IUCN – The World Conservation Union

1999

Status Assessment of Chameleons in Madagascar

by

Lee D. Brady and Richard A. Griffiths

This report was published by IUCN – The World Conservation Union. The field research was made possible by a grant from the European Commission and from the CITES Secretariat.

Citation: Brady, L. D. and Griffiths, R, A. 1999. *Status Assessment of Chameleons in Madagascar*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

Series Editor: Alison Rosser, IUCN Species Survival Commission Wildlife Trade Programme, Cambridge, UK.

Text Layout By: Victoria Freeman, IUCN Species Survival Commission Wildlife Trade Programme, Cambridge, UK

Cover Illustration By: Hermione Stewart

Printed By: Victoire Press, Cambridge, UK

Available From: IUCN SSC Wildlife Trade Programme
219 Huntingdon Road
Cambridge CB3 0DL
UK

Table of Contents

Tables

Figures

Appendices

Preface

The Significant Trade Process of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) provides a mechanism to identify species that are subject to unsustainable levels of international trade. The Animals Committee and CITES Secretariat then consult with individual Parties to determine the measures necessary to ensure that trade in the species concerned becomes sustainable. In some cases there is insufficient information on the population, distribution and life history parameters and insufficient monitoring of the levels and impacts of trade to enable CITES non-detriment findings to be made reliably. In the early 1990's recognizing this lack of information, IUCN – The World Conservation Union, through its Wildlife Trade Programme, associated with the Species Survival Commission, started to develop field projects to assess the status of certain CITES Species.

Following the Significant Trade Review of 1993, the CITES Animals Committee recommended an investigation of the biological basis for determining whether exports of chameleons from Madagascar are non-detrimental to the survival of species. The Direction Générale des Eaux et Forêts (DEF) asked IUCN for assistance to develop a project to undertake field assessments of the status of Madagascar chameleons. The project has been generously supported by the European Commission and the CITES Secretariat.

The Wildlife Trade Programme, in conjunction with national governments has undertaken several such field assessment projects. However, this study differs from earlier ones in attempting to collect information on a number of species and to estimate population numbers over an area the size of Madagascar. In addition to providing population estimates for several species of chameleon, the authors, working with students from the University of Antananarivo, have also developed a field assessment methodology that can be used for future rapid assessments of chameleon status. It is to be hoped that this methodology can be used in conjunction with the experimental management plan developed under the auspices of DEF.

This report has benefited from the comments of a number of reviewers knowledgeable about both the CITES processes and the challenges of CITES implementation in Madagascar. Reviewers and authors alike have drawn attention to the large degree of uncertainty associated with the calculation of national population estimates for the species studied. However, these high confidence limits are not surprising given the degree of extrapolation necessary to calculate national population estimates and are largely due to the variability of chameleon distribution and their differing microhabitat requirements. Indeed, the variability of such results serve to highlight the need to undertake local population monitoring in areas where chameleon collection occurs and underlines the need for national management to be based on local management, wherever possible. Although the status assessment project was initiated at the request of DEF and the CITES Secretariat, unfortunately the report has not benefited from comments by DEF.

Acknowledgements

We are obliged to the Direction des Eaux et Forêts (DEF), Association National pour le Gestion des Aires Protégées (ANGAP) and Université de Antananarivo for all permissions to undertake research and field support.

We gratefully acknowledge the help and support of all staff from the Malagasy Institut pour le Conservation de Environements Tropicale (MICET). In particular, we would like to thank Benjamin Andriamihaja and Liva Ravelonarivo who turned our numerous logistical problems into numerous solutions. Cabin Manager Aimée's efficiency and good humour made our stay at Ranomafana particularly pleasant. We are also indebted to Dr. Joanna Durbin, Hasina Randriamanampisoa and Hanitra Lewis from the Durrell Wildlife Conservation Trust for providing a safe haven in Tana for both us and our equipment.

We are especially grateful to Dr. Daniel Rakotondravony for his support and recommendation of several students, all of whom contributed significantly to this project. In particular, we would like to acknowledge the work of Michel Bisoa, Jeanneney Rabearivony, Vola Raherisoa, Domoina Rakotomalala, Hery Rakotondravony, Christian Randrianatoanoro and Bertrand Razafimahatratra.

Several British students (and one wife) also accompanied us, and although they ate more rice, drank more beer and generally didn't work as hard as our Malagasy friends, we would like to thank them non-the-less. Therefore, we tip our proverbial glasses to Richard Jenkins, Jessica Metcalf, Jonas Tam-Alkis and Sharon Tam-Alkis.

All interviews with collectors, intermediaries and exporters were organised and conducted by Andry Ravoninjatovo and Falitiana Rabemananjara. Additional field work was undertaken by Mamitina Andriamaro, M. 'Ndrina' Kotonirina, E. 'Réné' Rakotoarivao, Marcel Rakotoarimanana, J.ean Claude Rakotoniaina, Samuel Rakotondrajemy, Prosper Rakotondrasoa, William Ramamonjisoa, Victor Rasendrinirina, Jiojio Razafimarolahy, A. 'Zak' Razakatiana, J. Rehotsy, Laurent Rondrianantoandro, Olivier Sam Mamy and Justin Solo.

Without doubt our experience of working in tropical forests was greatly enhanced by the culinary skills of Maurice Nohela, Patrice Rakotondrasoa, James Randriaedson, Victor Rasendrinirina, Heriniaina Fanomezantsoa Randrianarimanga and Môka Tovoniaina.

The map of Madagascar (Fig. 2.1) was kindly provided by Dr. Franco Andreone, while permission to use the primary vegetation GIS data and map (Fig. 3.4) was granted by Dr. David Du Puy and Dr. Justin Moat (Royal Botanical Gardens, Kew). Minimal Convex Polygons and vegetation estimates were calculated by Bob Smith (DICE). Net CITES import data were provided by Dr. John Caldwell (World Conservation Monitoring Centre).

Feedback from Ardi Abate, Richard Jenkins, Juliet Kauffmann, Olaf Pronk, Alison Rosser, Marcus Rowcliffe and nine IUCN appointed referees helped to improve this manuscript.

All chameleon data used to develop recommendations for this project were collected during field-work supported financially by the Commission of the European Community, CITES and the British Government's Darwin Initiative for the Preservation of Species. Thanks to Alison Rosser (IUCN) and Valerie Richardson (DETR) for co-ordinating respective grants.

Finally, a big thank you to Brionny for letting Lee go and, more importantly, letting him come back.

Summary

Recent reports indicate that some species of Malagasy chameleon may be threatened by habitat loss and collection for western pet markets. However, neither the status of chameleon populations nor the impact of these threats are well understood. The aim of this project was to provide assistance to the Madagascar CITES Management Authority by collecting information on the status of chameleons for which recent trade levels have given rise to concern. Species identified as most at risk by the CITES Animals Committee include *Calumma brevicornis, C. globifer, C. nasuta, C. parsonii, Furcifer antimena, F. balteatus, F. campani, F. minor* and *F. willsii*. Additional information was also collected for all other species encountered during field work.

Field surveys were conducted from November 1998 to January 1999 in Mantadia National Park, Analamazoatra Special Reserve and the surrounding area (630 man days). Nine spatially distinct areas were selected across this region that differed in their apparent levels of forest disturbance. Chameleon densities were also estimated from previous fieldwork undertaken at Ranomafana National Park and Andranomay Forest (1 050 man days). Continued summer monitoring at Ranomafana allowed the investigation of annual population fluctuations for some species.

Chameleons were sampled at night using randomly located line transects. Transects were surveyed by teams of two persons at a rate of between 0.8 to 1.2 m per minute. All chameleons were identified to species, sexed and staged. Exact roost position (distance along transect, perpendicular distance from transect and roost height) was recorded, along with the time to process each individual. Population densities were estimated using distance sampling. Distribution maps were prepared from data collected from both this project and all other available literature sources. Range sizes for each species were estimated using Minimum Convex Polygons and the extent of suitable habitat remaining within each species' range estimated using GIS. National population levels were estimated by multiplying local population densities (based on minimum and maximum 95% confidence intervals) by the remaining area of suitable habitat within each species' recorded range.

Villages located near each study site were also visited and Participatory Rural Appraisal techniques used to determine the perceptions of local people to herpetofauna and conservation. Additional interviews with collectors and exporters were used to investigate key aspects of chameleon trade. A review of the capture permit and CITES export permitting systems was conducted in conjunction with the Madagascar CITES Management Authority in Antananarivo.

Chameleons were found to display highly structured populations with distinct lifestage groupings. Due to the paucity of published data, it was only possible to calculate approximate estimates for range reduction. For species that are thought to occupy primary habitat, range occupancy was found to be very low; varying between 3% (*F. willsii*) and 44% (*F. antimena*). Reports of extensive habitat loss and fragmentation within the recorded range of each species have probably led to significant declines in national populations. Local population densities of rainforest chameleons in Ranomafana National Park were found to display little annual variation. However, densities displayed considerable variation between different study sites, including areas located within contiguous blocks of forest. Such variation resulted in widely differing minimum and maximum national population estimates and highlights the need for more detailed long-term research aimed at unravelling the mechanisms responsible for regulating chameleon populations.

Trade in chameleons escalated in the early 1990's and for most species peaked in 1993/94. Interviews with collectors, intermediaries and exporters revealed post-capture mortality rates of up to 50%, with some intermediaries shipping compensatory quantities 10 – 25% above those ordered by exporters. The price structure of the chameleon trade in Madagascar is poorly regulated, with considerable price differentials between collector, intermediary and exporter. A trade moratorium has been recommended by the CITES Standing Committee for all species except *F. lateralis, F. oustaleti, F. pardalis* and *F. verrucosus*. Trade in these four permissible species has continued to rise, and in 1999

export quotas of 2 000 individuals per species were imposed by the Madagascar CITES Management Authority as part of a new Adaptive Management Programme.

Although chameleons are used for some traditional practices, the small quantities utilised by local communities are not considered to threaten wild populations. However, non-sustainable commercial collection for international trade could deplete local populations, including those species that are considered relatively abundant. Future sustainable use programmes should therefore aim to establish quotas based on site specific population estimates using rapid assessment techniques, with harvest rates monitored using ecological and bio-economic models.

To date, reptile breeding centres have not produced significant quantities of captive bred individuals, and almost all chameleons that have been commercially exported from Madagascar have been collected from wild populations. Until it is possible to reliably distinguish between wild caught and captive bred specimens we therefore believe that there should be no export of captive bred chameleons from Madagascar.

This study has developed monitoring methods and a draft management plan is include as an annex to promote further discussion.

Résumé

Selon des rapports récents, certaines espèces de caméléons de Madagascar seraient menacées par la destruction de l'habitat et le prélèvement pour les marchés occidentaux d'animaux de compagnie.

Toutefois, ni l'état des populations de caméléons ni les conséquences des menaces ne sont bien compris. Le présent projet avait pour but d'aider l'Organe de gestion CITES de Madagascar à rassembler des informations sur les caméléons dont la situation est préoccupante en raison des volumes atteints récemment par le commerce. Les espèces qui, selon le Comité pour les animaux de la CITES, sont les plus menacées sont: *Calumma brevicornis*, *C. globifer*, *C. nasuta*, *C. parsonii*, *Furcifer antimena*, *F. balteatus*, *F. campani*, *F. minor* et *F. willsii*. Des informations ont aussi été rassemblées sur toutes les autres espèces rencontrées durant le projet.

Des études de terrain ont eu lieu de novembre 1998 à janvier 1999 dans le Parc national de Mantadia, la Réserve spéciale d'Analamazoatra et la région environnante (630 hommes/jours). Neuf zones séparées, qui différaient par le degré apparent de perturbation subie par les forêts, ont été sélectionnées.

La densité des caméléons a également été estimée d'après des travaux de terrain précédents menés dans le Parc national de Ranomafana et dans la Forêt d'Andranomay (1050 hommes/jours). Une surveillance continue durant l'été, à Ranomafana, a également permis d'étudier les fluctuations annuelles des populations de certaines espèces.

Les caméléons ont été échantillonnés la nuit, dans des lignes-transects placées au hasard. Les transects ont été parcourus par des équipes composées de deux personnes à la vitesse de 0,8 à 1,2 m par minute. Pour tous les caméléons, l'espèce, le sexe et le stade de vie ont été déterminés. La position exacte des sites de repos (distance le long du transect, distance perpendiculaire au transect et hauteur) a été enregistrée ainsi que le temps d'étude de chaque individu. La densité de population a été estimée par échantillonnage des distances. Des cartes de distribution ont été réalisées à partir des données obtenues dans le cadre du projet et de toutes les autres sources disponibles de la littérature. Les dimensions de l'aire de répartition de chaque espèce ont été estimées à l'aide de polygones convexes minimums puis on a calculé l'étendue de l'habitat adéquat restant à l'intérieur de l'aire de répartition de chaque espèce, à l'aide du SIG. L'estimation de la population nationale a été calculée en multipliant la densité locale de chaque espèce (selon des intervalles de confiance minimaux et maximaux de 95%) par la superficie d'habitat adéquat restant dans l'aire de répartition calculée pour chaque espèce.

Les villages situés près de chaque site d'étude ont également été visités et des techniques d'Évaluation rurale participative ont servi à déterminer comment la population locale perçoit l'herpétofaune et la conservation. D'autres entretiens avec des pourvoyeurs de caméléons et des exportateurs ont permis de mettre en lumière certains aspects clés du commerce des caméléons. Une étude des permis de capture et des systèmes CITES de permis d'exportation a eu lieu en collaboration avec l'Organe de gestion CITES de Madagascar à Antananarivo.

Les caméléons sont organisés en populations extrêmement structurées et regroupées de manière distincte selon le stade de vie. Étant donné la rareté des données publiées, nous n'avons pu obtenir qu'une estimation extrêmement rudimentaire de la réduction des aires de répartition. Pour les espèces qui occuperaient des habitats primaires, le taux d'occupation de l'aire de répartition est apparu très faible, variant entre 3% pour *F. willsii* et 44% pour *F. antimena*. La destruction et la fragmentation marquées de l'habitat dans l'aire de répartition de chaque espèce sont probablement les causes du déclin significatif du nombre d'individus au niveau national. Dans le Parc national de Ranomafana, les densités locales de caméléons de forêt ombrophile présentaient peu de variations annuelles. En revanche, les variations étaient considérables entre différents sites d'étude, même dans des blocs d'habitat contigus. Ces variations ont donné lieu à des estimations minimales et maximales des

populations nationales très variables ce qui souligne la nécessité de mener des travaux de recherche plus précis et à long terme dans le but de révéler les mécanismes de régulation des populations de caméléons.

Il y a eu une escalade du commerce des caméléons dans les années 1990 qui a culminé, pour la plupart des espèces, en 1993-1994. Des entretiens avec des pourvoyeurs, des intermédiaires et des exportateurs révèlent des taux de mortalité post-capture s'élevant à 50%; certains intermédiaires expédient même des quantités compensatoires 10 à 25% supérieures à la commande des exportateurs.

La structure des prix du commerce des caméléons à Madagascar est mal réglementée et il existe des différentiels de prix considérables entre le pourvoyeur, l'intermédiaire et l'exportateur. Un moratoire sur le commerce a été recommandé par le Comité permanent de la CITES pour toutes les espèces à l'exception de: *F. lateralis*, *F. oustaleti*, *F. pardalis* et *F. verrucosus*. Le commerce autorisé de ces quatre espèces a continué d'augmenter et, en 1999, l'Organe de gestion CITES de Madagascar a imposé des quotas d'exportation de 2000 individus par espèce dans le cadre d'un nouveau Programme de gestion adaptative. Bien que des caméléons morts soient utilisés pour certaines pratiques traditionnelles, nous estimons que les petites quantités utilisées par les communautés locales ne sauraient constituer une menace pour les populations sauvages. En revanche, le prélèvement non durable à des fins commerciales, pour le marché international, pourrait décimer des populations locales, y compris d'espèces qui sont considérées comme relativement abondantes. À l'avenir, les programmes d'utilisation durable devraient viser à fixer les quotas d'après les densités de populations spécifiques à chaque site et le taux de prélèvement devrait être surveillé à l'aide de modèles écologiques et bioéconomiques.

À ce jour, les centres d'élevage en captivité n'ont pas réussi à produire des quantités importantes d'individus et presque tous les caméléons exportés commercialement de Madagascar sont capturés dans la nature. Tant qu'il ne sera pas possible de déterminer de manière fiable si un spécimen a été prélevé dans une population sauvage ou s'il provient d'un élevage en captivité, nous sommes d'avis que Madagascar ne devrait pas exporter de caméléons élevés en captivité.

1. Introduction

Madagascar's exceptionally rich biodiversity depends upon habitats that are under increasing pressure from habitat loss (e.g. Green and Sussman, 1990). Chameleons are of particular conservation interest by virtue of their high degree of endemism, interest to tourists and high price in western pet markets. Yet despite this high profile, previous research on chameleons in Madagascar has mainly focused on inventories and distribution, rather than ecology and conservation (e.g. Raxworthy, 1988, 1991; Raxworthy and Nussbaum, 1994, 1997).

1.1 Taxonomic Classification

Chameleons are Old World lizards that belong to the family Chamaeleonidae (= Chamaeleontidae). In recent years the classification of chameleons below the family level has been subject to considerable debate. Until recently most authors (e.g. Mertens 1966; Brygoo, 1971; 1978) divided Malagasy species into two genera: *Brookesia* and *Chamaeleo*. However, since this system did not adequately explain chameleon biogeography, Klaver and Böhme (1986) re-examined museum specimens and proposed a new classification based largely on hemipenis morphology. Although they have recently abandoned their proposed subfamily subdivision, Klaver and Böhme (1997) continue to recognise three genera for Malagasy species: *Brookesia*, *Calumma* and *Furcifer*. This classification is supported by biochemical analysis (Hofman *et al.*, 1991) and has been adopted by most recent fieldworkers (e.g. Glaw and Vences, 1994; Raxworthy and Nussbaum, 1994; Jenkins *et al.*, 1999).

However, documents published by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) continue to use the term *Chamaeleo* to describe all Malagasy chameleons listed on CITES Appendix II (e.g. CITES Secretariat, 1994, 1995). Throughout the current report we have adopted the modern classification (*Calumma* and *Furcifer*), with the term *Chamaeleo* only used when specifically cited within a CITES document.

1.2 Recent Trade History

A review in 1991 found that approximately 8% of the Malagasy chameleon species listed on CITES Appendix II were traded at levels likely to be a threat to wild populations (WCMC, 1991). Some of the species traded were known only from a single museum specimen (e.g. *F. belalandaensis*) and were considered too rare for collection. In March 1994 concerns over the identification of exported chameleons resulted in CITES issuing Notification to the Parties No. 784 (CITES Secretariat, 1994). Through this document all Parties were urged not to accept export documents issued by the Management Authority of Madagascar (Direction Générale des Eaux et Forêts; DEF) that did not accurately identify the species being traded.

The population ecology of all chameleon species reported as being present in the trade was very poorly understood, with not even preliminary estimates of population density being published. The impact of trade was 'unknown, but believed to be insignificant' for 47% of the 34 traded *Chamaeleo* (= *Calumma* and *Furcifer*) species, but 41% were too poorly known for an appraisal to be made (IUCN/SSC Trade Specialist Group *et al.*, 1993). On the basis of the 1989-1993 trade figures, the most heavily traded species of chameleon were *Chamaeleo* [*Calumma*] *brevicornis*, *Chamaeleo* [*Calumma*] *globifer*, *Chamaeleo* [*Calumma*] *nasutus*, *Chamaeleo* [*Calumma*] *parsonii*, *Chamaeleo* [*Furcifer*] *antimena*, *Chamaeleo* [*Furcifer*] *balteatus*, *Chamaeleo* [*Furcifer*] *campani*, *Chamaeleo* [*Furcifer*] *lateralis*, *Chamaeleo* [*Furcifer*] *minor*, *Chamaeleo* [*Furcifer*] *oustaleti*, *Chamaeleo* [*Furcifer*] *pardalis*, *Chamaeleo* [*Furcifer*] *verrucosus*, *Chamaeleo* [*Furcifer*] *willsii*. CITES became increasingly concerned over these rapidly escalating chameleon exports and complete lack of scientific data to support the Appendix II stipulation that 'export will not be detrimental to the survival of the species'. Therefore, in January 1995 the CITES Standing Committee recommended that from 1996 all Parties suspend imports of chameleons from Madagascar belonging to the genus *Chamaeleo*, with the exception of *Chamaeleo* [*Furcifer*] *lateralis*, *Chamaeleo* [*Furcifer*] *oustaleti*, *Chamaeleo* [*Furcifer*] *pardalis* and *Chamaeleo* [*Furcifer*] *verrucosus* (CITES Secretariat, 1995).

Despite the presence of several members of the genus *Brookesia* in the trade (particularly *B. peramarta*; IUCN/SSC Trade Specialist Group *et al.*, 1993), these potentially threatened species have not yet been included on any CITES Appendix.

1.3 Aim and Objectives

The aim of this project was to assist the Madagascar CITES Management Authority to collect information relevant to the status of chameleons for which recent trade levels have given rise to concern over threats to wild populations. The species targeted for this study were selected based on the rationale that the species being traded in the highest quantities represented the highest priority for research.

Specific objectives included:

1. The collection of recent reports and literature sources to update information on present range, estimate the area of distribution and estimate the possible extent of range reduction, in light of reports of extensive deforestation.

2. The estimation of population sizes in different types of habitat and in areas subject to different levels of human impact, including comparisons between exploited and non-exploited populations. The estimation of minimum and maximum population sizes based on estimated population densities and evaluation of the extent of different habitat types within the species' range.

3. The collection of life history data, including information on habitat preferences, movements, food, nesting requirements, seasonality and reproductive biology.

4. The investigation and documentation of aspects of exploitation. Using interviews with CITES Authorities, collectors, exporters and literature, aspects included:

   a) current levels of exploitation, legal and illegal, for international and domestic markets

   b) levels of collecting and trade prior to the moratorium (CITES data and regional capture permit records etc)

   c) methods of harvesting

   d) pre-export mortality rates at different stages of trade; and

   e) the origin of chameleons in trade and, to the extent possible, the approximate proportion of chameleons derived from farming.

5. The examination, to the extent possible, of benefits to local communities derived from past harvesting of chameleons and assessment of incentives for collecting.

6. The identification of factors other than exploitation that affect or potentially affect the survival of wild populations and assessment of their importance relative to trade (e.g. deforestation).

7. The provision of recommendations concerning future management of chameleons, with regard to:

   a) whether the present moratorium should continue and for how long; and

b) if the moratorium can be lifted, what measures would need to be implemented to ensure future sustainable exploitation, especially with regard to setting trapping and export quotas and future monitoring and management plans.

2. Survey Sites and Methods

2.1 Fieldwork Schedule

Fieldwork specifically targeted at this project was limited to a three month period between November 1998 and January 1999. Due to both time and logistical constraints we were unable to sample sites distributed across the whole of Madagascar. Instead, we focussed on a single 'site' (defined as the Mantadia region) that was known to contain at least four of the species for which population data had been requested. At this site we were able to conduct intensive quantitative surveys across nine different areas, allowing us to determine the variability of our density estimates between forest patches that were subject to different levels of disturbance. A brief visit was also made to Ambohitantely Special Reserve. Although it was not possible to collect density data from this site we were able to undertake a limited inventory based survey that has helped to extend the known range of at least three species (for map illustrating the location of each site refer to Fig. 2.1).

In order to provide population estimates for other species, we have included additional data from previous fieldwork undertaken at Ranomafana National Park and Andranomay Forest. Our continued summer monitoring programme at Ranomafana (Vatoharanana) has also allowed us to investigate annual fluctuations in the population densities of several species.

During each period of fieldwork 2 to 5 research teams (comprising students from the Université d'Antananarivo, local guides and British researchers) worked in parallel, carrying out simultaneous surveys in different areas within each study site.

2.2 Study Sites

2.2.1 Ranomafana National Park

Located 60 km from the province of Fianarantsoa, Ranomafana was inaugurated on 31 May 1991 when it became Madagascar's fourth national park (Wright, 1997). It is composed of 43 500 ha of rainforest and is situated between 800 and 1 200 m above sea level (m. a. s. l.), with a mean daily temperature ranging from 3 to 35 °C (Razafimamonjy, 1988). Rainfall averages 2 600 mm per annum and is unevenly distributed over *c*. 200 days. The national park is surrounded by a 3 km wide peripheral zone within which are located 93 villages, containing some 25 000 people (Grenfell and Robinson, 1995). Two areas (Talatakely and Vatoharanana) that contrasted in their recent history of timber exploitation were selected as study plots (Table 2.1). Each site was surveyed at least twice, once during the Malagasy summer (1996/97) and once during the following winter (1997). The least disturbed site (Vatoharanana) was selected for annual summer monitoring, with quantitative surveys continuing in 1997/98 and 1998/99.

2.2.2 Andranomay Forest

This area of unprotected forest is located approximately 57 km Northeast of Antananarivo (Rakotondravony and Goodman, 1998a). The forest is steep and mountainous and experiences an average annual rainfall of 1 200 mm, while the average temperature ranges from 12.7 to 18.3 °C (Donque, 1975). Like many other unprotected areas in Madagascar, Andranomay Forest is heavily exploited by local people. Such disturbance includes slash and burn agriculture (tavy), uncontrolled fires (often following the smoking of bees' nests to facilitate the collection of honey) and logging. Rakotondravony and Goodman (1998b) have recommended that this area should be included within Madagascar's network of protected areas. Two sites that differed in their degrees of fire disturbance were selected as study plots (Table 2.1) and surveyed during November - December 1997.

Figure 2.1. Location of Study sites in Madagascar (map courtesy of F. Andreone).

Table 2.1. Location, altitude and habitat information for each study area surveyed during this project.

Site	Area	Camp Location	Camp Altitude (m)	Habitat
Ranomafana National Park	Vatoharanana	21° 15' S 47° 25' E	1045	Mid-altitude rainforest recently subject to light selective logging.
	Talatakely	21° 15' S 47° 25' E	931	Mid-altitude rainforest recently subject to intensive exploitation for timber. Introduced *Guyava* present.
Andranomay Forest	Burnt Forest	18° 28' S 47° 57' E	1365	Mid-altitude rainforest heavily disturbed by tavy and uncontrolled fires 6 to 18 months before being surveyed.
	Unburnt Forest	18° 28' S 47° 57' E	1365	Mid-altitude forest subject to continued selective logging. Forest bordered by ricefields and heathland.
Mantadia Region	Analamazaotra Special Reserve	18° 56' S 48° 24' E	916	Mid-altitude rainforest subject to light selective logging more than 25 years ago.
	Sahanody	18° 47' S 48° 25' E	977	Mid-altitude rainforest subject to light selective logging more than 25 years ago.
	Andranomanamponga	18° 49' S 48° 26' E	952	Mid-altitude rainforest recently subject to selective logging and some tavy.
	Sity Forest	18° 55'S 48° 29' E	865	Mid-altitude rainforest subject to continued selective logging and tavy.
	Vohidrazana	18° 58' S 48° 30' E	875	Mid-altitude rainforest subject to continued selective logging and tavy.
	Maramiza	18° 58' S 48° 27' E	1010	Mid-altitude rainforest subject to continued selective logging and tavy.
	Mahanara	18° 50' S 48° 27' E	1066	Mid-altitude rainforest recently subject to intensive exploitation for timber.
	Analamazaotra Forest Station	18° 56' S 48° 24' E	916	Mid-altitude rainforest recently subject to intensive exploitation for timber. Introduced *Eucalyptus* and *Pinus* present.
	Analamazaotra Periphery	18° 56' S 48° 24' E	916	Roadside scrub habitat on edge of mid-altitude rainforest.
Ambohitantely		18° 11' S 47° 16' E	1579	Plateau rainforest recently subject to selective logging. Forest bordered by heathland.

2.2.3 Mantadia Region

This site is defined as the area surrounding both Analamazoatra Special Reserve (810 ha, Stephenson, 1993) and Mantadia National Park (9 875 ha; Shyamsundar and Kramer, 1996) and is located near the village of Andasibe (Périnet) some 30 km east of Moramanga. The altitude in this region ranges from

698 to 1 106 m. a. s. l. with average temperatures varying between 13.8 and 24.5 °C. Only a small proportion of the region is covered by primary forest, with the remaining areas dominated by invasive heliophilous plants and hill rice, most of which is cultivated illegally through tavy. All remaining forest not contained within the two protected areas is also subject to logging by local people. A French mining company operates on the periphery of Mantadia National Park and in the past has been granted logging concessions in areas that are now protected (e.g. Mahanara). We selected nine areas (detailed in Table 2.1) across this region that differed in their apparent levels of forest exploitation. All surveys in this region were conducted between November 1998 and January 1999.

2.2.4 Ambohitantely Special Reserve

This highly fragmented forest area is located on the Central High Plateau at *c*. 1 500 m. a. s. l. The special reserve covers an area of 5 600 ha, of which 50% is natural forest, 35% is anthropogenic grassland savannah (+ heather moorland) and 15% is exotic plantation (Langrand and Wilmé, 1997). The remaining primary forest consists of 2 737 ha distributed across 513 forest fragments, most of which (78%) are less than 3 ha. Only three fragments are larger than 50 ha, the largest being 1 250 ha. It was only possible to visit this area for a very short period of time (3 days) in January 1999. However, during this visit preliminary inventory surveys were completed within river valleys, across ridge tops and along the edges of forest fragments.

2.3 Chameleon Study Species

Information relevant to the status of nine chameleon species was requested by the CITES Animals Committee (Table 2.2). Data on all other species encountered during fieldwork was also collected and although we have only included additional national population estimates for *C. oshaughnessyi*, local density estimates have been calculated for all *Calumma* species recorded along line transects during our study. The four species that are still legally exported from Madagascar (*C. lateralis, C. oustaleti, C. pardalis, and C. verrucosus*) were not found within our study areas (*F. lateralis* was present at three sites, but only in locations not sampled by line transects) and we have therefore only included a preliminary discussion of their status based on recent trade levels.

2.4 Chameleon Survey Methods

2.4.1 Sampling methods

Trail and river/stream systems within each study area were mapped using a simple compass traverse (after Debenham, 1963; and fully described by Tam-Alkis, 1997). Marker pegs were positioned at 50 – 100 m intervals and line transects randomly assigned to a sub-sample of these predetermined locations. Transects were stratified based on topography (river valley, non-river valley and ridge top).

Transects (for total effort refer to Table 2.3), each consisting of three fully extended 150 m tape measures and arranged in parallel with a 20 m separation, were surveyed by teams of two people (following the methodology developed by Brady *et al.*, 1996 and Jenkins *et al.*, 1999). Each transect was sited *c.* 5 m from the nearest trail, with transect orientation derived from a random compass bearing (obtained from a thrown stick). In order to limit the effects of disturbance on the distribution of chameleons within the transect area, transects were arranged at least 24 hours before being surveyed.

Table 2.2. Malagasy chameleon species included in this study and their known distribution at each study site (1, Ranomafana; 2, Andranomay; 3, Mantadia; 4, Ambohitantely).

Genera	Species	Authority	Distribution
Chamaeleo [*Calumma*]	*boettgeri*[3]	(Boulenger, 1888)	3

Chamaeleo [*Calumma*]	*brevicornis*	(Günther, 1879)	1 2, 3, 4
Chamaeleo [*Calumma*]	*furcifer*[3]	(Vaillant & Grandidier, 1880)	3
Chamaeleo [*Calumma*]	*gallus*[3]	(Günther, 1877)	3
Chamaeleo [*Calumma*]	*gastroataenia*[3]	(Boulenger, 1888)	1, 2, 3, 4
Chamaeleo [*Calumma*]	*glawi*[3]	(Böhme, 1997)	1
Chamaeleo [*Calumma*]	*globifer*	(Günther, 1879)	2, 4
Chamaeleo [*Calumma*]	*malthe*[3]	(Günther, 1879)	3
Chamaeleo [*Calumma*]	*nasuta*	(Duméril & Bibron, 1836)	1, 2, 3, 4
Chamaeleo [*Calumma*]	*oshaughnessyi*[3]	(Günther, 1881)	1 (*C. o. oshaughnessyi*)
Chamaeleo [*Calumma*]	*parsonii*[1]	(Cuvier, 1824)	3 (*C. p. cristifer*)
Chamaeleo [*Furcifer*]	*antimena*[2]	(Grandidier, 1872)	-
Chamaeleo [*Furcifer*]	*balteatus*[1]	(Duméril & Bibron, 1851)	1
Chamaeleo [*Furcifer*]	*campani*[2]	(Grandidier, 1872)	-
Chamaeleo [*Furcifer*]	*minor*[2]	(Günther, 1879)	-
Chamaeleo [*Furcifer*]	*willsii*[1]	(Günther, 1890)	1, 2, 3

[1] Species for which only limited distribution/population data could be collected.

[2] Species occurring outside of study sites, for which only trade data could be collected.

[3] Species not reported as heavily traded but for which additional density data have been collected.

Roosting chameleons become very pale at night (Parcher, 1974) and are therefore relatively easy to detect with torch light (e.g. Raxworthy, 1988, 1991; Jenkins *et al.*, 1999). Therefore, surveyors were equipped with *Petzl* 'Mega' head-lamps (fitted with standard, non-halogen, bulbs) and, working at night, moved slowly along each line searching opposite sides for roosting chameleons. Survey time was recorded for each transect, with search speed dependent upon observer and terrain (typical speeds ranged from 0.8 to 1.2 m per minute). Variability in search effort between different observers was controlled by randomly assigning observers to teams on each survey occasion.

The following data were collected for all chameleons encountered along line transects:

> Species; sex; lifestage; distance along transect line (m); perpendicular distance (m) to chameleon; roost height (m); other roost information (e.g. posture and plant type); and processing time (min).

Table 2.3. Summary of sampling effort (man days) and (m searched) at each study site (interviews with collectors, exporters and their intermediaries are not included).

Year	Season	Effort (man days and meters searched)					
		Ranomafana		Andranomay		Mantadia	
		mdays	m	mdays	m	mdays	m
1996/1997	Summer	280	9 007	-	-	-	-
1997	Winter	280	9 494	-	-	-	-
1997/1998	Summer	140	4 800	210	8 800	-	-
1998/1999	Summer	140	4 800	-	-	630	27 526
TOTALS		**840**	**28 101**	**210**	**8 800**	**630**	**27 526**

Chameleon identifications were based on the keys, illustrations and descriptive notes published by Brygoo (1971, 1978) and Glaw and Vences (1994). Lifestage was classified as 0+, 1+ or 2+ (based upon the hatchling, juvenile and adult system of Jenkins *et al.* (1999), but without any preconceived assumptions concerning sexual maturity). Some animals were removed from their perches and taken back to our camp in numbered cloth bags for more detailed morphometric analyses (data not shown). However, all individuals were returned unharmed to their exact roost location the morning following each nocturnal survey session.

2.4.2 Estimating chameleon population density

Distance sampling (fully described by Buckland *et al.*, 1993) is considered to be well suited for the spatial and temporal comparison of chameleon population densities (Jenkins *et al.*, 1999). It provides an estimation of density through the calculation of a detection curve that is derived from a series of perpendicular distances. These distances are measured from a transect line of known length to the object of interest.

The four main assumptions of this method for surveying chameleons along line transects are:

1. Transect lines are placed at random in relation to the objects' distribution (note that it is therefore *not* an assumption that chameleons are randomly distributed).

2. All objects at zero distance from the transect line are detected (this includes chameleons roosting directly overhead, possibly at a great height). Since any ground based survey of arboreal animals is limited by a decreasing vertical detection rate, we conformed to this assumption by applying a vertical ceiling of 6 m to our data (i.e. chameleons roosting above this were excluded from the density calculation).

3. Objects are detected at their initial location, before any movement occurs as a result of disturbance from the observer (this was not found to be a problem for roosting chameleons).

4. Perpendicular distances can be measured accurately (again, this was not found to be a problem for roosting chameleons).

The computer program DISTANCE (v. 2.2, Laake *et al.*, 1993) was used to estimate chameleon densities. Estimates of density for chameleons with few observations are often associated with very high error. Therefore, we have used our results to provide guidance on the minimum acceptable sample sizes required for density estimates (see section 5.4).

2.4.3 Estimating chameleon range and national population sizes

Distribution data collected during the current project were augmented with distribution information previously published by Angel (1942), Brygoo (1971, 1978), Ramanantsoa (1974), Raxworthy (1988), Raxworthy and Nussbaum (1994) and Glaw and Vences (1994). All distribution maps were prepared within the computer program STATVIEW (v. 5.0, SAS Institute Inc., 1998).

Distribution data was transferred to program ARCVIEW (v. 3.1) where it was projected using an Equal-Area Cylindrical Projection over the total known area of primary vegetation derived from the vegetation map of Faramalala (produced in 1988, based on LANDSAT satellite imagery acquired between 1972 and 1979, and digitised by Conservation International, 1995; Du Puy and Moat, 1996). Minimal Convex Polygons were then generated within ARCVIEW to encompass the distribution of each chameleon species, and the remaining area of suitable habitat within each species' range was calculated. Reductions in chameleon range sizes were estimated by calculating the percentage of remaining suitable vegetation remaining within each chameleon's recorded distributional range.

National population levels for each species were estimated based on overall minimum and overall maximum density values (derived from the full range of upper and lower 95% confidence intervals calculated from all study sites) and multiplied by the area of remaining suitable habitat within each species recorded geographic range.

It is important to note that all estimates of chameleon range reduction and national population sizes rely upon the following assumptions:

1. Habitat preference classifications are accurate.

2. Chameleon ranges have not contracted at the edge of suitable habitat areas.

3. Minimal Convex Polygons are a reasonable reconstruction of each species' original range.

4. Suitable habitat completely covered the notional original range of each species.

5. The extent of suitable habitat has not declined since Faramalala's (1988) original appraisal.

2.5 Interview Methods

Villages located near each study site were visited in order to carry out community surveys (n=8). Participatory Rural Appraisal (PRA) techniques were used during interviews with local people to determine their perceptions of herpetofauna, the relative value attached to herpetofauna and how important chameleons are in overall rainforest conservation programmes and local economies.

Additional interviews with collectors and exporters were used to determine the past and present distribution and relative population levels of chameleons (Ravoninjatovo and Rabemananjara, 1999). These interviews also helped in the collection of information on the ecology and seasonal movements of some species, as well as aspects of past trade (e.g. trapping methods and post-trapping mortality levels). A review of permitting systems was conducted in conjunction with officials from the Madagascar CITES Management Authority in Antananarivo.

3. Survey Results

3.1 Chameleon Range Sizes

Information detailing historical chameleon range sizes is mostly anecdotal, and despite recent herpetological inventory surveys (e.g. Raxworthy and Nussbaum, 1997) only limited published data is available for distribution mapping (Fig. 3.3). It was therefore only possible for us to calculate very approximate estimates of range reduction. Based on the remaining area of suitable habitat (Table 3.1, Fig. 3.4) within each species' known range (Table 3.1, Fig. 3.3) we have calculated that the percentage of total range occupied by each species is: *C. brevicornis*, 16%; *C. globifer*, 15%; *C. nasuta*, 28%; *C. oshaughnessyi*, 22%; *C. parsonii*, 21%; *F. antimena*, 44%; *F. balteatus*, 75% (including secondary vegetation); *F. campani*, 99% (including secondary vegetation); *F. minor*, 98% (including secondary vegetation); *F. willsii*, 3%. Assuming that historical occupancy levels approached 100% it can be inferred that those species relying largely upon primary vegetation have suffered significant range reductions through habitat loss (e.g. Green and Sussman, 1990). However, for some species (e.g. *F. balteatus*) these range estimations may overstate true reductions since relatively large areas of unsuitable primary habitat (that were probably never occupied) remain within their geographic range. For other species (e.g. *F. campani* and *F. minor*) high percentage values are probably more indicative of the lack of available data on habitat preference (and the corresponding assumption that species occupy secondary vegetation), than a true reflection of range occupancy.

3.2 Chameleon Ecology Summaries

Although some species are believed to lay several egg clutches each year (Le Berre, 1995), we found chameleons to display highly structured populations with distinct lifestage groupings (Table 3.2). Therefore, although eggs may be laid throughout the year, embryo development is probably inhibited during the winter, and hatchlings from different clutches tend to emerge within a similar time period. Our data from Ranomafana suggests that for most species, hatchlings begin to emerge during December and January, with large numbers of new recruits visible in the population by May. Size differences between lifestages appear to be maintained into adulthood and can be categorised as: 0+ (hatchlings), 1+ (juveniles/young adults) and 2+ (mature adults). Growth curves illustrating these lifestages are shown in Figs. 3.1 and 3.2.

3.2.1 *Calumma brevicornis*

Description: *C. brevicornis* belongs to the *Calumma cucullata*-group, with the 'typical' form morphologically very similar to both *C. cucullata* and *C. malthe*, both of which are sympatric with *C. brevicornis* at some localities (e.g. Mahanara, Mantadia). *C. brevicornis* is a medium to large sized species that can grow up to 370 mm (Brygoo, 1971). It has a greyish, yellow-green or even brownish-red colouration (IUCN/SSC Trade Specialist Group *et al.*, 1993) and during the summer males often develop a bluish tinge to the legs (Glaw and Vences, 1994; L. Brady, pers. obs). Brygoo (1971) has characterised *C. brevicornis* by its well developed occipital lobes (covered by large scales) that are separated behind the head by a small notch. Males have a single, bony nasal appendage. However, Glaw and Vences (1994) consider that the taxon *brevicornis* may in fact represent a species complex that is composed of several distinct taxa.

Table 3.1. Estimated extent of range (km²) for chameleon species included in this study. Range was calculated using Minimum Convex Polygons encompassing known distributions and generated within ARCVIEW (v. 3.1). Estimated area (km²) of suitable remaining habitat within known distribution range of chameleon species included in this study. GIS primary vegetation data was derived from Du Puy and Moat (1996).

Species	Preferred Habitat Types Within Range	Estimated extent of Range (km²)	Estimated Remaining Habitat Within Range (km²)
C. brevicornis	Range (km²)	186 015	
	Evergreen Humid Forest (mid altitude)		28 285
	Evergreen Humid Forest (lower montane)		1 578
C. globifer	Range (km²)	53 606	
	Evergreen Humid Forest (mid altitude)		7 715
	Evergreen Humid Forest (lower montane)		551
C. nasuta	Range (km²)	219 790	
	Coastal Forest (eastern)		195
	Evergreen Humid Forest (low altitude)		28 891
	Evergreen Humid Forest (mid altitude)		31 376
C. oshaughnessyi	Range (km²)	127 641	
	Evergreen Humid Forest (mid altitude)		26 049
	Evergreen Humid Forest (lower montane)		1 482
C. parsonii	Range (km²)	184 592	
	Coastal Forest (eastern)		66
	Evergreen Humid Forest (low altitude)		17 844
	Evergreen Humid Forest (mid altitude)		20 714
F. antimena	Range (km²)	4 283	
	Deciduous Dry Southern Forest and Scrubland		1 876
	Deciduous Seasonally Dry Western Forest		8
F. balteatus	Range (km²)	2 875	
	Secondary Vegetation (including agricultural land)		2 167
F. campani	Range (km²)	23 159	
	Evergreen Humid Forest (lower montane)		31
	Secondary Vegetation (including agricultural land)		22 977
F. minor	Range (km²)	26 057	
	Evergreen Humid Forest (mid altitude)		78
	Secondary Vegetation (including agricultural land)		25 433
F. willsii	Range (km²)	92 705	
	Evergreen Humid Forest (low altitude)		1 518
	Evergreen Humid Forest (mid altitude)		987

Figure 3.1. Scatter plots illustrating population structure of a small bodied chameleon species (*C. nasuta*) during two seasons at Ranomafana National Park (1996-1997).

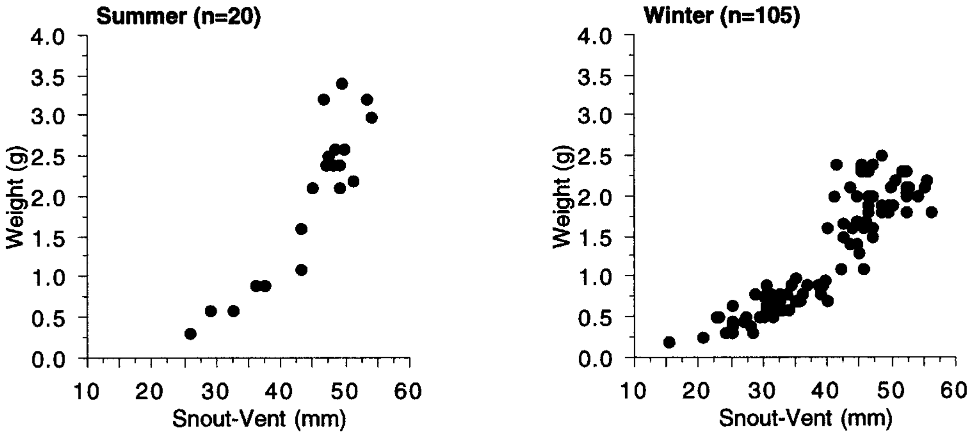
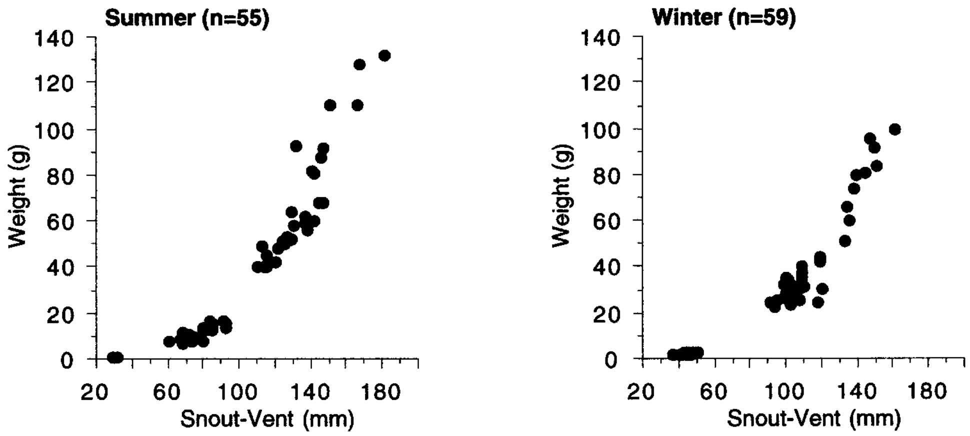


Table 3.2. Population structure of chameleons included in this study. Data represents pooled values from Ranomafana (1996-97 only), Andranomay and Mantadia. The total number of animals for which morphometric measurements were obtained is indicated by n. Estimates for *F. antimena*, *F. balteatus*, *F. campani*, *F. minor* and *F. willsii* are not included due to the lack of available data.

Species	**Season**	**Lifestage (proportion)**			
		n	**0+**	**1+**	**2+**
C. brevicornis	summer	88	0.32	0.13	0.55
	winter	13	0.08	0.08	0.85
C. globifer	summer	45	0.16	0.33	0.51
	winter	-	-	-	-
C. nasuta	summer	164	0.08	0.27	0.65
	winter	224	0.17	0.37	0.46
C. oshaughnessyi	summer	82	0.09	0.44	0.48
	winter	64	0.41	0.11	0.48
C. parsonii cristifer	summer	20	0.35	0.35	0.30
	winter	-	-	-	-

Figure 3.2. Scatter plots illustrating population structure of a large bodied chameleon species (*C. oshaughnessyi*) during two seasons at Ranomafana National Park (1996-1997).

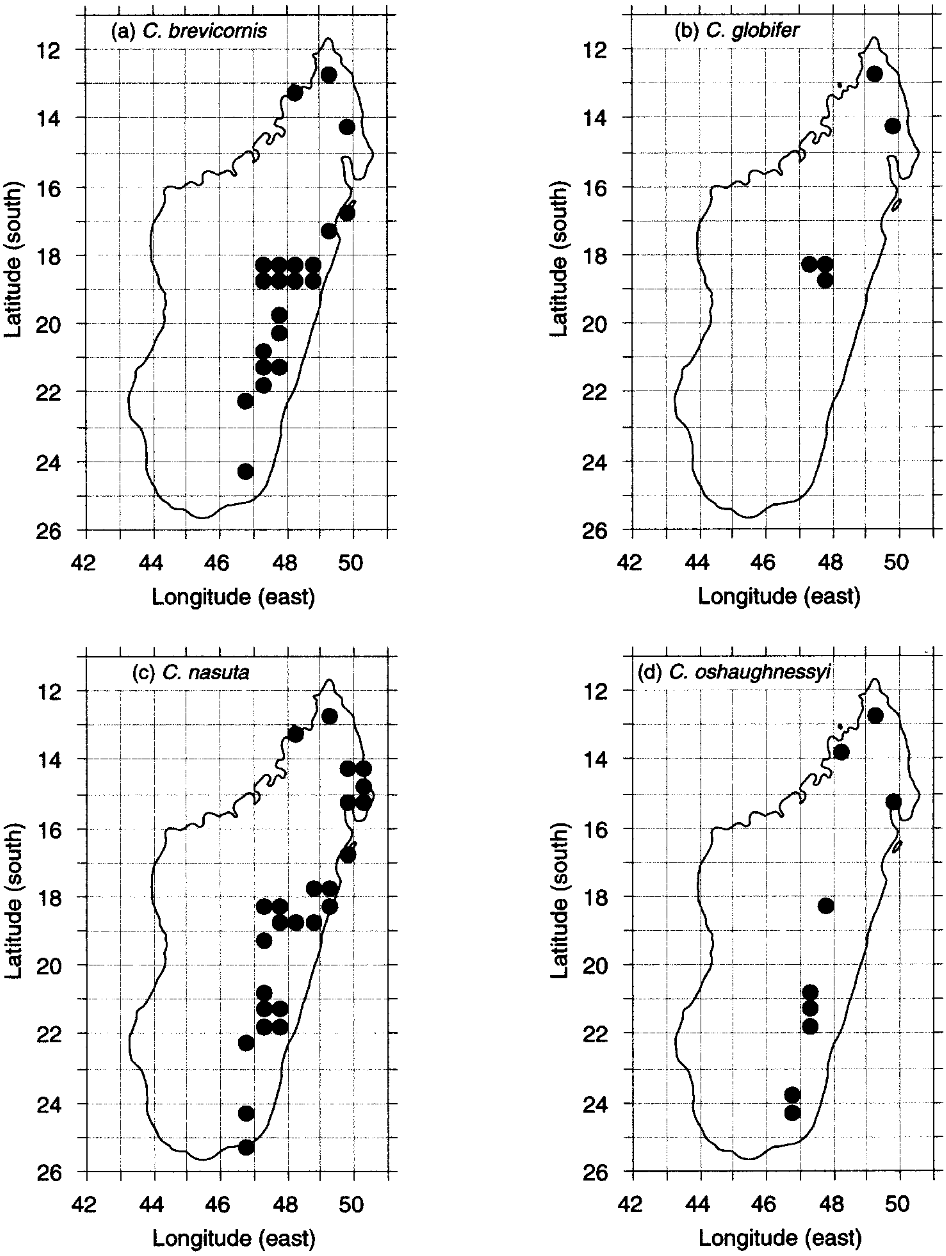


Distribution: *C. brevicornis* is widely distributed across eastern Madagascar (Fig. 3.3a) with a range that extends from Chaines Anosyenne to Montagne d'Ambre (Brygoo, 1978; Raxworthy and Nussbaum, 1994). The recorded altitudinal range of this species is between 900 (Angel, 1942) and 2 100 (Brygoo, 1978) metres above sea level (m. a. s. l.). We have recorded *C. brevicornis* at Ranomafana, Andranomay and Mantadia, although at Mantadia it is rather local and appears to occupy different areas of forest to *C. malthe*.

Habitats: Although *C. brevicornis* is reported to prefer 'wooded areas near running water and ponds' (IUCN/SSC Trade Specialist Group *et al.*, 1993), our observations suggest that this species is more typically encountered in disturbed areas away from water (but still within or close to rainforest). Jenkins *et al.* (1999) found that *C. brevicornis* was more often encountered along forest trails than within the forest interior and our own observations indicate that such a preference for disturbed edge habitat may even extend to roadside scrub (e.g. road running from Analamazaotra to Andasibe) and village gardens (e.g. Vohiparara and Ambatolahy, Ranomafana; Andasibe, Mantadia). Brygoo (1978) has also described specimens that were collected at the summit of the Marojezy mountains (2 000 – 2 100 m); one from within a dwarf palm and several upon the ground amongst grass. However, there is some confusion as to whether these specimens are actually *C. brevicornis* and it and it has been suggested that they may in fact represent a separate (as yet undescribed) species (Glaw and Vences, 1994).

Life History: Kauffmann (1994) has witnessed *C. brevicornis* at Montagne d'Ambre egg-laying in July (a clutch of 13 eggs). However, other workers operating in the same area (Raxworthy, Raselimanana and Ramanamanjato in: IUCN/SSC Trade Specialist Group *et al.*, 1993) have found gravid females (containing at least 12 eggs) between November and January. We have also observed gravid females at both Ranomafana and Andranomay during the same season. Parcher (1974) found that medium sized females bury their eggs (date unspecified) to a depth of 10-15 cm and newly hatched young have been observed at Ranomafana in December (Brady *et al.*, 1996). Le Berre (1995) considers that the clutch size of captive animals can vary from 5 to 16 eggs, with incubation (under artificial conditions) at 22.5 °C taking 5 months and sexual maturity being reached 8 months after hatching.

Figure 3.3. Maps illustrating recorded distribution of chameleon species included in this study.



Despite being described as a 'gregarious species that lives in small groups' (IUCN/SSC Trade Specialist Group *et al.*, 1993), we have found *C. brevicornis* to be highly aggressive and intolerant of other individuals (male or female). Such aggressive tendencies have also been described by Parcher (1974) who observed that displaying individuals mouth gaped, extended their gular sacs and spread their occipital lobes. Such displays between males could lead to fights and severe bites were sometimes inflicted. During the Malagasy winter at Montagne d'Ambre, Kauffmann (1994) calculated that *C. brevicornis* defended home ranges with a mean size of 29 m^2, with no overlap between male and female territories. Such territories were 'defended' without aggression or any obvious display. Kauffmann (1994) also found that, unlike adults, juveniles were not restricted to a defined home range. Juvenile *C. brevicornis* may therefore represent a dispersal phase. Kauffmann (1994) also described an 'inactivity pattern', where chameleons would slowly move from their roost location to a 'resting place' where they maintained a prolonged period of inactivity before returning to their roost.

Such resting places sometimes included leaf litter on the forest floor. An individual's colouration during such periods was often black.

3.2.2 *C. globifer*

Description: This is a large, greenish species that can grow up to 365 mm (Brygoo, 1971). *C. globifer* belongs to the *Calumma parsonii*-group (Glaw and Vences, 1994) and is morphologically very similar to *C. oshaughnessyi*. However, it can be identified by the lack of a dorsal crest and the male's two short, globular nasal appendages (in *C. oshaughnessyi* the nasal appendages are longer). Colouration is dull green and juveniles often possess white spots on the toes (L. Brady, pers. obs.).

Distribution: *C. globifer* is locally distributed in the eastern rainforest (see Fig. 3.3b), ranging from the Betsileo region to Marojejy (Brygoo, 1971, 1978). We have recorded *C. globifer* at Andranomay (mid-altitude rainforest) and Ambohitantely (plateau rainforest). Although it has also been reported from Montagne d'Ambre in the north (Brygoo, 1971), apparently this is now believed to be an identification error (Raxworthy, Raselimanana and Ramanamanjato in: IUCN/SSC Trade Specialist Group *et al.*, 1993). The reported altitudinal range of *C. globifer* is 1000 to 2550 m. a. s. l. (Anon, 1999).

Habitats: Very little published information is available for this species, but it is believed to be a rainforest specialist (Le Berre, 1995; Abate, 1999b). However, as well as recording this species in rainforest we have also found an adult male in a fruit tree within Andranomay village (an area 3 km from the forest edge and surrounded by heathland), but it is not known whether this individual was artificially introduced (local people claimed that it was not).

Life History: We have located both gravid females and hatchlings during December at Andranomay Forest. Le Berre (1995) reports that captive animals produce only a single clutch per year, but with each clutch consisting of 30 to 50 eggs. The incubation period of *C. globifer* (under artificial conditions) at 21 °C is 8 months, and sexual maturity is reached a further 8 months after hatching (Le Berre, 1995).

3.2.3 *C. nasuta*

Description: *C. nasuta* is a small bodied chameleon (growing up to 108 mm) that belongs to the *Calumma nasuta*-group of morphologically similar species (Glaw and Vences, 1994). Colouration is usually brownish to reddish-brown with variable dark brown bands on the flanks (Parcher, 1974). Both males and females possess a single, soft dermal nasal appendage, which has a more rounded shape in females (Raxworthy, 1988).

Distribution: *C. nasuta* is widely distributed in the eastern rainforest (Fig. 3.3c) and has been recorded from Tolagnaro to Nosy Be, where it occurs within both mid and low altitude rainforest (Brygoo, 1971, 1978). Although *C. nasuta* has also been recorded from Montagne d'Ambre (Brygoo, 1978) this is now believed to be an introduction (Raxworthy and Nussbaum, 1994). The species' recorded altitudinal range is 0 (Anon, 1999) to 1 300 m. a. s. l. (Angel, 1942). We have located the species at Ranomafana, Andranomay, Ambohitantely and Mantadia (where it appears to reside in different areas of forest than the closely related *C. gallus*). Our results only partially support Raxworthy and Nussbaum's (1994) claim that *C. nasuta* is allopatric (do not occur together) with the morphologically similar (but larger) *C. boettgeri*. Although we found *C. nasuta* and *C. boettgeri* to be allopatric across most of the Mantadia region, they were sympatric (occur together) in relatively undisturbed forest at Sahanody. Both species were also found at Andranomanoponga, but appeared to be allotopic (occur together but in different parts of the same area), with *C. nasuta* recorded in the more disturbed areas near the forest edge and *C. boettgeri* favouring the forest interior. However, *C. boettgeri* only occurred at a very low density in the Mantadia region (probably due to this area representing its most southerly distribution) and some overlap between the two species may therefore be expected.

Habitats: Although sometimes described as a primary rainforest species (IUCN/SSC Trade Specialist Group *et al.*, 1993), *C. nasuta* is also known to occur in secondary forest and forest edge habitats (Glaw and Vences, 1994; Raxworthy and Nussbaum, 1994). We have located *C. nasuta* in relatively undisturbed mid-altitude rainforest (e.g. Vatoharanana, Ranomafana) and a wide range of forest edge habitats, ranging from roadsides (Ranomafana, Mantadia) and shrubby vegetation alongside railway lines (Mantadia) to heathland (Ambohitantely). Our density results (see section 3.2.3 below) indicate that *C. nasuta* may actually prefer these more disturbed areas.

Life History: The most detailed account of *C. nasuta* was published by Parcher (1974), who investigated interactions between individuals at 'Périnet' (Analamazaotra) in the Mantadia region. During his study, Parcher (1974) found that males took longer to commence display (consisting of head jerks, lateral flattening and extended gular sac) to females from which he had amputated the nasal appendage (compared to non-mutilated, control females). Parcher (1974) also described five paired whitish paired 'threat spots' that appeared on the head of displaying females. We have also observed these threat spots (in both *C. nasuta* and *C. gallus*) in individuals found in the Mantadia region. At Ranomafana we have located gravid females and hatchlings (lifestage: 0+) throughout the Malagasy summer (December to January), with hatchling numbers increasing markedly between the summer and winter (May to July) seasons (Table 3.2). Gravid females and hatchlings have also been located during our summer field work at both Andranomay and Mantadia. Schmidt (1992) found that incubation of eggs (under artificial conditions) at 23.5 °C took 94 days.

3.2.4 *C. oshaughnessyi*

Description: *C. oshaughnessyi* is a medium to large species (males can grow up to 385 mm; Brygoo, 1971) that belongs to the *Calumma parsonii*-group (Glaw and Vences, 1994). It is morphologically similar to *C. parsonii* and *C. globifer*, from which it can be distinguished by the presence of a dorsal crest and distinct, but small, occipital lobes (Glaw and Vences, 1994). Colouration in adults is a dull green with distinctive bright patches around the eye (L. Brady, pers. obs) Although white spots can be present on the toes (Brygoo, 1971), we have only observed this in early lifestages. Males possess ossified, paired nasal appendages. At Montagne d'Ambre this species is represented by *C. o. ambreensis* (Ramanantsoa, 1974) which is brownish in colouration with very short nasal appendages (Kauffmann, 1994). Glaw and Vences (1994) consider that *C. o. ambreensis* may in fact be a sub-species of *C. globifer*. However, until further taxonomic descriptions are available we continue to include *ambreensis* as a sub-species of *C. oshaughnessyi*.

Distribution: This species is widely distributed in the eastern rainforest (Fig. 3.3d), and has been recorded from Chaines Anosyennes in the south to Montagne d'Ambre (Brygoo, 1978, Raxworthy and Nussbaum, 1994) in the north. It has a recorded altitudinal range of 600 (Angel, 1942) to 1400 m. a. s. l. (Anon, 1999).

Habitats: *C. oshaughnessyi* appears to be a strict rainforest species (Raxworthy and Nussbaum, 1994; Kauffmann, 1994; Brady *et al.*, 1996; Jenkins *et al.*, 1999). We have recorded *C. o. oshaughnessyi* from Ranomafana, where it appears to prefer relatively undisturbed habitat. Although the species does occur in disturbed forest at Talatakely, it does so at a much lower density than in the less disturbed forest at Vatoharanana. We have not recorded *C. o. oshaughnessyi* from the most highly disturbed patches of forest at Ranomafana, including areas alongside Route Nationale 25 (between Ambodiamontana and Ranomafana), and associated forest fragments (e.g. forest above the village of Ambatolahy and forest below the peak of Mahalaina).

Life History: The breeding colours of male *C. o. oshaughnessyi* have been described as extremely vivid, with the nasal appendage 'glowing red', the extended gular yellow/green with white spots, the tail and belly bright green and the back yellow, often with broad, black stripes (Brady *et al.*, 1996). Head jerks (consisting of a sharp upward movement of the head) have been observed at all times of the day in both males and females (Brady *et al.*, 1996). Head jerks have also been observed by Parcher (1974) in the closely related *C. parsonii*, who attributed them to assertive courtship displays, although if such displays are not accompanied by vivid patterns Le Berre (1995) has interpreted them as ‘claiming territory’. Brady *et al.*, (1996) found gravid females and hatchlings during December and January, but the species’ egg-laying period and incubation time are unknown.

Kauffmann (1994) and Kauffmann *et al.* (1997) have given provisional size estimates of winter home range for *C. o. ambreensis* at Montagne d’Ambre and summer home range for *C. o. oshaughnessyi* at Ranomafana. Kauffmann (1994) found that *C. o. ambreensis* occupied discrete home ranges (mean area: 29 m^2). At Ranomafana *C. o. oshaughnessyi* was found to use large overlapping areas through which individuals repeatedly passed, but at different times. However, the extent to which territories were maintained within these overlapping areas could not be determined. Brady *et al.* (1996) observed that bursts of movement during the day often coincided with light breezes, with *C. o. oshaughnessyi* moving relatively large distances in the early evening, just before arriving at their roost site. Such behaviour suggests that chameleons may be highly selective over their roost, preferring lianes and branches in open areas (L. Brady, pers. obs), perhaps to benefit from early morning sunshine (Reilly, 1982).

Like other large arboreal chameleons the diet probably consists of invertebrates and small vertebrates (Risley, 1997; Abate, 1998) with summer foraging occurring throughout the day but peaking between 11.00 and 12.00 hrs (Kauffmann *et al.*, 1996). Brady *et al.*, (1996) noted that prey capture was often preceded by rocking movements of the whole body, whilst the response to a potential threat (such as a passing lemur) was to freeze. Kauffmann (1994) observed that *C. o. ambreensis* displayed a similar response to large birds and mongooses with the exception that chameleons would first position themselves such that they were hidden (e.g. by a branch) from the source of the threat.

3.2.5 *C. parsonii*

Description: This is a large bodied chameleon with males that can grow up to 600 mm in total length (Angel, 1942). It belongs to the *Calumma parsonii*-group and is characterised by poorly developed occipital lobes, paired, flattened nasal appendages, and lack of dorsal, gular, or ventral crest (Brygoo, 1971). There are two well known chromatic forms of this species. Males in north-eastern localities (e.g. Nosy Boraha) are light turquoise blue in colouration, with orange eye turrets (Risley, 1997), and the upper surface of the casque, vertebral ridge, forehead, nasal appendages and labial region (scia dentata) whitish; these specimens are referred to as ‘white-lipped’ (Abate, 1998). Males from south-eastern localities (e.g. Ifanadiana) are blue-green in colouration with the upper surface of the casque, vertebral ridge, forehead, nasal appendages yellowish or tan. Eye turrets are green or yellowish. The labial region is yellow, hence the term ‘yellow-lipped’ (Abate, 1998). Females from north-eastern and south-eastern localities are a medium green or blue-green (Abate, 1998). In females, the canthirostrals are terminated separately without particular relief (Brygoo, 1971). A third distinct colour form may originate from the Masoala peninsula (Abate, 1998), where males have an overall yellowish colouration (Glaw and Vences, 1994). Females with an overall brownish-red hue have been photographed in captivity, but locality data was unavailable (Tröeger, 1995). Both sexes may exhibit a medio-lateral yellow spot. None of these colour forms currently have specific sub-species status.

C. p. cristifer has only ever been described from the Mantadia region (Glaw and Vences, 1994) and is characterised by a complete dorsal crest in both sexes. Overall colouration in males is green to blue-green with a large, irregular orange spot on each flank. Females may be tan or green and may also display an orange spot mid-flank.

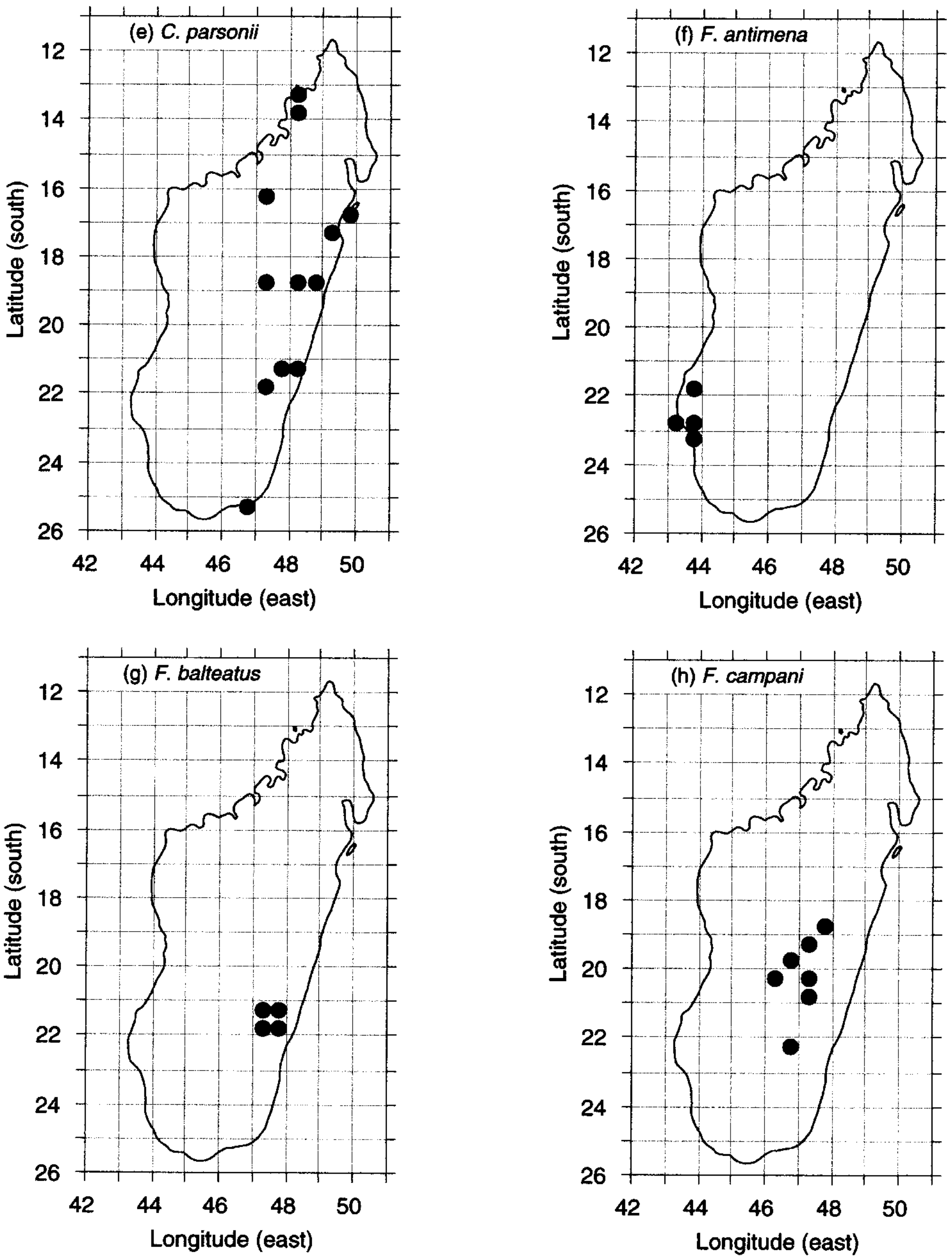
Distribution: Assuming that the different colour morphs do not represent distinct (but undescribed) species, then *C. parsonii* is widely distributed in the eastern rainforest of Madagascar (Fig. 3.3e). Its recorded range extends from Tolagnaro in the south to Tsaramandroso and maybe even Nosy Be in the north (Brygoo, 1971). However, it has been suggested that the Tolagnaro specimen *may* represent an identification error (with the specimen likely to be *C. oshaughnessyi*; IUCN/SSC Trade Specialist Group *et al.*, 1993) and its presence on Nosy Be is doubtful. *C. parsonii*’s recorded altitudinal range is 0 (Anon, 1999) to 1 300 m. a. s. l. (Kalisch, 1994).

Habitats: *C. parsonii* is described as inhabiting primary rainforest (Raxworthy, 1988; IUCN/SSC Trade Specialist Group *et al.*, 1993; Kalisch, 1994, 1998) where it has been found to avoid bright sunlight for extended periods (Risley, 1997). However, more recent reports suggest that the species may also be encountered in small fragments of secondary forest and even mature stands of agricultural tree crops (e.g. coffee plantations; Abate, 1998). Our observations of *C. p. cristifer* at Mantadia suggest that adult specimens are more often located in less disturbed areas of rainforest (e.g. Analamazoatra Special Reserve), with hatchlings (lifestage: 0+) appearing to be associated with running water. This association with water has also been observed by Schmidt (1993), who considered the typical biotope for *C. parsonii* to be narrow valleys and canyons, preferably with small streams. We only found juvenile (lifestage: 1+) *C. p. cristifer* in very degraded habitats at Mantadia (although we did locate a single adult female in recently disturbed forest at Mahanara). In a similar way to *C. brevicornis,* we therefore consider that juvenile *C. parsonii* may represent a dispersal phase, with mobile juveniles more likely to be encountered in sub-optimal habitat at the edges of forest fragments.

Life History: No field studies have been performed that detail the life history or reproductive biology of non-captive *C. parsonii*. Parcher (1974) made observations on captive *C. p. cristifer* at Périnet and found that males engaged in assertive courtship displays, composed of head jerks and lateral flattening of the body. During such displays body colouration became more intensified and a light green patch became visible behind each eye. Under captive conditions female *C. p. parsonii* are known to produce just a single clutch each year, but with each clutch containing between 30 and 60 eggs. Incubation of eggs (under artificial conditions) varies between 14 and 24 months for *C. p. parsonii* (Le Berre, 1995; Abate, 1994; Kalisch, 1994, 1995; Tröeger, 1997; Velten, 1997), but can take just 13 months for *C. p. cristifer* (Kalisch, 1998). Although Le Berre (1995) considers sexual maturity can be reached after 1.5 years, anecdotal evidence from several captive management programmes indicates that for most animals sexual maturity does not occur until 3 to 5 years after hatching (A. Abate, pers. comm.). This extended period of juvenile development is considerably longer than that reported for any other species of *Calumma* or *Furcifer* and may be an important factor in the regulation of natural populations.

During its juvenile growth stages *C. parsonii* feeds mainly on invertebrates, with small vertebrates becoming a more important dietary component in adult animals (Abate, 1998). Risley (1997) reported that his guide apparently observed *C. parsonii* taking the following bird species: Madagascar bulbul (*Hypsipetes madagascariensis*), Madagascar white-eye (*Zosterops maderaspatana*), blue pigeon (*Alectroenas madagascariensis)* and green pigeon (*Treron australi*). However, the validity of these observations has been questioned (O. Pronk, pers. comm.). Le Berre (1995) and Abate (1998) claim that other vertebrates, such as small lizards (e.g. *Phelsuma* spp.) may also be regularly consumed.

Figure 3.3 (cont.). Maps illustrating recorded distribution of chameleon species included in this study.



3.2.6 *Furcifer antimena*

Description: *F. antimena* is a medium to large sized chameleon (males can grow up to 338mm) that belongs to the *Furcifer rhinoceratus*-group (Glaw and Vences, 1994). Males are generally greenish in colouration and characterised by a high casque, with a single ossified nasal appendage and well developed dorsal crest. Females can be somewhat reddish-brown with a white lateral line and possess a smaller nasal appendage (Brygoo, 1971, Glaw and Vences, 1994).

Distribution: *C. antimena* is limited to the southwest of Madagascar (Fig. 3.3f) where it has been recorded between Toliara and Ihotry (Brygoo, 1971). Its recorded altitudinal range is 0 to 300 m. a. s. l. (Anon, 1999).

Habitats: *F. antimena* is reported to inhabit dry deciduous forest and shrubby plains (IUCN/SSC Trade Specialist Group *et al.*, 1993; Le Berre, 1995), and is sometimes found around the edge of villages (Brygoo, 1971). A male has been observed active at 22.00 h, on the ground (Brygoo, 1978).

Life History: Very little information is available for this species. Clutch sizes of 16 have been reported by Brygoo (1971), although Le Berre (1995) reports that clutches in captive animals may vary from 8 to 23 eggs, with 2 to 3 clutches deposited each year. In wild animals at least one clutch may be deposited in April (Brygoo, 1971). Incubation at 25 °C (under artificial conditions) takes 7 to 8 months and sexual maturity can be reached 6 months after hatching (Le Berre, 1995).

3.2.7 *F. balteatus*

Description: *F. balteatus* is the largest chameleon (total length 255 – 440 mm) within the *Furcifer bifidus*-group (Glaw and Vences, 1994). It is green in colouration and characterised by a bold diagonal white line on each flank (Brygoo, 1971; Glaw and Vences, 1994). Males have a pair of short ossified nasal appendages that are pointed and triangular in shape (IUCN/SSC Trade Specialist Group *et al.*, 1993).

Distribution: *F. balteatus* is very local and found only in the central south eastern forest region (Fig. 3.3g). Its known range extends from Ifanadiana to Fort Carnot (Brygoo, 1971). Altitudinal distribution data has not been published, but we have found specimens between 760 and 855 meters at Ranomafana. Using FTM maps we therefore estimate the species' altitudinal range to be from 200 (Anon, 1999) to 855 m. a. s. l. (our data).

Habitats: Despite being described as a rainforest species (Glaw and Vences, 1994; Abate, 1999b) we have never found *F. balteatus* within rainforest at Ranomafana. However, we have located individuals in roadside scrub and orchards between Ambatolahy and Ranomafana. Other specimens have been reported as occurring in similar habitats close to Ifanadiana (Pierre Talata [Ranomafana National Park research guide], pers. comm.).

Life History: No published information is available. We have found a single hatchling in a fruit tree at Ranomafana in December.

3.2.8 *F. campani*

Description: *F. campani* is a small to medium sized chameleon (up to 133 mm) that belongs to the *Furcifer lateralis*-group (Glaw and Vences, 1994). It is blackish brown to light green in colouration with roundish red spots and three light, longitudinal bands on each flank (Brygoo, 1971; Glaw and Vences, 1994). The dorsal crest is composed of a series of small granules (IUCN/SSC Trade Specialist Group *et al.*, 1993).

Distribution: *F. campani* is restricted to the central highlands (Fig. 3.3h) between Andringtra and Antananarivo (Brygoo, 1971, 1978; Nicoll and Langrand, 1989), where it has a recorded altitudinal range of 1 850 to 2300 m. a. s. l. (Anon, 1999).

Habitats: This species is reported to be found in residual high altitude forests and degraded areas (IUCN/SSC Trade Specialist Group *et al.*, 1993). Local collectors report taking specimens from grassy/shrubby savannah (Ravoninjatovo and Rabemananjara, 1999) and Le Berre (1995) describes the species as being found 'on prairies of high plateaus, near the edge of primary forest'.

Life History: Le Berre (1995) reports that 2 to 3 clutches are laid each year with each clutch containing between 8 to 12 eggs. Incubation (under artificial conditions) takes 9 months at 20 °C, with hatchlings measuring 22 – 24 mm (Le Berre, 1995; Schmidt, 1992). Sexual maturity can be reached as quickly as 3 months after hatching (Le Berre, 1995). Ravoninjatovo and Rabemananjara (1999) claim that this species buries itself (below leaf litter?) during the Malagasy winter.

3.2.9 *F. minor*

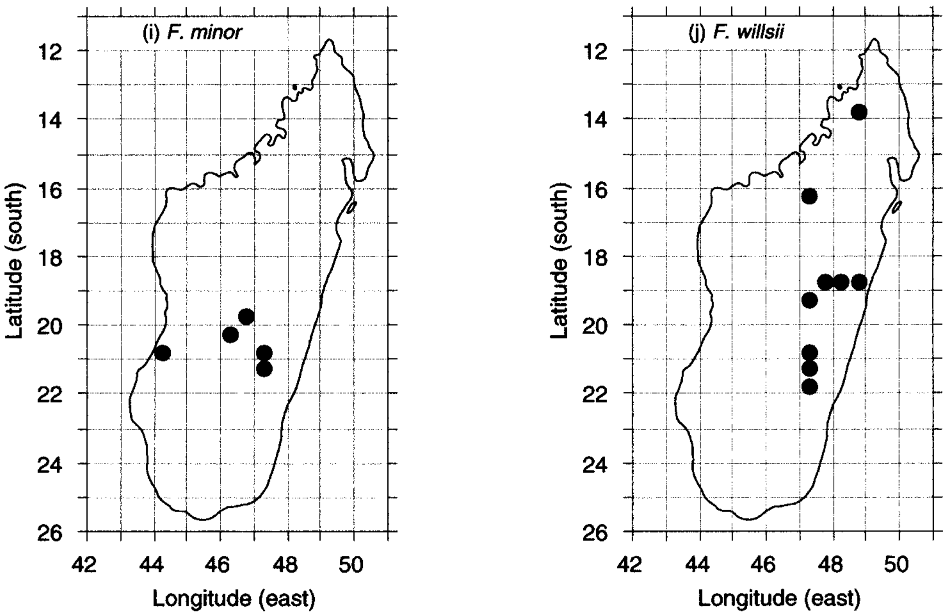
Description: This a small to medium sized chameleon (males grow up to 237 mm) that belongs to the *Furcifer bifidus*-group (Glaw and Vences, 1994). Males are generally reddish brown, although some specimens have been described as blackish or even light bluish, but always with two light coloured spots/marking on the anterior flank (Ramanantsoa, 1974; Brygoo, 1978; Glaw and Vences, 1994). Females are much more vivid, with light green to black bodies that are covered by small yellow spots and transverse yellow markings. Females are also characterised by two large, violet-blue spots on the anterior flank (Ramanantsoa, 1994; Glaw and Vences, 1994).

Distribution: *F. minor* is restricted to southern central Madagascar (Fig. 3.3i) and has been recorded from Fianarantsoa to Betafo (Brygoo, 1971). Although the species has been recorded from the west coast (Belo-sur-Mer), this observation consisted of a single female specimen (Brygoo, 1971, 1978). Altitudinal range has been recorded as extending from 1000 to 1650 m. a. s. l. (Anon, 1999).

Habitats: Very little published information is available. Although described as a 'forest species that frequents water edges' (IUCN/SSC Trade Specialist Group *et al.*, 1993), *F. minor* has also been found in coffee plantations at Itremo (Ramanantsoa, 1974). However, it is not known whether such disturbed habitats are typical since local collectors claim that the species occurs in nearby gallery forest (Ravoninjatovo and Rabemananjara, 1999).

Life History: A dissected female was found to contain 12 eggs and Ramanantsoa (1974) proposed that these would have been deposited in April. Le Berre (1995) states that clutch size in captive animals can vary from 11 to 16 eggs, with up to 3 clutches deposited each year. Incubation (under artificial conditions) at 19.5 °C takes 9 months and sexual maturity is reached 5 months after hatching.

Figure 3.3 (cont.). Maps illustrating recorded distribution of chameleon species included in this study.



3.2.10 *F. willsii*

Description: This is a small chameleon species (males grow up to 170 mm) that belongs to the *Furcifer bifidus*-group (Glaw and Vences, 1994). Males are characterised by well developed, paired nasal appendages that are flattened laterally (IUCN/SSC Trade Specialist Group *et al.*, 1993). Male colouration is green, while females are much more variable, with parallel longitudinal and transverse yellowish/whitish spots and markings (Brygoo, 1971; Glaw and Vences, 1994). *Furcifer willsii petteri* was once believed to be a subspecies (Brygoo, 1971), but is now considered to have full species status (*Furcifer petteri*; see Ramanantsoa, 1978).

Distribution: *F. willsii* is locally distributed in the central east (Fig. 3.3j) and has been recorded from Ikongo (Brygoo, 1971) to Andranomay (Raselimanana, 1998). Observations from northern Madagascar are now attributed to *F. petteri* (Glaw and Vences, 1994). *F. willsii*'s recorded altitudinal range extends from 600 (Anon, 1999) to 1 300 m. a. s. l. (Raselimanana, 1998).

Habitats: *F. willsii* is considered a rainforest species (Glaw and Vences, 1994; Abate, 1999b), that frequents shrubby strata and forest edges (IUCN/SSC Trade Specialist Group *et al.*, 1993; Le Berre, 1995). During our surveys at Ranomafana and Mantadia we only encountered the species in very degraded areas (e.g. roadside scrub at Ranomafana and Analamazaotra/Andasibe; secondary forest at Mahanara), never in primary forest. However, Raxworthy (1988) did report finding a single male *F. willsii* in primary forest at Périnet (Analamazaotra). Some authors have commented on the relatively high vertical strata that *F. willsii* occupies within rainforest. For example, Parcher (1974) regularly observed the species in trees at Périnet, but never less than 1 – 2 m above the ground. Raxworthy (1988) also reported finding a male in the same area, again at 2 m. At Andranomay, a dead male *F. willsii* was found on plastic sheeting above a tent and is believed to have fallen from above (Raselimanana, 1998; A. Raselimanana, pers. com). However, at Mandraka Brygoo (1978) observed a male less than 2 m above the ground, and in degraded forest on the periphery of Analamazaotra we have located a female roosting at 1.27 m. During interviews with local guides we were told that *F. willsii* is typically found low down in shrubs on the edge of forest areas. A high vertical roosting preference is therefore probably not a factor limiting the detectability of this species.

Life History: Parcher (1974) has described assertive courtship displays in male *F. willsii* that consisted of head jerks and lateral flattening of the body. In captivity females can lay up to 2 clutches per year, with each clutch containing between 8 and 15 eggs (Le Berre, 1995). Incubation time (under artificial conditions) at 23.5 °C is 5 months and sexual maturity appears to be very rapid, occurring just 4 months after hatching (Le Berre, 1995).

Figure 3.4. Remaining primary vegetation in Madagascar (map courtesy of Royal Botanic Gardens, Kew).

Table 3.3. Density of *Calumma* spp. (all lifestages except egg) ± standard error (S.E.) encountered within Ranomafana National Park. Densities were estimated using program DISTANCE, with a detection ceiling of 6m. Years with no available data are indicated by " – ".

Species	**Year**	**Mean Density (per ha) ± S.E. at Ranomafana**			
		Vatoharanana		**Talatakely**	
		Summer	Winter	Summer	Winter
C. brevicornis	1996-97	0.9 ± 0.4	1.9 ± 0.7	2.3 ± 1.7	0.9 ± 0.9
	1997-98	1.5 ± 0.5	-	-	-
	1998-99	3.0 ± 0.7	-	-	-
C. glawi	1996-97	9.1 ± 3.1	19.3 ± 4.0	1.4 ± 0.8	1.4 ± 0.9
	1997-98	6.6 ± 1.7	-	-	-
	1998-99	11.5 ± 2.2	-	-	-
C. nasuta	1996-97	2.1 ± 0.7	15.1 ± 3.6	16.7 ± 4.9	51.7 ± 8.2
	1997-98	3.1 ± 0.9	-	-	-
	1998-99	3.0 ± 1.1	-	-	-
C. oshaughnessyi	1996-97	11.5 ± 2.0	5.0 ± 1.5	4.6 ± 4.4	2.6 ± 0.9
	1997-98	11.5 ± 2.2	-	-	-
	1998-99	14.1 ± 2.2	-	-	-

Table 3.4. Density of *Calumma* spp. (all lifestages except egg) ± standard error (S.E.) encountered within Andranomay Forest during Malagasy summer 1997-98. Densities were estimated using program DISTANCE, with a detection ceiling of 6m. Burnt forest indicates habitat areas that were subject to tavy and uncontrolled fires 6 to 18 months before being surveyed.

Species	**Mean Density (per ha) ± S.E. at Andranomay**	
	Unburnt Forest	**Burnt Forest**
C. brevicornis	12.9 ± 6.6	2.4 ± 0.8
C. gastrotaenia	33.1 ± 6.1	14.3 ± 5.0
C. globifer	3.9 ± 1.0	5.2 ± 3.1
C. nasuta	5.4 ± 1.7	2.0 ± 1.6

3.3 Chameleon Abundance

The estimated densities of all *Calumma* and *Furcifer* species encountered within our three main study areas are detailed in Tables 3.3 – 3.5 and summarised in Table 3.6. From Table 3.3 it can be seen that for most chameleon species at Ranomafana there is little annual variation in summer population densities. However, there are differences between seasons that appear to be related to body size. Smaller bodied chameleon species (*C. glawi* and *C. nasuta*) displayed increases in population density between the summer and winter seasons, while the densities of larger bodied species (*C. brevicornis* and *C. oshaughnessyi*) tended to decline over the same period. The effects of habitat disturbance on chameleon densities was largely dependent upon species and is therefore more fully discussed in the individual species accounts below. Almost all species at Andranomay (Table 3.4) experienced declines in density in areas subject to extensive fire damage. In Ranomafana *C. nasuta* was clearly associated with the intensively logged Talatakely forest, while both *C. glawi* and *C. oshaughnessyi* were more abundant in the less disturbed Vatoharanana forest. Although the effect of habitat disturbance on chameleon abundance in the Mantadia region was more complex (Table 3.5), the densities of some species (e.g. *C. brevicornis* and *C. nasuta*) indicate an apparent preference for more disturbed areas.

We have estimated national population levels (Table 3.7) based on minimum and maximum density values (derived from upper and lower 95% confidence intervals pooled from all study sites; Table 3.6) and multiplied by the area of remaining suitable habitat within each species' recorded geographic range (Table 3.1). Calculating the density of chameleons is problematic when study sites encompass relatively large geographic areas, and for several species (e.g. *C. brevicornis* and *C. nasuta*), densities were found to display considerable variation even within contiguous forest blocks (e.g. Mahanara, Andranomanamponga and Sahanody within Mantadia; Table 3.5). This high level of variation has resulted in the estimation of national population sizes with widely differing minimum and maximum values (Table 3.7). Future sustainable use programmes should aim to establish quotas based on site specific population levels.

3.3.1 *C. brevicornis*

C. brevicornis has been described as one of the most abundant chameleon species in eastern rainforests (Brygoo, 1971, 1978). Parcher (1974) considers the species 'common' near Périnet (Analamazaotra) and unsupported claims suggest that densities may reach as high as 25 individuals per ha in the winter at Montagne d'Ambre (Raselimanana and Ramanamanjato in: IUCN/SSC Trade Specialist Group *et al.*, 1993). Conversely, during their summer study at Vatoharanana, Ranomafana, Jenkins *et al.* (1999) found very few *C. brevicornis* (<1.0 individual per ha) within the forest interior (although density increased to 6.7 individuals per ha along forest trails). Our results corroborate these earlier findings at Ranomafana. Over three summer seasons at Vatoharanana, densities in the forest interior varied between 0.9 and 3.0 individuals per ha (Table 3.3). The highest density that we estimated for *C. brevicornis* was in unburnt forest at Andranomay with 12.9 individuals per ha (Table 3.4). In the Mantadia region (Table 3.5) we found the species to be very rare or absent in relatively undisturbed forest (e.g. Sahanody), but with higher densities estimated from more disturbed habitat near forest edges (e.g. Analamazaotra Forest Station and Analamazaotra Periphery).

Table 3.5. Density of *Calumma* spp. (all lifestages except egg) ± standard error (S.E.) encountered within Mantadia region during Malagasy summer 1998-99. Densities were estimated using program DISTANCE, with a detection ceiling of 6m. Study areas included: (1) Analamazaotra Special Reserve, (2) Sahanody, (3) Andranomanamponga, (4) Sity Forest, (5) Vohidrazana, (6) Maramiza, (7) Mahanara, (8) Analamazaotra Forest Station, (9) Analamazaotra Periphery. Species that were encountered in areas not sampled by line transects are indicated by " † ". Unrecorded species are indicated by " – ".

Species	**Density (per ha) ± S.E. at Study Sites Within Mantadia**								
	Less Disturbed						**More Disturbed**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
C. brevicornis	1.3 ± 0.7	-	2.1 ± 1.3	-	-	-	1.5 ± 1.1	3.9 ± 1.7	3.1 ± 1.4
C. boettgeri	-	0.9 ± 0.9	1.0 ± 0.7	-	-	-	-	-	-
C. furcifer	-	-	-	1.1 ± 0.6	-	-	-	-	-
C. gallus	-	-	-	13.0 ± 3.6	13.4 ± 3.9	-	-	-	-
C. gastrotaenia	5.9 ± 2.4	0.8 ± 0.3	14.5 ± 2.6	-	-	10.1 ± 4.9	29.0 ± 5.9	10.0 ± 2.5	3.3 ± 2.9
C. malthe	-	1.4 ± 0.5	13.5 ± 3.7	-	-	15.1 ± 4.9	10.2 ± 1.9	-	-
C. nasuta	1.6 ± 0.7	0.3 ± 0.2	2.9 ± 0.9	3.5 ± 1.1	-	1.1 ± 1.1	5.1 ± 1.9	6.8 ± 2.6	8.6 ± 3.2
C. parsonii cristifer	3.9 ± 1.8	-	1.3 ± 1.3	-	-	-	0.5 ± 0.5	0.4 ± 0.4	1.1 ± 0.8
F. willsii	-	-	-	-	-	-	†	-	†

3.3.2 *C. globifer*

Brygoo (1971) considers *C. globifer* to be rare. We estimated densities in unburnt forest at Andranomay to be 3.9 individuals per ha (Table 3.4). Interestingly, the density of *C. globifer* was found to be slightly higher in burnt forest (5.2 individuals per ha). However, we attribute these results to the inclusion of hatchlings in our density estimates. A single group of 6 hatchlings was recorded on the edge of a burnt area during one of our sampling sessions and probably skewed our results. There is no evidence to suggest that females actively select burnt areas to deposit their eggs. It is more likely that eggs are deposited several months before forest is burnt through the activities of local people.

3.3.3 *C. nasuta*

Brygoo (1971) considers *C. n*asuta to be 'not rare' and even 'abundant' at Périnet. It has also been described as 'reasonably abundant' in the east-central region of Madagascar, with lower densities at the northern and southern limits of its range (IUCN/SSC Trade Specialist Group *et al.*, 1993). However, these claims have not been substantiated by published quantitative data. Jenkins *et al.*

(1999) estimated very low densities (0.2 to 1.6 individuals per ha) for *C. nasuta* at Vatoharanana (Ranomafana). Our results for three spatially distinct regions (Tables 3.2, 3.3 and 3.4) indicate that during the summer *C. nasuta* occurs within mid-altitude rainforest at densities ranging from 0.3 (Sahanody, Mantadia) to 16.7 (Talatakely, Ranomafana) individuals per ha, increasing to 51.7 individuals per ha during the winter (Talatakely, Ranomafana). This difference between summer and winter densities is attributable to an influx of new recruits into the winter population (Table 3.1). Our data also suggest that *C. nasuta* is more abundant in relatively disturbed habitats (e.g. Mahanara, Analamazaotra Forest Station and Analamazaotra Periphery, Mantadia; Talatakely, Ranomafana). However, this does not extend to areas that have recently experienced burning (e.g. burnt forest, Andranomay). Although Parcher (1974) considered *C. nasuta* to be 'common' at Périnet, his observations appeared to be largely restricted to the more disturbed areas close to Analamazaotra Forest Station.

3.3.4 *C. oshaughnessyi*

Brygoo (1971) has described this species as 'not very rare'. However, densities of *C. oshaughnessyi* (*C. o. ambreensis*) at Montagne d'Ambre have been reported as 'low', with unsupported claims of 7 individuals per ha (Raselimanana and Ramanamanjato, in: IUCN/SSC Trade Specialist Group *et al.*, 1993). In relatively undisturbed forest at Vatoharanana (Ranomafana) we found summer densities of *C. o. oshaughnessyi* to be fairly consistent between years, ranging from 11.5 individuals per ha in 1996/97 to 14.1 individuals per ha in 1998/99 (Table 3.3). However, between the summer and winter periods (1996-97) we estimated that the species' density decreased to 5.0 individuals per ha. Densities were also lower in the more disturbed forest areas sampled during 1996/97 (Talatakely), and again displayed a decrease between summer and winter seasons (4.6 to 2.6 individuals per ha).

3.3.5 *C. parsonii*

Density estimates for *C. parsonii* have never been published. However, Brygoo (1971) considers that it is 'not rare' within its range and Bloxam (in: IUCN/SSC Trade Specialist Group *et al.*, 1993) has described the species as 'locally abundant'. During 1996 – 1997 Abate (1998) visited nine locations within *C. p. parsonii*'s recorded range (Fianarantsoa, Ranomafana, Ifanadiana, Kianjavato, Mananjary, Fenoarivo, Soanierana-Ivongo, Ambanizana and Nosy Boraha). During these qualitative surveys, Abate (1998) found few *C. p. parsonii*, with most observations coming from small fragments of forest in Ifanadiana and Nosy Boraha. Our data suggests that *C. p. cristifer* occurs at very low density in the Mantadia region, with most animals (3.9 individuals per ha; but note the high degree of error) found in the relatively undisturbed forest in Analamazaotra Special Reserve (Table 3.5). Although this reserve is frequented by many tourists, we found that tourists tended to be restricted to trails within a fairly small area and probably had little impact on the population of *C. p. cristifer*. Of greater concern are reports of decreasing numbers of *C. p. parsonii* in areas where they were once considered abundant (e.g. Fenoarivo and Soanierana-Ivongo; Abate, 1998). Quantitative density estimates are unavailable for *C. p. parsonii* and we propose that baseline surveys specifically targeting this species in areas where collecting is known to occur are urgently required.

Table 3.6. Mean estimated densities and minimum - maximum 95% confidence intervals for *Calumma* spp. (all lifestages except egg) encountered in eastern Malagasy rainforest. All estimates were calculated from multiple sampling sessions (n), distributed over different sub-sites and years (see Tables 3.3 – 3.5). Unrecorded species are indicated by " – ". Species that were encountered in areas not sampled by line transects are indicated by "†".

Species	**Mean Density (per ha) Min. - Max. 95% Confidence Intervals**			
	Ranomafana		**Andranomay**	**Mantadia**
	Summer	*Winter*	*Summer*	*Summer*
C. boettgeri	-	-	-	1.0 (n=2) 0.2 – 5.1
C. brevicornis	1.9 (n=4) 0.4 – 13.0	1.4 (n=2) 0.2 – 4.9	7.7 (n=2) 1.2 – 34.1	2.4 (n=5) 0.4 – 12.2
C. cucullata	-	-	-	†
C. furcifer	-	-	-	1.1 (n=1) 0.3 – 3.3
C. gallus	-	-	-	13.2 (n=2) 6.7 – 25.6
C. gastrotaenia	†	†	23.7 (n=2) 7.0 – 129.9	10.5 (n=7) 0.4 – 43.4
C. glawi	7.2 (n=4) 0.4 – 21.4	10.4 (n=2) 0.4 – 28.9	-	-
C. globifer	-	-	4.6 (n=2) 1.6 – 20.6	-
C. malthe	-	-	-	10.1 (n=4) 0.8 – 31.0
C. nasuta	6.2 (n=4) 1.1 – 29.6	33.4 (n=2) 9.4 – 71.0	3.7 (n=2) 0.5 – 17.7	3.7 (n=8) 0.2 – 27.2
C. oshaughnessyi	10.4 (n=4) 2.3 – 19.1	3.8 (n=2) 1.2 - 9.7	-	-
C. parsonii cristifer	-	-	-	1.4 (n=5) 0.1 – 9.7
F. balteatus	†	†	-	-
F. lateralis	†	†	†	-
F. willsii	†	†	-	†

Table 3.7. National population estimates (excluding eggs) for chameleons included in this study. Densities are based on minimum and maximum 95% confidence intervals from multiple density estimates in different rainforest areas conducted during the Malagasy summer. National population estimates have been calculated by multiplying minimum and maximum densities by the total area of remaining suitable habitat within each species known range. Species with no available density estimates are indicated by "–".

Species	Total Habitat Area in Range (km^2)	Min.- Max Densities (km^2)	Lifestage	National Population Size (No. of Individuals)	
				Min.	Max.
C. brevicornis	29 863	40 – 3 410	**Total**	**1 194 520**	**101 832 830**
			0+	382 246	32 586 506
			1+	155 287	13 238 268
			2+	656 986	56 008 057
C. globifer	8 266	160 – 2 060	**Total**	**1 322 560**	**17 027 960**
			0+	211 610	2 724 474
			1+	436 445	5 619 226
			2+	674 506	8 684 259
C. nasuta	60 462	20 – 2 960	**Total**	**1 209 240**	**178 967 520**
			0+	96 739	14 317 402
			1+	326 495	48 321 230
			2+	786 006	116 328 888
C. oshaughnessyi[1]	27 531	230 – 1 910	**Total**	**6 332 130**	**52 584 210**
			0+	569 892	4 732 579
			1+	2 786 137	23 137 052
			2+	3 039 422	25 240 421
C. parsonii[1]	38 624	100 – 970	**Total**	**3 862 400**	**37 465 280**
			0+	1 351 840	13 112 848
			1+	1 351 840	13 112 848
			2+	1 158 720	11 239 584
F. antimena	1 884	-	-	-	-
F. balteatus	2 167	-	-	-	-
F. campani	23 008	-	-	-	-
F. minor	25 511	-	-	-	-
F. willsii	2 505	-	-	-	-

[1] We have only estimated densities for *C. o. oshaughnessyi* and *C. p. cristifer*, but used our results to estimate total population sizes for each species (i.e. all subspecies).

3.3.6 *F. antimena*

Brygoo (1971) believed *F. antimena* to be 'common' in the southwest, especially during the 'hot season'. Interviews with local collectors (Ravoninjatovo and Rabemananjara, 1999) suggest that this species may be very abundant is some areas. However, the results of quantitative density estimates have never been published, and baseline surveys are urgently required.

3.3.7 *F. balteatus*

F. balteatus is considered to be 'somewhat difficult to locate in its natural habitat' (IUCN/SSC Trade Specialist Group *et al.*, 1993) and quantitative density estimates have never been published. During our fieldwork at Ranomafana, the species was only located in areas that were not sampled using line transects and further survey work in more appropriate habitat is urgently required.

3.3.8 *F. campani*

Brygoo (1971) does not consider this species to be 'rare' in the forested massif of Ankaratra and local collectors claim that it is 'very abundant' in grassy/shrubby savannahs (Ravoninjatovo and Rabemananjara, 1999). However, no quantitative density estimates are available and baseline surveys that specifically target this species and its habitats are urgently required.

3.3.8 *F. minor*

Quantitative density estimates are unavailable. Brygoo (1971) considers this species to be 'rare'. However, observations by Ravoninjatovo and Rabemananjara (1999) suggest that *F. minor* may be 'abundant' between February and May. Baseline surveys in appropriate habitat throughout the summer and winter periods are therefore urgently required before any baseline densities can be estimated.

3.3.9 *F. willsii*

Both Brygoo (1971) and Parcher (1974) considered this species to be 'common' at Périnet. However, despite very intensive search effort across nine different areas, we were only able to find three specimens during our fieldwork in the Mantadia region. Local guides interviewed at Andasibe claimed that *F. willsii* numbers had declined due to collecting. At Ranomafana we only located *F. willsii* in areas not sampled by line transects (again in degraded habitat along the edge of the forest). More surveys in degraded edge habitat (preferably in areas that have not been subject to excessive collecting) are required before any baseline densities can be estimated.

4. Trade Review

4.1 Conservation Safeguards and Regulatory Structure

4.1.1 Conservation Strategy

In 1985 Madagascar launched a national conservation strategy and by 1990 the Malagasy Government had, in collaboration with the World Bank, United States Agency for International Development (USAID), United Nations Educational, Scientific and Cultural Organisation (UNESCO), United Nations Development Programme (UNDP), World Wide Fund for Nature (WWF) and Co-operation Suiss, initiated a 15 year Environmental Action Plan (Ravaoarinoromanga, 1997). This charter was designed to meet the needs of 'human development and the physical environment' and is divided into three phases:

1. 1991 – 1995. Creation and Management of new protected areas.

2. 1996 – 2000. Continuation of all actions undertaken in phase 1. Defining priorities for conservation and conducting research into natural resources. A scientific workshop was organised in April 1995 to define conservation priorities and ensure compliance with the Convention on Biodiversity that was ratified by Madagascar in June 1995.

3. 2001 – 2005. Continuation of activities undertaken in phases 1 and 2. By this phase all actions that have an impact upon the environment should be managed by a consortium that includes local communities, government agencies and non-governmental organisations (NGOs).

4.1.2 Protected Areas

Protected areas (Table 4.1) form the main framework for the conservation of natural resources in Madagascar (Ravaoarinoromanga, 1997). By 1997 protected areas covered approximately 1.9% of Madagascar's total land area and included many important areas of primary vegetation. On 6th June 1997 the management of all protected areas was made the responsibility of the Association National Pour le Gestion des Aires Protégées (ANGAP). ANGAP is a non-governmental organisation that is also charged with the development of tourism and ecotourism in Madagascar's National Park system.

4.1.3 Legislation Regulating Exploitation of Natural Resources

Direction Générale des Eaux et Forêts (DEF) manage all wildlife resources outside protected areas and are responsible for implementing Madagascar's obligations under CITES. Madagascar's existing legislation for the regulation of natural resource exploitation is described by a series of orders and decrees (ordonnances and decrets) dating from the early 1960's (Jenkins *et. al*, 1995; in: Ravaoarinoromanga, 1997). The principal laws concerning protection and hunting (hunting includes the collection of live animals for trade) are described in Table 4.2. Hunting without a valid permit issued by DEF is prohibited. Permits are usually fixed at between 100 and 200 individuals per genus and are valid in any area where collecting is allowed (Ravaoarinoromanga, 1997). Of particular interest is the fact that hunting/collecting using 'light' (Decret 61-093; Table 4.2) is forbidden. Therefore, searching for roosting chameleons at night using torches, for the purpose of commercial exploitation, is illegal.

Table 4.1. Summary of protected areas classification in Madagascar (modified from Ravaoarinoromanga, 1997).

Protected Area Category	Number Created	Description

Strict Nature Reserve	11	For the protection of flora and fauna. Access strictly forbidden except for scientific research.
Special Reserve	23	For the protection of flora and fauna. Access available by permit, but hunting (including fishing), livestock grazing and other activities leading to the exploitation of natural resources are forbidden.
National Park	7	For the protection of flora and fauna, and for the provision of educational and recreational facilities. Subsistence exploitation of some natural products by local people is permitted.
Biosphere Reserve	1	Created to conserve the biodiversity and integrity of biotic communities within their natural environment.
Forest Station	34	Created for undertaking experimental activities, such as nurseries for reforestation.
Classified Forest	260	Commercial forest exploitation is forbidden, but local people are permitted to use some products for traditional activities.

Table 4.2. Summary of the legislation regulating legal exploitation of natural resources in Madagascar.

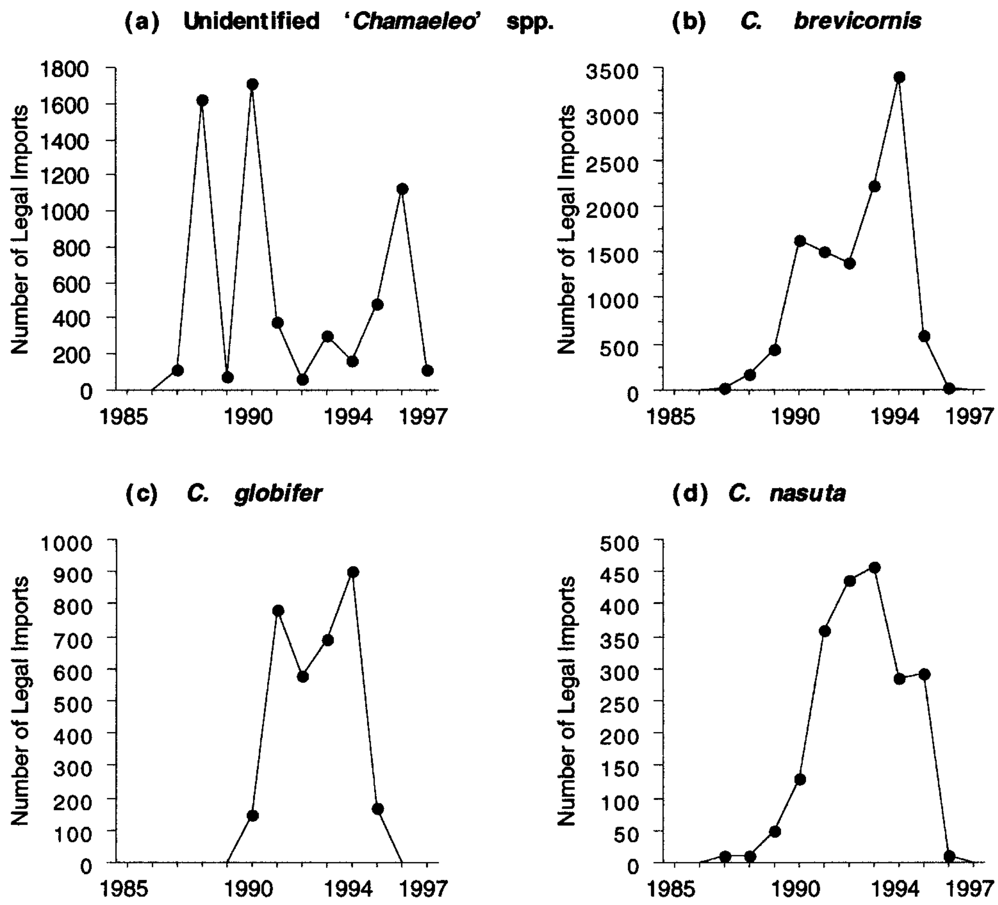
Category	Number	Date	Description
Ordonnance	60-126	3rd October 1960	Basic rules governing the regulation of hunting, fishing and protection.
Ordonnance	61-1316	13th July 1961	
Ordonnance	71-006	30th June 1971	Established rules for the management of wild animals and plants.
Decret	61-096	16th February 1961	Classified Madagascar's fauna into three categories: protected species, game species and pest species.
Decret	75-014	5th August 1975	Both of these decrets involve modification of decret 61 096. Notification of species currently listed on CITES Appendix II.
Decret	88-243	15th June 1988	
Decret	61-093	February 1961	Expanded upon regulations concerning hunting. Open season established from 1st May to 1st Sunday in October; from 1 hour before sunrise until 1 hour after sunset. Activities such as use of cars, motorboats, lights, drugs, explosions, pitfall traps and poisons during hunting/collecting are prohibited.
Decret	69-390	September 1969	Describes commercial hunting/collecting licences for persons trading in live or dead animals. From 1996 the period of this licence was reduced by DEF from 5 to 3 years, with all licences revalidated annually.

From 1997 permits were only issued to persons who possessed the 'appropriate infrastructure' to stock animals that they collected (Ravaoarinoromanga, 1997) and, as a consequence, by 1997 the number of persons licensed to commercially exploit live plants and animals was reduced from 58 to 43. However, due to resource constraints, it is unlikely that facilities will be inspected on a regular basis unless support from other sources can be found. Taxes are raised by the Direction of Durable

Management of Forest Resources (DGDRF) and currently fixed at 4% of the total amount declared on invoices to importers.

Although chameleons should be correctly identified to the level of species before export, there is evidence to suggest that this does not always occur. Abate (1999a) has reported on interviews in November 1997 with two agents from DEF in eastern Madagascar. Her interviews revealed that several permits issued in Antananarivo were for '*Chamaeleo* spp.'. In fact, data obtained from the World Conservation Monitoring Centre (WCMC) CITES Database indicates that despite the publication of Notification to the Parties No. 784 (CITES Secretariat, 1994), unidentified chameleons are still exported from Madagascar and accepted for importation by countries party to CITES (Fig. 4.1a). In 1996 the net quantity of unidentified *Chamaeleo* spp. (=*Furcifer* and *Calumma*) imported in this manner was 1 134 individuals, although the available data suggests that this had been reduced to 120 individuals by 1997.

Figure 4.1. Graphs illustrating CITES reported net imports of chameleons (1985-1997). Source: WCMC CITES Database.



4.2 Origin of Chameleons in Trade

Interviews with collectors and exporters have revealed that the majority of chameleons exported from Madagascar (both past and present) are derived from wild populations. (Ravoninjatovo and Rabemananjara, 1999). Although it is illegal to collect chameleons from within protected areas, interviews with local people have revealed that chameleons are still allegedly taken from some reserves. A small number of exporters have begun so called 'breeding farms', but these have been relatively unsuccessful in producing large numbers of hatchling chameleons. Indeed, Ravoninjatovo and Rabemananjara (1999) consider that most animals that are reported to be captive-bred in Madagascar are in reality the progeny of wild caught gravid females.

At one 'breeding farm' we witnessed (January 1999) overcrowded cages, heavily soiled with faeces. We also found dead individuals in several cages and an adult male *C. p. cristifer* with untreated wounds (including a severed nasal appendage) that were (according to a guide supplied by the facility) inflicted during a recent fight. There was no evidence that chameleons were being successfully bred at this establishment and interviews with staff revealed that almost all chameleons on display were apparently collected from the wild. Species for which legal export is currently prohibited (under the existing trade moratorium) are apparently still being collected from wild populations to stock this 'farm'. The extent to which chameleons are taken from the wild to stock this and other similar establishments is unknown. The Madagascar CITES Management Authority (DEF) recently responded to advice that purportedly captive bred chameleons were in reality either wild-caught or the offspring of wild-caught gravid females, by refusing to issue export permits for chameleons originating from supposed breeding farms. DEF currently lacks the expertise to determine whether farmed animals are truly captive bred and the government agency has therefore determined that the sale of captive bred animals will be prohibited until such time as the necessary expertise becomes available.

4.3 Collection and Transportation of Chameleons

4.3.1 Trade Networks

Five different mechanisms have been identified in the collection and export of chameleons (Ravoninjatovo and Rabemananjara, 1999):

1. Exporter organises collectors directly and orders specific quantities at different times of the year. Communication between exporter and collector is by letter and telephone. This form of network is (for the exporter) the least expensive and often applicable for areas located far away from Antananarivo (e.g. Antsiranana and Toliary).

2. Exporter travels to site and hires local collector. This mechanism is often applied for urgent orders in easily accessible areas (e.g. Moramanga, Tolongoina and Ifandiana).

3. An intermediary travels to site and hires several local collectors. This allows the collection of the required number of animals in as short period of time as possible. Intermediary sells animals to exporter. This form of network is most often applied in areas difficult to reach by exporters (e.g. Itremo, Ambatofinandrahana, south Ambohimanga).

4. In some cases when an exporter needs to fulfil an important/urgent order, an intermediary is hired to organise collection of animals. The first intermediary hires a second intermediary who meets and organises local collectors. The first intermediary is often another exporter who lives within target region or who has necessary contacts. This approach is often the most expensive commerce network due to the large number of people involved.

5. Local collectors provide animals directly to exporters without first receiving any instructions. Often villagers collect chameleons and sell them to local intermediaries who supply exporters. These intermediaries are often independent operators who may supply several exporters. Compared to the first four modes, the number of chameleons exploited directly by local villagers is low.

4.3.2 Collection Techniques

Interviews with local collectors indicate that collection techniques are similar in all regions (Ravoninjatovo and Rabemananjara, 1999). Collectors gather animals by hand (usually during the day) with many storing them in baskets (lined with ferns) for transportation. Animals stored in this way are not separated according to sex or lifestage and can therefore become highly stressed. Some collectors store chameleons in small cotton bags that are supplied by the intermediary or exporter. These are hung from a large board ('soubique') with each bag containing a single individual. In Sambava, Abate (1999a) witnessed chameleons being placed in small cloth bags which were tied shut and placed, layer upon layer, in a large cardboard box. Bags, baskets and cardboard boxes are collected by an intermediary and transported to the exporter. The mode of transportation used at each level of exploitation is detailed in Table 4.3. For many species, collectors simply gather all animals that they encounter without regard to sex or age. Intermediaries also tend to take all individuals offered, with the exception of those obviously in poor physical condition.

Table 4.3. The different modes of transportation of chameleon species at each stage of exploitation. Data based on interviews with collectors, intermediaries and exporters (Ravoninjatovo and Rabemananjara, 1999).

Species	**Mode of Transport**								
	Collector			**Intermediary**			**Exporter**		
	Foot	Car	Plane	Foot	Car	Plane	Foot	Car	Plane
C. brevicornis	■	■		■	■				■
C. globifer	■	■		■		■			■
C. nasuta	■	■		■	■				■
C. oshaughnessyi	■	■		■	■				■
C. parsonii	■				■	■			■
F. antimena	■					■			■
F. balteatus	■	■			■				■
F. campani	■				■				■
F. labordi	■					■			■
F. minor	■			■	■				■
F. petteri	■	■		■		■			■
F. willsii	■	■		■	■				■

4.4 Post-capture Mortality of Chameleons

4.4.1 Pre-export Mortality

Ravoninjatovo and Rabemananjara (1999) have found that for many species, mortality rates are reported as negligible up to the point that animals are delivered to the intermediary (usually because animals are delivered very soon after collection). However, collectors can mishandle animals, especially juveniles and gravid females, leading to injury and death. Abate (1999a) is particularly concerned that pulling chameleons forcibly from their perches can result in bone fractures and muscle, joint and tissue damage.

Intermediaries usually store animals for a period of several days, during which time they are periodically checked and fed (Ravoninjatovo and Rabemananjara, 1999). However, when many chameleons have been collected this operation can prove difficult and they may remain within their bags without being fed or watered for prolonged periods. Increased stress during such periods can result in unacceptably high levels of mortality. Some exporters even claimed that intermediaries may store animals for several months (in small cages), during which time they have been reported to experience mortality rates of up to 50%.

Mortality rates during transport to the exporter are dependent upon journey length and storage method. Prolonged journeys lead to increased mortality through injury, suffocation and overheating (Abate, 1999a). Therefore, intermediaries obtain surplus animals to compensate for mortality during transport. Mortality is particularly problematic when animals are transported in overloaded containers and compensatory collection figures, 10 to 25% above that ordered by exporters, have been quoted by intermediaries during interviews (Ravoninjatovo and Rabemananjara, 1999).

Mortality figures for chameleons held by exporters were not collected by Ravoninjatovo and Rabemananjara (1999). However, Abate (1999a) has described the facilities of several exporters based in Madagascar as inadequate; with water and food deprivation, overcrowding, unsanitary conditions and inappropriate temperatures.

Packaging used for the export of live chameleons from Madagascar should follow the standards outlined by the International Air Transport Association (IATA). These standards currently dictate that chameleons are placed in individual cotton sacks, with the length of the sack at least the same and the width double that of the chameleon contained within. Each sack should be hung along a bar set in a perforated wooden case (dimensions: 70 x 45 x 45 cm), with the number of sacks not so great as to impede free movement. The contents of each box should correspond to the list of chameleons registered in the exporter's invoice (including genus, species and quantity). However, new IATA guidelines for shipping live reptiles will be published in the 26th edition of the IATA Live Animals Regulations, effective October 1st 1999. Agents from DEF are expected to inspect animals before shipment (usually at Ivato airport) and any packaging which is deemed inappropriate should be rejected (Ravoninjatovo and Rabemananjara, 1999).

4.4.2 Post-export Mortality

Access to the facilities of importers is restricted to approved or invited buyers from the commercial trade and they are therefore not open to the public. Although importers, wholesalers and retailers may maintain records of mortality, refunds for dead or ill chameleons are not customary within the commercial trade. However, the frequency of illness leading to death of imported chameleons has historically been significantly higher than that reported for captive-born animals (A. Abate, pers. comm.). Indeed, the mortality of Malagasy chameleons (other than the four permissible trade species) exported prior to the trade moratorium is evident from the current known holdings of captive animals in 1999; for the majority of species this is zero (A. Abate, pers. comm.).

4.5 Levels of Trade

All data used to evaluate current levels of trade for chameleons were obtained from the WCMC CITES Database. These data represent CITES reported net imports. It does not therefore reflect all international trade, only that which is reported by countries Party to CITES. The quality of data reported by different Parties is variable, since some report actual imports, while others only report the number of permits issued. Whilst there are clearly caveats concerning the use of this data, it currently represents the most reliable way to gauge levels of legal international trade in CITES listed species. Nobody interviewed during the current project considered that there was a ready domestic market for chameleons in Madagascar (some animals are used in traditional ceremonies [see section 4.8.2], but numbers are very low and do not require harvesting at a commercial level). Although illegal trade in species included on the current moratorium (CITES Secretariat, 1995) almost certainly does occur, determining illegal trade levels is extremely difficult and it was not possible to collect reliable estimates for this report.

4.5.1 *C. brevicornis*

Similarities between *C. brevicornis* and other closely related species in the *C. cucullata*-group can lead to confusion in identification and this may account for the presence of some species (e.g. *C. cucullata* and *C. malthe*) in the pre-1998 trade. *C. brevicornis* has been recorded as present in the trade since at least 1987 (Fig. 4.1b) and is known to have been exploited at Moramanga, Andasibe-Mantadia and Ambaniasy, with most animals collected in secondary forest, often alongside roads (Ravoninjatovo and Rabemananjara, 1999). Interviews with collectors (Ravoninjatovo and Rabemananjara, 1999) revealed that animals were preferentially selected based on large size. Between February to October collectors would often receive orders for up to 200 individuals per week. Peak CITES reported net imports of this species occurred in 1994 with 3 395 animals legally imported from Madagascar (Fig. 4.1b). Despite the captive breeding potential of this species being described as 'good' (Le Berre, 1995), *C. brevicornis* (along with *C. cucullata* and *C. malthe*) is "not known to survive long-term in captivity, produce viable young from the eggs of newly imported gravid females or produce viable young through captive breeding" (Abate, 1999b).

Although *C. brevicornis* was not considered to be threatened by pre-1993 levels of trade (IUCN/SSC Trade Specialist Group *et al.*, 1993), local collectors report that encounters with *C. brevicornis* have decreased in areas subject to exploitation (Ravoninjatovo and Rabemananjara, 1999). Since *C. brevicornis* occurs at relatively low densities across at least part of its range, if trade restrictions on this species are lifted then, despite its widespread distribution, local populations of *C. brevicornis* may be at risk from non-sustainable collecting in some areas.

4.5.2 *C. globifer*

Collection of *C. globifer* mainly took place in Mandraka, although animals were also taken from Ambatolaona (Ravoninjatovo and Rabemananjara, 1999). Peak CITES reported net imports occurred in 1994 when 899 animals are known to have been legally imported from Madagascar (Fig. 4.1c). Although this species has been described as 'easy to rear in captivity' (Peyreiras in: IUCN/SSC Trade Specialist Group *et al.*, 1993), Le Berre (1995) has described the captive breeding potential of this species as 'average to poor'. In fact Abate (1999b) considers that once *C. globifer* is exported from Madagascar it is difficult to maintain and not known to have been bred in captivity. Abate (1999b) further reports that, outside Madagascar, only a single wild-caught *C. globifer* is known to remain alive in captivity.

Collectors interviewed during the present study (Ravoninjatovo and Rabemananjara, 1999) claimed that the species was not threatened by their activities and a previous assessment considered that pre-1993 trade levels did not pose a threat to this species (IUCN/SSC Trade Specialist Group *et al.*, 1993). However, we have found *C. globifer* to occur at relatively low densities and if the trade moratorium is lifted non-sustainable collecting may occur at some of the more easily accessible areas within its distribution range (particularly Mandraka where a baseline population estimate is urgently required).

4.5.3 *C. nasuta*

Collection of *C. nasuta* mainly occurred at Andasibe-Mantadia, Mandraka, Fiherenana and Ankeniheny (Ravoninjatovo and Rabemananjara, 1999) and the species has been recorded in international trade since 1987 (Fig. 4.1d). Peak CITES reported net imports occurred in 1993 when 457 individuals are known to have been legally imported from Madagascar. Interviews with collectors living near Andasibe revealed that this species can suffer very high mortality immediately after capture and it is therefore only collected upon demand (L. Brady, pers. obs.). Between January and July such orders can reach up to 20 specimens per week (Ravoninjatovo and Rabemananjara, 1999). Abate (1999b) considers *C. nasuta* to be relatively unpopular amongst international chameleon keepers, possibly due to its small size and drab colouration.

Previous assessments have described pre-1993 trade figures as insignificant (IUCN/SSC Trade Specialist Group *et al.*, 1993) and although we are in broad agreement with this conclusion, any resumption in trade must include safeguards to ensure that local populations are not overexploited.

4.5.4 *C. oshaughnessyi*

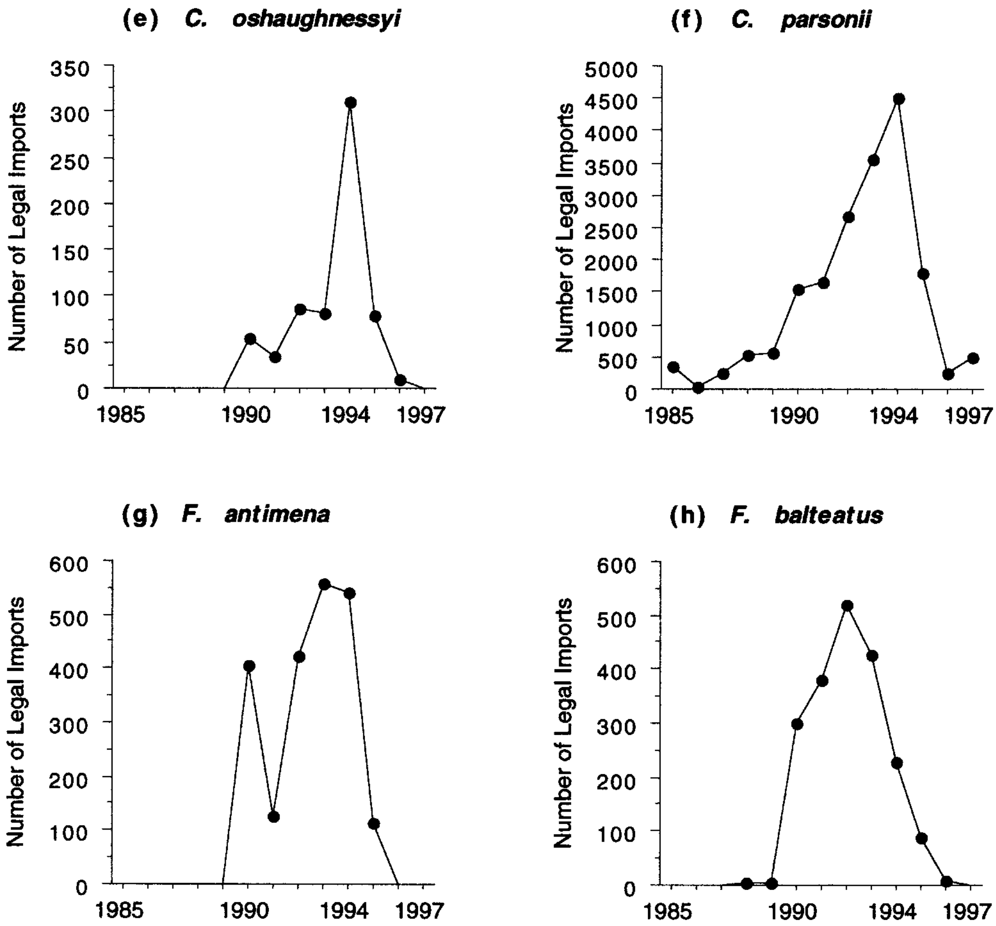
Collection sites for *C. oshaughnessyi* include Ifanadiana, southern Ambohimanga and Antoetra (Ravoninjatovo and Rabemananjara, 1999). This species has been recorded in the trade since 1990 and pre-1998 CITES reported net imports were very low, with a peak of 311 animals in 1994 (Fig. 4.1e). Collectors and intermediaries interviewed during the current project considered *C. oshaughnessyi* difficult to find with advance orders therefore limited by the species' apparent rarity (Ravoninjatovo and Rabemananjara, 1999). This species is considered difficult to maintain and is not known to have been bred in captivity (Abate, 1999b).

We agree with a previous appraisal that pre-1993 levels of trade were insignificant for this species (IUCN/SSC Trade Specialist Group *et al.*, 1993). However, any resumption in trade must include safeguards to ensure that local populations are not overexploited.

4.5.5 *C. parsonii*

C. parsonii was reported to be collected from a large number of locations including: Ifanadiana, Tolongoina, Ranomafana (outside the National Park), Ambatoharanana-Ambositra, Soanieran'Ivongo, Maroantsetra and Antalaha (Ravoninjatovo and Rabemananjara, 1999). The species has been recorded in international trade since at least 1985 with the highest CITES reported net imports recorded at 4 521 individuals in 1994 (Fig. 4.1f). Of particular concern is the fact that despite the trade moratorium this species was still being held by exporters (Abate, 1999a) and imported into both the United States of America and Italy up until at least 1997 (WCMC CITES Database; Fig. 4.1f). Intermediaries claim that they receive monthly orders for *C. parsonii*, each averaging about 40 animals. Intermediaries also claim that this species does not experience any significant mortality during its journey to the exporter. However, Abate (1999a) has commented on the poor physical condition of several *C. parsonii* that she witnessed at the facilities run by two different exporters in 1996 and 1997. Although this species can probably survive for 10 to 15 years with the correct captive management (A. Abate, pers. comm.), the breeding potential of *C. parsonii* is considered 'difficult' by Le Berre (1995). Indeed data accumulated by the Chameleon Information Network (A. Abate, pers. comm.) indicates that between 1993 and July 1999 only 80 confirmed hatchlings have been reported outside Madagascar (most of which were derived from imported gravid females). There have been no reported second generation hatchlings for this species.

Figure 4.1 (cont.). Graphs illustrating CITES reported net imports of chameleons (1985-1997). Source: WCMC CITES Database.



Pre-1993 levels of trade were not considered to pose a threat to this species (IUCN/SSC Trade Specialist Group *et al.*, 1993). However, we note the dramatic increase in levels of trade (between 1989 and 1994; Fig. 4.1f), that only appear to have been abated by the imposition of the current moratorium. *C. parsonii* commands a very high price outside Madagascar and retail prices of up to $1 000 have been quoted by dealers who anticipate a resumption in trade (Table 4.4). If the current moratorium is lifted *C. parsonii* is likely to be placed under considerable collection pressure due to its international market retail value. This is of particular concern given the low densities that we have estimated for *C. p. cristifer* in the Mantadia region (although *C. p. cristifer* was not exported in significant numbers prior to the moratorium, Kalisch, 1998) and reports of decreasing abundance of *C. p. parsonii* in those areas that have been most heavily collected (Ravoninjatovo and Rabemananjara, 1999). Given the relatively long time that *C. p. parsonii* requires to reach adulthood, any form of commercial exploitation that involves the collection of sexually mature individuals (especially females) could have an adverse effect on wild populations. Baseline survey work specifically targeted at *C. p. parsonii* and its habitats should be undertaken before any trade restrictions are lifted.

4.5.6 *F. antimena*

This species was collected from Toliara, Belalanda and Manombo, where it was usually taken from areas near the edges of villages and towns (Ravoninjatovo and Rabemananjara, 1999). Peak CITES reported net imports occurred in 1993 with the known legal export of 559 chameleons (Fig. 4.1g).

Animals were reported to be collected 'upon demand', with each order consisting of about 100 pairs (Ravoninjatovo and Rabemananjara, 1999). One exporter claimed that such quantities could be collected by 15 persons in just two hours. Another collector claimed that between November and March he was able to capture 30 to 40 individuals per day. During interviews collectors admitted that they prefer to take only adult males and non-gravid, females. Such preferences were apparently due to the high mortality experienced by juveniles (up to 80%) and gravid females (up to 10%) after capture (Ravoninjatovo and Rabemananjara, 1999). There has been at least one report of successful captive hatching for *F. antimena* (Abate, 1999b) and Le Berre (1995) considers the species' breeding potential to be 'good'. However, no specimens are known to remain alive in captivity outside Madagascar (Abate, 1999b).

Pre-1993 levels of trade were not considered to pose a threat to this species (IUCN/SSC Trade Specialist Group *et al.*, 1993). However, large numbers of individuals have been reportedly taken from relatively small areas and this may have adversely affected local populations. Although these collection figures suggest that the species may be relatively abundant, before the trade moratorium on this species is lifted, stringent controls should be implemented to prevent over exploitation of local populations. Baseline survey work targeted specifically at *F. antimena* and its habitats is urgently required.

4.5.7 *F. balteatus*

This species was collected from the Tolongoina region (Ravoninjatovo and Rabemananjara, 1999). Peak CITES reported net imports occurred in 1992 when 518 animals are known to have been legally exported from Madagascar (Fig. 4.1h). Individual orders are usually for just 10 animals (Ravoninjatovo and Rabemananjara, 1999). Such limited orders are due to the species' apparent rarity, and both collectors and intermediaries consider *F. balteatus* difficult to find. There are no captive *F. balteatus* known to remain alive outside Madagascar (Abate, 1999b).

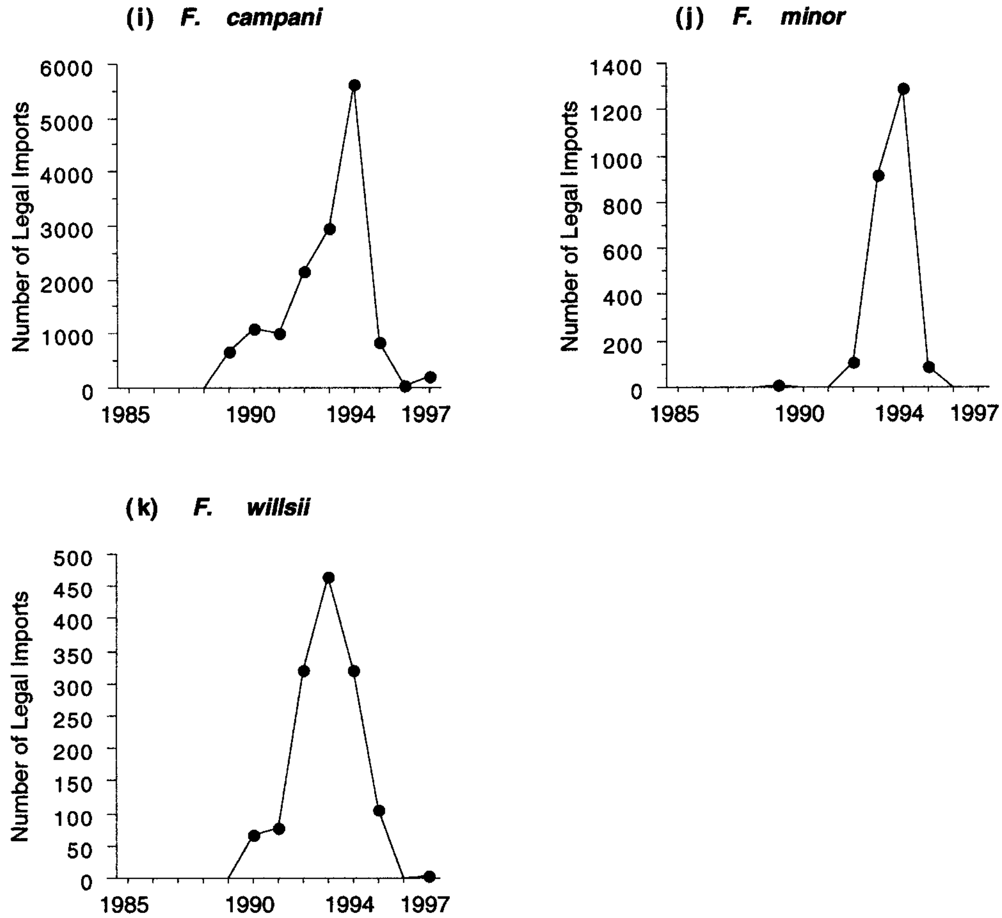
Pre-1993 trade levels were considered to be insignificant (IUCN/SSC Trade Specialist Group *et al.*, 1993). However, given the species' limited distribution and apparent rarity, any resumption in trade must include adequate safeguards to prevent over exploitation of local populations. Baseline survey work targeted specifically at *F. balteatus* and its habitats is urgently required.

4.5.8 *F. campani*

The principal area of collection for *F. campani* was in the region of Ankaratra, where it was usually collected from grassy/shrubby savannahs (Ravoninjatovo and Rabemananjara, 1999). Peak CITES reported net imports occurred in 1994 when 5 629 animals are known to have been exported from Madagascar (Fig. 4.1i). This species is usually collected during the day and local collectors claim that the species is very abundant (during the summer) and up to 1 000 individuals can be reportedly collected over a period of just 2 or 3 days. Individual orders (that may come in at any time of the year) consist of up to 150 animals. Collectors and intermediaries claim that mortality during transport does not exceed 10% (Ravoninjatovo and Rabemananjara, 1999). *F. campani*'s breeding potential has been described as 'difficult' (Le Berre, 1995) and no successful captive breeding has been reported outside Madagascar (Abate, 1999b). No specimens are known to remain alive outside Madagascar (Abate, 1999b).

We concur with a pre-1993 report (IUCN/SSC Trade Specialist Group *et al.*, 1993) that this species is insufficiently known to enable a reliable assessment of the impact of trade on wild populations. Of particular concern is the dramatic increase in animals entering the trade up to 1995. Before any resumption in trade can be contemplated, baseline survey work targeted specifically at *F. campani* and its habitats is urgently required.

Figure 4.1 (cont.). Graphs illustrating CITES reported net imports of chameleons (1985-1997). Source: WCMC CITES Database.



4.5.9 *F. minor*

F. minor was collected from the regions of Ambatofinandrahana, Itremo and Ambalavao (Ravoninjatovo and Rabemananjara, 1999). Collection was reported to be undertaken within coffee plantations and gallery forest where the species is considered to be 'abundant' between November and March (Ravoninjatovo and Rabemananjara, 1999). However, orders were limited by the considerable seasonality displayed by *F. minor*, with winter abundance reported as 'very weak'. Individual orders ranged from 30 to 135 pairs, with no distinction between lifestages. Intermediaries report that the number of annual orders may be as high as four. Mortality rates during transport from intermediary to exporter have been quoted at 3.7% (Ravoninjatovo and Rabemananjara, 1999). *F. minor*'s breeding potential has been described as 'good' by Le Berre (1995) and the species has been bred in captivity by several keepers with even second generation offspring reported (Abate, 1999b). However, this captive population was considered to be 'significantly depleted' by late 1997 (Abate, 1999b).

Pre-1993 trade levels were considered to be insignificant (IUCN/SSC Trade Specialist Group *et al.*, 1993), with only five animals reported in trade to CITES. Although this previous assessment considered that there was little evidence to suggest that levels would increase, the peak CITES reported net imports for *F. minor* occurred in 1994 when 1 257 animals are known to have been exported from Madagascar (Fig. 4.1j). Given the relatively narrow distribution range of *F. minor* such levels of collecting from local populations may be unsustainable. Baseline survey work targeted specifically at *F. minor* and its habitats should be undertaken before any trade restrictions are lifted.

4.5.10 *F. willsii*

The principal areas of collection for *F. willsii* included Andasibe/Mantadia, Moramanga and Mandraka (Ravoninjatovo and Rabemananjara, 1999). Peak CITES reported net imports occurred in 1993 with the known export of 466 individuals from Madagascar (Fig. 4.1k). *F. willsii* is reported to be both difficult to maintain and has not been breed in captivity, with only a single animal known to remain alive outside Madagascar (Abate, 1999b).

Pre-1993 trade levels were believed to be insignificant for this species (IUCN/SSC Trade Specialist Group *et al.*, 1993). However, local guides interviewed at Andasibe claimed that the species was once 'very common' in degraded areas on the periphery of Analamazaotra, but has since declined due to excessive collecting. Although Ravoninjatovo and Rabemananjara (1999) point out that collectors can mistake *F. willsii* for juvenile *C. parsonii*, no such identification errors were made by the guides that we interviewed at Andasibe (some of whom admitted to previously collecting chameleons). Since no baseline density estimates for Andasibe are available it is not possible to verify that a population crash has actually occurred, and whether any such crash was in fact due to collecting. However, future monitoring of this site could determine whether the *F. willsii* population displays any evidence of recovery following the 1996 trade moratorium.

4.5.11 Permissible Trade Species

The Malagasy chameleon species that can be legally exported from Madagascar currently include *F. lateralis*, *F. oustaleti*, *F. pardalis* and *F. verrucosus* (CITES Secretariat, 1995, 1999a). Prior to 1993, all of these were considered to be traded at levels that did not pose a threat to wild populations ((IUCN/SSC Trade Specialist Group *et al.*, 1993). However, for *F. pardalis* some concern was expressed that there had been 'no investigation of the impact of collecting on wild populations' (IUCN/SSC Trade Specialist Group *et al.*, 1993). Trade levels since 1993 have risen sharply for all species (Fig. 4.2), with peak CITES reported net imports of 14 079 (1996) for *F. lateralis*, 2 705 (1994) for *F. oustaleti*, 13 725 (1996) for *F. pardalis* and 1 439 (1997) for *F. verrucosus*. These recent trade levels reflect the species' great popularity amongst herpetoculturalists and the fact that since 1996 trade in all other Malagasy chameleon species has been prohibited. Although there are a number of private breeders outside Madagascar engaged in propagation of *F. pardalis*, reports of captive-bred or captive-born *F. lateralis*, *F. oustaleti* and *F. verrucosus* have been only sporadic (A. Abate, pers. comm.).

F. pardalis possesses several distinct colour morphs (Ravoninjatovo and Rabemananjara, 1999). These colour morphs (which do not currently have any sub-specific status) command different retail prices; with males of the more brightly coloured or unusual colour variants (e.g. cobalt blue banded *F. pardalis* from Ambanja) attracting a higher price than duller colour variants or females. Despite the fact that the CITES Animals Committee have recently recommended that export quotas of all four permissible species are limited to 2 000 animals for 1999 (CITES Secretariat, 1999a), all of these species (and especially the more popular colour variants of *F. pardalis*) may be overexploited in areas that are more easily accessible (for *F. pardalis* these include Nosy Be, Maroantsetra, Toamasina, Sambava and Antsiranana). Research investigating the impacts of collection on wild-populations is urgently required to determine whether proposed collection levels are sustainable.

4.6 Socio-economic Aspects of Chameleon Trade

In 1992 Madagascar's population was estimated to be 12 million people, growing at a rate of 3.18% per annum (WRI, UNEP and UNDP, 1992). Based on this projected growth rate, the 1999 Malagasy population is fast approaching 14.5 million people. Yet Madagascar's Gross National Product (GNP) per capita is just $190 per annum and the country is considered to be the twelfth poorest nation in the world (EIU, 1991). In recent years it has become increasingly apparent that the establishment of protected areas has not been a successful conservation strategy in poor tropical countries such as Madagascar (Shyamsundar and Kramer, 1996). Although forest cover within protected areas is currently believed to be relatively stable, incursions by local people for firewood, cattle grazing and agriculture do occur. Tourism (especially ecotourism) have been highlighted in Madagascar's Environmental Action Plan as a vital source of future revenue for conservation and development, but caution has also been expressed over the level of expected benefits (Durbin and Ratrimoarisaona, 1996)**.** Despite the fact that the trade in poorly known and rare species is a potential conservation threat, Jenkins *et al.* (1999) have suggested that the abundance of some species may allow a level of collection that will not harm wild populations. Such sustainable harvesting has the potential to benefit both species conservation and local communities (e.g. Allen and Edwards, 1995). However, Thorbjarnarson (1999) has warned on the difficulties in quantifying the economic benefits available to local people through the sustainable exploitation of reptiles.

Protected areas have in the past been established with little regard to local people, and conservation efforts have often conflicted with local subsistence demands (Shyamsundar and Kramer, 1996). Yet there is now a move towards involving local people in the management of protected areas through Integrated Conservation and Development Projects (ICDPs), such as at Andohahela, Soalala (Durbin and Ralambo, 1994) and Ranomafana National Park (Wright, 1997). Jenkins *et al.* (1999) consider that if local collectors are given a fair price for reptiles they may be more likely to value protected areas for the long-term revenue that they gain by collecting commercial species at agreed quota levels. Yet despite the continued exploitation of four chameleon species, no such price system has been implemented in Madagascar.

Due to the strict laws governing protected areas, chameleons may only be legally collected from sites (usually degraded) that receive no formal protection (known collection sites are listed in Appendix I). In these areas there is currently no conservation incentive to provide a fair price for local collectors and there is a considerable price differential between collector, intermediary and exporter (Table 4.4). Prices for chameleons in Madagascar vary according to species, collection site and level within network (Ravoninjatovo and Rabemananjara, 1999). We were unable to obtain price information directly from exporters, but have reproduced figures declared to the DGDRF (BIODEV, 1994) and prices quoted in invoices submitted to importers (Jenkins, 1994). The July 1999 wholesale and retail values for chameleons advertised in the U.S. are detailed in Table 4.4.

In general, Malagasy people have little interest in the commercial exploitation of chameleons (Ramanantsoa, 1984). Most Malagasy are often repulsed at the very sight of a chameleon and few are prepared to approach, let alone touch or handle one. Ramanantsoa (1984) was even warned not to 'tease' people by showing them a captive animal, or face the risk of 'uncontrolled violence'. However, when local people are aware of the potential economic benefits of tourism (principally near protected areas), chameleon imagery may be used in local craft products (in some areas live animals may also be sold to tourists; Ravoninjatovo and Rabemananjara, 1999). Although not necessarily traditional, craft products are popular with tourists (e.g. lace, key-rings, spoons, figurines etc at Ranomafana National Park). However, interviews that we conducted with local people at Ambatolahy, Vohiparara and Andasibe revealed that the revenue derived from the sale of handicrafts is generally lower than what was previously available from more traditional and direct exploitation of forest resources (e.g. sale of plant pots carved from tree-ferns).

Table 4.4. Typical prices for Malagasy chameleons (US$) sold by local collectors and intermediaries ($1 = 6,000 fmg), based on interviews conducted during 1999 (adapted from Ravoninjatovo and Rabemananjara, 1999). Exporter prices are based on figures declared to DGDRF (BIODEV, 1994) and invoices submitted to importers (Jenkins, 1994). US prices for Malagasy chameleons (U.S.$) were collected from the adverts of U.S. importers and retailers in July 1999. Source: L. A. Reptile, Reptile Haven, Ward's World of Reptile Propagation, Chameleons-n-Geckos, Mt. Pilot's Chameleon Rainforest, Texas Lizard Connection, Exclusively Reptiles. Unavailable data is represented by " – ". Prices are not controlled for inflation between years.

Species	Price (US$)					
			Malagasy Exporter			
	Malagasy Collector	Malagasy Intermediary	Declared	Invoiced	U.S. Wholesale	U.S. Retail
C. brevicornis	0.08 – 0.17	1.70	-	-	50	90 - 350
C. globifer	0.17	1.70	2.5 – 14	14 – 20	85	175 - 500
C. nasuta	0.42	0.83	-	-	40	100 – 120
C. oshaughnessyi	0.67	1.70	-	-	160	325 - 750
C. parsonii	0.17 – 1.70	0.83 – 4.17	5 – 20	10 – 45	325	525 – 1 000
F. antimena	0.42	1.00	-	-	50	110 - 300
F. balteatus	0.42	1.00	4 – 10	10 – 45	160	280 - 500
F. campani	0.04	0.42	1 – 10	5 – 7.5	40	80 – 95
F. labordi	0.08 (4.17[†])	0.67	-	-	60	140 - 300
F. lateralis					-	30
F. minor	0.04 – 0.08	0.50	-	-	95	175 - 300
F. oustaleti	-	-	2 – 10	7 – 20	-	95
F. pardalis	-	-	3 – 10	7 – 20		
F. pardalis (wild caught)[1]					-	85 – 125
F. pardalis (captive bred)					-	65 – 75
F. petteri	0.17	0.50	-	-	65	145 – 300
F. verrucosus	-	-	2 – 11	7 – 20	-	100
F. willsii	0.17	0.50	-	-	65	145 – 300

[†] Price when sold direct to tourists.

[1] Certain colour variants of *F. pardalis* command higher retail prices.

4.7 Other Factors Affecting Survival of Wild Populations

4.7.1 Habitat Loss

Without doubt the most important factor influencing the future survival of chameleons in Madagascar is habitat loss. Slash and burn subsistence agriculture (tavy) is practised by farmers who clear primary vegetation in order to exploit a nutrient rich soil. Although secondary forest may become established, this is also cleared in progressively shorter cycles. Based on detailed analyses of aerial photographs and satellite imagery, Green and Sussman (1990) estimated that by 1985 only 34% (3.8 million ha) of Madagascar's original rainforest (11.2 million ha) remained intact. Alarmingly, the average rate of deforestation between 1950 and 1985 was estimated to be 111 000 ha per year. Green and Sussman (1990) concluded that if this rate of forest clearance continues then only those forests located on the steepest slopes will remain by the year 2020. During his fieldwork in eastern Madagascar, Raxworthy (1988) noted that almost all the reptiles that he encountered were totally dependent upon the rainforest ecosystem. When forest is repeatedly cleared to the point where it is unable to re-establish itself the impoverished Malagasy soils can only support ferns and fire resistant grasses. In these highly degraded habitats Raxworthy (1988) only recorded a single species of chameleon, *F. pardalis*. Although we have recorded several species in areas where forest has been cleared (e.g. *C. brevicornis*, *C. nasuta*, *C. p. cristifer*, *F. balteatus*, *F. willsii*), each of these areas retained at least some tree cover (mostly secondary re-growth) and all were found close to the edges of less disturbed forest blocks. We have found *F. lateralis* in areas devoid of tree cover (e.g. amongst heather on the Central High Plateau) and like *F. pardalis* this is probably a generalist species that is able to successfully exploit disturbed habitats.

Chameleons that are found in habitats other than rainforest are also threatened by habitat loss (Nicoll and Langrand, 1989) and some species may even be vulnerable to the effects of chemical pesticides that are used to control insect pests such as locusts (O. Pronk, pers. comm.).

4.7.2 Traditional Uses of Chameleons by Local People

During our interviews with local people we discovered that a very widely held belief is 'Tody'. Do something bad to another person or creature and a bad thing will happen to you ('What comes around, goes around'). This influences the way people interact with their environment and very few traditions in Madagascar therefore involve killing chameleons. During his interviews with people from 18 different tribes Ramanantsoa (1984) was only able to find three such practices:

1. Ashes of female chameleons are used as a medicine to treat convulsions in children.

2. Blood is collected from the feet of a chameleon and used to create an amulet. The amulet is believed to increase a wrestler's agility when he tries to seize an opponent.

3. Chameleons are also used to make another amulet that is worn by an accused person on the day of judgement. It is believed to help reduce the severity of a judge's verdict.

Other similar traditional practices may exist across Madagascar. For example, in Antananarivo we have observed children collecting chameleons (usually *F. lateralis*) on the ends of long sticks and using them in staged fights. These fights often result in the death of one or other of the chameleon combatants. Conversely, in the Betsilio region we were told that parents warn their children that if they harm or kill chameleons the children will experience bad luck and may even die!

We do not consider any of the known traditional uses of chameleons as potential threats to wild populations.

5. Discussion and Recommendations

5.1 Population and Distribution Trends

Our results from three different rainforest areas have revealed that the densities of seemingly ubiquitous species (e.g. *C. brevicornis*, *C. gastrotaenia*, *C. nasuta*) can vary enormously between different sites, with considerable variation also evident within contiguous blocks of forest. Such variation has resulted in the calculation of national population levels that display widely differing minimum and maximum values. Tam-Alkis (1997) found that the extent of habitat disturbance was largely responsible for determining the assemblage structure of *Calumma* spp. across a rainforest ecotone at Ranomafana National Park. His results also demonstrated that small streams may act as barriers to the dispersal of some chameleon species (e.g. *B. superciliaris*). Further research aimed at identifying the mechanisms responsible for regulating chameleon densities will help in the determination of more accurate population trends. Long term population studies have not been reported for any Malagasy chameleon species. However, extensive habitat loss and fragmentation within each species' geographic domain (Nicoll and Langrand, 1989; Green and Sussman, 1990) have probably led to significant declines in overall population levels. Whilst large scale habitat loss remains the most pressing conservation problem in Madagascar, there is also widespread concern that overexploitation of some species may occur (Behra, 1993; IUCN/SSC Trade Specialist Group *et al.*, 1993; Abate, 1999b).

Raxworthy and Nussbaum's (1997) inventory based surveys have revealed high levels of regional endemism in Malagasy reptiles, with most of the sites that they visited possessing site-specific endemics. Continuation of this inventory work is required before it will be possible to adequately describe patterns of distribution. The combined impact of habitat loss and commercial exploitation has previously been highlighted as an important threat to wild populations of reptiles (e.g. Thorbjarnarson, 1999). For chameleons, the limited distributions of some species (e.g. *F. antimena*, *F. balteatus, F. campani, F. minor)* suggests that they are particularly vulnerable to the effects of habitat loss and collection for the commercial trade, whilst more widely distributed species (e.g. *C. brevicornis*, *C. p. parsonii*) are increasingly restricted to highly fragmented areas. Therefore, we caution that the collection of chameleons from habitat islands surrounded by an ever more degraded landscape may raise the spectre of Caughley's (1994) small population paradigm and extinction vortices.

5.2 Sustainability of Trade

The recent exploitation of chameleons in Madagascar has followed the pattern described by Thorbjarnarson (1999), where the primary objective was short term profit without regard to species conservation. Despite warning signs that the international community was not prepared to tolerate the unsustainable exploitation of chameleons, culminating in the 1996 trade moratorium (CITES Secretariat, 1995), exporters operating from Madagascar have continued to collect permissible trade species in ever increasing quantities. Escalating levels of trade in *F. lateralis*, *F. oustaleti*, *F. pardalis*, and *F. verrucosus* have recently prompted Madagascar to impose export quotas of 2 000 individuals for each species (CITES Secretariat, 1999a). Yet, although these species are widely distributed (Glaw and Vences, 1994), no data on local population densities or research aimed at determining the impact of collection on wild populations have ever been published. A recent proposal submitted to the CITES Standing Committee on behalf of DEF (Anon, 1999) has detailed an 'Experimental Management Program' (EMP) for Malagasy chameleons and day geckoes (*Phelsuma* spp.). The Parties were informed of this in Notification to the Parties No. 1999/51 of 30 July 1999. This management programme aims to develop a viable management system for the sustainable harvest and commercial export of permissible trade species.

Child (1987) has pointed out that when reptiles are commercially exploited their management is often given a higher priority at the national level, and in poor countries (such as Madagascar) Thorbjarnarson (1999) has argued that the commercial exploitation of reptiles could generate revenue for underfunded wildlife management agencies (i.e. DEF and ANGAP). Whilst we agree in principle with these conservation ideals, in order for commercial exploitation to achieve sustainability, managed harvests must be coupled with a monitoring programme and should be based on an understanding of the population biology of the species involved. Our results provide important baseline density estimates for several chameleon species across different rainforest areas. Some species may require relatively long periods for both incubation of eggs and juvenile development (e.g. *C. p. parsonii*) and it is therefore naïve to assume (e.g. Anon, 1999) that all chameleon species follow the demographic patterns observed in other small to medium-sized lizards. Basic life-history information for wild populations is severely lacking for almost all species, and more detailed long term research that specifically targets those species at greatest risk (from both habitat loss and collection) is urgently required.

5.2.1 Continuation of the Export Moratorium

The establishment of a monitoring programme designed to investigate the impacts of harvesting on wild populations is urgently required, and must be implemented before any resumption in trade of species included on the export moratorium. Monitoring should begin immediately in areas where chameleon harvesting is likely to occur (known collection sites are detailed in Appendix I). Our results have shown that the population densities of rainforest chameleons in Ranomafana National Park display little annual variation. Rapid one or two season assessments may therefore be possible in other areas that have not been previously surveyed. Although conservative at a national level, recently proposed export quotas for *F. lateralis*, *F. oustaleti*, *F. pardalis* and *F. verrucosus* (2 000 individuals per annum for each species) are of concern, since they do not prevent easily accessible local populations from being overexploited. Unfortunately, the rather simplistic calculations used to illustrate potential harvest yields in the recent EMP (Anon, 1999) fail to take account of local populations. Collection quotas must be specifically targeted at local rather than national populations, and this can only be achieved when population estimates are available for each of the proposed collection sites.

Sustainable harvest yields should be based on models that link demographic parameters with bio-economics. Such models can be applied in two different ways. First, as a one-off exercise in which the mechanisms operating in the system (both biological and economic) are explored, providing general principles and rules of thumb which can be used to guide management policy. Second, as a continuously maintained and updated tool which is actively used as part of the decision making process by which harvesting is regulated. Once the baseline research has been completed, the first of these approaches can be readily and cheaply applied. Applying the second approach is more costly in terms of time and expertise, and the level at which it is applied must depend on the resources (both financial and human) available. However, it offers a powerful technique by which harvesting can be managed with effective safeguards against overexploitation. Modelling of this kind fits well within an adaptive management approach, since their relative strengths and weaknesses complement each other. While some form of adaptive management provides the only ultimate test of harvesting effects in the real world, it is generally slow, difficult and costly to generate conclusive results by this method. In contrast, while models of the system generally suffer from uncertainties in parameters and assumptions, and hence predictions, they allow the rapid assessment of a very broad spectrum of potential management approaches, both from the biological and economic points of view. The ideal approach is therefore to feed information back between the approaches, using insights from models to guide action, and using the results of action to refine and update the models. A project based at the Institute of Zoology, London, has recently been started to begin developing simple and readily applied models which can serve this purpose in developing trade regulations for *F. oustaleti* (M. Rowcliffe pers. comm.).

Unlike chameleons, other species of lizards that have been the subject of commercial harvesting and captive breeding programmes, such as iguanas and tegus, have relatively well-understood patterns of reproductive biology and population structure (e.g. Werner, 1991; Fitzgerald *et al*., 1991). Even in these species, however, it is difficult to rigorously calculate rates of sustainable offtake from natural populations, or to estimate the long-term effects of harvesting on populations. It is probably unrealistic to maintain a total ban on the collection of chameleons until sufficient population data has been assembled to construct harvesting models – such research could take several years to complete. Conservative collection quotas may therefore be a second-best option for certain species, but such quotas must be based on the best available data for the species concerned. Equally, it is essential that exploited populations are rigorously monitored by independent parties (e.g. through the proposed EMP; Anon, 1999), and that collection quotas are reviewed and revised as new data come to light.

5.2.2 Implementation of Existing Trade Controls

The current trade controls operating in Madagascar do not facilitate sustainability because collection permits are valid in any area where exploitation is allowed. It has therefore not been possible to regulate collection at a site specific or even regional level. In some cases permits do not explicitly state what species may be collected, and despite guidelines issued by the CITES Secretariat (1994) these ‘unidentified’ chameleons continue to be imported into countries Party to CITES. We agree in principle with the ‘harvest regulation and supervision’ criteria of the proposed EMP (Anon, 1999) and suggest that DEF should review its criteria for issuing collection permits. Specific recommendations include:

1. Collection permits must accurately list the species to be collected.

2. Collection permits should be site specific with quotas that are based on sustainable harvest yields derived from monitored populations.

3. The price structure of the trade must be critically reviewed in each region where harvesting is to take place, and local collectors provided with a fair price. This price structure would need to be maintained by the establishment of minimum export prices set by the Direction of Durable Management of Forest Resources (DGDRF).

4. The current export tax of 4% could be increased to a more realistic level, with the extra revenue generated used to help finance the implementation of trade controls.

5. Exporters must maintain accurate records of post-capture mortality levels for each species (including those that die while being held by local collectors and intermediaries). All such data should be made available to the Madagascar CITES Management Authority (i.e. DEF) and exporters that fail to minimise post-capture mortality should have their collection permits revoked. Local collectors must not take surplus animals to offset losses caused by mortality during transport.

6. Exporter’s facilities should be open to random inspection by experts appointed by an independent conservation, scientific or academic organisation (e.g. ANGAP, DEF, WWF). These experts must be able to verify that only permissible species are being collected at agreed quotas.

7. All permits should be renewable on an annual basis and could be withdrawn on evidence of any irregularity in an exporter’s operation. Such stringent controls would help to protect the interests of legitimate exporters from the activities of operatives that seek to undermine the price structure of the trade.

8. Easy to use chameleon identification guides (in Malagasy, French and English) must be made available to all organisations within the trade network (including customs officials in importing countries Party to CITES).

5.3 Reduction of Post-capture Mortality

Although Ravoninjatovo and Rabemananjara (1999) have reported on post-capture chameleon mortality, their figures were based entirely upon interviews rather than personal observations. These results therefore need to be accepted with caution, as their stated mortality rates are probably underestimates. In order to reduce post-capture mortality, it is important to identify and remedy each of the factors responsible. Major health issues operating within the trade networks described by Ravoninjatovo and Rabemananjara (1999) include:

1. Injury, inflicted by rough handling.

2. Injury inflicted by other chameleons, when multiple animals are confined together.

3. Exposure to pathogens and parasites in unhygienic enclosures.

4. Malnutrition caused by food deprivation or poor diet.

5. Dehydration caused by water deprivation or inappropriate water delivery systems.

6. Illness or suffocation from exposure to inappropriate temperatures.

7. Deleterious effects of stress resulting from captivity.

8. Maladjustment to captivity by otherwise healthy chameleons can also lead to death.

According to Abate (1999a) many of these conditions may still prevail even after animals are exported and undergoing captive management by importers, wholesalers and retailers. Although it has been proposed that all animals should be examined by a veterinarian and certified healthy before they are exported, Abate (1999a) considers that due to financial constraints such requirements would be very difficult to implement in Madagascar. The proposed EMP (Anon, 1999) must be revised to ensure that health and welfare issues are thoroughly addressed.

We have not been able to acquire post-export mortality figures for chameleons originating from Madagascar and it appears that these data have not previously been recorded by the CITES Management Authorities of countries importing chameleons. The Partoes have recently expressed concern over the lack of information relating to post-export mortality and the Secretariat has issued notification to the Parties No. 1999/48 requesting the collection of information on *Chamaeleo senegalensis* (CITES Secretariat, 1996b).

In order to facilitate a reliable assessment of post-export mortality, we recommend that the CITES Animals Committee encourages all Parties to maintain accurate mortality records of all imported Malagasy chameleon species. These records, together with details of any violations of IATA guidelines or confiscation of chameleon shipments, should also be reported to the Madagascar CITES Management Authority.

5.4 Monitoring of Wild Populations

The recently proposed EMP (Anon, 1999) has indicated that survey and monitoring of chameleon populations subject to collection will be undertaken every two months using ‘recognised appropriate methodologies and techniques’. However, no further information on the methodologies or their implementation have been provided. Fieldwork on chameleons can be difficult due to their low densities, secrecy and crypsis, and unless appropriate search techniques are adopted encounter rates are liable to be very low. Diurnal searching tends to reveal only small numbers of individuals, especially in structurally complex habitats such as rainforest. Pitfall trapping is a widely used herpetofauna sampling technique (e.g. Greenberg *et al.*, 1994), but is inappropriate for arboreal chameleon species. In fact Raxworthy and Nussbaum (1994) found that pitfall trapping was inefficient even for ground dwelling *Brookesia* spp. Since chameleons become pale at night and tend to roost in prominent positions (Parcher, 1974; Raxworthy, 1988), they are relatively easy to pick out using torchlight (Jenkins *et al.*, 1999) and searching for roosting animals at night remains the most effective technique for finding chameleons.

Blomberg and Shine (1996) recommended the use of mark-recapture techniques to estimate reptile population densities and these have apparently been applied by Raxworthy and Nussbaum (in: Anon, 1999) at Montagne d'Ambre. However, Brady *et al.* (1996) have highlighted a number of shortcomings when applying this technique to chameleons (further discussed in Jenkins *et al.*, 1999). If chameleons are sampled using systematic searching of an area the available analytical methods assume that there is random mixing between marked and unmarked animals (Krebs, 1989). However, work by Kauffmann (1994) and Kauffmann *et al.* (1997) have shown that arboreal chameleons occupy well defined home ranges and the assumption of random mixing is therefore likely to be violated. Also, when fieldworkers undertake repeated surveys in relatively confined areas they very quickly become familiar with the approximate locations of individual chameleons, and marked animals are therefore preferentially selected (L. Brady, pers. obs.). This violates the assumption that marking animals does not affect their detectability (Krebs, 1989). Brady *et al.* (1996) attempted to avoid these problems by designing their search strategy such that individual observers were prevented from learning the approximate location of previously marked chameleons. This strategy was achieved by employing a relatively large number of observers and assigning each to a different segment within the sampling area on subsequent sampling dates. However, the very intensive effort that is required to both define mark-recapture sampling areas and obtain adequate sample sizes is a major impediment in countries such as Madagascar, where finite resources severely limit available trained manpower.

Jenkins *et al.* (1999) believe that ground-based surveys are currently the most practical method for monitoring chameleon population densities and they have recommended that monitoring programmes base their survey design on randomly located forest line transects. Jenkins *et al.* (1999) have also argued that since distance sampling controls for detectability, it is well suited for the spatial and temporal comparison of chameleon population densities. Comparisons are therefore possible between different populations or seasons and even between unrelated species that occur in different habitats. The most important caveat associated with distance sampling is that the analytical technique assumes all animals are detected at zero distance from the transect line; including animals roosting high within the forest canopy. Obviously any method that attempts to estimate the density or abundance of largely arboreal animals will be limited by a decreasing vertical detection rate. In order to limit density estimation errors caused by high roosting individuals, particularly those above the transect line, Jenkins *et al.* (1999) have suggested that fieldworkers apply a detection ceiling to all observations. Densities estimated for chameleons found in habitats where a detection ceiling is necessary (e.g. rainforest) are therefore likely to underestimate true densities. However, so long as full details of the applied detection ceiling are documented, this does not affect the repeatability of the technique.

Our results demonstrate that the combination of searching for roosting animals along randomly located forest transects and analysing the resulting data using distance sampling is a successful strategy for estimating chameleon densities in dense rainforest habitat. The repeatability of the technique is illustrated by the consistent results we have obtained (using different surveyors) for chameleon populations at Vatoharanana (Ranomafana). Although we have not had the opportunity to apply our techniques in other habitat areas, a recent Oxford University project undertaken at Ankarafantsika has shown that the methods can also be successfully used to estimate chameleon densities in Madagascar's dry western forests (J. Metcalf, pers. comm.). Follow-up surveys in dry forest habitat are currently being planned (M. Rowcliffe, pers. comm.) and we see no reason why our proposed methodology cannot be applied in other more open habitat areas.

Below we provide guidance for future monitoring programmes:

1. All surveyors must be adequately trained in search techniques before commencement of data collection. Our experience of training Malagasy fieldworkers indicates that this can be done very reliably, with inexperienced surveyors quickly acquiring chameleon search images.

2. Preliminary surveys can be used to determine encounter rates and therefore allow fieldworkers to efficiently plan their survey sessions. We propose that projects in areas not previously surveyed should aim for density estimates with less than 30% error (where error is represented by % coefficient of variation). However, where surveys form part of a long-term monitoring programme sample sizes should be increased sufficiently to reduce error to less than 20%. For small bodied species (e.g. *C. nasuta*) 30% error can be realised with 30 observations, while 60 observations are required to achieve 20% error (Fig. 5.1). For large bodied species (e.g. *C. parsonii*) 30% error can again be achieved with 30 observations, but 50 observations are needed to reduce error below 20% (Fig. 5.2).

Figure 5.1. Graph illustrating the minimum number of observations required to reliably estimate the density of small bodied chameleons using program DISTANCE.

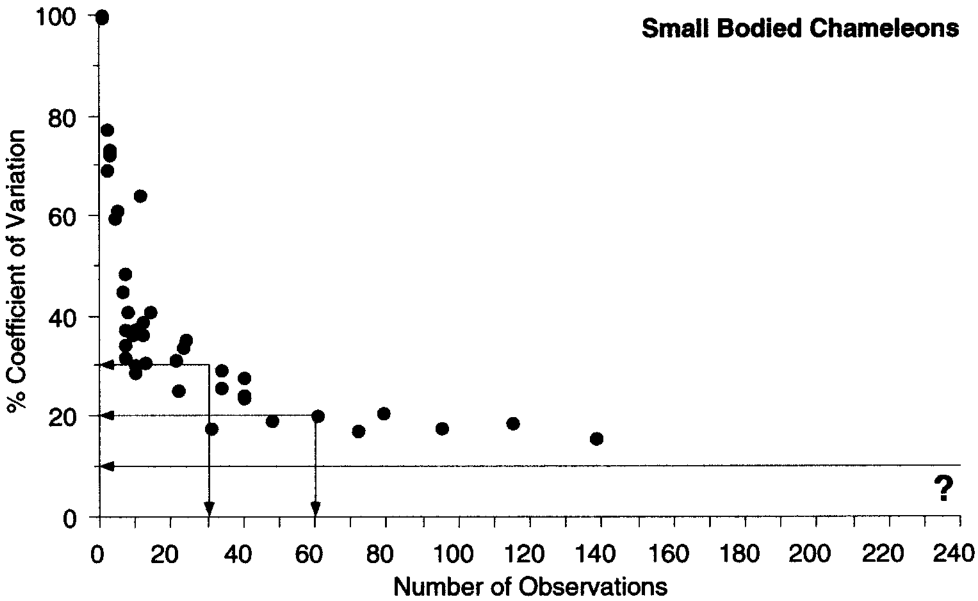
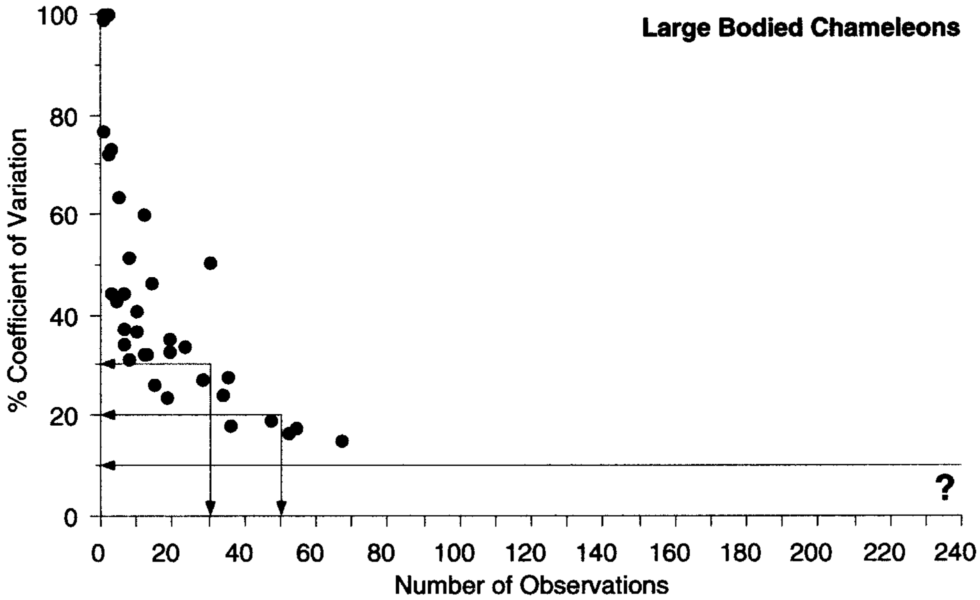


Figure 5.2. Graph illustrating the minimum number of observations required to reliably estimate the density of large bodied chameleons using program DISTANCE.



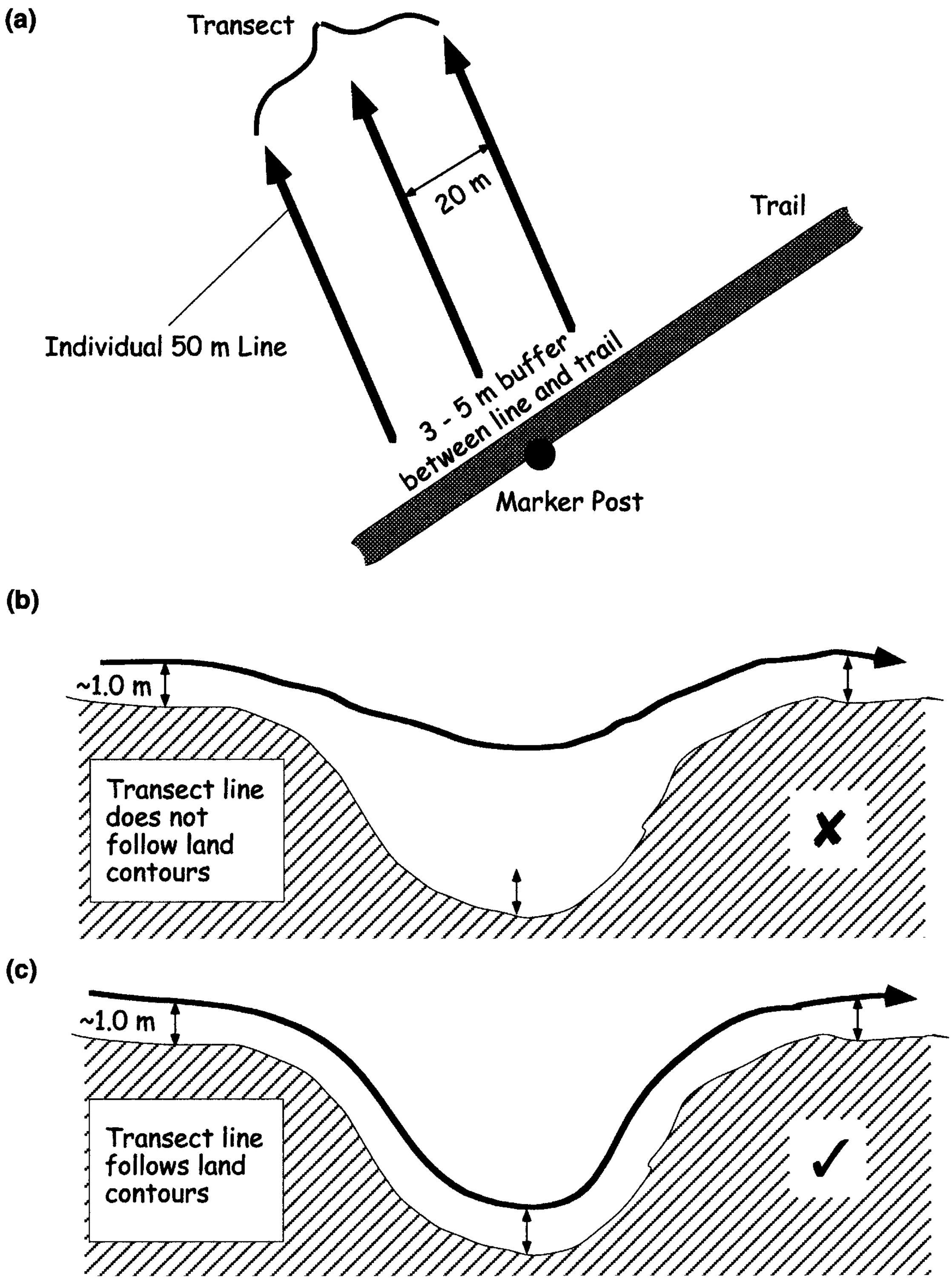
3. Since distance sampling assumes that transects are placed at random, some preparatory work is necessary. Chameleon abundance may be dependent upon particular landscape features (e.g. river corridors; Jenkins *et al.*, in prep). We therefore recommend that fieldworkers attempt to sample different topographical areas (e.g. river valleys, slopes and ridge tops) at each study site and include them within density analyses as separate strata. In order to prevent transect lines extending between different strata, several short lines can be used in parallel. Existing trails/streams within each strata can be quickly mapped, and marker posts set at predetermined intervals (e.g. every 100 m or every 5 - 10 minutes walk time). The position of individual transects can then be randomly determined from this list of available marker posts. Transects should be randomly assigned to one side of the trail (e.g. by tossing a coin), with the orientation determined by throwing a stick and following its bearing.

4. Density estimates should not be made from transects that are positioned only along the length of trails, since these may create bias and will not be representative of the site as a whole. For example, trails can have a different vegetation structure to less disturbed habitat areas (e.g. Brady *et al.*, 1996) and may therefore favour certain chameleon species (Jenkins *et al.*, 1999). Although trails facilitate accessing areas located deep within dense habitat, the beginning of each transect should be positioned some distance away from the trail edge (we propose a minimum 'buffer' of 3 – 5 m; Fig. 5.3).

5. When transects are being set, it is important that they follow the contours of the land and ideally each line should keep to within 1.0 m of the ground (see Fig. 5.3). In order to avoid disturbance to chameleons, transects must be set up at least 24 hrs before they are surveyed. Although this may appear time consuming, several transects can be quickly set up on any one day and surveys can proceed without interruption.

6. Transects ideally consist of several 50 m tape measures. However, when funds are limited measured lengths of nylon cord (readily available in Antananarivo) can be substituted.

Figure 5.3. Diagram illustrating placement of transects. (a) Correct spacing of individual lines, (b) line that does not accurately follow land contours resulting in a density overestimate, (c) line that correctly follows land contours.



7. Several short lines (we recommend no more than 3 - 4) may be used in parallel for each transect, but in order to prevent the same animal from being detected (and thus disturbed) from more than one line, these should be positioned with a minimum of 20 m separation between each line (Fig. 5.3). We recommend that individual transects do not exceed 150 - 200 m in total length and are surveyed at a speed of approximately 0.8 – 1.2 m per min. If only large bodied chameleons are being surveyed, this search speed may be increased, but we consider that due to the paucity of available information, fieldworkers should be encouraged to collect data on all chameleon species (including *Brookesia* spp.) that they encounter.

8. Searching for chameleons at night in dense habitat can be very difficult. We recommend that all surveyors are equipped with battery powered head lamps. Head lamps allow fieldworkers to concentrate on searching for chameleons while using both hands to pick their way through vegetation. Although carrying a full battery load on one's head can be uncomfortable, lamps are available that allow the battery compartment to be fixed at the waist (e.g. 'Petzl Mega Belt'). Since the detection distance between the observer and a low roosting chameleon is determined more by the density of vegetation than intensity of the available light source, we do not consider halogen bulbs to be suitable for use in dense habitat. Halogen bulbs can also be too bright when searching for chameleons close to the transect making it difficult to distinguish chameleons (particularly small bodied species) from the surrounding vegetation (L. Brady, pers. obs.). Standard 4.5v bulbs provide a more than adequate light source and have the added advantage that they do not rapidly deplete batteries (we recommend that only alkaline batteries are used; again these are available in Antananarivo).

9. In order to prevent density estimation errors caused by fieldworkers overlooking high roosting chameleons above the transect line, a detection ceiling should be applied to all observations. The height of this ceiling can be determined immediately prior to data analysis by examination of roost information and elimination of outliers. In rainforest habitats we recommend a detection ceiling of 6 m.

10. When time is limited and encounter rates are low, we propose that surveyors pool species within detection groups and calculate overall densities for each group (Brady *et al.*, 1996; Jenkins *et al.*, 1999). Grouped analyses assume equal detectability of member species and the criteria used to define detection groups should therefore include chameleon size and roosting behaviour. Examples include small bodied shrub/tree roosting chameleons (e.g. *C. nasuta*, *C. gastrotaenia*, *F. willsii*), large bodied shrub/tree roosting chameleons (e.g. *C. brevicornis*, *C. p. parsonii*, *F. oustaleti*) and small bodied herb/shrub roosting chameleons (e.g. *Brookesia* spp.). Densities of individual species can be estimated by calculating the relative proportion of observations contributed by different species within each detection group.

When financial and/or manpower constraints limit the available survey time, or when rapid assessments are required in areas where computer equipment is unavailable we suggest the following strategy:

1 All chameleon surveys should follow the basic principles outlined for line transects above (including randomisation of search location). Although actual transect lines are not necessary, it is vital that surveyors record search effort. Effort can be recorded either as net search time (total search time minus total processing time) or, preferably, total distance searched.

2 In order for surveys to be representative of the area under investigation, fieldworkers should consider a minimum of 5 – 10 sampling sessions, randomly distributed across different topographical strata.

3 Since rapid assessments are unlikely to obtain sample sizes large enough for reliable distance sampling analyses, we have calculated regression equations (Figs. 5.4 – 5.7) that allow *rainforest* chameleon densities to be predicted from the encounter rate of two person survey teams. Encounter rates for two person survey teams can be represented as number of chameleons per hour or number of chameleons per 100 m. Our regression equations indicate that if densities are predicted using encounter rates, recording total distance searched provides for more reliable estimates than recording net search time. It should be noted that these equations are strongly dependent upon chameleon detectability and further calibration work in different habitats is therefore required.

Figure 5.4. Graph illustrating relationship between small bodied chameleon abundance (number of individuals per 100 m per survey team) and DISTANCE estimated density (per ha). Dotted lines indicate 95 % confidence intervals for the slope.

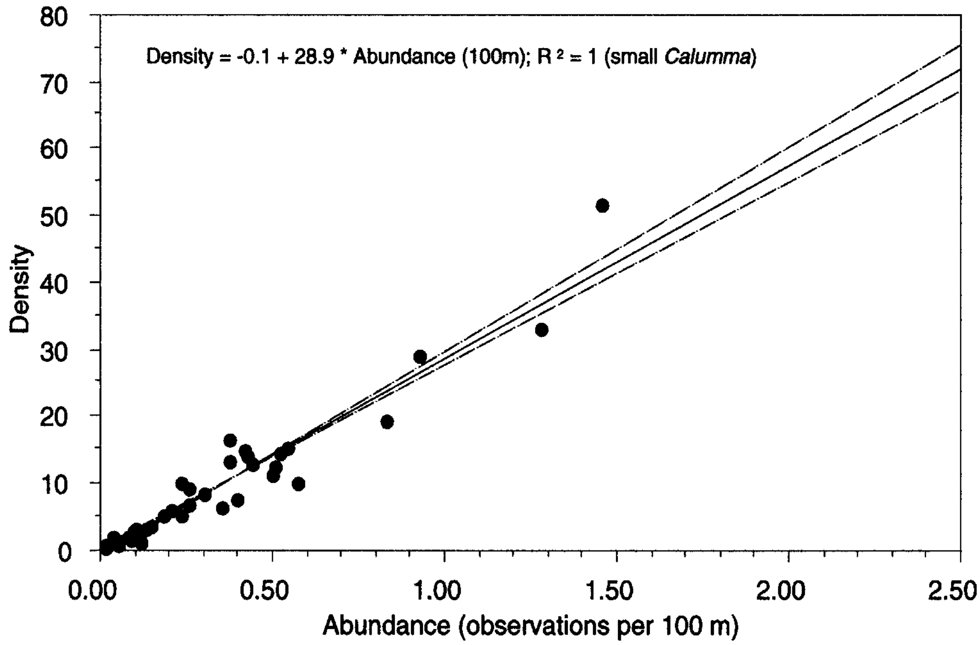


Figure 5.5. Graph illustrating relationship between small bodied chameleon abundance (number of individuals per search hour per survey team) and DISTANCE estimated density (per ha). Dotted lines indicate 95 % confidence intervals for the slope.

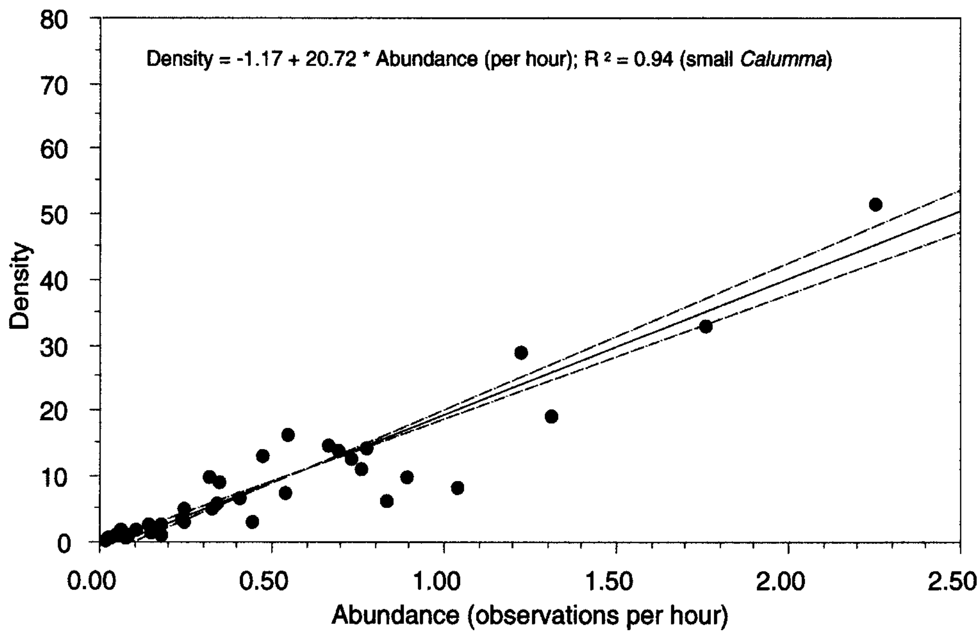


Figure 5.6. Graph illustrating relationship between large bodied chameleon abundance (number of individuals per 100 m per survey team) and DISTANCE estimated density (per ha). Dotted lines indicate 95 % confidence intervals for the slope.

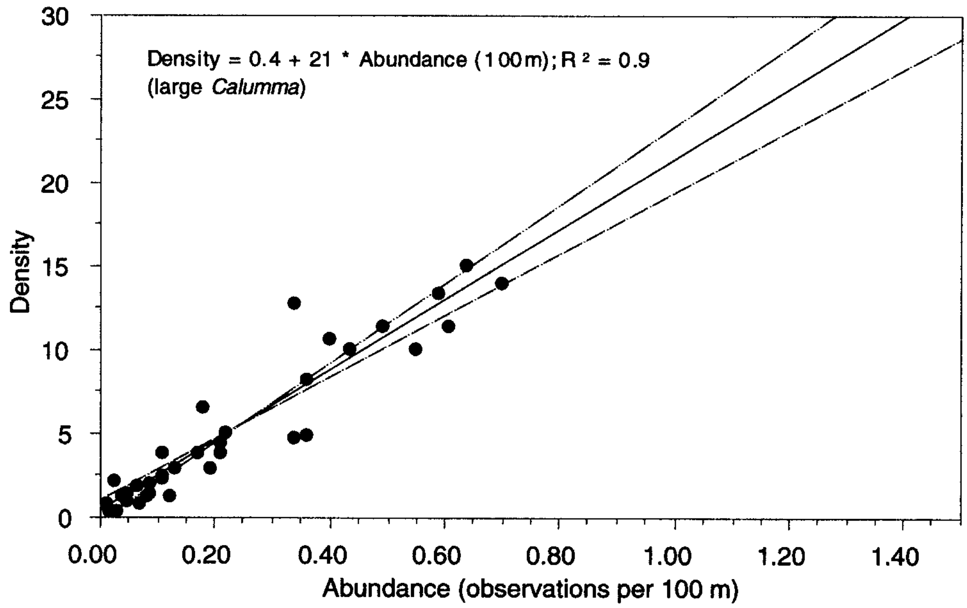


Figure 5.7. Graph illustrating relationship between large bodied chameleon abundance (number of individuals per search hour per survey team) and DISTANCE estimated density (per ha). Dotted lines indicate 95 % confidence intervals for the slope.

5.5 Commercial Captive Breeding Centres in Madagascar

Commercial breeding centres for reptiles are generally established as either farms or ranches. Thorbjarnarson (1999) has defined farms as closed-cycle operations where captive adult animals lay eggs that provide the stock subsequently sold by the farm. In contrast ranches rely on the collection of eggs or hatchlings from the wild. Thorbjarnarson (1999) has argued that although reptile farms can be economically successful and may generate both political and public interest in threatened species, the fact that they are not directly connected with the maintenance of wild populations means that they do not provide the necessary economic links that are fundamental to successful sustainable use programmes. In contrast, facilities that depend upon ranching have a vested interest in the maintenance of wild populations and their habitats. Since it is impractical to collect large numbers of chameleon eggs, ranches may be required to collect gravid females from wild populations. Yet the removal of gravid females could have a significant deleterious effect on populations that are also under increasing pressure from habitat disturbance. It is generally believed that to ensure ranches do not negatively impact donor populations all wild caught animals should be returned to the wild. However, we are not convinced that territorial animals, such as chameleons, can be successfully reintegrated into wild populations. Increased stress during handling has been identified as an important factor influencing chameleon mortality (Abate, 1999a; Ravoninjatovo and Rabemananjara, 1999). Even if local collectors could be sufficiently well trained in reptile handling techniques, it is unlikely that individual animals would be returned to their exact place of capture and we currently do not know what impact such large scale disturbance would have on the future reproductive capacity of wild populations. The release of any captive chameleon (including captive bred individuals) into a wild population is also confounded by issues such as disease and genetic pollution.

At present there is no evidence that chameleons have been captive-bred in Madagascar on a commercially viable and sustainable basis. Indeed, Malagasy chameleons have demanding requirements in captivity, and it is only in recent years that these have started to be understood (e.g. Bustard, 1989; De Vosjoli, 1990; Ferguson, 1994). There are, however, a number of suppliers in Europe and North America who are able to breed some species on a commercial basis. With investment in the appropriate technologies and expertise, theoretically it could be possible to breed some species in large numbers under captive conditions within Madagascar. However, we doubt whether such initiatives would reduce the collection pressure on wild populations, or have direct conservation benefits. As chameleons can be collected from the wild very cheaply, the collection of wild specimens will remain a more economically attractive option than breeding them in captivity in Madagascar. It is our opinion that the ‘farm’ we visited and the facilities described by Abate (1999a) do not promote the conservation of chameleons in Madagascar. In fact we believe that they may be very damaging in terms of the inappropriate conservation message they convey to tourists and potential customers. At present, there is neither the infrastructure nor the technology in Madagascar to ensure that wild-caught specimens are not laundered as captive bred specimens by unscrupulous dealers. Until it is possible to reliably distinguish between wild caught and captive bred specimens we therefore believe that there should be no export of captive bred chameleons from Madagascar.

Should the management authority of Madagascar consider licensing of the export of captive bred chameleons in the future, we believe the following criteria should be considered before any resumption of trade in these species:

1. Breeding centres should be established as ranches that rely on occasional recruitment of juveniles from wild populations. Juvenile animals are first taken from wild populations to form the basis of the initial breeding stock, with further regular (but limited) harvests of juveniles to supplement ranch bred animals and therefore minimise the possibility of inbreeding depression. By applying this model the breeding centre only takes a small proportion of its stock from the wild, but is still dependent upon the maintenance of wild populations and their habitats.

2. Due to the specific requirements of different chameleon species, individual breeding centres should specialise in a small number of locally occurring species. Breeding centres should

therefore only be established in or near a species' natural limit of distribution. This will help prevent maladjustment of animals to captivity due to inappropriate local conditions (e.g. climate).

3. Captive bred chameleons must be easily distinguishable from animals that may have been illegally taken from the wild. Available methods include the implantation of microchip transponders. However, there have been recent concerns over the effects such methods may have on reptile health and further research on alternative permanent marking methods may be necessary.

4. Breeding centres may be owned by commercial exporters, but they should be run by properly trained, local Malagasy residents; with regular supervision from experts acting on behalf of an independent conservation, scientific or academic organisation (e.g. ANGAP, DEF, WWF). Supervision by these organisations would help ensure the health and welfare of captive animals, verification that chameleons were being bred and ranched appropriately and that the operation retains its commercial integrity.

5. A network of participants must be identified for all stages of the operation, from collection to export. The price structure of the trade should be critically reviewed to ensure that appropriate prices are paid at each level of the network (including fair prices for local collectors), while allowing the breeding centre to remain profitable.

5.6 Conclusion - Summary of Future Research Objectives

We consider that in order for chameleon harvests to be based on sustainable quotas, the Madagascar CITES Management Authority should encourage non-governmental organisations, national and international research institutes, and the proposed EMP (Anon, 1999) to both adopt and fund the following research objectives:

1. *Expansion in knowledge of species range*. Continuation of inventory based surveys in areas not previously surveyed.

2. *Determine baseline population densities at key sites*. Rapid survey assessments are required to determine baseline population densities using the methods outlined in this report. Key sites include all protected areas and sites where chameleon harvesting has been proposed.

3. *Long-term monitoring of key sites*. Programmes should be initiated that will allow the monitoring of population fluctuations at key sites. Long-term monitoring is particularly important in areas where chameleon harvesting is proposed.

4. *Detailed ecological studies for key species*. Species identified as most at risk from habitat loss and/or collection for trade require long-term research projects to investigate population demographics and factors influencing dispersal.

5. *Development of harvesting models*. Development of ecological and bio-economic models that will allow scientifically credible sustainable harvest strategies to be initiated.

6. References

Abate, A. (1994) Report of a *C. p. parsonii* hatching. *Chameleon Information Network*, **13**, 4.

Abate, A. (1998) Reports from the field; Parson's chameleon. *Chameleon Information Network*, **29**, 17-25.

Abate, A. (1999a) Assessing the health of wild-caught chameleon. Part 2. *Chameleon Information Network*, **31**, 9-17.

Abate, A. (1999b) The exportation of chameleons from Madagascar – Past and present. *The Chameleon Information Network*, **32**, 9–17.

Allen, C. M. and Edwards, S. R. (1995) The sustainable-use debate: observations from IUCN. *Oryx*, **29**, 92-98.

Angel, F. (1942) Les Lézards de Madagascar. *Mémoires de L'Academie* Malgache, **36** [in French].

Anon (1999) *Experimental management program for the sustainable use and commercial export of Chamaeleonid and Phelsumid lizards in Madagascar*. Proposal to CITES Standing Committee, Direction Génerale des Eaux et Foréts, Antananarivo, Madagascar.

Behra, O. (1993) The export of reptiles and amphibians from Madagascar. *TRAFFIC Bulletin***, 13**, 115-116.

BIODEV (1994) *Développement de projets expérimentaux pour la valorisation des bénéfices du commerce de la faune et de la flore (une étude pour élaborer des projets pilotes d'exploitation durable des ressources naturelles)*. Rapport final de l'Etude I des Etudes Préliminaires pour la project TRADEM-USAID-Madagascar [in French].

Blomberg, S. and Shine, R. (1996) Reptiles. In *Ecological Census Techniques. A Handbook*. (ed. W. J. Sutherland), Cambridge University Press, Cambridge, pp. 218-226.

Brady, L. D., Huston, K., Jenkins, R. K. B., Kauffmann, J. L. D., Rabearivony, J., Raveloson, G. and Rowcliffe, M. (1996) *UEA Madagascar Expedition '93. Final Report.* Unpublished Report, University of East Anglia, Norwich.

Brygoo, E. R. (1971) Reptiles Sauriens Chamaeleonidae. Genre *Chamaeleo*. *Faune de Madagascar*, **33**, 1-318 [in French].

Brygoo, E. R. (1978) Reptiles Sauriens Chamaeleonidae. Genre *Brookesia* et complément pour le genre *Chamaeleo*. *Faune de Madagascar*, **47**, 1-173 [in French].

Buckland, S. T., Anderson, D. R., Burnham, K. P. and Laake, J. L. (1993) *Distance Sampling*. Chapman and Hall, London.

Bustard, R. (1989) Keeping and breeding oviparous chameleons. *British Herpetological Society Bulletin*, **27**, 1-16.

Caughley, G. (1994) Directions in conservation biology. *Journal of Animal Ecology*, **63**, 215-244.

Child, G. (1987) The management of crocodiles in Zimbabwe. In: *Wildlife Management: Crocodiles and Alligators* (eds. G. J. W. Webb, S. C. Manolis and P. Whitehead). Surrey Beatty and Sons, Chipping Norton, Australia.

CITES Secretariat (1994) Significant trade in animal species included in Appendix II. Recommendations of the Standing Committee. Notification to the Parties No. 784, CITES, Geneva.

CITES Secretariat (1995) Significant trade in animal species included in Appendix II. Recommendations of the Standing Committee. Notification to the Parties No. 833, CITES, Geneva.

CITES Secretariat (1999a) Export quotas for 1999. Recommendations of the Animals Committee. Notification to the Parties No. 1999/21, Geneva.

CITES Secretariat (1999b) Mortality of live animals in trade. Recommendations of the Animals Committee. Notification to the Parties No. 1999/48, Geneva.

De Vosjoli, P. (1990) *True Chameleons. Part I: Husbandry*. Advanced Vivarium Systems, Lakeside, California.

Debenham, F. (1963) *Map Making. Third Edition*. Blackie and Son Ltd, London and Glasgow.

Donque, G. (1975) *Contribution Géographique à L'étude du climat de Madagascar*. Nouvelle Imprimerie des Arts Graphiques, Antananarivo [in French].

Du Puy, D. J. and Moat, J. (1996) A refined classification of the primary vegetation of Madagascar based on the underlying geology: using GIS to map its distribution and to assess its conservation status. In: *Proceedings of the International Symposium on the Biogeography of Madagascar*. (ed. W.R. Lourenço), pp. 205--218, + 3 maps. Editions de l'ORSTOM, Paris.

Durbin, J. C. and Ralambo, J. A. (1994) The role of local people in the successful maintenance of protected areas in Madagascar. *Environmental Conservation*, **21**, 115-120.

Durbin, J. C. and Ratrimoarisaona, S. (1996) Can tourism make a major contribution to the conservation of protected areas in Madagascar? *Biodiversity and Conservation*, **5**, 345-353.

Economic Intelligence Unit (EIU) (1991) *Country Profile: Madagascar, Comoros*. The Economist Group, London.

Faramalala, M. H. (1988) Etude de la Végétation de Madagascar à l'aide des Données spatiales. Doctoral Thesis, Univ. Paul Sabatier de Toulouse, 167 p. + map at 1:1,000,000.

Ferguson, G.W. (1994) Old World chameleons in captivity: growth, maturity and reproduction of Malagasy panther chameleons (*Chamaeleo pardalis*). In *Captive Management and Conservation of Amphibians and Reptiles* (eds J.B. Murphy, K. Adler and J.T. Collins), SSAR, Ithaca, New York. Contributions to Herpetology, vol. 11, pp. 323-331.

Fitzgerald, L.A., Chani, J.M. & Donadio, O.E. (1991) *Tupinambis* lizards in Argentina: implementing management of a traditionally exploited resource. In *Neotropical Wildlife Use and Conservation*. (eds J.G. Robinson and K.H. Redford), Univ. of Chicago Press, Chicago and London, pp. 303-316.

Glaw, F. and Vences, M. (1994) *A Fieldguide to the Amphibians and Reptiles of Madagascar*. *Second Edition*. M. Vences and F. Glaw, Cologne.

Green, G. M. and Sussman, R. W. (1990) Deforestation history of the eastern rain forests of Madagascar from satelite images. *Science*, **248**, 212-215.

Greenberg, C. H., Neary, D. G. & Harris, L. D. (1994) A comparison of herpetofaunal sampling effectiveness of pitfall, single-ended, and double-ended funnel traps used with drift fences. *Journal of Herpetology*, **28**, 319-324.

Grenfell, S. and Robinson, L. (1995) *The Ranomafana National Park Management Plan (1996-2000)*. Ranomafana National Park Project Report.

Hofman, A., Maxson, L. R. & Arntzen, J. W. (1991) Biochemical evidence pertaining to the taxonomic relationships within the family Chamaeleonidae. *Amphibia-Reptilia*, **12**, 245-265.

IUCN/SSC Trade Specialist Group, BIODEV, IUCN/SSC Madagascar Reptile and Amphibian Specialist Group. (1993) *A preliminary review of the distribution and status of reptile and amphibian species exported from Madagascar*. Joint Nature Conservation Committee Report, Peterborough.

Jenkins, M. D. (1994) *Une revue des réformes nécessaires au niveau national pour améliiorer le contrôle du commerce d'exploitation des animaux et plantes sauvages de Madagascar et de leurs* *produits*. Rapport des Etudes d'avant project TRADEM, Natural Resource/USAID, Gainsville, Florida, USA [in French].

Jenkins, M. D., Razakanirina, D. and Rasolondraibe, D. J. (1995) *A review of the national level reforms necessary to improve control of export trade in Madagascar's wild animals and plants, and their products*. TRADEM (preproject studies).

Jenkins, R. K. B., Brady, l. D., Huston, K., Kauffmann, J. L. D., Rabearivony, J., Raveloson, G. and Rowcliffe, M. (1999) The population status of chameleons within Ranomafana National Park, Madagascar, and recommendations for future monitoring. *Oryx*, **33**, 38-46.

Jenkins, R. K. B., Brady, L. D., Bisoa, M., Rabearivony, J. and Griffiths, R. A. (in prep) The abundance of chameleons (Chamaeleonidae) across a rainforest riparian zone in Madagascar.

Kalisch, K. (1994) Chameleon profile: Parson's chameleon. *The Chameleon Information Network*, **12**, att. 2.

Kalisch, K. (1995) Parson's chameleon (*Chamaeleo parsonii*) natural history, captive management and breeding. In: *Care and Breeding of Panther, Jackson's, Veiled and Parson's Chameleons* (eds. P. de Vosjoli and G. Ferguson). The Herpetological Library. Advanced Vivarium Systems Inc. pp. 109-127.

Kalisch, K. (1998) The care and breeding of *chamaeleo* [*Calumma*] *parsonii cristifer*. *The Chameleon Information Network*, **27**, 15-17.

Kauffmann, J. (1994) Veldwaarnemingen aan *Calumma brevicornis* en *C. oshaughnessyi ambreensis* op Madagascar. *Lacerta*, **53**, 2-10 [in Dutch].

Kauffmann, J. L. D., Brady, L. D. and Jenkins, R. K. B. (1997) Behavioural observations of the chameleon *Calumma oshaughnessyi* in Madagascar. *Herpetological Journal*, **7**, 77-80.

Klaver, C. & Böhme, W. (1986) Phylogeny and classification of the Chamaeleontidae (Sauria) with special reference to hemipenis morphology. *Bonn Zoological Monograph*, **22**, 1-64.

Klaver, C. & Böhme, W. (1997) *Liste der Rezenten Amphibien und Reptilien. Chamaeleonidae*. Das Tierreich, Part 112, Verlag Walter de Gruyter and Co., Berlin, New York [in German].

Laake, J. L., Buckland, S. T., Anderson, D. R. and Burnham, K. P. (1993) *Distance User's Guide. Version 2.0*. Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins.

Langrand, O. and Wilmé (1997) Effects of forest fragmentation on extinction patterns of the endemic avifauna on the Central High Plataeu of Madagascar. In *Natural Change and Human Impact in Madagascar* (eds. S. Goodman and B. Patterson), Smithsonian Institute Press, Washington and London, pp. 280-308.

Le Berre, F. (1995) *The New Chameleon Handbook*. Barron's, Honk Kong.

Mertens, R. (1966) Liste der rezenten Amphibien und Reptilien Chamaeleontidae. *Tierreich*, **83**, 1-37 [in German].

Nicoll, M. E. and Langrand, O. (1989) *Madagascar: Revue de la conservation et des aires protégées*. WWF, Gland, Switzerland [in French].

Parcher, S. P. (1974) Observation on the natural histories of six Malagasy Chamaeleontidae. *Zeitschrift Tierpsychol*, **34**, 500-523.

Rakotondravony, D. and Goodman, S. (1998a) Breve description physique de la région forestiere d'Andranomay. In: *Inventaire Biologique Forest d'Andranomay, Anjozorobe*. (eds. D. Rakotondravony and S. Goodman), Recherches pour le Developpement. Série Sciences Biologique No. 13, Antananarivo, pp. 9-14 [in French].

Rakotondravony, D. and Goodman, S. (1998b) Recommandation et conclusions. In: *Inventaire Biologique Forest d'Andranomay, Anjozorobe*. (eds. D. Rakotondravony and S. Goodman), Recherches pour le Developpement. Série Sciences Biologique No. 13, Antananarivo, pp. 98-102 [in French].

Ramanantsoa, G. A. (1974) Connaissance des Caméléonidés communs de la Province de Diégo-Suarez par la Population Paysanne. *Bulletin Academie Malgache*, **51**, 147-149 [in French].

Ramanantsoa, G. A. (1984) The Malagasy and the Chameleon: A Traditional View of Nature. In: *Key Environments. Madagascar*. (eds. A. Jolly, P. Oberlé and R. Albignac). pp. 205-209, Pergamon Press, Oxford.

Raselimanana, A. (1998) La diversite de la faune de reptiles et d'amphibians. In: *Inventaire Biologique Forest d'Andranomay, Anjozorobe*. (eds. D. Rakotondravony and S. Goodman), Recherches pour le Developpement. Série Sciences Biologique No. 13, Antananarivo, pp. 43–59 [in French].

Ravoninjatovo, A. and Rabemananjara, F. (1999) *Evaluation of chameleon network in Madagascar*. Unpublished Report, Université de Antananarivo, Madagascar.

Ravaorinoromanga, C. H. M. (1997) *Exploitation of natural resources in Madagascar: Case study of chameleon and day gecko*. MSc. Thesis, University of Kent, Canterbury.

Raxworthy, C. J. (1988) Reptiles, rainforests and conservation in Madagascar. *Biological Conservation*, **43**, 181-211.

Raxworthy, C. J. (1991) Field observations on some dwarf chameleons (*Brookesia* spp.) from rainforest areas of Madagascar. *Journal of Zoology, London*, **224**, 11-25.

Raxworthy, C. J. and Nussbaum, R. A. (1994) A rainforest survey of amphibians, reptiles and small mammals at Montagne d'Ambre National Park, Madagascar. *Biological Conservation*, **69**, 65-73.

Raxworthy, C. J. and Nussbaum, R. A. (1997) Biogeographic patterns of reptiles in eastern Madagascar. In *Natural Change and Human Impact in Madagascar* (eds. S. Goodman and B. Patterson), Smithsonian Institute Press, Washington and London, pp. 124-141.

Razafimamonjy, D. (1988) Etude d'un écosystème forestier de Ranomafana. In *L'equilibre des écosystèmes forestiers á Madagascar. Actes d'un séminaire international* (eds L. Rakotovao, V. Barre and J. Sayer), IUCN, Gland and Cambridge, pp. 315-319 [in French].

Reilly, S. M. (1982) Ecological notes on *Chamaeleo schubotzi* from mount Kenya. *Journal of the Herpetological Association of Africa*, **28,** 1-3.

Risley, T. (1997) Preliminary observations on a small population of *Chamaeleo* [*Calumma*] *parsonii parsonii* Cuvier, 1824 in eastern Madagascar. *Chameleon Information Network*, **25**, 25-28.

SAS Institute Inc. (1998) *StatView Reference. Second Edition*. SAS Institute Inc.

Schmidt, W. (1992) Über die erstmalig gelungene Nachzucht von *Furcifer campani* (Grandidier 1872), sowie eine Zusammenstellung einger Eizeitigungsdaten von verschiedenen Chamäleon-Arton in Tabellenform. *Sauria*, **14**, 21-23 [in German].

Shyamsundar, P. and Kramer, R. A. (1996) Tropical forest protection: An empirical analysis of the costs borne by local people. *Journal of Environmental Economics and Management*, **31**, 129-144.

Stephenson, P. J. (1993) The small mammal fauna of Réserve Spéciale d'Analamazaotra, Madagascar: The effects of human disturbance on endemic species diversity. *Biodiversity and Conservation*, **2**, 603-615.

Tam-Alkis, J. V. (1997) *Factors afecting the abundance and distribution of a chameleon assemblage in Ranomafana National Park, Madagascar*. MSc. Thesis, University of Kent, Canterbury.

Thorbjarnarson, J. (1999) Crocodile tears and skins: International trade, economic constraints, and limits to the sustainable use of crocodiles. *Conservation Biology*, **13**, 465-470.

Tröger, M. (1997) remarks about the long-term captive care and first steps towards captive breeding of *Calumma parsonii* (Civier, 1824). *Chameleon Information Network*, **25**, 29-35.

Velten, R. (1997) A report of successful captive hatching (25 of 32 eggs) of *C. p. parsonii* in the U.S. *Chameleon Information Network*, **25**, 37-38.

Werner, D.I. (1991) The rational use of green iguanas. In *Neotropical Wildlife Use and Conservation (eds*. J.G. Robinson and K.H. Redford), Univ. of Chicago Press, Chicago and London, pp. 181-201.

World Conservation Monitoring Centre and IUCN/SSC Trade Specialist Group (1991) *Review of Significant Trade in Animals included in Appendix II of CITES. Draft report submitted to the CITES Animal Committee*. World Conservation Monitoring Centre and IUCN/SSC Trade Specialist Group. August 1991.

World Resources Institute (WRI), United Nations Environment Program (UNEP) and United Nations Development Program (UNDP) (1992) *World Resources 1992-93. A Guide to the Global Environment. Toward Sustainable Development*. Oxford University Press, New York.

Wright, P. (1997) The future of biodiversity in Madagascar: A view from Ranomafana National Park. In *Natural Change and Human Impact in Madagascar* (eds. S. Goodman and B. Patterson), Smithsonian Institute Press, Washington and London, pp. 381-405.

Appendix I.

Known collection sites for Malagasy chameleons (adapted from Ravoninjatovo and Rabemananjara, 1999). Location co-ordinates are expressed to nearest 30' and were derived from Glaw and Vences (1994).

Area	Location (longitude/latitude)	Species Known to be Collected
Ambalavao	E:46°30' S:21°30'	*F. minor*
Ambaniasy	?	*C. brevicornis*
Ambatofinandrahana (Fanano)	E:50° 00' S:14° 00'	*F. minor*
Ambatoharanana-Ambositra	E:48° 00' S:18° 30'	*C. p. parsonii*
Ambatolaona	E:47° 30' S:18° 30'	*C. globifer*
Ambohimanga (south)	E:47° 30' S:29° 30'	*C. oshaughnessyi*
Andasibe/Mantadia (Périnet)	E:48° 00' S:18° 30'	*C. brevicornis, C. nasuta, F. willsii*
Ankaratra	E:47° 00' S:19° 00'	*F. campani*
Ankeniheny	E:48° 00' S:19° 00'	*C. nasuta*
Antalaha	E:50° 00' S:14° 30'	*C. p. parsonii*
Antoetra	E:47° 00' S:20° 30'	*C. oshaughnessyi*
Belalanda	E:43° 30' S:23° 00'	*F. antimena*
Belo (Belo-sur-mer)	E:44° 00' S:20° 30'	*F. labordi*
Fiherenana	E:43° 30' S:22° 30'	*C. nasuta*
Ifanadiana	E:47° 30' S:21° 00'	*C. oshaughnessyi, C. p. parsonii*
Itremo	E:46° 00' S:20° 00'	*F. minor*
Ambohitra (Joffreville)	E:49° 00' S:12° 00'	*F. petteri*
Mandraka	E:47° 30' S:18° 30'	*C. globifer, C. nasuta, F. willsii*
Manombo	E:47° 30' S:23° 00'	*F. antimena*
Maroantsetra	E:49° 30' S:15° 00'	*C. p. parsonii*
Moramanga	E:48° 00' S:18° 30'	*C. brevicornis, F. willsii*
Morondava	E:44° 00' S:20° 00'	*F. labordi*
Ranomafana (outside of reserve)	E:47° 00' S:21° 00'	*C. p. parsonii*
Soanieran'Ivongo	E:47° 30' S:20° 30'	*C. p. parsonii*
Toliara (Tuléar)	E:43° 30' S:23° 00'	*F. antimena*
Tolongoina	E:47° 30' S:21° 30'	*C. p. parsonii, F. balteatus*

Appendix II: Proposed Draft Management Plan for Malagasy Chameleons, With Special Reference to International Trade

1. Introduction

Madagascar's national policy towards its environment dictates that any actions that are potentially damaging should be managed by a consortium that includes local communities, government agencies and non-governmental organisations. For chameleons, conservation should include protection of threatened species and their habitats. With appropriate management future strategies could include sustainable utilisation and benefits to local communities. This management plan aims to encourage:

a) the management of Madagascar's chameleons on a scientific basis

b) the protection of Madagascar's chameleons in the wild

c) development of a management strategy that could allow controlled and sustainable utilisation of appropriate species captured in the wild, with emphasis on protecting local populations and reducing post-capture mortality

All exports of live chameleons will be in accordance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Ordonnances 60-126, 61-1316, 71-006 and Decrets 61-096, 75-014, 88-243, 61-093, 69-390.

2. Legislation

In accordance with Madagascar's wildlife laws, four species of chameleon (*Furcifer lateralis*, *F. oustaleti*, *F. pardalis*, *F. verrucosus*) can be captured and exported under a licence issued by Direction Générale des Eaux et Forêts (DEF). Export quotas of 2 000 individuals per species have recently been recommended by the CITES Animals Committee for national populations.

Chameleons may only be collected from locations situated outside protected areas (managed by Association National Pour le Gestion des Aires Protégées; ANGAP), and only under permit from DEF. Under Decret 61-093, the open season for collection is between 1st May to 1st Sunday in October. Chameleons may not be harvested at night using light. Commercial collecting licences are issued for a period of three years and are revalidated annually.

3. Management in Protected and Open Areas

i) In all Protected Areas, Madagascar's chameleons will be fully protected and habitats managed to increase or maintain their numbers as appropriate. Utilisation of Madagascar's chameleons within Protected Areas will be limited to scientific research and tourist 'game viewing'.

ii) In areas defined as peripheral zones around Protected Areas, protection of Madagascar's chameleons will be encouraged. However, populations of appropriate species may be utilised through allocation of sustainable local quotas for collection.

iii) In non-protected areas, protection of Madagascar's chameleons will be encouraged. However, populations of appropriate species may be utilised through allocation of sustainable local quotas for collection.

4. Control of Chameleon Trade

The capture and export of *F. lateralis*, *F. oustaleti*, *F. pardalis*, *F. verrucosus* is permitted. However, from 1999, Madagascar will impose regulations that will define the numbers of appropriate chameleon species available for capture. Madagascar aims to ensure that the utilisation of chameleons is undertaken on a basis that is sustainable and profitable to the nation.

i) Species and Quotas to be Traded

DEF will set national collection quotas on an annual basis for each species to be traded, using the best available data on their geographic distribution and estimates of local population sizes. National quotas will be defined as the sum of local quotas that have been calculated for each proposed collection site, preferably using ecological and bio-economic models. Quotas will specify the individual species that can be traded rather than listing broad species or generic groups. Quotas will apply to the number of chameleons actually caught rather than the number exported.

ii) Pricing Mechanism

The Direction of Durable Management of Forest Resources (DGDRF), in collaboration with other key government institutions (e.g. DEF), will set minimum values for the export of each species of chameleon to be traded. Consultation with appropriate non-governmental organisations will allow the establishment of appropriate minimum export values. Remittances by licensed traders, which will be based on the minimum values set by DGDRF, will be checked regularly, and overseas authorities will be requested to verify shipment mortalities that result in non-remittance. Any non-compliance by traders in the above will result in the forfeit of their collection permit.

iii) Health and Welfare

Traders will be required by DEF to invest in their facilities so as to meet health and welfare considerations. Mortality at capture will be reduced by appropriate training of local collectors in reptile handling techniques. Mortality during transport within Madagascar will be reduced by ensuring that chameleons are housed individually and do not experience prolonged holding/journey times. Mortality in holding grounds will be reduced by improvements in cages (where necessary) to ensure that chameleons are not overcrowded, subject to inappropriate temperatures, or exposed to pathogens and parasites through unhygienic conditions. All chameleons will be fed an appropriate diet and watered using an approved water delivery system. Mortality during international transit will be reduced through improved crating that fulfils IATA regulations.

iv) Trade Regulation

Collection permits issued by DEF will accurately list the species to be traded. Collection permits will be site specific with collection quotas that are based on sustainable harvest yields derived from monitored populations.

A sustainable trade in live chameleons that makes an appropriate economic return to Madagascar can only be achieved when a well-priced quota is offered to a small number of traders. Therefore, collection permits will only be issued to approved traders who employ a trained and registered workforce of trappers that live in rural areas. Traders will maintain accurate records of post-capture mortality for each species, with all such data being made available to DEF. Traders that fail to minimise post-capture mortality will have their collection permits revoked. Trader’s facilities will be open to inspection by experts appointed by an independent conservation, scientific or academic organisation. These expert will verify that only permissible species are being collected at agreed quota levels and that health and welfare issues are being addressed. Collection permits will be renewable on an annual basis and, in order to protect the interests of legitimate traders, could be withdrawn at the least irregularity.

5. Surveys and Monitoring

Monitoring of traded populations will be undertaken regularly from:

a) field records collected by pre-existing field personnel after suitable training (e.g. members of Association Langha working under the proposed Experimental Management Programme) and using appropriate methodology (e.g. line transects with distance sampling analysis)

b) records of numbers of chameleons caught by traders

c) records of licences issued and actual exports made, using appropriate CITES reports

In addition, the Madagascar CITES Management Authority will encourage non-governmental organisations, national and international research institutes, and the proposed Experimental Management Programme to both adopt and fund the following research objectives where appropriate:

i. *Expansion in knowledge of species range*. Continuation of inventory based surveys in areas not previously surveyed.

ii. *Determine baseline population densities at key sites*. Rapid survey assessments are required to determine baseline population densities using the methods outlined in this report. Key sites include all protected areas and sites where chameleon harvesting has been proposed.

iii. *Long-term monitoring of key sites*. Programmes should be initiated that will allow the monitoring of population fluctuations at key sites. Long-term monitoring is particularly important in areas where chameleon harvesting is proposed.

iv. *Detailed ecological studies for key species*. Species identified as most at risk from habitat loss and/or collection for trade require long-term research projects to investigate population demographics and factors influencing dispersal.

v. *Development of harvesting models*. Development of ecological and bio-economic models that will allow scientifically credible sustainable harvest strategies to be initiated.

6. Captive Breeding

At present, there is neither the infrastructure nor the technology in Madagascar to ensure that wild-caught specimens are not laundered as captive bred specimens by unscrupulous traders. Until it is possible to reliably distinguish between wild caught and captive bred specimens there should be no export of captive bred chameleons from Madagascar.

7. Export and Trade

All live chameleons for export will be documented in accordance with CITES regulations. Exporters will be required to pay a tax to DGDRF per CITES Certificate issued on their behalf. CITES export documentation will only be issued on receipt of valid Certificate of Ownership. All certificates and invoices will include the number of individuals harvested from each collection site for each species being exported.

8. Revision of Plan

This management plan will be revised and updated, where necessary, by DEF every three years.