Land Snails as Models for Biodiversity Assessment in Sri Lanka

Final Report
March 2006

Contents

Darwin Initiative

Final Report

1. Darwin Project Information

Project Reference No.	E1 DPO 1 (ex 08-214)
Project title	Land snails as models for biodiversity assessment in Sri Lanka
Country	Sri Lanka
UK Contractor	The Natural History Museum (NHM)
Partner Organisation (s)	The Wildlife Heritage Trust Sri Lanka (WHT). (original partner: Ministry of Environment & Natural Resources (SLMoE), Sri Lanka)
Darwin Grant Value	
Start/End date	1.12.2003 – 30.11.2005
Project website	www.nhm.ac.uk/tropicalsnails
Author(s), date	Fred Naggs 24.3.2006

2. Project Background/Rationale

Land snails as models for biodiversity assessment in Sri Lanka sought to build on the work of our previous project, *Land snail diversity in Sri Lanka* (08-214), as a leading example for other taxonomic groups in Sri Lanka and as a regional model for land snail work. The main objectives were to revise the snail fauna, describe newly discovered species, investigate relationships, snail community structure, the impact of forest fragmentation on survivorship, threat status, and conservation priorities. In addition to snail based project outputs we were to work with our project partner in producing a book reviewing biodiversity research in Sri Lanka. At the invitation of the newly elected government of the United National Party we planned to make a significant contribution to the development of a National Biodiversity Authority under a new Biodiversity Act of the Sri Lankan Parliament, and the establishment of a National Rainforest and Biodiversity Institute. The act was drafted by our project partner, Rohan Pethiyagoda, then Advisor to the Minister of Environment.

3. Project Summary

The project logical framework is shown in appendix V. The purpose of the project was to provide a leading example of post-survey taxonomic revision and analysis with wide dissemination of the results.

The project was set in the context of there being a Sri Lankan government administration actively pursuing the rapid development of biodiversity capacity and research activity, in which we expected to play a significant role. With an unexpected change in the Sri Lankan government, this situation changed completely as recorded in our report dated 17th December 2004 and in sections 8 and 13 of this report. The

position was discussed with the Darwin Secretariat in April 2004. It was clear that our, and our project partner's vision of contributing to the development of Sri Lankan biodiversity work as a leading regional example would not be realized. As this was an important aspect for project legacy plans, a new priority was to develop a legacy outside of Sri Lanka.

However, with the single exception of producing a revised compact disc, for reasons explained under Training in Section 4, page 5, we achieved all of the immediate project objectives:

- Taxonomic and systematic revisions with descriptions of new species
- Advanced training and research experience for Dinarzarde Raheem, the 1999-2002 Sri Lankan project manager.
- Training and work experience in electronic media communication for Hasantha Sanjeewa.
- At least five research papers on the following subject areas: taxonomy and systematics, distribution and conservation.
- Expansion of the interactive CD-ROM guide
- A new field guide structured to show species associated with different habitat types and including pest and exotic species.
- Provision of an IUCN Red List evaluation of the Sri Lankan land snails.
- An assessment of the distribution of land snail diversity in Sri Lanka and of key areas for conservation.
- Promotion of research into Sri Lankan biota.

The research output was considerably greater than anticipated and the project had a regional impact that promises a significant future legacy in South and Southeast Asia. The coloured guide to snails associated with different habitats was published and added to our website. A version of the compact disc was added to our website but the updated version is behind schedule.

As set out in Appendix I, Articles of the CBD that best describe the project are Articles 7, 12 and 13.

Our projected timetable anticipated that the project could start at the beginning of October but the grant approval process resulted in a December 2003 start date when Fred Naggs was away on fieldwork and he could not commence work on the project until January 2004. The Darwin Secretariat is aware of a three-month delay in our projected outputs.

4. Scientific, Training, and Technical Assessment

Research

In addition to research on snails, our objective was to support work on other groups. We worked with our partner in producing the book *Contributions to biodiversity exploration and research in Sri Lanka,* which was published as supplement 12 of the *Raffles Bulletin of Zoology* (2005) A copy was sent to ECTF in October 2005 and all of the contributed papers can be viewed at *http://rmbr.nus.edu.sg/rbz/biblio/#s12.* Seventeen of the papers were by project partners including 'The Darwin Initiative project on Sri Lankan land snails: patterns of diversity in Sri Lankan forests'.

NHM and project partners published 'Local endemism within the Western Ghats-Sri Lanka biodiversity hotspot' followed by 'Biodiversity in Sri Lanka and the Western Ghats' in the high impact journal *Science*. These papers demonstrated that several Sri

Lankan groups contain ancient clades and concluded that Sri Lanka contains a significant reservoir of these ancient lineages of considerable conservation significance. The results of our work on Sri Lankan snail faunal origins were included in this assessment and subsequently published in *Records of the Western Australian Museum.* This latter paper was presented at the World Congress of Malacology where Fred Naggs was an invited speaker. This meeting, together with the papers in *Science,* were particularly helpful in raising the project's international profile. Our Sri Lankan samples made an important contribution to the historical biogeographical interpretation of the evolutionary relationships in pulmonate land snails that will be published in the next issue, volume 87, of the *Biological Journal of the Linnean Society.* We provided a case study on the lack of information prior to our projects having allowed slug and snail pests to become established in Sri Lanka published by BioNET-INTERNATIONAL.

Summary of key research findings

In 'Evolutionary relationships among the Pulmonate land snails and slugs' (In Press. *Biological Journal of the Linnean Society*) we present the relationships of pulmonate land snails based on a rDNA molecular tree. The tree confirms the basal placement of Sri Lankan Acavidae and Corillidae, which is consistent with their having a Mesozoic origin and being ancient relicts of a Gondwanan or even Pangaean biota. Support for this hypothesis is found in a small and very patchy fossil record. The Mesozoic fossil record of snails from the Deccan plate consists of a few shells that appear to correspond with modern Sri Lankan *Corilla*. Interestingly, these fossil land snails are known only from marine deposits where they are mixed with a shallow water marine fauna. This made sense in the light of our post-tsunami observations of the obliteration of coastal lowland snail faunas and of the large number of land snail shells washed out to sea described in 'Some observations on Sri Lankan snails including the impact of the Indian Ocean tsunami on lowland snail faunas and its importance as a major fossilisation event'. In calculations based on the rate of movement of the Deccan plate through the Mesozoic we demonstrated that major tsunami comparable to that of December 2004 would have occurred at frequent intervals and been a major selective force on the evolution of terrestrial coastal biotas in the region. The Mesozoic relict land-snail fauna is much reduced in India compared with that of Sri Lanka and we suggest that this may have prevailed since the massive Deccan Trap lava flows around the K/T boundary obliterated much of the endemic Gondwanan fauna in India. Geological evidence suggests that Sri Lanka may have acted as a biotic refuge; it was smaller at the KT boundary than the current island, was separated from India by a wider sea channel and the lava flows did not reach it. We discuss this in detail in our *Records of the Western Australian Museum* paper 'Sri Lankan snail diversity: faunal origins and future prospects' where we also noted that the invasive slugs and most of the invasive snails appear to have evolved in the Eocene of northern Europe. These groups are thought to have lived at high altitude in a moderate to cool climate at a time when northern lowlands had a 'tropical' climate and a tropical biota, including the land snail component. This tropical component largely died out in northern Europe with the much cooler climates that arrived at the Eocene/Oligocene boundary. The snail fauna, from what had been cool montane climates, is then thought to have spread to lowland habitats, which it has occupied ever since, shifting altitudinally and latitudinally in response to climate change. Thus, by occupying high altitude, cool climates in the tropics, pest components of the European fauna are exploiting a habitat that they evolved in during the Eocene and this may have contributed to their rapid success as tropical montane colonisers.

A revision of the Sri Lankan endemic genus *Ratnadvipia* has been published in *Systematics and Biodiversity.* A taxonomic review of cyclophorid prosobranchs and papers on two pulmonate groups are in preparation. Manuscripts of a revised annotated species list and of IUCN evaluations are ready for publication (Appendix VI, p.24). *An illustrated guide to the land snails of Sri Lankan natural forest and cultivated*

habitats summarises many of our findings on Sri Lanka's major land snail communities: Lowland rainforest, submontane/montane rainforest, moist monsoon forest, dry monsoon forest and cultivated habitats. This is available on our website and printed copies will be distributed in April 2006.

Our partners at WHT have been very active in publishing research, mostly on amphibians, fish and Crustacea, with additional contributions from NHM herpetologists on caecilians, culminating in *Contributions to biodiversity exploration and research in Sri Lanka*, as listed in Appendix III. The recognition of over 140 species of frogs for Sri Lanka is particularly noteworthy. The NHM contribution to amphibian work came directly through the Darwin project and although most of this non-molluscan work was undertaken independently of the Darwin project, the interaction was synergistic and fulfilled our wider objectives of interacting with and facilitating co-operation.

Our research findings are extensive and varied. The taxonomic work has demonstrated that although the fauna is related to that of the Western Ghats, Sri Lanka's fauna is a local hotspot of global significance in its own right. We have built on the taxonomic foundation of our work in ecological investigations, phylogenetic studies and historical biogeographical interpretations that together have contributed to proposals for a conservation strategy.

Work in progress

Although our taxonomic revisionary work was carried out early in the project and was the basis for our ecological investigations, phylogenetic studies, historical biogeographical work and identification of conservation strategies, we prioritised publication of analytical work over the publication of taxonomic papers. This was because of the need to establish new legacy objectives: we needed to achieve an early project impact that publication of taxonomic work alone might not have provided. We are currently working on additional taxonomic papers for early publication.

Manuscripts close to submission to journals and additional papers in preparation are listed in Appendix VI, p.24. Hardcopies and pdf files of these on compact disc are being sent with the printed copy of this report.

In 'A revised annotated list for Sri Lankan land snails' we summarise the taxonomic and nomenclatural status of all of the described species and in 'A Preliminary Red List for the Sri Lankan Land-snail Fauna' we provide the IUCN species status assessment. 'Some New Cyclophorid Land Snails from Sri Lanka' provides descriptions of new species of *Theobaldius* and *Lagochilus.*

Dinarzarde Raheem has four papers from her PhD thesis almost ready for publication. In 'History of rainforest fragmentation and degradation' she has carried out a detailed study that provides an essential background for understanding the current status of, and future prospects for, Sri Lanka's fragmented forests. These fragments occupy a total combined area less than half that of Greater London yet contain a snail fauna comparable in numbers to that of the whole of North-west Europe. We suggest that establishment of the pattern of species distributions and high diversity and endemism through time is directly linked to the highly variable topography of South-western Sri Lanka and hypothesise that the series of hills and valleys have allowed minor shifts in distribution to accommodate to past climate change. We conclude that a high priority for medium to long-term conservation is to restore connections between forest fragments.

'Land-snail species composition of fragmented lowland rainforest' demonstrates the short-term resilience of land snail faunal composition within forest fragments of different size and history of fragmentation. This differs from reported findings for other invertebrate groups.

‘Land-snail communities of fragmented lowland rainforest and village home gardens’ demonstrates the importance of traditional so called ‘home gardens’ as a part of the transformed mosaic of habitats that retain some components of the forest biota and are therefore of conservation importance.

‘Rarity in a fragmented landscape’ shows that a large proportion of the snail fauna consists of species with very restricted ranges. With rainforest loss having been in the order of 90% it is therefore inevitable that extinctions have occurred.

Training

Dinarzarde Raheem was able to register for a PhD at the University of Cambridge, her registration fees being waived for the two years of overseas fieldwork. The past two years part time registration was covered by a grant from the Stanley Gardiner Award, Department of Zoology, University of Cambridge, an award from the Natural History Museum and a gift from Sir Christopher Ondaatje. As summarised above and detailed in Appendix VI, page 24, the PhD was awarded on the basis of research papers, which form part of our project research output and will be submitted to peer reviewed international journals.

Fred Naggs continues to supervise Kithsiri Ranawana’s PhD at the University of Peradeniya and Lalith Karyawasam’s MPhil at Kelaniya University. Kithsiri Ranawana is a lecturer in the Zooloogy Department at Peradeniya University and Lalith Karyawasam is a curator at the National Museum, Colombo.

With additional support on computing from Jim Chimonides and image work from Harry Taylor, Hasantha Lokugamage worked with us for six months and received training in computer data management, image processing and literature research. Jim Chimonides is collating the data, with support from a volunteer worker, to incorporate information onto an updated compact disc. However, after suffering a heart attack, Jim’s input is behind schedule and publication of a revised faunal information resource on compact disc has been delayed.

5. Project Impacts

Our aim of being significant players with our project partner in a national biodiversity initiative has been successful in that, together with our partners, we have been instrumental in promoting a major increase in biodiversity activity in Sri Lanka. This is evidenced by the large number of publications, particularly in *Contributions to biodiversity exploration and research in Sri Lanka*. However, this level of activity is unlikely to be sustained without political support and the Biodiversity Act, Biodiversity Authority and Biodiversity and Rainforest Institute initiatives are no longer on the political agenda. Major constraints for future co-operation are the restrictions imposed on access to specimens. Despite our efforts, TV programme, numerous newspaper articles, exhibitions, seminars, public lectures and presentations, there is a widespread belief in Sri Lanka among the general public, academia and politicians that conservation simply means keeping people out, especially foreigners. The message that in order to conserve a biota we need to know what is present, to understand how it functions and came to exist where it does and to anticipate how environmental change will inevitable pose threats to its survival, has not yet been widely accepted. In the 11th December 2005 Sunday *Leader* newspaper there was an article giving the top priority of the new Minister of Environment as: "Preventing the export of biodiversity for research".

Nevertheless, it is possible to move beyond the still current need for research in specimen based alpha taxonomy and we have proposals for implementing conservation

measures in Sri Lanka based on our core findings. The following is quoted from our project partner Rohan Pethiyagoda, Deputy Chair, Species Survival Commission, Consultant to the Sri Lankan Ministry of Environment and Managing Trustee of The Wildlife Heritage Trust of Sri Lanka:

> Exploration of the Sri Lankan land snails in the course of the past decade by Dinarzarde Raheem and yourself has resulted in several important discoveries, not least the extraordinary diversity and endemism of this fauna, and a large number of new taxa. Thanks to your work, we now realise that habitat fragmentation represents arguably the most important threat to Sri Lanka's snail fauna (and indeed, to this island's biodiversity as a whole); and that a large number of alien invasive snail species have become established in disturbed habitats.
>
> In this context, I am pleased to note that the new project aims to monitor snail faunal recovery also in our forest restoration site at Agrapatana, in Sri Lanka's central mountains. Especially given that this site is an 'island' narrowly separated from the relatively undisturbed Agra-Bopat cloud forest only by an expanse of tea, monitoring of the snail fauna against other restoration parameters such as shade, soil quality, successional vegetation and colonisation by other species will be of obvious relevance to the national conservation and management planning process.
>
> Given that Sri Lanka's remaining rainforests are now reduced to less than 1,000 km^2 (five percent of their pre-colonial extent), and that even this persists only in the form of more than 100 fragments, knowledge of how to conserve biodiversity within a fragmented landscape is of immediate relevance and importance. We also need urgently to know how best to restore disturbed habitats so as to establish viable conservation corridors between forest fragments.
>
> Perhaps most important of all is the transfer of capacity to local individuals and institutions for monitoring and maintaining biodiversity: it is refreshing to note the priority you have given to this in your project proposal, using land snails as a vehicle. Your earlier studies have shown that land snails represent reliable and repeatable biodiversity indicators: trained local personnel will be invaluable in making assessments that flow from this.
>
> Obviously, it is both necessary and appropriate that this project engages not just with WHT but the wider community of biodiversity conservation practitioners within the government, academic and NGO communities. I would be happy to help facilitate this engagement, perhaps using the National Experts' Committee on Biodiversity (of which I am a member) as a forum. I would also be happy to brief the relevant staff of the Biodiversity Secretariat (which is the CBD and GEF focal point) of the Ministry of Environment (with whom I work very closely) on your project so as to obtain their active cooperation and support.

The main impact of our project has been international and it extends beyond our original objectives. Considerable interest has ranged from South and Southeast Asia to South America, with research groups and institutions wishing to collaborate with us on similar projects. This is extremely encouraging because there is an urgent need to build global expertise on a group of organisms that offer enormous potential for addressing key issues on biodiversity and biodiversity loss.

After six months at the NHM, Hasantha Lokugamage returned to his position with Jetwing Ecological Tours, where he is helping to develop ecotourism. Dinarzarde Raheem remains committed to biodiversity work, particularly in Sri Lanka, but the current situation does not allow her to work effectively if based in Sri Lanka. Dinarzarde continues to be based at the NHM in London where she plans to continue collaborating on snail biodiversity work with Fred Naggs.

6. Project Outputs

Project outputs are detailed in Appendix II, page 15. *An Illustrated Guide to the Land snails of Sri Lankan Natural Forests* and a total of 21 papers have been published in international peer reviewed journals by NHM and WHT workers, a further seven snail manuscripts are near completion with additional papers and compact disc in preparation Appendix VI, p.24, several more are planned. The illustrated guide will be distributed to schools, colleges, universities, environmental groups, natural history societies, government agencies and interested individuals throughout Sri Lanka. Subject to publisher's consent, which we have for most publications, published outputs are available as pdf files on our website: www.nhm.ac.uk/tropicalsnails.

As detailed in Section 4 under Training, page 6, Dinarzarde Raheem obtained a PhD from the University of Cambridge and Fred Naggs continues to supervise Kithsiri Ranawana's PhD at the University of Peradeniya and Lalith Karyawasam's MPhil at Kelaniya University.

Information has been widely disseminated in Sri Lanka by presenting seminars and extensive press coverage. Fred Naggs gave a presentation at the national workshop on current status of the Sri Lankan invertebrate fauna in August 2004, which was organised by SLMoE and IUCN. Dinarzarde Raheem presented seminars to the Sri Lankan Natural history Society and to the Wildlife and Nature protection Society in December 2004.

Presentations and seminars were given at the Department of Zoology, University of Cambridge, The Malacological Society of London meetings, Department of Zoology, NHM, Department of Zoology, Chulalongkorn University, Bangkok, Department of Zoology, University of Yangon, Mysore University at Hassan, The Western Australian Museum and The University of Western Australia.

Rohan Pethiyagoda, Managing Trustee of the Sri Lankan Wildlife heritage Trust, our project partner, has a very high profile in Sri Lanka through the media, government and academia and through international conservation agencies, such as his position as Deputy Chair of the Species Survival Commission. We plan to continue working with the WHT on a forest restoration site, using snails as indicators of faunal diversity recovery. Our project findings give a high priority towards establishing forest corridors, which are considered essential for the long-term survival of this unique fauna. We are currently seeking funding to support this work.

7. Project Expenditure

	Project funding	Project expenditure	balance
Salaries			
travel			
printing			
subsistence			
work permits			
overheads			
Audit fee			**approved by Sarah Moon 09-03-06**
totals			

8. Project Operation and Partnerships

Rohan Pethiyagoda was the main project partner, initially in his capacity as advisor to the Minister, SLMoE but, following the change in government, primarily in his role as Managing Trustee of the Sri Lankan Wildlife Heritage Trust. Rohan's government responsibilities were drastically reduced but he continues as a consultant to the Ministry and has daily contact with the National Biodiversity Strategy Office. Rohan played the major role in undertaking a wide range of research in vertebrate groups and in promoting and organising the review of Sri Lankan biodiversity research published in *Contributions to biodiversity exploration and research in Sri Lanka.*

The project was set in the context of there being a newly elected Sri Lankan United National Party (UNP) government that placed a high priority on international cooperation on biodiversity and which, in support of this, sought a formal agreement on biodiversity with the UK. Iinstitutional capacity for addressing biodiversity issues was recognised to be totally inadequate by the UNP and the Ministry of Environment (SLMoE) was actively engaged in setting up a new National Biodiversity Authority (NBA) and National Biodiversity and Rainforest Institute (NBRI). A biotic survey programme was to be launched early in 2004 with initial surveys in seven Protected Areas (PA) that had never been systematically surveyed for biodiversity. In addition to survey reports, these surveys, to be funded by the Asian Development Bank (ADB), Global Environment Facility (GEF) and the Netherlands government, would have established core collections of reference material and data for the NBRI. The original Darwin project provided a leading example for this initiative and the aim of the follow-up project was to continue to provide a leading role for land snails by working-up the discoveries from the original survey-based project. A major priority for the SLMoE was to have a sound taxonomic base for its biodiversity programme. It was intended that the snail project would continue to play a leading role by providing a model for other groups covered in the PA surveys and provide leverage for attracting funding for taxonomic revisions of other groups.

This situation completely changed following the elections held in Sri Lanka on 2nd April 2004 when the UNP lost the election to an alliance called the United Peoples' Freedom Alliance (UPFA). The change in government was unexpected because the UNP held a parliamentary majority and an expected 3-year term of office. However, the President exercised her executive powers to dissolve parliament and call national elections. The UPFA ended any interest in international cooperation in biodiversity. A new UPFA President was elected in November 2005 and the current government, an alliance that includes the nationalist Sinhala Janatha Vimukthi Peramuna party (JVP) remains hostile to international cooperation in biodiversity. Although establishment of the National Biodiversity Authority and Rainforest & Biodiversity Institute had cross party support prior to the 2004 election they have no prospect of being established in the foreseeable future. As mentioned on page 6, an indication of the current government's position is indicated in the *Leader* newspaper of 11th December 2005. An article gives the top priority of the new Minister of Environment as 'preventing the export of biodiversity for research'.

It thus became very clear at an early stage of the project that the expectations we had of rapid development of institutional biodiversity capacity in Sri Lanka would not be realised. In addition, access was restricted to the collections we had deposited in the Sri Lankan Department of National Museums. We were also required to return specimens we had on loan. The loan of additional material became impossible and even the loan of specimens of *Lissachatina fulica,* an invasive pest species from East Africa was refused. Fortunately for the project, the Department of National Museums prior to 2004 had donated some specimen collections from our previous project to the Natural History Museum.

This situation was recorded in our Half Year Report dated 17th December 2004 and the position was discussed with the Darwin Secretariat in April 2004. The position of our project partner, Rohan Pethiyagoda, as Advisor to the Sri Lankan Minister of Environment was a political appointment and this ended following the suspension of the Sri Lankan Parliament in November 2003. Our partnership with Rohan Pethiyagoda continued in has capacity as Managing Trustee of the Sri Lankan Wildlife Heritage Trust, Rohan is also Deputy Chairperson of the Species Survival Commission and is now also a consultant to the Sri Lankan Department of Environment.

Hasantha Lokugamage made the planned six-month visit in 2004 as discussed under Training in section 4, page 5.

9. Monitoring and Evaluation, Lesson learning

The post-project objectives were focussed on producing outputs from specimens and data collected in the original project with a small, highly motivated team such that progress on our logframe was transparently evident. There were two sets of outputs from this project. Rohan Pethiyagoda directed outputs from the WHT. We were in regular contact; Rohan also made frequent externally funded visits to London and Fred Naggs made one externally funded visit to the WHT research station at Agrapatna. Based on project data and a small subset of specimens from the project housed at the NHM, Dinarzarde Raheem and Fred Naggs worked on outputs with colleagues at the NHM. The primary result is research papers, a conservation strategy, and the potential for expanding this work internationally.

The problems for the project were the constraints imposed by changes in the political scene, the resultant need to rethink project legacy and the need to prioritise outputs that would deliver significant and timely impact as discussed under Work in progress, page 5.

10. Actions taken in response to annual report reviews (if applicable)

In the review of our March 2005 Annual Report we were asked to provide the manuscript or a summary of our proposed paper ‘High diversity and high extinction rates: how can land snails play a role in assessing conservation priorities’. This proposed paper was not one of our original objectives and we are currently concentrating on submitting papers listed in Appendix VI before completing it. The idea for this paper followed from Fred Naggs being invited to participate in the IUCN Sampled Red List Index Species Selection Workshop held at the Zoological Society of London in March 2005. This IUCN initiative is part of the response to amass data for evaluating the extent to which the 2002 World Summit on Sustainable Development 2010 commitment is achieved. At the Workshop Fred Naggs presented the case that although land snails have undergone more recorded extinctions than all other animal groups combined, and were therefore potentially a key group for determining extinction rates, there are currently too few snail workers to provide global monitoring of land snails. In addition, he considered that the IUCN criteria possibly presented problems of scale because many tropical snail species have very restricted natural ranges, which automatically qualify them as threatened or endangered under IUCN criteria. The proposed paper will address these issues but an important point will be to highlight the need for extending training and access to resources in countries rich in land snail diversity as exemplified by the support that the Darwin Initiative have given to our snail projects.

11. Darwin Identity

All of our papers have given clear acknowledgement to the Darwin Initiative in the

following journals*: Science, Systematics and Biodiversity, Biological Journal of the Linnean Society, Records of the Western Australia Museum, The Raffles Bulletin of Zoology, The Malacologist, Bulletin of the Malacological Society of London*. In addition, details of the Darwin Initiative and the Darwin Initiative logo are given in *An illustrated guide to the land snails of Sri Lankan natural forest and cultivated habitats* and the Darwin Initiative logo appears on our article in *The Malacologist.* The logo appears on the title and acknowledgements in our slide and power point presentations and posters, on our website, and has been included in some of the Sri Lankan press coverage. We have worked with several universities, government agencies and NGOs but our Darwin work in Sri Lanka is recognised to have a distinct identity. We take every opportunity to promote and explain the Darwin initiative and it is now widely known in Sri Lanka.

12. Leverage

Funding was in place for the National Biodiversity and Rainforest Institute from the Asian Development Bank (ADB), Global Environment Facility (GEF) and the Netherlands government but following the change in Sri Lankan government the project was abandoned. In the immediate future biodiversity work in Sri Lanka, especially that involving collaboration with overseas workers, is likely to contract.

However, rather than just being seen as a leading example of a post survey project for Sri Lanka the project has attracted international interest and we have received many requests to form similar collaborative programmes. External funding was obtained to expand our work in South Asia and into Southeast Asia and Fred Naggs visited India, Thailand and Cambodia and hosted externally funded visits from Indian, Thai and Nepalese workers.

Dinarzarde Raheem was awarded £7,000 from the John Stanley Gardiner Fund, Department of Zoology, University of Cambridge and together with an award of £5,000 from the NHM and £1,000 from Sir Christopher Ondaatje, this allowed her to submit selected papers from her research for a PhD at the University of Cambridge.

A large number of funding agencies supported work published in *The Raffles Bulletin of Zoology* Supplement 12 as cited in the acknowledgements of each paper.

13. Sustainability and Legacy

We consider long-term impact to be our overriding objective. Our work has received international recognition to an extent that allows us to think internationally with respect to sustainability and legacy. As discussed above, a change in government had a direct and immediate affect on project legacy prospects in Sri Lanka. We proceeded to engage in a considerable amount of groundwork towards establishing a new project legacy, following up in particular on direct approaches from potential partners throughout South and Southeast Asia. Fred Naggs was an invited speaker at the 2004 World Congress of Malacology in Perth, Australia, where a number of contacts were made and we have been collaborating with the Mollusca Research Group at Chulalongkorn University, Bangkok, for some years. Our experience led us to conclude that the main priority was to identify a well-established group, of sufficient size such that the partnership would not be entirely dependent on one or a few individuals and could offer a stable and robust, long-term partnership. Our strategy is to work with the Mollusca Research Group at Chulalongkorn University and to help establish them as a regional centre of research and expertise. We could then set up satellite projects, including those in ‘high risk’ countries where successful project outcomes cannot be guaranteed. We have applied for Darwin Initiative funding for this proposed project.

14. Value for money

We have achieved significant output in terms of publications, communication through media coverage, our website, seminars, presentations to research groups and a major international meeting. Our partner organisation in Sri Lanka is enacting our conservation strategy recommendations and has purchased an abandoned tea estate for a forest restoration project in which we plan to use snails for monitoring faunal richness.

Our project has achieved international recognition as evidenced by, for example, the number of approaches we have received from scientists wishing to collaborate with them in their countries on similar projects.

15. 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	5	Develop national strategies that integrate conservation and sustainable use.
7. Identification and Monitoring	45	Identify and monitor components of biological diversity, particularly those requiring urgent conservation; identify processes and activities that have adverse effects; maintain and organise relevant data.
8. In-situ Conservation		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		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		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		Establish economically and socially sound incentives to conserve and promote sustainable use of biological diversity.

12. Research and Training	45	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		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		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		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		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		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**

16. 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	1
1b	Number of PhD qualifications obtained	1
2	Number of Masters qualifications obtained	
3	Number of other qualifications obtained	
4a	Number of undergraduate students receiving training	
4b	Number of training weeks provided to undergraduate students	
4c	Number of postgraduate students receiving training (not 1-3 above)	1
4d	Number of training weeks for postgraduate students	
5	Number of people receiving other forms of **long-term** (>1yr) training not leading to formal qualification(i.e not categories 1-4 above)	
6a	Number of people receiving other forms of **short-term** education/training (i.e not categories 1-5 above)	
6b	Number of training weeks not leading to formal qualification	
7	Number of types of training materials produced for use by host country(s)	1
Research Outputs		
8	Number of weeks spent by UK project staff on project work in host country(s)	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)	
10	Number of formal documents produced to assist work related to species identification, classification and recording.	2
11a	Number of papers published or accepted for publication in peer reviewed journals	21
11b	Number of papers published or accepted for publication elsewhere	
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country	1
12b	Number of computer-based databases enhanced (containing species/genetic information) and handed over to host country	
13a	Number of species reference collections established and handed over to host country(s)	
13b	Number of species reference collections enhanced and handed over to host country(s)	

Dissemination Outputs		
14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	
14b	Number of conferences/seminars/ workshops **attended** at which findings from Darwin project work will be presented/ disseminated.	8
15a	Number of national press releases or publicity articles in host country(s)	6 published
15b	Number of local press releases or publicity articles in host country(s)	
15c	Number of national press releases or publicity articles in UK	1
15d	Number of local press releases or publicity articles in UK	
16a	Number of issues of newsletters produced in the host country(s)	
16b	Estimated circulation of each newsletter in the host country(s)	
16c	Estimated circulation of each newsletter in the UK	
17a	Number of dissemination networks established	1
17b	Number of dissemination networks enhanced or extended	
18a	Number of national TV programmes/features in host country(s)	
18b	Number of national TV programme/features in the UK	
18c	Number of local TV programme/features in host country	
18d	Number of local TV programme features in the UK	
19a	Number of national radio interviews/features in host country(s)	
19b	Number of national radio interviews/features in the UK	
19c	Number of local radio interviews/features in host country (s)	
19d	Number of local radio interviews/features in the UK	
Physical Outputs		
20	Estimated value (£s) of physical assets handed over to host country(s)	
21	Number of permanent educational/training/research facilities or organisation established	
22	Number of permanent field plots established	1
23	Value of additional resources raised for project	£16,000

17. 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

All of the following papers are by project personnel (NHM and/or WHT) or include project personnel among the authors.

Type * (e.g. journals, manual, CDs)	**Detail** (title, author, year)	**Publishers** (name, city)	**Available from** (e.g. contact address, website)	**Cost £**
Journal	Evolutionary relationships among the Pulmonate land snails and slugs. Wade,C., Mordan.P.B. Naggs, F. 2006.	*Biological Journal of the Linnean Society.* **87** – in press	Linnean Society, London	
Laminated guide	*An illustrated guide to the land snails of Sri Lankan natural forest and cultivated habitats.* Raheem, D. & Naggs, F. 2006	Natural History Museum, London Currently being printed in Singapore	www.nhm.ac.uk/tropicalsnails Printed copies free in Sri Lanka from: Wildlife Heritage Trust 95 Cotta Road Colombo 8 NHM shop from May 2006	free £3.00
Journal	The Sri Lankan endemic semi-slug *Ratnadvipia* (Limacoidea: Ariophantidae. Raheem, D & Naggs, F. 2006.	*Systematics & Biodiversity* 4: 99-126. Cambridge University Press	www.nhm.ac.uk/tropicalsnails also CUP Website	free
Journal	Some observations on Sri Lankan land snails including the impact of the Indian Ocean tsunami on lowland snail faunas and its importance as a major fossilisation event. Naggs, F., Raheem, D., and Platts, E. 2005.	*The Malacologist*	www.nhm.ac.uk/tropicalsnails Also at Malacological Society of London: http://www.malacsoc.org.uk/The_Malacologist/BULL45/tsunami.htm http://www.malacsoc.org.uk/The_Malacologist/BULL45/deccanplate.htm	free

Journal	Sri Lankan snail diversity: faunal origins and future prospects. Naggs, F., & Raheem, D. 2005	*Records of the Western Australian Museum* No. 68: 11-29.	www.nhm.ac.uk/tropical snails	free
Journal	Exploring Sri Lanka's biodiversity. Pethiyagoda, R. 2005.	*The Raffles Bulletin of Zoology* Supplement 12: 1-4.	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz001-004.pdf	free
Journal	The Darwin Initiative project on Sri Lankan land snails: patterns of diversity in Sri Lankan forests. Naggs, F. *et al.*	*The Raffles Bulletin of Zoology* Supplement 12: 23-29	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz023-029.pdf	free
Journal	*Lancaris,* a new genus of freshwater shrimp from Sri Lanka (Crustacea: Decapoda: Atyidae). Cai, Y., & Bahir, M.M. (WHT). 2005	*The Raffles Bulletin of Zoology* Supplement 12: 39-46	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz039-046.pdf	free
Journal	Descriptions of ten new species of freshwater crabs (Crustacea: Brachyura: Parathelphusidae: *Ceylonthelphusa*, *Mahatha, Perbrinckia*) from Sri Lanka. Bahir, M.M., & Ng, P.K. 2005	*The Raffles Bulletin of Zoology* Supplement 12: 47-75	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz047-075.pdf	free
Journal	A revision of the genus *Oziotelphusa* Müller, 1887 (crustacean: Decapoda: Parathelphusidae), with descriptions of eight new species. Bahir, M.M., & Yeo, D.C.J. 2005	*The Raffles Bulletin of Zoology* Supplement 12: 77-120	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz077-120.pdf	free
Journal	A conservation assessment of the freshwater crabs of Sri Lanka. Bahir, M.M. *et al.* 2005	*The Raffles Bulletin of Zoology* Supplement 12: 121-126	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz121-126.pdf	free
Journal	A review of the barbs of the *Puntius filamentosus* group Teleostei: Cyprinidae) of southern India and Sri Lanka. Pethiyagoda, R., & Kottelat, M. 2005	*The Raffles Bulletin of Zoology* Supplement 12:127-144	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz127-144.pdf	free

Journal	The identity of the South Indian Barb *Puntius mahecola* (Teleostei: Cyprinidae). Pethiyagoda, R., & Kottelat, M. 2005	*The Raffles Bulletin of Zoology* Supplement 12: 145-152.	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz145-152.pdf	free
Journal	Molecular phylogenetics of Sri Lankan *Ichthyophis* (Amphibia: Gymnophiona: Ichthyophiidae), with discovery of a cryptic species. Gower, D *et al.* 2005.	*The Raffles Bulletin of Zoology* Supplement 12: 153-161.	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz153-161.pdf	free
Journal	The Sri Lankan shrub-frogs of the genus *Philautus* Gistel, 1848 (Ranidae: Rhacophorinae), with descriptions of 27 new species. Manamendra-Arachchi, K., & Pethiyagoda, R. 2005.	*The Raffles Bulletin of Zoology* Supplement 12: 163-303.	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz163-303.pdf	free
Journal	Description of eight new species of shrub frogs (Ranidae: Rhacophorinae: *Philautus*) from Sri Lanka. Meegaskumbura, M., & Manamendra-Arachchi, K. 2005	*The Raffles Bulletin of Zoology* Supplement 12: 305-338	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz305-338.pdf	free
Journal	Reproduction and terrestrial direct development in Sri Lankan shrub frogs (Ranidae: Rhacophorinae: *Philautus*). Bahir, M.M. *et al.* 2005	*The Raffles Bulletin of Zoology* Supplement 12: 339-350	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz339-350.pdf	free
Journal	Description of five new species of *Cyrtodactylus* (Reptilia: Gekkonidae) from Sri Lanka. Batuwita, S., & Bahir, M.M. 2005	*The Raffles Bulletin of Zoology* Supplement 12: 351-380	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz351-380.pdf	free
Journal	*Calotes desilvai,* a new species of agamid lizard from morningside forest, Sri Lanka. Bahir, M.M., & Maduwage., K.P. 2005.	*The Raffles Bulletin of Zoology* Supplement 12: 381-392.	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz381-392.pdf	free
Journal	*Octocryptis nigristigma,* a new species of agamid lizard from Sri Lanka. Bahir, M.M., 7 Silva, A. 2005	*The Raffles Bulletin of Zoology* Supplement 12: 393-406.	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz393-406.pdf	free

Journal	A conservation assessment of the Sri Lankan Agamidae (Reptilia: Sauria). Bahir, M.M., & Surasinghe, T.D.	*The Raffles Bulletin of Zoology* Supplement 12: 407-412.	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz407-412.pdf	free
Journal	A second extinct big cat from the Late quaternary of Sri Lanka. Manamendra-Arachchi *et al.* 2005	*The Raffles Bulletin of Zoology* Supplement 12: 423-434.	http://rmbr.nus.edu.sg/rbz/biblio/s12/s12rbz423-434.pdf	free
Journal	Biodiversity in Sri Lanka and the Western Ghats. Bossuyt, *et al*. 2005	*Science* **308**: 199.	http://www.sciencemag.org/	Order online for $10.0
Journal	Local endemism within the Western Ghats – Sri Lankan biodiversity hotspot. Bossuyt *et al*. 2004.	*Science* **306**: 479-481	http://www.sciencemag.org/	Order online for $10.0
Book & website	Lack of information allows invasion of slug and snail pests in Sri Lanka. Naggs, F. 2004.	Case study 30 in Davies, H, King, N and Smith, R (Eds) *Taxonomy: targeting invasives*	BioNET-INTERNATIONAL. www.bionet-intl.org/case_studies	free

18. Appendix IV: Darwin Contacts

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

Project Title	Land snails as models for biodiversity assessment in Sri Lanka
Ref. No.	**E1 DPO 1 (ex 08-214)**
UK Leader Details	
Name	Fred Naggs
Role within Darwin Project	Project Leader
Address	The Natural History Museum, London SW7 5BD
Phone	
Fax	
Email	
Other UK Contact (if relevant)	
Name	Dinarzarde Raheem
Role within Darwin Project	Researcher
Address	The Natural History Museum, London SW7 5BD
Phone	
Fax	
Email	
Partner 1	
Name	Rohan Pethiyagoda
Organisation	The Wildlife Heritage Trust of Sri Lanka
Role within Darwin Project	Project partner
Address	WHT, 95 Cotta Road, Colombo 8, Sri Lanka
Fax	
Email	
Partner 2 (if relevant)	
Name	
Organisation	
Role within Darwin Project	
Address	
Fax	
Email	

19. Appendix V: LOGICAL FRAMEWORK

Project summary	**Measurable indicators**	**Means of verification**	**Important assumptions**
Goal:			
To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but poor in resources to achieve • the conservation of biological diversity • the sustainable use of its components, and • the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources			
Purpose			
Provide a leading example of post-survey taxonomic revision, new species descriptions and wide dissemination of information for biotic inventories in Sri Lanka	Provide a baseline of land snail species diversity and distributions by: 1. employing the outstanding project leader for two years to work up and publish her discoveries at the NHM 2. employing the best of the project's field/research assistants at the NHM for six months to contribute to the publication of a comprehensive Sri Lankan snail information resource	Publication of results in peer-reviewed journals Publication of comprehensive interactive CD-ROM Publication of user-friendly printed field guide	Sri Lankan project workers will work with Fred Naggs using the unique resources of the NHM to produce a high output of top-quality publications. Future biotic surveys in Sri Lanka will adopt the same pattern of work, with the development of ongoing co-operation with the NHM and other UK institutions and workers
Outputs			
1. taxonomic revisions 2. descriptions of new species 3. evaluation of entire recorded land snail fauna for IUCN red listing 4. publications on distributions 5. major development of CD-ROM 6. user friendly guide	1, 2. publication of taxonomic revision papers and new species descriptions 3. submission of information on extinction threat categories for all of the recorded Sri Lankan snail fauna to IUCN 4. publication of analytical paper(s) on aspects of Sri Lankan land snail distributions 5. addition of new species to CD-ROM, a summary of information for all species, including images of living specimens, habitat views and distribution maps 6. preparation of a user-friendly, laminated folding guide giving common species of different habitat types, including pest species	1, 2, 4. publication of papers in peer-reviewed journals 3. inclusion of Sri Lankan land snail fauna in the next Red List of Threatened Species. 5, 6. publication by Zoology Department of NHM and copies sent to the Darwin Initiative	1, 2, 4. processing of papers and publication can be achieved by journals within the deadline 3. data is processed in time by IUCN for inclusion in the next Red List of threatened Species that is due to be published in 2004. 5, 6. Publication of the CD-ROM and the snail guide can only go ahead after the new taxa have been formally published.
Activities	**Activity Milestones (Summary of Project Implementation Timetable)**		

Anatomical study of Darwin Intiative project specimens focusing on key anatomical features appropriate to systematic level, such as those of the reproductive system for species-level discrimination. Analysing data on distributions. Comparison of material with reference specimens and types in the NHM and, using the NHM literature resources, with published information. Compiling anatomical figures, writing descriptions and information on habitat, distribution and abundance Conducting specialist procedures such as light and electron microscopy to investigate microstructure. Preparing papers for publication. Inputting data to CD-ROM and developing for publication. Producing field guide.	Year 1 submit three papers for publication develop CD-ROM Year 2 submit two papers for publication *complete CD-ROM and field guide and place summary version of CD-ROM on WWW.*

20. Appendix VI: Papers in preparation

Printed copies of the following manuscripts and pdf files on compact disc are provided with the hardcopy of this report sent by post. Manuscripts indicated by* are papers included in the PhD thesis *Land-snail diversity in Sri Lankan rainforest fragments,* which is included with the posted report. All of the following will be submitted for publication in international, peer-reviewed journals.

A revised annotated list for Sri Lankan land snails
A preliminary Red List for the Sri Lankan land-snail fauna
Some new cyclophorid land snails from Sri Lanka
The history of human-induced fragmentation and degradation of rainforests in the southern wet lowlands of Sri Lanka*
Land-snail species composition of fragmented lowland rainforest in Sri Lanka*
Land-snail communities of fragmented lowland rainforest and village home gardens in Sri Lanka*
Rarity in a fragmented lowland rainforest landscape in Sri Lanka*

Papers on the following genera are in preparation: *Leptopoma, Aulopoma, Cyathapoma, Tortulosa, Glessula.*