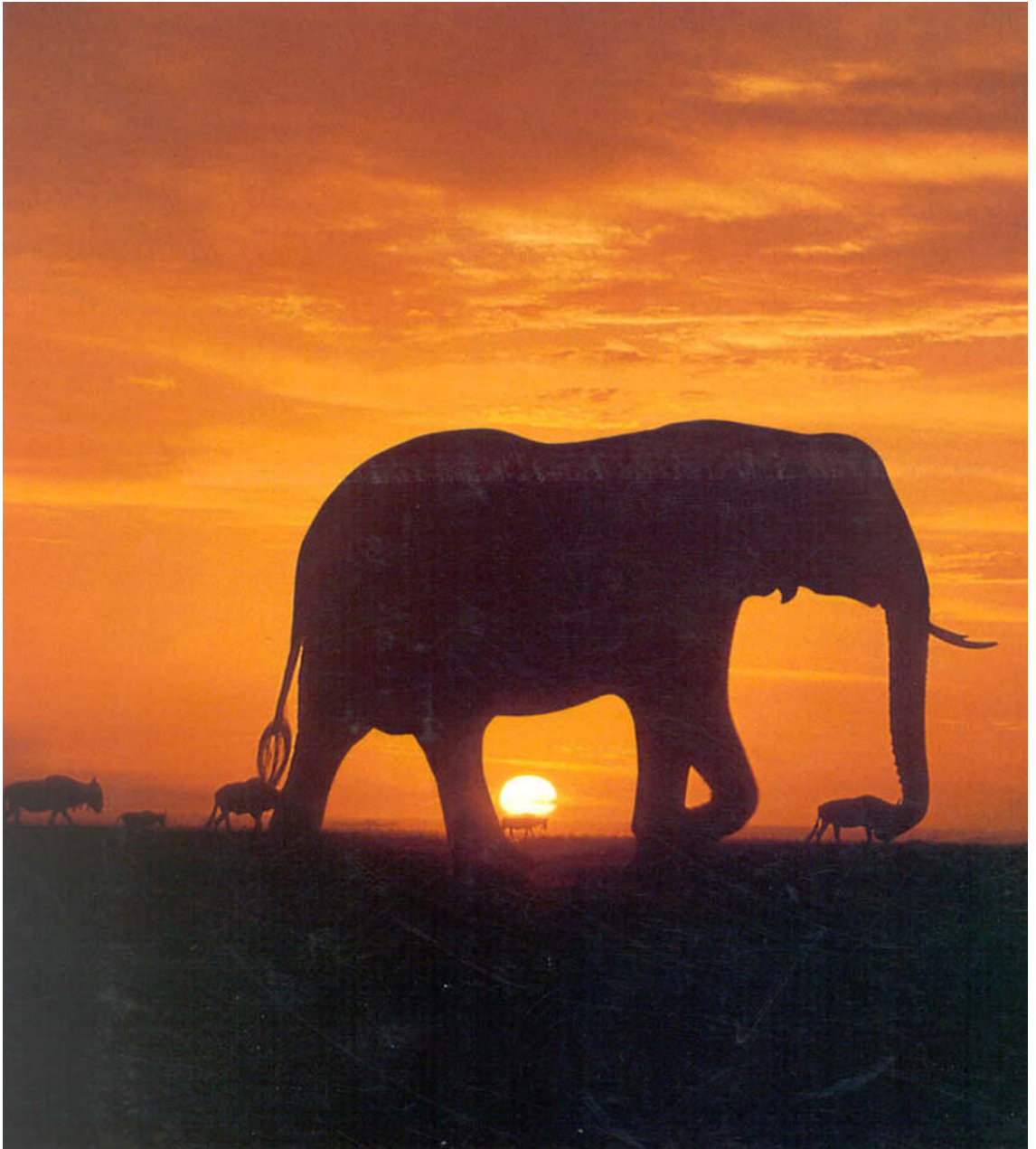


# Pachyderm

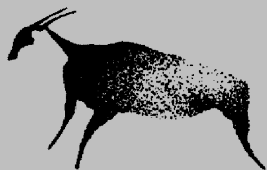
JAN-JUN 2000

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# IUCN

The World Conservation Union



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SURVIVAL  
COMMISSION

## **Pachyderm**

**Journal of the African Elephant, the  
African Rhino and the Asian Rhino  
Specialist Groups**

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*Pachyderm* is financed  
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Wildlife Service.

## Editorial

Judging by the number of pages, *Pachyderm* has grown considerably over the past two years. Judging by its contents, it has assumed a role that no other journal currently takes: 1) reporting as accurately as possible on issues directly related to the conservation of pachyderms, 2) reporting early signs of decline in any area concerning the species' survival or management and 3) developing effective management tools and procedures through scientific discussion. It is both a conservation journal and a serious scientific journal for species management. The next issue will see a new editor and we are currently looking for more volunteers to join the editorial board. If this appeals to you, please let us know. I would like to thank the members of the editorial board with whom I have worked for two issues. I would also like to state what a great pleasure it has been to work with the authors, who often made me share their enthusiasm about their work.

In this issue we have three important articles, which update the figures on elephant numbers and distribution since the publication of the 1998 African Elephant Database (AED): Burkina Faso, Ethiopia and the Democratic Republic of Congo (DRC). The article on the elephant population in the Virunga National Park (VNP) of DRC (L. Mubalama, pp 44-55), adjusts the figure for elephant density in the VNP that is reported in the AED 1998 on page 57.

While elephant populations are shrinking in certain parts of Africa, they enjoy considerable growth in other parts, bringing with it the need to control the population. No sensitive being is happy with the current method of culling. So, research must be done into less destructive ways of population control. The article on iodine as a means of controlling populations by A. Milewski is an effort in this direction.

I hope you will enjoy reading this edition.

*Martina Höft*

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**110 Book Reviews**

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## **ERRATA TO *PACHYDERM* NO. 27**

- I. Page 51, Figure 1, Legend:  $\leq 14$  mg,  $n=20$
- II. Page 71, Preliminary results and discussion: Reuling (unpubl.) estimated the elephant population to be between 1,500 and 4,000 elephants.
- III. Page 84, Photo 8: Adult female northern white rhino F5 “Mama Giningamba” found dead of natural causes in Garamba National Park in January 1995.
- IV. La version française contient une erreur récurrente. A chaque fois que le terme « southern African » est traduit en français (Southern African Development Community, elephant policies and management in southern Africa, southern African Rhino and Elephant Security Group), le texte français traduit « d’Afrique du Sud », qui correspond en fait à « south African ». La traduction correcte de « southern African » est « d’Afrique australe » (càd Communauté de Développement d’Afrique australe, Groupe de Sécurité pour le rhinocéros et l’éléphant d’Afrique australe etc.). Nous vous présentons nos excuses pour cette erreur et souhaitons attirer l’attention de nos lecteurs francophones sur le fait que les politiques de conservation de la faune sauvage dans la sous-région australe du continent sont réellement et de plus en plus régionales plutôt qu’uniquement nationales.

**Cover photo credit:** Cynthia Moss

**Caption:** A female elephant crossing a plain in Amboseli National Park, Kenya, at dawn.

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# **CHAIRS' REPORTS**

## **RAPPORTS DES PRESIDENTS**

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### **African Rhino Specialist Group (AfRSG)**

### **Groupe des Spécialistes des Rhinos Africains (GSRAf)**

**Martin Brooks**

PO Box 13055, Cascades 3203, KwaZulu-Natal, South Africa

#### **SADC RHINO PROGRAMME**

The inception phase of the Italian-funded SADC Rhino programme established the administrative and consultative framework for operations, and identified specific rhino conservation projects to be funded over the next six months. A Range State Planning Meeting was held in Johannesburg, South Africa, in March 2000 to discuss the programme and ensure participation of the various stakeholders and the recruitment of a full-time programme coordinator, the latter likely to be effective from June. The next phase of the programme will involve a review of the legal and policy frameworks in each range state, an evaluation of radio collars used in the region towards developing a really effective technique, assisting in the development of appropriate rhino databases, and assistance with the development of projects by the range states that can be considered for funding. The accent of the entire programme is on developing structures, processes and strategies that have a regional significance, and that will facilitate the implementation of improved rhino conservation pro-

#### **PROGRAMME POUR LE RHINO DU SADC**

La phase initiale du Programme pour le rhino du SADC, fondé par l'Italie, a permis la mise en place du cadre administratif et consultatif pour les opérations et l'identification des projets de conservation du rhino à subventionner pour les prochains six mois. Une réunion de planification des Etats de l'aire de répartition s'est tenue à Johannesburg, Afrique du Sud en mars 2000 afin de discuter le programme et d'assurer la participation des différents acteurs ainsi que le recrutement d'un coordinateur à plein temps, susceptible d'être opérationnel à partir de juin. La prochaine phase du programme comportera une revue des cadres légaux et politiques dans chacun des Etats de l'aire de répartition, une évaluation des colliers radio utilisés dans la région en vue de développer une technique vraiment efficace, une assistance au développement de banques de données appropriées sur le rhino, et un soutien au développement par les Etats de l'aire de répartition de projets susceptibles d'obtenir un financement. L'accent de l'ensemble du programme est mis sur le développement de structures, processus et stratégies de signification régionale ;

grammes. The effects should be lasting, and not of an ephemeral non-sustainable nature. The African Rhino Specialist Group's (AfRSG) main role in the Consortium is to provide technical advice and to recommend on the suitability of proposed projects within the continental and regional contexts.

## **ACTION PLAN**

The long awaited "Status survey and conservation action plan : African rhino" was published by IUCN in late 1999, and the AfRSG's Scientific Officer, Dr the Hon. Richard Emslie, is to be commended on an excellent product. I should like to thank the various AfRSG and IUCN staff members who contributed so energetically and productively towards the final version.

## **CAMEROON'S BLACK RHINO**

The last known remaining population of the Western African black rhino *Diceros bicornis longipes* continues to be the focus of attention with IUCN France, WWF and the AfRSG actively pursuing a solution with the Cameroon government. The specialist group and IUCN France are busy compiling background documentation for a workshop to be held in Cameroon soon after mid-year. The documents summarise the history and population trends of this critically endangered population, and outline a number of potential conservation strategies for consideration. As numbers are deemed to be well below 20, this may well be the last opportunity to save the subspecies from extinction.

## **AFRSG MEETING**

At the time of drafting this report, the final arrangements for the AfRSG meeting scheduled for 27 May - 1 June 2000 at Lake Manyara, Tanzania, were being finalised. Apart from the usual reports from the range States on their rhino conservation programmes, the meeting will review the status of all Africa's rhino populations (numbers will be

ceci facilitera la mise en place de meilleurs programmes de protection du rhino. Les effets doivent être durables et non de nature éphémère. Le rôle principal du Groupe de Spécialistes du Rhino Africain (GSRAf) au sein du Consortium est de fournir un conseil technique et d'émettre des recommandations sur l'adéquation des projets proposés dans les contextes continental et régional.

## **PLAN D'ACTION**

L' "Etude de situation et plan d'action pour la protection : rhino Africain" tant attendue a été publiée par l'UICN fin 1999, et l'officier scientifique du GSRAf, Dr Hon. Richard Emslie, mérite de nombreuses louanges pour cet excellent document. J'aimerais remercier les différents membres du personnel du GSRAf et de l'UICN qui ont contribué avec autant d'énergie et de productivité à la version finale.

## **RHINO NOIR DU CAMEROUN**

La dernière population connue de rhino noir d'Afrique occidentale *Diceros bicornis longipes* reste l'objet majeur de l'attention de l'UICN France, le WWF et le GSRAf recherchant activement une solution avec le gouvernement camerounais. Le groupe de spécialistes et l'UICN France sont occupés à rassembler des informations de fond pour un atelier de travail qui se tiendra au Cameroun au début du second semestre. Les documents résument l'histoire et les tendances d'évolution de la population de cette sous-espèce en danger critique, et soulignent un certain nombre de stratégies de conservation potentielles à considérer. Alors qu'on estime que leur nombre est largement inférieur à 20, ceci pourrait bien représenter la dernière chance de sauver cette sous-espèce de l'extinction.

## **REUNION DU GSRAF**

Au moment de la rédaction de ce rapport, les derniers préparatifs pour la réunion du GSRAf prévue du 27 mai au 1er juin 2000 au Lac Manyara, Tansanie étaient sur le point de se conclure. En plus des rapports habituels des Etats de l'aire de répartition sur leurs programmes de con-

reported in *Pachyderm* 29), report on technological advances, expose members to rhino support programmes, and workshop a number of key issues and strategies. The latter include a preliminary evaluation of the institutional and conservation models for Cameroon's black rhino, the further development of indicators for assessing black rhino performance, the potential effects of immobilisation on rhino fecundity, and the development of a funding strategy for the core activities of the AfRSG secretariat.

## ACKNOWLEDGEMENTS

The continued support of WWF-SA for the Chairman's expenses and of WWF International for supporting the Scientific Officer's position and specific projects as well as covering the costs of the AfRSG meeting is very much appreciated. We also acknowledge the financial assistance that US Fish and Wildlife Service provides to the Scientific Officer's position.

servation du rhino, la réunion passera en revue la situation de toutes les populations de rhino d'Afrique (les chiffres seront publiés dans *Pachyderm* 29), fera le point sur les avancées technologiques, familiarisera les membres avec les programmes de soutien au rhino et travaillera sur un certain nombre de sujets-clé et de stratégies. Ce dernier point inclut une évaluation préliminaire des modèles institutionnels et de protection pour le rhino noir du Cameroun, la poursuite du développement d'indicateurs pour déterminer les résultats sur le rhino noir, les effets potentiels de l'immobilisation sur la fécondité du rhino et le développement d'une stratégie de financement pour les activités centrales du secrétariat du GSRAf.

## REMERCIEMENTS

Le soutien continu du WWF-AS pour les dépenses du Président et du WWF International pour le poste de l'officier scientifique et des projets spécifiques ainsi que pour la prise en charge de la réunion du GSRAf est hautement apprécié. Nous remercions également l'US Fish and Wildlife Service pour sa contribution financière au poste de l'officier scientifique.

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# Asian Rhino Specialist Group

## (AsRSG)

# Groupe des Spécialistes des Rhinos Asiatiques

## (GSRAs)

**Mohd Khan bin Momin Khan<sup>1</sup>, Thomas Foose<sup>1</sup> and Nico van Strien<sup>2</sup>**

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<sup>2</sup>Julianaweg 2, 3941 DM Doorn, The Netherlands

The AsRSG Newsletter *Asian Rhinos* has resumed publication with issue number 3, March 2000. The objective is to publish two issues a year. A third editor Dr. L.C. ("Kees") Rookmaaker has been added to assist the AsRSG Programme Officers with this newsletter.

For *Rhinoceros sondaicus* (The "Javan" Rhino):

- In Indonesia, efforts to conserve this species have intensified over the last two years guided by recommendations from the Javan Rhino Colloquium conducted under the auspices of the AsRSG in 1997 with funds from USFWS RTCF and IRF.
- Rhino Protection & Monitoring Units (i.e. teams that conduct anti-poaching patrols and collect relevant biological data on the rhino) have been established on the model of the Rhino Protection Units (RPU) that have been operating since 1995 for Sumatran Rhino. The RPMU Programme is jointly sponsored by the International Rhino Foundation (IRF) and WWF-Indonesia Programme (WWF-IP) with significant support from many of the WWF National Organizations (WWF-Netherlands, WWF-UK, WWF-US, WWF-Switzerland). The US Fish & Wildlife Service Rhino and Tiger Conservation Fund (USFWS RTCF) is a major supporter of this programme.
- The latest track and transect census con-

La publication de la lettre du GSRAs *Asian Rhinos* a repris avec le numéro 3 de mars 2000. L'objectif est de publier deux numéros par an. Un troisième rédacteur, le Dr L.C. (« Kees ») Rookmaaker a été engagé pour assister les officiers du programme dans la préparation de ce bulletin.

Pour le *Rhinoceros sondaicus* (Rhino de Java) :

- En Indonésie, les efforts pour préserver cette espèce se sont intensifiés au cours des derniers deux ans, guidés par les recommandations du Javan Rhino Colloquium conduit sous les auspices du GSRAs en 1997 et financé par l'USFWS RTCF et l'IRF.
- Des Unités de Protection et de Suivi du Rhino (RPMU, à savoir des équipes effectuant des patrouilles anti-braconnage et la collecte de données biologiques adéquates sur le rhino) ont été établies sur le modèle des Unités de Protection du Rhino (RPU) opérant depuis 1995 pour le rhino de Sumatra. Le Programme RPMU est co-sponsorisé par la Fondation Internationale pour le Rhino (IRF) et le Programme du WWF pour l'Indonésie (WWF-IP) avec un soutien significatif de nombreuses organisations nationales du WWF (WWF-Pays Bas, WWF-Royaume Uni, WWF-Etats Unis, WWF-Suisse). Le Fond de Conservation du Rhino et du Tigre de l'US Fish and Wildlife Service (USFWS RTCF) est un sponsor majeur de ce programme.

ducted in late 1999 in Ujung Kulon National Park has estimated the population at 43-57, i.e. numbers still seem to be stagnating around 50, despite the general assessment that the carrying capacity of Ujung Kulon is perhaps as large as 100. A photographic census using camera-traps is being conducted by Nazir Foead of WWF-Indonesia Programme (WWF-IP) with significant support from the Bowling for Rhinos Programme of the American Association of Zoo Keepers (AAZK) through the Adopt-A-Park Programme of the Minnesota Zoo. A coordinated fecal-DNA population study is also being conducted by WWF-IP with support from the WWF system.

- In Vietnam, a coordinated photographic and fecal-DNA census is also being conducted for *Rhinoceros sondaicus*, where only seven to eight rhinos are estimated (by track/transect censuses in 1998 & 1999). This project is part of the major programme for conservation in Cat Tien National Park with funds provided by the Government of the Netherlands and administered through WWF-Vietnam Programme. The first photos from this study have been widely publicized. The DNA part of the study is also being coordinated with similar research being conducted in Ujung Kulon.
- AsRSG has been providing technical assistance for both formulation and implementation of the rhino conservation action plan in Vietnam.

For *Dicerorhinus sumatrensis* (The Sumatran Rhino):

- The Rhino Protection Units (RPUs) continue to operate in all areas where the species is known to survive in Indonesia and Malaysia. The RPUs do appear to be succeeding in controlling poaching for rhino, especially when compared to the situation for tigers which are being decimated in areas that are not covered by any anti-poaching patrols. Tigers are even being lost in Parks where there are RPUs but mainly in areas which the RPUs do not

- Le dernier recensement par pistage et transects conduit fin 1999 dans le Parc National Ujung Kulon a estimé la population entre 43 et 57 ; les chiffres semblent donc toujours stagner autour de 50 en dépit de l'estimation générale selon laquelle Ujung Kulon pourrait peut-être en accueillir jusqu'à 100. Un recensement photographique à l'aide de pièges-photo est en cours de réalisation par Nazir Foead du Programme du WWF pour l'Indonésie (WWF-IP) avec un soutien important du Programme « Bowling pour les Rhinos » de l'Association Américaine des Gérants de Zoo (AAZK) à travers le Programme Adopte-un-Parc du zoo du Minnesota. Une étude coordonnée de l'ADN fécal est également conduite par le WWF-IP avec le soutien de la structure WWF.
- Une étude coordonnée de l'ADN fécal est également conduite pour le *Rhinoceros sondaicus* au Vietnam, où seulement 7 ou 8 rhinos sont estimés (par recensements pistage/transects en 1998 et 1999). Ce projet fait partie du programme majeur pour la conservation dans le Parc National de Cat Tien réalisé à l'aide de subventions du gouvernement des Pays-Bas et administré par le Programme WWF pour le Vietnam. Les premières photos de cette étude ont été largement publiées. La partie ADN de l'étude est également coordonnée avec les recherches analogues menées à Ujung Kulon.
- Le GSRA a fourni une assistance technique pour la formulation et la mise en place du plan d'action pour la conservation du rhino du Vietnam.

Pour le *Dicerorhinus sumatrensis* (Rhino de Sumatra) :

- Les Unités de Protection du Rhino (RPU) continuent à opérer dans toutes les zones de survie connues d'Indonésie et de Malaisie. Les RPU ne semblent pas réussir à contrôler le braconnage du rhino, en particulier si l'on compare à la situation pour les tigres, qui sont décimés dans les zones non couvertes par les patrouilles anti-braconnage. Des tigres sont même perdus dans les parcs où les RPU sont en action mais essentiellement dans les zones non couvertes par les RPU du fait du petit

cover because there are few rhino there and resources are limited. Funds for the RPU in Indonesia outside Gunung Leuser are provided mainly by IRF, WWF-IP (through donations from other WWF National Organizations including WWF-US, WWF-UK, WWF-Netherlands, WWF-Switzerland), the USFWS RTCF, the Anna Merz Trust, and the AAZK Bowling for Rhinos Programs. Funds for the Gunung Leuser RPU are provided by the European Union (EU). Funds for the RPU in Peninsula Malaysia are provided by the IRF and the USFWS RTCF.

- A second major workshop was conducted in March 2000 in Indonesia and Malaysia by all managers and researchers from the 4 facilities that maintain the 17 (5 males and 12 female) Sumatran rhino under managed conditions. The participants reassessed the status of each animal and adaptively reformulated animal-by-animal recommendations in a continuing effort to reproduce this species under managed conditions.

nombre de rhinos dans ces zones et de la limitation des ressources. Le financement pour les RPU en Indonésie en dehors de Gunung Leuser est apporté essentiellement par l'IRF, le WWF-IP (à travers des dons d'autres organisations nationales du WWF parmi lesquelles le WWF-Etats Unis, le WWF-Royaume Uni, le WWF-Pays Bas, le WWF-Suisse), l'USFWS RTCF, l'Anna Merz Trust et les Programmes « Bowling pour les Rhinos » de l'AAZK. Les fonds pour les RPU de Gunung Leuser sont fournis par l'Union Européenne (UE). Les fonds pour les RPU de la péninsule malaise sont fournis par l'IRF et l'USFWS RTCF.

- Un second important atelier de travail a été conduit en mars 2000 en Indonésie et Malaisie par l'ensemble des gestionnaires de quatre infrastructures qui s'occupent de 17 rhinos de Sumatra (5 mâles et 12 femelles) sous conditions contrôlées. Les participants ont réévalué la situation de chaque animal et reformulé les recommandations animal par animal en les adaptant dans un effort continu pour obtenir la reproduction de cette espèce en conditions contrôlées.

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# **African Elephant Specialist Group**

## **(AfESG)**

# **Groupe des Spécialistes des Eléphants Africains**

## **(GSEAf)**

**Holly T. Dublin**

PO Box 62440, Nairobi, Kenya

It has been a very busy six months in the AfESG Secretariat. Then again, it is difficult to recall any such periods that were not just as frantic. Our primary focus has been on trying to secure future funding for all aspects of the AfESG. This has included proposals and negotiations on funding for many activities of the Group, including support for: a membership meeting within the coming year, the core running costs of the existing AfESG offices, the possible expansion of AfESG operations to Central Africa, the recruitment of a new Manager for the AED and running costs for the unit and the continuing production of *Pachyderm*. We have always had extremely generous supporters but “donor fatigue” is a very real phenomenon and I am beginning to experience this in trying to convince them of the need for their continued backing.

### **NATIONAL AND SUB-REGIONAL PLANNING**

AfESG input to national and sub-regional planning continues. It is very gratifying to play a catalytic role in progressing the need for strategic planning across the range states and all the more so to see the results of such planning beginning to take root. In July 2000, several members of the AfESG will travel to Accra at the invitation of the Ghana Wildlife Division to provide technical input to their national planning exercise. Ghana is grappling with many issues of interest to the Group at large. These include: the management of cross-border populations, the management of small, isolated

Les derniers six mois ont été très chargés au secrétariat du GSEAf. Mais à vrai dire il est difficile de se rappeler toute autre période qui n’ait pas été tout aussi agitée. Nous nous sommes concentrés en premier lieu sur la sécurisation de financements futurs pour tous les aspects du GSEAf. Ceci a comporté des propositions de projets et des négociations sur le financement de nombreuses activités du groupe, parmi lesquelles : une rencontre des membres dans l’année à venir, les coûts de fonctionnement de base des bureaux existants du GSEAf, l’expansion possible des opérations du GSEAf vers l’Afrique Centrale, le recrutement d’un nouveau directeur pour l’AED et les coûts de fonctionnement pour l’équipe et la production continue de *Pachyderm*. Nous avons toujours bénéficié de financeurs extrêmement généreux mais la « fatigue des donateurs » est un phénomène très réel et je commence à gagner de l’expérience à essayer de les convaincre de la nécessité de maintenir leur soutien.

### **PLANIFICATION NATIONALE ET SUB-REGIONALE**

La contribution du GSEAf à la planification nationale et sub-régionale continue. Il est très gratifiant de jouer un rôle de catalyseur en faisant avancer l’argument de la nécessité d’une planification stratégique à travers les espaces de l’aire de répartition, et à plus forte raison de voir les résultats de cette planification qui prend racine. En juillet 2000, plusieurs membres du GSEAf se rendront à Accra à l’invitation de la Division de la Faune du Ghana afin de fournir une contribution technique à leur exercice national de planification. Le Ghana lutte contre de nombreux problèmes intéressant le

forest populations, the control of illegal ivory trade and the need for strategic planning to ensure coordinated action to secure the many vulnerable elephant populations in the country.

Other initiatives are also underway. Although we are still awaiting word on funding for the first in a series of proposed national planning workshops for Botswana's elephants, I am hopeful that this support will be forthcoming shortly. Several members of the AfESG will be attending a meeting in late May in southeastern Cameroon to help further an innovative cross-border initiative for the conservation of forest elephants in the Cameroon, Central African Republic, Congo and Gabon. This meeting will accompany further MIKE training for the Central African sub-region, with particular emphasis on measuring law enforcement effort in the forest environment. This is characteristic of many exciting initiatives in the Central African sub-region, including recent discussions between myself and government, NGO and donor partners in the sub-region over the possibility of drafting a sub-regional strategic framework for the conservation of elephants. We have learned lessons from the West African strategic planning exercise and have growing confidence in the appeal of such frameworks to donors and decision makers, alike, through their increased support of conservation action on the ground.

## **MEDIATING SOLUTIONS TO HUMAN-ELEPHANT CONFLICT**

Under the guidance of the Human-Elephant Conflict Taskforce (HETF), a project was carried out to study priority issues in the context of human-elephant conflict between July 1998 and December 1999 (phase II). In January 2000 a workshop was held in Nairobi to synthesise the results of the studies, to derive recommendations for mitigating human-elephant conflict and to define the next steps. The discussion on the outputs from eight studies, which were completed during the second phase and the insights into remaining gaps of knowledge with respect to mitigating human-ele-

Groupe dans son ensemble. Parmi ceux-ci : la gestion de populations transfrontalières, celle de petites populations forestières isolées, le contrôle du commerce illégal de l'ivoire et le besoin d'une planification stratégique afin d'assurer une action coordonnée pour assurer la sécurité des nombreuses populations d'éléphants vulnérables dans le pays.

D'autres initiatives sont également en route. Bien que nous attendions encore une réponse quant au financement du premier d'une série d'ateliers de planification nationale proposés pour les éléphants du Botswana, j'ai confiance que ce soutien nous sera accordé prochainement. Plusieurs membres du GSEAf participeront à une réunion fin mai dans le Sud-Est camerounais afin de soutenir une initiative transfrontalière innovante pour la conservation des éléphants des forêts du Cameroun, de la République Centrafricaine, du Congo et du Gabon. Cette réunion accompagnera une formation supplémentaire MIKE pour la sub-région d'Afrique centrale, avec un accent particulier sur la mesure de l'effort de mise en application de la loi en environnement forestier. Ceci est caractéristique de nombreuses initiatives passionnantes dans la sub-région d'Afrique centrale, parmi lesquelles de récentes discussions que j'ai eues avec les partenaires gouvernementaux, non-gouvernementaux et financeurs dans la sub-région sur la possibilité de rédiger un cadre stratégique sub-régional pour la conservation des éléphants. Nous avons tiré les leçons de l'exercice de planification stratégique d'Afrique de l'Ouest et nous avons une confiance grandissante en l'attrait de tels cadres tant pour les financeurs que pour les décideurs, du fait de leur support accru aux actions de protection sur le terrain.

## **SOLUTIONS DE MEDIATION DANS LE CONFLIT HOMME-ÉLÉPHANT**

Sous la supervision de la force de travail Conflit Homme-Éléphant (HETF), une équipe a étudié entre juillet 1998 et décembre 1999 (phase II) les questions prioritaires dans le contexte du conflit homme-éléphant. En janvier 2000 un atelier de travail s'est tenu à Nairobi afin de faire la synthèse des résultats de cette étude, d'en dériver des recommandations pour atténuer les conflits homme-éléphant et de définir les prochaines étapes. La dis-

phant conflict, led to the conclusion that a continuation of the project would enhance the benefits to governments, decision makers in wildlife management and other parties, which are directly or indirectly concerned with human-elephant conflict. During the workshop, four further activities were suggested for phase III to address important issues that arose during the past two years. These include: the development of a Decision Support System (DSS) for problem elephant management; the documentation of literature on human-elephant conflict in West and Central Africa, an assessment of the economic implications of human-elephant conflict in different circumstances and site-specific studies that will put into practice our new standardized data collection protocols for further GIS analysis.

You will find a synthesis of the projects' achievements during phase II in this issue, the paper entitled "Projects of the Human-Elephant Conflict Taskforce (HETF) - Results and Recommendations" by Richard Hoare.

## **THE 11<sup>TH</sup> MEETING OF THE CONFERENCE OF THE PARTIES TO CITES**

Perhaps the best news of the last six months is that the CITES COP has once again come and gone. This time it has not left bitterness and acrimony in its wake but, rather, a very positive addition to the growing foundation of understanding and commitment amongst those most directly responsible for the conservation of Africa's elephants. The CITES COP was immediately preceded by the Fourth African Elephant Range States Dialogue meeting. The meeting was again characterised by the diplomacy and shared commitment to the cause of African consensus and elephant conservation that has become synonymous with the entire Dialogue process. The "spirit" of Dialogue presided throughout the CITES COP and resulted in a homegrown African solution to the difficult compromises before them. When the dust settled, their decisions stood firm. The elephant population of South Africa was added

cussion sur les résultats de huit études réalisées pendant la seconde phase et l'évaluation des lacunes restantes dans la connaissance de la limitation du conflit homme-éléphant ont mené à la conclusion que la poursuite du projet renforcerait les bénéfices pour les gouvernements, les décideurs de la gestion de la faune et les autres parties prenantes, concernées directement ou indirectement par le conflit homme-éléphant. Lors de l'atelier de travail quatre activités ont été suggérées pour que la phase III réponde aux questions importantes soulevées au cours des deux dernières années : le développement d'un système d'aide à la décision (DSS) pour la gestion des animaux à problème, l'inventaire de la littérature sur le conflit humain-éléphant en Afrique de l'Ouest et Centrale, une évaluation des implications économiques du conflit homme-éléphant dans les circonstances variées ainsi que des études spécifiques sur sites mettant en pratique nos nouveaux protocoles standardisés de collecte des données pour analyse ultérieure par des méthodes SIG.

Vous trouverez dans ce numéro une synthèse des résultats du projet au cours de la phase II : l'article intitulé « Projets de la force de travail Conflit Homme-Eléphant - Résultats et recommandations » par Richard Hoare.

## **LA 11<sup>ÈME</sup> REUNION DE LA CONFERENCE DES PARTIES DE CITES**

La meilleure nouvelle des derniers six mois est peut-être qu'une fois de plus l'heure est venue de la COP CITES, puis est passée. Cette fois elle n'a pas laissé de sentiments amers ni d'acrimonie dans son sillage mais au contraire un apport très positif au fondement croissant de compréhension et d'engagement entre les responsables les plus directs de la conservation des éléphants d'Afrique. La COP CITES était immédiatement précédée par la Quatrième Rencontre de Dialogue des Etats de la Zone de Répartition de l'Eléphant Africain. La réunion a été une fois de plus caractérisée par la diplomatie et l'engagement partagé pour la cause d'un consensus africain et de la protection de l'éléphant, qui sont devenus synonymes de l'ensemble du processus de dialogue. L'« esprit » de Dialogue a présidé tout au long de la COP CITES et résulté en

to those of Botswana, Namibia, and Zimbabwe on Appendix II and the trade in non-ivory products, in accordance with the specified annotations from these four countries, was allowed.

As a “veteran” of the ivory wars, it is not possible to express in words the feelings I experienced as the delegate from Cameroon read the decision of the African elephant range states to a room full of delegates and observers who sat in anticipation of the battle to come. It was not simply a feeling of relief but actually a feeling of enormous pride in all my colleagues who worked so long and with such conviction to make this happen. While the issue of ivory trade has by no means been laid to rest, I can only hope that it will go forward in the spirit of understanding and camaraderie that the Dialogue process has now enshrined.

## THE FUTURE OF MIKE AND ETIS

The CITES meeting was not only marked by its mutually-consensual resolution of the elephant listing proposals before it but also of other issues pertaining to the conservation of Africa’s elephants, namely the implementation of MIKE and ETIS (Res. Conf. 10.10). Overwhelming support was expressed by the African elephant range states for the immediate implementation of these two monitoring systems across the continent. Updates were presented to the Dialogue meeting and to the Parties to CITES on the first country reports provided by ETIS and the progress-to-date of MIKE implementation in Central and Southern Africa as well as an overview of the plans that are underway for implementation in the remaining sub-regions of Africa and Asia. In addition to the continued role of the Standing Committee’s Sub-Group on MIKE implementation, the CITES Secretariat announced the formation of a new Technical Advisory Group (TAG) to steer the technical evolution of MIKE in the years to come. I feel that this is a very positive development and one that the AfESG should support in every way possible. This is

une solution foncièrement africaine aux difficiles compromis entre les parties. Lorsque la poussière fut retombée, les décisions étaient fermes. La population d’éléphants d’Afrique du Sud a été ajoutée à celles du Botswana, de Namibie et du Zimbabwe dans l’Appendice II et le commerce de produits non-ivoiriens, en accord avec les annotations spécifiées par ces quatre pays, a été autorisé.

En tant que « vétéran » des guerres de l’ivoire, il m’est impossible de traduire par des mots le sentiment que j’ai éprouvé à la lecture par le délégué du Cameroun de la décision prise par les Etats de la zone de répartition, devant une salle remplie de délégués et d’observateurs déjà en position pour la bataille à venir. Il ne s’agit pas seulement de soulagement mais en fait d’un sentiment d’immense fierté pour tous mes collègues qui ont travaillé si longtemps et avec autant de conviction pour permettre à ce moment d’arriver. Alors que la question du commerce de l’ivoire reste tout aussi actuelle, je peux uniquement espérer que sa résolution pourra progresser dans l’esprit de compréhension et de camaraderie maintenant établi par le processus de Dialogue.

## LE FUTUR DE MIKE ET ETIS

La réunion de CITES n’a pas été marquée uniquement par sa résolution par consensus mutuel des propositions de classement de l’éléphant, mais aussi par d’autres questions se rapportant à la conservation des éléphants d’Afrique, à savoir la mise en place de MIKE et ETIS (Res. Conf. 10.10). Un soutien extrêmement chaleureux fut exprimé par les Etats de la zone de répartition de l’éléphant d’Afrique envers une mise en application immédiate de ces deux systèmes de suivi à travers le continent. Des mises à jour sur les premiers rapports par pays fournis par ETIS et les progrès réalisés à ce jour dans la mise en place de MIKE en Afrique Centrale et Australe furent présentées à la réunion du Dialogue et aux parties de CITES, ainsi qu’une vue générale des projets en cours pour la mise en place dans les sub-régions restantes d’Afrique et d’Asie. En plus du rôle reconduit du sous-groupe du Comité Permanent dans la mise en place de MIKE, le secrétariat de CITES a annoncé la formation d’un nouveau Groupe de Conseil Technique

where the MIKE process is likely to experience its best "reality check" and I hope many members of the AfESG will be called upon to bring their technical skills to bear on this process.

In addition to support from the African elephant Range States, the European Union and the US Fish and Wildlife Service confirmed their commitment to the CITES-approved monitoring systems and encouraged other Parties and donors to provide financial and in kind support to their implementation on the ground. The African elephant Range States also reminded their fellow Parties that monitoring, alone, cannot save Africa's elephants and that continued commitment from the donors must also be demonstrated to meet the real costs of assuring the security of the continent's remaining viable populations.

## PACHYDERM

As a result of (and a tribute to ) its own success, *Pachyderm* has become a very major undertaking. Over the past three years, it has required an ever-growing proportion of the available time of the AfESG Programme Officer here in Nairobi. After almost a decade of securing human and financial resources for the production of *Pachyderm*, I recently appealed to my fellow Chairs in the African and Asian Rhino Specialist Groups (the Asian Elephant Specialist Group produces its own publication, *Gajah*) to lend me a helping hand. Overseeing a group that faces as many demands as the AfESG, we need to find a way to relieve the pressure. I feel that a more equitable distribution of the work load, or at least a more balanced distribution of the responsibility for securing the necessary human and financial resources is in order. At present, the three Groups (the AfESG, AfRSG and AsRSG) are considering future arrangements for the editing and publication of *Pachyderm*. We sincerely hope to be able to carry out any necessary changes "behind the scenes" so you will not experience any disruption or delays in the timely production of the journal. In the interim, I have asked Martina Höft (who left her posi-

(TAG) afin d'orienter l'évolution technique de MIKE dans les années à venir. Je ressens ceci comme un développement très positif, qui devrait être soutenu par le GSEAf par tous les moyens. C'est ainsi que le processus MIKE fera l'expérience du meilleur des « tests de réalité » et j'espère qu'il sera fait appel à de nombreux membres du GSEAf afin qu'ils apportent leurs compétences techniques à ce processus.

En supplément au soutien des Etats de la zone de répartition de l'éléphant d'Afrique, l'Union Européenne et le Fish and Wildlife Service américain ont confirmé leur engagement envers les systèmes de suivi approuvés par la CITES et encouragé d'autres parties et donneurs à apporter un soutien financier et en nature à leur mise en application sur le terrain. Les Etats de la zone de répartition de l'Eléphant d'Afrique ont également rappelé à leurs partenaires des autres parties que le suivi ne peut pas à lui seul sauver les éléphants d'Afrique et que les donneurs doivent apporter un soutien renouvelé pour couvrir les coûts réels et assurer la sécurité des populations viables restantes du continent.

## PACHYDERM

En résultat (et en reconnaissance) de son propre succès, *Pachyderm* est devenu une opération majeure. Tout au long des trois dernières années, sa rédaction a requis une proportion grandissante du temps de travail du Chargé de Projet dans nos bureaux de Nairobi. Après avoir assuré pendant presque une décennie les ressources humaines et financières pour la production de *Pachyderm*, j'ai récemment fait appel à mes confrères Présidents des Groupes de Spécialistes du Rhino Africain et d'Asie (le Groupe de Spécialistes de l'Eléphant d'Asie produit sa propre publication, *Gajah*) pour solliciter leur aide. Pilotant un groupe devant faire face à autant de demande que le GSEAf, il nous est nécessaire de trouver un moyen de limiter la pression. Il me semble qu'une distribution plus équitable de la charge de travail, ou tout au moins une répartition plus équilibrée de la responsabilité d'assurer les ressources humaines et financières nécessaires serait raisonnable. Actuellement, les trois groupes (GSEAf, GSRAf et GSRAs) considèrent des arrangements futurs pour la rédaction et la

tion as the AfESG Programme Officer here in the Secretariat at the end of February 2000) to complete the production of this issue of *Pachyderm*. Our gratitude, as always, is expressed to the United States Fish and Wildlife Service who continue to provide us with support for the production and dissemination of *Pachyderm*.

## THE SITUATION AT THE SECRETARIAT

Since I last wrote, we have experienced a number of changes and there are more to come. Since Martina's departure from the AfESG Secretariat, Ms Rowena Costa-Correa has stepped in to help. Given the voluntary nature of my position and my very heavy work load for WWF, I could never have handled the current round of donor negotiations without Rowena's constant support and her ever-positive temperament, not to mention the many hours she has devoted to compiling all the financial documents required. A number of recruitments are currently in the offing. I am still in search of a new Programme Officer in the Secretariat and, if the proposals we have submitted are eventually funded, we will be recruiting a new AED Manager as well as a full-time, dedicated Programme Officer for Central Africa. By the time you receive this issue of *Pachyderm* we will also have moved to new offices here in Nairobi. We ask your continuing indulgence during this challenging transition period.

publication de *Pachyderm*. Nous espérons sincèrement parvenir à réaliser tous les changements nécessaires « en coulisses » de telle sorte que vous ne ressentiez aucune interruption ou délai dans la production du journal dans les délais. Dans l'intervalle j'ai demandé à Martina Höft (qui a quitté son poste de Chargée de Projet du GSEAf au Secrétariat fin février 2000) de terminer la production de ce numéro. Nous exprimons comme toujours notre gratitude au Fish and Wildlife Service des Etats-Unis qui continue à nous apporter son soutien pour la production et la distribution de *Pachyderm*.

## LA SITUATION AU SECRETARIAT

Depuis ma dernière lettre nous avons vécu un certain nombre de changements et d'autres sont à venir. Depuis le départ de Martina du Secrétariat du GSEAf, Mme Rowena Costa-Correa est intervenue pour apporter son aide. Etant donnée la nature bénévole de ma position et ma très importante charge de travail pour le WWF, je n'aurais jamais pu mener à bien la série actuelle de négociations avec les financeurs sans le soutien continu de Rowena et son tempérament toujours positif, sans mentionner les nombreuses heures qu'elle a consacrées à la préparation de tous les documents financiers nécessaires. Je suis toujours à la recherche d'un nouveau Chargé de Projet pour le secrétariat et, si les propositions que nous avons soumises sont financées, nous recruterons également un nouveau Directeur AED ainsi qu'un Chargé de Projet qui se consacrera à plein temps à l'Afrique centrale. Lorsque vous recevrez ce numéro de *Pachyderm* nous aurons également déménagé dans de nouveaux bureaux ici à Nairobi. Nous faisons appel à votre indulgence pendant cette période de transition difficile.

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# RESEARCH AND METHODOLOGY

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## **Etude des Effectifs et de la Répartition Saisonnière des Eléphants des Aires Classées de l'Est du Burkina Faso**

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### **RESUME**

Un recensement aérien de l'ensemble des aires classées des bassins des rivières Arly et Singou, dans l'est du Burkina Faso a été réalisé deux fois en 1999. Le premier recensement a eu lieu en milieu de saison sèche (février) et le deuxième en début de saison pluvieuse, après environ 200 mm de pluie (juillet).

La population d'éléphants de la zone survolée est d'environ 3 000, soit une densité moyenne de 0,41/km<sup>2</sup>. A cette densité il n'y a pas de conflits avec les populations humaines et la végétation n'apparaît pas dégradée. Selon les zones, les densités sont très variables allant en saison sèche de 0,03 (Koakrana) à 1,1 (Pama centre sud), et en saison pluvieuse de 0 (Koakrana) à 0,79 (Pama sud), indiquant une répartition plus large en saison pluvieuse. La valeur individuelle des zones varie donc de un à 37.

Avec l'arrivée des pluies, on assiste à un mouvement centripète vers le centre de la zone survolée. Les seuls mouvements en dehors de la zone recensée se font au sud, en traversant la rivière Pendjari. Les deux tiers environ de l'effectif sont concentrés dans le bassin hydrographique du Singou. La taille moyenne des groupes est de 6,7 en saison sèche et de 6,0 en saison pluvieuse.

Depuis 1982, le taux de croissance semble être de + 4,7% par an ce qui est compatible avec les paramètres de reproduction (optimum d'environ 6% par an), et n'indique pas d'apport d'éléphants de l'extérieur. Le taux d'observation de carcasses est de 0,7% de la population pour les deux saisons. Le deuxième recensement n'a pas révélé de carcasses fraîches.

### **ABSTRACT**

In 1999, two aerial sample counts were carried out covering all protected areas in the Arly and Singou river basins in eastern Burkina Faso. The first count took place in the middle of the dry season (February), the second took place at the beginning of the rainy season, after 200 mm of rainfall (July).

The elephant population in the area flown is about 3,000, representing ca.  $0.41/\text{km}^2$ . This density does not seem to pose problems with respect to the human population and the vegetation does not seem degraded. The densities within the areas are very variable, ranging from 0.03 (Koakrana) to 1.1 (Pama center south) in the dry season and from 0 (Koakrana) to 0.79 (Pama south) in the rainy season, indicating a wider distribution in the rainy season. The individual value in the zones varies between one and 37.

With the onset of the rains, a centripetal movement towards the center of the areas flown is witnessed. The only movements outside the flown area were recorded in the south, transgressing the Pendjari river. Approximately two third of the numbers are concentrated in the Singou basin. The average group size is 6,7 in the dry season and 6,00 in the rainy season. Since 1982, the rate of population increase seems to be +4.7% per year, which is compatible with an optimum reproduction parameter of ca. 6% per year and not indicative of loss of elephants due to external factors. The observed carcasses were 0,7% of the population for the two seasons. The second count did not reveal fresh carcasses.

## INTRODUCTION

Le recensement des grands mammifères sur une zone de 7 425 km<sup>2</sup> dans l'est du Burkina Faso a été réalisé deux fois, en saison sèche et en saison pluvieuse, par le Projet Arly, financé par la France par le Fonds Français pour l'Environnement Mondial (F.F.E.M.) et l'Agence Française de Développement.

Ce suivi a pour but de préciser le statut et la compréhension écologiques de ces zones, d'en appréhender les possibilités d'aménagement et d'exploitation afin de générer des recettes pour les populations locales dans le cadre d'une gestion participative pérenne. C'est également une partie importante du suivi et de l'évaluation des actions du projet.

Cet article donne les résultats de recensement de saison sèche et de saison pluvieuse, et compare les résultats avec celui des recensements précédents. Il décrit les différences numériques et spatiales entre les deux recensements, et apporte une contribution à l'étude des déplacements des éléphants dans cette zone, et à l'utilisation des ressources alimentaires au cours des saisons.

## DESCRIPTION DE LA METHODE

### Choix de la méthode

Le choix d'une méthode de recensement dépend de nombreux critères : chaque méthode présente des avantages et des inconvénients. Pour le présent recensement, il importe d'obtenir des informations sur la totalité de la zone (ce qui élimine le comptage en voiture : le réseau de pistes n'est pas assez dense pour cela), avec une bonne reproductibilité pour comparer année après année, et même saison après saison (ce qui élimine le comptage total de par son coût), rapide à organiser du fait que le Projet exécute de nombreuses activités, et peu coûteux (ces deux points sont en faveur du comptage aérien).

Techniquement, le recensement aérien présente les avantages suivants, par rapport au recensement pédestre par transects à largeur variable, généralement utilisé au Burkina Faso :

- Minimum de biais : variabilité des observateurs moindre (deux observateurs seulement au lieu de 45 à pied), pas de largeur de transect à calculer, pas de distance de vision à estimer (bande de recensement fixe donc



**Photo n°1.** L'équipes de forestiers burkinabés qui a effectué le recensement : de gauche à droite, Pascal ROUAMBA (Coordination, GPS, observations écologiques et humaines), Paulin NACOLMA (observateur droite), Adama OUEDRAOGO (observateur gauche).

pas de surestimation de la densité par sous-estimation des distances de vision), pas de facteur de correction difficile à calculer pour relier le profil de visibilité à la largeur réelle de bande, pas de déviation des transects du fait du suivi du GPS.

- Moindre importance de la repousse végétale : la visibilité verticale est meilleure que la visibilité horizontale au début de la période de reprise de végétation, en zone soudano-sahélienne (Pluviométrie moyenne de 677 mm par an à Diapaga). Ce phénomène influe à la fois sur le nombre d'animaux vus et sur la différence entre observateurs.
- Moindre importance du phénomène de fuite des animaux à la vue d'un observateur : la méthode de recensement terrestre à transects de largeur variable suppose que les animaux sont détectés avant leur fuite, de façon à déterminer un profil de visibilité. En début de projet, il est classique que les animaux fuient avant d'être vus : on obtient donc un profil de visibilité biaisé, qui sous-estime les populations animales en début de projet, et les surestime en fin de projet.
- A la différence des recensements pédestres,

il ne nécessite pas un minimum de 15 à 30 observations par espèce pour déterminer le profil de visibilité, ce qui rend le recensement terrestre valable pour les quelques espèces les plus abondantes seulement.

- Moins de matériel à acheter : pas de boussoles, de télémètres, un seul GPS, etc. Il suffit de disposer d'un avion adapté et d'un pilote compétent.
- Le coût est bien moindre : peu de salaires, peu de moyens de déplacement, peu de nourriture, formation moins longue des observateurs.

Concernant les résultats, on peut faire la remarque suivante : d'une manière générale le recensement aérien sous-estime les résultats, et d'autant plus que l'espèce est petite. Comme base de quota de chasse, il conduit à des estimations prudentes. Le recensement terrestre à transects de largeur variable conduit à des surestimations, donc à des quotas de chasse risqués.

Pour toutes ces raisons, c'est le recensement aérien par échantillonnage qui a été retenu par le Projet Arly.

## Description des paramètres techniques

Nous avons utilisé l'avion à ailes hautes CESSNA 172 de l'aéro-club de Ouagadougou. Les bandes de comptages ont été positionnées sur les haubans des ailes selon la méthode de Norton-Griffiths (1978), de façon à déterminer une largeur de bande de 200 m de part et d'autre de l'avion. Pour des raisons de coût, le taux d'échantillonnage retenu a été de 14%, ce qui détermine un espacement des transects de 3 km.

L'altitude de vol a été fixée à 91 m (300 pieds), et la largeur de bande a été vérifiée par le comptage d'espaces préfixés lors de sept passages perpendiculaires à la piste d'Arly. La vitesse de survol a été de 150 km/h (80 nœuds). Ces valeurs n'ont pas posé de problème, en particulier :

- A cette altitude, les observateurs ont estimé voir sans problème même les plus petites espèces : ils ont demandé à comptabiliser les ourébis lors du 2ème survol. Cette demande n'a pas été retenue pour ne pas multiplier les données à noter.
- La largeur de bande leur a semblé appropriée, en relation avec la végétation, la vitesse, et la hauteur de bande (effet « défilement »).
- L'espacement des transects, assez large pour une question de coût, a néanmoins conduit à des doubles comptages sur certaines zones. Il faut tenir compte de l'effet « passage de l'avion » : environ 90% des animaux, toutes espèces confondues, fuient au passage de l'avion. Rapprocher les transects demanderait la prise en compte de deux données supplémentaires : la position GPS des animaux et leur axe de fuite par rapport à la direction du transect. Cela demande une organisation supplémentaire, et en particulier un système de communication interne non disponible dans l'avion utilisé.

## Description de la collecte des données

Le Cessna 172 dispose de quatre sièges. Le siège avant gauche est celui du pilote. Les données relatives aux animaux sauvages ont été collectées

par les deux observateurs arrières, pour lesquels les bandes sur l'avion ont été individuellement calibrées. Ils ont donc réalisé tout le comptage. L'utilisation du GPS pour le pilotage a dégagé le siège avant droit du travail d'orientation. La collecte des données anthropiques et la prise des positions GPS a été réalisée par l'observateur avant.

Des fiches de prises de données ont été réalisées par le Projet Arly. Pour chaque transect on note : son numéro, le point GPS d'origine et de fin, l'heure à l'origine et à la fin. Pour chaque observation animale sont notées : l'espèce, le nombre, l'heure, le point GPS, éventuellement le numéro de la photo prise (pour des troupeaux importants). La présence d'espèces rares hors transects (lycaon, guépard, lion, etc.) est aussi notée.

Une deuxième fiche, utilisée par l'observateur avant, permet de noter les données en relation avec les activités humaines : présence d'homme, de camp, de bœufs, de champs, etc., en notant la position sur le transect.

Ces fiches ont donné satisfaction, étant à la fois faciles à remplir et collectant l'ensemble des données nécessaires.

Il a été demandé aux observateurs arrières de noter uniquement les huit espèces suivantes : éléphant, buffle, hippotrague, bubale, damalisque, cobe Defassa, cobe de Buffon et lion. Ces espèces, facilement détectables par avion, sont celles qui intéressent le plus les touristes, donc celles à prendre en compte pour l'aménagement du parc. En conséquence il n'a pas été obtenu de données concernant les ourébis, céphalophes, phacochères, singes, etc.

## Traitement des données

Les données ont été traitées par zone en considérant la totalité des transects concernés comme un seul transect. Le traitement est fait en deux temps :

- Un positionnement géographique des observations par ordinateur, en resituant chaque point sur un fond de carte de la zone (logi-

ciel MapInfo), ce qui permet d'attribuer à chaque animal ou fait observé un emplacement dans une zone ou concession donnée. On obtient ainsi des cartes de répartition des observations.

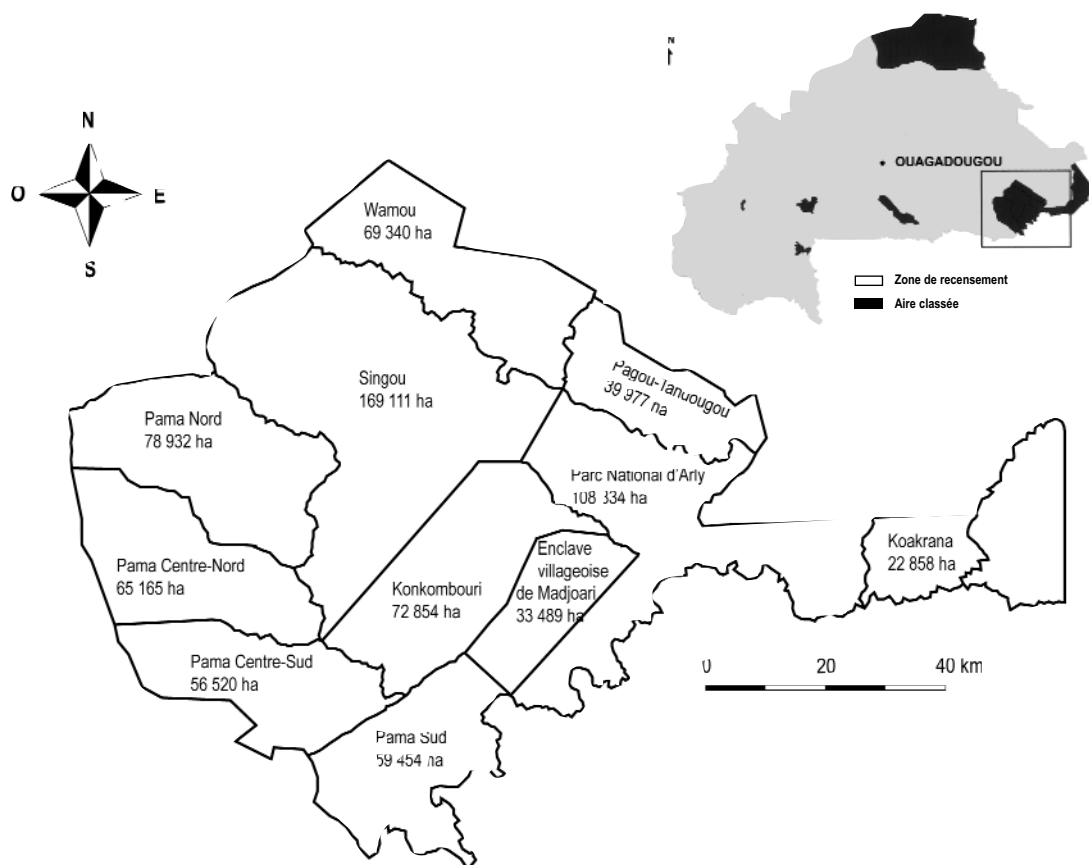
- Un traitement statistique par tableur Excel, en appliquant le loi de Jolly n°2, pour connaître l'intervalle de confiance à 95% de la moyenne calculée. Cet intervalle de confiance est un reflet de la distribution homogène des données autour de la moyenne, et évalue le risque lié à la non détection de certains d'entre eux.

Dans le cas particulier des éléphants pour le recensement de saison sèche, une stratification a été faite pour les trois zones sud de Pama, Konkombouri et Arly, du fait de la répartition

non aléatoire le long des cours d'eau qui augmentait la probabilité de rencontre. Leur répartition dans ces zones a été séparée en deux : une zone de faible densité, et une zone de haute densité. C'est cette stratification qui a permis de calculer l'effectif total, et d'éviter ainsi d'extrapoler les valeurs de la zone la plus dense à la totalité de la zone. Sans cette stratification, on aurait obtenu un effectif d'éléphants beaucoup trop élevé. La validité de la méthode a été démontrée à l'issue du recensement de saison pluvieuse qui a conduit au même effectif.

On peut produire alors des cartes de densités, de biomasse par espèces ou en totalité, et des cartes d'activités humaines illégales dans les aires classées.

**Figure n°1.** Aires classées au Burkina Faso et présentation de la zone de recensement.



## REALISATION DU SURVOL

### Zone de recensement

Les recensements de saison sèche et de saison pluvieuse ont couvert exactement la même zone, soit l'ensemble des Unités de Conservation d'Arly, Wamou et Pama, dans l'est du Burkina Faso. La carte ci-dessous représente les aires classées (Figure n°1).

Le total de la surface recensée est de 742 546 ha, totalement inhabités, mais incluant une enclave supplémentaire de 33 489 ha (Madjoari) comptant 6 000 habitants. Le calcul des surfaces des zones a été fait par le logiciel MapInfo, sur la base du fond de carte numérisée du PNGT/IGB, au 1/200.000ème. Elles tiennent compte de la présence d'enclaves agricoles telles que mentionnées dans les textes (Pama), ou définies par la présente étude.

### Position des transects

La zone a été couverte en 66 transects représentant une longueur totale de 2 413 km dans les aires classées. Ces transects ont été positionnés par rapport au réseau hydrographique dominant, de façon à ne pas sonder plus intensément une zone écologique plus qu'une autre et ainsi à ne pas créer de biais en sur-échantillonnant les zones à proximité de l'eau qui sont plus riches en faune sauvage. Il en résulte qu'une moitié des transects est orientée est-ouest, et l'autre nord-sud. La position du premier transect a été tirée au sort, puis les suivants ont été placés tous les 3 km.

### Largeur réelle de la bande

A chaque recensement, les largeurs réelles des bandes d'échantillonnage sont vérifiées par des

passages successifs au-dessus d'espaces matérialisés au sol:

- Pour le recensement de février, le calcul de la largeur de bande a donné une valeur de 225 m pour la bande de gauche, et de 210 m pour la bande de droite. La largeur totale est donc de 0,435 km. La surface échantillonnée est donc de 104 996 ha, soit 14,14%.
- Pour le recensement de juillet, les calculs ont donné une largeur de 250 m pour la bande de gauche, et 246 m pour la bande de droite. La largeur totale est donc de 0,496 m. La surface échantillonnée est donc de 122 735 ha, soit 16,53%.

### Réalisation du recensement

Le recensement de pleine saison sèche a eu lieu du 15 au 23 février 1999, à partir des terrains d'Arly et de Pama. Il a nécessité 26 heures de vol.

Le recensement de saison pluvieuse (après environ 200 mm de pluie) a eu lieu du 11 au 21 juillet 1999, à partir des terrains de Diapaga et de Fada N'Gourma. Il a nécessité 29 heures de vol.

### Description de la zone

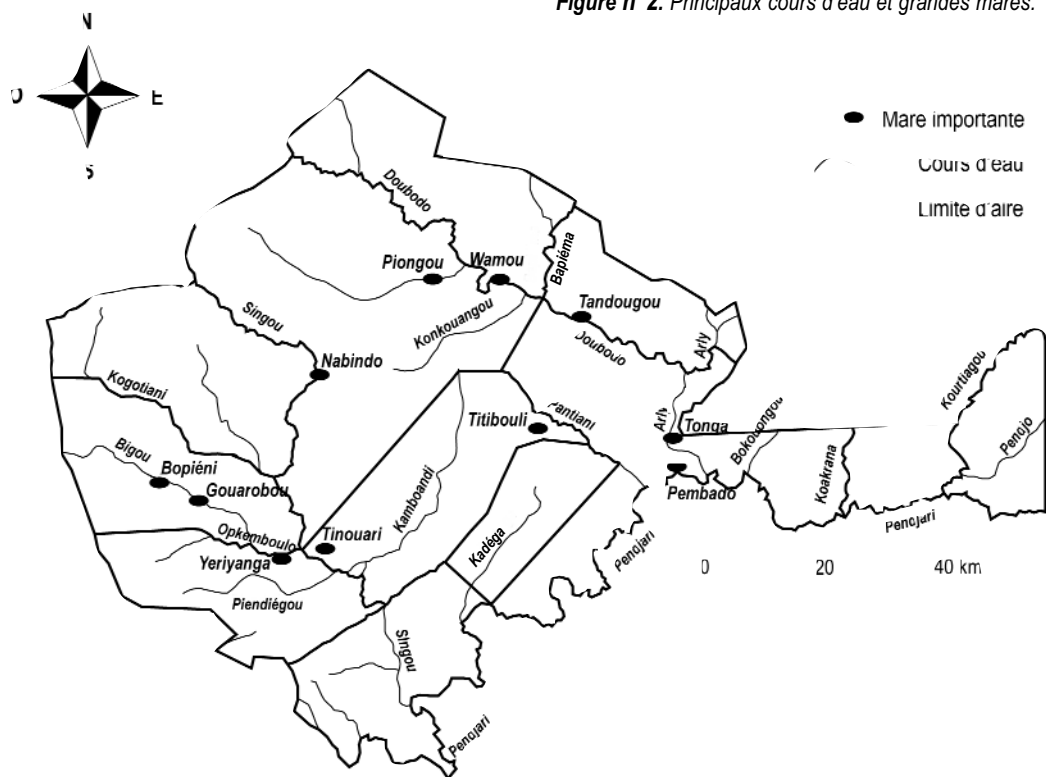
La zone survolée est majoritairement plate, correspondant à un plateau granitique couvert principalement de savane arbustive à arborée au nord, avec une dominance s'affirmant du nord au sud des graminées pérennes sur les annuelles qui ne subsistent plus que sur les cuirasses latéritiques. Au sud on trouve une savane arborée à boisée, le couvert graminéen y est essentiellement pérenne.

Le long des cours d'eau on rencontre des galeries ripicoles qui atteignent une taille importante le long des cours d'eau principaux (Singou,

**Tableau n°1.** Effectifs des éléphants observés en saison sèche et en saison pluvieuse.

	Nombre d'observations		Effectifs observés		Taille moyenne des groupes	
Date	Février 1999	Juillet 1999	Février 1999	Juillet 1999	Février 1999	Juillet 1999
Eléphants	94	82	632	492	6.72 ± 1.85	6.00 ± 1.16

**Figure n°2.** Principaux cours d'eau et grandes mares.



Arly-Doubodo) et d'autant plus que l'on va vers l'aval, et surtout le long de la Pendjari, qui présente en plus d'importants peuplements de rôniers. (Figure n°2).

Le sud de la zone présente des collines (Pama) et des falaises (Gobnangou, Madjoari) de grès, avant la pénéplaine schisto-argileuse de la Pendjari. L'altitude du plateau va de 250 m à 150 m (Pendjari), avec des collines atteignant 350 m (Yérianga près de Pama, Pagou près d'Arly) et la falaise culminant à 386 m (Madjoari).

La pluviométrie normale de ces dernières années se situe autour de 700 mm pour l'ensemble de la zone, et autour de 800 mm pour le sud de Pama.

## RESULTATS ET COMMENTAIRES

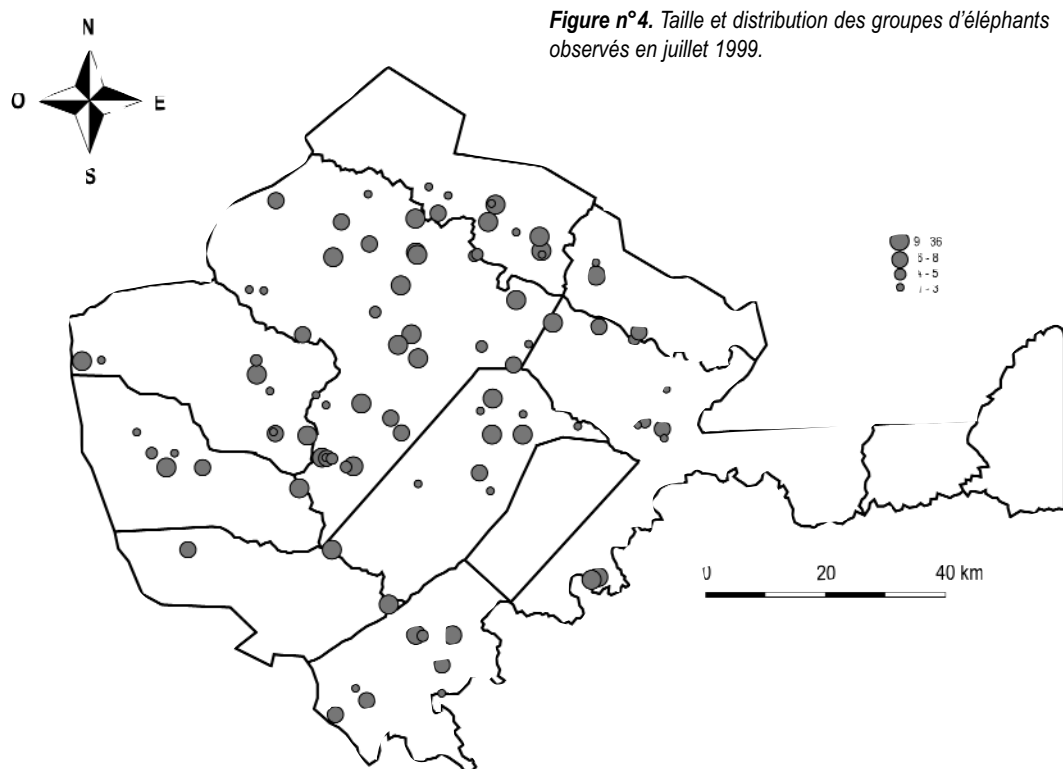
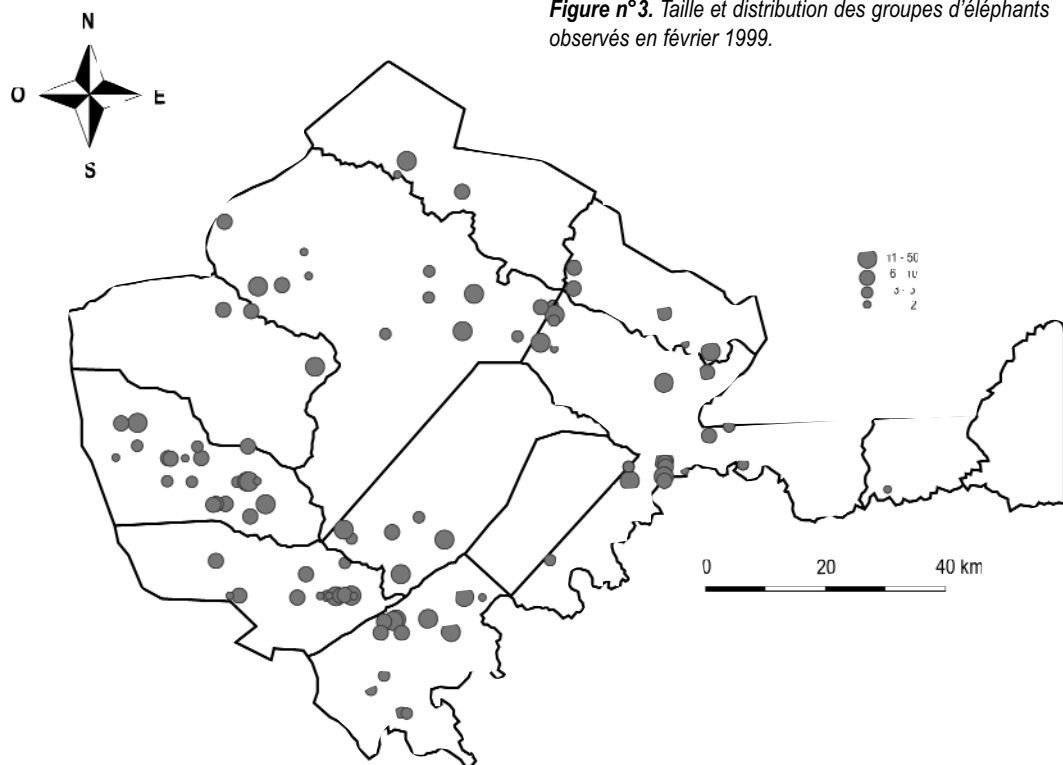
Pour chaque recensement, le nombre d'observations faites, d'animaux observés et les tailles moyennes des groupes ont été enregistrés (Tableau n°1, Figures n°3 et n°4).

Zone par zone, le calcul de la taille moyenne du groupe d'éléphants est présenté pour chaque saison (Tableau n°2.). Ces données conduisent à l'estimation de la densité dans l'échantillonnage. La moyenne est suivie de la valeur de son intervalle de confiance à la probabilité de 95%. C'est le calcul de cette moyenne qui conduit à la densité puis au calcul de l'estimation de l'effectif.

Les données permettent alors de calculer une densité d'individus avec un intervalle de confiance par unité de surface de l'échantillonnage, puis de la zone totale. Ce chiffre rapporté à chaque zone donne l'estimation suivante des populations animales, avec leur intervalle de confiance à la probabilité de 95%.

## Effectifs

Les chiffres obtenus proviennent des observations qui figurent sur la carte de taille et de répartition des groupes observés pour chaque saison (Tableau n°3).



Pour la saison sèche, il a fallu faire une stratification entre une zone de haute densité et de basse densité dans les zones où de nombreux éléphants étaient concentrés le long des points d'eau, et donc où la probabilité de détection était augmentée. La stratification a consisté à calculer l'aire réellement occupée par les éléphants, et à rapporter cette valeur à la surface totale, ce qui

constitue le coefficient de diminution de la valeur trouvée. Cette méthode a été utilisée pour les zones suivantes : Arly, Pama Centre-Nord, Pama Centre-Sud, Pama Sud, Konkombouri.

Les résultats trouvés ont été validés par le recensement de juillet : la répartition aléatoire n'a alors pas nécessité de stratification, et les

**Tableau n°2.** Taille moyenne du groupe d'éléphants dans les zones différentes pour la saison sèche (février) et la saison pluvieuse (juillet).

ZONE	Février 1999	Juillet 1999
ARLY	4,69 ± 1,32	5,20 ± 2,00
KOAKRANA	-	-
PAGOU	8,00 ± 4,08	3,50 ± 4,90
WAMOU	8,33 ± 6,23	3,21 ± 1,68
SINGOU	5,67 ± 1,78	6,48 ± 1,45
PAMA Nord	7,75 ± 2,58	5,33 ± 2,61
PAMA Centre N.	6,11 ± 1,85	5,60 ± 5,35
PAMA Centre S.	9,31 ± 6,30	-
PAMA Sud	6,40 ± 2,47	9,75 ± 8,10
KONKOMBOURI	9,40 ± 6,92	8,89 ± 2,73
<b>TOTAL</b>	<b>6,72 ± 1,85</b>	<b>6,00 ± 1,16</b>

**Tableau n°3.** Effectifs des éléphants dans les zones différentes pour la saison sèche (février) et la saison pluvieuse (juillet).

ZONE	Février 1999	Juillet 1999
KOAKRANA	7 ± 0	0
ARLY	411 ± 116	315 ± 121
PAGOU	170 ± 87	42 ± 59
WAMOU	175 ± 131	169 ± 91
SINGOU	481 ± 152	1059 ± 253
PAMA NORD	219 ± 73	194 ± 95
PAMA Centre Nord	495 ± 150	169 ± 162
Pama Centre Sud	623 ± 422	36 ± 0
PAMA SUD	343 ± 132	472 ± 392
KONKOMBOURI	156 ± 115	484 ± 231
<b>TOTAL</b>	<b>3080 ± 605</b>	<b>2940 ± 575</b>

**Tableau n°4.** Evolutions pour les dates extrêmes dans les zones survolées.

ZONES	1982	1999	Différence	Différence en %
Singou-Konkombouri	615	637	+ 22	+ 4%
Arly et Koakrana	110	418	+ 308	+ 280%
Pama	800	1680	+ 880	+ 110%
<b>TOTAL</b>	<b>1525</b>	<b>2735</b>	<b>+ 1210</b>	<b>+ 79%</b>

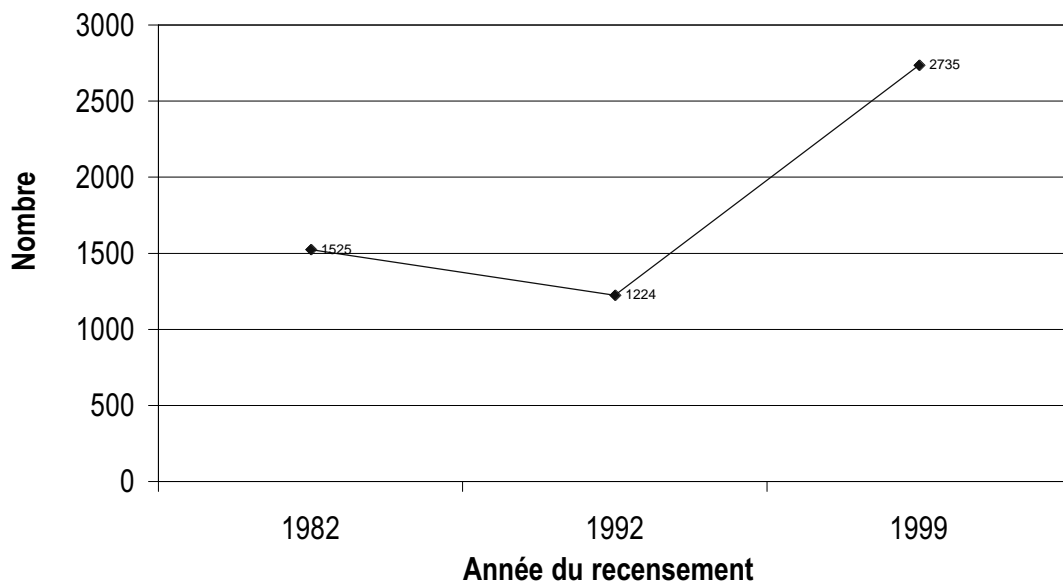
résultats trouvés confirment les valeurs calculées en février. Cette méthode de stratification peut donc être utilisée facilement en saison sèche pour corriger les importantes surestimations engendrées par la concentration le long de certains cours d'eau.

## Evolution

Dans l'est du Burkina Faso, il a été procédé trois fois à un recensement aérien de l'aire du projet : par B. Bousquet en 1982, par F. Lamarque et collaborateurs en 1992, et par B. Chardonnet et le Projet Arly en 1999. Cette aire comprenait uniquement huit zones, Wamou et Pagou-Tandougou n'ayant pas été survolées lors du deuxième recensement (Tableau n°4).

On note que sur 17 ans, et pour les zones comparables, l'augmentation moyenne annuelle a été de 4,7%, ce qui est compatible avec une évolution normale de la reproduction, hors braconnage et arrivée de populations d'éléphants exogènes.

Pour l'évolution par secteurs, on relève que le Singou et Konkombouri sont stables, tandis que Pama a connu une augmentation de 110%, et Arly de 280%. On a pu avancer comme hypothèse que le Singou s'était asséché pendant les années 70 et 80, et qu'une partie des éléphants se trouvent maintenant à Arly en saison sèche - le taux de reproduction des éléphants d'Arly ne pouvant pas expliquer une croissance moyenne annuelle sans apport extérieur de 16,5% par an. Une arrivée d'éléphants du Bénin

**Figure n°5.** Evolution du nombre d'éléphants dans huit concessions.

voisin n'est pas non plus à exclure. Des recensements suivant les mêmes méthodes dans la zone du parc national de la Pendjari permettraient de le savoir.

Le braconnage des éléphants n'a pas sévi dans le Singou durant cette période plus durement qu'ailleurs : il n'avait pas été observé un nombre significatif de carcasses lors des recensements de 1982 et 1992.

La croissance moyenne de la population de Pama (6,5% par an) est compatible avec une valeur de reproduction seule. La croissance de la population (aux valeurs statistiques et aux variations de méthodes de recensement près) est plus nette depuis 1992, soit après l'arrêt du commerce de l'ivoire (classement en Annexe I de la Cites) (Figure n°5).

Le chiffre de croissance du troupeau de 1982 à 1999 de saison sèche n'est pas modifié par l'estimation de saison pluvieuse. La croissance moyenne annuelle du troupeau reste de 4,7%.

## Les densités

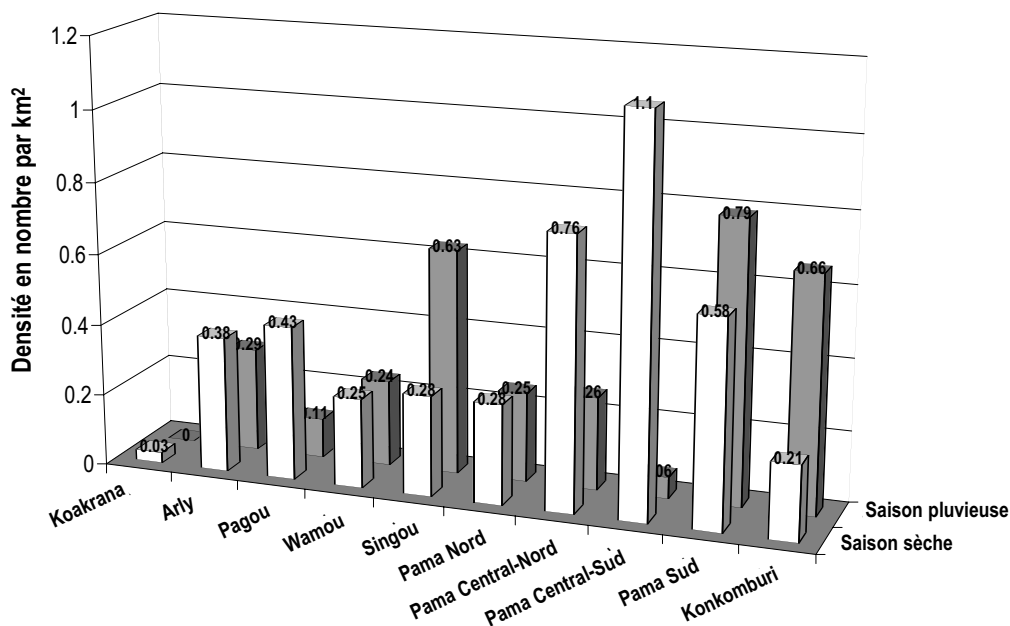
Zone par zone, les densités relevées d'éléphants (en nombre par km<sup>2</sup>) sont présentées dans la Figure n°6. Ces densités sont représentées sur les deux cartes de densité, une pour chaque recensement. (Figures n°7 et n°8).

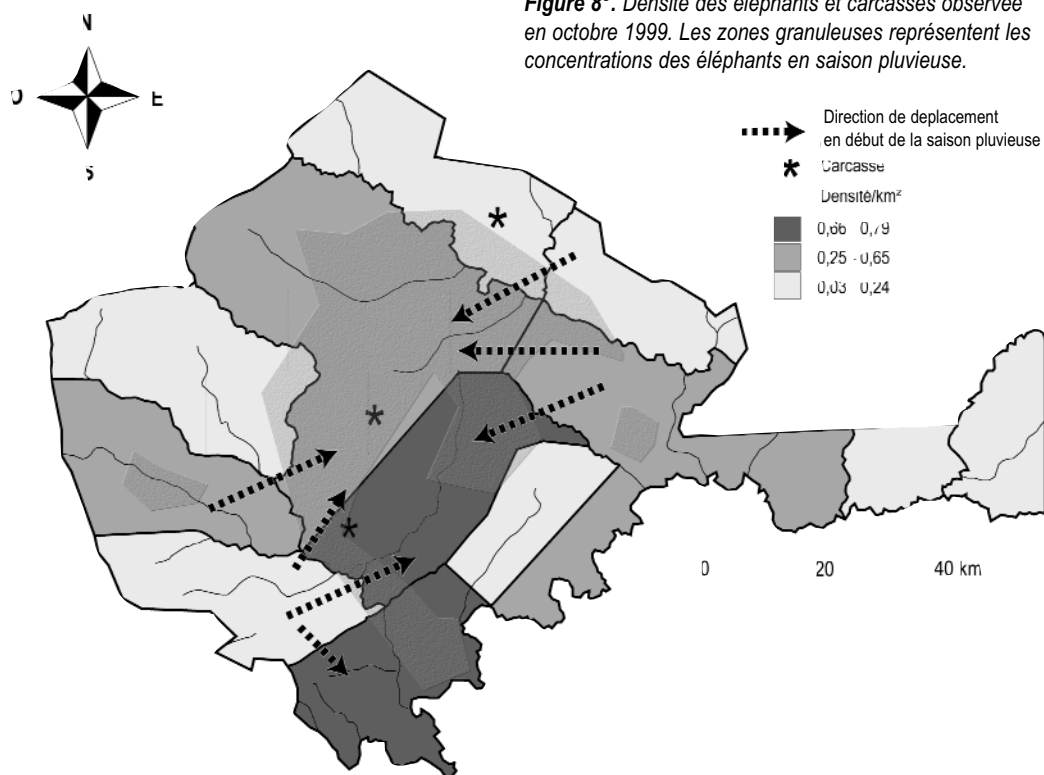
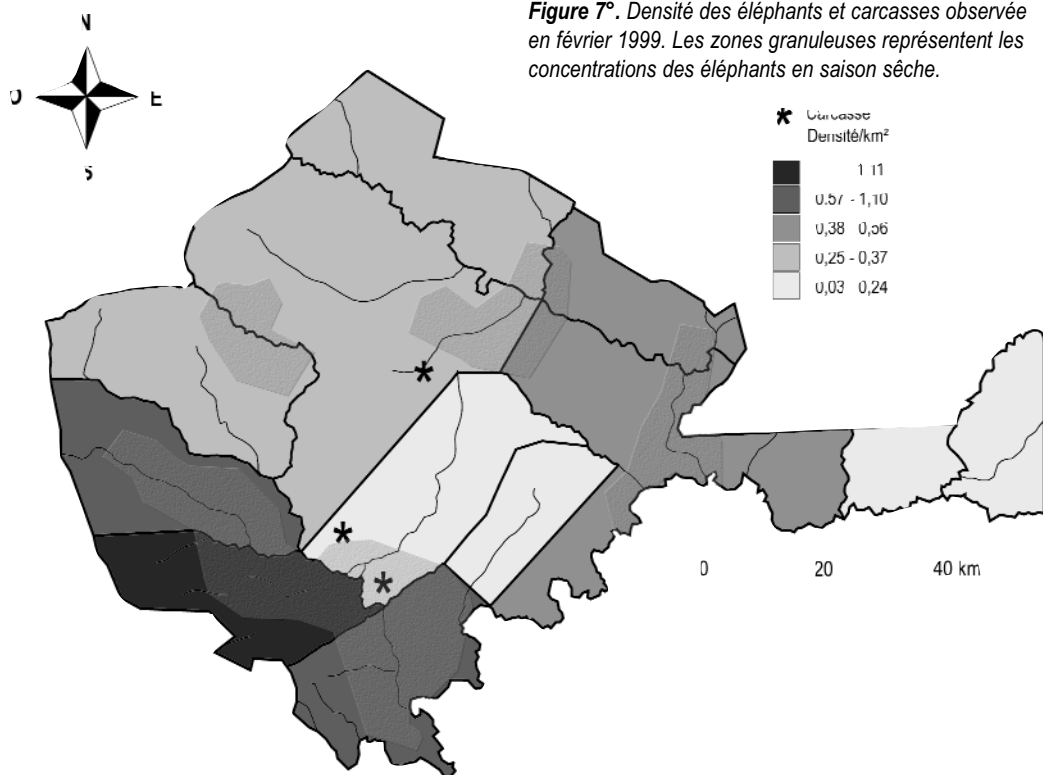
On note que les zones supportant les densités les plus importantes en saison sèche (Pama Centre-Sud et Centre-Nord : 1,1 et 0,76 éléphants/km<sup>2</sup>) supportent des densités faibles en saison pluvieuse : 0,06 et 0,26/km<sup>2</sup> respectivement.

De même les zones de Konkombouri et du Singou qui arrivent en deuxième et troisième position en saison pluvieuse avec 0,66 et 0,63 éléphants/km<sup>2</sup> supportent de faibles densités en saison sèche : septième et neuvième avec 0,28 et 0,21.

Le cas de la zone de Pama Sud est un peu particulier : elle supporte la 3<sup>ème</sup> densité en saison sèche (0,58/km<sup>2</sup>) et la première en saison plu-

Figure n°6. Les densités d'éléphants par zone.





vieuse (0,79/km<sup>2</sup>) : cela peut s'expliquer par la plus forte pluviosité recueillie (900 mm et plus par an) et une végétation présentant une densité et une taille d'arbres plus importantes.

En moyenne sur l'année il n'y a donc pas plus de 0,7 éléphants/km<sup>2</sup> pour la meilleure zone (Pama Sud) et autour de 0,5/km<sup>2</sup> pour les autres. La pression des éléphants sur la végétation n'est pas constante au cours des saisons, la concentration le long de certains cours d'eau en saison sèche étant suivie d'une importante dispersion en saison pluvieuse. Cela explique la faible importance des zones boisées dégradées.

## Les mouvements saisonniers

Après avoir reporté sur une carte les zones de plus importantes concentrations d'éléphants, à chaque saison, on peut observer que :

- En saison sèche, les éléphants sont principalement concentrés dans quatre secteurs. Le plus important est la basse vallée du Singou, de son embouchure à son confluent avec le Bigou, et se prolongeant le long du Bigou. Le cours moyen du Doubodo abrite également une importante population d'éléphants, principalement autour du marigot Konkouangou. La vallée de l'Arly, et de là en descendant la Pendjari après le confluent avec Bapiéma, est également une zone d'accueil de nombreux éléphants. Enfin le dernier site de concentration est la haute vallée du Singou, en amont de la mare de Nabindo (voir Figure n°7).
- En saison pluvieuse, la zone de plus forte densité est plus large, allant du Singou (principalement de sa rive gauche au Doubodo (surtout sur sa rive droite), en passant par les 3/4 sud de la zone du Singou et la haute vallée du Konkombouri. Des petites zones de concentration subsistent sur le haut Bigou et entre le cours de l'Arly et de Bapiéma, au centre du parc d'Arly (voir Figure n°8).
- Ces variations sont confirmées en comparant les cartes de densité zones par zone, et on peut décrire ainsi le sens des variations de densité : de la fin de saison sèche au début de saison pluvieuse on assiste à un

mouvement centripète vers la zone du Singou et aussi de Konkombouri. Ces deux zones abritent alors 50% des éléphants de l'est. (voir Figure n°8).

En comparant les données obtenues dans quelques autres aires écologiques d'Afrique (Tableau n°5) avec la même méthode de recensement aérien, on peut resituer la densité des éléphants de la zone du projet et de la partie sud de la vallée du Singou dans l'échelle des densités de saison sèche de certains parcs africains, relevant du même type de pluviométrie.

Cela confirme l'importance de la population d'éléphant et de l'écosystème de la zone de recensement, et plus encore pour la vallée du Singou. Cette importance est renforcée par la présence contigüe au Bénin de l'écosystème de la Pendjari, constituant ainsi un ensemble homogène d'environ 1 400 000 ha.

## Carcasses observées

En saison sèche, trois carcasses avaient été observées dans l'échantillonnage. Durant le recensement de saison pluvieuse à nouveau trois carcasses, toutes anciennes, ont été observées, dont l'une l'avait déjà été en saison sèche. Cela correspond donc à une vingtaine d'éléphants braconnés, soit un taux de 0,7% par rapport à la population totale (voir Figures n°7 et n°8).

## Dégâts

Cette population de 3 000 éléphants ne semble pas sortir de l'aire recensée de 7 425 km<sup>2</sup>, si ce ne sont des mouvements de part et d'autre de la rivière Pendjari (soit en direction du parc national et de la zone cynégétique de la Pendjari, au Bénin), qui ne constitue pas une aire d'accueil importante actuellement.

En effet, il n'est pas signalé de mouvements ou de dégâts aux cultures au delà des limites est, nord et ouest de la zone. Les rares dégâts aux cultures signalés le sont sur des terroirs agricoles qui ont été gagnés sur des aires classées et qui sont devenues à ces endroits des « enclaves agricoles ». Ces dégâts sont d'ailleurs le principal

**Tableau n°5.** Densités d'éléphants dans quelques autres aires écologiques d'Afrique avec un régime de pluviométrie comparable à celui de la zone est du Burkina.

Parc ou Ecosystème	Pays	Densité [nombre/km <sup>2</sup> ]
Hwange	Zimbabwe	2,07
Vallée du Zambèze	Zimbabwe	1,50
<i>Vallée du Singou</i>	<i>Burkina Faso</i>	<i>0,80</i>
South Luangwa	Zambie	0,79
Waza	Cameroun	0,65
Manyara	Tanzanie	0,60
Selous	Tanzanie	0,57
Ecosystème Nord Botswana	Botswana	0,45
Ruhaha-Rungwa	Tanzanie	0,45
North Luangwa	Zambie	0,45
<i>Zone Est du Burkina Faso</i>	<i>Burkina Faso</i>	<i>0,41</i>
Kruger	Afrique du Sud	0,41
Zakouma	Tchad	0,33
Masaï Mara	Kenya	0,31
Tsavo	Kenya	0,30
W du Niger	Niger	0,28
Pendjari / réserves périphériques	Bénin	0,15
Sabi Sand	Afrique du Sud	0,09
Serengeti	Tanzanie	0,08
Etosha	Namibie	0,08

Source : African Elephant Database 1995 (IUCN/SSC).

facteur limitant l'extension de l'agriculture sauvage dans les aires classées.

On ne constate pas à cette densité de 0,41 éléphants au km<sup>2</sup> en saison sèche, de dégâts sur la végétation, et le nombre d'arbres abîmés est très faible, localisé et réduit à quelques espèces, qui par ailleurs régénèrent souvent (*Acacia* sp.). Il en est de même pour la basse vallée du Singou (trois concessions du sud de Pama, et 200 km<sup>2</sup> de Konkombouri) qui supporte environ 0,8 éléphants/km<sup>2</sup> en saison pluvieuse. Cette densité

est tout à fait supportable pour cet écosystème recevant 700 à 900 mm de pluie par an.

Cette population de 3 000 éléphants occupe une place prioritaire en Afrique de l'ouest, dont la population totale est de 10 à 15 000 éléphants (African Elephant Database, 1995).

## CONCLUSION

Les deux recensements ont conduit à des estimations d'effectifs comparables, avec des

répartitions des observations très différentes. En saison pluvieuse la répartition est plus aléatoire, réalisant une meilleure occupation de l'espace.

Les zones présentant les plus fortes densités en saison sèche sont nettement délaissées en saison pluvieuse. Cela contribue à une utilisation optimale du biotope, en ne dépassant pas 0,7 éléphants au km<sup>2</sup> sur l'année, sans induire de dégradation. Les zones basses inondables sont nettement délaissées en saison pluvieuse au profit des zones plus élevées.

L'absence de mouvements enregistrés vers l'extérieur de l'aire à l'ouest, au nord et à l'est, ainsi que l'estimation voisine en saison sèche et en saison pluvieuse laisse penser que cette population de 3 000 éléphants ne se déplace pratiquement pas en dehors de cette aire de 7 425 km<sup>2</sup>. Les échanges semblent se limiter aux passages de part et d'autre de la rivière Pendjari, vers et depuis les aires classées voisines du Bénin.

Cette étude confirme que cette population d'éléphants, qui a subi une poussée de braconnage fin 1998, est l'une des plus importantes d'Afrique de l'ouest.

## REFERENCES

- Bousquet, B. (1982) Inventaire des ressources en faune sauvage et étude économique sur son utilisation en zone rurale. Haute-Volta. Résultats des inventaires aériens de la faune. *FAO, DP/UPV/78/008*, document de travail n°6, Rome.
- Chardonnet, B. et Barry, I. (non publié) Recensement aérien de la faune de l'unité de conservation d'Arly en 1998, Direction de la Faune et des Chasses, Ouagadougou, Burkina Faso 1998.
- Chardonnet, B., Rouamba, P., Barry, I., Ouedraogo, A. et Nacoulma, P. (non publié) Suivi écologique aérien des bassins de l'Arly et du Singou (Est du Burkina Faso) : Année 1999. Direction de la Faune et des Chasses, Ouagadougou, Burkina Faso 1999, 126 pp.
- Lamarque, F., Marchand, F., Lacroix, F., Pasquet, H., (non publié) Projet sauvegarde des éléphants du Burkina Faso : rapport final. Direction de la Faune et des Chasses, Ouagadougou, Burkina Faso 1993.
- Mbugua, S. (1996) Compter les éléphants par l'air - Comptages par échantillonnage. In : *L'étude des éléphants*, African Wildlife Foundation, Nairobi, Kenya. pp. 23-30.

Crédit photo: Bertrand Chardonnet



**Photo n°2.** En Afrique de l'ouest, non seulement il reste encore de nombreux éléphants, mais il subsiste aussi des porteurs de défenses assez grosses ("big tuskers") soulignant que la conservation a été assez efficace.

Crédit photo: Bertrand Chardonnet



**Photo n°3.** Groupe d'éléphants dans une mare aménagée de l'Afrique de l'ouest.

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# Study on the Elephants of Mago National Park, Ethiopia

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## ABSTRACT

A study was made on population estimates and movement patterns of elephants, *Loxodonta africana africana* Blumenbach 1797 in the Mago National Park, Ethiopia, from June 1997 to April 1998. The population size was estimated indirectly from the droppings using line transects within an area of 1,564 km<sup>2</sup>. The estimate of the elephant population for Mago National Park was between 387 and 575 and the observed density for the whole park was 0.3 elephant/km<sup>2</sup>. The maximum number counted from a total of seven sightings was 182. The present and former movement routes and areas of past distribution were identified. Elephants used to inhabit the surroundings of Jinka town, Woito valley, Hamer, adjacent areas of Omorate, and a large part of Tama Wildlife Reserve of South Omo Zone. However, a century ago, it was noted that people coming from the central and northern parts of the country had intensively exploited the elephants in order to demonstrate bravery and to gain ivory. Such continual activities have resulted in the extermination of elephants from most parts of South Omo. Data on elephant movement patterns suggest that at present, some of the elephants are moving south, travelling about 43 km outside the park boundary. The total range traversed from north to south by the elephants of Mago was 129 km. The calculated total home range was 1,597 km<sup>2</sup>. The study also assessed the extent of poaching on elephants. A total of 26 elephants was killed, mainly for ivory, between August 1997 and April 1998. Possible solutions to the current conservation problems were also enumerated.

## RESUME

Une étude sur les valeurs de population estimées et les migrations des éléphants *Loxodonta africana africana* Blumenbach 1797 a été conduite dans le Parc National Mago, Ethiopie entre juin 1997 et avril 1998. La taille de la population a été estimée indirectement à partir des excréments en utilisant des lignes de section sur une surface de 1 564 km<sup>2</sup>. La valeur estimée de la population d'éléphants du Parc National Mago se situe entre 387 et 575 et la densité observée pour l'ensemble du parc est de 0,3 éléphant par km<sup>2</sup>. Le nombre maximum compté sur un total de sept observations est de 182. Les itinéraires des migrations passées et actuelles ainsi que les zones de distribution antérieures ont été identifiées. Les éléphants étaient autrefois présents dans les environs de la ville de Jinka, la vallée de Woito, Hamer, les zones contiguës de Omorate et une large part de la réserve de faune Tama de la zone du Sud Omo. Cependant, il a été noté il y a une centaine d'années que les peuples provenant des zones centrales et nord du pays avaient exploité les éléphants de manière intensive afin de démontrer leur bravoure et d'obtenir l'ivoire. De telles activités continues ont conduit à l'extermination des éléphants dans la majeure partie du Sud Omo. Les données sur les types de mouvements actuels suggèrent qu'à présent certains éléphants migrent vers le sud, se déplaçant jusqu'environ 43 km à l'extérieur des limites du parc. La zone totale de déplacement des éléphants de Mago s'étend du nord au sud sur 129 km. La zone de résidence totale calculée est de 1 597 km<sup>2</sup>. L'étude a également déterminé l'étendue du braconnage envers les éléphants. Un total de 26 éléphants a été abattus, essentiellement pour l'ivoire, entre août 1997 et avril 1998. De possibles solutions aux problèmes de protection actuels sont également énumérées.

## INTRODUCTION

The subspecies *Loxodonta africana africana* Blumenbach 1797 is confined to south and southwest peripheral areas of Ethiopia. The available information suggests that, until the 1940s, they used to have a wide distribution (Largen and Yalden, 1987). However, at present the range of these animals is limited to small pockets in restricted localities of the country (EWCO, 1991; Yalden et al., 1986; Demeke, 1997b). As suggested by Kangwana (1993), this is because of the increased human population which provides intense competition with elephants for preferred habitats and water. This subspecies also occurs along the Mago Valley in the Mago National Park (MNP) inhabiting the bush, savanna and riverine vegetation.

Data from the field and interviews with local elders indicated that elephants had a very wide distribution and were comparatively common in the MNP and the adjacent areas (Demeke, 1994). However, in recent years, only small herds of elephants remain in the patchy forest and bush habitats of the park and its surroundings. This is mainly due to the pressure of hunting (Allen-Rowlandson, 1990; Largen and Yalden, 1987; Yalden et al., 1986; Demeke, 1994; (EWCO) 1991; Graham et al., 1997).

Attempts have been made to estimate the larger mammal populations of MNP (Stephenson and Mizuno, 1978; Graham et al., 1997). Since the initiation of elephant observations in the MNP (1972), a total of 35 sightings have been made: 14 from the air and the rest from the ground, by vehicle and on foot. Bolton (1971) was the first person to record about 60 animals in the MNP. The 1977 aerial surveys of Stephenson and Mizuno (1978) showed between 700-1000 individuals in Omo and Mago National Parks. In 1986, the staff of MNP counted about 400 elephants. About 900 elephants were also estimated to live in the MNP, Tama Wildlife Reserve and Murle areas by the staff of EWCO (Largen and Yalden, 1987). Since 1992, attempts have been made to assess their numbers, distribution and migration routes (Demeke, 1994). In addition,

Graham et al. (1996, 1997) made two aerial surveys in this national park and estimated 120 and 250 elephants in 1996 and 1997, respectively. However, all previous investigations dealt mainly with rough estimates and guesses within the shortest time possible. As a result, reliable estimates of the surviving elephant population in the national park have not been achieved.

Information about movements of elephants in the national park is scarce. The available reports indicate that herds of elephants have been sustained by seasonal migrations to the neighbouring areas of Omo National Park, Sudan and Kenya (Graham et al., 1996; Stephenson and Mizuno, 1978; Demeke, 1994). The 1992/93 study on elephant distribution and migration patterns indicated that there was a limited distance migration of the animal (to the south) outside the national park (Demeke, 1994). However, this information did not indicate the exact time taken or the localities to which the animals moved.

Lack of information was a major obstacle in developing the Mago's elephant management and conservation policy (EWCO, 1991; Hillman, 1993; Lamprey, 1994). Therefore, the present study aimed at collecting data from various methods of observation, in order to get a more accurate estimate of elephant numbers, together with realistic data on the range and movement patterns of elephants. The study also suggests possible solutions to the problem of the conservation status of elephants in this national park.

## STUDY AREA

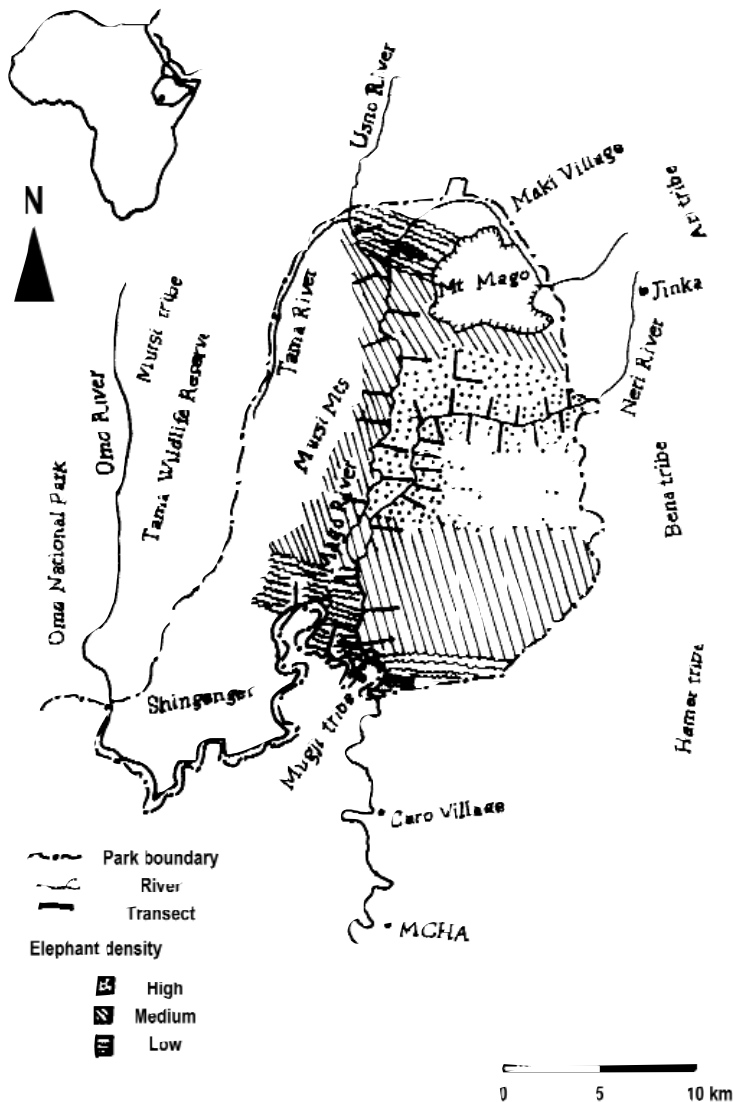
The study area is situated in southwestern Ethiopia, west of the main Rift Valley. It covers an area of 2,162 km<sup>2</sup> and lies between latitude 050 19'-050 56' N and longitude 350 56'-360 26' E. The altitude varies from 400 m - the low land plains in the south - to 1,776 m on top of Mt Mago. The central portion of the park area is flat plain, whereas the periphery is formed by mountains and chains of hills. Of the three permanent rivers, Mago and Neri traverse the park area from north to south. The Omo River bounds the park to the south and southwest.

Three conservation areas, Omo National Park to the southwest, Tama Wildlife Reserve to the west and Murle Controlled Hunting Area (MCHA) to the south, border the national park. The park is surrounded by settled agriculturists and semi-pastoralists consisting of six tribal groups (Figure 1).

Stephenson and Mizuno (1978) and Demeke (1994) described the characteristic climate of the study area as dry and semi-arid with a high mean annual temperature. The usual dry season

extends from December to early March. There are also two distinctly separate rainy seasons (Urban and Brown, 1968): the heavy rains from March to April and the lighter rains from August to September. The vegetation of the study area is described by Stephenson and Mizuno (1978) and is mainly bush (over 50%), savanna grassland, savanna bush land, open grassland and small patches of forest. *Tamarindus indica* Linnaeus 1735, *Terminalia brownii* Fresen 1837 and *Ficus sycomorus* Linnaeus 1735 are important components of the forest vegetation where transects

Figure 1. Elephant densities and location of transects in Mago National Park, Ethiopia.



were set up. The fauna of MNP is diverse. It is well documented by Stephenson and Mizuno (1978), Hillman (1993) and Demeke (1996a,b, 1997a).

## METHODOLOGY

### Sampling methods

The dropping count estimates, using transects, was carried out in this national park following the method of Barnes and Jensen (1987), Jachmann (1991), Dawson and Dekker (1992) and Barnes (1993). The basic concept is converting estimates of dung-pile numbers into estimates of elephant numbers. The method was employed based on the elephants' use of the habitats and the extent of human disturbance in the forest and other riverine vegetation of the park (following Omo, Mago and Neri Rivers). The study area was then divided into three strata: high, medium and low dung-pile densities see (see Figure 1). Transects were allocated in proportion to the approximate densities i.e. 1:2:3 for the low, medium and high density strata, respectively. A total of 36 transects, each of three km length, was run perpendicularly to the base-lines (Omo, Mago and Neri Rivers). Transects were placed at regular intervals: 2 km for the high density strata, 4 km for the medium and 6 km for the low. To complete a transect survey, a total length of 108 km of transects was covered on foot.

### Data analysis

The Elephant Programme recommended by Dawson and Dekker (1992) was used to analyze the dung-pile densities. The data for each stratum was analyzed separately and then combined to give an overall estimate for the whole study area following the work of Norton-Griffiths (1978) and Barnes et al. (1995).

It was impossible to carry out field work on defecation rate in the study area. This is because of the frequent mobility of the animal due to the pressure of hunting. Several field workers have estimated different figures (Wing and Buss, 1970; Merz, 1986; Tchamba, 1992). In this

study, the figure of Wing and Buss (1970),  $D = 17.0$  dung-piles per elephant per day, was used for the dry season data analysis. This figure was preferred because of the prolonged observation time (400 hr) in the Rwenzori National Park, Uganda.

Calculating decay rates is best described by Barnes and Jensen (1987) and Barnes and Barnes (1992). Since there was unusual rain in December, it was impossible to gather data on dung decay rate during the study period. Instead, the present investigators used the 1992/93 dry season figure of Demeke (1994) from Mago. Following the method of Barnes and Barnes (1992), the percentage for the daily decay rate of elephant droppings in the MNP for the dry season was 0.009.

### Movements and distribution

The park areas and adjacent localities were assessed to determine the seasonal movement patterns of elephants. These were monitored by following the animal and its characteristic tracks, droppings and feeding signs which elephant herds leave behind when passing through the bush, savanna grassland and riverine vegetation. To locate elephants and/or their signs, vehicle surveys were made on all available tracks at two week intervals between July 1997 and April 1998. These were made north to Mago bridge and further to Maki Village, south to Caro and Mugji roads (Figure 2) and additional drives to both sides of Neri river. In addition to vehicle drives, three long distance walks on foot were also undertaken: the first from 27 to 29 August 1997; the second from 19 to 22 February 1998, along the western side of the park, from Mago bridge following the eastern foothills of Mursi Mts via Bongoso to Mugji; and the third trip from Mago bridge south to Mago and Neri Rivers junction and then east to the park headquarters. In general, two circuits were made to assess movements across the park boundaries.

Questionnaires were also used to gather additional information about the present and/or past distribution and movement routes of elephants.

Interviews were conducted in six different tribal groups of twelve villages dwelling inside and outside the national park from 8 October to 12 November 1997. Traditional leaders, committee members and other settlers were selected systematically for the discussions.

To adequately represent the size of the home range of the animal, the method of Whyte (1993) was employed. The park areas and adjacent localities were assessed to locate elephants. This was done by following the animal and its char-

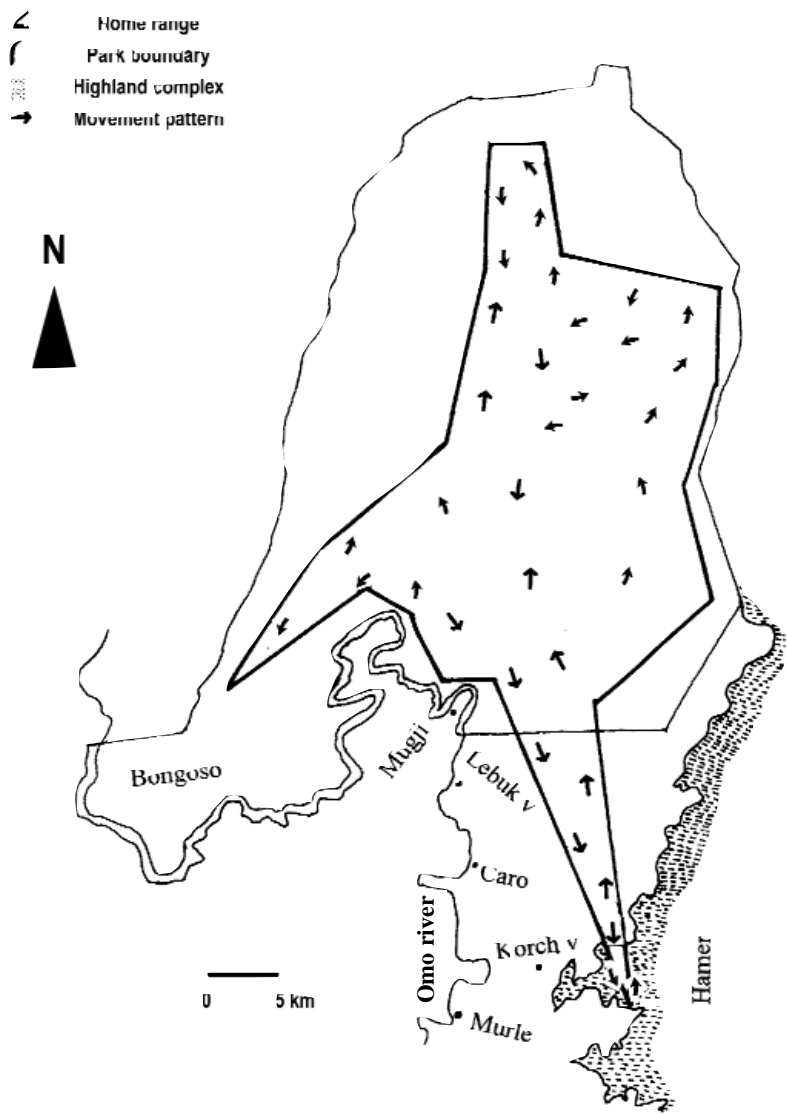
acteristic tracks, droppings and feeding signs. Extreme points reached by the animal were considered as fixes. Seventeen series fixes (four of them outside the national park) were produced and marked on a map (see Figure 2).

RESULTS

Sightings

Very few groups of elephants were observed along the tracks and paths of the park (Table 1).

Figure 2. Directions and patterns of movements of elephants in Mago National Park, Ethiopia.



Elephant numbers were also estimated from their droppings, based on the data using line transects from the forest and other riverine areas of the park (Table 2).

## Dung counts

Dung-pile visibility was limited due to dense vegetation. The number of dung-piles counted declined as the observer moved away from the centre line. The maximum recorded visible distances from the centre lines were 7.5, 6.5 and 6.4 m for the stratum 1, 2 and 3, respectively. The mean sighting distances for stratum 1, 2 and 3 were 2.2, 2.9 and 2.8 m, respectively. Dung-piles were seen better in the second and third strata than in the first. The majority of the dung-piles falls between 0 and 0.9 m.

Considering the mean decay rate of 0.009, defecation rate of 17 droppings per elephant per day and the mean dropping density of 738 drop-

pings/stratum the total estimate for the stratum area for the dry season was  $481 \pm 94$  elephants. Based on this estimate, the observed density for the home range (1,597 km<sup>2</sup>) park was 0.3 elephant/km<sup>2</sup>. The results of the transect survey, together with the low number seen, indicate that elephant numbers in this national park are low.

## Poaching

Shooting elephants has been a major problem in the national park. During the present study, three elephant carcasses, with skins and no tusks, were encountered in the central plain areas of the park. A few other skeletons were also found widely scattered on the riverine and forest areas of the Mago and Neri Rivers. A total of seven carcasses were sighted. In addition, information from the local people indicated that an additional 19 elephants were killed by people living adjacent to the park areas. This gives an estimate of 26 carcasses for the whole park area between

**Table 1.** Records of elephants during the study period.

Date	No. seen	Locality
19/7/97	87	Mago Omo-Mago junction
21/7/97	70	Kella
24/7/97	135	Observation site
25/7/97	45	Zingero Maderia
13/8/97	182	Lenin Meda
26/11/97	64	Dikule
08/3/98	80	South of Kurt Bahir

**Table 2.** Dry season dung-pile survey.

Stratum	Stratum area [km <sup>2</sup> ]	No. of transects	Transect length [km]	Sample area [km <sup>2</sup> ]	Number of droppings	Dropping density per stratum	Estimated elephant density per km <sup>2</sup>
1	397	19	57	0.13	129	992	0.53
2	540	11	33	0.09	56	622	0.33
3	292	6	18	0.04	24	600	0.32
<b>Total</b>	<b>1,229</b>	<b>36</b>	<b>108</b>	<b>0.26</b>	<b>209</b>		

August 1997 and April 1998. During the study period, three tusks were encountered in the Shingenger (Mursi) village. It was reported that there were many more kept in this village and other villages nearby. Most poaching activities took place in the dry season when the people were free from agricultural activities and were ready to collect honey.

Photo credit: Yirmed Demeke



**Photo 1.** Boy from Bena carrying the flesh of a poached young waterbuck.

## Distribution and movements

The present and former movement routes and areas of distribution were identified. Based on interviews with local people, in the previous century elephants used to inhabit the surroundings of Jinka town, Woito valley, Hamer area, adjacent areas of Omorate, and the large part of Tama Wildlife Reserve (Figure 3). However, it was noted that the people coming from the central and northern parts of the country had intensively exploited the elephants for different purposes, chiefly in order to demonstrate bravery and to gain ivory. Such continuous poaching activities have resulted in the extermination of elephants from most parts of the South Omo.

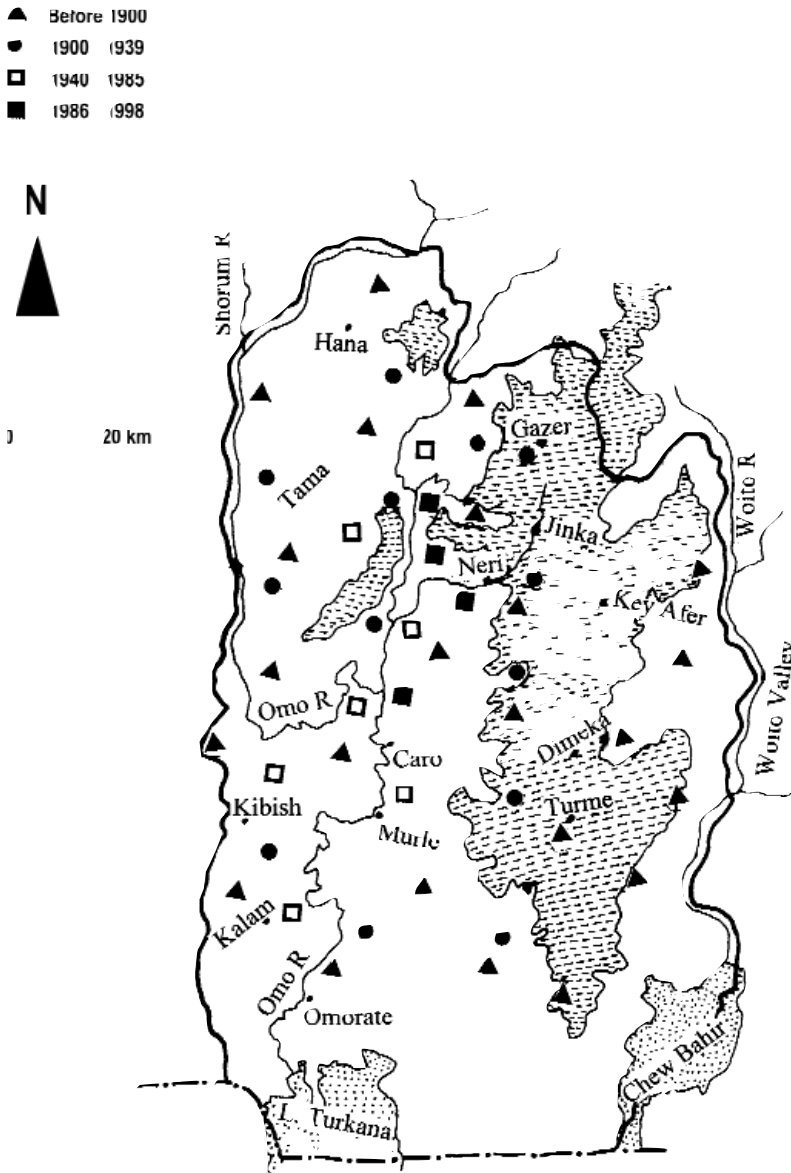
During the study period, two movement patterns (one in September 1997 and the other in March 1998) were noted across the park boundaries. They moved south to MCHA travelling about 43 km outside the park boundaries. These animals moved between the eastern escarpment and parallel to the Omo River passing to the east of Lebuk, Karo and Korch Villages (see Figure 2). By passing through the broken terrain of the foothills which borders MNP to the east and southeast, the animals reach a small valley surrounded by ridges known as Thampa. To the east, the area is bordered by the Hamer escarpments. It is dominated by extensive bush vegetation. Elephants stay here for up to a week depending on the presence of people. Finally, the study showed that, at the time of the park's establishment, elephants were believed to move north through Maki and west to Tama, Omo National Park, and most of the eastern parts of MCHA. However, at present, all movements, except to the south, are totally closed (restricted inside the national park). Observations on elephant migrations show that elephants in the MNP are a resident population, though part of the population occasionally forage outside the park areas. However, they do not show what proportion of the elephant population was involved. These short distance movements to MCHA occur at night during the rainy season. Because of this, the activities of people in the national park were minimal during this period.

Accurate grid references of the location of elephants were mapped by demarcating various fixes from several elephant tracks and feeding signs. The range traversed by elephants of MNP from north (northwest of Mt Mago) to south (southeast of MCHA) was about 129 km. The calculated average home range of the animal was 1,597 km<sup>2</sup> (see Figure 2).

## DISCUSSION

The estimated number of elephants ( $481 \pm 94$ ) is in line with the earlier data suggesting that MNP supports a small number of elephants. It is not possible to accurately compare this study with the previous estimates, as they used different survey methods. However, one can surmise

**Figure 3.** Distribution of elephants in the area of today's Mago National Park before 1900 and up to 1998.



whether the population increases, decreases or remains stable, by assessing the number of elephants counted in various groups and evaluating the extent of poaching. As shown in Table 1, the number of elephants in a group during the study period was small compared to the previous records. The 1,242 elephants observed in 1993 were most likely including immigrants either from Omo National Park or northern Kenya.

Guesses by the park staff at different times of the study period were less than 300. The previous estimates of Allen-Rowlandson (1990), Demeke (1994), Graham et al. (1997) and the present study imply that there has been a serious decline in elephant numbers. In all of the direct sightings of elephants during the study period, large sized ones are rarely encountered since large bodied elephants might be hunted selectively.

Destruction of the natural habitat and harassment by an ever-increasing human population with an increasing demand for land, has undoubtedly contributed to the rapid decline of the species.

Direct counts, sexing and aging of elephants of Mago were difficult because of the animal's night time activity (due to continual harassment by poachers) and the dense vegetation. During the dry season, the encroachment of people in the national park was high. As a result, the activities of elephants in the nearby savanna and bush habitats were restricted during the night. This has brought difficulties in direct observation of elephants during the day time.

Several methods can be used to estimate elephant population size: aerial census, vehicle survey, foot survey, and dung count. However, the dropping count technique is the preferred method for estimating elephant numbers in forest areas (Barnes and Jensen, 1987; Jachmann, 1991; Dawson and Dekker, 1992; Barnes, 1993). The use of line transect method gives estimates that are less biased and has a lower standard error (Burnham et al., 1985). However, to appreciate and standardize the method, it is advisable to employ the technique repeatedly and compare the result with other aerial and ground census methods.

Villagers living inside and outside the park hunt larger game regularly, using automatic rifles, snares and traps (Demeke, 1996b). Formerly, poachers were few in numbers and used traditional weapons which did not have a serious effect upon the

Photo credit: Yirmid Demeke



**Photo 2.** The survey team handing over Hamer poachers carrying flesh of hartebeast.

larger animals. However, at present, the availability of various kinds of modern fire arms in the South Omo has changed the situation. As a result, the wild animals of Mago and the neighbouring areas are an open-access resource to poachers. This is because of the absence of patrols and the lack of a strict wildlife law. As has been observed for several years in this national park, hunting elephants for meat is not a frequent phenomenon. However, during a period of drought, people of Mugji and Mursi used to hunt elephants as a food source.

The discussion with the local people and park staff, and the work of EWCO (1991) and Demeke (1994) indicate that ten years ago, ele-

Photo credit: Yirmid Demeke



**Photo 3.** Talks were held with Mursi people at Maki village about protecting elephants.

phants from MNP used to visit Tama Wildlife Reserve, Omo National Park and the northern areas of Mt Mago. These areas are the most preferable habitats for elephants (Stephenson and Mizuno, 1978). However, currently, most of the home ranges of elephants and the migratory corridors of the areas have become closed due to progressive settlement, agriculture and poaching.

The size of the home range of an elephant is an indication of the availability of food and water resources and the extent of human disturbances in the surrounding areas. The estimated home range of elephants in MNP (1,597 km<sup>2</sup>) is relatively large compared to e.g. Kruger National Park in South Africa which is 909 km<sup>2</sup> (Whyte, 1993). However, in a resource scarce environment like Namibia, the average size of the home range was between 5,860 km<sup>2</sup> and 8,693 km<sup>2</sup> (Lindeque and Lindeque, 1991). The area of MNP is large with abundant forage and plenty of water. This can probably harbour a very large number of elephants - about 4,400 individuals (Parker and Graham, 1989).

It is believed that the very high densities of people and their consequent settlement, agriculture and livestock, have been permanently displacing the wildlife species (Alers et al., 1992; Barnes et al., 1991; Fay and Agnagna, 1993). As pointed out by Parker and Graham (1989), normally with a human density of around 10 individuals/km<sup>2</sup>, an elephant density of 0.5 animals/km<sup>2</sup> would be expected. In the MNP and adjacent areas, the constant increase of the Mursi people with their permanent and semi-permanent villages and herds of cattle, have pushed the wild animals to the interior of the park areas (Graham et al., 1997). Since the Mursi people are semi-nomadic and keep their cattle and goats on the move across the Mursi range, elephants have never visited this side of the park. As Graham et al. (1997) suggested, the number of cattle adjacent to MNP has increased by 11% per annum to a population of nearly 55,000. Incursions of the Hamar tribesmen with their cattle, goats and sheep, into the main plains to

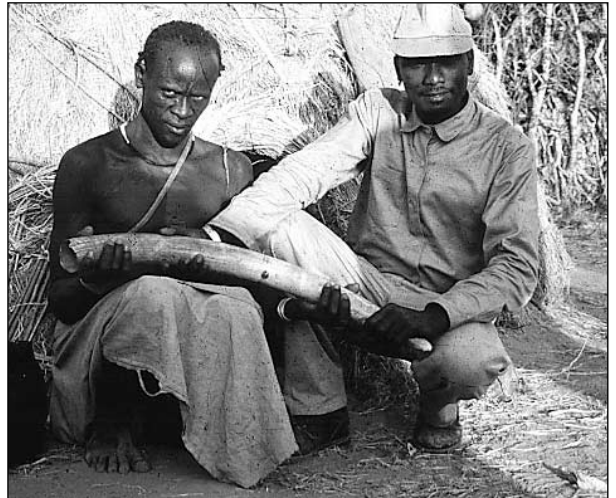
the south is a very recent activity. As estimated by Graham et al. (1997), at least 40,000 people encroach into the park with 9,000 different types of fire-arms which are potentially available for hunting. This has resulted in shrinking wildlife range and is associated with serious ecological degradation. In general, the people living inside and adjacent to the park, together with the very poor management of the park, are responsible for the destruction which may ultimately exterminate elephants and other large game animals from this area.

This study was an attempt to describe the population size and movement patterns of elephants of MNP. However, it is quite useful to know all these parameters in depth, including other aspects of their ecology, such as the habitat types and how they are utilized together with the population dynamics (growth, age and sex structure and rates of population increase in relation to habitat conditions) for proper management of the species.

## CONCLUSIONS AND RECOMMENDATIONS

Elephants in the MNP are few in numbers and live in semi-arid bush and riverine forests. So far the national park has remained a protected area capable of harbouring a significant elephant population. Almost the entire area of the National Park (except the top of Mt Mago,

Photo credit: Yirmid Demeke



**Photo 4.** Tusk found in Shingenger, a Mursi village.

which is rocky) consists of suitable elephant habitat. Based on the previous data together with this study, it is clear that elephants in this Park are endangered, due to poaching and habitat destruction. If the present state of decline in elephant numbers is allowed to continue, extinction of elephants in the Park is inevitable.

Finally, the authors would like to recommend that the migratory routes and foraging areas should be given complete protection to maintain the animal's natural migratory patterns without disturbance. In addition, it is better to maintain free access (migratory corridors) between the study area and Omo National Park, Tama Wildlife Reserve and MCHA.

In general, if elephants are to be secured from the threat of eventual extinction in the MNP, urgent and effective conservation measures (promotion of policies, wildlife legislation, regulations and restriction of harmful human activities) are essential. This will help to ensure the long-term survival of this small number of elephants.

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## REFERENCES

- Alers, M. P. T., Blom, A., Sikubwabo Kiyengo, C., Masunda, T. and Barnes, R.F.W. (1992) Preliminary assessment of the status of the forest elephant in Zaire. *Afr. J. Ecol.* 30, 279-291.
- Allen-Rowlandson, T.S. (unpubl.) Elephant survey in Ethiopia. Ethiopian Wildlife Conservation Organization, Addis Ababa, 1990. Mimeo, 21 pp.
- Barnes, R.F.W. (1993) Plenary paper two. Indirect methods for counting elephants in forest. *Pachyderm* 16, 24-30.
- Barnes, R.F.W. and Barnes, K.L. (1992) Estimating decay rates of elephant dung-piles in forest. *Afr. J. Ecol.* 30, 316-321.
- Barnes, R. F. W., Barnes, K. L., Alers, M. P. T. and Blom, A. (1991) Man determines the distribution of elephants in the rain forests of north eastern Gabon. *Afr. J. Ecol.* 29, 54-63.
- Barnes, R.F.W., Blom, A., Alers, M.P.T. and Barnes, K.L. (1995) An estimate of the numbers of forest elephants in Gabon. *J. Trop. Ecol.* 11, 27-37.
- Barnes, R.F.W. and Jensen, K.L. (1987) How to count elephants in forests. IUCN, African Elephant and Rhino Specialist Group *Technical Bulletin* 1, 1-6.
- Bolton, M. (unpubl.) Mago valley ecological survey. Ethiopian Wildlife Conservation Organization, Addis Ababa, 1971. Mimeo, 18 pp.
- Burnham, K.P., Anderson, D.R. and Laake, J.L. (1985) Efficiency and bias in strip and line transect sampling. *J. Wildl. Manag.* 49, 1012-1018.
- Dawson, S. and Dekker, A.J.F.M. (1992) Counting Asian elephants in forests. FAO, Bangkok.
- Demeke, Y. (1994) Elephants in the Mago National Park. An assessment of numbers, distribution and movements. EWCO, Ethiopia. *Walia* 15, 22-32.
- Demeke, Y. (1996a) The birds of Mago National Park. EWCO. *Walia* 17, 39-46.

- Demeke, Y. (1996b) Wildlife Conservation, Management and Development of Mago National Park (1978-1994). EWCO, Ethiopia. Monograph, 132 pp.
- Demeke, Y. (1997a) Notes on breeding, tail growth and other aspects of the biology of the Red-headed agama, *Agama agama* (Sauria: Agamidae) in Mago National Park, Ethiopia. *British Herpetological Bulletin*, 58, 19-25.
- Demeke, Y. (1997b) The status of the African elephant (*Loxodonta africana africana*) in Ethiopia. *Walia* 18, 15-27.
- EWCO (1991) Elephant conservation plan. Addis Ababa, Ethiopia, 52 pp.
- Fay, J. M. and Agnagna, M. (1993) Elephants and ivory in the Congo since the ban: the lull before the storm? *Pachyderm* 16, 51-58.
- Graham, A., Netsereab, B. and Enawgaw, C. (unpubl.) Trends in large herbivore numbers of Omo and Mago National Parks. National parks rehabilitation in southern Ethiopia. Project technical report No. 5, 1996. Addis Ababa, 1996, 16 pp.
- Graham, A., Netsereab, B. and Enawgaw, C. (unpubl.) Trends in large animals of Omo and Mago National Parks. National parks rehabilitation in southern Ethiopia. Project technical report No. 6. Addis Ababa, 1997, pp. 11.
- Hillman, J.C. (1993) Ethiopia: Compendium of wildlife conservation information. Addis Ababa: New York Zoological Society, The Wildlife Conservation Society and Ethiopian Wildlife Conservation Organization, 786 pp.
- Jachmann, H. (1991) Evaluation of four survey methods for estimating elephant densities. *Afr. J. Ecol.* 29, 188-195.
- Kangwana, F. K. (unpubl.) Elephants and Masai: conflict and conservation in Amboseli, Kenya. Ph.D. Thesis, 1993, University of Cambridge, UK.
- Lamprey, R.W. (unpubl.) Aerial census of wildlife of Omo and Mago National Parks, Ethiopia. Ecosystems consultants, 1994, 30 pp.
- Largen M.J. & Yalden D.W. (1987) The decline of elephant and black rhinoceros in Ethiopia. *Oryx* 21(2), 103-106.
- Lindeque, M. and Lindeque, P. M. (1991) Satellite tracking of elephants in northwestern Namibia. *Afr. J. Ecol.* 29, 196-206.
- Merz, G. (1986) Counting elephants (*Loxodonta africana cyclotis*) in tropical rain forests with particular reference to the Tai National Park, Ivory Coast. *Afr. J. Ecol.* 24, 60-68.
- Norton-Griffiths M. (1978) Counting animals. Handbooks on techniques currently used in African wildlife ecology No. 1. (ED. J.J. Grimsdell). AWF, Nairobi, 139 pp.
- Parker, I. S. C. and Graham, A. D. (1989) Elephant decline: downward trends in African elephant distribution and numbers, Part I. *Int. J. Environ. St.* 34, 287-305.
- Stephenson, J. and Mizuno A. (unpubl.) Recommendations on the conservation of wildlife in the Omo-Tama-Mago Rift Valley of Ethiopia. EWCO, Addis Ababa, 1978, mimeo, 62 pp.
- Tchamba, M. (1992) Defaecation by the African forest elephant (*Loxodonta africana cyclotis*) in the Santchou Reserve, Cameroon. *Nature et Faune* 7, 27-31.
- Urban, E. K. and Brown, L. H. (1968) Wildlife in an Ethiopian Valley. *Oryx* 9(5), 342-353.
- Whyte, I. J. (1993) The movement patterns of elephants in the Kruger National Park in response to culling and environmental stimuli. *Pachyderm* 16, 72-80.
- Wing L.D. and Buss I.D. (1970) Elephants and forests. *Wildlife Monograph* 19, 1-92.
- Yalden, D. W., Largen, M. G. and Kock, D. (1986) Catalogue of the mammals of Ethiopia. 6. Perissodactyla, Proboscidea, Hyracoidea, Lagomorpha, Tubulidentata, Sirenia and Cetacea. *Monitore zoologico italiano* (NS) Supplemento, 21(4), 31-103.

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# Population and Distribution of Elephants (*Loxodonta africana africana*) in the Central Sector of the Virunga National Park, Eastern DRC

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## ABSTRACT

Savanna-dwelling elephants (*Loxodonta africana africana*) were observed almost continuously over a three-month period in April-July 1998 in the central sector of the Virunga National Park (VNP). There were two aims: first and foremost, to provide preliminary information on the status and distribution of Virunga elephants in the aftermath of the civil strife following the outbreak of the Congolese Civil War in October 1996, and second, to furnish the basis for planning detailed sample surveys in the future. Direct observations indicated that the central sector of the VNP supported between 486 and 535 elephants, ranging over about 2,400 km<sup>2</sup>.

Based on dung counts, a mean density of 0.3 elephants km<sup>2</sup> was obtained. The distribution patterns and relative abundance of elephants are briefly discussed and results are compared with previous censuses in the early 1980s, and between 1990 and 1996. Based on this study the outlook for the Virunga elephant population appeared extremely positive. However, with the continued global demand for ivory, potential new markets springing up and easy financial rewards obtainable all accentuating poaching levels, the population's status remains a matter of significant concern.

## RESUME

Les éléphants de savane (*Loxodonta africana africana*) ont été observés de façon quasi continue pendant trois mois d'avril à juillet 1998 dans le secteur central du Parc National de Virunga (PNV). Un double but a caractérisé cette étude, en tout premier lieu, fournir des informations préliminaires sur le statut des éléphants au regard de l'éclatement de la guerre civile congolaise en octobre 1996, et ensuite, de mettre sur pied la base pour planifier des études détaillées dans l'avenir. Les résultats de cette étude ont indiqué que le secteur centre du PNV détient une population estimée entre 486 et 535 éléphants et la population se déploie sur une étendue de 2 400 km<sup>2</sup>.

Basé sur le comptage des crottes, une densité de 0.3 éléphants au km<sup>2</sup> a été obtenue. Les types de distribution et d'abondance relative des éléphants sont brièvement discutés et les résultats sont comparés avec les recensements antérieurs des années 1980, et entre 1990 et 1996. Tablant sur cette étude les perspectives pour la population d'éléphants apparaissent extrêmement encourageantes. Cependant, avec la demande globale d'ivoire, de nouveaux marchés resurgissant éventuellement, et le gain facile qui en découle incitant au braconnage, le statut de cette population reste toujours l'objet d'une grande préoccupation.

## INTRODUCTION

This study was initiated as a result of a widespread concern among wildlife managers, scientists and the public that Virunga elephant populations had suffered adverse effects from the recent strife in the eastern part of the Democratic Republic of Congo (DRC). All the ingredients were there: the period saw a phase of agricultural encroachment, reduction in forest cover, and a marked and steady deterioration in law and order in the midst of tremendous political instability and economic turmoil. This in turn has taken a heavy toll on wildlife populations and dramatically clouded the future of many large mammals, including elephants. Since 1991 most available information on elephant numbers in the Virunga National Park (VNP) has been based on guesswork and has not provided a suitable basis from which to determine population trends over time, or to discern the effects of policy or management (Said et al., 1995). The study was therefore clearly recognized as important.

### Historical trends in elephant distribution in the central sector of the Virunga National Park

An elephant survey in 1959 estimated numbers at 3,293 in the central sector of the VNP (Mertens, 1983; Delvingt et al., 1990), and elephants were considered to be 'fairly common to common' over much of their range throughout the Park. The elephant population declined from 674 to 621 (Delvingt et al., 1990; Verschuren, 1993) following drastic poaching that took place in the lawless early 1970s and 1980s. From 1970 onwards, the country underwent a major economic decline as the value of its primary product, copper, fell on the world market. Budget deficits, inflation, and foreign debts led to a decline in the capacity of government institutions, including the Institut Congolais pour la Conservation de la Nature (ICCN, formerly IZCN). Large-scale international traders encouraged African poaching, which was facilitated by the ease of obtaining firearms and ammunition, by apparent complicity between some park

rangers and the poachers, and by the reported immunity of the big buyers from prosecution because they enjoyed political protection (MacGaffey, 1991). Studies carried out by Mertens (1983) indicated that only about 631 elephants remained. A further decline occurred between 1988 and 1990 with estimates of 500 and 469 individuals respectively remaining, mainly localised in bushland, and frequently splitting into two or three important herds (Aveling, 1990; Delvingt et al., 1990; Verschuren, 1993).

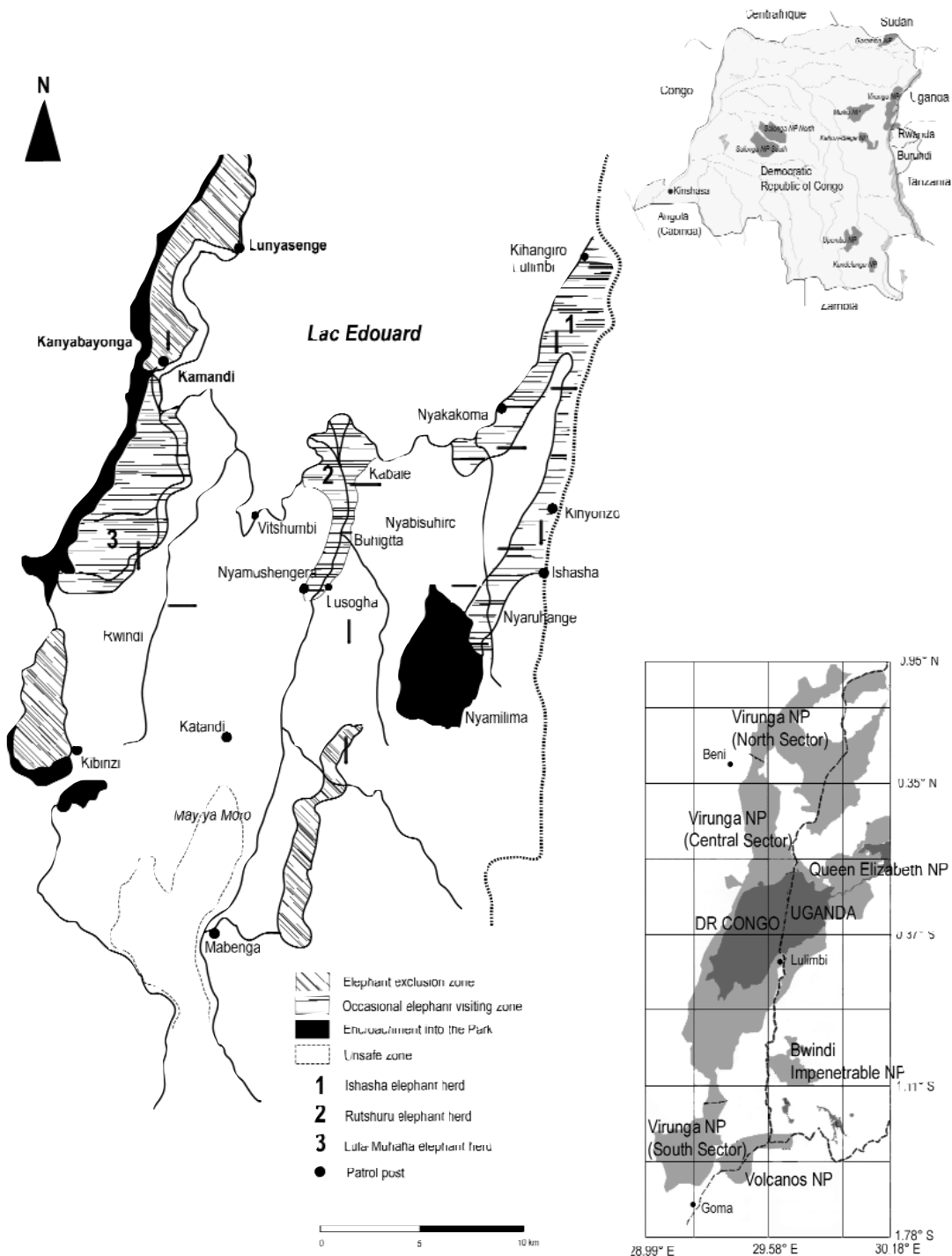
Throughout the 1990s, local and international conservationists struggled to stop the poaching of key species (elephant, mountain gorilla *Gorilla gorilla berengei*, hippopotamus *Hippopotamus amphibius*, buffalo *Syncerus caffer*). In some cases, despite facing heavily-armed refugees, anti-poaching patrols have partially controlled poaching and arrested both poachers and traders (Mubalama, 1999).

### STUDY AREA

The survey was restricted to the central part of the VNP, which comprises the plains of Rwindi-Rutshuru-Ishasha and encompasses about 2,400 km<sup>2</sup>, approximately 30% of the VNP's total area (Figure 1). It is an area of varied habitats including open grassland, grassland with thickets, thick bush, swamp, gallery forest and lakeshore, lying at an average altitude of around 1,000 meters. The region is well known for its spectacular scenery and its high levels of biodiversity. There are two headquarters in the central sector: Rwindi: 0°58'S, 29°19' E and Lulimbi: 0°31'S, 29°38'E. The Rutshuru River separates the Rwindi and Lulimbi sectors.

Along the Ishaha River the plains of Rwindi-Rutshuru-Ishasha are contiguous with the Queen Elizabeth National Park (QENP) in Uganda and together the two protected areas completely encircle Lake Edward (2,240 km<sup>2</sup>). They thus constitute 'transboundary' protected areas, physically and biologically linked, in which cross-border movements of elephant frequently occur.

**Figure 1.** Central sector of the Virunga National Park (DRC). Distribution patterns of elephant populations in the central sector of the Park and location of transects.



## METHODOLOGY

### Dropping count method

The spread of thickets and massive regeneration of *Acacia* species that followed the drastic reduction in elephant numbers to one sixth of its former size (Delvingt et al., 1990; Aveling, unpubl.) has led to poor visibility in the study site. A faecal census method was therefore used to determine abundance and relative densities of elephant populations.

I used a total of fifteen 2.5 km line transects to sample elephant dung. Because of the security situation in the region (several people were killed or wounded when travelling between Rwindi and Mabenga), the survey area was not stratified. Data were collected from two sample zones:

- 1) close to Rwindi and Lulimbi headquarters and existing and abandoned patrol posts (using different Virunga maps);
- 2) easily accessible areas close to gallery forest along the Rwindi, Rutshuru, Lula, Kasoso and Ishasha rivers. This sample zone was chosen because it was believed to be the eastern sub-population's dry season high-occupancy zone.

In general line transects were randomly placed within sampling zones (Norton-Griffiths, 1978). The distance along the transects and perpendicular distance were recorded for each elephant dung pile observed following the method outlined by Barnes & Jensen (1987) for censusing elephant populations. Foot surveys were carried out by a maximum of five observers using a 100 m string, a 50 m measuring tape and a compass. Unless an insurmountable obstruction was encountered, line transects were 2.5 km long and 10 m wide, and oriented at cardinal compass bearings from central points located across the surveyed area. Observer teams progressed along line transects at an average rate of 1.4 km/hr.

Along each transect, observers noted all elephant spoor, including dung piles, feeding and scratching sites, tracks etc. Only those dung piles that

could be seen from the line transect by the principal investigator or the field assistant were counted. In addition, distinctive indirect signs of elephants such as leaf stripping or de-barking of trees, breakage of main branches or trunks, and uprooting or pushing over of trees were recorded. Other data collected during the census included dominant vegetation species, evidence of human presence (including poaching) and spoor observations of all other large mammals, including hippopotamus, buffalo and antelope.

Elephant densities were calculated assuming a steady state system following the formula described by McClanahan (1986) and Barnes & Jensen (1987):

$$E = (Y * r) / D$$

where

E = Elephant density

Y = Dung pile density

r = Daily rate of dung pile decay

D = Defecation rate or number of dung piles produced per elephant per day

The daily rate of dung pile decay in VNP was measured during the study. Mean dung pile decay period was estimated as 61 days. Only four dung piles remained intact in the course of the survey ( $r=0.025$ , Mubalama & Sikubwabo, unpublished data). The data set that included one dry season sample and was based on 35 dung samples of known-age. Defecation rate was assumed to be 17 defecations per day (Wing and Buss, 1970).

### Direct elephant counts by herd recognition and observation

In addition to the indirect method (dung count) used to determine elephant densities, a direct method was devised to estimate elephant numbers. For this purpose, field data collection forms were distributed at the VNP headquarters (Rwindi and Lulimbi) and patrol posts after intensive training sessions on data collection had been given to selected game scouts. One data



Photo 1. Virunga National Park, South Sector. View on Nyamulagira volcano.

form was completed by game scouts when actively patrolling while another was completed at the headquarters and/or patrol posts when game scouts saw elephants from their camps. At the end of each month, data were centralized at Rwindi and Lulimbi headquarters, and provided considerable insight into elephant movements in the study area.

The Lulimbi headquarters and Kinyonzo patrol post bordering Ishasha River, where herds of elephant frequently came to drink, were selected as research bases, and often served as good observation points. Apart from some interruptions when I had to be away from VNP, I patrolled the Park almost daily trying to locate elephants. With the exception of the Kasali mountain area dominated by *Olea europea ssp africana* woodland where security was a matter of concern, patrols were organised to ensure as complete a coverage as possible. Most parts of the Park were entered every month.

Herd composition counts were made by walking to different areas on consecutive days. Individuals were classified, where possible, following Hanks' (1979) criteria for ageing (Moss, 1988): old adult (30-60 years); younger adult (15-30 years); sub-adult (10-15 years); juvenile

(3-10 years); calf (1-3 years); under one year (< 1 year). On the strength of continual observations by the end of the study we were able to identify the three most important elephants herds and their preferred and occasional ranges (see Figure 1).

## RESULTS

### Elephant distribution and abundance

Estimated elephant densities were higher in the Lulimbi plains and plateau (0.38 per km<sup>2</sup>) than in the Rwindi area (0.20 per km<sup>2</sup>) (Table 1). Lulimbi accounts for about two-thirds of the total area occupied by elephants in the central sector of the VNP.

In April-July 1998 elephants occupied a fairly restricted range in the Rwindi-Rutshuru-Ishasha plains. Surveys revealed general population movements but may have missed important details, including long-distance movements of small numbers of elephants that have been recorded after particularly good rainy seasons. The presence of a few individually recognizable elephants enabled us to monitor individuals to a limited extent, but most were rarely seen more than three to five times. One group of two, a

**Table 1.** Calculated dung and elephant densities / km<sup>2</sup> in the central sector of the Virunga National Park.

Transect Location	Length of transect [km]	No. of 0.25 km segm. with dung	Segments with dung		Dung density per km <sup>2</sup>	Elephant density per km <sup>2</sup>
			[km]	[%]		
Rwindi	10	10	2.5	7.5	138	0.20
Lulimbi	27.5	123	30.75	92.4	256	0.38
Total	37.5	133	33.25	99.9	-	-
Mean	-	-	16.6	-	197	0.29

r=0.025

female with an infant, and one group of five, two females with two infants, and one adult bull were however seen repeatedly over a period of 6 months from December 1997 to June 1998.

In addition, other family groups of 12 and 8 individuals as well as a lone elephant appeared to have been resident in the open short grass Lulimbi plains for short periods. However during most of the study they preferred thick bush, bushed grassland and gallery forest with easier access to water. Overall I recorded a total of 486 elephants, giving an estimated population size of between 486 and 535 for the central sector of the VNP (assuming a possible 10 % undercount).

The distribution of the main herds (see Figure 1) can be summarised as follows:

- 1) The “Ishasha herd” inhabiting the eastern part of VNP consisting of approximately 175 individuals, often split into two sub-groups. One “peripheral” group was frequently found to the north of Lulimbi headquarters near Lake Edward whilst the other moved in almost co-ordinated fashion towards the southern Ishasha area and was reportedly involved in shamba crop-raiding.
- 2) The “Rutshuru herd” comprising about 140 individuals, moving mostly between the Rutshuru delta and Nyabushi along the Rutshuru river where they were attracted to lush and abundant *Phragmites mauritanica* vegetation. Although both banks of the Rutshuru river were used by the same elephant community, individuals on the western bank seemed under considerably more stress, due presumably to the recent upsurge in poaching perpetrated by Mayi-Mayi fighters as well as military forces (Mubalama, 1999).
- 3) The “Lula-Muhaha herd” of about 65 elephants was frequently observed feeding on Pennisetum purpureum grass as well as *Coccinia grandis* and *Citrullus lanatus*, and was often found around the Tchanika swamp edges and lakeshore.

**Table 2.** Estimated elephant populations in Rwindi and Lulimbi areas (August 1998).

Area	Adults		Young		Total count		Observations
	Number	%	Number	%	Number	%	
Rwindi	144	73.8	51	26.2	195	100	Elephants wary
Lulimbi	188	64.6	103	35.4	291	100	Two herds freq. seen

Photo credit: Sylvie Candotti



Photo 2. Law enforcement office - Runangaba Field Station, Virunga National Park.

In general, social organisation was matriarchal with an old female leading the group, which consisted of her offspring and included males up to puberty and females of all ages. Other groups were interpreted as “extended family units” containing sub-groups led by mature females presumably after their mothers had died (Douglas-Hamilton, 1972; Laws et al., 1975). The group units varied in size from 10-20 individuals while mean ‘family unit’ size was 4.7. The mother-offspring unit was by far the most frequent family unit. One striking result was the tendency of elephant families to clump into herds of 100-200 individuals, a phenomenon also reported by Muhindo (unpubl.).

## DISCUSSION

Although elephants were undisturbed during this study and were sometimes seen moving slowly, herds were usually bunched very tightly forming a huge grey wall of elephant hide. Two years or so before this study, gunshots were frequent in the VNP, and I suggest that the large herds observed had formed in response to poaching. Disturbance by illegal hunting results in elephants adopting a more compressed distribution in safe areas and therefore aggregating in larger groups (Eltringham, 1977). Poaching activity has been suggested as a key external factor

determining differential use of habitat elsewhere (Douglas-Hamilton, 1987).

Despite evidence indicating that in the very recent past elephants were far more widespread in the Rwindi-Rutshuru-Ishasha plains (Mertens, 1983; Mubalama, unpubl.), elephant movements were rather small, on the order of 10-20 miles, and communities localised. No convincing evidence of large-scale migration was observed, other than one isolated observation that was regarded as an extension of the usual erratic displacement movements rather than a true migration. Elephant movements tended to be directed towards Lulimbi where the greatest concentration of elephants occurred, feeding on *Cyperus articulatus*, *Sporobolus consimilis*, *Carissa edulis*, *Capparis tomentosa*, *Acacia sieberiana*, *Coccinia grandis*, *Citrullus lanatus* and *Maerua mildbreadii*. Movements towards the Rwindi area were shorter and elephants did not appear to get very far beyond the Rutshuru and Muhaha rivers where a high density of well-defined but abandoned elephant trails were noted. Elephants also spent substantial time feeding in fairly dense *Cyperus articulatus* swamps, *Croton macrostachyus*, *Kigelia pinnata* and *Pterygota mildbreadii* gallery forest (Rutshuru and Ishasha rivers) as well as ambatch tree *Aeschynomene elaphroxylon* woodland and *Phragmites mauri-*

Photo credit: Leonard Mubalama



**Photo 3.** A lone aggressive bull elephant crossing the Ishasha river and setting off for the neighbouring Queen Elizabeth National Park in Uganda.

*tanica* lakeshore swamp. They were difficult to observe in these habitats. Elephant movements in these habitats were routine and very predictable (Abe, 1992).

Elephants were not seen in some areas of VNP, including the southern sector of Kibirizi and the steep rocky slopes of the Mitumba mountains between Lunyasenge patrol post and Tumbwe River. This distribution pattern was almost identical to that observed by Verschuren (1993).

During the 1995 survey (Mushenzi, unpubl.), the army and Mayi-Mayi fighters were frequently seen to kill hippos, buffaloes and antelopes with automatic weapons and on several occasions, persistent shots were heard in the Park (Plumptre et al., 1997). Five tusks weighing on average 9 kg were recovered. Remains of 117 buffaloes and antelopes and a mound of hippo carcasses too numerous to count were recorded during this study. I did not find any flesh-covered carcasses of elephant calves. Two elephant tusks were collected by game scouts in the Lulimbi area but the cause of death was not clearly ascertained. All skeletons observed were at least two to three years old according to Jachmann's (1988) ageing estimation, indicating that very few elephants died as a direct result of the recent conflicts since belligerents involved, including Mayi-Mayi, obviously targeted other large to medium-sized terrestrial animals (Mubalama, 1999). This sur-

prising result strongly contrasted with previous rumours of heavy elephant poaching.

A direct counting method is not a foolproof one, especially in a study area of relatively broad-leaved woodland, and it is possible that total elephant numbers may be higher than counted. In addition, with shy and elusive animals often taking cover in secluded areas before they could be counted, the portion of the population hidden in gallery or clump forest at any one time may be large, thus influencing the accuracy of counts. Some of the problems experienced might have been overcome through the use of aerial surveys, although these may be limited by financial (e.g. prohibitive cost of an ultra-light aircraft) and political constraints.

Mean elephant density has decreased as compared to 1.04 elephant / km<sup>2</sup> found by André (unpubl.) just before the outbreak of the recent hostilities. However, baby elephants appeared to be common during the study period (Moss, 1988), but the big question remains why this current baby boom and what are the trends?

I estimated the carrying capacity of the central sector of the Park to be between 1,000 and 1,200 elephants with an average of 0.5 elephant per km<sup>2</sup>, based on Pfeffer (1989). Given the present population, the central sector of VNP could probably support another 565 elephants and it is

conceivable that the population could reach these levels by about 2020, assuming that full protection over the whole area is provided, and that the recruitment and population growth rate of between 7-10 % per year in favourable conditions (Pfeffer, 1989) is maintained.

### Future threats to VNP elephants

The reduced law-enforcement operations maintained by ICCN with the collaboration of Forces Armées Congolaises (FAC) were still having a slight positive effect: some poachers were arrested, and some ivory and some AK 47s were recovered by joint patrols. However, there was little evidence of substantial anti-poaching support from the FAC, the police or the administration. Although law-enforcement staff numbers have been increased, budgets for wildlife protection have plummeted and morale among park staff had become severely eroded to the point that, in some cases, game scouts and rangers depended on kickbacks from illegal activities in order to survive. While such behaviour may be understandable it remains totally unacceptable. There is thus a crucial need to improve the motivation of the poorly paid wildlife staff to boost their morale and put teeth into wildlife law-enforcement. The poverty of the rural population on the periphery of the Park, the present lack of

knowledge of elephant dynamics and behaviour, the ineffectiveness of the national wildlife service, and corruption with poorly paid game staff being susceptible to bribery (Barnes et al., 1995) could all potentially facilitate poaching.

Despite the fact that there were about 250 active game guards assigned in Rwindi and Lulimbi sectors of VNP, deployment of game staff has always presented logistical problems (Hart & Hall, 1996). Although average guard densities were around one guard per 10 km<sup>2</sup> (above the level recommended by IUCN) most of the game staff were inadequately armed with old service rifles (muzzle loading guns), usually with no more than two rounds of ammunition each, no match against groups of heavily armed poachers. Many non-functioning weapons continue to be carried by game guards in an attempt to sustain the desired image. However, most poachers were aware of the reality and not surprisingly showed scant respect for the rangers.

Four large fishing villages (Vitshumbi, Kyavinyonge, Nyakakoma and Kisaka) within the VNP with more than 40,000 inhabitants were expanding in contradiction of the laws governing Congolese protected areas. The Park provided them with spare arable land, clean water, construction materials and fuelwood (Mubalama,

Photo credit: Leonard Mubalama



**Photo 4.** A handsome close unit group forming a huge grey wall of elephant hide and pricking up its ears at the slightest sound of steps in the safety of the thick grove of *Capparis tomentosa*, VNP, DRC.

1995). People from these villages were chopping down trees, over-exploiting the fish stocks of Lake Edward and hunting animals. This has inevitably resulted in a critical 'hard-edge' effect on the Park's boundaries. With human population pressure increasing and elephant range shrinking across the VNP, creative solutions are required to this problem as the further spread of villages and agriculture on the periphery of the Park will undoubtedly increase competition between men and wildlife for land.

## CONCLUSIONS AND RECOMMENDATIONS

Elephant numbers in the central sector of the VNP have declined drastically since 1959, but there is strong evidence that the population is now increasing despite persistent gloomy rumours about their fate following the recent mass die-off event of wildlife and the drastic reduction in wildlife range. If protection remains adequate or improves, the future of elephants in VNP seems assured for the next decade, especially in the framework of the recently initiated United Nations Fund for the World Heritage Sites in DRC.

It is however unclear how elephant status and distribution will change over the forthcoming decades given the obvious continuing tension in the Great Lakes region. Evidence from certain southern elephant range states suggests that there is still sufficient incentive to poach elephants (Dublin et al., 1995, Leader-Williams, 1996). Therefore, long-term efforts for the conservation of the central Virunga elephants and their habitat are more than ever required.

In conclusion, I stress that these results are preliminary and my hypotheses should be regarded as tentative. Continued data collection will help elucidate patterns and provide a better data set to compare with other elephant populations elsewhere in Africa. For a clear understanding of the social organisation of the Virunga elephants, long-term observations, combined with a thorough knowledge of most individuals in the population are absolutely necessary. How elephants use their range in the entire VNP and how they

interact with varied habitats remain open questions. Understanding the ecological scales of ecosystem dynamics in conservation areas is fundamental to the conception of appropriate policies (Waithaka, 1997).

It is imperative that in-depth research continues as an essential monitoring service. The impact of poaching on the stability of the family social structure of elephants should also be investigated, since it is vital to know the population's age structure in order to understand its dynamics. Such a study requires competent and consistent identification of all individuals and groups and should be a clear research priority. A radio-tracking programme with aerial monitoring support covering the whole of the VNP is required.

This study clearly emphasised the need for co-ordinated surveillance and research efforts in the VNP and the QENP and across international borders. In the same way, an elephant monitoring programme in the southern sector of the VNP could be performed and tied in with the International Gorilla Conservation Programme (IGCP) mountain gorilla census years.

Late and irregular payment of salaries should be solved under a new operational budget system proposed by the United Nations Fund. As additional conservation funding opportunities present themselves and tourism activities resume, wildlife staff should be provided with a performance-related salary. Meanwhile, the only current measure possible under today's harsh conditions is to exhort the game guards, in writing, to increase their efforts.

In the longer term, new equipment is required, including uniforms (different from the ones worn by military forces to avoid confusion), bullet-proof vests, boots, 4WD vehicles equipped with VHF mobile radio, speed boats, communication means (hand held VHF for foot patrols), camping gear, sleeping bags, rucksacks, rain-coats, etc. Run-down or abandoned former patrol posts which are not contributing to field operations need to be rehabilitated, including Ruti, Nyamitwitwi, Tchanzerwa/Busesa, Taliha, Lunyasenge, Mosenda, Muramba etc.

In order to improve anti-poaching performance, the Kabaraza elephant law-enforcement unit should be rehabilitated as a Strike Force whose efficacy will depend on good communication and mobility. This force should mount armed patrols throughout the Park on an unpredictable basis, and provide a rapid response unit to reports or calls for assistance forwarded by the various park headquarters. The unit should be properly armed and supplied with adequate ammunition to ensure that it is at least on an equal footing or better with poachers.

These recommendations could, at a relatively low cost, steer future work into effective channels to help in establishing a Virunga elephant management plan that integrates ecological management with the needs of the local people. I believe that the approach suggested above should reduce the great deal of strain in the relationship between park staff and local people. The VNP remains the showpiece of the ICCN and there is now an opportunity to manage Virunga elephants once more as a viable wildlife keystone species. The goal of conservation within Congolese policy should be to strive to maintain the VNP as a protected area where ecological processes can continue with minimum human influence: a goal worth striving for as we enter the twenty-first century.

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## REFERENCES

- Abe, E. L. (1992) The status of Elephants in Uganda: Queen Elizabeth National Park. *Pachyderm* 15: 49-52.
- André J. M. (unpubl.) Contribution au re-aménagement du Parc National des Virunga, Zaïre. Mémoire de fin d'études, 1996. Faculté des Sciences agronomiques de Gembloux-Belgique.
- Aveling, C. (unpubl.) Comptage aérien total des buffles et éléphants au Parc National des Virunga. Programme Kivu; Sous-programme Virunga, 1990. IZCN/UE.
- Barnes, R. F. W. & Jensen, K. L. (1987) How to count elephants in forests. *IUCN/AERSG Technical bulletin* 1, 1-6.
- Delvingt, W., Mankoto ma Mbaelele & Lejoly, J. (1990) Guide du Parc National des Virunga. Commission des Communautés Européennes. Bruxelles. 191 pp.
- Douglas-Hamilton, I. (1987) African elephant population trends and their causes. *Oryx* 21, 11-24.
- Dublin, H. T., Milliken, T. & Barnes, R. F. W. (1995) *Four years after the CITES Ban: Illegal hunting of elephants, ivory trade and stockpiles*. TRAFFIC International, Cambridge, UK.
- Eltringham, S. K. (1977) The numbers and distribution of elephants *Loxodonta africana* in the Ruwenzori National Park and Chambura Game Reserve. *Uganda. E. Afr. Wildl. J.* 15, 19-39.
- Hanks, J. (1979) A struggle for survival. The elephant problem. Country Life Books, Feltham, England.

- Hart, J. A. & Hall, J. S. (1996) Status of Eastern Zaïre's Forest Parks and Reserves. *Conserv. Biol.* 10(2), 316-324.
- Jachmann, H. (1988) Estimating age in African elephants: a revision of Laws' molar evaluation technique. *Afr. J. Ecol.* 22, 51-56.
- Laws, R. M., Parker, I. & Johnstone, R. (1975) *Elephants and their Habitats: the Ecology in North Bunyoro Uganda*. Oxford University Press, London.
- Leader-Williams, N. (1996) Monitoring law enforcement and illegal activities. In: *Studying Elephants*. (Ed. K. Kangwana.) African Wildlife Foundation, Nairobi.
- Mertens, H. (1983) Recensement aérien des principaux ongulés du Parc National des Virunga, Zaïre. *Rev. Ecol (Terre et vie)* 58, 51-64.
- MacGaffey, J. (1991) *The real economy of Zaire: the contribution of smuggling and other unofficial activities to national wealth*. James Currey, London.
- McClanahan, T. R. (1986) Quick population survey method using faecal droppings and steady state assumption. *Afr. J. Ecol.* 24, 61-68.
- Moss, C. J. (1988) *Elephant Memories. Thirteen Years in the Life of an Elephant Family*. William Morrow and Co., New York.
- Mubalama, L. K. (unpubl.) Rapport scientifique. IZCN-Août 1990: migrations des troupes d'éléphants dans la plaine Rwindi-Lulimbi. 11 pp.
- Mubalama, L. K. (1995) The Virunga National Park grappling with the problem of population pressure: A case of human ecology. *Wildlife and Nature* 11(2), 52-56.
- Mubalama, L. K. (1999) Fighting in the Forest. Biodiversity Conservation Amidst Violent Conflict. A View from Eastern Democratic Republic of Congo. In: *Conservation and Development Forum*. (Ed. L. T. Naughton) University of Florida, Gainesville.
- Muhindo, L. M. (unpubl.) Rapport annuel 1997. ICCN-Parc National des Virunga. Secteur Centre/Rwindi, 1998. 15 pp.
- Mushenzi, N. L. (unpubl.) Report mission. Present state of the Parc National des Virunga in the central and southern sectors: Infrastructures, Administration and Monitoring. ICCN/IGCP, 1996. 6 pp.
- Norton-Griffiths, M. (1987) Counting animals. *Handbook No. 1* in a series of handbooks on techniques currently used in African Wildlife Ecology. (Ed. J.J. Grimsdell). AWLF, Nairobi.
- Plumptre, A. J., Bizumuremyi, J. B., Uwimana, F. & Ndaruhebe, D. (1997) The effects of the Rwanda civil war on poaching of ungulates in the Parc National des Volcans. *Oryx* 32(4), 265-273.
- Pfeffer, P. (1989) *Vie et mort d'un géant: l'éléphant d'Afrique*. L'Odyssée/Flammarion, France. 192 pp.
- Said, M. Y., Chunge, R. N., Craig, G. C., Thouless, C. R., Barnes, R. F. W. & Dublin, H. T. (1995) African Elephant Database 1995. IUCN, Gland, Switzerland, 225 pp.
- Verschuren, J. (1993) Les habitats et la grande faune: Evolution et situation récente, In: *Exploration du Parc National des Virunga, deuxième série, fasc. 29*. Fondation pour Favoriser les Recherches Scientifiques en Afrique, Bruxelles. 133 pp.
- Waithaka, J. (1997) Management of elephant populations in Kenya - What have we learnt so far? *Pachyderm* 24, 33-35.
- Wing, I. D. & Buss, I. O. (1970) Elephants and the forest. *Wild. Monog.* 19, 1-92.

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# NOTES FROM THE FIELD

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## Egyptian Government Seizes Illegal Ivory Consignments

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Egypt has one of the largest retail ivory markets in Africa with over 21,000 items displayed in Cairo, Luxor and Aswan in 1998. Raw tusks are still being illegally imported into the country, mostly originating from Sudan and the Democratic Republic of Congo. Craftsmen in the Cairo area presently make a variety of ivory items such as Pharaohs, wild animals and jewellery. The commercial ivory trade is illegal as Egypt is a party to CITES, which bans the international ivory trade, and the Egyptian government has legislation prohibiting the domestic sale of ivory items within the country (Martin, 2000).

According to the Elephant Trade Information System (ETIS) managed by TRAFFIC, the Egyptian government has not reported a single ivory seizure from 1989 to 1999 (Milliken and Sangalakula, 2000). From September 1999 to early April 2000, however, the Egyptian authorities have made nine separate seizures of worked and raw ivory from traders and tourists leaving the country (see Table 1.). The largest by far was the 79 tusks weighing 173 kg which were confiscated from an Egyptian trader in Aswan. According to the trader, this raw ivory came

from "Sudan and other countries". Other information also confirms that ivory tusks are still being imported into southern Egypt from Sudan, the source for centuries.

For the last few years the CITES Standing Committee and individual conservationists have strongly criticized Egypt for allowing this illicit ivory trade to continue. From the latter part of 1999 Egyptian authorities have at last taken action by arresting offenders, for which they should be congratulated. So far, almost no action has been taken, however, towards eliminating the many thousands of ivory items offered for retail sale in the many souvenir shops. The Egyptian government needs also to take action on this matter.

### REFERENCES

- Martin, E. (2000) The present day Egyptian ivory trade. *Oryx* 34(2), 101-108.
- Milliken, T. and Sangalakula, L. (2000) A report on the status of the Elephant Trade Information System to the 11<sup>th</sup> meeting of the Conference of the Parties, CITES, Doc. 11.31.1 Annex 5.

**Table 1.** Ivory seizures within Egypt between September 1999 and April 2000.

Date of seizure	Date of report	Nationality of offender	Numbers of raw and worked ivory pieces	Weight [kg]
09.9.1999	26.3.2000	Egyptian	2	6
25.9.1999	26.3.2000	Egyptian	29	65
03.1.2000	26.3.2000	American	4	10
26.1.2000	26.3.2000	French	2	?
08.2.2000	26.3.2000	Turkish	7	30
13.2.2000	26.3.2000	Saudi Arabian	35	35
28.3.2000	01.4.2000	Egyptian	79	173
31.3.2000	01.4.2000	Egyptian	2	?
01.4.2000	03.4.2000	Turkish	2	8
<b>Total</b>			<b>162</b>	<b>327</b>

Source: Egyptian Management Authority

Photo credit: Esmond Martin

**Photo 1.** These three statues are typical of Egyptian carvings today.

Photo credit: Esmond Martin

**Photo 2.** Almost all ivory craftsmen in Egypt today work in the Cairo area.

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# Elephant Capture, Collaring and Radio-tracking in Tarangire National Park, Tanzania

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## INTRODUCTION

In order to collect data about the migration routes and spatial use of the Tarangire National Park elephant population, a capture, collaring and GPS radio-tracking programme was implemented in November 1997 within the framework of Tarangire-Manyara Conservation Project (TMCP).

TMCP is a joint project between the University of Insubria (Varese Branch), OIKOS NGO and Tanzania National Parks (TANAPA), which was first carried out between 1995-1998 with funding from the European Community, and continued in 1999 within the framework of the WWF/USAID funded project entitled "Support for Natural Resources Conservation in Tarangire National Park".

The focus of TMCP is on Tarangire National Park and its surrounding areas. The Park hosts one of the most important populations of wild herbivores in eastern Africa and the largest population of elephant in northern Tanzania with 2,000 individuals. During the rainy season most of these herbivores leave Tarangire NP and disperse into a wide area of the Masai Steppe; for more than six months they depend upon the resources available in this area, which they share with communities of pastoralists and agriculturists.

The project's main objective is to ensure the long-term conservation of the Tarangire Area, by reducing conflicts between people and wildlife in the area outside the Park.

## ELEPHANT CAPTURING

Five elephant females were initially captured in November 1997 and collared with GPS-1000 radio collars purchased from Lotek Engineering Inc. (Canada).

A recapture programme was later implemented in February 1999 in order to replace the collars before the expiry of the transmitters.

The captures were organized by Tanzania National Parks (TANAPA), Kenya Wildlife Service (KWS), Tarangire Manyara Conservation Project (TMCP) and conducted in co-operation with the Tarangire Elephant Project (TEP) and the Wildlife Division (WD).

Five female elephants were captured from 17 to 19 November 1997. These females were selected for collaring because they represented the three different sub-populations of elephants found in the Park. Elephant "Bella" was from the northern sub-population, "Fraha" and "Kikoti" represented the sub-population found in the central area of the Park around Tarangire Hill, while the last two, "Maajabu" and "Kibonge", belonged to the southern sub-population of the Park. During the recapture of February 1999, three elephants had the collars replaced and two new animals were collared ("Silale" and "Kusini").

## RADIO-TRACKING

Radio-tracking activity was conducted by both aerial (Frankfurt Zoological Society, FZS and TANA-

PA, Cessna 206) and ground surveys. The data collected in the field between February and March 1999 are shown in (Figure 1).

“Bella” (4A) used mainly the northern part of the Park, the north-eastern shore of Lake Burungi and the northern tip of Lolikisale Game Controlled Area (GCA).

“Fraha” (EA) remained inside the Park, mainly in the area around Tarangire river. She migrated only once outside the Park, in Lolikisale GCA, where she spent only one day.

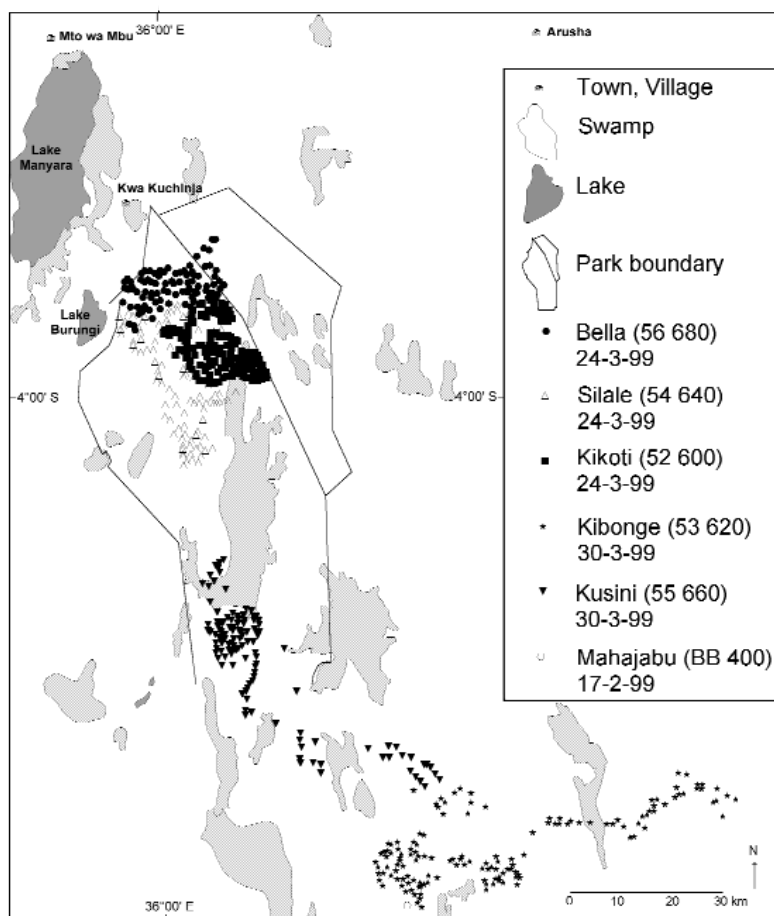
The collar of “Kikoti” (47) experienced technical failure very soon: in December 1997 data were downloaded for the last time. The data

available show that this female remained inside the Park, using an area located more to the south of the distribution of the previous two animals.

“Silale” moved inside the Park between Gursi and Silale swamp.

“Kibonge” (DC), “Kusini” (55) and “Maajabu” (BB) moved outside the Park 12 days after the capture, travelling in a south-easterly direction about 80 km from the Park boundary, to Kiteto region. They both crossed the Park boundary in a straight line, during the night, moving almost 15 km in 10 hours. From December 1997 to May 1998, they always used the same area.

**Figure 1.** Records of the movements of six elephants in Tarangire National Park, Tanzania, February to March 1999.



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# REVIEW AND OPINION

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## The Status of the Southern White Rhino (*Ceratotherium simum simum*) on Private Land in South Africa in 1999

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### ABSTRACT

A survey to determine the status of white rhinoceros (*Ceratotherium simum simum*) on private land in South Africa was conducted during August and September 1999. A minimum total of 1,656 white rhino are in private possession on 161 ranches, which is an increase of 10.8% over 1997. The white rhinos present in the private nature reserves, which now have no fences between themselves and the Kruger National Park, have also increased to 266 this year. This brings the minimum number of white rhino under private management in 1999 to 1,922. A minimum estimate of 372 kg of horn is in private possession.

### RESUME

Une enquête visant à déterminer la situation du rhinocéros blanc (*Ceratotherium simum simum*) sur les terrains privés d'Afrique du Sud a été réalisée pendant les mois d'août et septembre 1999. Un total minimum de 1 656 rhinocéros blancs est en propriété privée dans 161 ranchs, ce qui représente une augmentation de 10,8 % par rapport à 1997. Le nombre de rhinocéros dans les réserves naturelles privées n'ayant plus de clôtures les séparant du Parc National Kruger est également monté à 266 cette année. Ceci amène le nombre minimum de rhinocéros sous gestion privée à 1 922 en 1999. Un minimum estimé de 372 kg de corne est sous propriété privée.

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### INTRODUCTION

When the former Natal Parks Board (NPB) started translocating white rhinos from their reserves in 1961, the policy was to first of all send animals to *bona fide* nature conservation areas. (Brooks, 1989). In 1984 there were between 60 and 100 white rhinos on private land in the state of Natal. The criteria for possession of rhinos were somewhat relaxed, how-

ever, and by 1987 1,291 white rhinos had been moved to 149 privately owned properties all over South Africa, though not all came from the Natal Parks Board (Buijs and Anderson, 1989). At that time, the total number could have stood at 1,440 through natural breeding and taking natural and translocation mortalities into account, yet, in a survey conducted in 1987, only 931 white rhino on 103 properties could be accounted for.

One of the major causes of the state of affairs at that time was that rhinos were sold very cheaply by NPB. Therefore, a quick and very substantial profit could be made if an animal was sold by a private owner to a trophy hunter, which often happened within a few weeks after delivery. A bull which had been purchased for R 2,000 (US\$ 335, at a current exchange rate of US\$ 1 = R 6) could reach up to R 35,000 (US\$ 5,833) as a trophy (Buijs, 1988). These findings influenced the decision of the Natal Parks Board to reconsider the cheap dumping of rhinos, and in 1989 the first Parks Board auction was introduced.

The true value of the animals emerged when normal market forces were allowed to come into play (Du Toit, 1998). The average auction prices realized from 1986 onwards in South Africa are listed in Table 1, showing the increase in 1989, when NPB started its auctions. The drop in prices between 1991 and 1994 was due to political reasons, i.e. the Gulf war discouraged Americans to travel abroad, and people were reluctant to invest in rhinos due to the uncertainty of what the new South African dispensation would bring. After 1994, the demand increased and prices soared.

### Previous surveys on private land

The first comprehensive survey of white rhino on private land in South Africa was conducted in 1987 by the Rhino & Elephant Foundation (Buijs, 1988). Subsequent surveys were con-

ducted in 1995 and 1997 under the auspices of the African Rhino Owners Association (AROA), a working group of the Rhino & Elephant Foundation, as summarized in Table 2 (Buijs and Papenfus, 1996; Buijs, 1998). Between 1987 and 1995, the Sabi-Sand, Timbavati, Klaserie and Buffelshoek private nature reserves removed the fences between themselves and the Kruger National Park (KNP). They now form a principal part of KNP and the total unit is referred to as the Greater KNP (GKNP). The results of the 1997 survey indicate that private owners had a total of 1,494 white rhinos, which is 18.9% of the total estimated South African population of 7,913 (Emslie, 1998). If the 248 white rhinos under private management in parks bordering the Kruger National Park (then Timbavati, Sabi-Sand and Klaserie) are added, 22% were in private hands.

### METHODS AND OBJECTIVES

The goals of the survey were to establish the contribution of private rhino owners to rhino conservation and to gauge the opinion of rhino owners on responsible utilisation of white rhinos. For the first time an estimate of the number of rhino horns in private possession was also sought.

All known private nature reserves with white rhinos were contacted by telephone during the second half of 1999. The history of the rhino populations from the start of 1998 to July 1999

**Table 1.** Average auction prices for white rhinos in South Africa.

Year	US\$	R	Year	US\$	R
1986	10,167.00	1,694.50	1994	32,770.00	5,461.67
1989	48,732.00	8,122.00	1995	40,667.00	6,777.83
1990	48,524.00	8,087.33	1996	44,491.00	7,415.17
1991	44,188.00	7,364.67	1997	69,333.00	11,555.50
1992	29,230.00	4,871.67	1998	98,813.00	16,468.83
1993	28,350.00	4,725.00	1999	127,130.00	21,188.33

Source: Anonymous, 2000

**Table 2.** White rhinos on private land in South Africa, showing the total number of specimens and in brackets the number of populations.

Year	Private land	GKNP	Total	% growth
1987	931 (103)	Still fenced off	931 (103)	
1995	1,243 (150)	202 (3)	1,445 (153)	55.2
1997	1,494 (162)	248 (3)	1,742 (165)	20.5
1999	1,656 (161)	266 (3)	1,922 (164)	10.3

was recorded. A total number of about 200 people was contacted. They were not necessarily the owners or managers, and therefore did not always know the exact details of the history, age or sex structure of the population, but it was always ascertained that the total number was as accurate as possible. If there were any doubts, an effort was made to locate someone with better knowledge.

## RESULTS

### Rhino numbers

Table 2 shows the numbers of white rhino on private land in September 1999. A minimum total of 1,656 white rhino were in private possession, which is an increase of 10.8 % over 1997. The number of populations has decreased by one. Since 1997, at least 14 new populations were established, while 14 were deleted: six owners had sold all their rhinos, two could not be traced, two have been incorporated into other reserves by the removal of fences, and four populations have been moved to other ranches which already had other white rhinos. This makes a total of 161 ranches with white rhino in 1999. Of the 161 populations present in 1997, 147 still exist. Of these, 34 have decreased, 39 are the same and 74 have grown.

The white rhinos which are in the private nature reserves that have removed the fences between themselves and the Kruger National Park (KNP), have also increased to 266. This brings the minimum number of white rhino under private management to 1,922.

### Age and sex structures

The age and sex age structure (excluding the reserves which form part of the GKNP) are shown in Table 3. In cases where the respondent did not know the exact composition of the population, all animals were recorded as adults of unknown sex. Using only those populations where age and sex structures were known, the ratio of adult males to adult females was 1:1.6 (38% : 62%); subadult males to subadult females 1:0.9 (53% : 47%); and adults to subadults 1:3.7 (79% : 21%).

### Additions and losses to the population

At least 299 calves were born in 1998 and 1999, which represents 20% of the 1997 population. The known number of rhinos brought onto ranches as breeding stock was 141, i.e. 73 from private ranches and 68 from KwaZulu-Natal Conservation Services (KZNCS), whereas the rhinos leaving ranches alive numbered 189. This results in 116 rhinos of which the whereabouts are unknown (189 sold minus 73 bought). This figure does not include a few rhinos that left the country. The problem was that the sellers did not know the identities of the buyers because they worked through dealers, and the dealers were difficult to get hold of, or get information from. It is hoped that these discrepancies can be eliminated during future surveys.

Twenty deaths were caused by other rhinos, either through fights or when a bull wanted to mate with a female in oestrus and her calf got in the way. Unlike in the previous survey where 18

**Table 3.** Age and sex structure of the white rhino population on private land in South Africa, 1999.

	Males	Females	Unknown	Total
<b>Adult (&gt;6years)</b>	337	557	269	1,163
<b>Subadult</b>	125	113	255	493
<b>Total</b>	462	670	524	1,656

rhinos died during, or shortly after, transportation, this year no such mortalities were reported. The number poached has risen from two during 1996-97 (on one property) to 12 during 1998-99 (on five properties).

Thirty-one white rhino were reported to have been hunted, with another 16 sold by KZNCS as trophies, thus totalling 47. Excluding the last 16, 1.9% of the present population was thus hunted over an 18 month period. A few of these were necessary hunts because the bulls regularly started killing other rhinos, especially calves.

### Founder populations

It is widely believed that single bulls do not perform as well sexually as when there is a threat of competition. An analysis of founder populations, however, suggests that this is not the case in general. Thirty-seven founder populations were suitable for the calculations (all cows which could possibly have been pregnant when relocated had to be excluded). The data show that 22 populations with one bull bred successfully, whereas 15 populations have been unsuccessful over the last four years. Some of the latter animals were subadult when bought, and it is possible that they will breed as they are now reaching maturity. However, experiences in the various ranges differ. For instance, in one population, one bull and five cows had 11 calves since 1992, while in another one bull and five cows had 21 calves since they were bought (the exact year of introduction is uncertain), six of which were born since 1996. In both cases the male offspring were sold before maturity. On the contrary, a population of two bulls and two cows had no calves for five years, and another with two bulls and three cows have had no calves for four years.

### Rhino horn

Thirty-three respondents reported that they had white rhino horn stocks. These totalled 80 adult front horns, 50 adult rear horns, 47 horns from young animals or fragments, and 132 kg of unspecified horns. If the assumption is made that an average front horn weighs 2.5 kg, a rear horn 0.5 kg, and the small horns 0.3 kg, an estimate of 372 kg of horn is in private hands. Some non-rhino owners must also have horns from inheritances or gifts.

All respondents, without exception, were in favour of a legal trade, and welcomed the idea of a privately run registry for rhino horn.

### DISCUSSION

The survey was conducted over a period of two months and as this was a repeat of earlier ones, each person was contacted once only. The method of telephone contact implies that the information was not verified on the ground. In addition, the African Rhino Owners Association is reluctant to give names of the owners, making it even more difficult to verify the information. However, the figures obtained from this kind of survey are the best indications available with which the African Rhino Specialist Group has to work and hence the work itself deserves to be better known.

The increase of 10.8% in numbers on private land is an indication of the important role played by the private rhino owner in rhino conservation. Emslie (1998) estimated the total number of white rhino in South Africa as 7,913 in 1997. Therefore, the private sector owns 20.1% of the total South African population. When the rhinos

of the private GKNP reserves are included, it manages 24.3% of the white rhino in the country. These figures bode well for the future conservation of white rhinos. State land is reaching, and many reserves (especially in KwaZulu-Natal) have already reached, maximum stocking rates, implying that the private sector will control an ever-increasing percentage of the population. Although the record prices at the 1998 Natal auction show that the demand for white rhinos is still very high, it is inevitable that private land will also eventually become saturated. The prices, as well as the value of the investment in rhinos, could well decrease as supply starts to catch up with demand. The trophy hunting industry has stabilized and is unlikely to grow at the present prices, and other markets must be sought and developed if rhino ranching is to keep its momentum. These figures, coupled with the increase in poaching incidents, should indicate that the time is ripe to investigate the possibility of a legalized trade in rhino products.

It is envisaged that a privately managed registry for rhino horn will be founded in the near future, and that eventually all white rhinos will be fitted with microchips and individually registered (AROA, 1999). This should remove many misgivings about security and control should a legalized trade be considered. It will also enable future database managers to trace translocated white rhinos more effectively.

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## REFERENCES

- Anonymous (2000) Veilingpryse sedert 1990 [Auction prices since 1990]. *SA Game & Hunt*, Pretoria, 6(1), 11.
- AROA (1999) *Proceedings of a workshop on conservation of African rhinos on private land through utilization*. SAVA Wildlife Group, PO Box 12900, Onderstepoort, 0110, South Africa.
- Brooks, P.M. (1989) Proposed conservation plan for the black rhinoceros *Diceros bicornis* in South Africa, the TBVC states and Namibia. *Koedoe* 34(1), 1-30.
- Buijs, D. (unpubl.) A summary of the introduction of white rhino onto private land in the Republic of South Africa. Rhino & Elephant Foundation, 1988.
- Buijs, D. (unpubl.) Survey: white rhinos on private land, 1997. African Rhino Owners Association, 1998.
- Buijs, D. and Anderson, J. (1989) Disquiet was justified - White rhinos on private land in South Africa. *The Rhino & Elephant Journal* 2, 26 - 31.
- Buijs, D. and Papenfus, T. (unpubl.) Survey: white rhinos on private land, 1996. African Rhino Owners Association, 1996.
- Du Toit, J.G. (1998) *Rhino ranching - A manual for owners of white rhinos*. Wildlife Group: South African Veterinary Foundation, Pretoria.
- Emslie, R.H. (1998) African rhinos increase to 11000 in the wild. *The Rhino & Elephant Journal* 12, 4-7.

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# GIS as a Tool for Rhino Conservation

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## ABSTRACT

A Geographic Information System (GIS) is the hardware, software and personnel used for storage, manipulation and analysis of spatially referenced data. At its most basic it is simply a mapping tool, but it can also be used to relate different sets of spatial data and provides powerful analytical and predictive capabilities to assist management decision-making. The use of GIS is becoming increasingly widespread in the fields of resource management. Here, I discuss the use of GIS for rhino conservation and management. After describing different types of GIS software, I review some existing GIS uses in wildlife conservation and management, and consider some of the uses to which GIS could be put within *in situ* rhino conservation programmes.

## RESUME

Un Système d'Information Géographique (SIG) renferme l'instrumentation, les logiciels et le personnel employés pour le stockage, la manipulation et l'analyse de données référencées dans l'espace. Dans sa forme la plus simple il s'agit d'un simple outil de cartographie, mais il peut également être utilisé pour mettre en relation différents jeux de données spatiales et offre ainsi des possibilités d'analyse et de prédiction considérables pour aider à la prise de décisions de gestion. L'utilisation de SIG est de plus en plus répandue dans le domaine de la gestion des ressources. Je discute ici l'application des SIG à la protection et la gestion des rhinocéros. Après une description des différents types de logiciels de SIG, quelques utilisations existantes de SIG dans la protection et la gestion de la faune sauvage sont passées en revue, puis certains des usages envisageables du SIG dans les programmes de conservation du rhinocéros *in-situ* sont considérés.

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## WHAT IS GIS?

The acronym GIS stands for Geographic, or Geographical, Information System. There are countless definitions of GIS (Burrough, 1990; Scholten and van der Vlugt, 1990; Maguire et al., 1991; Martin, 1996; DeMers, 1997; Burrough and McDonnell, 1998; Heywood et al., 1998). Most agree that it is "a system for capturing, storing, checking, manipulating, analyzing and displaying data which are spatially referenced to the earth" (DoE, 1987). Essentially, GIS is a tool to aid decision-makers, be they town planners, foresters, fisheries scientists or protected area managers. In practice most GISs are computer-based, and consist of four components; hardware, software, personnel and the data to be managed and analyzed.

There are a variety of uses for GIS. First, it provides a way of displaying data and making measurements within data sets (*coverages* or *layers*), such as the length of roads and rivers, the average distance between water points, or the area of a particular habitat type or animal home range. It allows spatial layers to be constructed from sample data points using interpolation techniques, for example constructing a rainfall map using data from rainfall gauges. It also permits the classification of remotely sensed data such as aerial photographs or satellite imagery, with or without reference to data collected on the ground. Furthermore, new layers can be created from the original, showing for example the distance of each point on the ground from water.

Second, GIS allows different layers to be combined, or *overlaid*, to create more complex composite displays, or *maps*. Layers may come from a variety of sources, such as satellite imagery, topographic surveys, wildlife censuses, etc. Topographic map sheets are printed examples of a collection of overlaid layers, usually including relief, habitat, rivers, roads and human settlements. Other layers that could be added include soil type, rainfall distribution, fire maps, and the density or distribution of different wildlife species.

Perhaps the greatest value of GIS is that it permits analysis using multiple layers. Layers can be combined to create new layers. For example, one could create a layer showing all areas of bushed grassland that were burnt last year, or a layer showing all areas of logged forest within 1 km of a road or river. Furthermore, relationships between layers can be examined with appropriate statistical tests (e.g. Pereire and Itami, 1991). For example, one could examine whether the distribution of an animal species is related to the underlying habitat or soil types or to anthropogenic factors.

Once statistical relationships have been established, it is possible to undertake predictive modelling and simulation using GIS. For example, if it has been found that a species' occurrence is restricted to areas within 500m of water, one could create a map in a GIS showing all the areas where the species is likely to be found. Equally, if it were shown in one protected area that rhino density was significantly related to the density of acacia woodland, one could predict the density and distribution of rhinos in a second nearby protected area, given a map of acacia woodland density in that place. These are simple examples, and multiple data layers can be used to create very sophisticated models with high levels of accuracy.

## DIFFERENT TYPES OF GIS

When one thinks of GIS it is usually the software that comes to mind, since this is the core of the system. There are now many different GIS software packages on the market, including Arc

Info, Arc View, Map Info, Idrisi, Atlas, Camris, Map Maker and more. These software packages are becoming increasingly cheap and accessible, as are the personal computers needed to run them.

Essentially there are two kinds of GIS software, those that use a vector system and those that use a raster system. In a vector system, items are recorded and displayed as points, lines and polygons. In a raster system the coverage, or area, is broken up into a grid of pixels of a particular resolution. Vector and raster systems both have their own benefits and costs. Vectors generally take up very little computer memory since only the points of interest need be recorded. Rasters may take up a lot of memory, since each pixel of the area is assigned a value. Vectors are better for working with lines and polygons such as roads, rivers and boundaries, and for presentation purposes, while rasters are more appropriate when dealing with less clearly delineated data such as vegetation cover or topography, and are better for spatial analysis and simulation. At DICE we have been using Idrisi, a raster based system, and Arc View, a vector based system, to provide a complete suite of capabilities. Both systems are inexpensive and can be used on any Windows-based PC computer. Both are relatively simple to use after some initial training.

## GIS FOR WILDLIFE CONSERVATION AND MANAGEMENT

GIS technology is increasingly being applied to ecological problem-solving (Haslett, 1990), and over the past decade there have been an increasing number of published examples of the use of GIS for applied ecology and resource management. It is a common tool in forestry and landscape ecology, having been used for habitat classification, and to examine habitat change, fragmentation, utilization, restoration and conservation. It has been used in biodiversity management to analyze threats, the effect of climate change, and to analyze protected area coverage and representation.

Increasingly GIS is being used as a tool for wildlife conservation and management. It has

Photo credit: Matt Walpole



**Photo 1.** "Natumi" watching the photographer.

been used to examine animal home ranges, and the factors affecting their size and location (Thouless, 1996; Verlinden and Gavor, 1998; Ostro et al., 1999; Waithman et al., 1999). It has also been used to model habitat suitability (Donovan et al., 1987; Pereira and Itami, 1991; Clark et al., 1993; Boroski et al., 1996; Reading and Matchett, 1997; Waller and Mace, 1997). From this it has been possible to estimate and predict population size, density and distribution over wider areas (Yonzon and Hunter, 1991; Fabricius and Coetzee, 1992; Barnes et al., 1997; Lahm et al., 1998; Gros and Rejmanek, 1999; Pike et al., 1999), to evaluate potential habitat (Maehr and Cox, 1995; VanDeelen et al., 1997; Mladenoff and Sickley, 1998; Mace et al., 1999), and to identify and prioritize areas for protection (Smith et al., 1997; Corsi et al., 1999; Li et al., 1999). GIS has also been used to examine factors affecting population viability and longevity (Lindenmayer and Possingham, 1995, 1996), and the effects of poaching and other forms of conflict and utilization on populations (Michelmore et al., 1994; Hillman-Smith et al., 1995; Foster et al., 1997; Broseth and Pedersen, 2000). These studies have covered a range of species including elephants, wolves, pandas,

panthers, deer, cheetahs, grizzly bears, primates, prairie dogs and wild pigs.

## GIS and rhino conservation

*In situ* rhino conservation is based on security and biological management (e.g. Emslie and Brooks, 1999). Both of these issues rely on information about where rhinos are and why. Thus there is a distinct spatial element that makes data storage, presentation and analysis using GIS an appropriate approach. Moreover, spatial locating hardware such as radio and satellite collars and GPS are becoming increasingly available (Thouless et al., 1992; Thouless and Dyer, 1992; Douglas-Hamilton, 1998; Hofmeyr, 1999; Longh et al., 1999), and these provide a ready supply of spatial data that can be used in a GIS. Equally, digital satellite data for constructing habitat and other physical layers, and digital elevation models of topography are now more accessible at low cost, and in some cases are freely available.

Although GIS has been used frequently in elephant research (Thouless and Dyer, 1992; Michelmore et al., 1994; Hillman-Smith et al.,

1995; Thouless, 1996; Barnes et al., 1997; Gibson et al., 1998), published examples of the use of GIS in rhino conservation are rare. The most common use has been to measure and plot rhino home range and overlap (Huggins, unpubl.; Hearne, unpubl.; Rachlow et al., 1999; G. Chege, 2000, pers.comm.). One study overlaid black rhino home ranges onto habitat and soil layers and used regression to determine habitat preferences (Huggins, unpubl.). These examples barely scratch the surface of the potential of GIS for rhino conservation, although there may be other studies which have gone further but of which I am not aware. I would be interested to hear from other *Pachyderm* readers of the ways in which they are using GIS for rhinos.

There are at least eight ways that GIS could be used as a tool for *in situ* rhino management and protection.

### **1. Data storage**

Monitoring rhinos generates large amounts of data, on the locations of individuals, activities, health status etc. This can usefully be stored in a GIS database for ease of access, presentation and analysis.

### **2. Data presentation**

Simply creating hard copy maps of a rhino area with distribution, home ranges or density can be useful for two reasons. Firstly to aid in planning the deployment of human resources for security and monitoring, and secondly as a presentation aid in reports and proposals to funding organizations.

### **3. Home range studies**

Both raster and vector systems easily calculate, display and overlay home ranges. Arc View includes a module with various home range estimation methods, including minimum convex polygon and kernel estimate techniques (Hearn, unpubl.). Alternatively, home range packages such as Calhome can be used to calculate home range size, with GIS used to display ranges, calculate overlap and generate density maps (Rachlow et al., 1999).

### **4. Estimating population size and distribution**

In large areas or areas of thick bush, such as Selous Game Reserve in Tanzania, it may not be possible to know the precise population size and distribution of rhinos. By measuring the density of sightings or other signs in sample areas (Leader-Williams, 1985), and relating this to habitat features, it is possible using GIS to estimate distribution and density across much larger areas, given the appropriate habitat data. Such an approach has been taken for forest elephants using dung counts and habitat data (Barnes et al., 1997).

### **5. Evaluating patrol effort and efficiency**

Using GIS one can easily map the locations of patrol routes and calculate patrol effort in different zones. This can then be related to sighting data, poacher detection data, or data on population decline or recovery in each zone, so as to evaluate the performance or success of law enforcement (Leader-Williams et al., 1990). If habitat data are included one could examine how patrol efficiency varies with different habitat variables, and so more effectively design patrol strategies in heterogeneous landscapes.

### **6. Modelling population expansion**

Once habitat suitability has been established in an area occupied by rhinos, using GIS and statistical analysis, it is possible to predict how and where the population will expand into neighbouring areas. This may be useful in areas where a small population exists in part of the area but which is expected to expand into other parts of the area. Equally, the analysis may show that population expansion is unlikely and that carrying capacity is already reached.

### **7. Evaluating potential translocation sites**

Translocation is a common tool in black and white rhino management, given the need for more and larger populations to buffer against poaching and stochastic or genetic factors. Potential sites need to be assessed as to their suitability for rhinos and the likely population size that they could support. GIS offers a simple

means to generate prediction models of the likely distribution and density of rhinos within a new area. These could be based on resource surveys or habitat maps of the area and habitat suitability models from similar sites, or on simple area calculations based on known male home range size and topographic data.

### ***8. Predicting the effects of habitat change and management actions***

Where temporal data on habitat and rhino distribution are available, it is possible to examine how rhino use of an area has changed with changing habitat or human intervention. Factors such as fire, woodland decline, browse competitor density or tourism development may all have changed the value of an area for rhinos, and this may be reflected in changing use patterns. From these relationships, which can be easily examined using GIS, it may be possible to determine how management intervention could benefit rhinos by increasing carrying capacity.

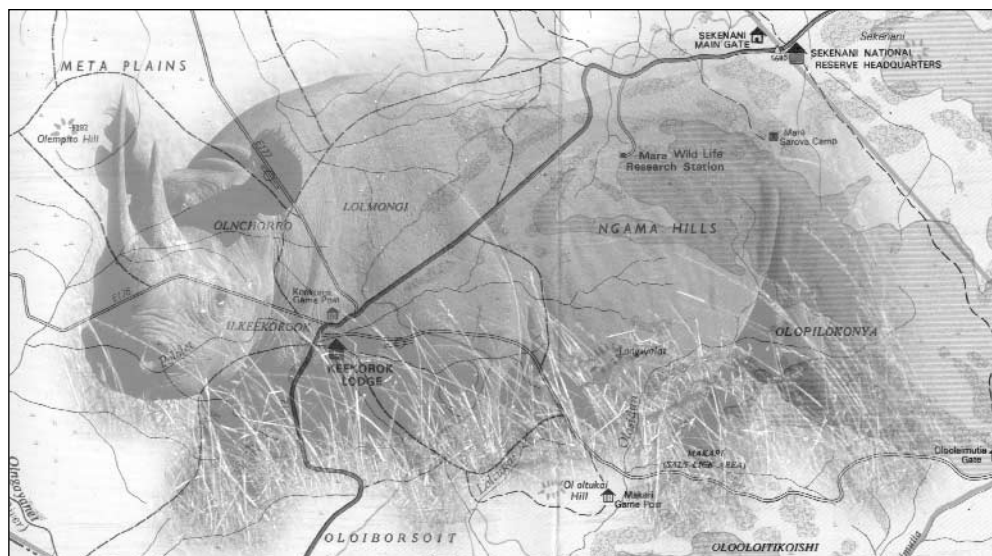
These are a few ways that GIS could be applied to rhino management. My own study of the black rhino population in the Masai Mara National Reserve in Kenya is using GIS in many of the ways described above. The Mara is a relatively large area that used to support a widely distributed black rhino population of over 100

individuals (Mukinya, 1973). At the current time the population is much smaller and more reduced in its distribution (Morgan-Davies, 1996, Walpole and Bett, 1999). Equally, over the past 30 years there have been changes in habitat and human presence within the Mara that may have reduced the capacity of the area for rhinos.

My study is using GIS to conduct spatial and temporal analyses of factors affecting rhino distribution and density, alongside traditional resource availability and utilization surveys, to assess how carrying capacity in the Mara has changed and what implications this has for the recovery and expansion of the population. The study is ongoing and the results will hopefully be presented in future issues of *Pachyderm*.

## OUTLOOK

GIS is a powerful tool for creating maps, making measurements, examining spatial relationships, and undertaking predictive modelling. As such it can greatly assist decision-making by wildlife managers. It has been used in a variety of ways for wildlife management and conservation, and has the potential to benefit rhino conservation by providing ways of presenting and analyzing data, estimating population size and distribution, modelling population performance, assessing the value of potential ranges and analyzing or



predicting the effects of management activities and law enforcement. To date, this potential has not been fully exploited.

Establishing a GIS is within reach of many organizations involved with rhino conservation, given the relatively low cost and high accessibility of personal computers, GIS software and satellite imagery. Data collection, for input into a GIS, could be easily facilitated by rangers equipped with a simple GPS and either a notebook or data capture unit (Liebenberg et al., 1999). Equally, GPS collars provide data downloaded directly into the computer (Douglas-Hamilton, 1998).

There is a need for initial training in the use of GIS and statistical packages for personnel, and there are considerations of data resolution and various error sources to be borne in mind when using GIS (Burrough and McDonnell, 1998). It is, however, undoubtedly a useful tool that will become increasingly widespread as costs decrease further and local skills develop.

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## REFERENCES

Barnes, R.F.W., Beardsley, K., Michelmores, F., Barnes, K.L., Alers, M.P.T. and Blom, A. (1997) Estimating forest elephant numbers with dung counts and a geographic information system. *J. Wildl. Manag.* 61, 1384-1393.

Broseth, H. and Pedersen, H.C. (2000) Hunting effort and game vulnerability studies on a small scale: a new technique combining radio-telemetry, GPS and GIS. *J. App. Ecol.* 37, 182-190.

Boroski, B.B., Barrett, R.H., Timossi, I.C. and Kie, J.G. (1996) Modelling habitat suitability for black-tailed deer (*Odocoileus hemionus columbianus*) in heterogeneous landscapes. *Forest. Ecol. Manag.* 88, 157-165.

Burrough, P.A. (1990) *Principals of geographical information systems for land resources assessment*. Monographs on soil and resources survey, 12. Oxford University Press, Oxford.

Burrough, P.A. and McDonnell, R.A. (1998) *Principals of geographical information systems*. Oxford University Press, Oxford.

Clark, J.D., Dunn, J.E., and Smith, K.G. (1993) A multivariate model of female black bear habitat use for a geographic information-system. *J. Wildl. Manag.* 57, 519-526.

Corsi, F., Dupre, E. and Boitani, L. (1999) A large-scale model of wolf distribution in Italy for conservation planning. *Conserv. Biol.* 13, 150-159.

DeMers, M.N. (1997) *Fundamentals of geographical information systems*. J. Wiley and Sons Inc., New York.

Department of the Enviroment (DoE) (1987) *Handling geographical information*. HMSO, London.

Donovan, M.L., Rabe, D.L. and Olson, C.E. (1987) Use of geographic information systems to develop habitat suitability models. *Wildl. Soc. Bull.* 15, 574-579.

Douglas-Hamilton, I. (1998) Tracking African elephants with a global positioning system (GPS) radio collar. *Pachyderm* 25, 81-92.

Emslie, R. and Brooks, M. (1999) *African rhino: status survey and action plan*. IUCN/SSC African Rhino Specialist Group. IUCN, Gland, Switzerland.

Fabricius, C. and Coetzee, K. (1992) Geographic information-systems and artificial-intelligence for predicting the presence or absence of mountain reedbeek. *S. Afr. J. Wildl. Res.* 22, 80-86.

Foster, J.R., Roseberry, J.L. and Woolf, A. (1997) Factors influencing efficiency of white-tailed deer harvest in Illinois. *J. Wildl. Manag.* 61, 1091- 1097.

Gibson, D., Craig, G.C. and Masogo, R.M. (1998) Trends of the elephant population in northern Botswana from aerial survey data.

- Pachyderm* 25, 14-27.
- Gros, P.M. and Rejmanek, M. (1999) Status and habitat preferences of Uganda cheetahs: an attempt to predict carnivore occurrence based on vegetation structure. *Biodiv. Conserv.* 8, 1561-1583.
- Haslett, J.R. (1990) Geographic information systems: a new approach to habitat definition and the study of distributions. *Trends Ecol. Evol.* 5, 214-218.
- Hearn, M. (unpubl.) Factors limiting fecundity and movement patterns of the black rhinoceros (*Diceros bicornis*) in Kunene region, Namibia. MSc Thesis, 1999. University of Kent, UK, 86 pp.
- Heywood, I., Cornelius, S. and Carver, S. (1998) *An introduction to geographical information systems*. Longman, Harlow, Essex.
- Hillman-Smith, A.K.K., de Morode, E., Nicholas, A., Buls, B. and Ndey, N. (1995) Factors affecting elephant distribution in Garamba National Park and surrounding reserves, Zaire, with a focus on human-elephant conflict. *Pachyderm* 19, 39-48.
- Hofmeyr, M. (1999) Comparison of four different radio transmitter attachments on black rhino in Madikwe Game Reserve. *Pachyderm* 26, 14-24.
- Huggins, A. (unpubl.) Assessing the habitat preferences of black rhinoceros (*Diceros bicornis*) in Mkuzi Game Reserve using a geographical information system. MSc Thesis, 1996. University of Kent, UK, 74 pp.
- Iongh, H. de, Tchamba, M., Tamis, W., Van't Zelfde, M., Prins, H., Haes, H.U. de, Bauer, H. and Tiawoun, S. (1999) Results of four years' satellite tracking of elephants in northern Cameroon. *Pachyderm* 27, 62-65.
- Lahm, S.A., Barnes, R.F.W., Beardsley, K. and Cervinka, P. (1998) A method for censusing the greater white-nosed monkey in north-eastern Gabon using the population density gradient in relation to roads. *J. Trop. Ecol.* 14, 629-643.
- Leader-Williams, N. (1985) Black rhino in South Luangwa National Park: their distribution and future protection. *Oryx* 19, 27-33.
- Leader-Williams, N., Albon, S.D. and Berry, P.S.M. (1990) Illegal exploitation of black rhinoceros and elephant populations: patterns of decline, law enforcement and patrol effort in Luangwa Valley, Zambia. *J. App. Ecol.* 27, 1055-1087.
- Li, W.J., Wang, Z.J., Ma, Z.J. and Tang, H.X. (1999) Designing the core zone in a biosphere reserve based on suitable habitats: Yancheng Biosphere Reserve and the red crowned crane (*Grus japonensis*). *Biol. Conserv.* 90, 167-173.
- Liebenberg, L., Steventon, L., Benadie, K. and Minye, J. (1999) Rhino tracking with the CyberTracker field computer. *Pachyderm* 27, 58-61.
- Lindenmayer, D.B. and Possingham, H.P. (1995) Modelling the impacts of wildfire on the viability of metapopulations of the endangered Australian species of arboreal marsupial, Leadbeater's possum. *For. Ecol. Manag.* 74, 197-222.
- Lindenmayer, D.B. and Possingham, H.P. (1996) Modelling the inter-relationships between habitat patchiness, dispersal capability and metapopulation persistence of the endangered species, Leadbeater's possum, in south-eastern Australia. *Landscape Ecol.* 11, 79-105.
- Mace, R.D., Waller, J.S., Manley, T.L., Ake, K. and Wittinger, W.T. (1999) Landscape evaluation of grizzly bear habitat in western Montana. *Conserv. Biol.* 13, 367-377.
- Maehr, D.S. and Cox, J.A. (1995) Landscape features and panthers in Florida. *Conserv. Biol.* 9, 1008-1019.
- Maguire, D.J., Goodchild, M.F. and Rhind, D.W. (1991) *Geographical information systems*. Longman, Harlow, Essex.
- Martin, D. (1996) *Geographic information systems: socioeconomic applications*. Routledge, London.
- Michelmore, F., Beardsley, K., Barnes, R.F.W. and Douglas-Hamilton, I. (1994) A model illustrating the changes in forest elephant numbers caused by poaching. *Afr. J. Ecol.* 32, 89-99.
- Mladenoff, D.J. and Sickley, T.A. (1998) Assessing potential gray wolf restoration in the northeastern United States: A spatial prediction of favorable habitat and potential population levels. *J. Wildl. Manag.* 62, 1-10.

- Morgan-Davies, M. (1996) Status of the black rhinoceros in Masai Mara National Reserve, Kenya. *Pachyderm* 21, 38-45.
- Mukinya, J.G. (1973) Density, distribution, population structure and social organisation of the black rhinoceros in Masai Mara Game Reserve. *E. Afr. Wildl. J.*, 11, 385-400.
- Ostro, L.E.T., Young, T.P., Silver, S.C. and Koontz, F.W. (1999) A Geographic Information System method for estimating home range size. *J. Wildl. Manag.* 63, 748-755.
- Pereire, J.C. and Itami, R. (1991) GIS-based habitat modeling using logistic multiple regression: a study of the Mt. Graham red squirrel. *Photogram. Engin. Rem. Sens.* 57, 1475-1486.
- Pike, J.R., Shaw, J.H., Leslie, D.M. and Shaw, M.G. (1999) A geographic analysis of the status of mountain lions in Oklahoma. *Wildl. Soc. Bull.* 27, 4-11.
- Rachlow, J.L., Kie, J.G. and Berger, J. (1999) Territoriality and spatial patterns of white rhinoceros in Matobo National Park, Zimbabwe. *Afr. J. Ecol.* 37, 295-304.
- Reading, R.P. and Matchett, R. (1997) Attributes of black-tailed prairie dog colonies in north central Montana. *J. Wildl. Manag.* 61, 664-673.
- Scholten, H. and van der Vlugt, M. (1990) A review of geographic information systems applications in Europe. In: *Geographic information systems: developments and applications* (Ed. L. Worral). Belhaven Press, London, pp. 13-40.
- Smith, A.P., Horning, N. and Moore, D. (1997) Regional biodiversity planning and lemur conservation with GIS in western Madagascar. *Conserv. Biol.* 11, 498-512.
- Thouless, C.R. (1996) Home ranges and social organisation of elephants in northern Kenya. *Afr. J. Ecol.* 34, 284-297.
- Thouless, C.R. and Dyer, A. (1992) Radio-tracking of elephants in Laikipia district, Kenya. *Pachyderm* 15, 34-39.
- Thouless, C.R., Hoare, R.E. and Mulama, M. (1992) Satellite tracking of elephants in Laikipia district, Kenya. *Pachyderm* 15, 28-33.
- VanDeelen, T.R., McKinney, L.B., Joselyn, M.G. and Buhnerkempe, J.E. (1997) Can we restore elk to southern Illinois? The use of existing digital land-cover data to evaluate potential habitat. *Wildl. Soc. Bull.* 25, 886-894.
- Verlinden, A. and Gavor, I.K.N. (1998) Satellite tracking of elephants in northern Botswana. *Afr. J. Ecol.* 36, 105-116.
- Waithman, J.D., Sweitzer, R.A., vanVuren, D., Drew, J.D., Brinkhaus, A.J. and Gardner, I.A. (1999) Range expansion, population sizes, and management of wild pigs in California. *J. Wildl. Manag.* 63, 298-308.
- Waller, J.S. and Mace, R.D. (1997) Grizzly bear habitat selection in the Swan Mountains, Montana. *J. Wildl. Manag.*, 61, 1032- 1039.
- Walpole, M.J. and Bett, P. (1999) An apparent decline in the Masai Mara black rhino population. *Pachyderm* 26, 123.
- Yonzon, P.B. and Hunter, M.L. (1991) Conservation of the red panda (*Ailurus fulgens*). *Biol. Conserv.* 57, 1-11.

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# Projects of the Human-Elephant Conflict Taskforce (HETF) - Results and Recommendations

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## HISTORY OF THE HETF

In 1996 the AfESG decided it needed to become fully involved in HEC issues and so in 1997 officially inaugurated a five person Human-Elephant Conflict Taskforce (HETF). A first phase of activities was launched in 1997 and carried out on a voluntary basis:

- An inventory of Human-Elephant Conflict (HEC) sites throughout Africa was compiled;
- A bibliography on HEC-related literature was compiled;
- Priority topics for further investigation of human-elephant conflict were identified;
- Terms of reference for the HETF were drawn up and approved at a full AfESG meeting.

At the end of Phase 1 a proposal was developed for Phase 2. The proposal was entitled "Assessing the problems and investigating the prospects of mitigating human-elephant conflict in Africa". The project obtained funding from WWF and Phase 2 involved employing consultants through IUCN to investigate the priority topics. This report briefly outlines the activities and outputs of Phase 2 in 1998 and 1999.

During Phase 2 the HETF continued to evolve around three activities which are within its terms of reference:

- linking people with an interest in and co-ordinating activities with respect to HEC,
- fulfilling a catalytic role in getting HEC related studies underway,
- providing technical advice and expertise to elephant range state governments.

## CURRENT RESEARCH TOPICS

Eight studies in three categories were completed by ten consultants during the second phase of the project (June 1998 - December 1999).

Under the category heading "*Determination of significant factors in HEC*" these included:

1. The social dimensions of HEC in Africa, with special regard to an assessment of the relative importance of elephants in the spectrum of economically and socially important pest species in rural agricultural situations (Lisa Naughton, Robert Rose and Adrian Treves);
2. A survey of elephant damage in the Dzanga-Sangha area of Central African Republic (Andrea Turkalo and Ami Kamiss);
3. A crop damage survey (combined with an elephant census and assessment of seasonal elephant movements) in the Bia National Park region of Ghana/Côte d'Ivoire (Moses Kofi Sam);
4. An assessment of evidence supporting the existence and local importance of individual elephants which appear to be "habitual problem animals" (Richard Hoare).

Under the category heading "*Spatial analysis of HEC*" the following three studies were completed:

5. An assessment of the suitability of a single data collection and analysis protocol to a range of HEC sites (Richard Hoare);
6. The development of a training package for people who have no research experience, to gather AED-compatible data on HEC sites (Richard Hoare);
7. A GIS model to assess the relative importance and interaction of spatial, temporal and other factors in predicting HEC (Bob Smith and Sam Kasiski).

Under the category heading "*Control of problem elephants*" one study was completed:

8. Reviewing official existing policy options for problem elephant control measures in southern African countries and providing recommendations for directing all interested parties towards various elephant management options (Russell Taylor).

## **SUMMARY OF GENERAL FINDINGS**

The current set of projects greatly increased our understanding of critical aspects of human-elephant conflict and improved the chances of providing effective advice on its mitigation. Specifically the following were achieved:

### **Determination of significant factors in human-elephant conflict**

- Levels of elephant damage in subsistence agricultural communities were placed much more in context with losses from other pest species.
- The factors which make rural peoples' attitudes to elephants so hostile were identified.
- An improved understanding was gained of human-elephant conflict dynamics in the forest elephant range.
- The idea of a problem elephant sub-population was proposed and evidence for its social ecology was presented.

### **Spatial analysis of human-elephant conflict**

- The usefulness of standardizing data collection and analysis in the study of human-elephant conflict was confirmed and a standard protocol was developed to assist local-level conflict management.
- The potential for GIS to store, analyse and present data on human-elephant conflict was made evident and its vital future role in the study of the subject was confirmed.

### **Control of problem elephants**

- Policy vacuums on how countries officially deal with problem elephants were identified.
- Principles of how to approach the management of problem elephants were formulated.

## **SYNTHESIS OF THE FINDINGS**

### **Perceived and actual elephant damage**

As we now know from the study of tolerance to pests, elephants attract disproportionate levels of

complaint - i.e. the perceived elephant problem often bears little relationship to the actual problem. Elephant raids are localized and unpredictable, frequently causing more damage per raid than damage from other pests. Costs of elephant raids are therefore borne individually by a few people in a community - i.e. risk is individualized. In most range states elephants tend to be perceived as a significant pest at the local level but at a larger scale (e.g. at national level) the level of threat is demonstrably insignificant. At broader spatial scales, rodents, primates and suids cause far greater agricultural losses than elephants. The potentially severe impact of problem elephants is what often shapes the attitudes of neighbouring communities to the protected areas (and often to other wildlife). This 'social dimension' of elephant problems must be regarded as very important (Table 1).

### **Conflict dynamics in the forest elephant range**

Human-elephant conflict in African forest ecosystems has not been as widely researched as in the savannas. From the available information and literature we have begun to suspect that human-elephant conflict in forests is not as severe as in savannas. Increasing distance of cultivation from villages and the presence of secondary forest surrounding farms were identified as important factors contributing to human-elephant conflict. Fields far from villages are seldom guarded effectively while secondary forest is the preferred habitat of elephants.

It would, however, appear that contact between forest elephants and cultivated plots is more 'incidental' than in savannas, where elephants seem to display far more 'intent' in their raiding movements. This would fit with the differences in the respective physical environments: forest farms are islands in a matrix of natural forest acting as a reservoir of elephants whereas in savannas smaller elephant refuges more usually occur in a matrix of land transformed for agriculture.

As a most interesting follow-on, it seems anything which alters forest elephant distribution (e.g. logging disturbance, poaching threat, chang-

**Table 1.** Factors influencing local tolerance to wildlife pests (those applicable to elephants are in bold).

<<<TOLERANCE		INTOLERANCE>>>	
SOCIO-ECONOMIC FACTORS			
Abundant	Land availability		Scarce
Abundant, inexpensive	Labour availability		Rare, expensive
Low	Capital and labour investment		High
Various	Alternate income sources		None
Varied, unregulated	Strategies for coping		Narrow, regulated
Small	Size of discussion group		Large
<b>Subsistence</b>	Type of crop damaged		<b>Cash or famine crop</b>
Community, group	Social unit absorbing loss		<b>Individual, household</b>
Low	Potential danger of pest		<b>High</b>
High	Game value of pest		<b>Low</b>
ECOLOGICAL FACTORS			
Small	Pest size		<b>Large</b>
Early	Raid timing relative to harvest		<b>Late</b>
Solitary	Pest group size		<b>Large</b>
Cryptic	Damage pattern		<b>Obvious</b>
Narrow, one crop	Pest's crop preference		<b>Any crop</b>
Leaves only	Crop parts damaged		<b>Fruit, tuber, grain, pith</b>
Diurnal	Circadian timing of raids		<b>Nocturnal</b>
Self-limited	Crop damage per raid		<b>Unlimited</b>
Rare	Frequency of raiding		<b>Chronic</b>
<<<TOLERANCE		INTOLERANCE>>>	

Source: Naughton, L., Rose, R. and Treves, A. (unpubl.) The social dimensions of human-elephant conflict in Africa. A report to IUCN/SSC AfESG, Gland, Switzerland, 2000.

ing water distribution, fruiting of trees) may influence the level of this incidental contact with human settlements and therefore, potentially, the number of human-elephant conflict incidents. There is some evidence emerging, for instance, of a link between logging disturbance in forests and increased levels of human-elephant conflict incidents in cultivated gardens and plantations.

Local attitudes to wildlife authorities in forest countries are generally quite hostile and human-elephant conflict, whether perceived or actual, contributes to much of the complaint. The ability to conserve key protected areas is often so lacking in forest countries that foreign or international NGO assistance is provided on site to the Government ministry responsible. This has

led to the situation where, from the local residents' point of view, the NGO becomes the perceived management authority of the protected area. Poor relations between villagers and these NGO - assisted conservation projects, for whatever reason, compromise the objective study and mitigation of human-elephant conflict. A further problem complicating the management of human-elephant conflict in parts of central Africa is the existence of various superstitious beliefs that nocturnal elephants raiding farms can be 'transformed' people who have evil intent against the landholder.

A particularly disturbing development at the present time is evidence for the use of human-elephant conflict as a pretext for elephant poaching in the forest range. It is well known that logging and wildlife poaching activities in forests can be closely linked. Co-operation between the HETF and the CTES 'Monitoring of the Illegal Killing of Elephants' (MIKE) pilot project in central African forest sites has been initiated.

## **Habitual problem elephants**

The study on the existence of habitual problem elephants suggests little evidence for levels of elephant problems showing density-dependence. This means that virtually any elephant population may potentially contain a problem sub-population which authorities must expect to have to manage. Unfortunately, for a number of reasons this sub-population is very difficult to identify.

It is suspected that where problem individuals are identified and either destroyed or removed, fairly rapid 'replacement' of these problem individuals may occur. This casts doubt upon the long-term effectiveness of their destruction or removal.

## **Study methodology in human-elephant conflict**

Because of the importance of scale in both the perceived and actual level of elephant problems a hierarchical approach to data collection and analysis was proposed, so that management of

the problem can likewise be viewed from the local, intermediate and national scales. Primary data on problem elephant incidents have to be collected in the field by personnel specifically trained for this purpose. Systematic recording of these data by trained enumerators is not expensive or complicated but must be done over as much of a conflict zone as possible and for an adequate study period (minimum two, preferably three years). Local annual summaries of these data provide information on the distribution, frequency and severity of problem incidents and act as a filter for distinguishing serious from trivial cases. Options are given for ranking areas according to various criteria, e.g. (a) total numbers of elephant incursions, (b) serious incidents or (c) overall damage levels. Informed local management decisions can be made on the basis of these simple summary analyses.

All such data are geo-referenced and are therefore GIS compatible. Incident data can be supplemented with multiple layers of environmental and elephant population attributes so that more complicated analyses are possible on multiple data sets from different sites. At more sophisticated levels of analysis on multiple data sets the following should be achievable: strict delimitation of conflict zones; valid comparisons of problem severity between sites; testing of hypotheses on causal factors of conflict; production of predictor variables for conflict.

## **Official policies and the management of problem elephants**

There is a universal desire amongst African elephant range states to afford official protection to the species, even in countries where populations are not threatened. The countries of southern Africa are generally acknowledged as having fairly comprehensive policy environments in their official wildlife management sectors. Given the longstanding duration and widespread nature of complaint about problem elephants, it is surprising that this study revealed a definite lack of pro-active policy on tackling the matter and budgeting for the costs of it in six out of seven countries in that region.

In effect, problem elephant issues are often officially dealt with on an individual case-by-case basis with a strong reliance on the traditionally easy, cheap and popular methods of disturbance shooting and shooting to kill. The long-term effectiveness of this strategy, however, is now in question. There is growing recognition of shortcomings in the policy and its implementation and central government agencies are becoming more predisposed towards devolving authority and responsibility for problem elephant management to local institutions.

Managing human-elephant conflict has to be integrated with the management objectives of different elephant populations and with other practicalities of elephant management (e.g. law enforcement, effects on habitats and other wild species, policy on utilisation schemes).

## RECOMMENDATIONS

The following recommendations draw on what we have learned so far from this research and which is both new and relevant to improved elephant conservation.

### Management recommendations

- Wildlife authorities will have to manage problem elephants with a dual strategy involving both the animals and the 'public relations' associated with their presence. There are strong indications that officially centralized approaches to problem elephant management are less likely to succeed than ones where some decision making is devolved to a local level.
- A decision support system (DSS) for problem elephant management needs to be created for use by wildlife authorities. This DSS may help stimulate policy formulation (even perhaps retrospectively) in those countries which do not have relevant policies on problem animals. Any DSS must specifically state its scale of application (e.g. incident

level, village level, community level, district level, regional level, national level).

- It may be better to pursue the longer term policy options of managing the problem elephant element of a population *in situ* (e.g. by land use planning, community conservation initiatives, fencing) rather than destroy a valuable resource (by frequently killing selected animals) or risk exporting the problem to another site (e.g. through translocation of individual animals).

### Research recommendations

- The standardized data collection protocol should be simultaneously tested in a representative sample of human-elephant conflict sites in both the savanna and forest elephant range. The sample should include suspected high, medium and low intensity conflict sites from a range of countries with different wildlife policies and varying degrees of external support for conservation projects.
- Data from these human-elephant conflict sample sites should be input into a Geographic Information System and be processed through a range of relevant analyses in order to: compare problem severity between sites; test hypotheses on causal factors of conflict; produce predictor variables for conflict.
- In the forest range where information on elephants is especially hard to collect, conservation efforts for the species would benefit greatly from linking together data collection and analysis on numbers, distribution, illegal offtake and human-elephant conflict incidents.
- More research is required on the community-level response to human-elephant conflict including for example the following: the collective management of risk; how benefit distribution in community-based natural resource management can be linked to elephant problems.

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# Iodine as a Possible Controlling Nutrient for Elephant Populations

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## ABSTRACT

The geography and physiology of iodine deficiency in humans and domestic ungulates suggests that the nutritional content of ground water may hold a key to humane and efficient management of population sizes of elephants. Artificial bore water in dry climates in southern Africa appears to be, on average, a good supplement of this easily leached element, and may have inadvertently boosted the reproductive rates of elephants in several conservation areas. The largest land mammals are likely to be limited by deficiency of iodine, inasmuch as their plant foods are deficient in this element relative to the hormonal requirements associated with exceptional brain size and relatively great thyroid size. Extrapolation from domestic ecosystems suggests that elephants exceed medium-sized wild herbivores in the sensitivity of their reproductive rates to subclinical deficiency of iodine, partly because the rate of loss of iodine from the body is likely to be hyperallometric to those of energy, protein, and water, with increasing body size. Elephants pass food and water rapidly for their body size, but this allows maximal intakes of iodine, which can potentially be further supplemented by absorption through the skin. The great variation in concentrations of iodine between adjacent aquifers suggests a versatile approach to population control. Closure of iodine-rich bore holes in overpopulated areas may reduce rates of sexual maturation, conception, birth, and weaning, with minimum artificial distress to adults or surviving juvenile elephants. Conversely, selection of the bore waters richest in iodine may help to promote population growth in areas recently restocked with elephants. All proboscideans became extinct in the Americas and temperate Eurasia at the end of the Pleistocene, when glacial melting had profoundly depleted iodine, and humans had the means to monopolize the remaining sources of supplementary iodine. The maximal intelligence and fecundity of those megaherbivores which have survived the era of domestication may have made these species depend on supplementation of iodine.

## RESUME

La géographie et la physiologie de la déficience en iode chez les humains et les ongulés domestiques suggère que le contenu nutritionnel de la nappe phréatique puisse détenir la clé d'une gestion humaine et efficace de la taille des populations d'éléphants. L'eau de forages artificiels dans les climats secs d'Afrique australe semble apporter en moyenne un complément conséquent de cet élément facilement éliminé par filtration. Elle est susceptible d'avoir fait augmenter par inadvertance les taux de reproduction des éléphants dans plusieurs zones de protection. Il est probable que les plus grands mammifères terrestres seraient limités par une déficience en iode, attendu que leurs aliments végétaux ne peuvent couvrir les besoins hormonaux associés à une taille de cerveau exceptionnelle et une taille de thyroïde relativement grande. Une extrapolation à partir de systèmes domestiques suggère que les taux de reproduction sont plus sensibles à une déficience en iode en dessous du seuil clinique chez les éléphants que chez les herbivores sauvages de taille moyenne ; ceci est en partie dû au fait que le taux d'élimination de l'iode du corps est susceptible d'être hyperallométrique par rapport

à celui de l'énergie, des protéines et de l'eau lorsque la taille corporelle augmente. Les éléphants évacuent les aliments et l'eau rapidement pour leur taille corporelle, mais ceci permet une consommation d'iode maximale, qui peut être encore complétée par une absorption à travers la peau. Les grandes variations des concentrations en iode entre des aquifères adjacents suggèrent une approche versatile du contrôle des populations. La condamnation de forages riches en iode dans les régions surpeuplées pourrait réduire les taux de maturité sexuelle, de conception, naissances et sevrage avec un impact minimum sur les adultes ou les jeunes éléphants survivants. Inversement, la sélection des forages riches en iode pourrait aider à encourager la croissance de la population dans les régions où des éléphants ont récemment été réintroduits. Tous les proboscidiens se sont éteints sur le continent américain et en Eurasie tempérée à la fin du Pléistocène, lorsque la fonte des glaciers avait largement réduit la quantité d'iode et que les humains avaient les moyens de monopoliser les sources complémentaires d'iode restantes. L'intelligence maximale et la fécondité des méga herbivores qui ont survécu à l'ère de la domestication pourraient avoir rendu ces espèces dépendantes de la fourniture en iode.

## INTRODUCTION

There is an urgent need for humane methods of population control for elephants. Populations of the African elephant, *Loxodonta africana* (Blumenbach, 1797) have increased rapidly in southern Africa, despite their artificial confinement to conservation areas. Public sentiment for elephants is partly based on a perception that, like whales, they are among the most intelligent of animals, with relative brain size exceeding those of all other ungulates (Quiring, 1950; Bauchot, 1978). Elephants share the longevity, measured reproduction, social bonds, dexterity and tool use, management of food resources, potential destructiveness of vegetation, and mining activities which characterize humans. Elephants also have a striking affinity with water, and are able to swim farther than any other land mammals (Johnson, 1980).

Elephants reproduce and grow far more slowly than do like-size whales, suggesting that the poor quality of plants as food limits the maximum body sizes of animals on land. Further suggesting nutritional constraints are the extreme behaviours of elephants foraging for inorganic nutrients: excavation of large caves (Bowell et al., 1996), digging of seepage pits in preference to drinking adjacent running water (Spinage, 1994), and conversion of large termittaria to concave wallows (K.L. Tinley, pers. comm., 1999). I suggest that a critical nutrient is

iodine, of proven importance in domestic, but neglected in wild, ecosystems (Milewski, 1999). This is based on my integration of the medical and veterinary literature, in relation to several paradoxes of elephant anatomy and behaviour.

## EFFECTS OF DEFICIENCY OF IODINE ON MAMMALIAN REPRODUCTION

Among the many nutrients with their complex interactions, iodine most closely approaches the status of a metabolic megacatalyst (Milewski and Diamond, in press). Iodine is essential to mammals in quantities great enough to produce frequent deficiency in herbivores. It is needed by plants in negligible quantities, and has never been shown to be deficient for plant physiological functions (Shkolnik, 1984).

## Iodine, the neglected nutrient in wildlife ecology

Iodine incorporated in thyroid hormones has control over exceptionally many enzyme reactions in the mammal body (Underwood, 1981, Hetzel and Maberly, 1986, McDowell, 1992). Iodine is the only nutrient used mainly in an endocrine gland and its hormones. It has the greatest concentration of any micronutrient in one organ relative to the rest of the body: more than 70% of iodine in the body is stored in non-

toxic form in the thyroid (Prasad, 1978), which has the only extracellular store of hormones contained in any endocrine gland (Lee and Knowles, 1965). It was the first micronutrient to be recognized as such, and is responsible for the first disease (goitre, *viz* increase in the mass of the thyroid which compensates to some degree for iodine deficiency) scientifically attributed to the environment rather than infection (Oliver, 1997). It has the greatest atomic mass and ionic radius among nutrients (Plant and Raiswell, 1983), yet (like chlorine and bromine), is mobile regardless of environmental pH and  $E_h$  (Plant et al., 1996). It is the only nutrient which is more concentrated in soils than in parent rocks, but not actively retrieved from the gaseous state (Plant and Raiswell, 1983; Stewart and Pharoah, 1996; Milewski and Diamond, *in press*). Of all micronutrients, it has the greatest ease in passing from blood to milk, and the greatest degree to which concentration in milk reflects maternal nutrition (Prasad, 1978; Underwood, 1981). It also has the most categorical separation of any nutrient between animals (required) and land plants (not required) (Sauchelli, 1969; Shkolnik, 1984). Despite its high rank in the nutritional hierarchy, iodine is the least frequently analyzed of all important nutrients for wild ungulates (see McNaughton, 1989).

### **Iodine as a key nutrient for brain growth**

Iodine is directly and indirectly essential for the brain, although not concentrated in this energy-demanding organ (Wayne et al., 1964; Prasad, 1978). Brain tissue has rapid metabolism, and requires thyroid hormones indirectly for maintaining its thermal homeostasis (Quiring, 1950; Sokoloff et al., 1977; Hetzel and Maberly, 1986). A reduced metabolic rate of the cells of the cerebral cortex results in prolonged reaction time, and brain function is sensitive to the supply of thyroxine, even in normal persons (Lee and Knowles, 1965; Stewart and Pharoah, 1996). However, thyroid hormones control normal brain function and development, and affect neuronal activity, even in poikilothermic vertebrates (Lee and Knowles, 1965; Stewart and Pharoah,

1996). The priority taken by the brain in ontogenetic growth means that the supply of iodine affects reproduction.

Nearly one in three humans living today is deficient in iodine, to the degree of risking retarded metabolism and reduced intelligence (WHO, 1996). There is a continual gradation of effects between sufficiency and clinical deficiency. The children of clinically deficient parents risk permanent damage to the brain, even when the parents are otherwise well-nourished (Stewart and Pharoah, 1996). The largely irreversible defects of cretinism are life-threatening even with intensive social support.

### **Iodine as a key nutrient for reproduction**

The supply of iodine affects reproductive rate, since age of sexual maturation, and frequency of oestrus, depend on hormonal sufficiency, and are, in turn, dependent on the thyroid as an integral part of the endocrine system. Thyroxine is required in relatively large quantities for the rapid metabolism and growth of mammalian offspring, which depend on the mother for iodine until weaned. Milk contains minimal thyroxine, and is rich in iodine only where maternal intake of this nutrient is ample. Human milk has a concentration of iodide 20-30-fold that in blood plasma (Wayne et al., 1964), and the daily requirement for iodine of cows successfully weaning their offspring is five-fold that of non-lactating, non-pregnant cows (Campbell, 1983). However, the quantity of iodine in cows' milk varies greatly, from being deficient for calves, to being excessive for human consumers (Hemken, 1980; Underwood, 1981; McDowell, 1992). This is because subclinically deficient cows produce milk deficient in iodine, although sufficient in energy, protein, and other nutrients. Domestic ungulates have been selectively bred for production of meat and milk, which has been possible by virtue of supplementing their supply of iodine. I suggest that, in wild ungulates, the mother takes priority in providing for her own thyroid, partly by delaying her reproductive attempts until she has access to sufficient iodine to support offspring.

Iodine is the micronutrient most frequently deficient among domestic ungulates worldwide, despite their relatively small brains (Underwood, 1981; McDowell, 1992). Mild clinical deficiency of iodine, undiagnosed in adults, produces goitre in neonates, and goitre in adults produces mortality of foetuses and neonates (Sauchelli, 1969; McDowell, 1992). My inference from a voluminous veterinary literature is that reproductive rates may be reduced by subclinical deficiency which does not necessarily produce ill-health in adult cattle and sheep. No other micronutrient appears to affect either brain function and development, or reproduction, to the degree that iodine does.

## ENVIRONMENTAL SUPPLY OF IODINE

Recent data have shown that potable ground water under dry climates in southern Africa is rich in iodine on average, even in areas of Kalahari sand (Table 1), and that concentrations vary greatly among adjacent aquifers (CSIR, 1982). This suggests that the provision of artificial bores has boosted the original availability of a valuable supplement of iodine for herbivores. In order to understand the potential power of this mode of supplementation of a megacatalyst in wildlife management, one must understand the limitations on the supply of iodine to terrestrial ecosystems in general.

Iodine nutrition is precariously balanced, because of the narrow tolerances of this potentially toxic nutrient in animal bodies, and the boosting of requirements by goitrogens and other antagonistic substances, ranging from simple elements to complex organic compounds (Stewart and Pharoah, 1996; Oliver, 1997). Slight excess of iodine (absolute or relative to other elements) may produce similar effects to its deficiency (Hetzel and Maberly, 1986). Although the thyroid stores a certain amount of iodine, this delays deficiency by only weeks or months, once daily intakes become deficient.

## Availability of iodine from plants

No data appear to be available for the concentrations of iodine in plants eaten by elephants or other herbivores in elephant habitats, or the proportions of iodine derived from soil as opposed to atmosphere. However, wild plants are likely to be a deficient source of iodine, because of the inutility of iodine for their metabolism. Land plants have no reason to translocate iodine from roots to foliage, except possibly in mutualism with their consumers (e.g. in domestication). Certain crops selectively bred as human foods are possibly among the few plants conveying iodine from soil to leaves and fruit. Because iodine is incorporated by land plants mainly from the atmosphere, partly *via* precipitation intercepted on foliage and stems (Whitehead, 1984), this element is likely to reach fibrous tissues, other than bark, in minimal concentrations. Perhaps to compensate for the inevitable passive absorption of certain amounts of iodine, many plant genera produce goitrogenic secondary chemicals, which reduce the amount or effectiveness of iodine taken up by the thyroid, thus boosting requirements for iodine several-fold in domestic herbivores (WHO, 1996; Milewski and Diamond, *in press*).

Human requirements for iodine are met mainly from non-plant sources: sea food and bovine milk (Hetzel and Maberly, 1986; WHO, 1996). Artificially iodized salt has demonstrated the potential simplicity of supplementation of iodine, but deficiency prevails in many human populations because of political factors (Stewart and Pharoah, 1996). Several species of cultivated herbaceous plants have sufficient iodine relative to goitrogens, as foods for humans (Sauchelli, 1969; Oliver, 1997). Elephants frequently risk their lives to raid human crops (Spinage, 1994), possibly because these are profitable sources of iodine compared to wild plants (Table 2). However, many species (e.g. legumes, brassicas, cassava, sorghum) remain goitrogenic even after selective breeding for

**Table 1.** Mean concentrations of iodine in potable ground waters from natural springs and artificial bore holes, under dry climates far inland but not separated from the sea by high mountains. Salt refers to total dissolved solids except where asterisked (sodium only), using sea water for comparison. Sources are CSIR (1982), McCaffrey (unpubl.), and sources cited by Milewski and Diamond (in press).

Source of water	Dissolved content	
	Iodine	Salt
	[mg/l]	[mg/l]
Sea	0.05	34,500
<b>Southern Africa:</b>		
Springbok Flats, north of Pretoria (rainfall ca 700mm/year)		
Ecca shale	0.07	<1,100*
Irrigasie shale	0.12	<3,570*
granite	<0.01	<300*
Southeast Namibia (rainfall 150-350 mm/year)		
Kalahari sand	0.10	826
quartzite	0.10	987
sandstone	0.14	1,440
gravel	0.09	530
granite	0.37	1,200
<b>Central Australia:</b>		
west and northwest of Alice Springs	0.25	1,060
border, Northern Territory/South Australia	0.05	1,090
mound springs, south and west of Lake Eyre	0.1	1,000

agriculture (Stewart and Pharoah, 1996; WHO, 1996). Partly for this reason, deficiency of iodine remains widespread in human populations which rely on plant foods, even near the coast (WHO, 1996).

**The iodine cycle**

It is time for wildlife ecologists to assess the degree to which the elusiveness of iodine on land, and its redundancy in the sea, have limited herbivory (Milewski and Diamond, in press). Analytical techniques may soon be available and affordable for an element found in extremely

small concentrations, and able to diffuse through plastic (Plant et al., 1996).

The mobility of iodine explains its continual supply and depletion at the land surface. A combination of solubility (as iodide) and volatility (as elemental iodine and methyl iodide) ensures that concentrations of iodine occur naturally only in certain situations. Iodine is easily leached, and is lost into the atmosphere once exposed to oxygen and light, and certain microbes found in acidic substrates (Whitehead, 1984). Iodine is rapidly and thoroughly absorbed by the body from food and water, but is also eas-

**Table 2.** Potential sources of iodine for elephants, showing the importance of ground water where this is available. Assumptions are that an average adult elephant of body mass 3,000 kg requires 10 mg of iodine per day, eats 30 kg/day dry matter, and drinks 30 litres/day of water. Quantity required/day is a maximum, based on iodine being supplied only by the substance in question. Real quantities required would be less than the stated values, in proportion to the contributions of various substances via oral consumption, and potentially also percutaneous absorption.

Substance	Iodine [mg/kg]	Quantity required/day	Comment
<b>Organic matter (dry state):</b>			
Cultivated herbaceous leaves	0.3	20 kg	incurs risk
Goitrogenic wild leaves	0.2	>60 kg	requires suppl.
Seaweed	500	12 g	ample
Marine organic sediment	50	120 g	inaccessible
<b>Rocks and soils:</b>			
Volcanic rock	0.1	60 kg	impossible
Shale	5	1.2 kg	impracticable
Sandstone	0.1	60 kg	impossible
Selected soil	8	0.75 kg	possible
Salt crust in volcanic cave	1,000	6 g	ample
<b>Waters:</b>			
Sea water	0.05	120 l	too saline
River/ground water in moist areas	0.003	2,000 l	impossible
Melted snow	0.002	3,000 l	impossible
Ground water in dry areas	0.1	60 l	possible

ily lost in urine (Wayne et al., 1964; Prasad, 1978; Stewart and Pharoah, 1996).

areas last glaciated thousands of years ago (Hetzel and Maberly, 1986).

The main supply of iodine to terrestrial ecosystems is atmospheric, decreasing with distance from the coast, and with altitude (Whitehead, 1984; Stewart and Pharoah, 1996). Gaseous and aerosol iodine are deposited in rain, but rapidly drained back to the sea (Whitehead, 1984). Iodine deficiency is widespread among humans living in mountains and along floodplains of major rivers. The melting of glaciers can thus deplete iodine profoundly across whole landscapes, as indicated by modern deficiency in

Iodine is potentially enriched on land relative to sodium chloride, because iodine is exceptionally volatile at the sea surface, and aerosol is fractionated in favour of iodine (Whitehead, 1984). Iodine accumulates in soil organic matter, perhaps by virtue of its uninvestigated use as a nutrient by fungi, as much as from its passive uptake by plant roots. However, iodine incorporated in humus is exposed, like nitrogen, to depletion by fire. Iodine is not known to be replenished by microbes such as those which

actively concentrate atmospheric nitrogen (Oliver, 1997).

Although the cycling of iodine is imperfectly known, several anomalies may be explained by the hypothetical supply of this element to continental interiors by repeated volatilization of iodine from the land surface (Fuge, 1996). Salinas (e.g. Kalahari pans) accumulate sodium chloride of ultimately marine origin, but the accompanying iodine tends to accumulate in subsurface brine toxic to herbivores. Concentrations of iodine found recently in potable ground water in the dry interiors of southern Africa and Australia (see Table 1) appear to have no precedence in well-studied North America. This reflects the blockage of iodine from sea air from reaching the dry interiors of Asia and the Americas, by mountain barriers (Fuge, 1996). Iodine tends to accumulate in alkaline earths, because of its conversion to iodate, which does not easily volatilize (Whitehead, 1984; Fuge, 1996). The apparent tendency for limestone areas to be deficient in iodine (Edmunds and Smedley, 1996; Fuge, 1996) may be a result of poor volatilization from the ground surface, hence poor absorption from the atmosphere by plants (R.Fuge, pers. comm., 2000). However, iodate is available in natural mineral licks, possibly explaining much of the geophagia (earth-eating) observed in elephants and other herbivores (Bowell and Ansah, 1994).

### **The nutritional value of ground water**

The greatest concentration of iodine relative to salts in ground water appears to have been achieved in those dry areas receiving considerable input of gaseous iodine. Potable ground water in most of Namibia contains on average double the concentration of iodine, at less than 5% of the concentration of salt, found in sea water (CSIR, 1982), including areas far too far inland to receive marine aerosol (see Table 1). This suggests that ground water over a wide area of the interior of southern Africa may contain an average of 0.1 mg/l of iodide, equivalent to the sufficient concentrations in milk, and the dry

plant matter eaten by non-lactating cattle (Underwood, 1981; WHO, 1996). Under modern conditions, the ubiquity of artificial bores may allow ungulates in dry areas routinely to obtain as much iodine from drinking water as from food (see Table 2). Ground water may be as valuable a supplement of iodine inland as seaweed is at the coast (Underwood, 1981; Whitehead, 1984). It is unknown whether natural springs far inland produce iodine-rich water for native herbivores, or whether elephants utilize iodine-rich springs.

### **ARE EXTREMELY LARGE MAMMALS PRONE TO DEFICIENCY OF IODINE?**

Although the scaling of nutrient requirements with body size has been neglected in wildlife ecology, one study of domestic herbivores suggests that a widening disparity between micronutrients, including iodine, and other food resources may arise with increasing body mass (Milewski and Diamond, in press). Use of energy, protein and water all scale to the logarithmic exponent of ca 0.75 when daily total requirements of the body are plotted against adult body mass among species of mammalian herbivores (Calder, 1984). Requirements for iodine are poorly known for wild ungulates, and unknown for any species larger than cattle. However, food intake and thyroid size indicate that nutritional allometry affects the requirements for iodine by the largest species.

Rate of consumption of food relative to body mass decreases four-fold with increasing body mass of ungulates (Owen-Smith, 1988). The proportion of the diet consisting of fibre also increases with increasing body size, because even the elephant trunk is less efficient than small mouthparts in selecting the smallest, least ligneous part of plants. Large herbivores compensate partly by releasing energy from cellulose to a degree thermodynamically uneconomical for even those small herbivores with elaborate fermentation chambers in their guts (Owen-Smith, 1988). However, I suggest that elephants risk iodine deficiency if they do not supplement

the limited quantity and quality of plant matter they eat, with respect to this element.

Scaling of thyroid mass (Quiring, 1938; Calder, 1984) and requirements for iodine (Smith, 1980, 1981) among herbivores follow an allometric exponent of ca 0.9, exceeding those of other metabolic organs (adrenal, liver) as well as those of metabolism and food intake. Brain and thyroid mass are relatively great in elephants, despite their relatively low body temperature (Quiring, 1950). Based on available data, the thyroid mass of the African elephant is double that predicted for a herbivore of its body mass (Milewski and Diamond, in press).

## **The biogeography of proboscideans in relation to iodine**

Any allometric tendency for iodine to be most deficient in the largest herbivores would be critical, because of regimes of predation by modern humans. It is anomalous that elephants survive only on two continents, in view of their wide distribution only 10,000 years ago. Climate changes, and extermination by humans, are only partial, and proximate, explanations of their sudden disappearance in the Americas and temperate Eurasia, in view of the survival of proboscideans through several previous glacial cycles, and through the era of domestication in Africa and parts of Asia. I suggest that an ultimate explanation is nutritional: megaherbivores in periglacial areas had a precarious iodine sufficiency, which failed at the end of the last Ice Age with the combination of widespread melting and leaching, and competition for the remaining sources of iodine with predatory and technologically advanced humans. The affinity of proboscideans for islands, on which they have been among the most successful of mammalian colonizers (Johnson, 1980), is consistent with the importance of iodine. Most of the Americas is likely to be relatively poor in iodine, because the Rockies and Andes are not only deficient, but have isolated the dry interiors (e.g. Great Basin desert, Sonoran desert, Monte desert) from atmospheric iodine (see Whitehead, 1984). Furthermore, both the mountains and most areas above latitude 35

degrees (north and south) were glaciated in the Pleistocene. Most of low-altitude North and South America is drained by rivers arising in mountain snows, and tropical South America is additionally leached by heavy rainfall.

When humans developed the tools routinely to kill healthy adults of even the largest species of elephantids, only species with maximal fecundity and maximal intelligence survived. Many species of megaherbivores (e.g. ground sloths) with both small brains and slow reproduction had survived natural predation, but were hunted to extinction by humans at the start of the Holocene (Milewski and Diamond, in press). If extant elephants exceed extinct proboscideans in relative brain (and thyroid) size in response to selective pressure by human predation, the cost in terms of iodine may be unaffordable in many environments.

I suggest that southern Africa provided a particularly suitable environment for elephants, because of its topography and freedom from past glaciation. The African plateau is uplifted and dissected enough to produce leakage of ancient ground water at the surface, without having mountains high enough to block the atmospheric supply of iodine. Before the advent of artificial bore holes, herbivores far from the sea depended on scattered patches of earth impregnated with iodate, and possibly natural springs and termitaria. Thus, original populations of elephants may have been sparser, reproducing at lesser rates, than those in several conservation areas in southern Africa today.

## **SUPPLEMENTATION OF IODINE BY ELEPHANTS**

I hypothesize that elephants rely on three concurrent pathways of intake of iodine:

- 1) rapid consumption of plants, favouring species and plant parts with maximum ratios of concentration of iodine to goitrogens,
- 2) routine oral consumption of inorganic supplements, by geophagia and drinking of mineralized water, and
- 3) absorption of iodine through the complex

skin, by wallowing, bathing, and spreading dust on the wet body.

## **Evidence of iodine in geophagia by elephants**

Geophagia appears to be normal behaviour of elephants in most of their habitats (Sikes, 1971; Hanks, 1979; Spinage, 1994). Generations of elephants have excavated large caves on volcanic slopes in East Africa, by consuming salt crusts precipitated by seepage of ground water on rocks within, where the iodine content is protected from light and heat. The concentration of iodine attained (ca. 1,140 mg/kg, *Bowell et al.*, 1996) in this supplement rivals that in seaweed (*Whitehead*, 1984), and is more than 100-fold the mean concentrations of iodine in the richest rocks or soils (*Milewski and Diamond*, in press). Water rich in iodine outside the caves is contaminated with fluoride, which becomes less concentrated as iodine becomes more concentrated, in the formation of salt crusts in the caves (*Bowell et al.* 1996).

Although megaherbivores may depend to an extreme degree on iodine extraneous to their food, even medium-size herbivores may show geophagia for this nutrient as much as for any other. Neglect of iodine in the many published analyses of mineral licks may help to explain the generally inconsistent compositions of earths eaten, and the emphasis, partly by default, on sodium in the literature (e.g. *Weir*, 1972; *Jones and Hanson*, 1985).

## **Drinking of iodized water by elephants**

Where iodized ground water is available, drinking is likely to be as efficient a means of supplementing iodine as is geophagia, because of the relative quantities which can be consumed. For example, ground water in the area where elephants utilize large caves (*Bowell et al.*, 1996) is at least 50-fold richer in iodine than the worldwide average for ground water (*Edmunds and Smedley*, 1996), despite the poverty of basalt for iodine. Iodine is concentrated a fur-

ther ten-fold in water percolating into the caves to evaporate (forming the iodine-rich salt crust eaten by elephants here), and up to 100-fold in the saline pore waters of surface soils also utilized for geophagia in the general vicinity of the caves (*Bowell et al.*, 1996). At this location, even non-saline surface pools have concentrations of iodine exceeding those of sea water ca. ten-fold, suggesting an additional potential for supplementation of iodine by immersion of the body.

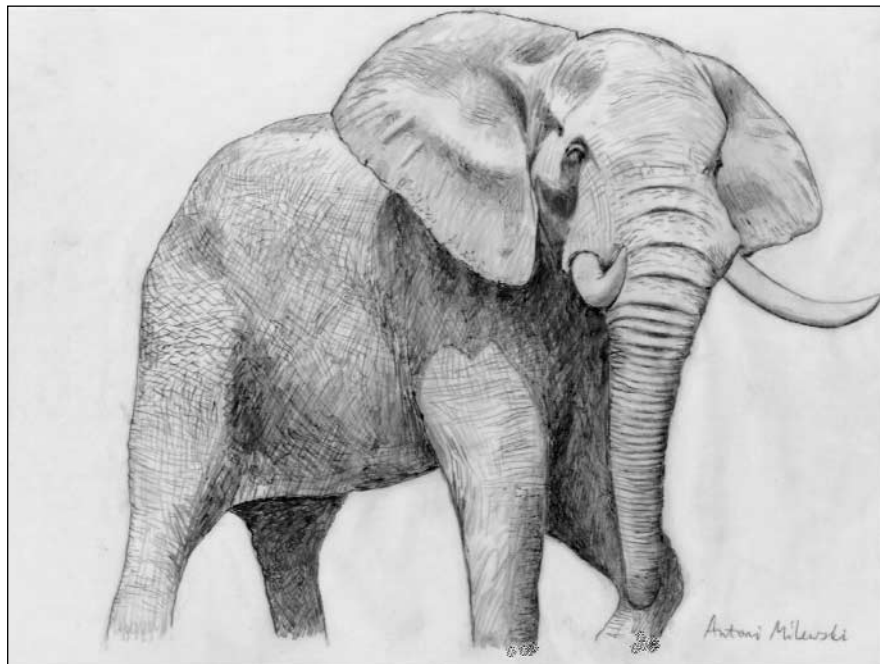
## **Percutaneous absorption of iodine by elephants**

The complex skin of the African elephant contrasts with its simple gut, and is potentially an organ of nutrition as well as thermoregulation. Although wallowing has usually been assumed to control ectoparasites, it is paradoxical that the elephant skin is so complicated as to provide refuge for parasites, and so well vascularized and enervated that elephants are vulnerable to mosquitoes, and do not tolerate oxpeckers (*Maclean*, 1985; *Spinage*, 1994). Folding, wrinkling and papillation of the dermis, and the sizes of ears, trunk, tail, and genital organs, compensate for the allometric reduction of the ratio of surface area to body mass which accompanies increasing body size (*Calder*, 1984). Percutaneous absorption has an advantage over drinking, in reducing the inevitable margin of loss of iodine in urine, and possibly excluding fluorine.

Iodine in topically applied iodophor disinfectants is proven to diffuse rapidly through the intact epidermis into the blood, increasing the supply of iodine to thyroid and milk of domestic ungulates (*Hemken*, 1980). In human infants, this inadvertent supplementation is sometimes so great as to be toxic (*Cohen*, 1996). Iodide is known to diffuse slowly through micropores in wet skin (*Milewski and Diamond*, in press), which may be significant relative to oral consumption where pools are too saline or contaminated to be potable. However, I suggest that conversion of iodate (likely to be available in surface mud) to methyl iodide (volatile enough to

penetrate skin), is promoted by microbes harboured in the acidic microenvironment of skin folds, based on processes known to occur in soils (see Whitehead, 1984).

way of controlling reproductive rates of elephants without affecting smaller herbivores to the same degree. Available data suggest that adjacent bore holes may have iodine concentra-



### Nutrient control as a means of population control?

Populations of apparently healthy elephants are flexible in their reproductive rates (2-7% per year), partly because elephants exceed medium-size herbivores in the variation of age at onset of sexual maturity, and of intervals between pregnancies (see Owen-Smith, 1988; Whyte et al., 1998). If reproductive rates reflect the supply of key resources as I hypothesize, population increases may be minimized by enforcing sub-clinical deficiency of iodine, at levels calculated to ensure minimum distress in adults and offspring. Conversely, where elephants have been recently reintroduced, or the habitat is deficient in iodine, managers may find that artificial supplementation with iodine boosts reproduction. Populations can possibly be maintained static in the long-term at reproductive rates of ca. 3% per year, balanced by episodic natural mortality on an acceptable scale. The water supply offers a

tions ten-fold different (CSIR, 1982), potentially allowing the deliberate reduction or increase of the supply of iodine to elephants, by the appropriate selection of water points.

The literature on iodine deficiency in humans and cattle differs in emphasis, and in neither case quantifies effects on reproductive rates directly. The best-known effects of iodine deficiency are on development and function of the brain in humans, and on the viability of offspring in cattle selectively bred for fecundity and rapid growth. Human culture may obscure the biological effect of iodine deficiency on human reproductive rates, whereas the relative decephalization of cattle may reduce effects on bovine intelligence.

In Hwange National Park in Zimbabwe, the combination of sandy soils and dry climate suggests that ground water has been a critical resource for wildlife, and elephants here are

known for their attraction to sodium-rich earths and bore waters (Weir, 1972). At both Addo and Knysna in South Africa, small populations of elephants were spared a half-century ago, followed by opposite reproductive trends after effectively being cut off from the coast. In Addo National Park, the dry climate and brackish ground water suggest that bore hole establishment provided a critical supply of iodine at the time the population was confined by fencing.

## **RECOMMENDATIONS FOR FURTHER RESEARCH**

The remarkable frequency and impact of iodine deficiency in humans and cattle indicates the potential importance of iodine deficiency in elephants, which are highly encephalized, and apparently reproduce as rapidly as is possible for land animals of their body size. The possible allometric divergence between iodine and other nutritional factors, and the extreme selective pressure on megaherbivores at the end of the Pleistocene, add to the likelihood that iodine is a controlling nutrient for populations of the largest herbivores. However, this proposal remains mainly circumstantial until tested.

Basic surveys are required: of concentrations of iodine in waters, earths, and muds utilized for drinking, bathing and wallowing; of concentrations of iodine and goitrogens in woody plants and bark; and of relative brain and thyroid sizes of extinct proboscideans. Experiments need to be performed: on preference for iodine-rich water sources; on passage of iodine from mud, through skin, into blood; and on the long-term effect of subclinical deficiency on reproductive rate. Assumptions should be tested: of the greater incidence of surface sources of iodine inland in Africa and India than elsewhere; of relatively great requirements for iodine by the large thyroids of elephants; and of the greater requirements for iodine by extant than by extinct species of proboscideans. The following are suggested research topics in this context:

- Verification of the concentration of iodine in

bore water artificially provided in conservation areas.

- Quantification of the contributions of bore holes, natural mineral licks, and natural springs in parts of northern Botswana where elephant populations have increased rapidly in the last two decades.
- Verification of percutaneous absorption of iodine by elephants (e.g. utilizing isotopes as markers), including whether micropores enhance capillarity and diffusion of iodide, and whether microbial symbioses in skin folds enhance generation of methyl iodide and other volatile forms of iodine.
- Quantification of the mass-balance of iodine in the elephant body, by characterization of thyroid mass according to sex and age, concentration of iodine in the thyroid, and rates of loss of iodine in urine and faeces (see Mahaney and Hancock, 1990).
- Investigation of the incidence of goitre in relation to iodine supply, in captive populations of elephants.
- Evaluation of the availability of iodine from various tissues of woody plants, by analysis of concentrations (including bark and shed leaves), and quantification of the incidence and effects of goitrogens, e.g. cyanogenic glycosides.
- Quantitative analysis of the effects of subclinical deficiency of iodine in reducing rates of oestrus, ovulation, conception, pregnancy, birth, lactation, and weaning in elephants, in comparison to other ungulates including equids.
- Experimentation on the effects of supplemental iodine in triggering musth in male elephants.
- Preference by elephants for water rich in iodine over water poor in iodine, when presented with a choice of drinking waters in captive and free-range situations.
- Comparison of cranial volumes of extinct and extant species of proboscideans, to test the possible increase of brain sizes relative to body sizes in response to increased predation pressure from humans in the late Pleistocene.

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## REFERENCES

- Bauchot, R. (1978) Encephalization in vertebrates. *Brain, Behav. and Evol.* 15, 1-18.
- Bowell, R.J. and Ansah, R.K. (1994) Mineral status of soils and forage in the Mole National Park, Ghana, and implications for wildlife nutrition. *Environ. Geochem. Health* 16(2), 41-58.
- Bowell, R.J., Warren, A. and Redmond, I. (1996) Formation of cave salts and utilization by elephants in the Mount Elgon region, Kenya. In: *Environmental geochemistry and health with special reference to developing countries* (Ed. J.D. Appleton, R. Fuge and G.J.H. McCall). Geological Society of London Special Publication no. 113, pp. 63-80.
- Calder, W.A. (1984) *Size, function and life history*. Harvard University Press, Cambridge, Massachusetts.
- Campbell, E.A. (1983). Animal health in Australia, vol. 3: *Nutritional deficiencies and diseases of livestock*. Australian Bureau of Animal Health.
- Cohen, B.A. (1996) Pediatric dermatology. In: *Cutaneous medicine and surgery: an integrated program in dermatology*, vol. 2 (Ed. K.A. Arndt, P.E. Le Boit, J.K. Robinson and B.U. Wintroub), chapter 184. W.B. Saunders, Philadelphia, pp. 1889-1899.
- CSIR (1982) 'n Waterkwaliteitskaart van die ondergrondse waters in Suidwes-Afrika, met spesifieke verwysing na die benuttingswaarde van die water. Regional Lab., National Institute for Water Research, Council for Scientific & Industrial Research, Windhoek.
- Edmunds, W.M. and Smedley, P.L. (1996). *Groundwater geochemistry and health: an overview*. In: *Environmental geochemistry and health with special reference to developing countries* (Ed. J.D. Appleton, R. Fuge and G.J.H. McCall). Geological Society of London Special Publication no. 113, pp. 91-106.
- Fuge, R. (1996) Geochemistry of iodine in relation to iodine deficiency diseases. In: *Environmental geochemistry and health with special reference to developing countries* (Ed. J.D. Appleton, R. Fuge and G.J.H. McCall). Geological Society of London Special Publication no. 113, pp. 201-212.
- Hanks, J. (1979) *A struggle for survival: the elephant problem*. Struik, Cape Town.
- Hemken, R.W. (1980) Milk and meat iodine content: relation to human health. *J. Am. Vet. Med. Ass.* 176 (10), 1119-1121.
- Hetzel, B.S. and Maberly, G.F. (1986). Iodine. In: *Trace elements in human and animal nutrition*, vol. 2 (Ed. W. Mertz). Academic Press, Orlando, pp. 139-208.
- Johnson, D.L. (1980) Problems in the land vertebrate zoogeography of certain islands and the swimming powers of elephants. *J. Biogeog.* 7, 383-398.
- Jones, R.L. and Hanson, H.C. (1985) *Mineral licks, geophagy and biogeochemistry of North American ungulates*. Iowa State University Press, Ames, Iowa.
- Lee, J. and Knowles, F.G.W. (1965) *Animal hormones*. Hutchinson University Library, London.
- Maclean, G.L. (1985) *Roberts' birds of southern Africa*. The Trustees of the John Voelcker Bird Book Fund, Cape Town.
- Mahaney, W.C. and Hancock, R.G.V. (1990) Geochemical analysis of African buffalo geophagic sites and dung on Mount Kenya, East Africa. *Mammalia* 54, 25-32.
- McCaffrey, L.P. (unpubl.) Distribution and causes of high fluoride groundwater in the western Bushveld area of South Africa. PhD Thesis, 1998. University of Cape Town.
- McDowell, L.R. (1992) *Minerals in animal and human nutrition*. Academic Press, San Diego.
- McNaughton, S.J. (1989) Interaction of plants of the field layer with large herbivores. Zoological Symposium no. 61. *Zool. Soc.*

- Lond. pp. 17-29.
- Milewski, A.V. (1999) Iodine as an important nutrient for elephants. *Newsletter of the Zoo Nutrition Center of the Wildlife Conservation Society* (New York) 9, 2-3.
- Milewski, A.V. and Diamond, R.E. (in press) Why are very large mammals absent from Australia? A new hypothesis of micronutrients. *J. Biogeog.*
- Oliver, M.A. (1997) Soil and human health: a review. *Eur. J. Soil Sc.* 48, 573-592.
- Owen-Smith, N. (1988) *Megaherbivores: the influence of very large body size on ecology*. Cambridge University Press, Cambridge.
- Plant, J.A. and Raiswell, R. (1983) Principles of environmental geochemistry. In: *Applied environmental geochemistry* (Ed. I. Thornton). Academic Press, London, pp. 1-39.
- Plant, J.A., Baldock, J.W. and Smith, B. (1996) The role of geochemistry in environmental and epidemiological studies in developing countries: a review. In: *Environmental geochemistry and health with special reference to developing countries* (Ed. J. D. Appleton, R. Fuge and G. J. H. McCall). Geological Society of London Special Publication no. 113, pp. 7-22.
- Prasad, A.S. (1978) *Trace elements and iron in human metabolism*. Plenum Medical Book Co., New York.
- Quiring, D.P. (1938) A comparison of certain organ and body weights in some African ungulates and the African elephant. *Growth* 2, 335-346.
- Quiring, D.P. (1950) *Functional anatomy of the vertebrates*. McGraw-Hill, New York.
- Sauchelli, V. (1969) *Trace elements in agriculture*. Van Nostrand Reinhold, New York.
- Shkolnik, M. (1984) *Trace elements in plants*. Developments in Crop Science 6. Elsevier, Amsterdam.
- Sikes, S.K. (1971). *The natural history of the African elephant*. Weidenfeld and Nicolson, London.
- Smith, R.M. (1980) Trace element requirements. *Proc. Nutr. Soc. Aust.* 5, 36-43.
- Smith, R.M. (1981) Trace element needs of species in relation to body size. *Proceedings of the Fourth International Symposium on Trace Element Metabolism in Man and Animals*. Australian Academy of Science, Canberra, pp. 9-13.
- Sokoloff, L., Fitzgerald G.G. and Kaufmann E.E. (1977) Cerebral nutrition and energy metabolism. In: *Nutrition and the brain*, vol. 1 (Ed. R.J. Wurtman and J.J. Wurtman). Raven Press, New York, pp. 87-139.
- Spinage, C.A. (1994) *Elephants*. T. and A.D. Poyser, London.
- Stewart, A.G. and Pharoah, P.O.D. (1996) Clinical and epidemiological correlates of iodine deficiency disorders. In: *Environmental geochemistry and health with special reference to developing countries* (Ed. J.D. Appleton, R. Fuge and G.J.H. McCall). Geological Society of London Special Publication no. 113, pp. 223-230.
- Underwood, E.J. (1981) *The mineral nutrition of livestock*. 2nd ed. Commonwealth Agricultural Bureaux, Farnham Royal, England.
- Wayne, E.J., Koutras, D.A. and Alexander, W.D. (1964) *Clinical aspects of iodine metabolism*. Blackwell, Oxford.
- Weir, J.S. (1972) Spatial distribution of elephants in an African national park in relation to environmental sodium. *Oikos* 23, 1-13.
- Whitehead, D.C. (1984) The distribution and transformation of iodine in the environment. *Environ. Int.* 10, 321-339.
- WHO (1996) *Trace elements in human nutrition and health*. World Health Organization, Geneva.
- Whyte, I., van Aarde, R. and Pimm, S.L. (1998) Managing the elephants of Kruger National Park. *Anim. Conserv.* 1, 77-83.

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# Price for Rhino Horn Increases in Yemen

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## ABSTRACT

Rhino horn traders in Yemen are putting renewed pressure on Africa's rhinos. From 1985 to 1997 the price of rhino horn remained stable at around \$1,200 a kg. By early 1999 it rose to \$1,400 a kg. This price increase is due to two factors. The supply of rhino horn in Yemen has fallen because of shrinking stockpiles in the country, and very few rhino horns have been smuggled into Yemen over the last few years. In 1998 only three rhino horns are known to have been imported into Yemen, the least number probably ever recorded. The Sanaa traders are getting desperate for more rhino horns, and this trade could increase once more unless action is taken. Both the Yemen government and the international community have done virtually nothing to try to stop Yemen's rhino horn trade since 1997 when Yemen joined CITES, despite agreements of assistance to Yemen.

## RESUME

Les négociants de corne de rhinocéros du Yémen mettent à nouveau le rhino d'Afrique sous pression. Entre 1985 et 1997 le prix de la corne de rhino est resté stable autour de 1 200 \$ le kg. Mais début 1999 il était monté à 1 400 \$ le kg. Cette augmentation des prix est due à deux facteurs. Les réserves de corne de rhino au Yémen ont diminué du fait de la réduction des stocks à travers le pays, et très peu de cornes de rhino ont été passées au Yémen en contrebande ces dernières années. Pour 1998 seuls trois cas de cornes importées par contrebande sont connus, sans doute le chiffre le plus bas jamais enregistré. Les négociants Sanaa ont absolument besoin de cornes de rhino supplémentaires et ce commerce pourrait augmenter une fois de plus si aucune action n'est entreprise. Les efforts tant du gouvernement yéménite que de la communauté internationale pour essayer de stopper le commerce de corne de rhino du pays depuis que le Yémen a rejoint CITES en 1997 ont été quasiment nuls, malgré des accords d'assistance au Yémen.

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## INTRODUCTION

Until 1970 only the privileged elite could afford *jambiyas* with rhino horn handles. Then, beginning in the early 1970s, many Yemenis worked in Saudi Arabia during the oil boom years, earning much money which permitted them to buy new daggers with the revered rhino horn handles. Prices for rhino horn thus shot up in the 1970s and early 1980s. Most of eastern Africa's rhinos were poached to meet this increasing demand. Before the Gulf War of 1991, one million men of Yemen's labour force were working outside the

country (mostly in the Gulf states) sending back to Yemen over nine hundred million dollars a year. These remittances were widely distributed among the population, and demand for rhino horn daggers remained high through the 1980s in what was then the Yemen Arab Republic. After 1991 many Yemenis were sent home and remittances fell on a per capita basis, although they still account for 1.1 billion dollars a year (Central Bank of Yemen, 1998), Yemen's major source of foreign exchange. With a resultant declining economy in Yemen and a crackdown on rhino poaching in Africa, rhino horn imports into

Yemen have gradually fallen. Nevertheless, Yemen remains one of the most significant markets for rhino horn in the world.

METHODOLOGY

The authors have been visiting Sanaa’s old souk on a regular basis since 1986 to survey the rhino horn trade. Here, the major dealers in rhino horn are to be found and expensive *jambiyas* with rhino horn handles, both old and new, are sold. In mid-June 1999 a survey was conducted in the souk, the first for two years. Counts were made of the open workshops where craftsmen make *jambiyas* and repair handles, and of the number of craftsmen in the shops. The pieces of rhino horn seen and new rhino horn handles being made in the workshops were also counted. *Jambiya* handles crafted from various substances were priced. Information was collected on the prices of raw rhino horn and on current smuggling routes. Various academics, diplomats and other experts on Yemen’s economy and *jambiya* industry were interviewed. Follow-up meetings with government officials, including the Prime Minister, were conducted to discuss legislation concerning rhino horn. Other towns in Yemen were visited by either the authors or their informers to investigate the demand for *jambiyas*.

RESULTS

The *jambiya* shops in Sanaa

The *jambiya* workshops situated in Sanaa’s old souk numbered 59 in June 1999, very similar to

the average of 60 open shops seen on random afternoon surveys from 1986 to 1996 (Martin et al., 1997). Craftsmen numbered 100, again similar to the average of 92 at any one time from 1986 to 1996 (Martin et al., 1997). Craftsmen now spend more time making handles of buffalo horn and repairing old *jambiyas* with rhino horn handles than making handles with new rhino horn. During the authors’ three different visits to the souk in 1999, only one craftsman was seen working new rhino horn handles. No plastic handles were being made. (Photo 1).

The overall numbers of retail outlets for daggers with buffalo horn handles have increased since 1997 in Sanaa, with more street stalls outside the old town gates of Bab al Yemen. Prices of daggers vary greatly (Table 1), according to the materials used and quality of workmanship. Shops in the souk or the street stalls usually sell belts and sheaths separately. Nearly all are factory-produced, costing about 600r (\$4) and 400r (\$2.5) respectively.

Rhino horn smuggling from Africa to Yemen and prices for the horn in Sanaa

Four traders, including the main *jambiya* businessman in Yemen, were approached for information on the late 1990s trade routes. According to these traders, various individuals, usually Yemenis and Sudanese (living in Kenya, Uganda, Sudan and Ethiopia) bring rhino horns to Yemen. Some bring them by aeroplane to Sanaa airport where contacts help them smuggle

Table 1. Average retail prices of jambiyas in Sanaa in June 1999.

Handle type	Price in rials	Price in US dollars
Plastic	500	3
Wood	500	3
Water buffalo horn	2,000	12
Camel hoof	2,500	15
New rhino horn	65,000	394
Rhino horn over 10 years old	120,450	730

the horn through Customs. Others bring it overland *via* Saudi Arabia. Yemen's long coastline extends from Saudi Arabia in the west to Oman in the east, making it difficult to control smuggling. The most popular route is *via* Djibouti and across the Red Sea by boat, usually a *zarook* (Photo 2).

Photo credit: Lucy Vigne



**Photo 1.** Rhino horns such as the two seen here in Sanaa's old souk in 1990 would not be on view today. The trader in the front is holding four roughly carved rhino horn handles.

These dhows carry many smuggled items from Djibouti to Yemen, including whisky and electronic goods. The sailors often cross at Bab al Mandab, the narrowest point where the Red Sea meets the Indian Ocean, and they land near Mocha on the Yemen coast. The three horns known to have reached Sanaa in 1998 were smuggled into Yemen by this route. A Sudanese businessman brought the horns from Sudan to his office in Djibouti, hidden in sacks of foodstuff (such as sesame seeds and groundnuts). A member of the main *jambiya* family went to Djibouti and bought the horns for \$1,200 a kg. This person gave the horns to a boat owner and flew back to Yemen, probably meeting the boat owner at a pre-planned place near Mocha, according to confidential sources in Yemen.

In mid-1999, undercover work was organized by the authors in Djibouti. It was found that rhino horn can sell in Djibouti wholesale for around \$600-\$800 a kg. Yemeni men in the textile business had recently bought rhino horns, according to Djibouti sources. There is thus no doubt that rhino horn is nowadays being taken to Djibouti and sold there to be exported illicitly to Yemen.

Photo credit: Esmond Martin



**Photo 2.** Zarooks, as seen here in Djibouti harbour, sometimes carry smuggled goods.

When a person who has smuggled rhino horn into Yemen sells it in the Sanaa souk, he receives \$1,400 a kg if it is good quality. This is a rise of \$200 compared with 1997, or 17%. There has also been an equivalent price increase in the handles and the leftover horn chips and shavings. About three or four handles are made from a kg of horn and each unfinished handle is worth about \$300. In order for the workshop owners to recoup the increased price of rhino horn, they illegally sold the leftover chips and shavings for about \$650 a kg in June 1999 to Chinese and Koreans working in Yemen. They smuggled the chips and shavings to China and South Korea to be sold illegally for traditional medicines.

### Efforts against the rhino horn trade

The Yemen government joined CITES in 1997, largely in order to control better the illegal trade in rhino horn. Since then, the Scientific Authority for CITES has been the Environment Protection Council (EPC) in Sanaa while the Management Authority has consisted of officials at the Ministry of Supply and Trade. Although officials in the EPC are trying to fill out the CITES forms for wildlife products, EPC employees are untrained and want assistance, as promised to them when they joined the Convention.

No rhino horn has been confiscated in the last few years, but the EPC has tried to reduce rhino horn demand. In 1997 the EPC distributed

framed photographs of *jambiyas* with handles of alternative materials to rhino horn in ministries and schools. The EPC also co-ordinates lectures with teachers and school clubs on rhino horn and the environment.

One enterprising individual, Ahmed al Wazir, has for several years been making *jambiya* handles with locally obtained semi-precious stones, mostly agate and jasper, as alternatives to rhino horn (Martin and Vigne, 1995, Photo 3). In 1998 he made 13 *jambiyas* with stone handles, which were bought by the President of Yemen to give as presents to dignitaries on a state visit to Oman. The President had on previous occasions given some to various world leaders, including President Mitterrand, Chancellor Kohl, Queen Juliana of the Netherlands, King Hussein of Jordan, and the Sultan of Oman (as rhino horn is unacceptable abroad). The President himself

wears a *jambiya* with an agate handle, but only when he is not in Yemen. The daggers with stone handles retail for about \$1,300 each (down from \$1,700 in 1995 due to the devaluation of the rial) and thus, due to the high price, the semi-precious stone makes a suitable alternative to rhino horn for a high quality dagger. Gold decoration is added to these handles. The blades are very good quality from al Bayda, usually

Photo credit: Esmond Martin



Photo 3. Ahmed al Wazir, the maker of *jambiyas* with semi-precious stone handles, holds his own *jambiya* of agate and gold.

costing Ahmed al Wazir around 7,000r (\$42) each, and the leather sheaths and belts cost him 4,000r (\$24). His most expensive dagger (with a red agate handle and gold decoration) was sold to a rich Yemeni for about \$2,500. Demand for stone handles is low, however, and Ahmed al Wazir now only makes one or two daggers a month, mainly for Yemenis in Saudi Arabia.

## Meeting with the Prime Minister

When the authors met with Dr Abdul Karim al Iryani, who was Prime Minister of Yemen at the time of their 1999 visit, he telephoned the Minister of Supply and Trade and requested him to organize an inspection of the souk. No recent official inspection had taken place to determine whether rhino horn was being used for new dagger handles. He also instructed the Ministry to issue a decree setting penalties against those dealing in or working new rhino horn. Dr al Iryani requested that Mohammed al Haymi, Deputy Minister of Industry, follow up these two matters. He hoped assistance concerning CITES enforcement would be provided soon, as agreed in 1997.

## Jambiyas for sale in Sadah, Hodeidah and Aden

### Sadah

Although Sanaa is the main centre of the *jambiya* industry (followed by Taiz and Dhamar), Sadah in the far north of the country near the Saudi Arabia border has had *jambiya* shops for many years. No quantitative survey had previously been carried out. The 30 or so small shops in Sadah's souk offering belts, sheaths and daggers are shabby and poorly stocked. Today the traders get ready-made daggers mostly from Sanaa. Some shops sell only sheaths and belts that are made in Sadah from materials bought in Sanaa. Prices vary according to quality and decoration. The intricate hand-sewn belts are made by women in their houses and by prisoners; machine-sewn belts are also available. There are six main shops specializing in daggers. Most of these have water buffalo horn handles. Four out

of six of these shops have seven craftsmen doing repair work. Three of the men can also make the daggers, but they no longer use rhino horn. The raw horn has not been available in Sadah since the early 1990s, according to the shop owners, despite the town being on a main transit route from Saudi Arabia to Sanaa. Traders would willingly buy the horn if it were offered to them cheaply, and they stated they could get it through Sanaa airport, as well as *via* Saudi Arabia. The small supply of rhino horn reaching Yemen nowadays all goes to Sanaa where traders are richer and can consequently offer the best prices. In the 1980s Saudis of Yemeni origin used to visit Sadah traders to buy new and old carved rhino horn handles, which they brought back mostly to Khamis Mushayt (in Saudi Arabia) to put onto blades (Martin, 1990). In June 1999, three old *jambiyas* with rhino horn handles were being polished in Sadah, but there were no new ones with rhino horn for sale.

### Hodeidah

Hodeidah, west of Sanaa on the Red Sea coast, also has several traditional dagger and belt shops, but all the traders buy ready-made *jambiyas*, sheaths and belts from Sanaa (Photo 4). They do not manufacture, nor do they buy rhino horn any more. They advise anyone dealing in rhino horn to sell it to the main *jambiya* trading family in Sanaa. Up to 1992, some Hodeidah traders bought rhino horn from seamen at the port, which they then sent to Sanaa, but they no longer have ready cash to act as middlemen. Business is slack with fewer people wearing daggers in Hodeidah compared to the past, and one dagger shop owner is considering closing down in order to open a grocery store instead. The small town of Al-Zaydiya, an hour's drive north of Hodeidah on the coast, was once famous for its *dhumas* (the less curved *jambiyas* of the religious elite), but today there are no dagger shops in the souk, and only the older people still wear *jambiyas*.

### Aden

There is no recent tradition in Aden for daggers, because the British and later the Marxist govern-

ment (1967-1990) banned the wearing of them. Since unification of North and South Yemen in 1990, men in Aden have not chosen to emulate the northern tribes in dress, even though more Aden women are again veiled because of the northern influence. Qat (*Catha edulis*, previously banned, except at weekends) is now chewed by many people in Aden on a daily basis. Only two visitors to Aden were seen wearing *jambiyas* on a full day's survey in June 1999: a man from Taiz and a man from Al Baydha province.

In 1994, two shops selling and repairing *jambiyas* were opened in Aden by a Sanaa *jambiya* trading family. One shop was in the souk area of Aden crater, but it was closed in 1997 due to a court case. The other shop is in the northern suburb called Shaikh Uthman. The young shop vendor goes to Sanaa to buy many of his *jambiyas*, which he displays, as well as belts, some jewellery and various ornaments. There was no dagger with a rhino horn handle in the shop except his own, worth 200,000r (\$1,212). Several daggers for sale were the smaller handled southern style of *jambiya*. Most had second-hand water buffalo horn handles, and some were made of plastic or wood. There used to be a tradition of crafting elephant ivory handles in the southern governorates and these *jambiyas* were worn by affluent people including the sheikhs and sultans. Carving ivory handles stopped by 1967 when the making and wearing of *jambiyas* were

Photo credit: Lucy Vigne



**Photo 4.** Jambiyas with rhino horn handles are displayed in Hodeidah.

prohibited throughout South Yemen (Renaud Detalle, pers. comm., 2000).

The shopkeeper buys a few southern-style daggers from the rural people in the southern governorates such as Lahej, Shabwa and al Bayda. His buyers are usually rural people from the governorates and provinces north of Aden. Since unification, more and more countryside men in the south are wearing their old

daggers once again. This is particularly so in the large Shabwa province. Aden people do not buy *jambiyas* except to decorate their walls. The shop owner claims to sell 10 to 15 a day, which is probably an exaggeration, and he says business is getting better (Photo 5).

Photo credit: Esmond Martin



**Photo 5.** The young owner of the one *jambiya* shop in Aden displays a variety of *jambiyas* for sale.

The old town of Aden itself shows little sign of economic growth with many buildings crumbling, and many poverty-stricken people dressed in tattered clothes. Sanaa, with its shops well stocked with imported goods, looks prosperous by comparison. There are still many more southerners working in Sanaa than people from the north resident in Aden.

## DISCUSSION

### The source of Sanaa's rhino horns in the late 1990's

The few rhino horns reaching Sanaa in the late 1990s have probably originated from rhinos that were poached in Kenya, Tanzania, Cameroon and the Democratic Republic of Congo's (DRC) Garamba National Park (Martin and Hillman Smith, 1999). In June 1999, Sanaa traders mentioned for the first time Uganda as a source for rhino horn, which probably links with the horn from nearby Garamba. In 1996 and 1997 a minimum of four white rhinos were poached in Garamba National Park. At least one of these horns is recorded to have been taken from the small town of Aru in the DRC, just across the border, to Arua town in Uganda for sale in 1997 (Martin and Hillman Smith, 1999).

Traders in Sanaa also state they have received horns from Kenya. According to sources in East Africa, at least three black rhino horns were offered for sale in Kenya from March 1998 to March 1999. One horn reportedly originated from Tanzania and was transported to Mtito Andei in Kenya and then to Nairobi for sale. A second horn reportedly came from an area south of Garissa towards the northern part of Tsavo East National Park and was taken to Nairobi by a woman involved in the curio business. The third horn came from the Taita/Taveta area in Kenya, but it probably originated in Tanzania. The owners of these horns offered them for sale in Nairobi for 35,000 Kenya shillings (\$538) to Ksh 50,000 (\$833) with an average price of Ksh 40,000 (\$667) per horn, not per kg (TRAFFIC East/Southern Africa, pers. comm., 1999). If the average weight of a black rhino horn in Kenya is

1.44 kg (Martin, 1979), then these middlemen were earning about Ksh 27,778 (\$463) per kg. The exporter buys the horn for around Ksh 45,000 (\$750) per kg. Reports from Kenyan traders state that some horns are exported from Nairobi in diplomatic bags.

Sanaa traders also report that rhino horn is reaching them from Sudan and Ethiopia. Some of this horn probably originates from animals killed in Cameroon. From 1990 to 1998, on average three black rhinos have disappeared each year, presumably poached, from northern Cameroon (Planton, 1999). In 1998 there were at least four pairs of black rhino horns for sale in Garoua town in northern Cameroon. Each pair was priced on average at CFA 1,000,000 (\$1,667) (Planton, pers. comm., 1998). If the average pair weighs 2.88 kg (the average weight for a pair of Kenyan black rhino horns), then the horn was priced at the equivalent of \$579 a kg. According to Hubert Planton, who has been in Cameroon since 1987, one rhino was killed in Bénoué National Park in 1996; the pair of horns weighing 5.5 kg was removed and brought to Garoua for sale. The owner wanted CFA 2,200,000 for the pair, which is the equivalent of \$667 a kg. Almost all the horn in Cameroon is exported because there is little demand for it within the country. Planton was told that occasionally it is used by traditional doctors when they pray. Trucks from Sudan come all the way across Africa to collect coffee in southern Cameroon. When the drivers come to Garoua on the return journey, some ask for rhino horns and put them in their trucks and drive back to Omdurman or Khartoum (information from shipping agents in Cameroon to H. Planton and then by pers. comm. to the authors in 1998). From Sudan the horn is exported, eventually finding its way to Yemen.

Due to the ongoing wars in the Horn of Africa and the migration of refugees from Somalia, Ethiopia and Eritrea to Yemen, it is likely that some rhino horn has also entered Sanaa with these refugees (Mohammed al Haymi, Deputy Minister of Industry, Yemen, pers. comm., 1999).

## The effect of Yemen's economy on demand for *jambiyas* in Sanaa

Remittances (from Yemeni workers abroad), oil and to a lesser extent tourism are Yemen's major sources of foreign exchange. After the Gulf War about half the Yemeni workers in the Gulf States were made redundant, reducing remittances significantly. Government earnings from oil roughly halved in 1999 from about a billion dollars each year in 1996 and 1997. Tourism crashed following the kidnapping of 16 tourists in December 1998 and the deaths of four of them. Confidence in Yemen by foreign companies is thus low and few foreign businessmen are investing in the country. In October 1997 the Yemeni rial was 132 to the dollar, but in mid-June 1999 it was fluctuating from 160 to 170. The middle class is declining in Yemen. Those that can emigrate are increasingly doing so. Government economic reforms have been discussed for the last 10 years, and some major changes have been made, but still the country does not export much besides oil. The Aden Free Zone container terminal, which was opened in March 1999, offers some hope for the economy, if it is successful. This has been one of the largest foreign investments into Yemen in recent years.

Meanwhile, the human population expands at 3.6% a year, faster than the economy. Despite the depressed economy and gloomy prospects, there is still a major market for *jambiyas*, although less so for rhino horn ones. In Yemeni rials the prices of most new *jambiyas* have gone up since 1997. In dollar terms the prices have fallen due to the 30% devaluation of the rial from 1997 to mid-1999. The few daggers with new rhino horn handles in the Sanaa old souk have risen in dollars, however, due to the increased cost of rhino horn. There is still a demand for them as a new rhino horn handle is less expensive than an older one due to its less attractive patina. As for old rhino horn *jambiyas*, some very rich Yemenis invest in these so the market for them continues.

## The future of rhino horn alternatives

In the Sanaa old souk, craftsmen have stopped making the more brittle plastic handles that were introduced by the main *jambiya* trading family in 1982 as an alternative to rhino horn because of their growing unpopularity. They can crack if dropped and will melt if touched by a match or cigarette. The production of cheap water buffalo horns handles has steadily increased due to their durability and demand from the growing human population. Water buffalo horn handles are much faster to make than those of rhino horn, which is why the numbers of workshops and craftsmen have remained the same for many years.

Most Yemenis who wear a dagger daily still would prefer rhino horn if they could afford it as it is traditionally revered and is tough and cannot break if dropped, unlike the only expensive alternative: semi-precious stone. If prices for stone handles were reduced, they could become popular among the educated middle class who do not wear *jambiyas* daily and the few who have accepted conservationists' arguments against the use of rhino horn. Only if 100 daggers with stone handles were made and sold a month would it be possible to reduce prices significantly, according to their maker Ahmed al Wazir. The rich traditional elite, such as the sheikhs and their sons, generally wear rhino horn daggers. A *fatwa* issued by the Grand Mufti of Yemen on 20 May 1992 stated: "Islam prohibits the killing of animals except for those slaughtered for their meat (i.e. goats, cows and camels) or predatory animals for protection of mankind". The sheikhs say that rhinos can also die from natural causes and they have therefore been unwilling to give up rhino horn for stone so far. Publicity has been lacking on this issue and there have not yet been enough education campaigns to counter the sheikhs' argument (Photo 6).

## CONCLUSION AND RECOMMENDATIONS

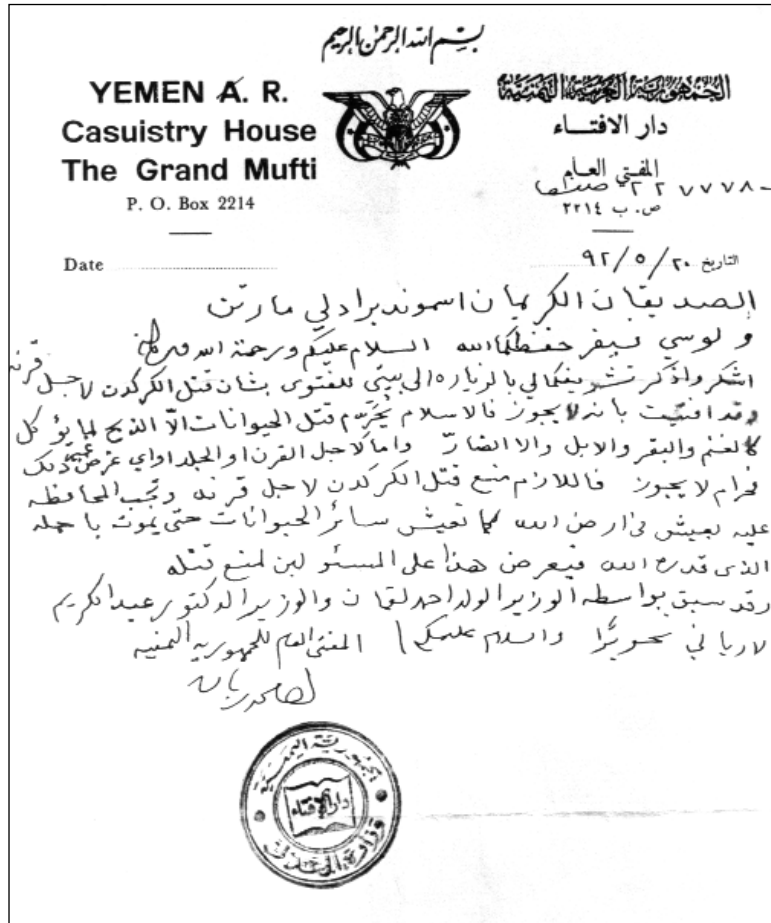
Despite the falling economy in Yemen, the price of rhino horn in dollars has increased in Sanaa

from 1997 to 1999, due to Yemeni demand for a much smaller supply of African horn on the world market. With available stockpiles almost exhausted in Yemen and with rhino poaching reduced in Africa, less rhino horn is available. Although most Yemenis can now only afford cheap daggers, in Sanaa some people can still afford *jambiyas* with new rhino horn handles. Yemeni traditions die hard, and expensive alternatives to rhino horn like agate and jasper handles are not selling well. With a fast growing human population, the number of cheap water buffalo horn *jambiyas* being produced is steadily rising, keeping most craftsmen in the business, especially in Sanaa. This is being augmented by the expanding market in the south of the country where some people in the rural areas

have reverted from western-style clothing to traditional dress. Business is increasing in Aden's dagger shop, the first for perhaps nearly a century, to cater to some southern Yemenis in the rural areas. A number of issues needs to be addressed in Yemen to reduce the poaching pressure on rhinos in eastern and central Africa. These include the following:

1. A decree instituting penalties against Yemenis dealing in new rhino horn must be finalized.
2. The Yemeni Ministry of Supply and Trade, which can close down any shop breaking the law, should ensure regular checks for new rhino horn handles being produced or sold.
3. More publicity is needed in Yemen to disseminate information on rhino conservation

Photo credit: Esmond Martin



**Photo 6.** The Grand Mufti of Yemen produced this religious edict in 1992, following a meeting with the authors, to try to stop Yemenis from using rhino horn for dagger handles. The edict states that killing rhinos for their horns is not allowed by Islam.

and to encourage more sales of stone handles for *jambiyas*.

4. An information centre should be set up at the new Sanaa zoo, which was opened at the end of May 1999 and attracts many Yemenis (Vigne and Martin, 1999), to discourage people from buying daggers with new rhino horn handles.
5. An NGO office should be established in Sanaa to help Yemeni officials ensure that all the various regulations are implemented, and to provide educational materials such as film footage for television, posters, etc.
6. Serious consideration should be given to more dialogue with the main *jambiya* trading family to come up with viable solutions.
7. Assistance from TRAFFIC and IUCN i.e. training Customs officials about illegal wildlife products, giving help to implement CITES, and organizing intelligence gathering) should be provided.
8. The CITES Secretariat needs to assist Yemen with support and training regarding enforcement of the Convention.
9. An internationally funded project is needed to monitor the illegal trade in rhino horn both within and outside Yemen.

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## REFERENCES

- Martin, E.B. (1979) The International trade in Rhinoceros Products. IUCN/WWF, Gland, Switzerland, pp. 50-76.
- Martin, E.B. (1990) Survey of Wildlife Products for Sale in Saudi Arabia. *TRAFFIC Bulletin* 11(4), 66-68.
- Martin, E.B. and Vigne, L. (1995) Agate replaces rhino horn in Yemen's new dagger handles. *Oryx* 29(3), 154.
- Martin, E.B., Vigne, L. and Allen, C. (1997) *On a Knife's Edge: The Rhinoceros Horn Trade in Yemen*. TRAFFIC International, Cambridge, UK, p. 21.
- Martin, E. and Hillman Smith, K. (1999) Entrepots for Rhino Horn in Khartoum and Cairo Threaten Garamba's White Rhino Population. *Pachyderm* 27, 76-85.
- Planton, H. (1999) Rhinocéros Noir du Nord Ouest de l'Afrique (*Diceros bicornis longipes*): Le Compte à Rebours Continue. *Pachyderm* 27, 86-100.
- Vigne, L. and Martin, E.B. (1999) A new zoo in Yemen. *Int. Zoo News* 46(7), 398-406.
- Yemen Government (1998) Central Bank of Yemen Financial Statistical Bulletin July-September 1998 - 9, 3.

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# The Value of Captive Breeding Programmes to Field Conservation: Elephants as an Example

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## ABSTRACT

Wildlife conservation is among the highest priorities of professionally managed zoological parks and aquariums. Even if reintroduction is not the goal of a captive breeding programme, zoos and aquariums can contribute to wildlife and habitat conservation in a number of ways, including public education, scientific research, development of relevant technologies, professional training and technology transfer, ecotourism, political action and involvement in field conservation. Here, we use elephants as an example of how such efforts support conservation activities.

## RESUME

La conservation de la faune sauvage fait partie des premières priorités des parcs zoologiques et aquariums gérés professionnellement. Même si la réintroduction n'est pas l'objectif d'un programme de reproduction en captivité, les zoos et aquariums peuvent contribuer à la protection de la faune sauvage et des habitats de diverses façons, comprenant l'éducation du public, la recherche scientifique, le développement de technologies adaptées, la formation professionnelle et le transfert de technologies, l'écotourisme, l'action politique et un engagement dans la protection sur le terrain. Ici, nous prenons les éléphants comme exemple pour montrer comment de tels efforts soutiennent les activités de protection.

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## INTRODUCTION

Professionally managed zoological parks and aquariums play an important role in conserving the world's imperiled species. Although these facilities once sought to fulfill this role by serving as modern "Noah's Arks", where many taxa would be bred in captivity for eventual release (Foose 1986), rapidly increasing numbers of endangered species and loss of wildlife habitat have rendered this approach less tenable. Although modern zoos no longer view captive breeding for reintroduction as a panacea for the endangered species problem, there is still a necessity for scientifically-managed captive breeding programmes (Hutchins and Conway, 1995; Hutchins et al., 1995a; Hutchins et al., 1996a).

The American Zoo and Aquarium Association (AZA) originally developed the Species Survival Plan (SSP®) as a co-operative breeding programme to help sustain selected species of wildlife in captivity. More recently the SSP has evolved to include associated field conservation, education, and research efforts (Wiese and Hutchins, 1995). As a result, many species benefit from captive propagation, even when reintroduction is not the immediate or even the ultimate goal.

The AZA Elephant SSP is an excellent example of a programme where reintroduction is not currently a priority, but where captive breeding and exhibition programmes can be of great value to *in situ* conservation, both directly and indirectly. With careful genetic and demographic management, zoos are able to maintain populations of

Photo credit: Rick Barongi



**Photo 1.** A research team working on assisted reproduction techniques.

elephants that have the potential to contribute to conservation in numerous ways. These include public education, scientific research, development of relevant technologies, professional training and technology transfer, ecotourism, political action, and involvement in field conservation (Hutchins and Conway, 1995; Hutchins et al., 1996a).

## PUBLIC EDUCATION

Informing the general public about the plight of endangered species is an important aspect of conservation. It is difficult to make conservation work if people are unconcerned with nature and wildlife, or are unaware of the problems (DeLapa, 1994; Kellert, 1993). AZA member institutions attract 121 million visitors each year (AZA, 1999), many of whom have the opportunity to observe live elephants and learn about the conservation problems facing these animals. Research has demonstrated that the presence of live animals does stimulate interest and curiosity (Saunders and Young, 1985) and that contact has a positive impact on affective learning (Sherwood et al., 1989). The vast majority of zoo visitors are urban dwellers who may know little about wildlife conservation issues and would never have an opportunity to see elephants in the wild.

Many institutions have specialized displays on elephant biology and conservation, which reach millions of people annually. For example, New York's Bronx Zoo/Wildlife Conservation Park recently renovated its historic Elephant and Rhino Building. Inside this structure is an extensive graphic presentation, including computerized displays which depict the loss of elephant populations over the past century. Similarly, the Oregon Zoo in Portland, Oregon has an elephant museum in its grounds which educates people about elephant biology and conservation. The National Science Teachers Association supports and advocates this type of informal science education - and it singles zoos and aquariums out as important and effective centers for science education (AZA, 1999).

AZA member zoos also have outreach programmes which allow them to spread their conservation message beyond those people who come through their gates. Some specifically target elephant conservation. "Suitcase for Survival", a co-operative educational programme developed by the AZA, World Wildlife Fund, and the US Fish and Wildlife Service, has reached thousands of school children and adults across the United States (Hardie, 1987). The programme is intended to discourage people from purchasing wildlife products. Confiscated

items, such as products made from elephant ivory, are used in this educational programme along with lectures and written educational materials. The “Elephant Ivory Trade Worksheet” provides data on why elephants are endangered, what laws are protecting them, and what the average person can do to help.

## SCIENTIFIC RESEARCH

Zoos also play an important role in conservation through scientific research. As a group, AZA institutions are estimated to invest \$51 million in scientific research each year. Since 1990, zoo scientists and their university collaborators have also produced more than 4,000 publications on wildlife topics, including peer-reviewed scientific papers, conference proceedings, book chapters and books (AZA, 1999).

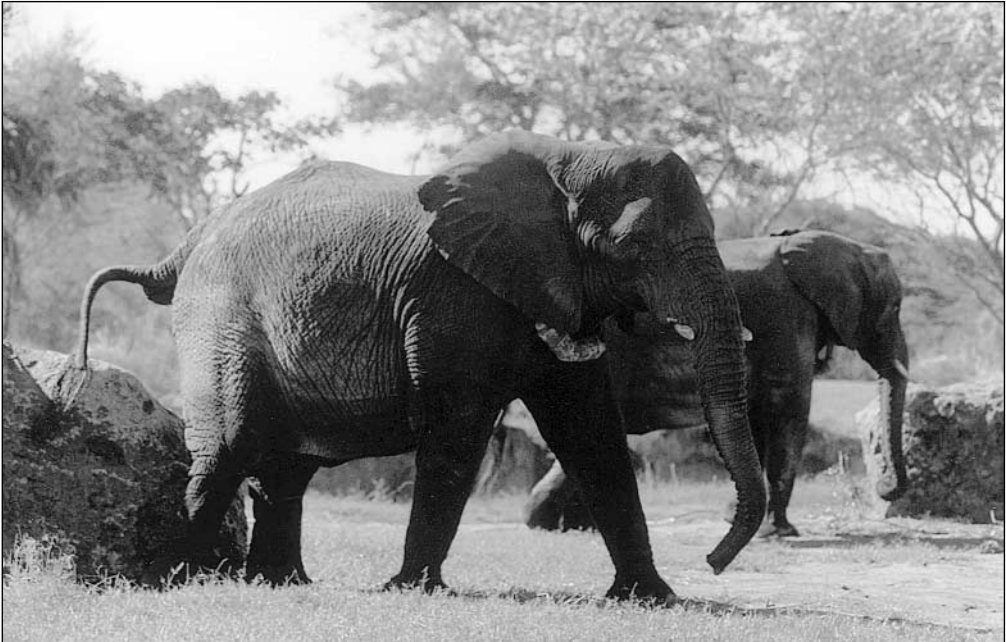
Successful conservation programmes require a detailed knowledge of the animals involved. Field studies can be complemented by captive studies, providing a more detailed picture of an animal’s biology and ecology. Field studies also benefit from the technical support of zoo-based

specialists, such as nutritionists, physiologists, veterinarians, pathologists, and reproductive biologists (Hutchins et al., 1996b).

Most research on elephant reproductive biology has been conducted at zoos, and due to this work we now have a detailed understanding of elephant oestrus cycles and the physiology of the reproductive system (Hess et al., 1983; Jainudeen et al., 1971; Olsen et al., 1994), and chemical signals associated with oestrus and musth (Rasmussen and Schulte, 1998). Information on chemical communication is currently being examined for its effectiveness as a repellent against crop-raiding wild elephants in Zimbabwe (Osborn and Rasmussen, 1995).

Nutritional analyses have been conducted on captive populations of elephants to determine the type and amount of foods consumed (Dierenfeld, 1995). Using zoo-based analytical laboratories, nutrient assays can be performed to find out how animals meet their nutrient requirements. This information could potentially be used to determine adequacy of food resources in the wild.

Photo credit: Walt Disney World Co.



**Photo 1:** Radio-collared elephants at Disney’s Animal Kingdom.

Infrasonic communication in elephants was first discovered and studied in captive elephants (Payne et al., 1986). This knowledge is vital for understanding how wild elephants coordinate their movements over great distances. Disney's Animal Kingdom is currently analyzing vocalizations and behavior of a herd of captive African elephants (Savage, pers. comm.). The goal is to develop a comprehensive vocal repertoire that incorporates both the behavioral and functional aspects of communication.

Basic biometric data on Asian elephants was accrued by zoo-based scientists from research on captive elephants in India and Nepal. Systematic collection of this information provides a basis for morphological comparison and enhances our understanding of elephant biology (Wemmer and Krishnamurthy, 1992).

## **DEVELOPMENT OF RELEVANT TECHNOLOGIES**

Technologies relevant to field conservation can also be tested on captive animals before being used in nature (Hutchins and Conway, 1995). For example, research on elephant reproduction has led to technologies for both enhancing and preventing reproduction. Contraceptive methods - although not a panacea for population problems - might prove to be useful for controlling the numbers of free-ranging elephant populations (Brown et al., 1992; Fayrer-Hosken et al., 1997). Culling programmes, although often deemed necessary in fragmented habitats and isolated national parks (Pienaar, 1969), are strongly opposed by politically powerful animal welfare and animal rights groups and may not always be a viable management option (Poole, 1992).

Advances have been made in artificial reproduction techniques, as evidenced by the recent successful artificial inseminations of two African cows (Olson, 1999) and successful live birth from artificial insemination of one Asian cow. Further development of these technologies would be valuable not only to captive management, but also potentially to wild populations, where genetic variability could be increased in

small, isolated or highly fragmented populations that have little possibility of natural genetic interchange. Technology developed in zoos to detect fecal steroid concentrations (Wasser et al., 1996) can also be used to non-invasively monitor reproductive status in wild populations.

Development of methods for tracking the movements of elephants has also been conducted at zoos such as the Bronx Zoo/Wildlife Conservation Park and the National Zoological Park. Radio and satellite tracking programmes have been developed to follow animals through a variety of habitats. The satellite tracking technique, developed and tested by Bronx Zoo scientists on Asian elephants in the Wild Asia exhibit, is now being used successfully to track the movements of forest-dwelling elephants in central Africa (Nobbe, 1992).

Zoo-based veterinarians and pathologists have done much to advance our knowledge of exotic animal diseases, including methods to diagnose and treat various pathogens. This has important implications for monitoring and controlling disease in free-ranging populations (Hutchins et al., 1991; Cook et al., 1995).

One of the most important technologies to arise from zoos is the collection of DNA samples using non-invasive techniques (Ryder, 1990). Dr. Samuel Wasser of the Woodland Park Zoological Gardens in Seattle, Washington, has recently obtained genetic information from elephants through DNA collected from fecal samples. This technique may make it possible to construct a geographic map of gene frequencies of wild elephant populations. Zoo researchers have also developed a technique for collecting DNA from ivory (Wasser, pers. comm.). By comparing ivory DNA to gene frequency maps, scientists may be able to determine the region where the ivory originated. This, in turn, may make it easier to track its origin and allow controlled culling of elephants in countries with excellent track records in conservation. With the CITES decision of 1997 to downlist elephants from Botswana, Namibia, and Zimbabwe from Appendix I to Appendix II, it will be important to determine if ivory has originated from these

countries, or if it comes from countries where trade remains illegal.

Knowledge of small population biology and management also has relevance to *in situ* conservation. Habitat loss and fragmentation continues unabated, and some African national parks are surrounded by fences to prevent poaching and human/animal conflicts. Because of this, loss of genetic diversity is a risk that even wild elephants face. Zoo-based geneticists, such as Dr. Robert Lacy of the Brookfield Zoo in Chicago, Dr. Jon Ballou of the National Zoological Park, and Dr. Robert Wiese of the Fort Worth Zoo, have been leaders in the development of genetic management techniques for small populations, as well as methods for Population Viability Analysis (PVA). Dr. Lacy developed the VORTEX software program, which is now widely used as a basis for many such analyses (Lacy, 1993).

## PROFESSIONAL TRAINING AND TECHNOLOGY TRANSFER

Training local conservation professionals is an important part of protecting and managing wildlife and wildlife habitats for the future (Wemmer et al., 1993). Several zoos participate in range country programmes which train resident biologists to address local conservation needs.

For example, the Wildlife Conservation Society (WCS), which operates the Bronx Zoo/Wildlife Conservation Park, Aquarium for Wildlife Conservation, Central Park Wildlife Center, Prospect Park Wildlife Center and Queens Wildlife Center, sponsors a field veterinary programme, which augments continuing conservation efforts by dealing with current health concerns of wild populations (Gorman, 1994; Cook et al., 1995). Zoo-sponsored veterinarians travel to many countries to monitor and assess the health of wild populations and to train local veterinarians in topics such as anatomy, physiology, genetics, nutrition, pathology, and clinical medicine. They also provide training in animal capture, restraint, transport, and record keeping. In

addition, WCS conducts extensive training programmes in field conservation methods worldwide (Rabinowitz, 1993).

Similarly, the National Zoological Park's Conservation and Research Center (CRC) has also developed an innovative programme to train professionals from developing countries in the field of wildlife biology (Wemmer et al., 1990). Experts from the CRC travel to other countries and host classes at their facility to share their knowledge on the development and use of the latest techniques in radio-telemetry, computer modelling, population management, non-invasive monitoring of reproductive cycles, and Geographic Information Systems (Jhala, 1994).

## ECOTOURISM

Many zoos have travel programmes that, when properly administered, can help provide an economic incentive for wildlife and habitat conservation in developing countries. They also build support for conservation by allowing participants to see and experience wildlife in nature. African countries are a major destination for zoo-based travel programmes, and a closer connection between such programmes and wildlife conservation efforts is possible (Hutchins et al., 1995b).

## POLITICAL ACTION

AZA accredited zoos and aquariums have close relationships with local and state governments, and have become a powerful lobbying force for conservation. The AZA Department of Government Affairs has developed a legislative alert network consisting of 185 member institutions and over 7,000 zoological professionals. When important legislation is being considered by the US Congress, this network can spring into action, providing timely comments that can influence pending legislation. For example, AZA member institutions wrote letters of support and AZA staff and representatives testified on behalf of the African Elephant and Asian Elephant Conservation Acts, both of which eventually were passed. The African Elephant

Photo credit: Walt Disney World Co.



**Photo 3.** Researcher studying elephant vocalizations.

Conservation Act has provided millions of dollars to support in situ research and conservation initiatives (Phillips, 1998) and the Asian Elephant Conservation Act has the potential to do the same. In addition, the AZA teamed with other partners, such as World Wildlife Fund and Wildlife Preservation Trust International, to organize receptions for Congressional Representatives and their aides to help promote this legislation.

## **DIRECT SUPPORT OF FIELD CONSERVATION**

Zoos are also able to benefit wild populations with their ability to raise money for field conservation and habitat protection (Hutchins and Conway, 1995). AZA institutions supported or conducted nearly 700 field conservation and research projects in 80 countries during 1997 alone (AZA, 1999).

Some AZA members have provided substantial direct support for elephant field conservation

and related research. The WCS has a long history of supporting elephant conservation in Africa, having provided financial and logistical support for many relevant projects, including David Western's "African Elephant Action Plan" and Richard Barnes' study of forest-dwelling elephants in Ghana (Barnes et al., 1995a) and his review of the status of forest elephants in central Africa (Barnes et al., 1995b). Similarly, the Minnesota Zoo has "adopted" Way Kambas National Park in Sumatra, Indonesia, and is providing support to improve the park's infrastructure. The park is an important refuge for Asian elephants in Sumatra (WWF, 1998). Disney's Animal Kingdom established the Disney Wildlife Conservation Fund in 1995. Through the Fund, annual cash awards are distributed to nonprofit organizations to protect and study endangered and threatened animals and their habitats. To date more than \$3 million has been dedicated to programmes in more than two dozen countries under the auspices of 40 nonprofit environmental and conservation organizations. Several of the projects involve elephant

conservation. North Carolina Zoological Park has joined with WWF-Cameroon to initiate a joint study on human/elephant interaction. The zoo provides veterinary expertise in anesthetizing elephants to place tracking collars on them and supplies collars, receivers, and satellite time to track the elephants from space.

## CO-OPERATION BETWEEN AZA AND IUCN/SSC

AZA and IUCN/SSC already have a solid partnership. AZA and 15 of its member institutions are members of IUCN. In addition, AZA zoo and aquarium professionals chair several taxonomic SSC specialist groups (e.g. Dr. Chris Wemmer, National Zoological Park, Deer Specialist Group; Wendy Worth, Zoo Atlanta, Hornbill Specialist Group and Dr. George Rabb, Director of the Chicago Zoological Society, is a member of the SSC Steering Committee, which he chaired for seven years.)

*In situ* elephant conservation could be furthered if the AZA were able to develop even stronger ties with the SSC African and Asian Elephant Specialist Groups. This could be achieved by designating IUCN/SSC liaisons to the AZA Elephant SSP to communicate current research and conservation needs. Information exchange and IUCN/SSC participation in SSP planning could help the SSP strengthen the link between zoos and elephant field conservation. IUCN could also partner with the AZA Conservation Action Partnership (CAP): East Africa and CAP: Southeast Asia to help organize co-operative field projects in those regions. CAPs are special committees designed to help coordinate the conservation and scientific activities of AZA institutions working in specific geographical regions of the world. The chairs of the AZA CAPs: East Africa and Southeast Asia have considerable experience with African and Asian conservation and are just beginning to develop their programmes.

IUCN could also improve zoo-based education and public relations programmes by keeping zoo educators informed about recent issues and

developments in elephant field research and conservation. In response, the AZA and its members could potentially assist IUCN/SSC Elephant Specialist Groups with developing educational materials for use in range countries. For example, the Bronx Zoo/Wildlife Conservation Park's exhibit design and education staff recently redesigned the Nairobi Animal Orphanage, which is now being renovated with support from the WCS; and, North Carolina Zoological Park, in their partnership with WWF-Cameroon, is working to educate people living in and around the study areas.

The timing for intensified co-operation is excellent, since modern, professionally-managed zoos are in a transitional period. AZA is currently engaged in an Elephant Planning Initiative which is examining critical issues in zoo based elephant management and conservation, such as population management, husbandry and management, importation from range countries, and links to *in situ* conservation (Smith and Hutchins, 1999). The ultimate goals of this initiative are to improve accepted standards of professional conduct and elephant care and to increase contributions to conservation. The elephant initiative is just one example of how zoos are in the process of developing a stronger link between their living collections and the fate of animals and their habitats in nature (Wiese and Hutchins, 1995; Hutchins and Conway, 1995; Hutchins et al., 1996b).

## REFERENCES

- AZA (1999) *The Collective Impact of America's Zoos and Aquariums*. American Zoo and Aquarium Association, Bethesda, MD.
- Barnes, R.F.W., Blom, A., Alers, M.P.T. and Barnes, K.L. (1995a) An estimate of the numbers of forest elephants in Gabon. *J. Trop. Ecol.* 11, 27-37.
- Barnes, R.F.W., Blom, A. and Alers, M.P.T. (1995b) A review of the status of forest elephants *Loxodonta africana* in central Africa. *Biol. Conserv.* 71(2), 125-132.
- Brown, J.L., Bush, M., Monfort, S.L. and Wildt, D.E. (1992) Fertility regulation in female

- elephants: applicability and potential problems of using steroidal hormones for contraception. In: *Proceedings of the Elephant Contraception Symposium*. Nairobi, Kenya.
- Cook, R.A., Dierenfeld, E., Karesh, W. and McNamara, T. (1995) Linking the knowledge of zoo animal health to the needs of free-ranging wildlife. In: *AZA Annual Conference Proceedings 1995*. Wheeling, WV, pp. 96-100.
- DeLapa, M.D. (1994) Interpreting hope, selling conservation: Zoos, aquariums, and environmental education. *Museum News*, May/June, 48-49.
- Dierenfeld, E.S. (1995) Nutrition and feeding. *J. Ele. Manag. Ass.* 6(3), 32-39.
- Fayrer-Hosken, R.A., Brooks, P., Bertschinger, H.J., Kirkpatrick, J.F., U.W. Turner and Liu, I.K.M. (1997) Management of African elephant populations by immunocontraception. *Wildl. Soc. Bull.* 25(1), 18-21.
- Foose, T. J. (1986) Riders of the last ark: the role of captive breeding in conservation strategies. In: *The Last Extinction* (Eds.: Kaufman, L. and Mallory, D.). MIT Press, Cambridge, MA, pp. 141-165.
- Gorman, P. (1994) The doctor is out. *Wildl. Conserv.* 97, 58-67.
- Hardie, L.C. (1987) *Wildlife Trade Education Kit*. WWF, TRAFFIC, Washington, DC.
- Hess, D.L., Schmidt, A.M. and Schmidt, M.J. (1983) Reproductive cycle of the Asian elephant (*Elephas maximus*) in captivity. *Biol. Reprod.* 28, 767-773.
- Hutchins, M., Foose, T. and Seal, U.S. (1991) The role of veterinary medicine in endangered species conservation. *J. Zoo and Wild Anim. Med.* 22, 277-281.
- Hutchins, M. and Conway, W. (1995) Beyond Noah's ark: the evolving role of modern zoological parks and aquariums in field conservation. *International Zoo Yearbook* 34, 117-130.
- Hutchins, M., Willis, K. and Wiese, R. (1995a) Strategic collection planning: theory and practice. *Zoo Biol.* 14 (1), 2-22.
- Hutchins, M., Basel, J., Fascione, N., Horwich, R., Mills, R., Mittermeier, R., and Wood, M. (1995b) Zoos, ecotourism and conservation: a panel discussion. In: *AZA Annual Conference Proceedings 1995*. Wheeling, WV, pp. 229-255.
- Hutchins, M., Wiese, R. and Willis, K. (1996a) Why we need captive breeding. In: *Proceedings of the AZA Regional Conference 1996*. Wheeling, WV, pp. 77-86.
- Hutchins, M., Paul, E. and Bowdoin, J. (1996b) Contributions of zoo and aquarium research to wildlife conservation and science. In: *The well-being of animals in zoo and aquarium-sponsored research* (Eds. G.M. Burghardt, J.T. Bielitzski, J.R. Boyce. and D. Schaffer). Scientist's Center for Animal Welfare, Greenbelt, MD, pp. 23-29.
- Jainudeen, M.R., Eisenberg, J.F. and Tilakeratne, N. (1971) Oestrous cycle of the Asiatic elephant, *Elephas maximus*, in captivity. *J. Reprod. Fert.* 27, 321-328.
- Jhala, Y. (1994) CRC wildlife conservation and management course comes to India. *CRC News*, Fall, 7.
- Kellert, S.J. (1993) Values and perceptions of invertebrates. *Conserv. Biol.*, 7(4), 845-855.
- Lacy, R. (1993) VORTEX: a computer simulation model for population viability analysis. *Wildl. Res.* 20, 45-65.
- Nobbe, G. (1992) Going into orbit. *Wildl. Conserv.* 95, 62-64.
- Olsen, J.H., Chen, C.L., Boules, M.M., Morris, L.S. and Coville, B.R. (1994) Determination of reproductive cyclicity and pregnancy in Asian elephants (*Elephas maximus*) by rapid radioimmunoassay of serum progesterone. *J. Zoo and Wildl. Med.* 25, 349-354.
- Olson, D. (1999) Recipe for a successful artificial insemination. *J. Ele. Manag. Ass.*, 10(1), 21-31.
- Osborn, F.V. and Rasmussen, L.E.L. (1995) Evidence for the effectiveness of an oleoresin capsicum aerosol as a repellent against wild elephants in Zimbabwe. *Pachyderm* 20, 55-64.
- Payne, K.B., Langbauer, Jr., W.R. and Thomas, E. (1986) Infrasonic calls of the Asian elephant (*Elephas maximus*). *Behav. Ecol. Sociobiol.* 18, 297-301.
- Phillips, M. (1998) African elephant conservation act. *Endangered Species Bulletin* 23(2-3), 38-40.
- Pienaar, U. De V. (1969) Why elephant culling is

- necessary. *Afr. Wildl.* 23(3), 180-194.
- Poole, J. H. (1992) Logistical and ethical considerations in the management of elephant populations through fertility control. In: *Proceedings of the Second International Conference on Human and Animal Reproduction*. Nairobi, Kenya, pp. 278-283.
- Rabinowitz, A. (1993) Back to basics. *Wildl. Conserv.* 96(4), 78-79, 82.
- Rasmussen, L.E.L. and Schulte, B.A. (1998) Chemical signals in the reproduction of Asian and African elephants. *Anim. Reprod. Sc.* 53, 19-34.
- Ryder, O. (1990) Saving species in their habitats: the transfer of genetics research technologies. In: *AZA Annual Conference Proceedings 1990*. Wheeling, WV, pp. 41-45.
- Saunders, W. and Young, G. (1985) An experimental study of the effect of the presence or absence of living visual aids in high school biology classrooms upon attitudes toward science and biology achievement. *J. Res. Sc. Teach.*, 22(7), 619-629.
- Sherwood, K.P., Rallis, S.F. and Stone, J. (1989) Effects of live animals vs. preserved specimens on student learning. *Zoo Biol.* 8, 99-104.
- Smith, B.R. and Hutchins, M. (1999) AZA elephant planning initiative. *J. Ele. Manag. Ass.* 10(2), 150-151.
- Wasser, S.K., Papageorge, S. and Brown, J.L. (1996) Excretory fate of estradiol and progesterone in the African elephant (*Loxodonta africana*) and patterns of fecal steroid concentrations throughout the estrous cycle. *Gen. Compar. Endocr.* 102(2), 255.
- Wiese, R. and Hutchins, M. (1995) *Species Survival Plans: Strategies for Wildlife Conservation*. American Zoo and Aquarium Association, Bethesda, MD.
- Wemmer, C. and Krishnamurthy, V. (1992) Methods for taking standard measurements of live domestic Asiatic elephants. In: *Symposium on Ecology, Biology, Management and Diseases of the Asian Elephant*. India, pp. 34-37.
- Wemmer, C., Rudran, R., Dallmeier, F. and Wilson, D.E. (1993) Training developing country nationals is the critical ingredient to conserving global biodiversity. *BioScience* 43, 762-767.
- Wemmer, C., Pickett, C. and Teare, J.A. (1990) Training zoo biology in tropical countries: A report on method and progress. *Zoo Biol.* 9, 461-470.
- WWF (1998) Asian Rhinoceros and Elephant Action Strategies Workshop Report. Ho Chi Minh City, Vietnam.

# BOOK REVIEWS

## ON A KNIFE'S EDGE: THE RHINOCEROS HORN TRADE IN YEMEN

**Esmond Bradley Martin, Lucy Vigne  
and Crawford Allen**

**A TRAFFIC Network Report, published by  
TRAFFIC International, 1997, 45 pp.**

*Reviewed by Kes Hillman Smith  
PO Box 21285  
Nairobi, Kenya*

Since the early 1970s, Yemen has been one of the largest consumers of rhino horn in the world, importing over 40% of the annual trade during that time. Beautiful and durable, the horn is prized there for the manufacture of dagger handles, *jambiyas*, worn by only the richest and most influential of men. Yet, responsible for the deaths of some 22,350 rhinos over the last 26 years, most Yemenis until recently barely even knew of the rhinos themselves, if anything, confusing them with the giraffe. Although still a significant threat to the few remaining rhinos, the trade of rhino horn into Yemen has dropped massively. The imports of the main *jambiya* producing family, for example, have dropped from 1,585 kg in 1982 to 15 kg in 1996.

Although driven by a complex mixture of value, status, *per capita* income, lack of trade controls and availability, much of this reduction in trade in rhino horn has been due to the persistent efforts of Esmond Bradley Martin. Over the years Martin has investigated, documented, and motivated efforts to control and reduce this threat to rhinos. Well known for their studies of rhino horn and ivory trade over the years, Esmond Bradley Martin and Lucy Vigne join here with Crawford Allen of TRAFFIC to pro-

duce a thorough and painstakingly researched documentation of the rhino horn trade and the use of rhino horn in Yemen.

With a background on the history and culture of the use of rhino horn, the legislation relating to its control and the statistics of the trade, this monograph focuses in most detail on the studies and control actions carried out since 1990. Organized into methods, results and discussion, these details cover an interesting mixture of statistical, factual and anecdotal evidence. This is an extremely valuable record of a strange but highly significant cause of death for very many of Africa's rhinos in this century. The authors end with a series of recommendations. Has the Rhinoceros Task Force been established yet, to follow through all the actions needed, one asks?

Photo credit: Lucy Vigne



**Photo 1.** A *jambiya* shop in Sanaa's old souk.

## THE ART OF RHINOCEROS HORN CARVING IN CHINA

Jan Chapman

Christie's Books Ltd, London 1999

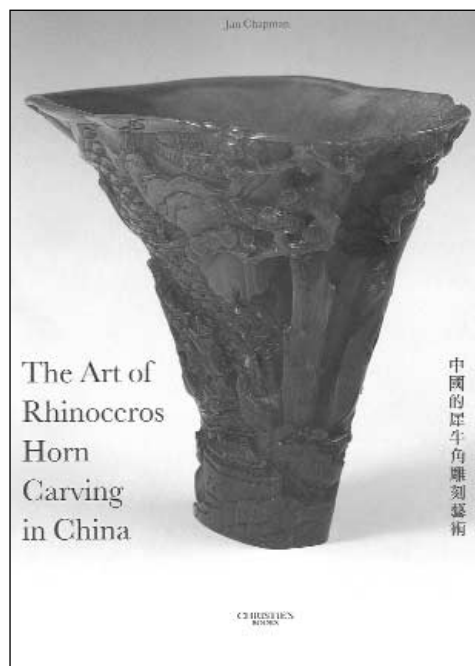
228 pages, 185 colour and 215 black and white illustrations, 85 pounds sterling

ISBN: 0-903432-56-0

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Having been Far Eastern Curator of the Chester Beatty Library in Dublin for many years, Jan Chapman was able to study the museum's 219 rhino horn carvings, the world's largest known collection, as well as classify and catalogue carvings in other collections throughout the world. Her detailed research has resulted in a magnificent and important book, *The Art of Rhinoceros Horn Carving in China*. Flicking through its beautifully illustrated pages, you can almost feel the smooth texture of the carved and polished rhino horn objects; the quality of the pictures is superb. The aim of the book is to bring attention to this largely ignored Chinese art

form and elevate its status to that of other masterpieces carved in jade and ivory. The book is highly informative and written in an easy, personal style. It is the first of its kind and will be of fascination to art historians, lovers of Chinese art and of rhinos. They have played a unique role in China's cultural history, as the book explains. As a result of this work, Chapman has helped to save many antique rhino horn cups from being ground into powder for Chinese medicines, a sad development of the late 20th century, as described in the foreword by Esmond Bradley Martin.

An excellent introduction full of enticing pieces of information gives the novice a true grasp of the subject and beckons one to read further. Rhino horn is not agglutinated hair but long filaments of keratin packed closely together. The earliest written records refer to rhino horn used as wine cups when rhinos existed in the forests of China. *The Book of Songs*, written in 500 BC and attributed to Confucius, described rhino horn cups, filled with wine as libations for long life. Gradually magical legends grew about rhino horn and the unicorn, from which it was thought to come. But it was never used in China as an aphrodisiac, as Chapman hastens to point out. It was noted in 12th century European writings that poison would bubble and could be detected in a rhino horn cup. For this reason many rulers, such as Emperor Rudolf II of Germany (1522-1612), paid exorbitant prices for rhino horn drinking cups, although some in his collection have proved to be water buffalo horn imitations. In the Bronze Age 2,000 BC the Asian rhino horn cup shape was copied for making bronze wine goblets and could even have been the precursor of the wine glass shape.

The book has three parts, the first on rhinos and their horns, the second on rhino horn carvings, and the third on the impact and influence of rhino horn carving in China, Europe and Central Asia. Chapman gives an historical background with literary and archeological evidence of rhino horn carvings and trade. She then describes the five rhino species and the various shapes and structure of their horns, dealing with water buffalo horn as well. As few zoologists have writ-

ten on the subject, she had to research rhino horn shapes herself, learning that black rhino horn has a round base, white rhino horn a horse-shoe shaped base, that Asian horn tends to have a vertical groove and a splaying skirt, and other such details. She is now an expert at distinguishing the cups, although pointing out that in the future, improved microscopy and carbon-14 dating will more accurately be able to judge the age and type of the horn. The carvings are classified by their shapes. Most carvings are cups (defined as containers capable of holding liquid) and the type of cup shape varies according to the original rhino horn. One of Jan Chapman's favourites, and I agree, is a caryatid cup of a small Chinese boy holding aloft a large lotus leaf by its stalk. There are also carvings from the wall of the horn (used for making leaf-shaped cups), animal and human figures and other objects, such as snuff bottles, boxes for powdered incense, brush stands, ladles, swords and scabbards. Dress fasteners or toggles are rare, probably, Chapman thinks, as many are in collections where they have been mistaken for Japanese netsukes.

Part 2 first explains what we can learn from the carver's inscriptions although only 10% of the cups are inscribed and not usually with the dates or the carver's name, making the puzzle of dating them harder to solve. Rhino horn carvings are also classified by their surface decoration. Generally, the more complex the decoration the later the date of carving. A rare group of cups is undecorated. Half of all the pieces recorded are decorated with flora and fauna such as flowers, trees, fruits, dragons and the phoenix which are comprehensively listed and described. There is also figure decoration, both from the natural world (landscape scenes and historical or legendary events) and the supernatural world (demons, gods and immortals). Chapman then explains the dating of the carvings she has recorded. Tang dynasty (618-907) cups were plain, polished Sumatran horn. Towards the end of the Song dynasty (960-1279), inscriptions started. By the start of the Yuan dynasty (1280-

1368) the Imperial Household employed 150 craftsmen making furniture and ornaments for the palace. In the Ming dynasty (1368-1644), quantities of African horn were imported; the larger ones with light and dark patterning were the most desirable. Although Asian horns dominated the carving industry, African horn cups progressively increased throughout the Qing dynasty (1644-1911), perhaps because horns from Indochina were becoming rarer. Ming cups tend to be honey coloured while Qing cups were dyed mid-brown and by the late 19th century black, and had an increasingly busy composition.

Part 3 shows how rhino horn carvings influenced other types of Chinese decorative art such as the porcelain known as *blanc de chine*, ivory, jade, soapstone, wood, bamboo, silver and bronze which were sometimes carved into the identical shapes of rhino horn cups. Chapman goes on to describe the popularity of rhino horn carvings in Europe from the late 16th century, and how some were carved in the Himalayan region.

One wonders what effect rhino horn carving, the main focus of the book, had on rhino populations in different regions compared with the demand for horn for Chinese medicines historically and with human population expansion. I was also curious to know about the prices of rhino horn cups today. It would be interesting to learn where the cups that were destined for Chinese medicine are now and who has researched this. A follow-up report in *Pachyderm* would be appreciated.

The text could possibly have been set slightly higher on the page, and in a few places I was confused by the labelling in finding a diagram or picture (the diagram on page 253 seems to be missing altogether). An Appendix helpfully lists and describes the major public collections of rhino horn carvings. Jan Chapman's book is a work of art in itself and, with its wealth of information, will surely be a collector's item like the objects she so skilfully describes.

## Recommandations aux auteurs

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### Objectifs et champ d'action

*Pachyderm* publie des articles et notes concernant tous les aspects touchant à l'éléphant africain, au rhinocéros africain et au rhinocéros asiatique en mettant l'accent sur la protection et la gestion de ces espèces à l'état sauvage. La revue est en même temps une plate-forme pour la diffusion d'informations concernant les activités des Groupes de Spécialistes des Eléphants Africains, des Rhinos Africains et des Rhinos Asiatiques de la Commission pour la Survie des Espèces de l'UICN (CSE).

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### Notes de terrain :

Le journal accepte volontiers des notes de terrain. Elles peuvent contenir une figure et/ou un tableau mais doivent être brèves.

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*Pachyderm* invite les auteurs à soumettre des critiques d'ouvrages récemment publiés dans la limite de 1 500 mots.

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