

Nematode biodiversity and worldwide pollution monitoring

Plymouth Marine Laboratory
(and Natural History Museum)

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Nematode biodiversity and worldwide pollution monitoring – final report

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Darwin Initiative for the Survival of Species

Final Report

1. Darwin Project Information

Project title	Nematode biodiversity and worldwide pollution monitoring
Country	Brazil, Poland, Pakistan, India, Trinidad and Tobago, South Africa, Kenya, Chile, Vietnam
Contractor	Plymouth Marine Laboratory (and Natural History Museum)
Project Reference No.	162/8/140
Grant Value	£163,200
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2. Project Background/Rationale

The ubiquity, abundance and diversity of marine nematodes make them an important part of the marine ecosystem. Nematodes dominate an ecologically defined group of small organisms known as meiofauna that live in all marine habitats but particularly the sediments that cover more than 90% of the seabed. Meiofauna are food for shellfish and juvenile fish but they also play a major role in decomposition and recycling of dead and decaying animals and plants. In this respect they are similar to earthworms in soil. They are also good indicators of marine pollution. Despite their importance meiofauna and nematode worms are generally poorly studied world-wide because they are perceived to be difficult to identify. As experts in marine meiobenthos, the meiofauna of the seabed, Plymouth Marine Laboratory (PML) and the Natural History Museum (NHM) were (and still are) frequently approached by marine biologists from other countries for assistance in meiobenthic taxonomy, either to provide training or to identify specimens.

Meiofauna have evolutionary and ecological characteristics which distinguish them as a group from other benthic species and which make them extremely useful indicators of environmental stress. Small, easily handled samples can yield 1000's of individuals from highly diverse communities in all marine habitats from estuaries to the deep sea.

Globally, an increasing number of researchers are using meiofauna to estimate the health of the environment. Outside of Europe and the US most of these analyses were to major taxa level i.e. phylum. We were often asked to referee papers describing these studies which had been submitted to scientific journals. Little meaningful information can be extracted from these surveys, they do not aid in environmental management and they do not further local or regional knowledge of biodiversity.

There was a requirement for a rapid increase in the number of biologists worldwide able to identify meiofauna and utilise this ecological information for monitoring of the local environment and empowering local management decisions, particularly with respect to pollution. Most coastal pollution in resource limited countries occurs in the poorest regions affecting local economies by harming fisheries and aquaculture as well as tourism prospects. In many situations the local people do not have the

necessary skill base to make assessment of their coastal environment and hence influence management decisions to alleviate the pollution.

The free-living marine nematodes are usually the dominant phylum in the meiofauna. Their communities are highly diverse, abundant in almost all habitats and also extremely productive. Yet the expertise to identify them to putative morphological species was found only amongst a handful of researchers, the majority of whom were based in north Western Europe. The term putative species is used because outside of European waters it is estimated that only between 0.4% and 0.04% of nematodes species have been described.

The project aimed to assist countries to assess the local biodiversity of nematodes as well as using this group to assess local environmental quality. This included creation of a virtual museum nematode collection to enable scientists to give new, undescribed species names which can be used by their colleagues whilst the species await formal description in the scientific literature.

PML and NHM had received request for training in nematode identification and the use of nematodes in environmental assessment from a wide diversity of countries and continents (Poland, Brazil, Chile and Pakistan). Additionally we were aware from submitted manuscripts and through meeting people at international meiofauna meetings, of individual researchers who were trying to come to grips with using meiofauna for environmental assessment. Again these people were geographically widely dispersed. Therefore we decided to aim the project at multinational partners, particularly via training workshops in the UK and use of the Internet to seed understanding and use of meiofauna world-wide rather than focusing on partners from just one or two countries.

3. Project Summary

The purpose of the project was to assist biologists worldwide to assess the local biodiversity of nematodes as well as using this group to assess local environmental quality.

The project objectives were to

1. develop an easily accessible and updateable marine nematode internet key;
2. provide a UK based advanced training workshop in meiofaunal identification and specifically in marine nematode taxonomy for 15 biologists;
3. collaborate on specific regional and local marine environmental monitoring/biodiversity censusing projects in Poland and Brazil, providing further advanced training and thus developing local facilities and expertise;
4. provide a UK based advanced training workshop on statistical analysis of community data.

Articles under the Convention on Biological Diversity (CBD) which best describe the project are:

1. exchange of information (on nematode identification)
2. research and training (training to enable nematode research and use of nematode ecology in the assessment of environmental degradation)
3. identification and monitoring (identification of marine nematodes).

The objectives of the project were all successfully met. The take-up of the nematode identification key, both on the Internet and on CD-ROM has exceeded our expectations. The geographical coverage of the countries accessing the web site and

key and requesting the key on CD-ROM has been enormous.

The two training workshops were successfully run in Plymouth with enthusiastic participants and extremely positive feedback on the workshop content and teaching. The participants particularly enjoyed the multinational aspects of the workshops as a means of forging new collaborations and of sharing their experiences with scientists from other countries who feel similarly ‘isolated’ (within their own country) in their specialist work on meiofauna and nematodes.

The collaboration on projects within Poland and Brazil involved assisting scientists on several projects that were already underway in each country. This assistance included helping with nematode identifications and providing further training in identification to additional scientists who had not been to the Plymouth workshop; rationalising procedures for analysing meiofauna; advising on sampling and data analysis protocols and informal lectures on biodiversity (to university staff and students in Brazil). Bringing together scientists from different parts of the country (in Brazil and Poland) has enhanced their communications and promoted a sense of scientific community. A new Darwin research project sampling nematodes in the mangroves has been initialised in Brazil and sample analyses is still underway by the Brazilian scientists. Scientists in Poland were already heavily committed to their own meiofauna research programmes concerning pollution monitoring in the Baltic and biodiversity monitoring in the Arctic and in the deep sea. Some of these projects were already part of national collaborations and it was not appropriate to initialise additional new collaborative projects. PML scientists have therefore assisted Polish scientists in the analysis of their samples and provided more advanced training for the analysis of the data being produced.

Every effort has been made to publicise the project in local media, to increase awareness of the Darwin Initiative and its objectives, and to increase awareness of the need for determining the effects of man’s activities in coastal regions.

4. Scientific, Training, and Technical Assessment

Training workshops in Plymouth

Nematode identification

PML hosted a one-week Darwin Nematode Identification Workshop for 16 scientists from Brazil, Chile, Trinidad & Tobago, Poland, Kenya, South Africa, India, Pakistan and Vietnam. Participants were selected through three mechanisms to enable wide geographic coverage:

1. From people who had previously written to PML and NHM staff requesting such training
2. By asking other European nematode experts (Belgium, Sweden) who also work with scientists in developing countries for names of scientists who have similarly requested training
3. By approaching scientists in developing countries with a recent publication record in meiofaunal ecology, thus showing a committed interest in meiofauna, but who had not published species level data indicating a lack of training in species identification

In the letter of invitation to selected candidates it was made clear that the workshop training was aimed at:

- biologists who are already using, or intend to use marine meiofauna studies

for pollution monitoring but who do not currently have the expertise to analyse their samples and data with sufficient rigor to obtain data that can most usefully assist them in their environmental management

- teaching staff at universities who will further spread their knowledge to other students.

At the workshop initial training was given in identification of nematodes to genus level, use of the electronic and paper identification keys, and in sample preparation and analysis. Training was given through

- 1-2 daily informal lectures,
- hands on practical identification sessions with a high power research microscope provided for each participant including two microscopes with video monitors
- demonstration of practical techniques used at Plymouth and the NHM for meiofaunal sample preparation

Workshop participants established a Darwin Nematode network that is active through the Darwin Nematode web site and through personal email contact.

At the end of the workshop each participant was given a copy of the nematode identification keys (R.M. Warwick, H.M. Platt, P.J. Somerfield 1998. Free-living marine nematodes Part III Monhysterids. Field Studies Council, Shrewsbury) and a starter pack of laboratory materials necessary to analyse nematode samples (63µm sieve, evaporating dishes, slides, coverslips and coverslip forceps, metal applicators, paraffin wax and Bioseal sealant (for preparing wax rings in which to mount and seal samples on slides with coverslips), diamond tipped glass pens).

From participants feedback (verbal and questionnaire forms - see Annex 1) the multinational Darwin Nematode Identification workshop was a great success. The participants' previous experience in meiofauna work, ages and English language competence varied considerably. Therefore feedback ranged from suggestions for more basic information on identification, sampling, extraction and ecology from the novices, to suggestions for more detailed lectures and practical sessions on the finer points and more complicated aspects of nematode taxonomy from those with more previous experience! It is difficult to see how this could be avoided. We had not met the majority of the participants before the workshop and were unable to determine their levels of experience even though we had requested this sort of information on the application forms (although perhaps not explicitly enough). On the other hand, the mix of abilities probably increased the group rapport and helped to show the more experienced participants new and simpler ways of explaining the basics of nematode taxonomy to trainees, thus helping them in their future teaching. Group discussions were clearly a popular part of the workshop and most participants suggested this element of the workshop could be increased. Most also suggested the workshop should have been longer to allow for extra sessions, more detail and more group discussion. Several participants expressed strong enthusiasm for regional workshops so that the workshop could be tailored to the local fauna and the local ecology. We are investigating the possibility of this in future grant applications.

With British Council funding Dr Thanh (Vietnam) stayed on at PML for one month. Dr Fernando (India) also stayed on at PML for one week funded by her university. Both spent the time working with PML scientists on nematode taxonomy and benthic ecology.

Analysis of community data

From October 1st PML hosted a second extremely successful one week training workshop on statistical analysis of community data using PRIMER software for 16 trainees from Brazil, Trinidad, Poland, Pakistan, India, Kenya, South Africa, Vietnam. The trainees were re-invited from those who had attended the first nematode identification Darwin workshop. One invitee (from Chile) was unable to attend and an additional participant was invited from Vietnam instead. Dr Chau Choc was from the same institute as Dr Thanh who had attended the first Darwin workshop. He had written to me requesting that he could come to the workshop. Since Dr Thanh's English was a limiting factor at the first workshop we decided to invite Dr Chau Choc to increase the possibility that a good grasp of the techniques would be collectively taken back to their institute. The workshop was well publicised with TV and radio broadcast and newspaper articles.

The PRIMER statistical analysis training course on multivariate and univariate analyses of community data has been given many times in many different countries both through government sponsorship and commercial funding. It is designed to meet the needs of biologists interpreting species data and associated environmental variables, from impact assessments or fundamental biodiversity studies. Training was aimed at biologists without specialist knowledge of statistics. Whenever possible, each course is tailored to the participants and the Darwin PRIMER workshop was geared towards analysis of benthic data and particularly nematode and meiofauna data.

The course covered the basic methodology of defining similarity of two assemblages, hierarchical clustering of samples (CLUSTER), ordination by non-metric multi-dimensional scaling (MDS) or principal components analysis (PCA), hypothesis testing on similarity matrices (ANOSIM) and other permutation tests (eg RELATE), linking biotic patterns to associated environmental variables (BIO-ENV), identifying species mainly responsible for observed community pattern (SIMPER, BVSTEP), comparison of ordinations (eg 2nd stage MDS), dominance curves, biodiversity indices, including new measures and tests based on taxonomic relatedness (TAXDTEST), etc. It also tackled interpretational and practical issues (taxonomic level, causality, design, differences between faunal types, method sensitivity etc).

Training was given through:

- 2-3 daily informal lectures,
- hands on practical sessions working through case studies on literature data with 2-3 participants working together on one computer.

Materials included the book 'Change in marine communities', including updates on the most recent methodology. Participants were encouraged to bring their own community data, in simple species-by-samples layout in Excel, for analysis and interpretation during the practical sessions. Only a few participants brought data of suitable experimental design for statistical analysis using PRIMER. Each participant was given the PRIMER software, manuals and a single-user licence for the new Windows version of PRIMER (v5), released at the end of 2000, which was used for all practical sessions. Participants had the opportunity to discuss technical details of the software with the programmer for PRIMER v5, Ray Gorley. Participants were given reprints of publications detailing the use of PRIMER software for specific examples of monitoring of marine benthos and biodiversity for environmental impacts. They were also given a CD-ROM version of the nematode identification key

and Darwin nematode web site.

From participants feedback (verbal and questionnaire forms- see Annex 2) the multinational Darwin Nematode Identification workshop was also a great success. Again there were mixed abilities and former experience amongst the participants with respect to statistical analysis of data. The feedback shows that some participants found the practical sessions too long but wanted more time to analyse their own data whilst other wanted more time for practical sessions. All participants have indicated that they plan to use the PRIMER software in the future.

The three Brazilian participants (Ms Pinto de Kramer, Mr, Esteves and Mr Castro) stayed on for an additional week at PML at their own expense to carry out further nematode taxonomy in collaboration with PML scientists.

Local workshops and training

Brazil

Three scientists from PML visited the Department of Zoology at the Federal University of Pernambuco in Recife, Brazil during October-November. We advised on meiofaunal study techniques used in the department and suggested improvements. We provided further training on meiofaunal sampling, extraction and analysis and assisted on nematode identification. Training was extended to 7 scientists from the Universidade Federal de Pernambuco in Recife, additional to the three who attended the Plymouth workshop (Francisco Castro, Universidade Federal de Pernambuco; Andre Esteves, Universidade Federal do Rio de Janeiro and Taciana Kramer Pinto Universidade de Rio Grande). Travel funds were provided to enable students to travel to Recife to participate in the further training. Fieldwork was carried out in sandy beach habitats, abandoned fish farms and in a mangrove area. A joint sampling program was initiated in the mangrove to assess the diversity of meiofauna and particularly nematodes in microhabitats within the mangrove using a novel sampling design. Sample analysis was divided amongst the three PhD students who came to the identification workshop at PML. We are still awaiting completion of nematode analysis by one of the scientists. His efforts on these samples were delayed as he had to complete his PhD by a deadline. We intend to assist the Brazilian scientists in their data analysis and in the publication of their results.

Poland

Two scientists from PML visited the Sea Fisheries Institute, Gdynia, Poland during May 2001. Four Polish scientists attended the informal workshop. Three scientists had already attended the nematode identification workshop at PML: Alexander Drgas (Sea Fisheries Institute, Gdynia), Maria Szymelfenig (Institute of Oceanography, University of Gdansk), Joanna Rokicka-Praxmajer (Department of Oceanography, Faculty of Marine Fisheries and Food Technology, Agricultural University in Szczecin). Barbara Urban-Malinga, (Institute of Ecology PAS) had not attended the workshop and was a beginner in nematode identification. PML scientists advised on meiofaunal study techniques used in Poland and suggested improvements. We provided further training on meiofaunal sampling, extraction and analysis and spent considerable time assisting with nematode identification and providing further training. We particularly helped with Polish samples for environmental monitoring from the Baltic and with samples for biodiversity analysis from the Arctic and the

deep sea. Travel funds were provided to enable Joanna Rokicka-Praxmajer to travel to Gdynia from Szczecin to participate in the further training.

Darwin Nematode web site

The Darwin Nematode web site gives background information on the Darwin Initiative and information about the objectives and aims of the Darwin Nematode project including information about and photos of the Plymouth workshops. It hosts the Darwin Marine Nematode Identification Key – Nemkey, and the Darwin Virtual Collection for nematodes. The site also hosts web pages on nematode morphology. There is a laboratory manual describing techniques for processing meiofauna samples, including information on required equipment and chemicals as well as a list of suppliers. The laboratory manual also gives information about other major taxa in the marine meiofauna. The Darwin Nematode network is hosted on the Darwin nematode web site. This provides a discussion forum for all issues on marine nematodes.

Information about the web site and the Darwin Nematode Keys and Virtual Collection has been presented at four international meetings and in three publications:

Oral presentations:

Second BioNET international global workshop (BIGW2) 22-29th August, Cardiff, Wales

- Austen, M.C., Ferrero, T., Caithness, N., Kendall, M.A., Lambshead, P.J.D., Nicholson, S.K., Paterson, G.L.J., Virtual Collections and Interactive keys: Taxonomy on the Internet.

Porcupine Marine Natural History Society, The marine natural history of the NE Atlantic: approaches to identification, Plymouth, UK

- Austen, M.C., Demystifying nematodes

Eleventh International Meiofauna Conference, Boston, USA July 2001

- Austen, M.C., Demystifying nematodes

Fourth International Congress of Nematology, Tenerife, Spain, June 2002

- Austen, M.C., Natural nematode communities are useful tools to address ecological and applied questions.

Poster presentations:

Eleventh International Meiofauna Conference, Boston, USA July 2001

- Austen, M.C., Atkins M. and Nicholson, S.K., Online nematode identification systems and virtual collections

Fourth International Congress of Nematology, Tenerife, Spain, June 2002

- Austen, M.C., Atkins M. and Nicholson, S.K., Online nematode identification systems and virtual collections

Publications:

- Austen, M.C., Ferrero, T., Caithness, N., Kendall, M.A., Lambshead, P.J.D., Nicholson, S.K., Paterson, G.L.J. 2000. Virtual Collections and

Interactive keys: Taxonomy on the Internet. In: Proceedings of the second BioNET international global workshop (BIGW2) 22-29th August. Jones, T. and Gallagher S. (eds), BioNET International, Egham, UK. pp. 259-267.

- Austen, M.C. 2000. Demystifying nematodes. Porcupine Newsletter, 5, 28-33.
- Austen, M.C. in press. Natural nematode communities are useful tools to address ecological and applied questions. *Nematology*

On-Line Internet based marine nematode identification keys

A remedy to problems with nematode identification

Most marine nematode genera are cosmopolitan and a pictorial key to world-wide genera has been available since 1983 (Warwick and Platt 1983) with the most recent update in 1998 (Warwick et al 1998). However, the key is daunting to use for the beginner and is expensive and not readily available outside of the UK.

To simplify the procedure of finding the correct place in the pictorial key, an Internet based updateable identification program has been written which speeds up the browsing process required to reach the correct pages in the key. The key acts as a shortcut to finding the pictorial images, from the Warwick et al keys, that correspond to the nematode being identified. Within the electronic key the user selects states of characters (morphological features) which most closely correspond to those observed on the users specimen. The key then presents the user with figures of several genera indicating which most closely correspond to their nematode according to their selection of features.

By determining the state of just 4 morphological characters (amphid, buccal cavity, tail shape, cuticle) the identifier can reach the relevant pages of the key and in most cases a choice of between 1-10 possible genera. The computer key tabulates pictorial representations (line drawings) of each possible state of each of the 4 morphological characters. For each character the user selects the character state which most closely matches that of the specimen being identified. The program crosschecks the selection and presents a browser style page of the nematodes whose descriptions include the 4 characters in the appropriate states. Hypertext links to full descriptions aid full confirmation of these identifications. The key is available free of charge on the Darwin nematode web site (www.pml.ac.uk/nematode) and on CD ROM. It is accompanied by a user help manual and web pages with information on nematode structure morphology.

Each genus figure consists of drawings of the head and tail region. These drawings are not of individual species, except for monotypic genera, but are idealised 'caricatures' designed to show the diagnostic features of each genus. Where a character is variable within a genus, the representation is biased towards the more commonly reported species. Important diagnostic features, including some which may not be illustrated, are given in a text description for each genus. Each drawing and pen-picture in the description is only a brief outline and does not constitute a strict generic definition.

The electronic key software is provided across the internet as a Java 2 applet and is based on an XML database. Programming using Java and XML has made the key a truly cross-platform project, meaning that the software will run on many different

machines and across the internet.

Over 180 copies of the Key software have been distributed on CD since the start of the project. The key can also be run directly from the internet as a Java applet, but this requires a fast internet connection (better than a modem connection) and the installation of Java 2.

The key can run on all of the following systems:



- Windows 95, 98, 2000, NT4 and XP
- Mac OS X
- Mac OS 8.1 - 9.x
- AIX
- HP-UX
- Linux
- Solaris
- Unix (Java 2 enabled)
- Other Java 2 platforms

The recommended minimum system requirements for running the nematode key software are:

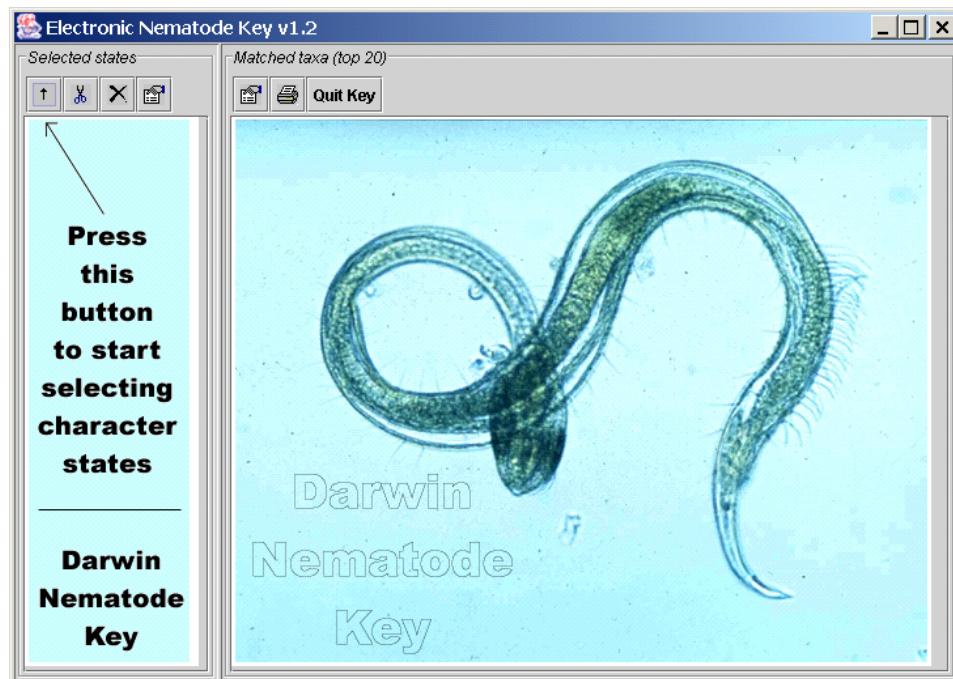
	Windows 95, 98, 2000, NT4 and XP	Pentium 133	64Mb RAM	256 colours
	Mac OS X	Power PC	64Mb RAM	256 colours
	Mac OS 8.1 - 9.x	Power PC	64Mb RAM	256 colours
	AIX	-	128Mb RAM	256 colours
	HP-UX	-	128Mb RAM	256 colours
	Linux	Pentium 150	64Mb RAM	256 colours
	Solaris	-	128Mb RAM	256 colours
	Unix (Java 2 enabled)	-	128Mb RAM	256 colours
	Other Java 2 platforms	-	128Mb RAM	256 colours

Using the key

Startup

On running the Darwin Nematode Key software, a splash screen appears bearing project partner logos, the user clicks on the Run Key button to start the key. There is a pause while the key's images are pre-loaded. This pause will be much longer if the software is being run across the internet but should not be more than a few seconds with the CD-installed version.

Nemkey Main Screen:



The main screen consists of two windows. The left-hand window (the 'Selected States' window) is where characters or features of the current animal are displayed. The right-hand window (the 'Matched taxa' window) is where the top 20 nematode genus matches for the current set of characters or features are displayed pictorially.

Main Window Button Functions:



Button functions (in order from left to right):

Selected states window	
↑	Bring up a new Character Selection window to enable addition of characters to the current list
⤓	Remove the currently selected character from the current character state list and update matches
ⓧ	Clear ALL character state selections from the list, ready to start over again
ⓘ	Bring up information on the currently selected character state (also by double clicking a character state in the list)

Matched taxa window	
ⓘ	Display full-size image and textual information about the currently selected taxa image in the taxa window
🖨️	Print a textual list of best matches
Quit Key	Quit the software !

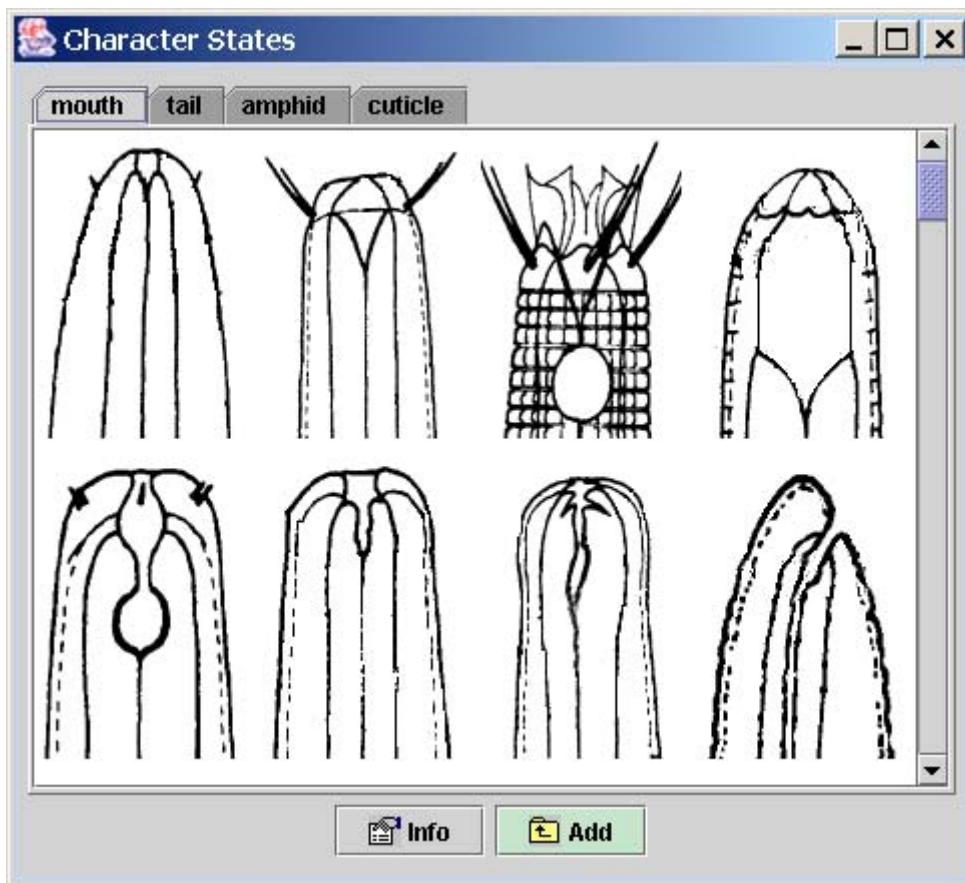
Selecting Character States

To start selecting character states, the user clicks on the up-arrow button to start selecting character states (see image below).



All the buttons in the Nemkey software have tool-tip help. That is to say, if the user moves the mouse over a button and pauses for a while, a little text box will pop-up telling the user what that button does.

Pressing the up-arrow (character selection) button activates a new character state selection window. This is where the user can find characters or features that he/she can see in their current sample.



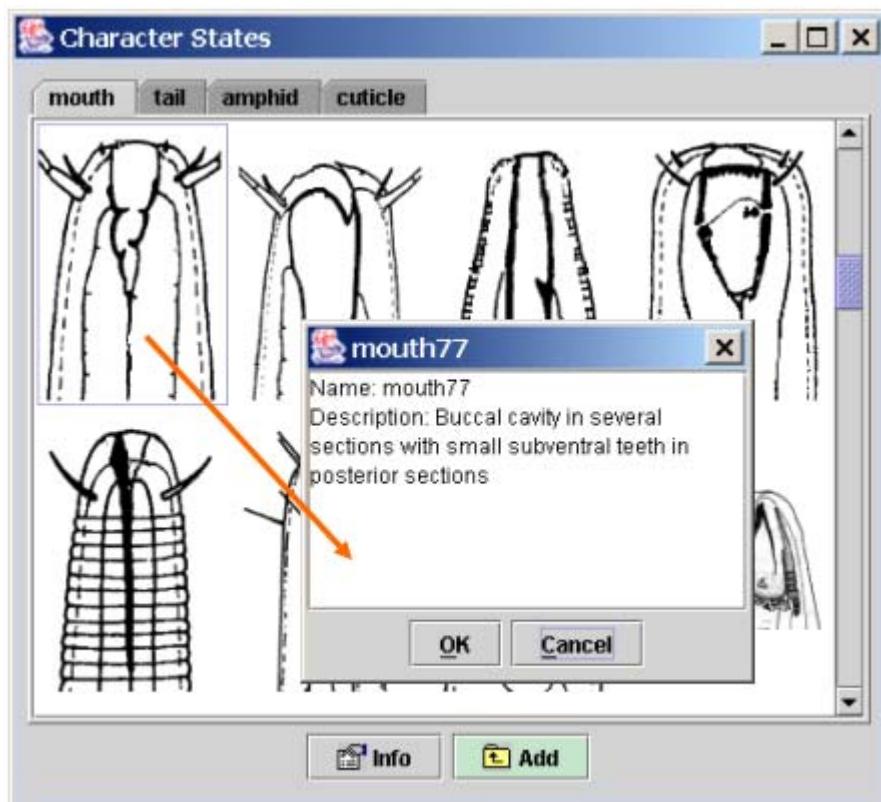
There are four tabs along the top of the window. These tabs group the character state images by mouth types, tail types, amphid types and cuticle types. Clicking on one of the tabs switches the images shown below into images of that type.

The basis of the key is that by selecting images of just 4 characters of a nematode it is possible to arrive at usually just one, but sometimes up to 4 or 5 nematode genera that have matching characters, one of which will be the nematode being identified. To select a character state that best matches what the user sees in their specimen, he or she will scroll down through the images in each group. Once the user has found a good match, he/she can either double-click the image to add it to the list of character

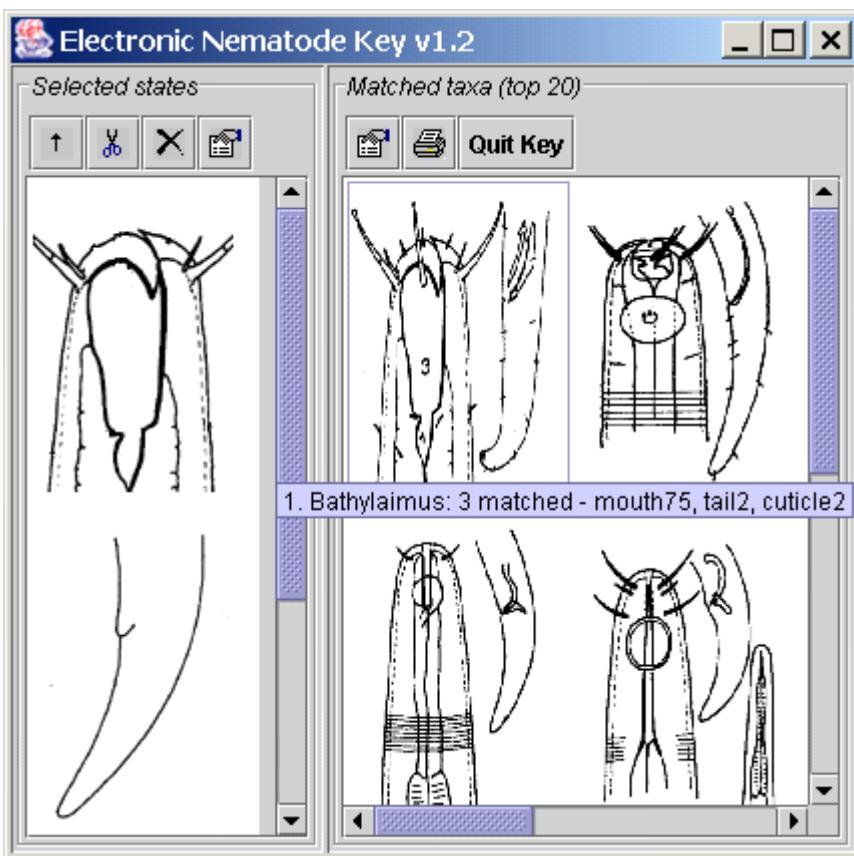
states in the main screen or select it and click the Add button (a box around the image will show it is selected).

Character State Information (text)

If the user is not exactly sure which image most closely resembles the character in the nematode being identified, he/she can select and add more than one image for each character. When the user is selecting character images he/she may find the written description of that character helpful in deciding which image is most appropriate. To see the description, the user clicks on an image and then clicks on the grey ‘info’ button. A pop-up box containing textual information will appear as below.



In the main window, as character states are added, the selected states window becomes populated. The software finds the nematode genera that most closely match the users' specimen, based on the characters selected so far, and displays them in the matched taxa window.



The user tries to select an image for each of the four characters. Each character window is selected using the buttons marked at the top of the character states window. The key will attempt to find the 20 closest matches whether the user has selected images of just one, two, three or all four characters. When the user has selected the character images, he/she can look at the window behind to see the closest 20 matches to their nematode specimen (currently, these are not displayed in a logical taxonomic order). If the user pauses the mouse pointer over the image of each suggested match for their specimen, tool tip text will appear indicating how many and which characters were matched.

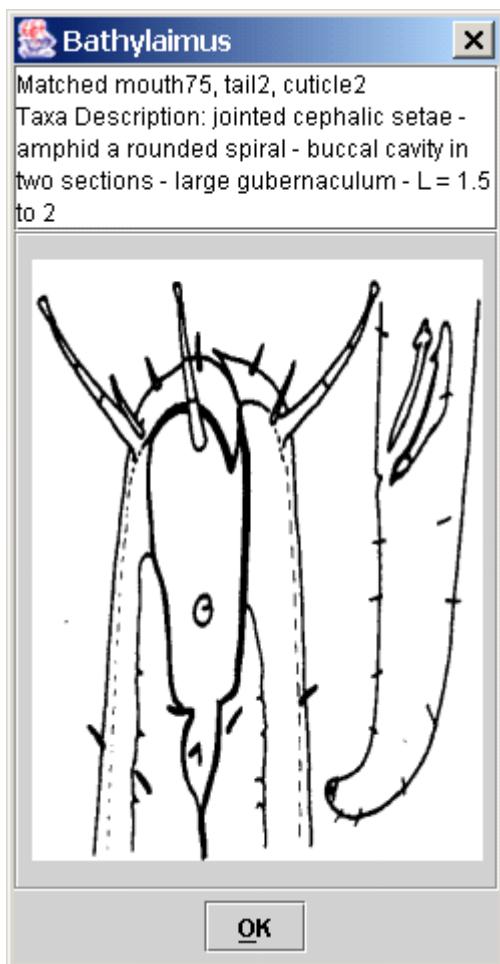
When the user has finished selecting characters, he/she can close or minimise the character state window.

Refining Character Selections

It is possible to refine the character selection by removing selected characters from the list (this can be done with a character selection window still open). To do this, the user selects a character in the selected states window and clicks on the scissors icon at the top of the window. The matched taxa window updates in real-time to make the new best matches for the amended list of character states. To clear ALL selected character states from the list, click on the remove all icon (the big cross).

Taxa Details

To get more information about a taxa in the matched taxa window, the user either double-clicks on the taxa image or selects an image with a single click and then clicks the information button at the top of the matched taxa window. A window with the full-resolution picture of the nematode together with a textual description is then displayed, as shown below.



Printing (Not on Mac OS classic systems)

A rudimentary print function is available for printing a text list of best taxa matches. The user clicks on the print button to generate a tabular preview of what will be printed. On the internet version the program may ask the user if he/she you will allow permission for it to print using one of their local printers. The user then simply clicks on yes to carry on and print the list.

The screenshot shows a window titled "Print Preview" with a blue header bar. The main content area is a table with two columns: "Name" and "Results". The table lists nine entries, each consisting of a name followed by a list of results. At the bottom of the table is a "Print" button.

Name	Results
2 matched - tail3, amphid2	1. Tricom
2 matched - mouth37, amphid2	2. Trichotheristu
2 matched - mouth37, amphid2	3. Theristu
2 matched - mouth37, amphid2	4. Theristu
2 matched - mouth37, amphid2	5. Thalassomonhyster
2 matched - mouth37, amphid2	6. Subsphaerolaimu
2 matched - mouth37, amphid2	7. Stylotheristu
2 matched - mouth37, amphid2	8. Steineri
2 matched - mnuth37 amnhid2	9. Steineri

Nemkey Software Updates *Power Update Feature*

The Nemkey software can be updated across the internet using ZeroG's Power Update™ software. This has been integrated into the Nemkey CD software.

Darwin Virtual Museum Nematode Collection

For ecological monitoring purposes identification to genus level is usually sufficient. For biodiversity studies the situation is more complex and outside of coastal European waters only a small percentage (4%) of marine nematode species are formally described. The underlying database of the online identification system has been used to develop online updateable virtual collections to create a database of informal descriptions of species awaiting formal taxonomic description, checked by specialist taxonomists before they go online but readily available to identifiers worldwide. The underlying database for the Virtual Museum Nematode Collection is an extension of the XML nematode database used for the nematode genera identification key. Users are invited to enter information about potentially new species of nematode either using an online form or by downloading Word or Adobe Acrobat documents which can be completed offline or by hand. Figures and drawings of specimens can be scanned in by the user and submitted online or posted to the manager of the Virtual Collection to be scanned and entered into the database. The database is currently searchable by country, habitat and identifier.

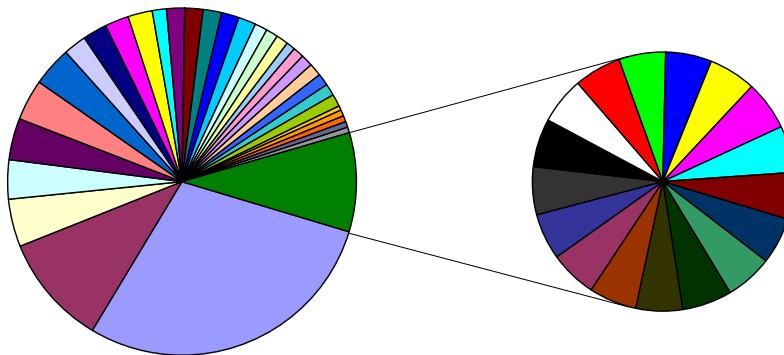
The database has been populated with a small number of species from published descriptions by staff at the Plymouth Marine Laboratory. As yet there has been virtually no interest in the Collection. Most of the Darwin Nematode Network participants' interests lie in using nematodes for ecological monitoring of environmental impact. The Pakistan participants, Dr Zarina Begum and Dr Maqbool expressed interest in the Collection but currently they appear to have extremely limited access to the Internet.

5. Project Impacts

The evidence of the success of the project lies mostly in statistics on the use of the web site and on applications for the CD-ROM incorporating the nematode identification key and the web site information. Further evidence was presented in the enthusiastic verbal feedback from the workshop participants. The same enthusiasm was seen in the anonymous written questionnaires that participants completed after each workshop (see Annex 1-2). Finally an additional questionnaire was sent to the workshop participants to seek input into this final report (Annex 3). Only one workshop participant did not respond to this final questionnaire. The responses are again enthusiastic and indicate that in most cases, participants at the workshops are continuing to use the skills acquired at the workshops, to use the web site and to maintain contacts with their colleagues at the workshop (Annex 3).

A surprising outcome of the web site was the interest in the nematode keys and web site from scientists in developed countries such as the USA and the UK and also the huge variety of countries sending us requests for the software. The outreach of the Darwin project has extended to a much wider audience of scientists from developing countries than we had expected. By the end of October 2002 there were 184 requests for the key from 49 countries.

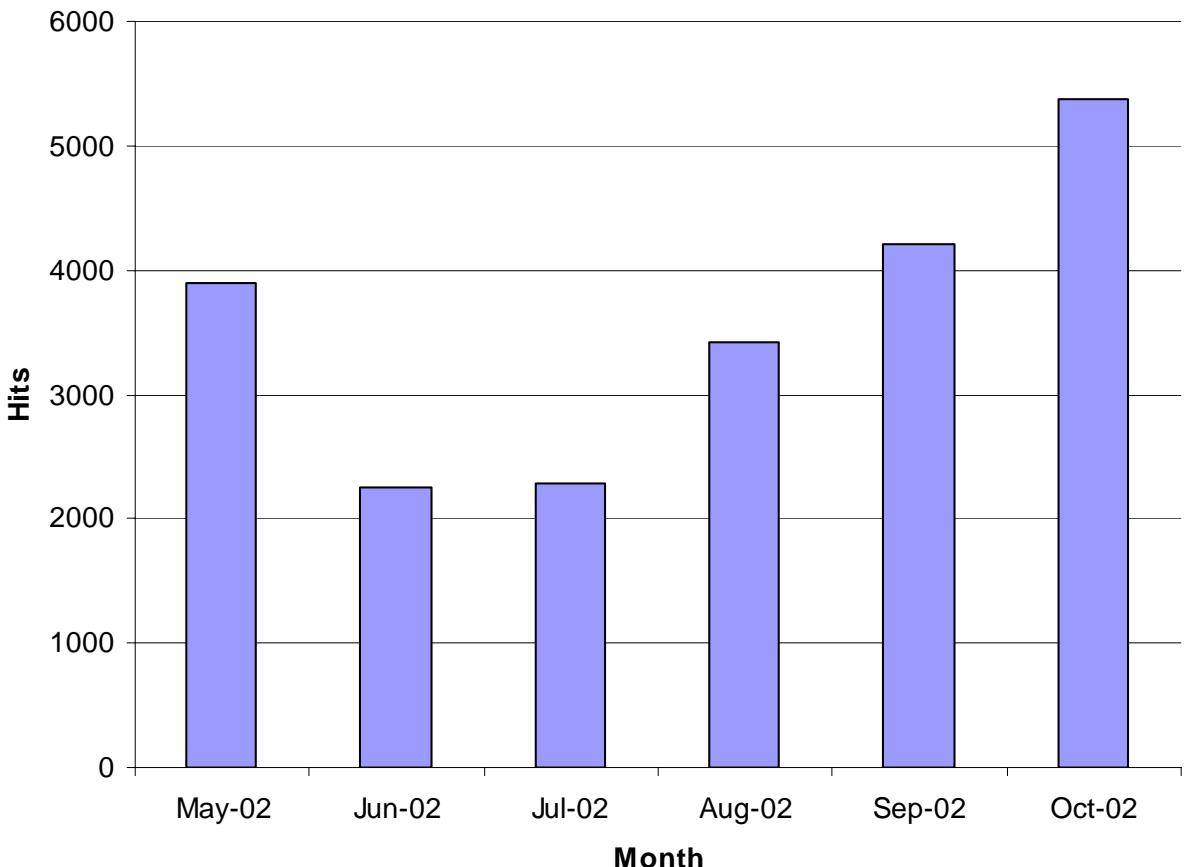
Countries receiving CD-ROMS - a total of 184 CD's sent up to end of October 2002



United States	United Kingdom	India	Australia
Brazil	Iran	Canada	Philippines
Turkey	Egypt	Spain	New Zealand
Pakistan	Germany	Portugal	Russia
Poland	West Indies	China	Romania
Columbia	Austria	New Caledonia	Netherlands
Belgium	Cuba	Ireland	Burma
Denmark	Costa Rica	Malaysia	Chile
Croatia	Puerto Rico	Vietnam	UAE
The Netherlands	Thailand	Taiwan	Japan
South Africa	Finland	Norway	Kenya
Argentina	Italy	Israel	Indonesia
Switzerland			

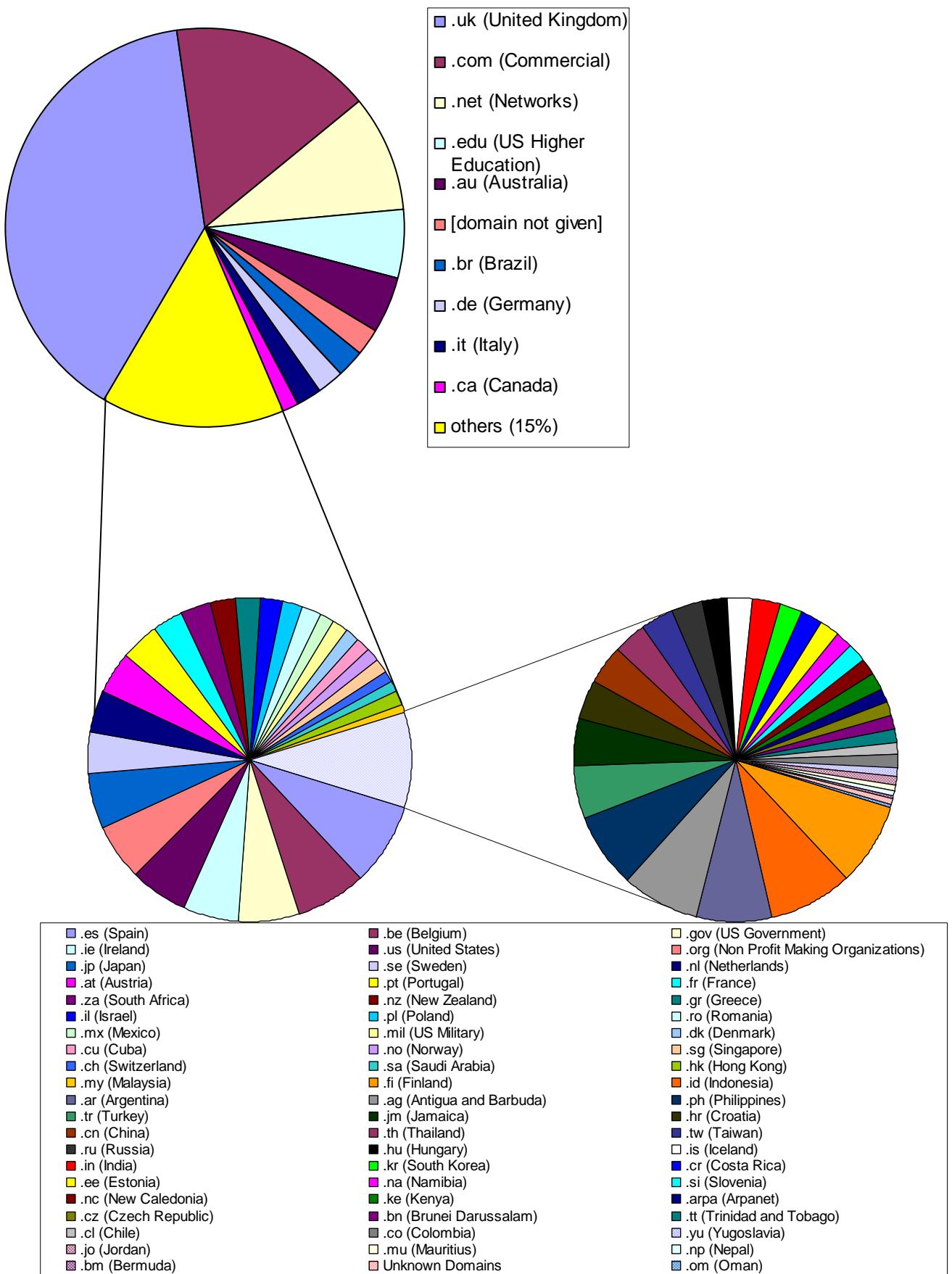
From May 2002 we were able to monitor the number of web page requests and the domains from which these requests were seen. Between May and October 2002 there were a total of 21422 web page hits on the Darwin nematode web site. This corresponds to an estimated yearly total of estimated total of 42844 web page hits.

Web Page Hits May to Oct 2002



The web hits came from 73 domains corresponding to 64 identifiable countries. During demonstrations of the web site and nematode identification key at international conferences (the Meiofauna conference and the Nematode conference) the response was very enthusiastic. Dissemination at these events probably encouraged people to go and have a closer look at the web site when they returned home.

Total web page requests by domain



The project has been successful in training people from other countries to identify and monitor marine biodiversity and to train other people to do this. Through the web site and nematode key the project has provided a useful resource to pass expertise in marine nematode identification and research from the UK to other countries. In this respect the project has been successful in achieving its goals. The project will help scientists to achieve the necessary science to underpin their countries programmes of conservation and legislation to meet their obligations under the CBD.

Details of how the workshop has improved participants abilities to carry out biodiversity work in their own countries is given in their response to questionnaires in Annex 3. The questionnaires were sent out to all workshop participants in October 2002. Some of the responses are summarised here and in the next sections

All of the workshop participants are using their Darwin training, either in research or teaching or environmental monitoring. A small number are not particularly utilising the nematode identification training but these people are using the statistical analysis training. Whilst the Darwin nematode project only involved small-scale local collaborations the general feedback is that the participants really appreciated the contact with scientists from PML and the NHM. All of them would like to find opportunities to continue collaboration with PML. Some would like to collaborate with other workshop participants. Many of the participants are involved in national and/or local biodiversity monitoring programmes.

Further training and capacity building achievements and ongoing work

In Brazil, Dr Andre Esteves has successfully completed his PhD. His Darwin training contributed to his research. He has also started training other undergraduates in nematode identification and has run a training course on the biology and classification of marine nematodes to graduate students and professors at the Universidade Estadual do Norte Fluminense, in Campos dos Goytacazes, Brazil. Andre has started to analyse deep sea nematode samples from the Brazilian coast. Andre is preparing two articles for publication including a check list of Brazilian nematodes and has submitted a paper for publication. He is participating in a program to survey resources along the Brazilian coast (REVIZEE PROGRAM), in which he is identifying the Nematoda present in the macrofauna samples.

After her Darwin training Taciana Kramer Pinto (Rio Grande, Brazil) changed her PhD research to include nematode identification and new data analysis. She is about to submit her thesis for examination. She has submitted two papers for publication and is preparing a third. She is seeking postdoctoral funding for a project which includes teaching post and under-graduate students meiofaunal ecology and nematode identification.

Fransisco Castro (Recife, Brazil) is also using his Darwin training in his PhD studies on estuarine nematodes. His will be the first list of nematodes from an estuary in north-east Brazil and he is looking at the impacts of pollution. Fransisco Castro presented some of his results in posters at an international meiofauna meeting and at a national meeting. He is close to completing his PhD research. He has been teaching nematode identification to other undergraduate and masters students at his university and will continue to carry out nematode research in his university after he has finished his PhD.

Dr Matthew Lee of Santiago, Chile is using nematodes experiments to assess pollution. He is seeking funding to build up information on the diversity of nematodes in Chile and to research meiofaunal ecology in the high energy sandy beaches of Chile. He is in the process of setting up a website on the meiofauna of Chile (www.meiochile.cl) which refers to the Darwin project and is a mirror site for some of the Darwin web site pages on sample processing. He plans to translate these pages into Spanish

Alicia Laurent from Trinidad is currently working in London but she is also writing up research papers from her MPhil project in Trinidad using the statistical analysis training she received in Plymouth. She is planning to carry on using her training in statistical analysis for environmental monitoring and planning to teach these skills to others when she returns to Trinidad and Tobago.

In Goa, India, Drs Baban Ingole and Zakir Ansari are involved in environmental monitoring of the deep sea and coastal habitats in the Indian Ocean for which they say they find the Darwin training very helpful. Dr Baban Ingole is training a student who is working on the ecology of marine nematodes. Both Dr Ingole and Dr Ansari have passed on information about their training to other colleagues and students at their institute. They are also both preparing papers for publication and are trying to seek funding to host similar workshops to the Darwin workshops in their institute. Both are working on local and national biodiversity monitoring projects.

In Tamil Nadu, India, Dr Olivia Fernando is training a PhD student in mangrove meiofauna and is passing on her training to research students through university lectures. She is using PRIMER to analyse her own and students' benthic fauna data and will be writing up the results for publication.

Dr Zarina Begum (Karachi, Pakistan) has been passing on her training informally to colleagues and students. She has written a taxonomic paper describing marine nematodes from the Arabian Sea and is preparing another one for submission. She is working on taxonomy of marine nematodes, the effects of metal pollution and is screening for the nematicidal activity of marine algae on plant-parasitic nematodes. She is involved in the Pakistan national biodiversity strategy programme and is carrying out monthly surveys of marine nematode biodiversity in beaches.

Martin Hendricks (Cape Town, South Africa) is a part time student registered for a PhD. He is studying the impact of marine sewage on nematodes. At the University of Cape Town, where Martin is a senior technician, he has passed on his training in sample processing and analysis to undergraduate students. He has also helped MSc and PhD students with data analysis.

Julius Okondo, (Mombasa, Kenya) has found the Darwin workshop training very helpful to his PhD study on the ecology of shallow sub tidal benthic in fauna of Gazi Bay, Kenya which is nearing completion. He is also using his data analysis skills in the assessment of macrofaunal evolution in a mangrove regeneration program also in Gazi Bay, Kenya. He is helping colleagues in his own and in collaborating institutes to apply the statistical analysis methods to their biological and chemical ecosystem research. He says that other colleagues in his institute are also using the Darwin Project in the development of the Marine Species Data Base (Masdea) which is importantnt both for staff development and as a contribution towards national and global Biodiversity programs.

Dr Chau Choc (Hanoi, Vietnam) emailed to me that his science activities would also be included in Dr Nguyen vu Thanh's response to the questionnaire. Dr Thanh

(Hanoi, Vietnam) and Dr Choc also work on freshwater nematodes and found the Darwin training particularly helpful for statistical analysis of the data they collect to monitor environmental quality of streams, rivers and coastlines. They have organised two further training course in Ho Chi Minh City and in Hanoi, Vietnam where they passed on their Darwin training to 30 biologists, chemists and ecologists from 14 different institutes in Vietnam. Darwin training is helping in long-term programmes investigating and monitoring the biodiversity and ecology of the Mekong Delta wetlands, mangrove and coastal areas and inland waters of Vietnam.

As a result of the Darwin training she received Joanna Rokicka-Praxmajer (Szczecin, Poland) registered for a PhD and is about to write her thesis. The Darwin project gave her an opportunity to consult with nematode specialists, interact with a group of similarly minded international scientists and improve her collaborative links with others from her own country. The Darwin project helped her to present two posters. The first was at the Eleventh International Meiofauna Conference (ELIMCO) in Boston, USA 2001 “Free-living nematodes in meiobenthos of a Pomeranian Bay (southern Baltic) near-shore station, directly affected by river plume”. For the second poster Joanna Rokicka-Praxmajer was a co-author and the presentation was made at the Baltic Sea Congress in Stockholm, Sweden 2001 - “Free-living nematodes and phytal pigment contents in sediments of the Pomeranian Bay”. She is preparing a manuscript for publication: “Free-living nematodes of the Pomeranian Bay (southern Baltic), Preliminary analyses of nematode variability in an area directly affected by freshwater runoff”. She intends to continue working on nematodes occurring in the meiobenthos of the Pomeranian Bay, an area subject to fluctuating environmental conditions and hopes to go on to study nematodes from other Baltic near-shore areas.

The Darwin project has helped Dr Maria Szymelfenig (Gdansk, Poland) in her studies of meiofauna in several intertidal and subtidal projects in the Arctic, along a depth gradient in the North Atlantic and in sand beaches in the Baltic. She is still working on meiofauna from the Arctic and the Baltic but she has told PML that her research on nematodes is limited due to lack of access to a good quality research microscope at her university. She is passing on her Darwin training informally to colleagues and students working in collaborative projects.

Dr Aleksander Drgas (Gdynia, Poland) has found the Darwin training helpful in a State Committee for Scientific Research supported project on the influence of sediment type on the nematodes community structure in the Gdansk Bay. He has passed on his Darwin training through consultations on nematode taxonomy and by giving an informal seminar on the application of the multivariate techniques in ecological research. He has written that the Darwin project has increased the number of scientists in Poland experienced in nematode taxonomy and improved the skills of the persons previously involved in this area of research. Experience gained through the Darwin project allowed him to contribute to preparation of the successful proposal for EC Fifth Framework funding “Polish Marine Fishery Science Center” (workpackage: Developing tools and skills for better understanding of marine ecosystem). It also prompted a successful collaborative application with the Plymouth Marine Laboratory for additional funding to enable Polish collaboration in the EC funded project COST-IMPACT Costing the impact of demersal fishing on marine ecosystems which will start in January 2003. Dr Aleksander Drgas is working on nematodes in an ongoing project on the influence of anthropogenic pressure on the benthic communities in the Gdańsk Bay and is participating in another EC funded project: Characterisation of the Baltic Sea Ecosystem: Dynamics and Function of

Coastal Types in which he is distinguishing of the benthic communities with multivariate statistical techniques.

As head of the Polish National Marine Biodiversity Network, Dr Marcin Weslawski, (Polish Institute of Oceanology, Sopot, Poland) has written:

'The workshops in PML and in Poland were of great importance for building from the beginning the competence in marine Nematoda identification in Poland. Four people who participated in workshops were both very active in effective use of the new knowledge, but also (and more important) they created a group of others who are getting interested and more familiar with difficult taxonomic groups recognition. Following the experience from Darwin we (newly established National Marine Biodiversity Network) managed to get the funds for development and further learning of meiofauna taxonomy. Our plans are to organise two workshops for young scientists (MSc , PhD students and assistants) in Poland in 2003-2004. We want to invite former Darwin Nematode Project teachers to assist us in preparation as well as specialists from other difficult taxonomic groups. In practical terms this mean that in coming years we shall have in Poland at least several persons trained in identification of Nematodes, Oligochaets, Harpacticoids, Ciliates. This will increase our competence in marine biodiversity research and international collaboration.

So far, there were no publications or degrees directly fueled by Darwin Project, the new and small group of young researchers is still in the phase of training. Very soon, they will be using their knowledge in multi-authored biodiversity studies.'

Collaborations

The Brazilian workshop participants regularly maintain contacts with each other and these contacts will certainly continue in the future. Taciana Kramer Pinto (Rio Grande, Brazil) is also in contact with other meiofauna scientists in universities in the South of Brazil and Fransisco Castro (Recife, Brazil) is collaborating in a project with the Brazilian Naval Ministry.

Dr Ingole and Dr Ansari (Goa, India) are preparing a collaborative project with Drs Than and Chao Choc from Vietnam and are increasing collaborative contacts on meiofauna research with other scientists in India. Dr Olivia Fernando (Tamil Nadu, India) intends to stay in contact with Darwin participants from other tropical countries.

As probably the only marine nematologist in South Africa Martin Hendricks (Cape Town, South Africa) felt very isolated. He particularly appreciated the Darwin Nematode network and the opportunities the Darwin project gave him to meet other researchers in the Southern hemisphere. He plans to stay in contact with these researchers and others in Africa. Julius Okondo, (Mombasa, Kenya) plans to resume stronger contacts with other Darwin workshop participants once he has finished his PhD thesis.

Through the Darwin project Dr Thanh (Hanoi, Vietnam) has started collaborating with Dr Zhang Zhinan of Qingdao Ocean University in China who collaborated with PML in a previous Darwin project on the meiofauna of the Bohai Sea.

The Polish project participants Dr Aleksander Drgas (Gdynia), Dr Maria Szymelfenig (Gdansk) and Joanna Rokicka-Praxmajer (Szczecin) have collaborated in a National project in the Baltic and plan to continue collaborations and stay in regular contact with each other and other participants in the workshops. In addition, Dr Aleksander Drgas is now collaborating with PML in nematode identification from benthic

samples collected from the Baltic, Crete and the Skagerrak in an EC funded project (COST-IMPACT).

6. Project Outputs

Project outputs are listed in Appendix II and details of the web site, nematode key and publications that can be publicly accessed are given in Appendix III.

As well as oral and poster presentations at conferences, publications and local media press releases, radio and television articles, a major route of dissemination of the projects outputs is the Darwin nematode web site. This will continue to be maintained by PML. The Darwin Nematode Virtual Collection database is currently hosted on PML's Darwin nematode web site. If interest in the virtual collection increases then PML and NHM will review whether it may be more appropriate for the NHM to host this facility.

7. Project Expenditure

TOTAL DARWIN GRANT	£163,200
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Annual Distribution of Darwin Grant
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1999/2000	£65,700
2000/2001	£38,700
2001/2001	£5,880

DARWIN GRANT :	Expenditure	(£)
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Expenditure details	Budget	Actual Spend
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£163,210.00	£277,245.87
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The actual spend on salary includes the £93,000 that was PML's contribution to the project. The remaining overspend was due to additional staff costs for generating the nematode keys and providing more teaching staff at the workshops than originally planned. Actual spend for registration fee at the Eleventh Meiofauna Conference was less than anticipated. Registration fees for the Porcupine Marine Natural History Society meeting in Plymouth and for the Fourth International Congress of Nematology in Tenerife as well as travel and subsistence costs for the latter meeting were paid for by PML.

8. Project Operation and Partnerships

As indicated above, the Darwin Nematode project was concerned with knowledge transfer and with training and building up the scientific capacity of a large group of scientists from a diverse range of countries rather than a close partnership with one or two countries. PML scientists did visit Brazil and Poland but these visits involved mostly further training. The project was planned after consultation with biologists

from Poland, Chile, Brazil and Pakistan who agreed that such an approach would be of use to them. There were sixteen workshop participants from 9 countries across five continents. As discussed above, they were either biologists who were already using, or intending to use marine meiofauna studies for pollution monitoring or teaching staff at universities who could further spread their knowledge to other students. Mostly these were from national institutes or from Universities. All partners were graduates; half had PhDs and just over a third were PhD students. As can be seen from the questionnaires in Annex 3 many of the workshop participants are involved in national biodiversity monitoring programmes.

Darwin nematode project partners and workshop participants

Partner name	institute	Attended Plymouth workshops
Dr John Agard*	University of the West Indies, Trinidad and Tobago	
Dr Zakir A. Ansari	National Institute of Oceanography, Goa, India	both
Dr Zarina Begum	National Nematological Research Centre, University of Karachi, Pakistan	both
Francisco Castro	Universidade Federal de Pernambuco, Recife, Brasil	both
Dr Nguyen Ngoc Chau	Department of Nematology, Institute of Ecology and Biological Resources, Hanoi, Vietnam	Statistical analysis
Dr Alexander Drgas	Sea Fisheries Institute, Gdynia, Poland	both
Dr Andre Esteves	Dept. Zoologia, Universidade Federal do Rio de Janeiro Rio de Janeiro, Brasil	both
Dr Olivia J. Fernando	Centre for Advanced Study in Marine Biology, Annamalai University, Tamil Nadu, India	both
Martin Hendricks	Dept. Zoology, University of the Western Cape, Rep of South Africa	both
Dr Baban S. Ingole	National Institute of Oceanography, Goa, India	both
Dr Matthew Lee	Ecology Department (ECIM), Catholic University of Chile, Santiago, Chile	Nematode identification
Alicia Laurent	University of the West Indies, Trinidad and Tobago	both
Dr M.A. Maqbool	National Nematological Research Centre, University of Karachi, Pakistan	both
Julius P. Okondo	Kenya Marine & Fisheries Research Institute, Mombassa, Kenya	both
Taciana Kramer Pinto	Laboratório de Ecologia de Invertebrados Bentônicos Rio Grande, Brasil	both
Joanna Rokicka-Praxmajer	Department of Oceanography, Agricultural University of Szczecin, Szczecin, Poland	both
Dr Paulo Santos*	Universidade Federal de Pernambuco, Recife, Brasil	
Dr Maria Szymelfenig	Institute of Oceanography, University of Gdansk, Poland	both
Dr Nguyen Vu Thanh	Department of Nematology, Institute of Ecology and Biological Resources, Hanoi, Vietnam	both
Dr Marcin Weslawski*	Polish Institute of Oceanology, Sopot, Poland	

* responsible for selecting national participants and/or local coordinator

9. Monitoring and Evaluation, Lesson learning

The project had a series of milestones which were regularly monitored to ensure targets were met or review why they were not being met. The evaluation of the success of training workshops was achieved through informal verbal feedback and through formal, anonymous questionnaires (Annex 1-2). An emailed questionnaire sent to all involved in the Darwin project indicates a high level of satisfaction with the

project (Annex 3). Only one workshop participant did not respond to this final questionnaire. Evaluation of interest in the Darwin web site was through monitoring the number of ‘hits’ (only technically possible from May–October 2002) and the domains and countries accessing the web site. We also kept records of the people and their nationalities requesting free CD’s with the nematode identification key. Feedback has also come in emailed responses from those who have received and used the key.

Our project was completed later than originally proposed. Darwin projects need to make allowances for the short time interval between being informed of the success of a Darwin proposal and the start date for the project. If new staff are required to carry out the project (e.g. a computer programmer) it is difficult to ‘hit the ground running’. From our experience we would recommend a lead in period to get all staffing and partnerships in place. In retrospect the timing of the Darwin nematode projects milestones was over ambitious.

Our experience was that multinational workshops are a hugely popular and successful method of training. This is particularly so for the more obscure groups of organisms such as meiofauna that are important because they are found worldwide and contribute to the ecology and are the basis of food webs and detritus pathways. Yet these organisms are less charismatic than larger invertebrates and vertebrates and there is a shortage of expertise in their study and monitoring. The multinational approach promotes a baseline group of scientists to study the biodiversity of these organisms and encourage others to do so in their own country and yet helps these scientists to feel that they are part of a scientific community and not isolated in their own countries.

With such training workshops there is an occasional tendency in some places to view travel as a perk reserved for senior staff. In one case we managed to avoid this by setting age/experience limits to filter staff. In another case we were not fully aware of this problem until the workshop participant arrived. If we had been, we would have asked candidates to indicate how they would hope to use Darwin training over a defined period, perhaps 5 years after training (to avoid the workshop being used as a travel perk for staff close to retirement).

10. Darwin Identity

All correspondence inviting participants to Darwin workshops in Plymouth explained the origin of the funding for the participants and featured the Darwin logo. The Darwin logo features on the Darwin web site where there is also information about the Darwin Initiative and a link to the Darwin Initiative web site. The Darwin logo and the same information are also on the CD-ROM. In the October 2002 questionnaire we posed questions to workshop participants about peoples awareness of the Darwin Initiative in their countries. From the responses (Annex 3) it is clear that workshop participants have made efforts to inform their colleagues about the Darwin Initiative. In many cases, the discussion of the Darwin Initiative has been quite widespread and has achieved quite a strong awareness in many different countries amongst a wide variety of scientists.

11. Leverage

Most partners were unable to invest much additional funding into the Darwin Nematode project. Contributions consisted of local travel within their own country for several workshop participants, international flights for Matthew Lee (Chile) and Martin Hendricks (South Africa) to attend workshops, provision of manpower and facilities to assist with work in Poland and in Brazil.

The Estuarine and Coastal Sciences Association and Field Studies Council kindly agreed to allow us to adapt the published keys of Warwick et al for use in the Darwin nematode key and for use on the web site.

PML has provided £93,000 towards staff costs as originally proposed plus an additional £21035. PML and the Marine Biological Association waived bench fees, room hire costs and fees for use of laboratory and teaching facilities for the two Plymouth workshops. The NHM paid £4540 towards their staff costs and waived the costs of using specimens from the National Nematode Collection (£2000). PML paid the costs of Dr Austen's attendance at a Porcupine meeting and an International Nematode meeting where she presented and demonstrated the Darwin Nematode project, web site and nematode identification key.

PML has assisted a coalition of Indian biologists, led by the National Institute of Oceanography workshop participants, to obtain funding for regional training workshops similar to the Darwin workshops. They have obtained some National funding but further funding is still required. Dr Weslawski in Poland has secured funding from the EU for further training within Poland in invertebrate taxonomy and statistical analysis by PML and other UK scientists (see Annex 3). PML has successfully helped the Sea Fisheries Institute in Poland to win EC funding to participate in an EC project using their skills in nematode identification. PML and Dr Thanh (Vietnam) put an unsuccessful bid for funding to the DFID and the NHM and Dr Thanh put another unsuccessful bid to the British Council. A similar project based on these proposals with Dr Thanh collaborating with the University of Ghent, Belgium, has been subsequently funded by a Belgian funding agency. As a result of suggested contacts from PML, Dr Thanh is now collaborating with nematologists in China. When PML scientists visited Brazil there were discussions about possible joint collaborations to be submitted for national and international funding but these are still in the discussion phase.

12. Sustainability and Legacy

As can be seen in section 5 above and Annex 3 all but one of the workshop participants (Dr Maqbool, Pakistan, retired) plans to continue using the training received through the Darwin project either in their research or in national biodiversity monitoring or in teaching and often in a combination of these activities. The workshop participants plan to keep in touch both nationally and internationally. PML will continue to host the Darwin Nematode web site and the Nematode identification keys on this site. The nematode network will also continue on the web site although email seems to be a preferred method of communication. It is difficult to see how the projects outputs could be more widely applied. If the Darwin virtual nematode collection had proved popular it would have left an even greater legacy and it is still available for the future as and when the Darwin workshop participants develop their nematode identification skills further to require such a service.

There has been interest in expanding the Darwin nematode identification key

approach to involve other taxa. One proposal (unsuccessful) has already been submitted in collaboration with US scientists to incorporate harpacticoid copepods (also in the meiofauna) and provide nematode identification training to US scientists. The Darwin project has generated widespread interest and requests for further marine nematode identification training, often from European and Australian biologists. As discussed in the section above, in some cases efforts are being made to secure funding for further training workshops.

13. Value for money

The Darwin Initiative's contribution to the accounted costs of the project was 58%. For £163,210 of Darwin grant the project trained 16 scientists in two separate areas – nematode identification and statistical analysis of community ecology and developed completely novel software and a web site to pass on rare expertise to an extremely wide audience. The training, including travel and subsistence costs for participants from all over the world, for two 1 week workshops in Plymouth, was at a cost to the Darwin Initiative of approximately £5000 per workshop participant. This seems reasonably good value for money given that the training workshops in the UK and in Brazil and in Poland were facilitated by specialised scientists with rare expertise in taxonomy and highly developed skills in statistical analysis of marine benthic data. Approximately half of the Darwin grant was used towards the costs of developing bespoke nematode identification software and placing a large amount of information on a web site freely available to all. Again this material is based on, and was developed using extremely rare scientific expertise. In a commercial market the costs of development of the Darwin nematode project software and web site would seem like extremely good value. Through the training and the web site the expertise of a small number of marine nematode taxonomists has been made available to biologists all over the world which, in terms of the Darwin Initiative, should surely be viewed as a useful achievement.

Author(s) / Date

Dr Melanie Austen, December 12th 2002

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

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

Project Contribution to Articles under the Convention on Biological Diversity		
Article No./Title	Project %	Article Description
6. General Measures for Conservation & Sustainable Use		Develop national strategies which integrate conservation and sustainable use.
7. Identification and Monitoring	5	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	45	Establish programmes for scientific and technical education in identification, conservation and sustainable use of biodiversity components; promote research contributing to the conservation and sustainable use of biological diversity, particularly in developing countries (in accordance with SBSTTA recommendations).
13. Public Education and Awareness		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	50	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

Code No.	Quantity	Description
4c	7	Training for post graduate students at Nematode Identification workshop
	6	Training for post graduate students at statistical analysis workshop
	3	Training for post graduate students at University of Pernambuco, Brazil
4d	1	Training for post graduate students at Nematode Identification workshop
	1	Training for post graduate students at statistical analysis workshop
	1.5	Training for post graduate students at University of Pernambuco, Brazil
6a	9	Training for scientists (not postgrad students) at Nematode Identification workshop
	10	Training for scientists (not postgrad students) at statistical analysis workshop
	7	Training for scientists (staff and mixture of undergrad and postgrad students) at University of Pernambuco, Brazil
	4	Training for scientists at Sea Fisheries Research Institute at Gdynia, Poland
6b	1	Training for post graduate students at Nematode Identification workshop
	1	Training for post graduate students at statistical analysis workshop
	1.5	Training for scientists (staff and mixture of undergrad and postgrad students) at University of Pernambuco, Brazil
	2	Training for scientists at Sea Fisheries Research Institute at Gdynia, Poland <i>Several of the workshop participants were postgraduate (PhD) students and these have been recorded in output 6a. We were able to provide training for 16 workshop participants instead of the total of 15 originally proposed for the project. It was not possible for either the host country scientists or PML staff to be in Poland or Brazil for three weeks as originally proposed. An additional member of PML staff travelled to the Brazil workshop to increase the staff-trainee ratio.</i>
	7	Overheads for workshop sessions Online guides to extracting and processing meiofauna samples Online guides to Nematode morphology Online Software manual available for NemKey Online marine nematode identification key – Nemkey All online products are available on-line at www.pml.ac.uk/nematode and on CD-ROM
8	5	Three staff to Brazil for 10 days each
	4	Two staff to Poland for 2 weeks each
11a	1	Austen, M.C. in press. Natural nematode communities are useful tools to address ecological and applied questions. Nematology

Code No.	Quantity	Description
11b	3	<p>1 paper in Symposium proceedings, 2 papers in journals.</p> <p>Austen, M.C., Ferrero, T., Caithness, N., Kendall, M.A., Lambshead, P.J.D., Nicholson, S.K., Paterson, G.L.J. 2000. Virtual Collections and Interactive keys: Taxonomy on the Internet. In: Proceedings of the second BioNET international global workshop (BIGW2) 22-29th August. Jones, T. and Gallagher S. (eds), BioNET International, Egham, UK. pp. 259-267.</p> <p>Austen, M.C. 2000. Demystifying nematodes. Porcupine Newsletter, 5, 28-33.</p> <p>K, Nasira, M. A. Maqbool, T. A. Turpeenniemi and B. Zarina (2000). Description of <i>Microlaimus somianensis</i> n. sp. with observation on <i>Microlaimus arenicola</i> schulz, 1938 and <i>calomicrolaimus arenarius</i> Blome, 1982 (chromadorida: Microlaimidae) from Arabia Sea of Pakistan. Pak. J. Nematal: 18 (1&2): 1-10.</p> <p><i>Only two papers were originally planned for this project. It is apparent from workshop participant comments (Annex 3) that additional publications resulting from Darwin training are likely within the next 12 months.</i></p>
12a	1	Nematode identification key database online
13a	1	On-line virtual collection key data base – formatted and ready for population

Code No.	Quantity	Description
14b	4	<p><u>Oral presentations</u></p> <p><i>Second BioNET international global workshop (BIGW2) 22-29th August, Cardiff, Wales</i></p> <p>Austen, M.C., Ferrero, T., Caithness, N., Kendall, M.A., Lambshead, P.J.D., Nicholson, S.K., Paterson, G.L.J., Virtual Collections and Interactive keys: Taxonomy on the Internet.</p> <p><i>Porcupine Marine Natural History Society, The marine natural history of the NE Atlantic: approaches to identification, Plymouth, UK</i></p> <p>Austen, M.C., Demystifying nematodes</p> <p><i>Eleventh International Meiofauna Conference, Boston, USA July 2001</i></p> <p>Austen, M.C., Demystifying nematodes</p> <p><i>Fourth International Congress of Nematology, Tenerife, Spain, June 2002</i></p> <p>Austen, M.C., Natural nematode communities are useful tools to address ecological and applied questions</p> <p><u>Poster presentations:</u></p> <p><i>Eleventh International Meiofauna Conference, Boston, USA July 2001</i></p> <p>Austen, M.C., Atkins M. and Nicholson, S.K., Online nematode identification systems and virtual collections</p> <p><i>Fourth International Congress of Nematology, Tenerife, Spain, June 2002</i></p> <p>Austen, M.C., Atkins M. and Nicholson, S.K., Online nematode identification systems and virtual collections</p>
15c	1	Article in NERC annual report: Nematode ID parade. Natural Environment Research Council Annual Report 2001-2002, page 15
15d	6	Darwin press release concerning Nematode Identification workshop. Coverage of Darwin statistical analysis workshop featured in 5 local newspapers
17a, 17c	1	Establishment of Darwin Nematode Network at Plymouth workshop and perpetuated internationally through web site pages and email
19c	1	Coverage of Darwin workshop featured on local radio
19d	2	Coverage of 2 Darwin workshops featured on local TV news
	1	Darwin Nematode project web site www.pml.ac.uk/nematode
20	£1510 £8,183	Materials given to Darwin workshop participants to enable them to extract and prepare nematode samples Trainees given PRIMER software and manuals and CD-ROM with Nematode identification keys and Darwin nematode web site to enable them to continue work at home

<i>Code No.</i>	<i>Quantity</i>	<i>Description</i>
23	£93,000	PML for staff costs,
	£4,540	NHM for salaries,
	£7,500	PML and Marine Biological Association for provision of teaching facilities at two workshops
	£2,000	NHM for use of specimens from the National Nematode Collection
	n/a	International travel for Martin Hendricks paid for by Royal Society
	n/a	Local travel paid by several workshop participants (see Annex 3)
	£840	Registration fees, travel and subsistence to additional meetings to present and demonstrate Darwin Nematode project, web site and nematode identification key at Porcupine and International Nematode meetings

16. Appendix III: Publications

Type *(e.g. journals, manual, CDs)	Detail (title, author, year)	Publishers (name, city)	Available from (e.g. contact address, website)	Cost £
Web site	Hosting pages for Darwin marine nematode identification key, Darwin nematode web site including guides to: extracting and processing meiofauna samples; Software manual for NemKey web master: Martyn Atkins	Plymouth Marine Laboratory, UK	www.pml.ac.uk/nematode	FREE
Darwin Marine Nematode Identification key NemKey	Darwin Marine Nematode Identification key produced by M.C. Austen and Martyn Atkins	Plymouth Marine Laboratory, UK	www.pml.ac.uk/nematode	FREE
CD-ROM *	Darwin Marine Nematode Identification key produced by M.C. Austen and Martyn Atkins	Plymouth Marine Laboratory, Plymouth, UK	Martyn Atkins, Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, UK	£5
Paper in book * (photocopy)	Austen, M.C., Ferrero, T., Caithness, N., Kendall, M.A., Lambshead, P.J.D., Nicholson, S.K., Paterson, G.L.J. 2000. Virtual Collections and Interactive keys: Taxonomy on the Internet. In: Proceedings of the second BioNET international global workshop (BIGW2) 22-29th August. Jones, T. and Gallagher S. (eds), pp. 259-267.	BioNET International, Egham, UK.	BioNET International, Bakeham Lane, Egham, Surrey TW20 9TY UK	

Type * (e.g. journals, manual, CDs)	Detail (title, author, year)	Publishers (name, city)	Available from (e.g. contact address, website)	Cost £
Paper in journal *(photocopy)	Austen, M.C. 2000. Demystifying nematodes. Porcupine Newsletter, 5, 28-33.	Porcupine Marine Natural History Society	Frances Dipper (hon. Editor), 7 Rutland Green Hilton Huntingdon Cambs PE28 9NT UK	
Paper in journal	K, Nasira, M. A. Maqbool, T. A. Turpeenniemi and B. Zarina (2000). Description of <i>Microlaimus Somianensis</i> n. sp. with observation on <i>Microlaimus arenicola</i> schulz, 1938 and <i>Calomicrolaimus arenarius</i> Blome, 1982 (chromadorida: Microlaimidae) from Arabia Sea of Pakistan. Pak. J. Nematol: 18 (1&2): 1-10.	Pakistan Society of Nemetologists	National Nematological Research Centre, University of Karachi, Karachi 75270 Pakistan	Rs 50.00 US\$ 18.00
Paper in journal *(photocopy)	Austen, M.C. in press Natural nematode communities are useful tools to address ecological and applied questions	Nematology	Brill, Postbus 9000, NL-2300 PA Leiden, The Netherlands	
Article in NERC Annual Report *	Nematode ID parade. Natural Environment Research Council Annual Report 2001-2002, page 15	Natural Environment Research Council	Natural Environment Research Council, Polaris House, North Star Avenue Swindon SN2 1EU, UK	FREE

(*) all publications and other material included with this report

17. Appendix IV: Darwin Contacts

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

Project Title	Nematode biodiversity and worldwide pollution monitoring
Ref. No.	162/8/140
UK Leader Details	
Name	Dr Melanie Austen
Role within Darwin Project	Project leader
Address	Plymouth Marine Laboratory Prospect Place West Hoe Plymouth PL1 3DH
Phone	
Fax	
Email	
Other UK Contact (if relevant)	
Name	Dr Tim Ferrero
Role within Darwin Project	Associate collaborator assisting training workshop in marine nematode identification and with conceptual design of identification key and virtual nematode collection
Address	Department of Zoology The Natural History Museum London SW7 5BD, UK.
Phone	
Fax	
Email	

Partner name	institute	Attended Plymouth workshops
Dr John Agard*	Faculty of Agriculture and Natural Sciences, School of Zoology, University of the West Indies, St. Augustine, Trinidad and Tobago	
Dr Zakir A. Ansari	National Institute of Oceanography, Dona Paula, Goa 403004, India	both
Dr Zarina Begum	National Nematological Research Centre, University of Karachi, Karachi 75270, Pakistan	both
Francisco Jose Victor de Castro	Universidade Federal de Pernambuco-Centro de Ciências Biológicas-Departamento de Zoologia., Av. Professor Moraes Rego – S/N – Cidade Universitária – Recife – PE. Brasil	both
Dr Nguyen Ngoc Chau	Department of Nematology, Institute of Ecology and Biological Resources, NCST 15 Hoang Quoc Viet Rd., Hanoi, Vietnam	Statistical analysis

Partner name	institute	Attended Plymouth workshops
Dr Alexander Drgas	Sea Fisheries Institute, street Kollataja 1, postbox 345, Gdynia 81-332, Poland	both
Dr Andre Morgado Esteves	Dept. Zoologia - IB – CCS – Universidade Federal do Rio de Janeiro Ilha do Fundão , Cidade Universitária, Rio de Janeiro, RJ Brasil 21941-570	both
Dr Olivia J. Fernando	Centre for Advanced Study in Marine Biology, Annamalai University, Parangipettai 608502, Tamil Nadu, India	both
Martin Hendricks	Dept. Zoology, University of the Western Cape, Private Bag X17, Bellville 7535, Rep of South Africa	both
Dr Baban S. Ingole	National Institute of Oceanography, Dona Paula, Goa 403004, India	both
Dr Matthew Lee	Ecology Department (ECIM), Catholic University of Chile, Santiago, Chile	Nematode identification
Alicia Laurent	127 Jasper Avenue, Diamond Vale, Diego Martin, Trinidad and Tobago	both
Dr M.A. Maqbool	National Nematological Research Centre, University of Karachi, Karachi 75270, Pakistan	both
Julius P. Okondo	Kenya Marine & Fisheries Research Institute (KMFRI), P. O. Box 81651, Mombasa, Kenya	both
Taciana Kramer Pinto	Laboratório de Ecologia de Invertebrados Bentônicos Av. Itália, km 08, Cx.P. 474, CEP-96205-040, Rio Grande-RS- Brasil	both
Joanna Rokicka-Praxmajer	Department of Oceanography, Faculty of Marine Fisheries and Food Technology, Agricultural University in Szczecin ul.Kazimierza Krolewicza 4, 71-550 Szczecin, Poland	both
Dr Paulo Santos*	Universidade Federal de Pernambuco-Centro de Ciências Biológicas-Departamento de Zoologia., Av. Professor Moraes Rego – S/N – Cidade Universitária – Recife – PE. Brasil	
Dr Maria Szymelfenig	Institute of Oceanography, University of Gdansk, street Pilsudskiego 46, Gdynia 81-346, Poland	both
Dr Nguyen Vu Thanh	Department of Nematology, Institute of Ecology and Biological Resources, NCST 15 Hoang Quoc Viet Rd., Hanoi, Vietnam	both
Dr Marcin Weslawski*	Polish Institute of Oceanology, P.O. Box 68, Powstancow Warszawy 55, 81-712 Sopot, Poland	

* responsible for selecting national participants and/or local coordinator

Annex 1

Darwin Nematode Identification workshop: participants' feedback - questionnaire forms

Annex 2

Darwin analysis of community data workshop: participants' feedback - questionnaire forms

Annex 3

Darwin Final report participants' feedback - questionnaire forms