Conservation biology and genetics of the western lowland gorillas in Gabon

Final Report

Darwin Initiative for the Survival of Species

Ref 162/08/044

Project information	01
Project background and rationale	01
Project summary	03
Scientific, training and technical assessment	06
Project impacts	11
Project outputs	13
Project Expenditure	13
Project operation and partnerships	14
Monitoring and evaluation, lesson learning	16
Darwin Identity	18
Leverage	19
Sustainability and legacy	19
Value for money	20
Appendices I-IV	21
Contents of appendices 1-14	27

1. Darwin Project Information

Project title	Conservation biology and Genetics of the Western Lowland Gorilla in Gabon
Country	Wales, UK; Gabon
Contractor	University of Wales, Cardiff
Project Reference No.	08/044
Grant Value	148,133
Staring/Finishing dates	October 1, 1999 - Aug 31, 2002

Mireille was actually employed from 15/09/99

2. Project Background/Rationale

- *Describe the location and circumstances of the project*

Gabon is an important centre of tropical diversity with substantial tracts of closed canopy forest still remaining. These forests are some of the most botanically diverse in Africa with regional centres of endemicity in the three montane areas of the country. Gabon is also a stronghold for some of the largest remaining populations of Africa's large forest mammals. Census estimates from the 1980s indicate that Gabon's forests are home to as many as 35000 gorillas, 64000 chimpanzees and around 60000 elephants. It has been argued that the persistence of forest refuges during arid phases of the late Pleistocene may have also contributed to the high regional diversity in plants. The impact of these forest refugia on contemporary population structure of Central African rainforest species however remains largely unexplored. Preliminary studies of patterns of genetic variability in the rainforest tree *Aucoumea klaineana*, the mandrill *Mandrillus sphinx* and western lowland gorilla *Gorilla gorilla gorilla* have revealed regional patterns of differentiation that may be consistent with Pleistocene refuges in region. These so-called refuges are thought to be forested islands that survived the arid phases of the last 2 million years and served as refuges for forest mammals. However, range-wide studies of rainforest species in the Afro-tropics are still relatively rare making it difficult to come to draw any general conclusions at the present time.

Gorillas were chosen as the research focus for this project for a number of reasons. Gabon encompasses some of the largest and most viable populations of great apes left in the world. The recent establishment of a network of protected areas (and now the gazetting of 13 new National Parks) throughout the country has provided Gabon with an unrivalled opportunity to formulate long-term strategies for great ape conservation. Relevant to these management concerns are questions relating to how genetic diversity within central African gorilla populations is distributed and whether genetically unique populations for conservation can be identified. This project has addressed this question by sampling at different spatial scales and has benefited substantially from preceding studies carried out by S. Clifford (Leverhulme Trust) and from ongoing work by Ph.D. student K. Jeffery (Cardiff University/Wildlife Conservation Society). Sampling of gorilla hairs and faeces was carried out in Gabon and Central Africa by survey teams and/or wildlife biologists working in collaboration with the Wildlife Conservation Society of New York (WCS). These collections have provided this project and the preceding Leverhulme Trust-funded project with a unique and fascinating opportunity to examine the geographic distribution of genetic diversity within gorillas and contribute genetic data to a future national action plan for the long-term management of gorilla populations in Gabon.

The problem.

With the decline in the oil industry, Gabon's forests and their associated fauna are increasingly under threat due to logging pressure. Despite existing hunting laws, lack of enforcement combined with better transportation has also facilitated the increased consumption of bush meat. With a population of a little over 1.2 million, Gabon has few resources with which to plan conservation measures and monitor their impact. Furthermore, there is a considerable lack of national expertise in the domains of applied ecology, wildlife management and conservation. Research and training opportunities for students and scientists are limited. At present, higher education in the biological sciences is limited to (i) the national university - Université des Sciences et Techniques de Masuku (USTM) which does not presently teach biology beyond the *premier cycle* (diploma of university studies) and (ii) the national training school for natural resource management - *École Nationale des Eaux et Forêts* (ENEF). Before the beginning of this grant, neither institute had a formal programme in ecology or conservation biology. Furthermore, although the principle partner in Gabon, the *Centre International de Recherches Médicales de Franceville* (CIRMF) is an established national research institute, molecular ecology and conservation genetic research were not considered a *primary mission.*

Project need.

The *Unité de Génétique des Écosystèmes Tropicaux* (UGENET) and the *Station d'Études des Gorilles et des Chimpanzés* (SEGC, Lopé Reserve) of the *Centre International de Recherches Médicales de Franceville* (CIRMF) are two of a handful of research institutes/facilities within the country that have the capacity to sustain an applied ecological and genetic research programme. Both identified a need to enhance capacity in conservation science, both at a technical level within CIRMF and at an academic level at the national science university. The University of Wales in Cardiff (UWC) is a nationally recognised centre of excellence in both teaching and research. In particular, the project co-ordinator's laboratory has strengths in conservation biology and genetic resource management and was thus selected as a suitable UK institution for training national scientists and for facilitating the transfer of appropriate technologies to Gabon. Through collaborative links set up through the Darwin Initiative, UWC was also well placed for (a) creating and ultimately transferring a programme/teaching course in conservation biology to USTM (b) establishing a research programme in collaboration with the Wildlife Conservation Society of New York (WCS) and CIRMF on gorilla conservation genetics.

3. Project Summary

- What were the purpose and objectives (or purpose and outputs) of the project? Please include the Logical Framework for this project (as an appendix) if this formed part of the original proposal or has been developed since, and report against this.

Genetic research: *Development of a national research program on gorilla genetic diversity and generation of genetic data applicable to the long-term management of the species.*

Understanding how genetic variability is geographically distributed within a species has important implications for the conservation of genetic diversity and for the maintenance of evolutionary flexibility within populations. In particular, spatial analyses of genetic variation can help managers identify evolutionarily distinct population units for conservation and assess partitioning of genetic variability among populations in different areas. The Darwin Initiative research programme therefore sought to examine patterns of genetic variation in wild gorilla populations at local, national and continental scales and derive specific management recommendations from these findings. In collaboration with Kathryn Jeffery (Ph.D. student, UWC), genetic data on gorilla social structure, ranging and dispersal is currently being compiled and will provide a unique perspective on local population dynamics and group behaviour. At

larger geographic scales, understanding how genetic variation is geographically distributed will provide an insight into the recent evolutionary history of gorillas and aid in the identification of regional areas for their conservation. Genetic data from this project and from a preceding project by Stephen Clifford (Leverhulme Trust) will be incorporated into a management action plan for western lowland gorillas that is currently under development within the context of the new National Parks system (which was not in existence until the last few months of the project). In the long term, the Darwin Initiative in Gabon has sought to lay down the foundations for a durable molecular ecology research programme on tropical mammals. Work has initially focused on the western lowland gorilla but is currently being or will be expanded to other species in the future e.g. mandrills (*Mandrillus sphinx*), the newly reclassified African forest elephant* (*Loxodonta cyclotis*) and forest duikers (genus *Cephalophus*), respectively.

Technology transfer and training: *Training of national research specialists, students and scientists in genetic techniques applicable to conservation and the transfer of appropriate technologies to the designated host institution in Gabon (CIRMF).*

The technical training component of this program is tied closely to the research objectives and was implemented through a partnership between Cardiff University and UGENET at CIRMF. Molecular training has focused principally on a research technician (Mireille Bawe-Johnson), whose position was created for this project and who will continue to work at CIRMF after the Darwin grant terminates. She will then commence a postgraduate degree in 2003. Other opportunities for technical training were also envisaged for university students identified during the teaching course (see below) and for university faculty looking to expand their existing research expertise. Transfer of appropriate technologies has focused on the detection and visualisation of genetic variation in wild gorilla populations using hypervariable genetic markers in the mitochondrial and nuclear genome. Molecular assays for the rapid screening of variation in populations played a key role in the research applications of this project.

Conservation education: *Development of a university course in conservation biology and integration of this programme into the national university curriculum.*

A primary goal of the education component of this project was the development and implementation of an undergraduate level course in conservation biology. In addition to a formal teaching component, the course included a number of guest speakers from around the country were invited to participate in open seminars designed to inform students on conservation activities and opportunities in Gabon. Practical work included both classroom exercises and a short (one day) and longer (one week) field course in basic ecological/field survey techniques. This course was taught in conjunction with WCS/SEGC project leaders and scientists. Internship opportunities in molecular and field ecology at CIRMF/SEGC were also offered to eight university students over the course of the Darwin Initiative project.

- Were the original objectives or operational plan modified during the project period? If significant changes were made, when was approval given by the Darwin Secretariat?

  No.

- Which of the Articles under the Convention on Biological Diversity (CBD) best describes the project? Summaries of the most relevant Articles to Darwin Projects are presented in Appendix I.

  Articles 7, 8, 12, 16 and 17.

- Briefly discuss how successful the project was in terms of meeting objectives. What objectives were not achieved, or only partly achieved, and have there been significant additional accomplishments?

Overall, the project successfully achieved all three objectives. Accomplishments and problems faced in completing the three principal objectives of this project (research, technology transfer and education) are discussed separately below.

Research: Despite a slow start, the research component of this project has advanced considerably in the final year of the grant although a shortage of funds constrained the scope of the final phase of the work and not all available samples could be analysed. Sampling was at two levels. The first range-wide set of samples, collected over the past 10 years from collectors and researchers collaborating with CIRMF and WCS (Appendix 1) had originally formed the basis of an earlier genetic study carried out by S. Clifford and funded by the Leverhulme Trust. The second set of samples was collected over a period of two years during this project through ongoing wildlife surveys coordinated nationally by WCS Gabon (Appendix 2). These samples proved much more difficult to find than previously expected, often due to extreme declines of local gorilla populations and sometimes due to logistical constraints of sending out field teams and recovering samples to the laboratory. The unexpected delay in samples arriving from Gabon field surveys has also meant that a lot of sequencing and data processing was then compressed into the final year of the project. This in itself did not present an insurmountable problem since more time was then reallocated to capacity building and teaching earlier in the grant but it also meant that the research money earmarked for the final year was woefully inadequate. Additional funding is now being sought to complete the sequencing of all samples available to this study. Analysis of nuclear genetic variation has been hampered by the difficulties of working with non-invasive sampled DNA. However the development of an efficient method for the co-amplification of multiple nuclear loci by Kathryn Jeffery has advanced this component of the study and substantially reduced costs for the Darwin Initiative project.

Overall, considerable advances in the techniques available and the quantity and quality of data have made the research component of this project much more valuable than was originally envisaged. This was in part due to the inheritance of a large pan African sample set from previous work carried out by the Leverhulme Trust. Initial findings have led to a preliminary publication comprising data from both projects (currently in revision) on patterns of mitochondrial sequence variation in western lowland gorillas (Appendix 3). These data are currently being reanalysed to include much greater sample sizes and with additional funding should constitute an additional major publication. Significant additional accomplishments include:

(i) Genotyping of several family groups and lone males from the SEGC Zone d'Etude in the Lopé . This study will provide data to supplement an ongoing study of gorilla social structure and family dynamics by Kathryn Jeffery, Caroline Tutin and Kate Abernethy and will be integrated into a genetic database linked to hair collections made over the past 10 years at the Lopé (Appendix 4).

(ii) A range-wide assessment of nuclear genetic variation in a subset (N=6) of gorilla populations chosen to represent the major geographic/genetic groups evident in the mitochondrial data set. This work was not originally thought possible but has been facilitated by both the availability of pan-African samples and technical advances made in the co-amplification of multiple nuclear loci.

Technology transfer and training: Technology transfer has involved the development of appropriate molecular technologies at a recognised centre of excellence (Cardiff University), training of a research technician in these methods (Mireille Johnson) and their implementation in the corresponding partner institution (CIRMF). Mireille has received training in a range of molecular techniques aimed at examining genetic variation in natural populations and actively participated in all aspects of the research component of this project, including scientific presentation in the English language. Limitations to the present collaborative framework have become apparent during the course of this project. Delivery of reagents to Gabon was often problematic and always expensive. Although many of the techniques developed during the course of this project were implemented in both countries (U.K. and Gabon), research work was eventually divided to regulate the costs of molecular work in two laboratories situated several

thousand miles apart, and to avoid duplication of effort. Training of three faculty members from the university and three university students in molecular ecology techniques constituted an important additional output that was not previously envisaged at the outset of this grant.

Education: The primary goal of the educational component of this project was to establish a course in undergraduate conservation biology and integrate it into the national university curriculum. The first part of this objective was highly successful, the second is still awaiting the development of a *deuxième cycle* (i.e. courses at the final year of the bachelor's and master's level) at USTM into which the conservation biology course will be integrated. In addition to formal classroom sessions and directed exercises, two field courses were developed in collaboration with Lee White (WCS) and Kate Abernethy (SEGC). These field courses focused on developing basic skills in inventory and survey techniques. A CD copy of all course contents including practical exercises and exercises developed in the field course is attached (see Appendix 5).

Teaching in the final year of the project was prevented by a national university strike that persisted throughout the academic year 2001/2. As a result, time was devoted to transferring course materials to faculty who had been identified by the Department of Biology as candidates for teaching the conservation biology course in the future. Additional training in basic molecular ecology techniques was also provided to all 3 faculty who participated in transfer sessions and one member of the faculty (Christiane Atteke) came to Cardiff University for a further 2 months training in molecular ecology and conservation. A copy of her final report to the university is attached in Appendix 6.

Although teaching was frustrated by strikes, there were unforeseen benefits to the Darwin Research Associate's 2002 session in Gabon since faculty were free to work closely with the Darwin Research Associate and Project co-ordinator on course contents. Furthermore, two faculty (Christiane Atteke and Patrick Mickala) will be pursuing research projects in the future and continue to work in collaboration with Darwin personnel at CIRMF and WCS as well as the former Darwin Research Associate, whose advanced scientific skills and hands-on conservation, training and teaching experience helped her to obtain a faculty position in conservation biology at the University of New Orleans, USA.

4. Scientific, Training, and Technical Assessment

- Please provide a full account of the project's research, training, and/or technical work.
- **Research** - this should include details of staff, methodology, findings and the extent to which research findings have been subject to peer review.

Research staff and their respective roles in this project are as follows: Prof. Mike Bruford (Cardiff University, Project Co-ordinator), Dr. Nicola Anthony (Cardiff University, Research Associate), Ms. Mireille Bawe-Johnson (Research Technician, CIRMF), Dr. Jean Wickings (Head of UGENET, CIRMF), Dr. Caroline Tutin (former SEGC director, CIRMF and University of Stirling) Dr. Kate Abernethy (SEGC director, CIRMF and University of Stirling), Dr. Lee White (Gabon and central African programme Director, WCS). Two additional research collaborators also played a major role in the research component of this study: Ms. Kathryn Jeffery (graduate student, Cardiff University) and Dr. Stephen Clifford (Research Associate, CIRMF funded by the US NIH, and formerly funded by the Leverhulme Trust for his work on gorilla genetics). Research projects are divided into work on either (a) mitochondrial or (b) nuclear genetic markers.

(a) Mitochondrial phylogeography of western lowland gorillas.

Although gorillas exhibit substantial ecological and morphological diversity, molecular studies have only recently begun to quantify levels of genetic variation in wild gorilla populations.

Previous studies of mitochondrial DNA (mtDNA) sequence variation have revealed high levels of variability within western gorillas. However, samples sizes have generally and sometimes necessarily been small and little information has been available on patterns of genetic variation in gorilla populations of *known* geographic origin – unlike the present study.

Work carried out by this project in collaboration with earlier work carried out by Stephen Clifford has focused on a 252 bp fragment of the HV1 domain of the mitochondrial control region. The HV1 region of the mitochondrial genome was chosen for this study because it is sufficiently variable to resolve population level differences in genetic variation. Initial analyses are based on cloned PCR products from this study (N = 18), direct sequencing of PCR products (N=24) and presumed mitochondrial or nuclear translocated copy (numt) sequences available from GenBank (N=28). Cloning of representative haplotypes (N = 3-5 clones/PCR product) proved to be a necessary step for separating out the mitochondrial copy from putative numts. More recently, sequencing in Cardiff has increased sequence sample sizes to as many as 55 cloned and 110 direct PCR product sequences (see Appendix 7). However additional sequencing will be required since some of these samples are either yet to be sequenced or require further sequencing to confirm the data.

Sequences were aligned in Clustal X and a 30bp region encompassing a polycytosine (PolyC) domain of HV1 was excluded due to difficulties in alignment and possible length heteroplasmy (multiple length copies per individual) within this region. However, motifs within this region could be used to discriminate putative numts from mitochondrial DNA copies and for classifying numts into different groups. Percentage sequence divergence estimates and phylogenetic analyses were carried out using the PAUP 4.0b8 and Arlequin 2.0 population genetics software package. For phylogenetic analyses, the appropriate nucleotide substitution model and gamma shape parameter was estimated using the program ModelTest. This program selects the model that best fits the data using a hierarchical log likelihood ratio test. Sequences were clustered using the neighbour-joining method and bootstrap consensus dendrograms were constructed using 1000 replicates. Arlequin version 2.0 was used to carry out a hierarchical Analysis of Molecular Variance, to reconstruct a minimum spanning network of pair-wise differences between mtDNA haplotypes and in the analysis of pair-wise sequence distributions. Great circle distances were calculated between sites and the effect of geographic distance on genetic distance values was assessed using a Mantel test. Significance values for the correlation between the two distance matrices was assessed with 1000 matrix permutations. Arlequin was also used to assess the shape and the distribution of pair-wise sequence differences within major haplogroups in order to detect genetic signatures of past demographic events.

Nuclear transfers of mitochondrial DNA copies have been reported in humans, non-human primates and many other mammals and represent a significant challenge to phylogenetic analyses based on mitochondrial DNA. Two PCR products cloned in the initial study contained two highly divergent sequence types, one of which is presumed to be a nuclear copy. Further cloning work identified numt sequences similar to those identified by other groups and now available in Genbank (Jensen-Seaman pers. comm., Bradley pers. comm.). It is interesting to note that several western lowland gorilla sequences previously submitted to Genbank as mitochondrial DNA copies also cluster with putative numts, indicating that the classification of these sequences may have been erroneous. All known numts and those identified in our initial studies were incorporated into alignments and phylogenetic analyses. From this we were able to develop a diagnostic key based on shared derived characters and distinctive poly C motifs that allowed us to separate out putative numt groups from mitochondrial DNA sequences. Phylogenetic analyses support up to five distinct haplogroups composed of putative numts identified in this study or available in Genbank. The fact that near identical putative numt sequences occur in both eastern and western lowland gorilla sequences suggest that these insertions may have occurred prior to the divergence of eastern and western gorilla and become subsequently “fossilised” in the nuclear genome.

As reported previously, phylogenetic analyses of mitochondrial sequences reveal a major evolutionary split between eastern and western gorillas. Mountain gorillas in Bwindi Impenetrable Forest, Uganda and the Park National des Volcans in Rwanda fall into a single Haplogroup (A) that is clearly differentiated from eastern lowland gorilla sequences in Haplogroup B. This eastern lowland haplogroup contains sequences from the Parc National de Kahuzi-Biega, Mt. Tshiambero and the Itombwe Massif in the Democratic Republic of Congo. Within western lowland gorillas, four geographically distinct haplogroups C-F are apparent:

- Haplogroup C spans a large area from Mount Afi in the Cross River area, Nigeria, to the Parc National de Lobéké in south-eastern Cameroon
- Haplogroup D is restricted in our current sample to the Bai Hokou region in Central African Republic and adjacent Nouabalé-Ndoki in northern Congo.
- Haplogroup E comprises sequences from Mont Alen National Park, Equatorial Guinea.
- Haplogroup F covers a large geographic area encompassing much of Gabon and adjacent central and southern Congo.

Although initial sample sizes were very small, the possible relationship between genetic distance and geographic isolation (isolation by distance) was investigated using Mantel tests. When all eastern and western gorilla populations were considered, there was a significant positive association between geographic and genetic distance. However, when only western lowland gorillas were considered, this relationship was not significant. These results suggest two things. Firstly, that the large genetic and geographic distances between eastern and western gorillas are likely to be driving the first statistically supported relationship and secondly, the lack of a significant isolation by distance effect within western gorillas indicates that patterns of regional genetic diversity do not conform to a simple model of restricted gene flow. An analysis of the distribution of pair-wise sequence differences within haplogroups indicates that populations within most major western haplogroups conform to a model of recent demographic expansion. Such genetic signatures of past historical events may aid in the interpretation of the historical impacts of local climatic alterations subsequent to polar glacial periods and concomitant alterations in vegetational cover, hence gorilla range, on contemporary population structure. However, larger sample sizes are required in order to elucidate these patterns further.

Results from this study were submitted for publication to the *Proceedings of the Royal Society of London Series B.* (see appendix 3) and the manuscript was recently rejected with encouragement to resubmit for 2 reasons. The first objection was the insufficient coverage of cloned mitochondrial and numt copies from across all major geographic groupings. This has largely been addressed by increasing the sample size of cloned PCR products. The second major objection was the sample sizes for statistical analysis. This can and will be readily addressed by using different population groupings in the current analysis and once sequencing of the larger sample set is completed. In addition to this publication, a book chapter has recently been submitted to Cambridge University Press on non-invasive genetic methods in primates (Appendix 8).

(b) Patterns of nuclear genetic variation in wild gorilla populations. A selection of seven polymorphic microsatellite markers and a sex-linked genetic marker were selected from the human genome and optimised for genetic work on gorillas. Microsatellite allelic markers consist of a chain of tandemly repeated nucleotide repeats that are usually 2-4bp in length. Alleles can be readily differentiated by differences in the number of repeat units. These markers have the advantage of being codominant and extremely polymorphic and have been used in a broad range of applications in population ecology from assessing paternity and relatedness to providing indirect estimates of gene flow, population structure and demographic change.

For over the last 15 years, researchers Caroline Tutin and Kate Abernethy have been collecting

nest hairs from identified families within the SEGC Zone d'Etude of the Lopé Reserve. Using nest hairs as a source of DNA, genetic typing of several family groups and lone males from the Lopé Reserve has recently been completed and will be added to an existing database of genetic fingerprints currently being compiled by Kathryn Jeffery as part of her thesis work. These genetic IDs will be used to track individuals through space and time and to assess social structure and local population dynamics over a fifteen-year period.

In parallel with this study, work is also now in progress to examine patterns of microsatellite variation in gorillas across their entire range to examine whether there is a correspondence between patterns of mitochondrial and nuclear variability. Approximately 20-30 individuals have been genotyped from each of the following 6 key populations: Lopé, Gabon; Lossi, Congo; Afi Mountains, Nigeria; Bai Hokou, Central African Republic; Bwindi, Uganda; Kahuzi-Biega, Democratic Republic of Congo to enable us to compare genetic variation within and among populations at final resolution and to measure gene-flow more accurately. Samples were repeatedly typed at all loci four times and heterozygotes were only accepted if each allele was typed independently twice. Homozygotes were only accepted if typed independently four times which was adequate for five of the seven loci but is insufficient for two loci where stochastic preferential amplification of one allele (allelic drop out) was particularly severe (Kathryn Jeffery, pers. comm.). Results from this study are currently being compiled but will provide valuable complementary data to that already accumulated for mitochondrial DNA. To our knowledge, this work also represents the first study of patterns of nuclear genetic variation in wild gorilla populations.

- **Training and capacity building activities** – this should include information on selection criteria, content, assessment and accreditation.

  Training and capacity building activities were carried out at three levels:

  (i) Technical (basic molecular techniques, DNA extraction, amplification and visualisation of variable genetic markers; population level screening of genetic variation). Automated DNA sequencing, assembly and phylogenetic and population-level analysis.

  (ii) Practical (basic field ecology techniques, mammal survey techniques, design of classroom and field exercises for undergraduate classes)

  (iii) Academic (design and implementation of an undergraduate course in conservation biology, grant writing and outreach activities aimed at increasing research capacity in molecular ecology at the national science university).

  Training and capacity building activities focused on three different groups:

  (i) Research technician at CIRMF (Mireille Bawe-Johnson)

  (ii) Darwin-funded student interns selected from the undergraduate conservation class (Nic Geordan Mbadinga, Gaspard Abitsi and Stephan Ntie).

  (iii) Faculty from the Department of Biology, USTM (Christiane Atteke, Patrick Mickala and Daniel Obame).

Selection criteria varied between groups. Mireille had already worked on a temporary basis in UGENET prior to the project, but core funding was not available to provide a permanent position for her. Hence, at the beginning of the Darwin Initiative she was already well qualified for the Darwin technical position, having a master's degree and substantial research experience in a diversity of settings. Her position has now been formalised by CIRMF and is funded by the unit's core budget. She will occupy a central role in the running of the lab at CIRMF and in training incoming students and researchers. She is also beginning her own PhD project next year on the molecular ecology of central African forest elephants and will continue to use many of the techniques she has developed throughout the Darwin.

Student interns were selected on the basis of final exam results and interviews. We were very happy with our selection and had exceptionally motivated intern students. Students were

encouraged to develop a small research project and were introduced to the basics of molecular biology and to field ecology at the Lopé Reserve. The first two students have gone on to commence higher degrees in France and it is hoped will continue in science. Stephan Ntie in particular excelled as an intern and stayed on to work for 9 months in UGENET on an N.I.H. funded project on mandrill genetic diversity, whilst awaiting a place at the University of Marseille, France, to continue his studies.

Faculty were essentially self-selecting or selected by the Department of Biology as suitable candidates for teaching and training in molecular ecology and conservation. Both Patrick and Christiane are planning to develop research interests in molecular ecology and will continue to work collaboratively with UGENET. In addition, Patrick is planning to take a sabbatical year off to work with the Darwin Research associate at the University of New Orleans on genetic diversity in forest duikers (genus *Cephalophus*).

The conservation course represented a major component of the research associate's time in Gabon and evolved from a short six-week course in the first year to a 16 session-long course with weekly practical exercises. Due to the university strike we were not able to hold a student field course in 2002. However the week-long course held in 2001 (see appendix 9) was very popular and it is hoped will continue in the future if USTM is able to attract external funding to run it at the newly constructed field training centre in the newly created National Park.

A large number of second year students (N = 30-60) elected to attend the conservation course in both years that it was run (1999/2000, 2000/2001). In the first year a certification of participation (see appendix 10) was given to all students who took the final exam and a certificate of success for all those who passed. The top 5 were then selected for interview for the 2 available Darwin funded student internships. In 2000/1, the system was modified to only award a certificate of participation to students who attended a minimum of 6 out of 8 sessions and those passing the exam were also awarded a certificate of success. Students were asked to fill out an evaluation form each year (appendix 11) and criticism and feedback from these forms was used to modify course material in subsequent years. At the end of the final session of 2001 a list of opportunities in conservation and environmental research was distributed to students who took the final exam (appendix 12). Following the strike that ensued for the academic year 2001/2002, five students were subsequently hired to work for WCS on studies of bush meat consumption in urban markets. Four of these have gone on to higher education and one remains in employment with the WCS survey team.

5. Project Impacts

- What evidence is there that project achievements have led to the accomplishment of the project purpose? Has achievement of objectives/outputs resulted in other, unexpected impacts?

In terms of research, the project has succeeded (after a slow start) in procuring and for the most part in analysing the genetic samples necessary to provide information for management of Gabon's gorilla population. The late arrival (indeed samples continue to arrive) of much of the material has meant that analysis is still ongoing, although the great majority of the work has been finished successfully and the remainder will be completed by March 2003. The production of the final data set and analysis of results is prerequisite for the final management plan meeting in Summer 2003. The utilisation of pan-African samples at the beginning of the project has meant that a more in-depth analysis of samples throughout Central Africa has been possible than first envisaged. This analysis has resulted in a paper currently in revision for *Proceedings of the Royal Society*. The research associate is joint first-author on this paper.

In terms of training and technology transfer, the project has met all of its requirements. The technician is now fully competent in molecular ecology techniques, and is capable of running the molecular laboratory within UGENET, including being in charge of the automated sequencer. The laboratory is now able to handle all types of material except hair samples, which proved exceptionally difficult and require more stringent handling in a high technology laboratory.

Evidence of the technician's excellent progress comes from the fact that she will enrol for PhD studies at Cardiff University. The three student interns were a resounding success and show promise for a scientific career in molecular ecology.

In terms of teaching, the course was a great success at USTM, and save for the recent industrial dispute which has led to the University being closed for 2001/2, may well have been incorporated into the curriculum of the *deuxième cycle* in Biology for 2002/2003. Until this course is set up, the conservation biology course will be taught to second year students. An unanticipated outcome of this situation was the opportunity to train the three faculty from USTM in the laboratory and to invest in one-to-one discussion of course materials in greater depth.

- To what extent has the project achieved its goal, i.e. how has it helped the host country to meet its obligations under the Biodiversity Convention (CBD), or what indication is there that it is likely to do so in the future? Information should be provided on plans, actions or policies by the host institution and government resulting directly from the project that building on new skills and research findings.

The project has generated a great deal of genetic data on western lowland gorillas in Gabon, and by the time of the Management Plan workshop in 2003, as complete a picture as is feasible to produce will be available. With the gazetting of 13 new National Parks, however, additional work will need to be done in the future to cover all regions. WCS is currently collecting these samples and funding will be sought to analyse samples from parks for which samples are currently scarce. Thus the key components of this project pertinent to Articles 7 and 8 of the CBD will be met. (See below for Articles on training and capacity building).

- Please complete the table in Appendix I to show the contribution made by different components of the project to the measures for biodiversity conservation defined in the CBD Articles.

See Appendix I

- If there were training or capacity building elements to the project, to what extent has this improved local capacity to further biodiversity work in the host country and what is the evidence for this? Where possible, please provide information on what each student / trainee is now doing (or what they expect to be doing in the longer term).

In terms of training and technology transfer (Articles 12, 16, 17) the project has entirely met its goals of establishing a viable course in Conservation Biology in Gabon and in training and transferring molecular ecology capacity. The course has already produced 5 students who last year worked for WCS in its bushmeat survey and the three intern students have all gone on to continue their higher education – a career in conservation biology in Gabon is undoubtedly theirs if they wish to pursue this goal. There is no doubt, however, that the future of this element rests with the future stability of the university system in Gabon. The three faculty we have trained to teach the course are the key to its continued success and while their motivation is strong, the political environment surrounding higher education in Gabon is currently not conducive to maintaining productivity. We will all continue to support them closely through the coming years. The technician is now fully competent to run a molecular ecology laboratory and to carry out research in a high technology laboratory. She will start her PhD studies in 2003.

- Discuss the impact of the project in terms of collaboration to date between UK and local partner. What impact has the project made on local collaboration such as improved links between Governmental and civil society groups?

The project has had a strong impact among local partners, and it is especially worth highlighting the strong collaboration between UGENET and USTM, since this was not evident prior to the project's commencement. The recent appointment of a full time, CIRMF-funded post doctoral staff member, Dr. Michel Cazemajor, with a specific remit to continue to support the Conservation Biology course and the training of faculty at USTM, is a real breakthrough element

of this project. Indeed the relationship with USTM, despite the problems with industrial action etc. has become extremely strong, largely thanks to the enthusiasm, commitment to education and skill showed by the Darwin Research Associate, which in turn engendered enthusiasm from USTM staff.

Initial contact with the ENEF, through the one-day workshop held in April 2002, was an important breakthrough in terms of broadening the geographic scope of the educational activities of the Darwin Initiative. ENEF presently has no formal programme in conservation biology. There is a general willingness and interest among staff and students at the school to incorporate biodiversity into their curriculum. What is lacking are teachers capable of teaching this course. One possible solution would be for the 3 USTM faculty to act as guest lecturers at ENEF, as was the case when the course was presented in 2001. This may depend on the availability of staff and the progress that the university itself makes in developing the *deuxième cycle* but will definitely depend on USTM/ENEF committing the necessary financial resources.

One additional local partner, who in hindsight was somewhat neglected, was the *École Polytechnique* situated at the same location as USTM in Franceville, and under the same Rector (Dean). Although agricultural students and teachers were invited to initial sessions of the biodiversity course, more effort could have been made and will be made in the future to engage both polytechnic staff and students in the biodiversity course.

- In terms of social impact, who has benefited from the project? Has the project had (or is likely to result in) an unexpected positive or negative impact on individuals or local communities? What are the indicators for this and how were they measured?

The social impact of this project must be considered to be via its educational output. This project has not been designed or focused around local communities, although much of this work is carried out effectively by CIRMF (through medical outreach) and SEGC (through community conservation at Lopé) who are our local partners. However, through the education of young Gabonese scientists, we have influenced a cohort of the country's future influential society and made them aware of both the wealth of biodiversity in their country and the potential opportunities for careers in the environment. As conservation biology has never previously been taught at USTM and few students have the opportunity to visit protected areas around the country, many students were simply unaware of their natural heritage. For example, most of the students on the field course in 2001 had never been to the Lopé Reserve or seen an elephant (animals in general, gorillas, chimpanzees, etc, etc, etc) in the wild. Our indicators of progress in this field can simply be measured by the number of students who took the course and particularly those who had sufficient enthusiasm to persevere with it, despite the fact that it was non-compulsory and ran for three hours on Saturday mornings during terms heavily committed to course work and examinations.

6. Project Outputs

- Quantify all project outputs in the table in Appendix II using the coding and format of the Darwin Initiative Standard Output Measures.

See Appendix II

- Explain differences in actual outputs against those in the agreed schedule, i.e. what outputs were not achieved or only partly achieved? Were additional outputs achieved? Give details in the table in Appendix II.

The management plan is not yet finalised and the sequence dataset is not quite complete. Three genetic databases are currently being compiled but are not yet available: (i) mitochondrial D-loop sequences for the entire project which will also be deposited in GenBank (ii) multi-locus microsatellite genotypes from the Pan-African sample set. (iii) Multi-locus genotypes of individuals from family groups in the Lopé Reserve (in collaboration with Kathryn Jeffery).

- Provide full details in Appendix III of all publications and material that can be publicly accessed, e.g. title, name of publisher, contact details, cost. Details will be recorded on the

Darwin Monitoring Website Publications database which is currently being compiled.

See Appendix III

- How has information relating to project outputs and outcomes been disseminated? Will this continue or develop after project completion and, if so, who will be responsible and bear the cost of further information dissemination?

Information from the research outcomes will be published in the scientific literature and disseminated to the relevant conservation organisations (WCS), national government bodies (Direction de la Faune, Ministry of Forestry and Water Resources) and global conservation initiatives (U.N Great Apes Survival Program or GRASP). We anticipate at least two additional publications to those listed in Appendix III. The first will be detailed phylogeographic analysis of mitochondrial DNA variation in Gabon and central Africa. The second will be an analysis of nuclear patterns of genetic variation in Pan African samples. Additional publications are also envisaged in collaboration with SEGC scientists and Kathryn Jeffery on local family dynamics.

7. Project Expenditure

- Tabulate grant expenditure using the categories in the original application.

Details of the grant expenditure are presented in Table 1.

- Highlight agreed changes to the budget

Transfer of salary costs to consumables was first agreed with the Darwin Secretariat and was always reported at each year-end in annual reports.

- Explain any variation in expenditure where this is +/- 10% of the budget

Spending significantly exceeded the budget (> 10% over-budget) for laboratory consumables. This excess expenditure was due to the high costs of running experimental work in two countries and to the expenses ordinarily associated with working on DNA extracted from shed hair and faeces. DNA sampled non-invasively in the field is frequently degraded and at low concentrations such that repeated analysis of the same sample is required in order to obtain accurate genotypes. Large sample sizes are also required because of the relatively low success rate, and because of the geographical area covered. Over expenditure of consumables was largely offset by savings made in the salary component. Money was saved here because the research technician was employed on a salary scale below that budgeted for at the outset of the project, and also during her 3-month maternity leave was not paid by the Darwin. In addition, the research associate on the project was also paid at a lower wage than was budgeted in the original grant. Transfer of salary costs to consumables was first agreed with the Darwin Secretariat and was always reported at each year-end in annual reports.

The unspent money in the salaries category was also used offset an additional over-expenditure in the travel and subsistence. These additional expenses were due to a) an additional final visit to Cardiff by Mireille to help process the large number of samples arriving towards the end of the project, b) to fund the travel costs for Christiane to the Darwin Initiative Annual Meeting and c) to cover travel to the Society for Conservation Biology meetings in Canterbury, Kent in June 2002 for Darwin-employed staff. Over the total period of the project, the component of the project covered by the Darwin budget overspent by approximately £1,800 pounds. Funds are currently being procured from elsewhere to meet this shortfall.

8. Project Operation and Partnerships:

- How many local partners worked on project activities and now does this differ to initial plans for partnerships? Who were the main partners and the most active partners, and what is their role in biodiversity issues? How were partners involved in project planning and implementation? Were plans modified significantly in response to local consultation?

There were three principal local partners working on project activities in Gabon. The first two were both subdivisions of CIRMF (UGENET, SEGC) and were implicated in the original project

proposal. Both always maintained an integral role in all three principal activities of the Darwin throughout the lifetime of the project. A third local partner (USTM), although incorporated into plans for the original project, adopted an increasingly important role in the development and implementation of the Darwin educational program. Each partner and their role in the project and in biodiversity conservation are discussed in detail below.

UGENET: This research unit of CIRMF has played a key role in technology transfer and training of Gabonese nationals. CIRMF also provided a base for activities of the Darwin research associate on the project as well as providing logistical support for the conservation biology course at USTM. In terms of research, UGENET played a key role in providing access to the pan-African collection of gorilla hair samples, in organising and extracting DNA from incoming samples and for archiving material for future work. Laboratory facilities were made available for the training of students and faculty staff, and this component will outlast the duration of the project

SEGC: SEGC has been an important field research centre in primatology and tropical ecology since its foundation in the early 1980s by Caroline Tutin and Michel Fernandez. The hair collections made from identified family groups established an important resource for genetic work on wild gorillas and has set a precedent for other non-invasive genetic studies in the future. SEGC is also an important educational centre and hosted the Darwin field course in 2001 as well as a brief workshop for USTM faculty in field exercises for students in 2002.

USTM: USTM is the only science university in the country although there is a sister campus in arts and humanities in the capital, Libreville. Before the project was initiated, Kate Abernethy contacted the university and presented an outline for the development of a course in population biology. With the advent of the Darwin Initiative, the scope of the original course was greatly expanded to include basic principals in general ecology, biogeography and evolutionary biology as well as practical applications of biological principals to conservation problems. Both ecology and evolutionary biology are at the core of many conservation biology principals and, until the development of the biodiversity course, were largely absent from the existing curriculum.

Throughout the duration of the Darwin project the university was not able to allocate time for an accredited slot during the week but did agree for the Darwin to teach an optional course to biology second year undergraduates, for 3 hours on Saturday mornings. During the second year of the Darwin, the course was expanded from a six to an eight-week course with an option for a limited number of students to participate in a weeklong course in field ecology at the Lopé Reserve. During the second year the vice chancellor and other faculty (less frequently) attended the course on Saturdays and participated in working group sessions with students. The success of this course in the first two years meant that the University subsequently decided that the course should be integrated into the *deuxième cycle* of the University bachelor's degree programme, due to begin in 2002/3. With the strike, this start has been now delayed until 2003/4. In the final year of the project, the university was either on strike or closed for most of the 2002/3 academic session. Nevertheless, the university maintained its interest in the Conservation Biology course and three university lecturers subsequently participated in a 3-month unforeseen training programme with the Darwin Research Associate. One faculty member (Christiane Atteke) was elected by the department for additional training at Cardiff University. The purpose of her visit was to augment USTM capacity in molecular biology research and to develop student practical work in molecular biology. This overseas internship was partly financed by the university and partly by the Darwin Initiative, reflecting perhaps a greater commitment on the part of the university to embracing biodiversity and molecular ecology studies.

- During the project lifetime, what collaboration existed with similar projects elsewhere in the host country? Was there consultation with the host country Biodiversity Strategy (BS) Office?

A potential collaborative exchange between CIRMF, USTM and ENEF was initiated in the form of a one-day workshop towards the end of the project. ENEF is responsible for training the country's natural resource managers but currently has no formal programme in conservation biology. It is hoped that in the future there may be greater exchange between USTM faculty and

ENEF, when the biodiversity course becomes fully integrated into the university curriculum. In terms of research, CIRMF is unique to Gabon in being one of the few places with the capacity to carry out molecular ecology. Opportunities for academic exchange were also unique to this project in that USTM is the only science university in the country.

WCS in collaboration with WWF and the country's Department of Wildlife (Direction de la Faune) have jointly laid down plans for a network of protected areas though out the country. Thirteen of these protected areas were recently awarded national park status. These protected areas were also inventoried during the evaluation process and as a result became *de facto* sites for non-invasive sampling of gorillas for the Darwin Initiative. In this way, the sampling strategy in Gabon was thus tied very closely to the country's current biodiversity strategy. Although Gabon has no formal Biodiversity Strategy Office, The Direction de la Faune et de la Chasse was consulted and kept informed at all stages of this project, and on all other research activities carried out in conservation genetics at CIRMF.

- How many international partners participated in project activities? Provide names of main international partners.

The principal international partner working with the Darwin was the Wildlife Conservation Society (New York, USA). WCS as described previously have orchestrated sampling strategies at regional and continent-wide scales and played a key role in field training programs throughout the duration of the Darwin Initiative.

- To your knowledge, have the local partnerships been active after the end of the Darwin Project and what is the level of their participation with the local biodiversity strategy process and other local Government activities? Is more community participation needed and is there a role for the private sector?

UGENET has continued to coordinate samples for the Darwin Initiative and will play a central role in collaborative research projects on the genetics of tropical flora and fauna in the future. In particular, three projects with links to past Darwin activities are currently in development. These are: (1) the conservation genetics of central African forest elephants (Mireille Bawe-Johnson) (2) phylogeography of African forest duikers (Nicola Anthony and Patrick Mickala) (3) sexual morphology and recolonisation dynamics of Okoumé in Gabon (Michel Cazemajor). As previously mentioned, Michel Cazemajor is the new postdoctoral research associate at UGENET with a remit to underpin all Darwin-initiated education and training activities at the university as well as to liaise between USTM faculty and students and CIRMF.

USTM anticipates starting a new term in January, 2003. UGENET will continue to assist in building molecular capacity within the university and in the development of the biodiversity course. It is hoped that faculty will ultimately develop a satellite molecular ecology laboratory on site, and replace the Darwin funding of student field courses and invited speakers, through, for example, the American Embassy funding or some other small grants programme. Both Patrick Mickala and Christiane Atteke anticipate pursuing their respective interests in research over the next few years and will be seeking research funding in the future; UGENET will continue to sustain their activities.

Work with WCS on gorilla genetic diversity and the formulation of a national action plan will continue into 2003. Additional funding is being sought from the UN Great Apes Survival Project (GRASP). WCS will also continue to play a central role in sample coordination and in the formulation of conservation policy throughout Central Africa. The sampling network developed within Gabon and across central Africa during the past years will serve as a source of samples for future mammal and plant genetic and biological diversity studies.

9. Monitoring and Evaluation, Lesson learning

- Please explain your strategy for monitoring and evaluation (M&E) and give an outline of results. How does this **demonstrate** the value of the project? e.g. what baseline information was collected (e.g. scientific, social, economic), milestones in the project

design, and indicators to identify your achievements (at purpose and goal level).

Technology transfer and research activities were regularly evaluated by the Conseil Scientifique (CS) of CIRMF. The CS is an external review body that meets twice annually to assess ongoing research within CIRMF. Evaluation is by assessing reports and round-table discussions with Council members. The Project co-ordinator became in 2000 the first Anglophone member of the CS in the history of CIRMF and therefore was able to actively participate in monitoring performance from a different perspective. Darwin partners also met regularly to discuss problems and progress in each of the project's activities and regular email contact (where possible) was maintained throughout the duration of the project. Problems were encountered, however, during periods of email failure, which occurred regularly during the project. The perception of UGENET as a reference facility within the central African forest block for conservation genetics has been singularly enhanced during the 3 years of the project, such that international recognition of the research unit has been achieved.

In terms of education, evaluation forms were given out to students at the end of teaching sessions in 2000 and 2001, and the content and breadth of the course was modified accordingly. The Darwin Research Associate also met with USTM faculty regularly to review the course and discuss plans for future course work.

The project has been able to demonstrate its value through three principal outputs:

1. Creation of a conservation biology course and anticipated integration of a new discipline into the university curriculum

2. Active and durable participation of university students and faculty in molecular ecology research and technology development

3. Anticipated contribution of concrete genetic data to a national and international biodiversity action plan for great apes as well as peer-reviewed publications in the scientific community

- During the project period, has there been an internal or external evaluation of the work or are there any plans for this?

In additional to Darwin Initiative secretariat evaluation, external evaluation has been carried out regularly by the Conseil Scientifique of CIRMF, which, as previously stated, had the project co-ordinator as a member.

- What are the key lessons to be drawn from the experience of this project? We would welcome your comments on any broader lessons for the Darwin Initiative as a programme or practical lessons that could be valuable to other projects, as we would like to present this information on a website page.

Budget flexibility is vital: throughout the duration of this project minor adjustments and creative modifications to ongoing components of the project meant that different demands on the budget were made at different times. The flexibility of the Darwin in allowing us to move money between different budget categories greatly facilitated our work and maximised productivity on what was essentially an extremely small budget.

More funding is needed to do serious science. With respect to genetic work, an annual budget of £4900 was insufficient for us to adequately finance two full-time researchers and sustain a collaborative research program between two countries thousands of miles apart. Either the research scope needed to be cut back considerably (which would compromise a very important output of the project) or additional research funding (over and above in-kind contributions and from the Darwin Initiative or elsewhere) needed to be secured early on in the project.

Newly appointed fellows (such as the present research associate) would benefit enormously from a short leave of absence at the beginning of the project to travel around the host country and make contacts in the conservation arena. It is very difficult for a UK researcher to otherwise build a conservation programme and find suitable case studies for course work with little or no prior experience of the host country. This would also promote Darwin visibility in the host country and foster future on the ground collaborations in both education and research. This is especially

important in a non-Anglophone country.

When the Darwin fellow and research technician need to travel regularly to and from a costly location (like Gabon) it is important to have additional funding in the travel category for meeting participation. This not only facilitates contacts outside the immediate environs of the project but also raises project visibility and possibly outreach capabilities.

Moving to and from the UK host institution and local partner institution in Gabon caused considerable personal disruption to both the research associate and the research technician on the project. Whilst a certain amount of disruption is to be expected, limited allowances could be made such as providing additional assistance for childcare, subsistence etc. for the project personnel from the host country.

10. Darwin Identity:

- What effort has the project made to publicise the Darwin Initiative, e.g. where did the project use the 'Darwin Initiative' logo, promote Darwin funding opportunities or projects? Was there evidence that Darwin Fellows or Darwin Scholars/Students used these titles?

The research findings of the Darwin project were publicised widely towards the end of the project. Meetings attended included:

1. Participation and presentation of Darwin project research at the European Federation of Primatology meeting in London (December, 2000)
2. Participation and presentation of Darwin project activities to gorilla researchers at the western lowland gorilla conservation workshop at the Max Planck Institute for Evolutionary Anthropology, Leipzig (May, 2002).
3. Presentation of research findings at the Society for Evolutionary Biology annual meeting in Champagne, Illinois. (August 2002)
4. Presentation of research findings and Darwin project activities at the annual meeting of the Society for Conservation Biology (SCB), Canterbury University, Kent (July 2002).
5. Various seminars presented by Darwin staff, especially the project co-ordinator, in university departments throughout the project.

BBC Radio 4 has recently made a program - "The Gene Team" about the gorilla genetic work carried out by Lopé, CIRMF and Darwin researchers working on this project – this is due for transmission January 10th, 2003. Information on Darwin activities in gorilla genetics have been posted on the gorilla conservation website (*www.westerngorilla.org*) that came about as a direct result of the western lowland gorilla workshop in Leipzig. The Darwin research associate has also participated in a conservation education workshop at the SCB meetings and is presently exploring the possibility of contributing CD contents of the biodiversity course to the American Museum of Natural History's biodiversity education programme.

- What is the understanding of Darwin Identity in the host country? Who, within the host country, is likely to be familiar with the Darwin Initiative and what evidence is there to show that people are aware of this project and the aims of the Darwin Initiative?

The Darwin Initiative logo was publicised both within CIRMF, ENEF and at the national science university. As a condition for working in Gabon, the BBC will be required to produce a French version of "The Gene Team" for national broadcasting. This broadcast will raise the visibility of the Darwin research activities in both the national and international popular media. The Darwin research technician will write a short article on the Darwin initiative for the national environmental newspaper "*Le Cri du Pangolin*".

- Considering the project in the context of biodiversity conservation in the host country, did it form part of a larger programme that dwarfed Darwin funding or was it recognised as a distinct project with a clear identity?

The Darwin had a clear *local* identity that was separate from /over and above that of its

collaborating organisations CIRMF, WCS and USTM. This may in part be due to the unrivalled opportunity that the initiative presented in building links between recognised national institutions of higher education and research facilities in Franceville, and the fact that it was the first Darwin Initiative-funded project in Gabon. This however also limited the Darwin geographic scope as much of the in-country activity was focused either in Franceville or at the Lopé Reserve.

11. Leverage

- During the lifetime of the project, what additional funds were attracted to biodiversity work associated with the project, including additional investment by partners?

CIRMF made substantial in-kind investments in smoothing out logistics at all levels. Additional funding was sought for meeting participation and research consumables from the Royal Society of London. Whilst the former application was successful the latter was not, perhaps in part due to the fact that the said application was made too late towards the end of the Darwin funding period.

- What efforts were made by UK project staff to strengthen the capacity of partners to secure further funds for similar work in the host country and were attempts made to capture funds from international donors?

The Darwin research associate has worked with USTM faculty member Patrick Mickala in his sabbatical applications in obtaining research funding for the sampling component of his project in Gabon. Patrick has been granted permission and financing by USTM to do one year's sabbatical at the University of New Orleans where the research associate has recently obtained a faculty position in conservation biology. UGENET continues the DRA activities in supporting Christiane Atteke's efforts to develop a research project on plant genetics. WCS programme director Lee White has agreed to try and secure funding to complete the unfinished mtDNA sequencing of this project. Mireille Johnson is seeking funding for her PhD project on forest elephant conservation genetics in conjunction with UGENET and Cardiff University, having submitted funding application to IUCN, USFWS and WCS.

12. Sustainability and Legacy

- What project achievements are most likely to endure? What will happen to project staff and resources after the project ends? Are partners likely to keep in touch?

The conservation education programme we hope will be integrated into the university curriculum although this very much depends on the stability of the university in the coming years. Solid research foundations and future collaborations between Cardiff University, University of New Orleans and CIRMF had been laid down by this project and a durable collaborative network established. As future genetic work between CIRMF (UGENET and SEGC) and both the project co-ordinator and research associate is envisaged in the future, there is no doubt that project partners will maintain an active collaboration. The post-doctoral associate Michel Cazemajor will ensure project continuity in education and technical development at CIRMF and USTM.

- Have the project's conclusions and outputs been widely applied? How could legacy have been improved?

Application of research findings awaits completion of data processing and analysis, which should be completed in the next 3 months. Biodiversity education and technology transfer were ultimately effective given the fact that a collaborative network was already in place. An additional year of funding would have helped solidify the transfer of the biodiversity course but with the arrival of the new CIRMF post-doctoral scientist would have probably been unnecessary. Participation of Darwin personnel in a future workshop held in the host country to finalise the national management plan for gorillas (anticipated for September 2003?) will be an essential means of promulgating research findings to interested parties and will assist in making the necessary link between research and conservation policy.

- Are additional funds being sought to continue aspects of the project (funds from where and

for which aspects)?

Yes, funding will be procured from the conservation community to complete the mtDNA sequencing that remains (an estimated $1,500 dollars is required). Money for developing field courses for USTM students could be sought from the American Embassy small grants programme. USTM faculty member Patrick Mickala is seeking funding from WCS to carry out the field component of the collaborative study on genetic diversity in forest duikers with the former Darwin research associate. He has already acquired the necessary permission and stipend to do a post-doc abroad but because of the strike at USTM has had to delay his sabbatical by a year. Mireille Johnson-Bawe will be carrying out her PhD project based on funds sought and procured by DI project partners at Cardiff and UGENET.

13. Value for money

- Considering the costs and benefits of the project, how do you rate the project in terms of value for money and what evidence do you have to support these conclusions?

We were able to achieve a genuine wealth of outputs with very little money. The teaching programme was particularly cost effective. Genetic work on non-invasive samples is expensive and this project was able to reduce costs by teaming up or profiting from earlier work by fellow collaborators (Kathryn Jeffery and Stephen Clifford). Technology transfer is also expensive and difficult in Africa but we were able to achieve our goals. Ultimately, the division of labour between a high technology, high throughput laboratory, such as Cardiff, and a relatively well equipped but well placed laboratory in Africa was a necessary but valid strategy in order to maximise the cost-effectiveness of the project.

Author(s) / Date

Nicola Anthony Mike Bruford Kate Abernethy Jean Wickings

December 31st, 2002

14. Appendix I: Project Contribution to Articles under the Convention on Biological Diversity (CBD)

Please complete the table below to show the extent of project contribution to the different measures for biodiversity conservation defined in the CBD Articles. This will enable us to tie Darwin projects more directly into CBD areas and to see if the underlying objective of the Darwin Initiative has been met. We have focused on CBD Articles that are most relevant to biodiversity conservation initiatives by small projects in developing countries. However, certain Articles have been omitted where they apply across the board. Where there is overlap between measures described by two different Articles, allocate the % to the most appropriate one.

Project Contribution to Articles under the Convention on Biological Diversity		
Article No./Title	**Project %**	**Article Description**
6. General Measures for Conservation & Sustainable Use	0	Develop national strategies which integrate conservation and sustainable use.
7. Identification and Monitoring	35	Identify and monitor components of biological diversity, particularly those requiring urgent conservation; identify processes and activities which have adverse effects; maintain and organise relevant data.
8. In-situ Conservation	5	Establish systems of protected areas with guidelines for selection and management; regulate biological resources, promote protection of habitats; manage areas adjacent to protected areas; restore degraded ecosystems and recovery of threatened species; control risks associated with organisms modified by biotechnology; control spread of alien species; ensure compatibility between sustainable use of resources and their conservation; protect traditional lifestyles and knowledge on biological resources.
9. Ex-situ Conservation	0	Adopt ex-situ measures to conserve and research components of biological diversity, preferably in country of origin; facilitate recovery of threatened species; regulate and manage collection of biological resources.
10. Sustainable Use of Components of Biological Diversity	0	Integrate conservation and sustainable use in national decisions; protect sustainable customary uses; support local populations to implement remedial actions; encourage co-operation between governments and the private sector.
11. Incentive Measures	0	Establish economically and socially sound incentives to conserve and promote sustainable use of biological diversity.

12. Research and Training	25	Establish programmes for scientific and technical education in identification, conservation and sustainable use of biodiversity components; promote research contributing to the conservation and sustainable use of biological diversity, particularly in developing countries (in accordance with SBSTTA recommendations).
13. Public Education and Awareness	5	Promote understanding of the importance of measures to conserve biological diversity and propagate these measures through the media; cooperate with other states and organisations in developing awareness programmes.
14. Impact Assessment and Minimizing Adverse Impacts	0	Introduce EIAs of appropriate projects and allow public participation; take into account environmental consequences of policies; exchange information on impacts beyond State boundaries and work to reduce hazards; promote emergency responses to hazards; examine mechanisms for re-dress of international damage.
15. Access to Genetic Resources	0	Whilst governments control access to their genetic resources they should also facilitate access of environmentally sound uses on mutually agreed terms; scientific research based on a country's genetic resources should ensure sharing in a fair and equitable way of results and benefits.
16. Access to and Transfer of Technology	25	Countries shall ensure access to technologies relevant to conservation and sustainable use of biodiversity under fair and most favourable terms to the source countries (subject to patents and intellectual property rights) and ensure the private sector facilitates such assess and joint development of technologies.
17. Exchange of Information	5	Countries shall facilitate information exchange and repatriation including technical scientific and socio-economic research, information on training and surveying programmes and local knowledge
19. Bio-safety Protocol	0	Countries shall take legislative, administrative or policy measures to provide for the effective participation in biotechnological research activities and to ensure all practicable measures to promote and advance priority access on a fair and equitable basis, especially where they provide the genetic resources for such research.
Total %	**100%**	**Check % = total 100**

15. Appendix II Outputs

Please quantify and briefly describe all project outputs using the coding and format of the Darwin Initiative Standard Output Measures.

Code	Total to date (reduce box)	Detail (←expand box)
Training Outputs		
1a	Number of people to submit PhD thesis	0
1b	Number of PhD qualifications obtained	0
2	Number of Masters qualifications obtained	0
3	Number of other qualifications obtained Course participation Examination pass Field course	(2000/2001) Approx. 50 Approc 35 10 certificates
4a	Number of undergraduate students receiving training	20-40 year 2000; 30-60 year 2001 10 for field course 2001
4b	Number of training weeks provided to undergraduate students	14
4c	Number of postgraduate students receiving training (not 1-3 above)	0
4d	Number of training weeks for postgraduate students	0
5	Number of people receiving other forms of **long-term** (>1yr) training not leading to formal qualification(i.e not categories 1-4 above)	1 (Mireille Bawe-Johnson)
6a	Number of people receiving other forms of **short-term** education/training (i.e not categories 1-5 above)	3 student interns
6b	Number of training weeks not leading to formal qualification	15-20 weeks total (3 student interns)
7	Number of types of training materials produced for use by host country(s)	1 CD of biodiversity course contents and teaching aids
Research Outputs		
8	Number of weeks spent by UK project staff on project work in host country(s)	N. Anthony = 64 M. Bruford = 6
9	Number of species/habitat management plans (or action plans) produced for Governments, public authorities or other implementing agencies in the host country (s)	0
10	Number of formal documents produced to assist work related to species identification, classification and recording.	1 (field methods chapter on non-invasive genetics)
11a	Number of papers published or accepted for publication in peer reviewed journals	0
11b	Number of papers published or accepted for publication elsewhere	1 (in revision) 2 (in the future)
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country	1 (WCS Gabon samples) 1 (Products for sequencing) 2 (pan African microsatellite and sequence data
12b	Number of computer-based databases enhanced (containing species/genetic information) and handed over to host country	1 hair genetic database (in prep.)
13a	Number of species reference collections established and handed over to host country(s)	1
13b	Number of species reference collections enhanced and handed over to host country(s)	0

Dissemination Outputs		
14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	0
14b	Number of conferences/seminars/ workshops **attended** at which findings from Darwin project work will be presented/ disseminated.	6 (including two participants at the Primate Society of Great Britain and the Society for Conservation Biology)
15a	Number of national press releases or publicity articles in host country(s)	0
15b	Number of local press releases or publicity articles in host country(s)	0
15c	Number of national press releases or publicity articles in UK	0
15d	Number of local press releases or publicity articles in UK	0
16a	Number of issues of newsletters produced in the host country(s)	Anticipated in the Cri du Pangolin
16b	Estimated circulation of each newsletter in the host country(s)	?
16c	Estimated circulation of each newsletter in the UK	N/A
17a	Number of dissemination networks established	0
17b	Number of dissemination networks enhanced or extended	0
18a	Number of national TV programmes/features in host country(s)	0
18b	Number of national TV programme/features in the UK	0
18c	Number of local TV programme/features in host country	0
18d	Number of local TV programme features in the UK	0
19a	Number of national radio interviews/features in host country(s)	?
19b	Number of national radio interviews/features in the UK	2
19c	Number of local radio interviews/features in host country (s)	?
19d	Number of local radio interviews/features in the UK	0
Physical Outputs		
20	Estimated value (£s) of physical assets handed over to host country(s)	N/A
21	Number of permanent educational/training/research facilities or organisation established	1
22	Number of permanent field plots established	0
23	Value of additional resources raised for project	£500

16. Appendix III: Publications

Provide full details of all publications and material that can be publicly accessed, e.g. title, name of publisher, contact details, cost. Details will be recorded on the Darwin Monitoring Website Publications Database that is currently being compiled.

Mark (*) all publications and other material that you have included with this report

Type * (e.g. journals, manual, CDs)	**Detail** (title, author, year)	**Publishers** (name, city)	**Available from** (e.g. contact address, website)	**Cost £**
*** Journal article**	Mitochondrial DNA phylogeography of western lowland gorillas (*Gorilla gorilla gorilla*). Stephen L. Clifford*, Nicola M. Anthony*, Mireille Bawe-Johnson, Kate A. Abernethy, Caroline E.G. Tutin, Lee J.T. White, Magdelena Bermejo, Michelle L.Goldsmith, Kelly McFarland , Kathryn J. Jeffery, Michael W. Bruford, E. Jean Wickings. * Equal first authorship. Manuscript in preparation for resubmission to: *Proceedings of the Royal Society Ser. B (London)*.[	**Royal Society (if accepted)**	**www.royalsoc.ac.uk**	**N/A**
*** Book chapter**	**Collection, storage and analysis of non-invasive genetic material in primate biology** Benoît Goossens, Nicola Anthony, Kathryn Jeffery, Mireille Johnson-Bawe and Michael W. Bruford	**Cambridge University Press**	**www.cam.cup.ac.uk**	**Not available yet**
CD of course contents	**Biodiversité et sa conservation**	**Available on request**	**Nicola Anthony (anthonynm2000@yahoo.co.uk), Mike Bruford (brufordmw@cf.ac.uk)) Jean Wickings (jeanwickings@yahoo.co.uk)**	**Free**

17. Appendix IV: Darwin Contacts

To assist us with future evaluation work and feedback on your report , please provide contact details below.

Project Title	Conservation biology and Genetics of the Western Lowland Gorilla in Gabon
Ref. No.	**08/044**
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Role within Darwin Project	Project co-ordinator
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Partner 1	
Name	Dr. E. Jean Wickings
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Role within Darwin Project	Local co-ordinator
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Partner 2 (if relevant)	
Name	Dr. Kate Abernethy
Organisation	Station d'Etudes des Gorilles et des Chimpanzés (SEGC), Lopé National Park, Lopé, Gabon
Role within Darwin Project	Local Partner
Address	c/o CIRMF, BP 769, Franceville, Gabon
Fax	
Email	

Appendices

1. Table of collectors that contributed hair samples to the pan-African genetic study funded by the Leverhulme Trust and more recently the Darwin Initiative [CD].
2. Database of gorilla hair and faecal samples collected by Wildlife Conservation Society as part of their national assessment of candidate protected areas in Gabon. [CD]
3. Mitochondrial DNA phylogeography of western lowland gorillas (*Gorilla gorilla gorilla*). Stephen L. Clifford*, Nicola M. Anthony*, Mireille Bawe-Johnson, Kate A. Abernethy, Caroline E.G. Tutin, Lee J.T. White, Magdelena Bermejo, Michelle L.Goldsmith, Kelly McFarland , Kathryn J. Jeffery, Michael W. Bruford, E. Jean Wickings. * Equal first authorship. Manuscript in preparation for resubmission to: *Proceedings of the Royal Society Ser. B (London*).[CD]
4. Database of hair samples collected from 1990 to the present in the Zone d'Etude of the SEGC field station, Lopé , Gabon. [CD]
5. Contents of the course "*Biodiversité et sa conservation*", USTM 2002. Course is organised by session and is available on CD from Nicky Anthony (small_mammal@yahoo.co.uk), Mike Bruford (brufordmw@cf.ac.uk) and Jean Wickings (jeanwickings@yahoo.co.uk). [CD]
6. Final report written by Dr. Christiane Atteke for USTM on the Darwin Initiative activities for her training period in 2002. [CD]
7. List of purified PCR products for sequencing. Product code denoted by a T is a unique identifier for each individual. T coded products in yellow have been cloned; products in purple have been sequenced directly and unfilled boxes are not yet sequenced. [CD]
8. Book chapter on non-invasive genetics (in press): Field and Laboratory Methods for Primatologists: A practical guide, Cambridge University Press. [CD]
9. Justification for the USTM field course held at the Lopé in 2001 and submitted to the Gabonese Department of *Eaux et Forêts* by Kate Abernethy. [Hard copy attached]
10. Representative certificate of attestation for the conservation biology course. Originals were in colour. [Hard copy attached].
11. Evaluation forms filled out by students at the end of each course. [CD]
12. List of opportunities for students in conservation and environmental research in Gabon. [CD]
13. Powerpoint poster presentation of the Darwin Initiative in Gabon exhibited at the British Primatological Society Meeting in London, 2000 and subsequently displayed at Cardiff University, CIRMF and USTM.
14. Powerpoint poster presentation exhibited at the Darwin Initiative annual meeting in 2002 and currently displayed in the School of Biosciences, Cardiff University and CIRMF, Gabon.