



Land snail diversity in Sri Lanka

Darwin Initiative Final Report

1st October 1999 – 30th September 2002

1. Darwin Project Information

Project title	Land snail diversity in Sri Lanka
Country	Sri Lanka
Contractor	The Natural History Museum
Project Reference No.	08/214
Grant Value	
Starting/Finishing dates	1 st October 1999 to 30 th September 2002

2. Project Background/Rationale

- The project was based on a programme of land snail faunal surveys throughout Sri Lanka (excluding the war area, which is low-diversity Dry Zone). The main local institutional partners were the Department of National Museums in Colombo and the Department of Zoology, University of Peradeniya.
- Loss of tropical rainforest and its associated biodiversity is considered to be the main cause of the current global biodiversity crisis. Of the global biodiversity hotspots, Sri Lanka is in the highest category of risk as assessed by high human population density.
- Sri Lanka's biota is diverse and highly endemic with a significant component of Gondwanan relicts in the snail fauna. These relict taxa are largely absent from India making the Sri Lankan fauna the most distinctive in South Asia.
- Sri Lanka's biota is continental in origin, as opposed to oceanic with origins based on long-distance dispersal, and possesses a correspondingly broad-based taxonomic diversity. Its relatively small size allows island-wide study as a model investigation of a rich continental fauna.
- Snails are considered to be key indicator species and they play a significant role in nutrient recycling and in soil formation.
- Sri Lankan land snails were known to be diverse and highly endemic and a number of unidentified species were causing severe damage to agriculture and horticulture. Resources and capacity for identifying land snails in Sri Lanka were almost non-existent and very little was known about snail distributions.
- The Natural History Museum (NHM) was approached independently from several sources in Sri Lanka. The initial contact in 1995 was from the Environmental Management in Forestry Developments Project: Conservation Evaluation of Natural Forests in Sri Lanka., a project of the Forest Department Ministry of Lands, Irrigation and Mahaweli Development in association with UNDP, FAO and IUCN – WCU. Land snails were recognised as a valuable indicator species in the programme and help was sought with their identification. In 1996 The Department of Zoology, University of Colombo contacted the NHM for help in identifying molluscs, which resulted in the 1996 joint NHM/University of Colombo workshop

on the taxonomy and identification of Sri Lankan Mollusca, held in Colombo. This was followed by approaches from the National Education Commission and the Zoological Survey Committee of the Natural Resources, Energy and Science Authority of Sri Lanka. There was a clear need for the project but lack of institutional capacity and responsibility for addressing such biodiversity issues in Sri Lanka.

3. Project Summary

Revised December 1999

- To carry out molluscan collecting surveys, to provide distributional information and to establish reference collections and computerised databases at the Department of National Museums, Colombo and the University of Peradeniya.
- Preparation of a CD Rom guide and information resource on the Sri Lankan snail fauna based on a review of the literature and including figures of all taxa and types where available. (enhanced objective but development suspended as of April 2001)
- Preparation of a field guide
- Preparation of a guide to the synanthropic/pest species
- Training of personnel to: (i) identify material (ii) conduct surveys (iii) undertake research projects
- Run an exhibition on the project at the National Museum, Colombo and at the Postgraduate Institute of Science, Peradeniya, Kandy. (added 2000/2001)
- The following Articles under the Convention on Biological Diversity (CBD) best describe the project: Articles 6, 7, 12, 13, 17.

An extensive survey programme provided in-country reference collections and data for computerised databases at the Department of National Museums and the University of Peradeniya. The illustrated species list based on Natural History Museum resources was published as a CD Rom and book in 2000. This was a major transfer of an information resource. An interactive version will be published in spring 2003. The CD Rom will be developed as an enhanced product and, in addition to extensive primary and revisionary literature, will incorporate the project's field and research findings. The field guide was published in October 2002 and the guide to synanthropic/ pest species is in press. Funding has been obtained from the World Bank to publish Tamil and Sinhala versions of the field guide in spring 2003. These will be the basis of a World Wide Web guide offered in English, Tamil and Sinhala. World Bank funding also provides for the publication of posters for identifying pest species. Training was provided for undergraduates and the projects of two PhD students and one MPhil student continue to be supervised. Two successful project exhibitions were mounted: Colombo in February 2001 and Kandy in September 2002. Most importantly, the project made a significant contribution to achieving government recognition of the need for an effective institutional base for systematics and taxonomy.

4. Scientific, Training, and Technical Assessment

Research Projects

The survey programme

An island-wide survey of all forest types was conducted in the first year of the project (Figure 1 and appendix V). This was followed by more intensive surveys in the lowland wet forests, which are confined to South-western Sri Lanka, and the Knuckles range of hills in the Central Highlands

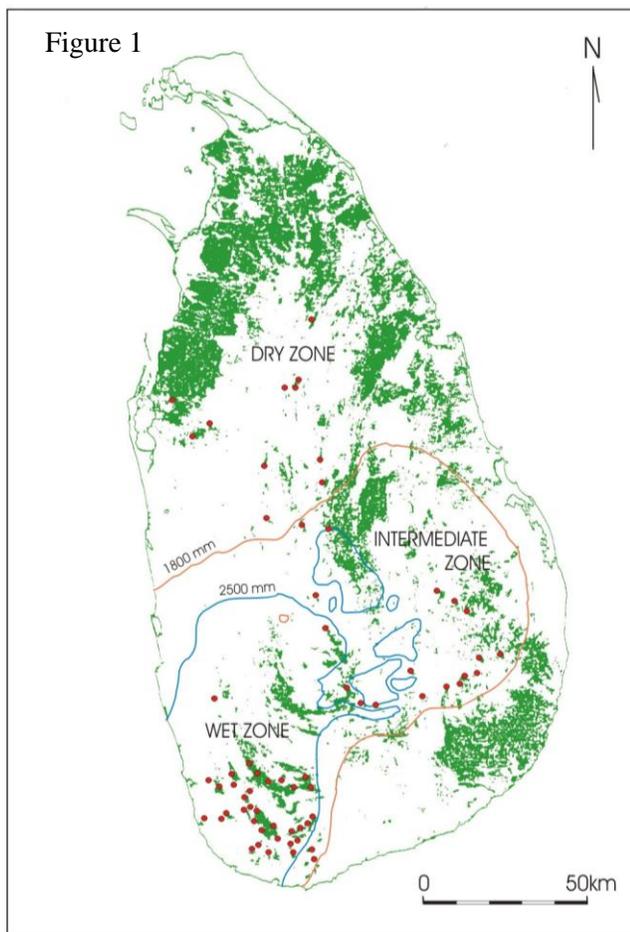


Figure 1

The survey programme was central to the project because it provided material for reference collections and the data for research and for the databases. Survey staff are listed in appendix VI. As the project manager in Sri Lanka, Dinarzarde Raheem was responsible for all management on a day-to-day basis, including financial control. For the field programme Miss Raheem provided overall supervision including the identification of survey areas, organisation of logistics such as permits, provisions, accommodation, transport and access. In addition, Miss Raheem provided training in field practice and sampling methodology. Further responsibilities included co-ordination and establishment of common practice between two field teams. One team based at the Department of National Museums in Colombo was led by Miss Raheem and the second team based at the University of Peradeniya, near Kandy, was led by Kithsiri Ranawana.

Figure 1. Map of Sri Lanka's natural forests and climatic zones. Red dots show where Darwin Initiative land-snail surveys have been carried out but exclude the detailed Knuckles Range surveys and overlapping dots are not shown. The Wet Zone is bounded by the 500 mm isohyet and the boundary between the Intermediate and Dry Zones is the 1,800 mm isohyet.

Source of forest cover data: 1:50,000-scale forest map by Legg and Jewell (1992 and 1995).

A key focus of the project has been to develop a basic understanding of the distribution and conservation status of Sri Lanka's endemic and indigenous land snails through exploratory surveys of natural forests and synanthropic habitats. During the course of the first year of the project (1999-2000) a survey of a range of forest habitats across Sri Lanka's three major climatic regions, the wet, dry and intermediate zones, was carried out. This was complemented by intensive investigations of the land-snail faunas of two discrete areas within the island: the tropical lowland rainforests of the wet lowlands (2000-2002) and of the climatically and vegetationally diverse forests of the Knuckles range of hills (1999-2002). The surveys were based on a standardized method of sampling using 2m x 100m belt transects to permit direct comparison between different sites. In addition to the transect-based sampling, we carried out life history studies of selected species and initiated a preliminary survey of the exotic and pest species of synanthropic habitats.

The main aim of the first year's 'island-wide' survey was to establish collections and records and develop an understanding of the broad distributional patterns of Sri Lankan land snails with respect to climatic and vegetational zonation. Natural forest sites in the four major climatic zones (dry, intermediate, lowland wet and highland wet) and across nine districts (Anuradhapura, Badulla, Galle, Kandy, Kurunegala, Matale, Moneragala, Nuwara Eliya and Puttalam) were sampled. Four major forest types were sampled: the dry monsoon forests (dry zone), moist monsoon forest (intermediate zone), lowland evergreen rainforest (lowland wet zone) and montane rainforest (highland wet zone).

Approximately 150 morphospecies were recorded over the three years including 110 endemic species. A large number of species are considered to be new to science. Approximately 50 new taxa are clearly distinct and a further 20-30 species-level taxa are part of species-level complexes that will be more difficult to resolve. A number of taxa are undescribed genera. Several exotic species were recorded in Sri Lanka for the first time. A simple analysis of the 99 species recorded in the first year of the project, when an approximately equivalent amount of sampling effort was expended for the four climatic zones, shows that the vast majority of species were recorded from the wet zone (Figure 2).

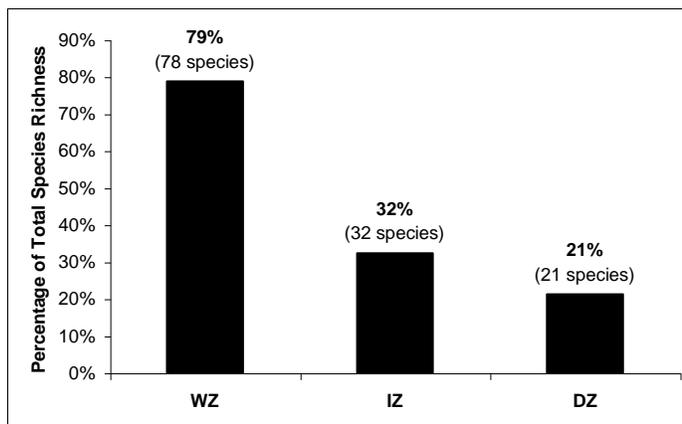


Figure 2. A comparison of the land-snail species richness of Sri Lanka's wet (WZ), dry (DZ) and intermediate (IZ) zones as recorded during the 'islandwide' survey in the first year of the Darwin Initiative Project.

Of the 99 species recorded during the 'island-wide' survey nearly 80% were recorded from the wet zone (lowland and highland wet zone). Land-snail diversity as recorded for the other two zones was much lower: 32% of species recorded in the first year were found in the intermediate zone and 21% in the dry zone.

An investigation of species ranges across climatic zones shows that more than 60% of species were recorded only from the wet zone (Figure 3). Species restricted to one of the other two zones make up a relatively small proportion of total diversity as do species ranging across two or three climatic zones. This pattern strongly suggests that the wet zone is the centre of land snail diversity and endemism and is therefore of great importance to the conservation of the Sri Lankan land snail fauna.

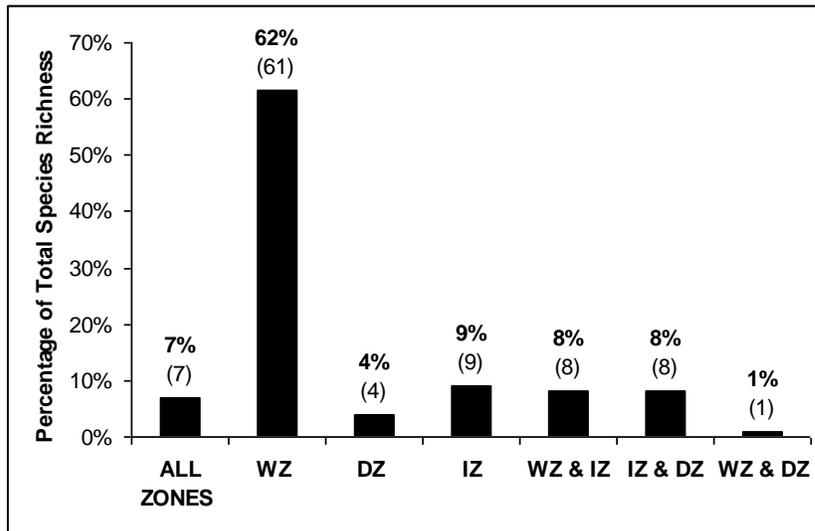


Figure 3. Relative contribution of species ranging across one zone, two zones or three zones to total land-snail species richness as recorded during the ‘island-wide’ survey.

Species fall into one of seven categories. Those confined to either the dry (DZ), intermediate (IZ) or wet (WZ) zone. Those confined to two zones, either the wet and intermediate zones (WZ & IZ), the intermediate and dry zones (IZ & DZ) and the wet and dry zones (WZ & DZ). Those ranging across the three zones (ALL ZONES).

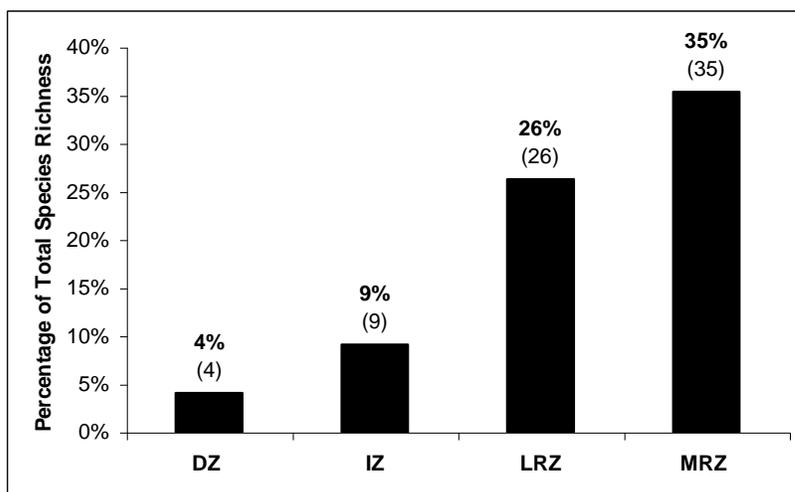


Figure 4. Relative contribution of species restricted to the dry (DZ), intermediate (IZ), lowland rainforest (LRZ) and montane rainforest zones (MRZ) to total land-snail species richness as recorded during the ‘island-wide’ survey.

A closer examination of the 61 species recorded only from the wet zone shows that they fall into two discrete categories: species recorded only from the lowland wet zone or the lowland rainforest zone and species recorded only from the highland wet zone or the montane rainforest zone (Figure 3). Of the exclusively wet zone species 35 species were limited to the montane rainforest zone (>3500 ft. or 1067m) and 26 species were limited to the lowland rainforest zone (<3500 ft. or 1067m). This underlines the point that not only are many Sri Lankan land snails restricted to the wet zone, but that they are restricted to particular parts of the wet zone.

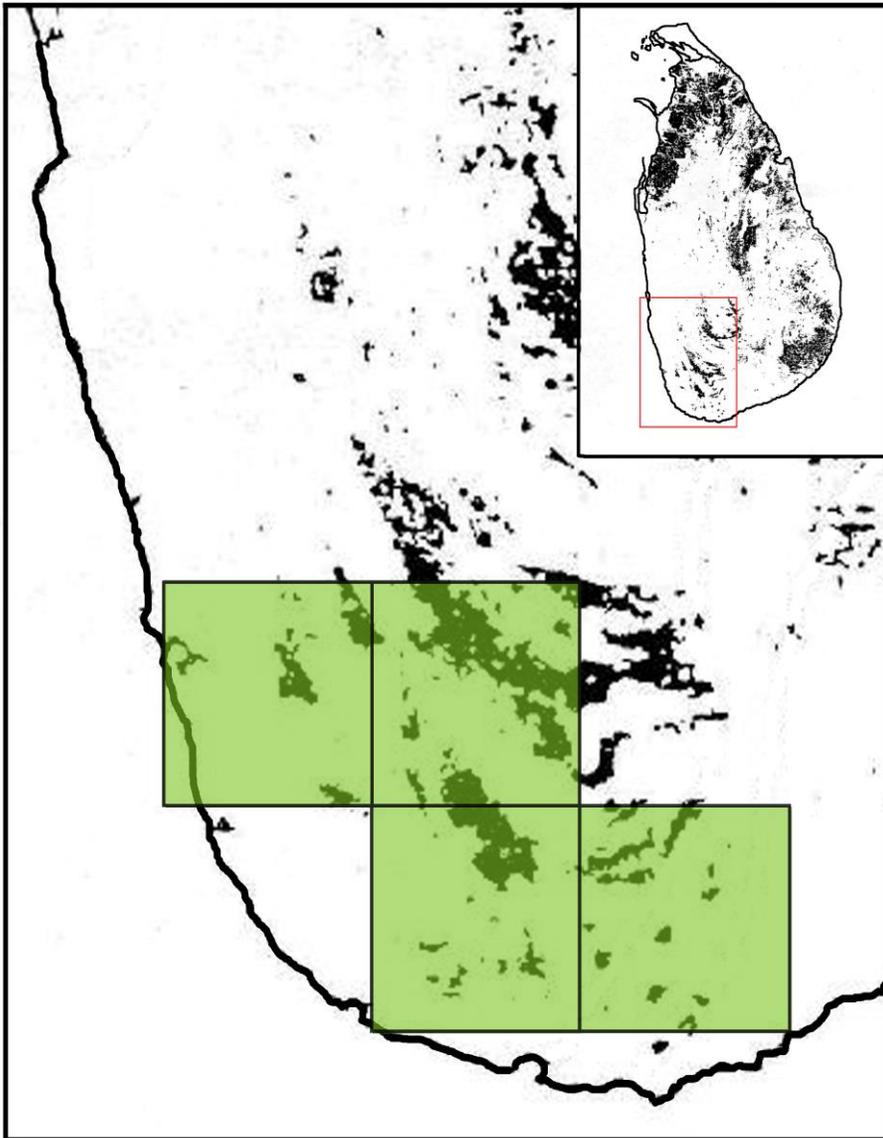
These results demonstrate that the two main ecological subzones of the wet zone, the lowland rainforest zone and the montane rainforest zone have distinctive faunas. For example, the lowland rainforest fauna is composed of a widely distributed element and a localised or restricted-range component. Widely distributed lowland rainforest species include *Cryptozonia chenui*, *Ratnadvipia irradians*, *Acavus phoenix*, *Corilla adamsi*, *Beddomea albizonatus*-aggregate and *Leptopoma semiclausum*. These taxa range across most or all of the forested area of the lowland wet zone; some species like *Ratnadvipia irradians* occur in both forest and non-forest habitats. In contrast, the localised element is comprised of taxa with restricted ranges within the compass of the wet lowlands. Examples include forest species such as *Tortulosa aureus* and the two acavids, *Acavus haemastoma* and *Acavus superbus*, both of which occur at very high densities in synanthropic habitats.

The fauna of the montane rainforest zone like that of the lowland rainforest zone is separable into widely distributed and localised elements. Among taxa characteristic of the montane rainforest zone as a whole are *Cryptozonia ceraria*, *Euplecta colletti*, *Euplecta gardeneri*, *Glessula parabilis* and *Beddomea trifasciatus*-aggregate. Species with localised ranges within the montane zone include *Mirus stalix*, *Euplecta isabellina*, *Oligospira skinneri*, *Thysanota bicilliata* and *Theobaldius bairdi*.

While the results discussed above provide only a brief overview of the preliminary findings of the project they indicate how crucially important the wet zone is as a centre for land-snail diversity and endemism. We now know that while the wet zone does have a substantial share of the island's land-snail diversity and endemism, many species are restricted to localised areas of the wet zone. This serves to underline that the conservation of Sri Lanka's unique and rich land-snail fauna is critically dependent on the conservation of practically all of the fragmented and highly threatened rainforest that remains in the wet zone today.

The above are only the initial findings from the project's first year of surveys, which have been reported in Naggs & Raheem (In Press, Appendix III, page 33). During the second and third years of the project a considerable amount of data and specimen material was acquired from lowland forests and from the Knuckles ranges of the Central Highlands. Dinarzarde Raheem's team carried out 77 transects across 21 rainforest fragments of lowland (up to 1200m) rainforest. Many of these areas were remote and extremely difficult to access. The data from these surveys will form the basis of Dinarzarde Raheem's PhD study on the impact of forest fragmentation on survivorship (Appendix VII). These are issues of central importance to the conservation of biological diversity and the survey data is already being used by the Sri Lankan government in new legislation extending protected status to areas of forest previously thought to be of little conservation value (Appendix VII).

For each transect site measurements were made of the canopy density, altitude, soil pH, slope and aspect. GPS readings were taken and the nature of the leaf litter and forest floor matter recorded. All live individuals and shells encountered were identified to species level in the field and representative samples taken for confirming field identifications.



This is the most detailed set of information on the distribution of a tropical land snail fauna that has ever been assembled. It is a rich resource for investigating patterns of distribution and abundance in what proves to be a centre of land snail diversity and endemism of global significance. In addition, it has demonstrated that a comprehensive survey of all of Sri Lanka's remaining wet zone forests is achievable. The collections will be a valuable resource for many years to come.

Figure 5. Distribution of lowland rainforest in Sri Lanka. The four quarter degree grid squares defining the study area (highlighted in green) lie between longitudes 80°00'E and 80°45'E and latitudes 6°00'N and 6°30'N.

The Peradeniya team's Knuckles Conservation Region surveys in the Central Highlands

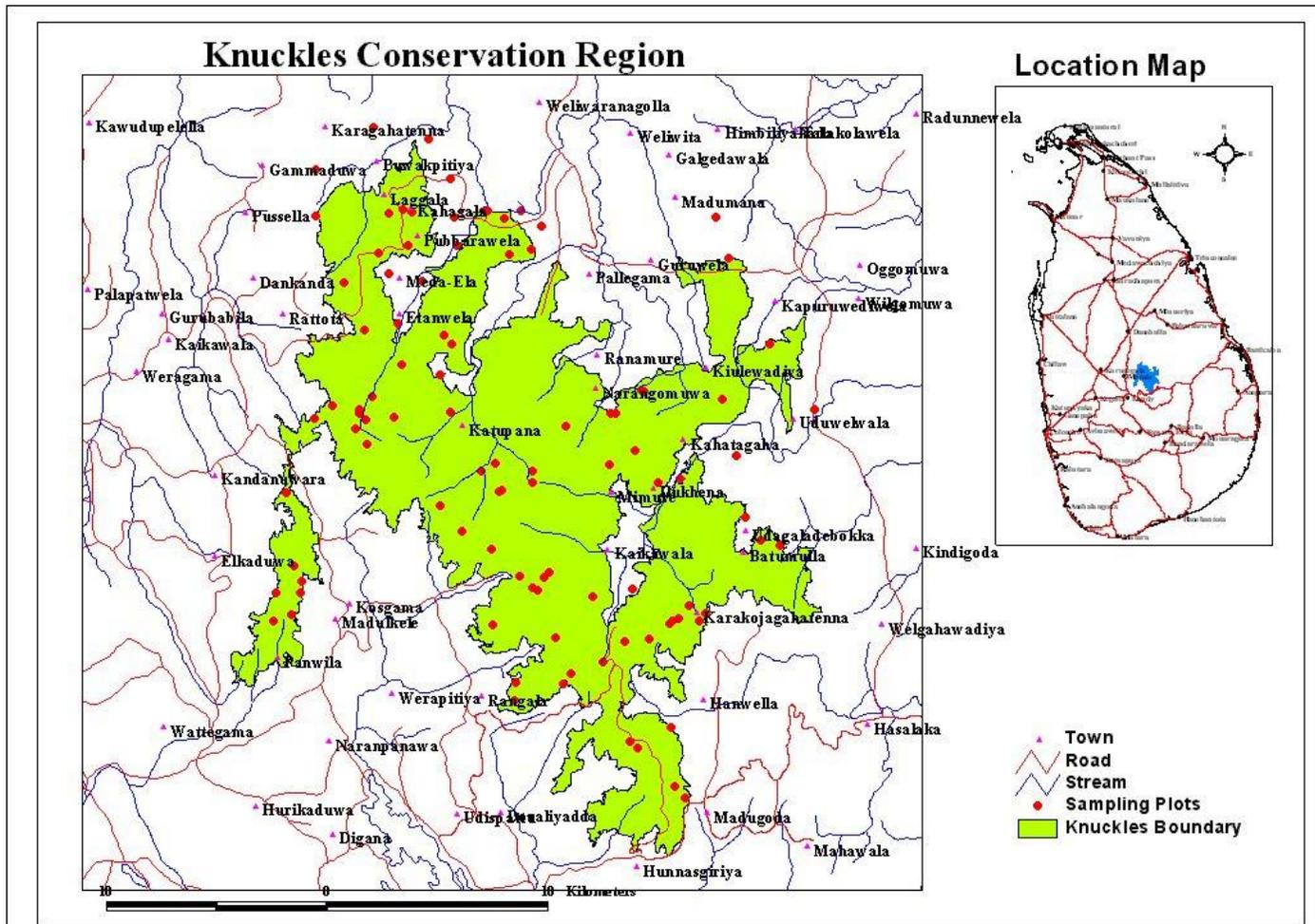


Figure 6. The Knuckles Conservation Region showing the extent of the protected area and the survey sites investigated by the Peradeniya based team led by Kithsiri Ranawana.

In the study of land snail distributions in the Central Highlands, Kithsiri Ranawana's team carried out 110 transects in the Knuckles Range up to June 2002 (Appendix VIII, pages 44-46). In addition to this study the Peradeniya based team have surveyed pest species and carried out life history studies on *Oligospira* and *Acavus*. Molluscan pests have been a rapidly growing problem in Sri Lanka (Kumburegama, Project Report supplied & Naggs 2002, Appendix III page 32) and the study has attracted considerable interest. Of particular concern is the spread of a tropical South American freshwater Golden Apple Snail pest across tropical Asia and the Pacific region. Although freshwater snails were outside the scope of the objectives of this project it was timely and appropriate to alert Sri Lanka to the predicted arrival of *Pomacea canaliculata*, a species notorious for the devastating damage it causes to rice cultivation. A survey established

that the species of *Pomacea* that had already arrived in Sri Lanka was not *Pomacea canaliculata* but the relatively harmless *Pomacea diffusa*. The guide to pest and exotic species will include details of both *Pomacea* species and the native *Pila globosa*, with which they might be confused.

Snail shells and palaeoclimate investigations

The behaviour and life-history studies were initiated to facilitate interpretation of radio-isotope data in a palaeoclimate study based on Sri Lankan fossil snails. These studies are of enormous potential interest because they offer a unique opportunity to determine palaeo-rainfall patterns in a tropical terrestrial ecosystem by a direct means (Leng, M.J., and Naggs, F., 1999 [Appendix III, page 31]). By investigating the oxygen O_2^{16}/O_2^{18} isotope profile in a snail shell's successive growth increments it is possible to establish the origin and pattern of rainfall through time. This is because different sources of rainfall, such as the southwest or northeast monsoons have characteristic isotope profiles. The fossil material available from cave deposits in the rainforest areas of Sri Lanka are continuous deposits dating back some 35,000 years, well into the last Ice Age. *Acavus* is particularly well represented in these deposits and being large it is a convenient subject for study. The current view prior to our investigations was that *Acavus* species remained in trees where they fed on wet lichen and surface algae following rain. This made them ideal subjects for isotope study because rainfall water would be absorbed immediately after precipitation and a faithful record of the rain's isotope profile would be fixed in the growing shell. This behaviour needed to be confirmed. Another question to address was the period of time from hatching to maturity, when growth of the shell ceases. This would allow a chronological calibration.

Observations of *Acavus* showed little daytime activity and no obvious feeding. However, observations after nightfall demonstrated that historical observations were wrong. *Acavus* rapidly move down to ground level at night and, probably by means of chemo-reception, congregate on rotting fruit in large numbers. Far from rapidly incorporating rainfall the water incorporated into their shells is derived from groundwater taken up by trees over a period of time as fruit grows, ripens and eventually drops from the tree. Interpretation of the isotope profile is therefore complex and difficult. However, although *Acavus* may live for ten or more years, life history studies demonstrated that growth to full size is completed within one year, allowing the shell growth increments to be calibrated.

A taxonomic study of *Euplecta*

Euplecta is primarily a South Asian genus with the largest radiation at species level in Sri Lanka. The MPhil project being followed by Lalith Kariyawasam is a study of the species limits and distribution of *Euplecta* in Southwestern Sri Lanka. The fieldwork for this project has been completed.

Ancient relict groups in Sri Lanka

The molecular biology study of land snail evolution led by Peter Mordan (NHM) and Chris Wade (NHM, now Institute of Genetics, University of Nottingham) is a pioneering

programme that has allowed new insights into the significance of ancient elements of the Sri Lankan fauna (Wade *et al.* 2001. [Appendix III, page 31]). The results of this study support the hypothesis that some Sri Lankan snail groups are ancient Gondwanan relicts with their closest relatives in the Gondwanan continental fragments of South America, Africa, Madagascar and Australia. The presence of the acavid group in Sri Lanka is particularly significant because it is absent from India and Sri Lanka can be recognised as the sole refuge of such taxa on the Deccan Plate, giving them an independent lineage for over 100 million years.

To expand these studies Mordan, Wade and Naggs have submitted a research proposal to the Leverhulme Trust. Fred Naggs is particularly interested in testing the hypothesis that formation of the Deccan Traps obliterated most of the Gondwanan fauna from India early in the Cenozoic. Some Gondwanan elements such as *Corilla* and possibly *Glessula*, abundant in Sri Lanka, are barely represented in southernmost India. The occurrence of *Glessula* and the corilliform *Plectopylis* in the north-eastern extremity of India might be indicative of a second Gondwanan K/T boundary refuge on the northeastern limits of the Deccan Plate. In the case of *Plectopylis* the relationship might be much older with *Plectopylis* being a Laurasian relict of this conservative morphological form. These historical biogeographic studies in molecular biology are central to understanding the origins and significance of the Sri Lankan fauna and how important it is for it to be conserved.

Training

Training was of four main kinds:

- (i). Projects and courses for undergraduate students.
- (ii). Postgraduate research
- (iii). Informal on the job training both in the field and in the laboratory
- (iv). Formal training and specialist experience at the NHM

(i). Undergraduate students

Over the three year period about 30 undergraduate students in the Zoology Department at Peradeniya University attended a series of lectures on molluscs given by Mr Ranawana. These were based on the project and students gained field experience and training as part of the pest species surveys. Fred Naggs gave additional lectures and training on his visits to Sri Lanka. The best of these students, Miss Kumburegama, carried out a seven-month survey and wrote up the results as her final year Special Degree project (Report supplied). This was an excellent undergraduate report and Miss Kumburegama was awarded a first class honours degree. Two of the field assistants were also registered for part-time degrees.

(ii). Postgraduate students

Miss Raheem has been registered for a PhD at the University of Cambridge from October 2000. Richard Preece at Cambridge acts as the internal supervisor and Fred Naggs the external supervisor. The project *Land snail diversity in Sri Lankan rainforest fragments*

(Appendix VII, pages 38-43) addresses key issues on patterns of diversity in Sri Lankan rainforest and on the effect of forest loss and fragmentation. Miss Raheem is an outstanding worker but despite our best efforts we were unable to obtain sufficient funding for the final year of her PhD, which was to have commenced in October 2002.

Mr Ranawana has been registered at the Postgraduate Institute of Science for his PhD project *Patterns of distribution and ecology of land snails in the Knuckles region, Sri Lanka* (Appendix VIII, pages 43-45), since March 2000. Mr Ranawana is a senior lecturer in the Zoology Department at the University of Peradeniya. The external project supervisors are Fred Naggs and Peter Mordan and the Sri Lankan supervisor is Professor Jayatunga, Department of Zoology, University of Colombo.

Mr Kariyawasam was appointed in 2000 as an assistant curator by the then Acting Director of National Museums to be seconded to the project full time. As set out in the MOU between the NHM and the Department of National Museums, Fred Naggs agreed to act as a supervisor for the post holder's MPhil. Mr Kariyawasam registered his MPhil project *A study of the species limits and distribution of Euplecta in southwestern Sri Lanka* at the University of Kelaniya in May 2001. The internal supervisor is Professor Wijeyaratne. Mr Kariyawasam will need considerable support from Fred Naggs to reach a sufficient standard.

(iii). Work practice in Sri Lanka

All field assistants were trained in field practice including field safety. Training was given in transect sampling methodology, specimen identification and field preparation and documentation, the use of a global positioning system, pH meter and canopy densitometer. Laboratory and field training in Sri Lanka included detailed procedures for narcotization, fixing and preservation and documentation of specimens.

(iv). Training at NHM

On visits to the NHM in London extensive training was provided in curatorial practice and the use of specimen reference collections and library resources. Comparative specimen reference material and type specimens were used to work up the survey collections. James Chimonides (NHM) provided extensive training on Geographical Information Systems based on MapInfo. Additional training was provided in the use of several software packages including Excel, Paradox and ArcView.

5. Project Impacts

For the duration of the project emphasis was placed on obtaining as much material and data as possible from the field programme. The project objective of establishing reference collections with detailed information on distributions has set in place a resource that will be a baseline for future monitoring and of value for the foreseeable future. The most significant initial finding is that some 35% and possibly more than 50% of the snail fauna

recorded on the project is new to science. The extent of newly discovered species was unexpected and establishes Sri Lanka as a globally significant centre of molluscan diversity. Mapping of distributions, taxonomic revisions and studies such as those on the impact of forest fragmentation and loss are ongoing. The pest -species survey identified all of the major molluscan pests and the resulting guide will allow control practice to be focussed appropriately. The danger of the rice pest species *Pomacea canaliculata* reaching Sri Lanka has been highlighted and a notification procedure for the appearance of this and unidentified pest species is in place.

To quote from Rohan Pethiyagoda, Advisor to Sri Lanka's Minister of Environment: 'Studies such as Ms Raheem's have greatly influenced the government of Sri Lanka in its decision to pursue the establishment of a national biodiversity institute especially to facilitate and conduct studies of this nature'. (Letter from Rohan Pethiyagoda to Whitley Foundation, 8th May 2002, Supplementary Appendix letter file). Such a facility is urgently needed. It was clear from the launch of this project that institutional weakness for addressing biodiversity issues is a major impediment to Sri Lanka achieving CBD objectives and the current project exemplified the partnership problems that have been inherent in dealing with Sri Lankan organisations.

Current activities of personnel given training on project

Dinarzarde Raheem^{1,2} (Project Manager, Sri Lanka and leader of the Colombo-based group. Registered for PhD, University of Cambridge). Dinarzarde was to have completed the final year of her PhD from last October but we were unable to secure funding. However, Museum funding has been obtained to employ Dinarzarde until April for her to make a start on working up the many new species we have discovered.

Lalith Kariyawasam. Lalith is a curator at the Department of National Museums. He was appointed soon after the project started and seconded to it full time. Lalith is continuing his investigation of *Euplecta* for his MPhil studies, registered at the University of Kelaniya. He continues to hold the post of Assistant Zoology Curator at the Department of National Museums, Colombo.

Rohana Wasantha Jayasekera (Project field and research assistant): Rohana is following a Sri Lankan Open University diploma course in wildlife management. He is interested in following a career in wildlife and forest conservation.

Indrajith Perera (Project field and research assistant). Currently unemployed, Indrajith is uncertain about his future direction.

K.L.G. Hasantha Sanjeeva (Project field and research assistant, photography and computer support). Hasantha is employed on overseeing our World Bank funded translation project in Sri Lanka. Hasantha is the most promising of our field assistants. He is in the third year of a four-year part time zoology degree.

Kithsiri Ranawana (Leader of Peradeniya-based group, Senior Lecturer, Department of Zoology, University of Peradeniya. Registered for PhD, Postgraduate Institute of Science, Peradeniya). Kithsiri now runs an undergraduate series of lectures on Mollusca. His research on snails and investigations on pest species are ongoing.

Prasantha Paranagama (Project field and research assistant). Prasantha is employed as a field assistant at Peradeniya University.

Menaka Chandrasekera (Project field and research assistant). Menaka has set himself up as a 'design consultant'.

Pradeep Samarawickrema (Project field and research assistant). On completion of the project Pradeep was employed by IUCN Sri Lanka and he is carrying out faunal surveys. He is in the final year of a part time zoology degree

Dhammithra Samarasinghe (Project field and research assistant and photography). Dhammithra left the project after two years and is employed as a consultant on natural history and related issues for a Sri Lankan media and television company.

Shalika Kumburegama (Special honours undergraduate student 2000-2002, 2002-2003 Assistant lecturer, University of Peradeniya). Now a member of the permanent teaching staff at Peradeniya University, Shalika wishes to undertake postgraduate studies on invasive molluscs.

N.H. Chithrasekera (occasional field assistant/guide). Chithrasekera is a Forestry Department watcher for the Galle District. Employed as a guide on the project for remote rain forest areas he was trained in a wide range of field practice and is currently involved in developing the visitor resources and infra structure at Kanneliya Forest Reserve, the second largest lowland rainforest area in Sri Lanka.

A new institutional base for biodiversity in Sri Lanka

When the current government assumed power in Sri Lanka following the general election a year ago they had many issues to address and the peace process had top priority. However, environmental issues, including biodiversity were high on their agenda. Rohan Pethiyagoda, the leading Sri Lankan environmentalist, natural historian and life sciences publisher, was brought in to the administration to implement the plan for a new biodiversity authority. During the course of the project Fred Naggs has explored the need for an effective institutional base and legislative authority for biodiversity work in Sri Lanka with Rohan Pethiyagoda. He has known Mr Pethiyagoda through the Sri Lankan Wildlife Heritage Trust since 1996 and is an editor of the Trust's journal *Zeylanica*, previously the *Journal of South Asian Natural History*. To date, the outcome of Mr Pethiyagoda's efforts has been that the legal framework for a biodiversity authority has been put in place and work has begun on the building of a National Biodiversity & Rainforest Institute, located near the New Parliament Building in Sri Jayewardenepura, Kotte, Colombo. The intention is to open up biodiversity work in Sri Lanka and actively engage with the international scientific community both in running the institute and in

developing international partnerships and collaboration. The UK is sought as the main partner (Supplementary Appendix letter file). This is primarily because of our close historical links, which have resulted in The Natural History Museum holding a monopoly on specimen reference collections, particularly type material and comprehensive specialist literature resources for the region. Rather than just establishing an institution to institution MOU, the Sri Lankan Government, through their Ministry of Environment, is seeking an official agreement on biodiversity co-operation. In September 2002 Hon. Rukman Senanayake, Minister of Environment & Natural Resources wrote to the British High Commissioner in Sri Lanka (Supplementary Appendix letter file). The intention was to set the wheels in motion for a bilateral agreement on biodiversity co-operation between Sri Lanka and the UK. As of February 2003 the NHM has not been contacted by the Foreign & Commonwealth Office about this approach and the Sri Lankan Minister of Environment has not received an acknowledgement to his letter.

The Biodiversity Authority is to be a governing body implementing government policy on biodiversity but largely independent of day-to-day government political control. Administrators having a trustee role are to be designated by leading academic institutions, at least two of which are to be non-Sri Lankan. The proposal is that one member should be from the Natural History Museum, London, and the other from The Museum of Comparative Zoology, Harvard. The Biodiversity Authority will be responsible for the stewardship of The Biodiversity and Rainforest Institute. The Institute will be responsible for national faunistic and floristic (in co-operation with the Botanic Gardens, Peradeniya) programmes, including surveys, research and administration of government biodiversity policy. The Institute will hold the National Collections of specimens and have a small permanent curatorial staff. Research at the Institute will seek to include international expertise and be based on external funding and international partnerships. A secretariat will take over the current Wildlife Department responsibility of issuing collecting and export permits. The Wildlife Department's activities will be restricted largely to the management of National Parks. The Biodiversity Authority and Institute will be financed by an endowment fund, which will be managed by a separate board of trustees appointed by leading industrial and commercial organisations. Their role will be confined to financial control and the Biodiversity Authority governing body will determine all policy in line with government biodiversity objectives.

There is exciting potential for Sri Lanka to be transformed from its current inability to actively engage with the international scientific community in furthering national CBD objectives. As outlined in the Project Background/Rationale in section 2, page 1, Sri Lanka's biota has many attributes that would justify its being a high priority and focus of international attention in biodiversity such as by means of a Royal Society International Research Programme. There is undoubtedly considerable opposition to these changes from, for example, the Natural History Section of the National Museum, which would be marginalised, and from many in the Wildlife Department. It remains possible to establish productive partnerships with university research groups but during the current transitional phase it will continue to be difficult to establish effective partnerships with government departments. However, the programme has the full backing of the Minister of Environment and is supported by the Prime Minister. It has every chance of being achieved and deserves support from the UK.

6. Project Outputs

Project outputs are shown in the table in Appendix II, pages 29-30, using the coding and format of the Darwin Initiative Standard Output Measures. Sri Lankan partners held the view that printed local newsletters would not be an effective way of disseminating information about the project. Project information was posted on *Sri Lankan Wildlife News* a natural history and conservation e-mail newsletter (e-mail gehan@jetwing.lk with "Subscribe Wildlife News" in the subject header). These newsletter reports can be viewed at the on-line message board of the Jetwings Hotel Group ecotourism section at: www.jetwingeco.com/web_pages/news_board/news_board_wildlife.html#. Details of the project's CD Rom were reported in *Tentacle* the international newsletter of the IUCN/SSC Mollusc Specialist Group, Species Survival Commission, IUCN and the World Conservation Union. Information on the snail guide has been published in the *Bulletin of The Malacological Society of London*. Although a newsletter was not produced two information leaflets were widely circulated (Appendix III, page 32). The pest species leaflet has been posted as a pest alert at: <http://pestalert.applesnail.net/>. The two public exhibitions organised by Dinarzarde Raheem were additional outputs central to publicising the project in Sri Lanka. These were a great success and were launched with special viewing for academics and representatives from government departments. They were very well attended with a full programme of school bookings and a great deal of public interest and press coverage. Young Asia Television followed up their coverage of the exhibition with a request to make a programme of the project, including field-



Figure 7. Project Exhibition at the Department of National Museums, February 2001. Dinarzarde Raheem giving a tour of her exhibition for Young Asia Television.

work. The programme was broadcast in Sinhala and English in 2002. The exhibition held in Peradeniya attracted particularly good press coverage including a Sinhala centre fold

spread in a young person's science magazine (Supplementary Appendix: press cuttings). The NHM's Department of Communications and Development funded a senior Museum photographer, Harold Taylor, to join Fred Naggs' visit to Sri Lanka in February/March 2002. The following publicity in the UK included a presentation of project images in the NHM's public galleries as part of an exhibit on the Museum's Photographic Unit's work. The NHM hosted a meeting of the Friends of Sri Lanka Association in December 2002 and in addition to presentations on the project by Dinarzarde Raheem and Fred Naggs, Harold Taylor presented a photographic exhibition of the material obtained on his visit to Sri Lanka.



Figure 8. Meeting of the Friends of Sri Lanka Association. Fred Naggs explains why Sri Lanka is home to ancient snails that are not found in India. They originated over 100 million years ago and were contemporary with dinosaurs

resources have not been available to do this and it will be published in its current stage of development with the intention to publish a second larger edition at a later date. Publication of the Tamil and Sinhala editions of the snail guide was made possible by an award of US\$8,400 from the Forests and Biodiversity fund of the World Bank/Netherlands Partnership Programme. One thousand copies of each edition will be distributed free to schools colleges, universities, government departments and natural history societies throughout Sri Lanka. A further 500 copies of each will be available for retail sale at the subsidised price of Rs100 (about 75p). A project website based on the snail guide and a selection of habitat and field images is currently in preparation for the NHM's Zoology Department site at: <http://www.nhm.ac.uk/zooology/>.

7. Project Expenditure

Table A

	Budget	Expenditure	Over/underspend
Staff			
Postage, telephone and stationery			
Local overheads			
Travel and subsistence			
Conferences, seminars etc			
Printing			
Capital items, computers and software, GPS, Altimeter			
Vehicle hire			
NHM Overheads			
Total of spend			

The above are pre-audited figures. The budget was based on actual predicted costs as determined on the bases of 1988 prices and did not allow for inflation, which was particularly high for travel and subsistence costs in Sri Lanka. A small overpayment on salaries was made in 2001 and the exact figure is awaited from Chessington Computer Centre before a request for repayment can be made.

8. Project Operation and Partnerships:

The Zoological Survey of Sri Lanka (ZSSL) was to be the managing partner but the arrangement fell through at the launch of the project as detailed in the first project report. The ZSSL is an advisory committee of the Sri Lankan National Science Foundation and its attempts to occupy the position of a biodiversity institution have not progressed. In the absence of a competent institutional base for overall management of the project the credit for the project's success must be attributed entirely to the efforts of Dinarzarde Raheem as the local project manager. The survey programme remained central to the project and followed the original objectives.

The University of Peradeniya was the base for the Central Highlands field team and was a satisfactory local partner throughout the project. Mr Ranawana is continuing his studies of the Knuckles Range snail fauna and on molluscan pests. He also continues to run a molluscan course for undergraduates. Two field assistants continue to be employed on his research projects, which include a GIS mapping programme using computer equipment from the project.

Miss Raheem was based at the department of National Museums (DNM) in Colombo. Although there is a long tradition of natural history at the DNM, it is involved with a wide range of disciplines of which natural science has become a small part. It had one of the best natural history libraries in Asia but this has been seriously neglected for many years and it is in a poor state. Many valuable books have disappeared. The appointment of Dr Mapatuna as Acting Director revived hopes that the Colombo Museum might be restored to play a meaningful role in biology. Mr Kariyawasam continues to work on the curatorial care of the proportion of the project's collections that are housed at the DNM and, using project funded computer equipment, continues to work on the snail fauna database and mapping. However, the Museum's established personnel in the natural sciences are of very poor calibre. Dr Mapatuna attempted to bring in new staff such as Mr Kariyawasam, but the existing staff occupy tenured positions and they proved impossible to work round. They seem to be incapable of good work and were hostile to all of Dr Mapatuna's efforts to engage in scientific projects. They successfully contributed to Dr Mapatuna's failure to have her post confirmed. The new director was obstructive to the project. There appears to be no prospect of the Department of National Museums acting as an effective institutional base for biodiversity work in Sri Lanka. This was widely recognised in the Sri Lankan academic community and is now accepted by the current government. The new Biodiversity Authority, and steps to establish a Biodiversity and Rainforest Institute, are the foundation of the government's agenda for biodiversity

9. Monitoring and Evaluation, Lesson learning

Monitoring and evaluation

The survey programme was carefully structured and followed an agreed timetable. Research components of the project were and continue to be monitored by the internal management system in the NHM and by university supervisors in the Department of

Zoology, Peradeniya University, The Postgraduate Institute of Science, The University of Colombo, the Faculty of Graduate Studies, University of Kelaniya and the University of Cambridge, with formal reporting ranging from six monthly to annual intervals.

Lesson learning

- Detailed advance planning is essential but only so much can be planned in advance: it is essential to be prepared to rethink strategy at any stage of the project.
- The most critical consideration is the effectiveness of local management. Where local capacity for managing projects is at all doubtful, a directly appointed local manager can be indispensable.

10. Darwin Identity:

The Darwin Initiative has been promoted and the Darwin Initiative logo used at every opportunity. Examples include:

- Posters:
 - used to promote the project and advertise the exhibitions
 - presented at conferences in Sri Lanka, the UK and internationally
- Publications:
 - Information leaflets
 - Abstracts and papers
 - Field guides
 - CD Roms
 - Book
- Media coverage
 - Press releases
 - Newspaper articles
 - Science magazine articles
 - Television programmes
- Meetings, conferences and workshops

An example of the minimum information given is that shown in the *Sri Lankan Snails* guide:

The Darwin Initiative



The Darwin Initiative <http://www.nbu.ac.uk/darwin> was launched at the 1992 United Nations Conference on Environment and Development (the Rio 'Earth Summit') as part of Britain's response to the resulting convention on Biological Diversity <http://www.biodiv.org>. The Darwin Initiative seeks to help safeguard the world's biodiversity by drawing on British biodiversity strengths to assist countries that are rich in biodiversity but poor in financial resources.

In addition to publicity provided by our main partners, The Department of National Museums (at least for the first two years) and the University of Peradeniya, information on the Darwin Initiative has also been disseminated by our many institution contacts in Sri Lanka. These include the Postgraduate Institute of Science, The University of Kelaniya, The University of Colombo, the Sri Lankan Wildlife Heritage Trust, The National Science Foundation and the Young Zoologists Association. In addition, in a display of its activities, the project is featured in an exhibit at The Zoological Museum, University of Cambridge.

The Darwin Initiative is widely known and well regarded in Sri Lanka both in academia and by the general public. *Land snail diversity in Sri Lanka* gained wide publicity through exhibitions, workshops, a conference and speakers at various meetings ranging from those of the Asiatic Society to the Young Zoologists Association. Newspaper articles, some of which were very detailed, and television programmes reached out to the widest possible audience.

Land snail diversity in Sri Lanka was closely associated with the Darwin Initiative and it had a very distinctive identity within Sri Lanka. Considerable popular interest was generated because snails were a neglected group and there was a great deal of curiosity about the project. The value of snails as an indicator group and the ignorance of their importance as pest species attracted the attention of scientists ranging from conservation biologists to agricultural workers.

11. Leverage

Additional funding

The largest source of additional support was the accommodation provided for Sri Lankan project staff to visit London. Property owned by Manel Herat and the Ananda J. Herat Trust was made available free of charge and, with the provision of mini-bus transport, the saving amounted to at least £XX (based on the cost of hostel/budget hotel accommodation). Instead of the two project leaders and four field assistants visiting the NHM over the duration of the project, this allowed all ten Sri Lankan project workers to receive training at the NHM and for some extended visits to be made.

Mr & Mrs I. Raheem provided accommodation in Colombo to the value of £XX for Fred Naggs' visits.

The Sri Lankan Wildlife Trust provided accommodation for Harold Taylor, Dinarzarde Raheem and Fred Naggs in Agradatana to the value of £XX.

US\$8400 (approx. £XX) was obtained from The World Bank for local language translations of the snail guide into Sinhala and Tamil and production of poster guides (Appendix IX, pages 47- 49).

£XX provided by the Linnean Society's Percy Sladen Memorial Fund and £XX from the Friends of Sri Lanka Association was used for an additional visit to Sri Lanka by Miss Raheem.

The Communications & Development Department at the NHM provided £XX towards the cost of Harold Taylor's visit to Sri Lanka in February/March 2002 and a further £XX towards the cost of preparing a photographic exhibit of the project.

The NHM's Student Fund has made an award of £XX towards the final year of Miss Raheem's PhD at Cambridge.

The NHM's Special Award Programme has provided £XX and the Department of Zoology's Zoology Research Fund Committee £XX towards the cost of employing Miss Raheem to make a start on describing the new species she has discovered.

Additional external funding: £XXX

In addition, NHM staff costs were £XXX

Total additional funding £101,080

In-country capacity

As discussed under Section 6 (pages 13-14) a complete reorganisation of the Sri Lankan government's legal framework, institutional base and funding of biodiversity is in progress. The NHM has been invited to participate in this process and to develop a programme of long-term co-operation.

12. Sustainability and Legacy

- The survey programme has established a baseline database for all future studies of Sri Lankan land snails.
- 30-60% of the recorded taxa are new to science and their descriptions under the aegis of the Darwin Initiative will be referred to as long as the Linnean system of zoological nomenclature remains in use.
- Close links have been established with the Sri Lankan government and its biodiversity programme and there is the prospect of a major collaborative programme.
- The information gained has already been used by the Sri Lankan government to re-evaluate rainforest fragments.
- Collaboration with the University of Peradeniya will continue.
- Mr Kaiywasam continues his molluscan work at the Department of National Museums.
- Most project personnel will continue to work in the field of biodiversity. The current activities of project staff are shown in Section 6 (pages 12-13).
- Computer equipment was divided equally between the two main partners.
- Copies of the book, field guide and CD Roms were widely distributed to academics, academic institutions and government departments.
- 2,000 copies of the local language snail guides will be distributed free to schools, colleges, universities and natural history societies throughout Sri Lanka.
- Several permanent links have been established.

- The survey collections and data will be a research resource for many years and a significant number of research papers will result.

Additional funds: future co-operation and research

The research output from the project is in its early stages. Six main areas of research can be recognised:

1. New taxa: a large number of new species and several undescribed genera have been discovered. The level of snail diversity and endemism establishes Sri Lanka as a centre of terrestrial molluscan diversity possessing global significance.

For study of this fauna to take place it is absolutely essential that these new taxa are described. Although significant resources for identifying and studying snails have been established in Sri Lanka the capacity for undertaking major revisions and new species descriptions is still held at the NHM and nowhere else. To attempt to describe the new species solely in Sri Lanka would inevitably result in confusion and it is essential that the new species are critically compared with type material and reference series in the NHM. In addition and although vigorous steps are being taken, there is currently no suitable institutional base in Sri Lanka for carrying this work out and for holding primary type material. As stated in the application for NHM Special Funds: ‘This is a unique opportunity for several reasons. Miss Raheem is uniquely qualified to publish the new taxa she has discovered, her field knowledge being of critical importance for this work’. A total of £9,000 has been raised from Museum Special Funds and The Zoology Research Fund to allow Miss Raheem to begin this work. These are the maximum awards available for this purpose under these schemes and additional funding is urgently needed.

The Darwin Initiative is no doubt considering what role it might play in supporting such work. Although taxonomy is recognised as the ‘essential bricks on which biodiversity knowledge is founded’ funding agency support for taxonomic work of this kind is almost non-existent. The House of Lords May 2002 Select Committee on Science and Technology notably recommended that the Darwin Initiative support taxonomy. The Select Committee report was published immediately before the June 2002 Darwin Initiative seminar for DI project developers and managers and was not included in the agenda for the meeting. However, Diane Edwards (Darwin Advisory Committee) raised the issues on systematics presented in the Select Committee report at the meeting. In reply, the Minister, the Rt Hon Michael Meacher, pointed out that the Darwin Initiative addresses issues wider than systematics alone but explained that the Government would be considering the Select Committee’s report. However, the current priority given to systematics and taxonomy by the Darwin Initiative is clear from the sixty-one-page seminar report *Increasing alignment with the Convention on Biological Diversity*: after referring to Diane Edwards question, it does not mention the word ‘systematics’ again. In connection with Article 7, ‘taxonomy’ is mentioned twice in the report as passing references to the Global Taxonomic Initiative (pages 10, 34). On page 34: ‘However, attempts to implement Article 7 have highlighted a shortage of trained taxonomists and curators, and the lack of taxonomic infrastructure in the biodiverse countries of the south’. Despite all of the hyperbole, debate, media attention and endless discussion about

biodiversity the reality is that there are few practitioners who can identify let alone describe biological diversity, and they are becoming fewer. This is not a shortage confined to the countries of the southern-hemisphere; it is global. The resources for dealing with identifying and describing living diversity are concentrated in the world's few major international museums but the expertise for dealing with it has diminished. The impediment is not simply a matter of training; taxonomists need to be employed both in the south and in the north and there needs to be a dynamic interaction, not simply a transfer of resources. Disney (1998)¹ pointed out that although Darwin Initiative funding was based on harnessing British expertise and resources it did not extend to funding British taxonomists to conduct alpha taxonomy as part of this process. While British taxonomists working in isolation might make major contributions to taxonomy and systematics it is only by working together with host-country personnel that the potential of resources, such as those at the NHM, can be fully realised. Our work seeks to do this.

2. The interactive CD Rom *Land snail diversity in Sri Lanka* can also be developed in a web version. It is a model exercise in transferring information and in incorporating research findings. As pointed out by Edward Wilson just last week² high resolution digital images of types can be made available for the first time. We have demonstrated one way in which this can be carried forward by the use of interactive images of shells that can be rotated as if the actual specimens were held in the hand. This project has been developed to the stage where it requires the input of large amounts of information. Additional funding will be required for employing help with this but to date we have not identified a potential funding source.

3. Dinarzarde Raheem's PhD studies focus on the subject of *Survivorship in fragmented rainforest*. This is the issue at the heart of the biodiversity crisis, and extinctions are thought to be taking place at levels unprecedented since the K/T Boundary. Snails possess a number of unique attributes as indicator species and apart from meriting conservation in their own right, their study is of considerable importance for recognising high diversity centres of endemism and for understanding what happens to biotas when forests are fragmented.

On the basis of her fieldwork on this Darwin Initiative project, Miss Raheem registered for her PhD at the University of Cambridge in October 2000. However, the generous support of Cambridge in allowing the first two-year's fees to be waived has in fact added to the difficulty of obtaining funding. The standard PhD award is for three years duration and several otherwise promising possibilities were excluded on this basis. Despite making considerable efforts to secure funding for Miss Raheem's final year at Cambridge we were unable to secure sufficient funding for the 2002/2003 academic year and the final year has been deferred. The NHM's Studentship fund has awarded £5000, the maximum amount available, towards the final year of Miss Raheem's PhD.

¹ *Nature* **394**: 120

² *Trends in Ecology and Evolution* **18**: 77-80

This investigation on the ecology of tropical land snails goes far beyond anything previously attempted for terrestrial Mollusca both in scale and in detail. A joint University of Cambridge and NHM supervision of this project provides the very necessary standard of intellectual and infrastructure support that is not available in Sri Lanka. In addition to carrying out excellent research, Miss Raheem is extremely hard working and totally committed. In the shifting sands of running the project in Sri Lanka Miss Raheem was absolutely reliable and her considerable efforts cannot be faulted. Miss Raheem is clearly a person capable of making a major contribution to the future of biodiversity in Sri Lanka. There can be few more deserving individuals or worthy subjects for a Darwin scholarship.

4. Studies on the evolution origins and historical biogeography of the Sri Lankan snail fauna. As a major fragment of Gondwana, the Deccan Plate has long been recognised to possess an impoverished relict fauna. This might be partly attributed to the collision with Eurasia having taken place some 30 million years ago and faunal fusion having a long history, but the formation of the Deccan Traps would have wiped out much of the Deccan biota some 65 million years ago. As a southern refuge in which Gondwanan relicts survive Sri Lanka has the most distinctively South Asian biota and is the key to investigating the regions early faunal identity and origins. A joint NHM/Nottingham University application for funding to address these and other issues in land snail evolution has been submitted to the Leverhulme Trust. This work will be based on molecular studies and will make extensive use of the snail tissue samples collected on the project.

5. Pattern and process giving rise to high diversity faunas. The tempo and mode of speciation and the degree of biotic mixing that gives rise to rainforest biotic diversity has major implications for justifying rainforest conservation and the Sri Lankan land snail fauna may supply key answers. Questions that are often asked about the origin of rainforest diversity include: does it exhibit long lived species or is speciation highly dynamic with rapid speciation and high extinction rates? Do rainforests exhibit long term stability in species community structure or is there a dynamic biotic interchange? Although Sri Lanka may have been connected by land bridges to the Indian mainland at various times, the rainforests of Southwestern Sri Lanka appear to have been ecological islands for most of their history. Long-term faunal continuity in a very small area for a long period of time is evidenced by the snail faunal endemism being greater than 90%. There are continuous cave fossil records of snail shells, particularly *Acavus*, going back 35,000 years in the same locality. Historical biogeographical and molecular evidence supports the hypothesis that *Acavus* is a Gondwanan relict and the morphology of *Acavus* appears to have changed little in over 100 million years. Yet at the species level *Acavus* appears to be in a dynamic state. Investigating such issues is important for understanding the pattern of diversity through time and for identifying faunas that have changed radically and those that have remained stable through long periods.

Oceanic island faunas generally exhibit radiations from relatively few colonising species and even continental faunas often exhibit a dominant family. However, an interesting feature of Sri Lanka's snail fauna is that, although there are several radiations, it is not dominated by any one group. In West Africa for example the Streptaxidae, an ancient

family of carnivorous snails, forms 65% of the rainforest snail fauna, this reduces to 50% in East Africa, 25% in Madagascar and in Sri Lanka streptaxids are just 5% of the snail fauna. Streptaxids are carnivores that feed on other invertebrates and are thought to have specialised diets. Such partitioning of food resources would give streptaxids a high potential for species diversity. In addition, streptaxids possess classical lock and key reproductive isolating mechanisms with penial hooks and corresponding vaginal pits that may facilitate rapid speciation. But why should a successful strategy in West Africa not meet with similar success in Sri Lanka?

The well-publicised views of Philip Stott^{3 4} and others that present counter arguments to rainforest conservation have received wide publicity. Their assertions that all rainforests have changed significantly and therefore do not represent pristine relicts of diversity that need to be cherished are as simplistic as the arguments expounded by some proselytising environmentalists that they seek to counter. The limited evidence we have suggests that the species-level diversity of snails in Sri Lanka may be dynamic, but it may also be dependent on patterns of faunal integrity over very long periods of time. Of major concern is that in the future even minor shifts such as those in the altitudinal distribution of faunas in response to climate change will be largely prevented owing to forest fragmentation. This may be a major factor contributing to extinctions in the medium term. Because these issues are of critical importance in conservation biology they need to be urgently addressed. Land snails are key groups for investigating these complex issues and the development of molecular techniques allows the investigation of testable hypotheses.

6. Extended comprehensive survey. As a continental fragment of sufficient size to exhibit a wide-ranging taxonomic base to its biota but small enough to allow comprehensive island-wide study, Sri Lanka offers an ideal subject for model faunistic studies. This will be a priority for consideration by the new biodiversity authority and institute and, as outlined above, it has high potential for funding and international attention such as by means of a Royal Society International Research Programme.

Peradeniya University based surveys of pest species and of the Knuckles range will continue as part of the research activity of Mr Ranawana. Life history studies of *Acavus* and *Oligospira* will probably be extended to include other genera.

The Biodiversity Authority and Rainforest Institute

The close historical links that bind the UK and Sri Lanka are reflected in the rich resources for regional taxonomy and systematics held at the NHM, which are essential for unlocking knowledge on Sri Lanka's biota. For many groups these amount to a monopoly of resources because they are found nowhere else. With the CD-Rom, a start has been made in transferring taxonomic resources but total self-sufficiency is not the answer. Both Sri Lanka and the UK have more to gain by sharing their resources and expertise. It is to

³ Stott, P & Sullivan Eds. *Political Ecology*. Arnold. London

⁴ Stott, P. 1999. *Tropical rain forest: a political ecology of Hegemonic myth making*. The Institute of Economic Affairs, London.

be expected that Sri Lanka will turn to the UK when seeking to develop its biodiversity capacity but the NHM and the UK scientific community also have a vested interest in responding to such approaches. If the NHM is to engage in the leading issue of understanding and conserving biodiversity and not simply acting as an increasingly irrelevant repository of historical information, we need to enhance our resources in line with current research needs and conservation issues.

With the Sri Lankan Prime Minister's active support the Sri Lankan Minister of Environment has sought to gain UK Government support for help in developing their imaginative and well thought out plans for a Biodiversity Authority and Biodiversity and Rainforest Institute. The NHM recognises the potential for mutual benefits as well as the obligation to make its resources available. The continued support of the Darwin Initiative would greatly facilitate this potentially significant partnership between Sri Lanka and the UK.

Niche-ecotourism: adult education and field study tours

Helpful links were established with the Sri Lankan Tourist Board who facilitated travel arrangements by, for example, arranging increased weight allowance for transporting research collections. The Tourist Board is interested in promoting ecotourism as part of the Sri Lankan Government's policy of seeking ways of promoting wildlife and tourism in a complementary and sustainable way. Plans are being put in place for Fred Naggs to lead field study tours in Sri Lanka from 2005 as part of the NHM's Adult Education programme. This will be run in conjunction with Jetwings Hotels Ecotourism Group, which is active in supporting and publicising research on Sri Lanka's biota <http://www.jetwingeco.com/>.

13. Value for money

As detailed above, the Darwin Initiative funding allowed additional support to be secured, which amounted to 42% of the total budget. The above report is considered to present robust evidence that the Darwin Initiative funding represented excellent value. In addition to achieving its stated objectives, the project has resulted in many additional outputs and opened up several avenues of research in areas of key importance to understanding biological diversity and the implications for conservation strategy. It has resulted in the discovery of many new species and recognition of Sri Lanka as a centre of global significance for land snail diversity and endemism. It has contributed to the Sri Lankan government's vigorous efforts to advance its capacity for engaging in biodiversity issues and meeting its obligations on the CBD and planning to operate in the international arena.

Author / Date

Fred Naggs, 14th February 2003.

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	5	Develop national strategies which integrate conservation and sustainable use.
7. Identification and Monitoring	70	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		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	10	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	10	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

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	2 Sri Lankan
1b	Number of PhD qualifications obtained	
2	Number of Masters qualifications obtained	
3	Number of other qualifications obtained	
4a	Number of undergraduate students receiving training	105 Sri Lankans
4b	Number of training weeks provided to undergraduate students	180
4c	Number of postgraduate students receiving training (not 1-3 above)	1
4d	Number of training weeks for postgraduate students	16
5	Number of people receiving other forms of long-term (>1yr) training not leading to formal qualification(i.e not categories 1-4 above)	8
6a	Number of people receiving other forms of short-term education/training (i.e not categories 1-5 above)	2
6b	Number of training weeks not leading to formal qualification	
7	Number of types of training materials produced for use by host country(s)	
Research Outputs		
8	Number of weeks spent by UK project staff on project work in host country(s)	24
9	Number of species/habitat management plans (or action plans) produced for Governments, public authorities or other implementing agencies in the host country (s)	1
10	Number of formal documents produced to assist work related to species identification, classification and recording.	6
11a	Number of papers published or accepted for publication in peer reviewed journals	2
11b	Number of papers published or accepted for publication elsewhere	2
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country	3
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)	2
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	6
14b	Number of conferences/seminars/ workshops attended at which findings from Darwin project work will be presented/ disseminated.	5
15a	Number of national press releases or publicity articles in host country(s)	6
15b	Number of local press releases or publicity articles in host country(s)	
15c	Number of national press releases or publicity articles in UK	4
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	
17b	Number of dissemination networks enhanced or extended	
18a	Number of national TV programmes/features in host country(s)	2
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)	2
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)	15,850 (computer equipment, books, identification guides)
21	Number of permanent educational/training/research facilities or organisation established	
22	Number of permanent field plots established	4 (ongoing life-history studies will not continue indefinitely)
23	Value of additional resources raised for project	49,800

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 £
NERC Report	Carbon and oxygen isotope variations within the shells of the Sri Lankan land snail <i>Acavus</i> : records of global patterns of air mass circulation. Leng, M.J., and Naggs, F., 1999. <i>NERC Isotope Geosciences Laboratory Report Series 145</i> : 1-12	<i>Natural Environment Research Council.</i>		
Book*	Land snail diversity in Sri Lanka Naggs, F., & Raheem, D. 2000	Department of Zoology, The Natural History Museum, London.	F. Naggs, Department of Zoology, The Natural History Museum, London, SW75BD	£95.00
CD Rom* To be replaced by interactive version	Land snail diversity in Sri Lanka Naggs, F., & Raheem, D. 2000	Department of Zoology, The Natural History Museum, London.	F. Naggs, Department of Zoology, The Natural History Museum, London, SW75BD	£35.00
Journal*	A phylogeny of the land snails (Gastropoda: Pulmonata) Wade, C., Mordan, P., & Clarke, B. 2001. <i>Proceeding of the Royal Society B 268</i> : 413-422.	Royal Society, London		
Abstract*	A preliminary survey of pest snails and slugs of vegetable crops in four districts of Sri Lanka. Kumburegama, N., Ranawana, K., & Naggs, F. 2001	Institute of Biology, Sri Lanka		

Abstract*	Land snail diversity in Sri Lanka, Naggs, F., Raheem, D., & Mordan, P. 2001	Unitas Malacologia, Vienna		
Field Guide*	Sri Lankan snails. Naggs, F., Raheem, D., & Taylor, H. 2002	Department of Zoology, The Natural History Museum, London.	The Museum Bookshop The Natural History Museum, London SW7 5BD Odel Bookshop Colombo 7 Barefoot Bookshop Colombo 5 Vijitha Bookshops (4 stores in Colombo 1 in Kandy) Mark Bookshop, Kandy. Jetwings Hotels bookshops: http://www.jetwing.net/ Department of Zoology University of Peradeniya	£3.50 Rs300
Leaflet*	<i>Land snail diversity in Sri Lankan rainforest fragments: snails as key indicators for conservation priorities.</i> Naggs 2002. Darwin Initiative Project: Land snail diversity in Sri Lanka, Information leaflet	Department of Zoology, The Natural History Museum, London	Fred Naggs Department of Zoology, The Natural History Museum, London	Free on request
Leaflet*	<i>Molluscan pests in Sri Lanka: voracious exotics having a major and rapidly increasing impact on agriculture.</i> Naggs 2002. Darwin Initiative Project: Land snail diversity in Sri Lanka, Information leaflet	Department of Zoology, The Natural History Museum, London	Fred Naggs Department of Zoology, The Natural History Museum, London	Free on request

Journal	The Darwin Initiative project on Sri Lankan land snails: patterns of diversity in Sri Lankan rainforest. Naggs, F., & Raheem, D. (In Press). <i>Biodiversity and Conservation Special Supplement of the Journal of Conchology</i> .	Conchological Society	Mr C.L. Gillard, 1 Court Farm, Hillfarrance, Taunton, Somerset, TA4 1AN	Not known
Field Guide	Pest and exotic Sri Lankan molluscs. Mordan, P.B., Naggs, F., Ranawana, K., & Taylor, H. (In Press: publication March 2003)	Department of Zoology, The Natural History Museum, London.	The Museum Bookshop The Natural History Museum, London SW7 5BD Odel Bookshop Colombo 7 Barefoot Bookshop Colombo 5 Vijitha Bookshops (4 stores in Colombo 1 in Kandy) Mark Bookshop, Kandy. Jetwings Hotels bookshops: http://www.jetwing.net/ Department of Zoology University of Peradeniya	£3.50 Rs300
CD Rom* Interactive	Land snail diversity in Sri Lanka Naggs, F., Raheem, D. & Chimonides, J. (In Preparation: publication March 2003)	Department of Zoology, The Natural History Museum, London.	F. Naggs, Department of Zoology, The Natural History Museum, London, SW75BD	£35.00
FieldGuide	Sri Lankan land snails. Naggs, F., Raheem, D., & Taylor, H. In Tamil Translated by J. Cankaye (In Press: publication March 2003)	Department of Zoology, The Natural History Museum, London & The World Bank, Washington	Wildlife Heritage Trust 95 Cotta Road Colombo 8 Odel Bookshop Colombo 7 Barefoot Bookshop Colombo 5 Vijitha Bookshops (4 stores in Colombo 1 in Kandy)	Free to schools, colleges, universities and government departments Rs100

			<p>Mark Bookshop, Kandy. Jetwings Hotels bookshops: http://www.jetwing.net/</p> <p>Department of Zoology University of Peradeniya</p>	
FieldGuide	<p>Sri Lankan land snails. Naggs, F., Raheem, D., & Taylor, H.</p> <p>In Sinhala.</p> <p>Translated by K.L.G. Hasantha Sanjeewa. (In Press: publication March 2003)</p>	<p>Department of Zoology, The Natural History Museum, London & The World Bank, Washington</p>	<p>Wildlife Heritage Trust 95 Cotta Road Colombo 8</p> <p>Odel Bookshop Colombo 7</p> <p>Barefoot Bookshop Colombo 5</p> <p>Vijitha Bookshops (4 stores in Colombo 1 in Kandy)</p> <p>Mark Bookshop, Kandy. Jetwings Hotels bookshops: http://www.jetwing.net/ Department of Zoology University of Peradeniya</p>	<p>Free to schools, colleges, universities, government departments, natural history and environmental societies</p> <p>Rs100</p>

17. Appendix IV: Darwin Contacts

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

Project Title	Land snail diversity in Sri lanka
Ref. No.	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	P. Mordan
Role within Darwin Project	Deputy Leader
Address	The Natural History Museum, London SW7 5BD
Phone	
Fax	
Email	
Partner 1	
Name	Miss D. Raheem
Organisation	
Role within Darwin Project	Project Manager
Address	1. 36/7A Sir Marcus Fernando Mawatha, Colombo 7, Sri Lanka 2. The Natural History Museum, London SW7 5BD
Fax	
Email	
Partner 2 (if relevant)	
Name	K. Ranawana
Organisation	University of Peradeniya
Role within Darwin Project	Team Leader
Address	Department of Zoology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka
Fax	
Email	

18. Appendix V: Forest Areas Surveyed

Wet Zone	Intermediate Zone	Dry Zone
<ul style="list-style-type: none"> • Auwegalakande OSF • Beraliya (Kudagala) PR • Campbell's Land FR • Dediya gala FR • Delgoda PR • Habarakada PR • Handapan Ella OSF • Haputale FR • Haycock FR • Hopewell OSF • Ingiriya FR • Kalubowitiyana OSF • Kalugala PR • Kombala-Kottawa PR • Kanneliya FR • Morapitiya-Runakanda PR • Nakiyadeniya PR • Namunukula PR • Malambure FR • Mulatiyana FR • Ohiya PR • Oliyagankele FR • Pattipola FR • Polgahakanda FR • Rammalakande FR • Sinharaja NHWA • Tangamalai Sanctuary • Udawattakelle FR • Viharekele FR • Waratalgoda PR • Welikanda PR • Yagirala FR 	<ul style="list-style-type: none"> • Doluwakanda PR • Galgiriya kanda PR • Gal Oya Valley National Park • Gannoruwa Forest • Kitulhela OSF • Korathalhinna OSF • Madiyala OSF • Menikdeniya OSF • Monerakelle OSF • Murutukanda OSF • Namandiya OSF • Neugalkanda PR • Opalagala OSF • Velihela OSF • Viyanahela OSF • Wadinahela OSF • Westminster Abbey OSF 	<ul style="list-style-type: none"> • Getalagamakanda OSF • Inamalawa PR • Ipolagama PR • Katupotakanda OSF • Sangappale PR • Wanniyagama PR • Wedakanda OSF • Weerakulicholai-Elavankulam PR • Yoda Ela PR

FR: Forest Reserve
PR: Proposed Reserve
OSF: Other State Forest
NHWA: National Heritage Wilderness Area

19. Appendix VI: Project Personnel

At the Natural History Museum

Fred Naggs (Project Leader)
Peter Mordan (Deputy Project Leader)
Jeni Stewart (Grant Administrator)
James Chimonides (Geographical Information Systems and Computer Expert)
Harold Taylor (Photographer)

In Sri Lanka

Team based at the Department of National Museums, Colombo:

Dinarzarde Raheem^{1,2} (Project Manager, Sri Lanka and leader of the Colombo based group.
Registered for PhD, University of Cambridge)
Yasantha Mapatuma (Nominal Principal Investigator, Acting Director of Museums, Department
of National Museums)
Lalith Kariyawasam² (Zoology Curator, Department of national Museums. Registered for MPhil,
University of Kelaniya)
Rohana Wasantha Jayasekera^{1,2} (Project field and research assistant)
Indrajith Perera^{1,2} (Project field and research assistant)
K.L.G. Hasantha Sanjeewa^{1,2} (Project field and research assistant, photography and computer
support)

Team Based at the University of Peradeniya:

Kithsiri Ranawana² (Leader of Peradeniya based group, Senior Lecturer, Department of Zoology,
University of Peradeniya. Registered for PhD, Post Graduate Institute of Science,
Peradeniya)
Prasantha Paranagama^{1,2} (Project field and research assistant)
Menaka Chandrasekera^{1,2} (Project field and research assistant)
Pradeep Samarawickrema^{1,2} (Project field and research assistant)
Dhammithra Samarasinghe^{1,2} (Project field and research assistant and photography)
Shalika Kumburegama (Special honours undergraduate student 2000-2002, 2002-2003 Assistant
lecturer, University of Peradeniya)

Additional personnel:

Wasana Perera (Driver and administrative assistant)
Ajith Hemachandra (Driver)
Chaminda Ranatunge (field assistant)
Lasitha De Silva (field assistant)
N.H. Chithrasekera (field assistant)
R.H. Weerasinghe (field assistant/camp assistant)
Ravindra Wikremanayake (field assistant)
Chamil Perera (field assistant and support driver)
Pesh Framjee (Honorary Financial Advisor UK).

Notes; 1. Employment funded by Darwin Initiative. 2. Working full time on project.