# *Darwin Initiative for the Survival of Species*

# *Annual Report*

## 1. Darwin Project Information

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| Project title | **TOOLS FOR MONITORING SOIL BIODIVERSITY IN THE A.S.E.A.N. REGION** |
| Country(ies) | Malaysia |
| Contractor | The Natural History Museum |
| Project Reference No. | 162/09/003 |
| Grant Value | £100,633 |
| Start/Finishing dates | 1 May 2000 – 30 March 2003 |
| Reporting period | 1 May 2000 – 30 March 2001 |

## 2. Project Background

The countries of ASEAN (Malaysia, Indonesia, Thailand, Philippines, Vietnam, Brunei and Singapore) contain a large proportion of the world's biological diversity. Much of this biodiversity occurs in forests and silvicultural habitats, where it lives in association with soil. Invertebrates form an integral part of healthy soils and help to regulate soil processes and maintain soil quality. However, across ASEAN, many of these species-rich habitats are being lost or degraded at an unprecedented rate, and there is growing concern that agricultural intensification is leading to loss of biodiversity, declining soil fertility and unsustainable levels of production.

Under the Convention on Biological Diversity (CBD), countries are required to develop national strategies for the conservation and sustainable use of biological diversity. An important prerequisite to that goal is the ability to assess the biodiversity that exists. In recognition of that fact, Article 7 of the convention suggests two practical activities:

(1) to monitor, through sampling, the components of biological diversity, and

(2) to monitor, through sampling, activities that are likely to have adverse impacts on the conservation and sustainable use of biological diversity.

In addition, Article 7 also states that countries should pay particular attention to ecosystems or habitats of agricultural or other economic value. Terrestrials soils, therefore, should be a focus of CBD initiatives because they support high biodiversity, they play a critical role in delivering ecosystem services of significant economic and social value, and they are under increasing threat from land-use change.

Successful implementation of the CBD requires the assessment of spatial or temporal patterns in biodiversity. For some groups of organisms it may be feasible to compile inventories of all species that occur at a site. But for most groups this is a practical impossibility. The use of standardised collecting methods is, therefore, the only way to ensure that within- and between-site comparisons are strictly comparable. However, at present there is a lack of well-established methodologies to undertake biodiversity assessment and monitoring. This is particularly true of soil biodiversity, partly because policy initiatives are running far ahead of ecological know-how. Thus there is an urgent need to develop practical tools for monitoring soil biodiversity in primary forests and silvicultural systems. Faced with limited funds, time and trained personnel, the sampling protocols that are adopted must be rapid field methods so that the amount of biodiversity assessment undertaken can be maximised.

Among the fauna of tropical soils, termites, earthworms, ants and beetles are of particular importance due to their abundance, species richness and ecological impact on soil processes. Termites, earthworms and ants are regarded as "ecosystem engineers" because of their major influence over the physical and chemical properties of soils. Termites feed on dead wood, litter and soil, and are highly abundant, making them the most important arthropod decomposers. Earthworms also feed on soil and leaf-litter, and can have a huge biomass. Ants are highly abundant, and are probably the most important predators and scavengers in tropical forests. These three groups are responsible for major perturbations of the soil profile due to their tunneling, ingestion, nest-building, and the translocation and mixing of organic matter and soil. These activities alter properties such as the structure, bulk density, CEC and pH of the soil, and in turn effect soil quality and fertility. Beetles are the most species-rich group of insects in tropical forests and therefore represent a sizeable proportion of local biodiversity. They also exhibit a wide array of life types and feeding habits. Together, these four groups of invertebrates help to structure soil communities, regulate decomposition and nutrient cycling, and are critical to the healthy functioning of soils.

At a national level, most countries of ASEAN currently lack sufficient ecological and taxonomic expertise to study soil invertebrate biodiversity. At a regional level, the few individual scientists who are experts on one or more of these groups of invertebrates are isolated and without the means to pool their knowledge and collaborate on research programmes to monitor soil biodiversity.

## 3. Project Objectives

The **main aim** of this project is to develop Rapid Biodiversity Assessment (RBA) protocols for termites, earthworms, ants and beetles. Once the RBAs have been developed, several objectives follow;

(1) To test the protocols in different locations and under different land-use regimes.

(2) To publish the results of the fieldwork using these RBA protocols in international peer-reviewed journals.

(3) To produce a handbook describing the RBA protocols and how they can be applied. The handbook will also discuss which type of land-use practices help to reduce negative impacts on the species-richness of these key organisms.

(4) To establish training workshops to teach the RBA protocols to biology, forestry and agricultural specialists from ASEAN countries.

(5) To set-up a Soil Biodiversity specialists group within the ASEAN region, and link this with the ASEAN Regional Centre for Biodiversity Conservation (ARCBC). The ARCBC will act as a clearing house for relevant information, while the specialists group country co-ordinators will be responsible for disseminating results of the RBAs to the agencies formulating national Biodiversity Action Plans.

(6) To establish a species-level database using the results of the RBAs to allow future investigates of biogeographical patterns of covariation in soil invertebrate biodiversity across the ASEAN region.

(7) To encourage taxonomic training within ASEAN, and to encourage further research into soil biodiversity and its impact on soil processes.

**Selection criteria for project participants**

As the main aim of this project is to develop RBAs for termites, earthworms, ants and beetles, the essential requirement is a team with sufficient taxonomic, ecological and sampling expertise in these four groups. The project advisors (see list of workshop participants below) was drawn from experts at the Natural History Museum (NHM), plus Dr Patrick Lavelle (Paris) who is the world's foremost tropical earthworm expert. The project has two Malaysian co-leaders: Dr Maryati Mohamed, Head of the Institute of Tropical Biology and Conservation, University Malaysia Sabah (UMS), and Dr Chey Vun Ken, Head of Entomology, Forest Research Centre (FRC), Sepilok, Sabah. Dr Maryati is an ant expert, while Dr Chey is an expert on termites and beetles. The two co-leaders selected the most suitable individuals from their institutions to be Darwin Fellows. Dr Homathevi Rahman (UMS) has a PhD on the ecology and taxonomy of Sabah's termites, Dr Arthur Chung (FRC) has a PhD on the ecology and taxonomy of Sabah's soil beetles, while Mr Bakhtiar Effendi (UMS) is currently doing research on the taxonomy of Sabah's ants. No other country in ASEAN has this amount of high quality expertise in soil invertebrates, and therefore Sabah was the only suitable host for this project.

## 4. Progress

The first year of the project can be divided into three phases.

1. A planning workshop at the NHM for all consortium members. The workshop aimed to design the sampling protocols and select field sites.
2. Fieldwork in Sabah (Malaysia) to run the agreed protocols at the selected sites.
3. Identification of specimens collected during the fieldwork.

**Workshop - May 2000.**

A five-day planning workshop was organised at the Natural History Museum, London. The workshop was attended by 15 scientists:

Dr David Jones (NHM; project co-leader and termite specialist)

Dr Maryati Mohamed (UMS; project co-leader and ant specialist)

Dr Chey Vun Khen (FRC; project co-leader and specialist on beetles and termites)

Dr Homathevi Rahman (UMS; Darwin Fellow and termite specialist)

Dr Arthur Chung (FRC; Darwin Fellow and specialist on beetles and ants)

Mr Bakhtiar Effendi (UMS; Darwin Fellow and ant specialist)

Dr Paul Eggleton (NHM; advisor on termite ecology, taxonomy and sampling)

Mr Barry Bolton (NHM; advisor on ant taxonomy and sampling)

Mr Peter Hammond (NHM; advisor on beetle taxonomy and sampling)

Dr Frank Krell (NHM; advisor on soil beetle taxonomy, ecology and sampling)

Dr Patrick Lavelle (Paris University; advisor on earthworm ecology and sampling)

Dr David Bignell (QMW, University of London; advisor on sampling soil macro-fauna)

Dr Bill Dubbin (NHM; soil scientist)

Dr Richard Davies (NHM; advisor on soil invertebrate sampling and statistics)

Dr Sarah Donovan (NHM; advisor on termite ecology and feeding habits)

The purpose of the workshop was to bring together all members of the project consortium in order to achieve the following aims;

1. to review the methods for sampling termites, ants, beetles and earthworms

2. to devise rapid sampling protocols for these groups, and plan suitable methods for testing their effectiveness

3. to plan the fieldwork, and set deadlines for the next three years.

The workshop was divided into several sessions, each being led by the most experienced scientist in that field (see workshop programme: Appendix 1). The most important sessions were those that dealt with sampling methods. The session leader reviewed existing methods for sampling their group of invertebrates, followed a “round table” discussion centred on what methods would best fit with the project aims. The workshop produced lively discussions, and included animated debates on the following questions:

1. how much sampling effort is required for each target group? A rapid assessment protocol must involve a trade-off between trying to minimise the size of the samples in order to reduce the time spent collecting and sorting, and the need for samples that are large enough to be representative of the local assemblage.

2. the definition of "soil", and whether translocated soil (e.g. soil plastered inside dead logs by termites) and suspended soils should be included in the protocols?

3. should there be one combined protocol that seeks to sample all four target groups, or a separate protocol for each group? The latter approach would allow a "modular" sampling package whereby the user can collect only those groups they are interested in (and/or have the taxonomic expertise to identify)

4. what sampling methods would be suitable for use in ASEAN? For example, Tullgren funnels are very effective at extracting invertebrates from soil samples but require an electricity supply. The consortium wanted relatively simple, "low-tech" sampling methods that could be run in remote areas.

By the end of the workshop the consortium had agreed to adopt the following sampling methods, and test them in the first year of fieldwork. The whole RBA package would consist of two distinct parts.

**Winkler sampling for ants and beetles**. The Winkler sampling method is the easiest method of extracting beetles and ants from leaf litter and soil, and does not require an electricity supply. 15 quadrats (each 1 m x 1 m) of leaf-litter and surface soil would be collected per site. The collected material is then sieved and hung in Winkler bags for 72 hours.

**A belt transect for sampling termites and earthworms**. For termites and earthworms it was decided to sample along a belt transect. The belt transect is 100 m long by 2 m wide, and divided into 20 sections (each 5 m x 2 m). In each section 12 soil samples (12 cm x 12 cm x 10 cm depth) are collected and hand-sorted *in situ* for termites and earthworms. This is followed by 30 minutes of qualitative collecting effort in each section. The qualitative collecting aims to increased the species richness of the RBA sample by hand searching in "hotspots" such as organic-rich deposits between the buttress roots of large trees, soil under rotting logs and inside and beneath termite mounds and earthworm casts.

**Fieldwork – 27 September to 3 November 2000**

The objectives of the fieldwork were:

1. To examine whether RBA samples collected at the same site gave results that were not significantly different from each other. Does the RBA produce a consistent "within-site" signal, or is the signal swamped by random "noise"?
2. To examine whether RBA samples collected in different habitats produce significantly different signals. Can the RBA detect "between-site" differences due to different forest size or land-use practices?

Fieldwork was undertaken at three sites in Sabah, Malaysia. These were:

1. Primary forest at Danum Valley; a large area (43,800 ha) of continuous primary forest
2. Primary forest at Sepilok; a small area (4,300 ha) of primary forest
3. Oil palm plantation at Segalud-Lokan

**Identification of specimens (three months during November 2000 to April 2001)**

The Darwin Fellows worked on the material in Sabah and London, and made preliminary identifications of most specimens. The three Darwin Fellows were at the Natural History Museum in March 2001 for six weeks to check their identifications and work with the museum taxonomists to ensure the identifications were correct. The input of the museum staff was essential to provide taxonomic quality control.

**Training**

This project has two training elements. The first is the informal and on-going training given to the Malaysian members of the consortium by the UK experts. The second element of training is the provision of the RBA training course. The first RBA training course will be scheduled to occur near the end of the third year of the project and will be offered to people from ASEAN countries.

During the first year of the project, the informal training has included many aspects, such as learning new field sampling techniques, statistical design and improving taxonomic skills. In addition to the three Darwin Fellows, other Malaysians have also benefited. Specifically, three UMS undergraduates and four FRS technical staff worked as field assistants to the project during the fieldwork where they learnt a range of field sampling techniques. In the evenings I taught the assistants how to recognise different invertebrate groups and how to sort the mixed samples of specimens from the Winkler bags.

**Difficulties encountered during the first year**

1. The termite fauna of Danum Valley is very known due to extensive research in the past. Therefore, it will be possible to calibrate the RBA samples in order to determine what proportion of the termite fauna is being sampled by the RBA protocol. And it will also be possible to determine whether the RBA protocol produces a sample that is representative of the taxonomic and functional composition of the local termite assemblage. At the

workshop it became clear that such calibration may not be possible for ants, beetles or earthworms because the amount of baseline data available for these groups is very limited compared with the amount of data available for termites.

2. The plan was to run two entire RBA samples at each of the three sites during the fieldwork. However, the early on-set of the rainy season meant that we lost several days of fieldwork. This resulted in us only running one RBA sample at the oil palm site. This eliminated the possibility of a within-site comparison in this habitat type.
3. At Danum Valley two RBA samples were undertaken in what appeared to be similar areas of primary forest. However, the second area was later found to be an anomolous site with an unusually high soil pH (despite the forest structure and topology being similar to the first site). This, in turn, appears to be associated with the recorded differences in species richness and abundance observed between the two areas. This limits our intention of testing whether the RBA protocol can reproduce the same results in the same habitat type.
4. While doing fieldwork at Sepilok, the Winkler bags were hung up at the FRC laboratory. During the night five of the 15 collecting pots were stolen from the bottom of the Winkler bags. It is believed that children from the neighbouring residential area climbed through a hole in the perimeter fence and removed the pots. Therefore, the within-site comparison will consist of 15 versus 10 Winkler samples. This will compromise the statistical analysis of differences in species richness and composition.
5. The taxonomy of Sabah's termites is relatively well known compared to the other three groups. It was therefore possible to identify most termite specimens to named species, and the remainder were identified to numbered morphospecies within named genera. A total of 255 vials of termites were collected, and contained a total of 48 species. For ants, almost all of the 14,143 specimens were identified to named genera. However, because of alpha taxonomic difficulties (such as recognising intraspecific polymorphism), and the large number of specimens, not all the material was identified to morphospecies by the end of the first year. This resulted in slippage – see below.
6. Of the 1318 earthworm specimens, all were identified to morphospecies by the end of the first year. However, further laboratory studies of the specimens are needed to assign the morphospecies to families, genera and functional/feeding groups. This resulted in slippage – see below.
7. The 1,986 beetle specimens also proved to be difficult because of sexual dimorphism and difficulties associated with the smallest specimens. By the end of the first year, not all specimens were identified to numbered morphospecies within named families, subfamilies or genus. This resulted in slippage – see below.

**Changes to the first year workplan**

The only change during the first year was to adjust the timing of the visit of the three Darwin Fellows to London. In the original plan their six week stay was due to finish at the end of March 2001. However, due to other work commitments this had to be moved, and the six week stay finished at the end of April 2000. This was agreed with Valerie Richardson.

**Timetable – workplan for second year**

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| April 2001 | Last three weeks of the 3 Malaysian Darwin Fellows stay in London. |
| April 2001 | One day workshop for 6 UK staff and 3 Malaysian Darwin Fellows to discuss results of first year and plan fieldwork for second year. |
| May 2001 | Finish identifying ants, beetles and earthworms from first year's fieldwork. |
| June 2001 | Establish Soil Biodiversity specialist group network across the ASEAN region. |
| July 2001 | Mr Bakhtiar Effendi (Darwin Fellow) to attend Ant conference in USA. |
| Aug 2001 | Submit manuscript on first year results to peer-reviewed journal. |
| Sept 2001 | Four weeks fieldwork in Sabah. |
| Oct 2001 | Set-up species-level database at UMS. |
| Oct 2001 | Identification of second year specimens (three months work) |
| Nov 2001 | Dr Arthur Chung and Mr Bakhtiar Effendi (Darwin Fellows) to attend ASEAN conference on arthropod biodiversity. |
| Dec 2001 | Send out first Soil Biodiversity newsletter to Specialist group across ASEAN. |
| Mar 2002 | Three Darwin Fellows to come to London for six weeks for taxonomic work with museum specialists. |
| Mar 2002 | Submit RBA manuscript to peer-reviewed journal |

## 5. Partnerships

The project was fortunate to collaborate with Dr Mark Hassall (University of East Anglia). He was planning to supervise one of Dr Maryati's graduate students on a project to investigate the impact of land-use change on woodlice (terrestrial isopods). It was decided that Dr Hassall and his student would design their own RBA for woodlice and then dovetail with our consortium in the field in order to sample in the same sites. This was a mutually beneficial arrangement because the woodlice project could share our logistical arrangements while we would have access to data from a fifth group of soil invertebrates. All expenses of Dr Hassall and his student were paid by grants from UMS and the Royal Society.

I have also linked up with Alex Monro (Botany Department, NHM) and plan to conduct soil biodiversity sampling in El Salvador. Alex Monro is Principal Investigator of the Darwin Initiative project "Empowering local people to manage the biodiversity of El Salvador". The government of El Salvador is very keen to support research into soil invertebrates, and so I will be collaborating with several of their scientists to study soil biodiversity under different land-use regimes. This work will be funded partly by the government of El Salvador and partly by a donation from the Harold Hyam Wingate Foundation (a UK charity).

## 6. Impact and Sustainability

University Malaysia Sabah has set-up a modern Zoological Reference Collection at their new campus. Dr Maryati's aim is for the collection, called *Borneenis*, to become the largest and most important zoological collection dedicated specifically to the fauna of Borneo. UMS is therefore delighted that the Darwin project has already started adding identified specimens to *Borneensis*, thus enhancing its capacity for biodiversity research.

The Darwin project has received very favourable media coverage in Malaysia. While in Sabah I arranged an interview with the Daily Express (one of Malaysia's leading broadsheet newspapers) which resulted in a two page article about the project entitled "Unlocking our forest's secret to healthy soil", published on 28 January 2001. I understand that Dr Arthur Chung and Dr Chey Vun Khen have also given interviews to local journalists.

In August 2000, I attended the XXI International Congress of Entomology at Iguassu, Brazil. I presented a paper entitled "Evaluating practical methods for sampling soil invertebrate bioindicators". During the talk I outlined the aims of the Darwin project. This generated much interest and many valuable contacts were made. It is clear that there is growing demand for standardised sampling methods for monitoring terrestrial biodiversity.

**Exit strategies**

When the grant period has ended, UMS and FRC will have significantly enhanced institutional capacity due to the Darwin project and all the training that has taken place. These institutions will take over responsibility for the following activities;

1. UMS will assume responsibility for running the annual RBA training courses. The UMS and FRC Darwin Fellows will be sufficiently trained and competent to become the trainers on these courses.
2. Drs Maryati and Homathevi (UMS) will initially assume responsibility for co-ordinating the Soil Biodiversity specialist group network. However, it is hoped that the ASEAN Regional Centre for Biodiversity Conservation (based in the Philippines) will take over this role, and will disseminate information and help to organise enrolment in the annual RBA training courses. ARCBC and UMS will also be instrumental in seeking commitments from donor agencies to provide regular financial support for future RBA training courses.

After their participation in the RBA training course, the specialists from ASEAN will be able to run the RBAs in the home countries. They will then supply the results of their own RBAs for inclusion in the species-level database.

## 7. Outputs, Outcomes and Dissemination

- Please expand and complete Table 1. **Quantify** project outputs over the last year using the coding and format from the Darwin Initiative Standard Output Measures (see website for details) and give a brief description. Please list and report on appropriate Code Nos. only. The level of detail required is specified in the Guidance notes on Output Definitions which accompanies the List of Standard Output Measures.

**Table 1. Project Outputs (According to Standard Output Measures)**

| Code No. | Quantity | Description |
|---|---|---|
| 14B | 15 people | 5 day planning workshop (May 2002, London) |
| 8 | 2 people | Arthur Chung and David Bignell inspect field sites (1 week, June 2000) |
| 14D | 1 person | David Jones gave oral paper at XXI International Congress of Entomology (Brazil, Aug 2000) |
| 15B | 1 | 1 local press release in Sabah about launch of project (September 2000) |
| 8 | 4 UK experts | Four weeks fieldwork in Sabah (Oct 2000) |
| 4 | 3 people | 3 Darwin Fellows trained during 4 weeks of fieldwork |
| 4A | 3 people | 3 UMS undergrads trained during 4 weeks fieldwork |
| 4C | 1 person | 1 UMS postgrad trained during 4 weeks fieldwork |
| 4 | 4 person | 4 FRC technical staff trained for two weeks each during fieldwork |
| 13B | three | Enhanced beetles, ant and termite collections at UMS and FRC |
| 15A | one | Two page feature article about Darwin project in national newspaper (Daily Express, Jan 2001) |
| 4 | 3 people | 3 Darwin Fellows trained at Natural History Museum for six weeks (March & April 2001). |

The only outputs not achieved was 22 – the establishment of permanent research plots. After discussions with the senior management at Danum Valley and Sepilok Forest Reserve, it was decided that the establishment of permanent plots would not be appropriate or compatible with their management plans.

**Table 2: Publications**

| **Type *** (e.g. journals, manual, CDs) | **Detail** (title, author, year) | **Publishers** | **Available from** (e.g. contact address, website) | ***Cost £*** |
|---|---|---|---|---|
| Conference abstract (available in book and CD ROM format) | "Evaluating practical methods for sampling soil invertebrate bioindicators". Jones, DT & Eggleton, P. (2000) | Abstracts of the XXI International Congress of Entomology. Londrina: Embrapa Soja, 2000. Vol. 1, page 106. | ISSN 1516-781X | |

## 8. Project Expenditure

**Table 3: Project expenditure during the reporting period**

| Item | Budget | Expenditure |
|---|---|---|

## 9. Monitoring, Evaluation and Lessons

The most valuable lesson learnt so far is the need for open and honest communication between all members of the consortium. Only through open discussions at the workshop were we able to overcome potential conflict of interests which otherwise may have become a problem in future.

Another valuable lesson is the fact that we underestimated the amount of material the protocols would collect, and the subsequent time required to sort, mount and identify the specimens. More time must be allowed for this in future.

## 10. Author(s) / Date

David T. Jones. 12 October 2001.