

Darwin Initiative for the Survival of Species

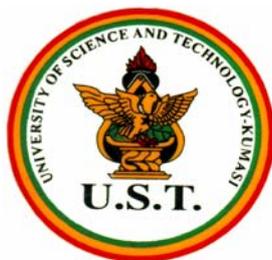


Conservation of *Albizia* tree species in Ghana
Project No 162/06/159

Final Report



University of Dundee
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GHANA

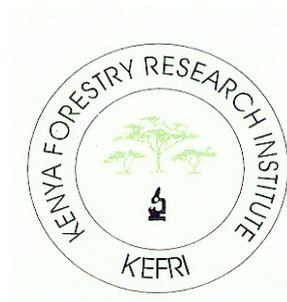


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Darwin Project Information

Project title: Conservation of seed and microsymbionts of *Albizia* tree species in
Ghana

Country: Ghana

Contractors: Dr Joan M Sutherland, University of Dundee, Dr Kwame Twum-Ampofo, Institute of Renewable Natural resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, Dr David Odee, Kenya Forestry Research Institute, Nairobi, Kenya.

Project Reference No.: 162/6/159

Grant value: £98,371

Starting/finishing dates: June 1997/May 2000

1. Project Background/Rationale

The project was located at the Agroforestry Department, Institute of Renewable Natural Resources, KNUST, Kumasi, Ghana.

The problem that the project aimed to address was the need to develop agroforestry strategies to help to reduce the exploitation of the remaining natural wet/moist forest in Ghana.

The project was identified by staff of the Agroforestry Department, Institute of Renewable Natural Resources, the only institute in Ghana that teaches forestry/agroforestry at degree level. The disappearance of *Albizia* species had been noted by the Rural Forestry Division of the Department of Agriculture, KNUST. A subsequent student project determined that the trees grew poorly outside their native

range and lack of appropriate symbionts was considered a possible cause. Work at the University of Dundee on Central American albizias suggested that some species have unusually high specificity in their rhizobial requirements, and that many tropical tree rhizobia die or lose their capacity to fix nitrogen during storage and different techniques are required from those used for temperate strains.

2. Project Summary

The principal objectives of the project were:

- a. To conserve germplasm in Ghana of indigenous, highly valued *Albizia* species, *A. adianthifolia*, *A. ferruginea* and *A. zygia* and their rhizobial and mycorrhizal microsymbionts;
- b. To train a technician at UST in all techniques relevant to this conservation and to ensure that the microbiology laboratory at the IRNR, is fully functional for microsymbiont conservation and research;
- c. To teach legume tree and microsymbiont biology and the principles of Darwin in an existing 2-year MSc Agroforestry/Forestry course;
- d. To supervise MSc research projects the overall objective of which was to test the hypothesis that the failure of *Albizia* species to establish outside their existing ecological zones is due to the absence of microsymbionts by (i) collecting seed and root nodules from trees and soil from around trees throughout their range in Ghana (ii) isolating and testing rhizobial and mycorrhizal strains in both sterile and unsterile (nursery) conditions, (iii) planting seedlings with and without effective symbioses in farmers fields and monitoring establishment;
- e. To facilitate a link between UST and an established successful microsymbionts laboratory at Kenya Forestry Research Institute.

Original objectives were modified during the project period. Approval for these was sought on 28.8.97 and obtained from the Darwin Secretariat on 2.9.97. Unexpected cessation of World Bank funding of IRNR meant that available transport was very expensive. Also the laboratory which was to be used by the project was unfinished.

This necessitated the purchase of a vehicle and alternative arrangements for beginning rhizobial isolation and testing. The former was possible by cancelling the first planned workshop and the latter by transferring the initial laboratory work to KEFRI, and sending the IRNR student/technician to KEFRI for training. The technician appointed to the project went home on the death of his father and failed to return so the first MSc student Mr Patrick Kumordzie was appointed to act both as student and as technician for the project. This released funds intended to pay the technician. The discovery of significant recalcitrance in the seed of species of *Albizia* together with a short seed production season (Feb-March) meant that by the time agroforestry MSc students were ready to begin their research projects in June or July few viable seed were available. A planned survey of the genetic variation of albizias project was therefore changed to a vegetative propagation project.

Contribution to Articles under the Convention on Biological Diversity (CBD):

9. Ex-situ conservation	20
12. Research and Training	70
17. Exchange of Information	10

Progress on objectives

Code	Output	Target	Achieved
3.17	Training		
2	MSc degrees	5-6	2
4a	No. undergraduates receiving training		57
4b	No. training weeks provided to undergraduates		5.7
4c	No. postgraduates receiving other education		20
5	No. people receiving other education (not 1-4)	1	
6a	No. people receiving other education (not 1-5)	50-60	27
6b	No. training weeks provided	100-120	50.6
7	No. training materials produced	2	
3.18	Research		
8	No. weeks spent by UK staff in host country	50	15
9	Management plans	1	
11a	Papers published in peer reviewed journals	1	1
13a	No. of species reference collections	3	1

3.19	Dissemination		
14a	No. workshops etc organised in host country		2
14d	No. conferences attended and work presented	4	5
15a	No. national press releases in Ghana		
15b	No. local press releases in UK		
17b	No. dissemination networks extended	3	

Major accomplishments

- Two MSc theses were completed.
- Original data sufficient to promote the use of *Albizia* species for agroforestry have been produced.
- A method for the vegetative propagation of *A. ferruginea* has been developed.
- A collection of strains of rhizobia which form effective nitrogen-fixing symbioses with species of *Albizia* has been established and stored in three places including at -80°C in Dundee.
- A workshop was run for 20 students, technicians, and scientists from various university departments and research institutes from around the Kumasi area. Practical and theoretical aspects of the conservation of seed, mycorrhiza and rhizobia in relation to forest conservation were covered.
- Lectures on Darwin principles and approaches to the conservation of Ghana indigenous forests were delivered to 77 undergraduate and postgraduate students and 27 people received other training.
- Five people (two Ghanaians and three Kenyans) were involved in trainer/trainee visits between Ghana and Kenya.
- A workshop was held to develop an EU project. A scientist from Côte d'Ivoire was invited to participate and Dr Odee contributed from his 10 years of collaborating on EU projects and Dr Sutherland conveyed information from an information day in Brussels specifically on the call being targeted. Unfortunately the other European partner did not participate as promised. However the team formed was able to produce a different proposal that is currently being for funding under the budget line Tropical Forests and Other Forests in Developing Countries.

Problems encountered

- The World Bank funding of IRNR ended unexpectedly necessitating that the Institute charge for the use of transport. It was calculated to be cheaper and more convenient to purchase a project vehicle. One workshop was cancelled (with Darwin permission) to pay for this.

- There was also delay in finishing the laboratory which the project was to use necessitating the switch of initial laboratory work to KEFRI.
- The technician appointed to the project went home on the death of his father and did not return so the first MSc student also acted as technician – this may have contributed to his not completing his thesis.
- It was discovered that *Albizia* seed survive less than six months in standard seed storage conditions and, since seed production occurs in Feb-March and MSc projects usually begin in June or July, time and energy were wasted using non-germinating seed and waiting for the next seed production season.
- Dr David Odee of KEFRI was unable to participate in the training workshop as planned due to a family bereavement.
- A second planned workshop had to be cancelled as a result of a University staff strike.
- Throughout the project was plagued by controlling perfectionism on the part of the local collaborator exacerbated by local political and communications problems.

Unforeseen benefits

- The necessity of moving the rhizobia isolation and strain testing work to Kenya resulted in more exchange visits between the two institutes to the greater benefit of both.
- The absence of Dr Odee from the workshop meant that Dr Robert Abaidoo from the Biochemistry Department stepped in at the last minute and he is a collaborator on project proposal currently being reviewed in Brussels.
- The recalcitrance of *Albizia* seed necessitating the research into vegetative propagation produced a simple method for propagating all three species particularly *A. ferruginea* (the most endangered species) from root cuttings. This allows IRNR staff to promote the use of this method through teaching of their undergraduate and postgraduate students. Since *A. ferruginea* was also shown to be fast growing as well as nitrogen fixing this allows the species to be promoted as a useful agroforestry species.

- The inability to hold a second seed and microsymbionts workshop allowed the holding of a workshop to develop an EU project. Dr Odee was able to pass on his considerable experience of EU projects – he has since become the first African scientific co-ordinator of an EU research project. The project developed at this workshop could not be submitted as the French partner dropped out. However, the network, which Dr Dominic Blay, FORIG (Forestry Research Institute of Ghana), was able to submit a different project to the Programme on Tropical Forests and other forests in Developing Countries. This project survived the first selection process and is currently being considered.

4. Scientific, Training and Technical Assessment

Three MSc projects were carried out and two theses were successfully completed in spite of the finding that *Albizia* seed are recalcitrant. Together these theses provide a significant body of information on the differing silvicultural conditions required by the three species enabling agroforesters in Ghana to promote these species for agroforestry. The raw data and some analyses of the data from the incomplete project are given in appendix 1. Copies of the completed theses have not been received but their abstracts are given here. A copy of the peer reviewed paper from Gerald Danquah's thesis is given in appendix 1. The project also contributed, in the form of advice from Drs Twum Ampofo and Sutherland, to the successful completion of a University of Aberdeen BSc honours project on *A. adianthifolia* by Emily Clark, supervised by Dr M. D. Swaine, an expert on forest ecology in Ghana.

MSc Research Projects

(a) Patrick Tettey Kumordzie

The purpose of Patrick's experiments was to determine whether the reported lack of regeneration of species of *Albizia* in farmer's fields is due to absent or inappropriate microsymbionts. Three species, *A. zygia*, *A. ferruginea* and *A. adianthifolia*, were grown in a nursery in four different soils: (i) soil with no albizias growing in the area; (ii) cocoa farm soil with albizias; (iii) forest soil with albizias; and (iv) farmland soil with albizias. Patrick's second factorial experiment included the three species, three nitrogen fertilizer and three phosphorous fertilizer treatments and the same four soils

as in experiment 1. Analyses of the mineral (nitrogen, phosphorous, potassium, calcium and magnesium) contents were performed but JMS has not received any of the other data for this experiment.

The project showed:

- Growth data (height and diameter) at 6 weeks showed that *A. zygia* does not grow well in cocoa soil in spite of the soil used having had *Albizia* species growing in the vicinity. This was the species that Nkyi (1989) reported was not regenerating in farmer's fields. After 16 weeks differences between species performances in the different soils were less pronounced particularly that of *A. ferruginea*, the fastest-growing species which by that time had its roots growing through the base of the black plastic tubes into the nursery soil. *A. zygia* continued to perform badly in the cocoa soil and also the farmland soil;
- Nodulation patterns differed considerably between the three species in the four soils. Nodulation (number + dry weight) was lowest for *A. adianthifolia* in the soil without albizias growing in it. Nodule dry weight of *A. zygia* was also lowest in soil 1. This suggests that rhizobia were obtained from both the test soils and the nursery soil and that there is specificity in rhizobia.
- Nutrient contents of the leaves from experiment 2 showed considerable variation. However, content (%) data are difficult to interpret without the dry weight data which JMS did not receive. The data do show that the three species responded differently to the fertilizer treatments.

Conclusion

In spite of being incomplete these data provide useful insights into the differing growth conditions necessary for the three species. They also show that *A. ferruginea* (the most endangered of the three species) is also the fastest growing.

(b) Stephen Twumasi (2002) Influence of Arbuscular mycorrhizal fungi and phosphorus on early growth and nodulation of indigenous *Albizia* species. Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. MSc thesis.

Abstract

This study was conducted to determine the response of four (4) species of arbuscular mycorrhizal fungi (*Glomus clarum*, *G. intraradices*, *G. etunicatum* and *Gigaspora rosea*) on early growth and nodulation of species of *Albizia* (*A. adianthifolia*, *A. ferruginea* and *A. zygia*), and to evaluate the interaction of phosphorus fertilizer in the form of triple superphosphate (TSP) with arbuscular mycorrhizal fungus (*Glomus clarum*). *Albizia* seedlings were grown in pots under nursery conditions and treatments applied to both sterilised and unsterilised soil conditions.

- Arbuscular mycorrhizal fungi differed in their effectiveness in enhancing early growth, dry matter accumulation, nutrient (N, P, K and Mg) uptake and root colonisation in all three species. *Glomus intraradices* was the most preferred fungus in *A. adianthifolia*, *Glomus clarum* in *A. ferruginea* and *Glomus etunicatum* in *A. zygia*. In general, *Glomus clarum* proved to be the most efficient fungus in almost all parameters considered. Moreover, *A. ferruginea* gave the most promising initial growth characteristics as well as nutrient uptake and root colonization. However, the sterilized uninoculated soil treatment showed superiority in almost all the three *Albizia* species in terms of the growth measurements taken which is contrary to earlier reports made by some authors but recorded significantly low root colonization.

- Phosphorus addition in the form of TSP markedly stimulated nodulation (nodule number and nodule dry weight), increased plant growth, nutrient uptake and mycorrhizal infection in both uninoculated and inoculated plant seedlings of *A. ferruginea* but was more pronounced in the inoculated seedlings. Phosphorus fertilizer application at 50kg/ha (100mgTSP), gave significantly higher plant growth and arbuscular mycorrhizal fungal infection whilst these parameters declined above 100kg/ha (200mg TSP).

- The outcome of this study indicates that arbuscular mycorrhizal fungi differ in their effectiveness on indigenous *Albizia* species. In P-deficient soils it is possible to reduce the phosphorus fertilizer application with AM fungal inoculation and still maintain high productivity. Therefore, in most tropical soils AM fungi strains may

help plant growth and establishment on degraded soil or plant that cannot adequately meet their nutrient requirements

(c) Gerald Danquah (2000) Vegetative propagation of indigenous *Albizia* species. Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. MSc thesis.

Two experiments were conducted at the Institute of Renewable Natural Resources (IRNR) Research Farm to determine the vegetative parts of *Albizia adianthifolia*, *A. ferruginea* and *A. zygia* suitable for propagation. Experiment 1 dealt with nursery studies where sprouting and rooting potentials of soft wood, semi-hard wood, hard wood and root cuttings of the *Albizia* species were investigated, and how these plant parts were affected by application of rooting hormone (0.25% w/w Naphthylacetic acid (NAA) and 2.25% captan). The second experiment consisted of transplanting of sprouted root cuttings to the field to assess their growth performance for 12 weeks.

- Species showed significant difference with respect to sprouting over time with *Albizia adianthifolia* showing the highest sprouting potential as against *A. ferruginea* and *A. zygia*. Sprouting of stem cuttings started at 2 weeks after planting and at 6-8 weeks for root cuttings. Rooting hormone significantly increased sprouting of semi-hard wood cuttings but reduced sprouting of root cuttings.
- Sprouting mortality was observed in all the species, plant parts and their interactions with rooting hormone. High sprouting mortality (started at 4wap) was recorded for soft wood and hard wood cuttings of *A. ferruginea* with hormone treatment, hard wood cutting of *A. ferruginea* without hormone treatment and semi-hard wood cutting of *A. adianthifolia* without hormone treatment at 10wap.
- Sprouts from stem cuttings of the three *Albizia* species and their interactions with rooting hormone, showed a decrease in height, stem diameter, leaf petioles production and dry matter accumulation from 6wap to 12wap, probably because they did not develop roots to absorb water and nutrients to sustain their growth. Sprouts from root cuttings of the three species on the other hand, showed a steady increase in height, stem diameter, leaf petioles and dry matter production. The highest number of roots developed per cutting (11.6) was recorded for root cuttings of *A. ferruginea* without hormone treatment at 12wap.

- Transplanted root cuttings showed appreciable increase in height, stem diameter, leaf petioles production and dry matter accumulation with *A. ferruginea* performing better than *A. adianthifolia* and *A. zygia*. Species showed significant difference ($p < 0.05$) in growth. However, interaction between root cuttings and rooting hormone had no significant effect on height, stem diameter, leaf petioles production, root development, nodules production and dry matter accumulation at 12 weeks after transplanting.
- It could be inferred that, root cuttings of *Albizia* species have the potential of being propagated vegetatively without rooting hormone treatment.

Research in Kenya

Nodules from *Albizia* collected in Ghana were taken to KEFRI, Kenya for isolation and testing on homologous and other hosts while the laboratory at IRNR was undergoing repair. A total of 14 of the isolates were confirmed as rhizobia. With only one exception all were slow-growing (*Bradyrhizobium*). These strains were further differentiated using intrinsic antibiotic resistance (IAR) patterns. All isolates were effective on their homologous hosts and 5 were effective and 6 less effective on *A. lebbek* – used as a test species since seed of the three Ghana species was scarce. These preliminary results show diversity of morphology, growth types, IAR patterns and effectiveness of *Albizia* tree rhizobia. A poster was presented on this work at the African Association for Biological Nitrogen Fixation Biannual Conference in Cape Town, South Africa. (Appendix 3).

5. PROJECT IMPACTS

Contribution to Articles under the Convention on Biological Diversity (CBD):

9. Ex-situ conservation	20
12. Research and Training	70
17. Exchange of Information	10

- As head of the only university agroforestry department in Ghana the principal collaborator is in a position to influence both national policy and ensure its implementation nationwide through his continuing teaching both at undergraduate and post graduate levels. The significant results (both predicted

and unpredicted) on all three species by all three MSc projects will be used in both in teaching and in formulating policy and will be built on in future MSc projects.

- Gerald Danquah, is working with a cocoa purchasing firm (Royal Commodities Ltd, Accra) and is in a position to advise farmers directly on best methods of establishing *Albizias*. Stephen Twumasi has just completed his MSc and hopes to be able to find a place to do a PhD. Patrick Kumordzie, who did not complete his MSc, may now be school teaching where his agroforestry training will allow him to convey both the need to conserve the natural forest and practical approaches enabling that conservation (including the importance of *albizias* and best methods of their establishment). His experience of travel to Kenya would better enable him to evaluate the strengths and weakness of Ghanaian society and to discuss those with his students.
- All 20 workshop participants will understand the need to conserve natural forests, the importance of nitrogen-fixing legumes in maintaining those forests, and the importance of the soil microbial flora – in particular the microsymbionts – in maintaining natural systems. Project participants were drawn from government and research institutes around the Kumasi region, with one participant from the University in Legon, nr Accra and one from Tanzania, East Africa. All of these participants would be able to convey the conservation lessons learned to their colleagues, students and in some cases the public. The exercise would also be useful for developing the ideas and clarify policy issues of the trainers who attended most lectures as well as the valuable discussion session. The trainers (Dr Twum-Ampofo and Dr Blay) contributed to policy making in the previous government and are likely to be more actively involved with the present government.
- The purpose of the final workshop June –July 2000 was to further develop a grant proposal which had been discussed in general during a previous visit. Dr Sutherland had attended an ETFRN-sponsored information meeting in Brussels specific to the call being targeted. She conveyed that information and Dr David Odee contributed from his 10 years of experience of collaborating on EU research projects. An existing collaborator of Dr Blay, Dr Kadio Aimée from Côte d'Ivoire was invited to attend and he invited a French former

colleagues to participate in the submission of the proposal. Local experts were consulted during the formulation of the proposal (see notes on the workshop by Dr Odee, Appendix 3.)

6. Project Outputs

Summary

Code	Output	Target	Achieved
3.17	Training		
2	MSc degrees	5-6	2
4a	No. undergraduates receiving training		57
4b	No. training weeks provided to undergraduates		5.7
4c	No. postgraduates receiving other education		20
5	No. people receiving other education (not 1-4)	1	
6a	No. people receiving other education (not 1-5)	50-60	27
6b	No. training weeks provided	100-120	50.6
7	No. training materials produced	2	
3.18	Research		
8	No. weeks spent by UK staff in host country	50	15
9	Management plans	1	
11a	Papers published in peer reviewed journals	1	1
13a	No. of species reference collections	3	1
3.19	Dissemination		
14a	No. workshops etc organised in host country		2
14d	No. conferences attended and work presented	4	5
15a	No. national press releases in Ghana		
15b	No. local press releases in UK		
17b	No. dissemination networks extended	3	

Major accomplishments have been listed in the summary. Major items still incomplete include a training manual and accompanying video. On the former we are considering collaborating with colleagues at CEH, Edinburgh who are experts on mycorrhizas to produce a training manual on the microsymbionts. Funding for this has not yet been discussed. We also have 10 hrs of video footage of rhizobia technology and legume nodulation which we will give to the publicity department at KEFRI who are fully equipped to edit it.

Our failure to publicise the project in the wider media was due to the lack of communication with the local collaborators and our feeling of being in a “political minefield”.

Publications

Joan M. Sutherland¹, Kwame Twum-Ampofo², David W. Odee³, Shona G. McInroy¹ and Janet I. Sprent¹ (1998). Conservation of seed and microsymbionts of *Albizia* tree species in Ghana. Eighth Congress of the African Association for Biological Nitrogen Fixation. November, 1998. Cape Town, South Africa (Poster Abs). (Appendix 3)

David W. Odee, Patrick T. Kumordzie, John Ochieng, Kwame Twum-Ampofo, Shona G. McInroy and Joan M. Sutherland (1998). Nodulation and effectiveness of rhizobial isolates from root nodules of *Albizia* tree species in Ghana. Eighth Congress of the African Association for Biological Nitrogen Fixation. November, 1998. Cape Town, South Africa. (Poster Abs). (Appendix 3).

Joan M. Sutherland¹, Kwame Twum-Ampofo², Gerald Dankwa², Patrick Kumordzi², Stephen Twumasi², David W. Odee³, Shona G. Mcinroy¹ and Janet I. Sprent¹. (2000) Towards understanding the barriers to regeneration of *Albizia* tree species for shade in cocoa in Ghana. In: *Challenges and Imperatives for BNF Research and Application in Africa for the 21st Century* Ninth Congress of the African Association for Biological Nitrogen Fixation. 25-29 Sept, 2000. Nairobi, Kenya. p 77. (Oral presentation).

Danquah, G; Twum-Ampofo, K and Sutherland, JM (2001). Vegetative propagation of indigenous *Albizia* species in Ghana. In Karanja, NK and Kahindi HP (eds), *Challenges and Imperatives for BNF Research and Application in Africa for the 21st century*, pp 280-288. Ninth Congress of the African Association for Biological Nitrogen Fixation 25-29th September, 2000, Nairobi, Kenya. Printed by John Philips Africa Limited, Nairobi Kenya. ISBN 9966-879-41-2. (Appendix1)

Danquah, G (2000) Vegetative Propagation of Indigenous *Albizia* species. MSc Thesis, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Also relevant

McInroy SG, Machua J, Obote M, Ochieng J, Odee DW, Sprent JI and Sutherland JM (2002) Storage and preservation of rhizobia isolated from African acacias and other tropical trees. In: Karanja NK and Kahindi HP(eds), *Challenges and Imperatives for Biological Nitrogen Fixation Research and Application in Africa for the 21st century*, pp 73-85.

7. Project Expenditure

Year	Original	Revised 2/9/97	Actual
1997/98			
1998/99			
1999/2000			
2000/2001			
Total	£98,468	£98,468	£98,468

Category	Original	Revised 2/9/97	Actual
Rent, rates, etc			
Travel, subs, conferences			
Consumables & vehicle running			
Capital items			
Salaries			
Total	£98,468	£98,468	£98,468

The major changes in the budget were the purchase of a vehicle and the inability to appoint a dedicated technician for the project in Ghana.

8. Project Operation and Partnerships

The major partner was Dr Kwame Twum-Ampofo, IRNR, KNUST who first identified the problem and communicated it to Dr Sutherland while he was studying in Dundee. He was responsible for the major supervising of students and organising workshops.

Dr David Odee, KEFRI and his colleagues Dr Geoffrey Muluvi and Mr John Ochieng Otieno as well as other staff in his laboratory played a major role in ensuring that major project objectives relating to rhizobia technology were accomplished.

Dr Robert Abaidoo, Biochemistry Department, KNUST and Dr Dominic Blay, FORIG (Forestry Research Institute of Ghana) contributed significantly particularly to the training workshops. Dr Abaidoo has a PhD student now working on nitrogen fixation in Ghana trees directly as a result of the Darwin project. Dr Blay identified and contributed significantly to the writing of the project proposal currently being evaluated in Brussels. This would be a fully integrated community project involving government, academia and the private sector. Dr Kadio A. Aimé, SODEFOR, Ivory Coast; Dr Charles Anning, FORIG; and Dr Kwaku A. Nkyi, IRNR were involved in the project proposal writing workshop. Dr Aidoo, Institute of Land Management and Administration (ILMAD); Mr Kinsley Boateng, IRNR and Dr Kofi Diaw, Dept of Land Management, KNUST were also consulted.

Discussions were held with Dr Emmanuel Asibey, a highly respected figure in forestry and wildlife who was instrumental in forming CBUD – the Centre for Biodiversity Utilisation and Development within IRNR. CBUD now has a Dutch-funded project on *Tetrapleura tetraptera* – identified as nitrogen-fixing during Darwin project work.

Discussions were also held with Professor Seth Danso, University of Ghana, Legon, for whom a new institute was built on his return to Ghana from the IAEA, Vienna.

There was also significant input (seed and discussions) from Mrs Augustina Gyima, Head, Seed and Tree Improvement Section, FORIG. The project was able to convey to her the information on the recalcitrance of *Albizia* seed.

Discussions were also held with: Dr Chris Newell of Twin/Twin Trading which is active in the cocoa industry in Ghana, Dr Roy Fawcett and Dr Julian Evans who completed a DFID project on modelling of agroforestry options for Ghana (Dr Evans is a collaborator on the submitted EU project); staff of the University of Bangor who had an agroforestry project funded by the ICCO (International Coffee and Cocoa Organisation).

9. Monitoring and Evaluation

Full annual reports are valuable for easing the production of final reports.

A major lesson was how much easier it is, particularly for a European woman in Ghana, to operate through an African scientist of status until a functional network is built up. We have found in this, as well as in previous projects, that South – South communications are established more easily than North-South links and should be more encouraged.

10. Darwin Identity

Official Darwin Initiative documents formally recognising Fellows and Scholars would promote (i) more local and national Publicity and (ii) increase pressure on local universities to ensure that students complete on time.

11. Leverage

IRNR contributed the use of an office and the laboratory as well as the salary of Dr Kwame Twum-Ampofo; the university also contributed the salary of Dr Robert Abaidoo. KEFRI, Kenya contributed the time and salary of Dr David Odee, Dr Geoffrey Muluvi and Mr John Ochieng as well as other staff and facilities. All participants used cheap accommodation and did not claim their usual per diem rates. The University of Dundee contributed the salaries of Prof. Sprent and Ms Shona McInroy as well as used equipment such as a photomicroscope. Dr Joan Sutherland contributed significant unpaid time during and since the end of the project to try to capture further funds.

12. Sustainability and Legacy

The links formed are likely to endure as is the scientific information gathered through the continued teaching and contributing to policy making of the principal collaborators. The legacy could have been improved by completion and distribution of

the training manual. It is hoped that this will be completed with input from other collaborators.

13. Value for money

In spite of the problems, and failures (due in part to over ambition in the beginning), there were sufficient outputs that the project still represented good value for money.

Author: Dr Joan M. Sutherland, Oct. 19th 2002.