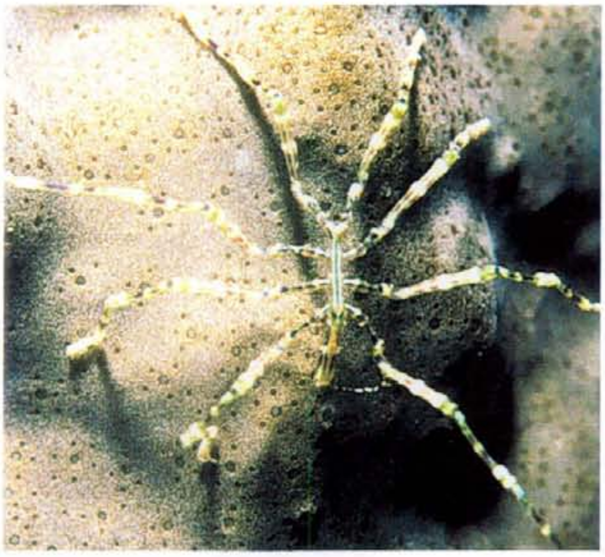
Morphological and Molecular Phylogenetic Analysis of the Sea Spiders (Arthropoda, Pycnogonida) and Taxonomic Study of Tropical Australian forms



Thesis submitted by
Claudia Patricia Arango BSc

in February 2002

For the degree of Doctor of Philosophy
School of Tropical Biology & School of Marine Biology and Aquaculture
James Cook University

Statement of access

I, the undersigned, the author of this thesis, understand that James Cook University will make it available for use within the University library and, by microfilm or other means, allow access to users in other approved libraries. All users consulting this thesis will have to sign the following statement:

> In consulting this thesis I agree not to copy or closely paraphrase it in whole or in part without the written consent of the author; and to make proper public written acknowledgment for any assistance that I have obtained from it.

Beyond this, I do not wish to place any restriction on access to this thesis.

Claudia P. Arango

23rd May 2002
Date

ACKNOWLEDGEMENTS

First of all I thank my family for their immense love and support. I have no words to express all my gratefulness to them. To Guillermo, I owe him so much, without him, all this would have been ten thousand times harder; I am so glad we have shared all this together. I am very grateful to Drs. Richard Rowe and John Collins for their guidance and support, for sharing with me their enthusiasm for little creatures and for patiently reading many drafts. Thanks to Dr. David Blair for his expertise on molecular techniques and handling of data and all his comments and suggestions since the very beginning. Special thanks to Dr. Lynne van Herwerden for her kind help in the DNA lab and for discussion and comments; to my mates in the DNA lab, Selma, Julia and Line. Special thanks to all the people who helped me with the collection of material and field work, especially 'G' Díaz-Pulido, Jamal Jompa, Drs. Laurence McCook; Jurgen Otto and Warren Lee-Long, to Oli Floerl and 'Michelle' Lee and to Ms. Liz Turner from the Museum of Tasmania. Thanks to all the volunteers that looked for pycnogonids during their dives. Special thanks to overseas specialists, Drs Katsumi Miyazaki, Tomás Munilla and Karl-Heinz Tomaschko for kind donations of material, to Karl for running ecdysteroid essays with my samples. To Julianne Hancock, Barry Russell and Penny Berents for their assistance with loan of specimens. To David Staples for advice and loan of material. Thanks to Dr. George 'Buz' Wilson for his help with analysis and his support and friendliness during my visit to the Australian Museum. To Dr. Don Colgan for his kind help and his almost incredible support allowing me to be part of the Evolutionary Biology Unit (EBU Australian Museum) for a few weeks. I want to thank Dr. David Yeates for his help, advice and friendship. Thanks to Glenn Graham and Corinna Lange for helping me with molecular analyses. Special thanks to Dr. Allan Child (Smithsonian Institution) for his taxonomic expertise and his support since my early beginnings in pycnogonid taxonomy. To Dr. Roger Bamber (British Natural History Museum) for advice and good conversations, for comments on material collected. To N. Campbell and K. Wilson (Australian Institute of Marine Science) for helpful advice and aliquots. Thanks to Faye Christidis and David Slaney for sharing their experience in systematics with me. Thanks to all the JCU staff that made my life much easier during this process. Finally, I want to acknowledge the financial support of the School of Tropical Biology and the School of Marine Biology and Aquaculture James Cook University during these years.

ABSTRACT

Pycnogonida is a subphylum of marine arthropods showing unique characteristics. Their position within the Arthropoda is not yet clear, but strong evidence has suggested they may be the extant sister taxon to all other arthropods. The phylogenetic affinities among the extant families of pycnogonids: Ammotheidae, Colossendeidae, Callipallenidae, Nymphonidae, Phoxichilidiidae, Pycnogonidae, Austrodecidae, Rhynchothoracidae, and the position of problematic genera such as *Endeis*, *Pallenopsis* and *Tanystylum*, are uncertain. Traditionally, it has been assumed that an evolutionary trend of gradual reduction of numbers of segments of the appendages, mainly involving chelifores, palps and ovigers (head appendages) has taken place within the group. Modern cladistic techniques have not been applied to resolve phylogenetic conflicts of the sea spiders. I approached the problem of the uncertain higher-level phylogenetic affinities of pycnogonids to propose hypotheses of relationships based on cladistic analysis of morphological characters, thereby testing the hypothesis of a reduction trend. Additionally, I used a preliminary molecular approach to confront the morphological results. This is one of the first attempts to use molecular data in the study of systematics of pycnogonids. Phylogenetic relationships among the main lineages of extant sea spiders were studied using cladistic analysis of 36 morphological characters and 38 species from all the recognized families. A preliminary exemplar method was employed, and different assumptions of multistate character transformations were used to trace the evolution of the head appendages. Fragments of nuclear ribosomal DNA (18S and 28S) were sequenced to reconstruct the phylogenetic relationships among six higher taxa of sea spiders. Hypotheses of relationships were obtained from separate and combined analyses of these data sets under both maximum parsimony and maximum likelihood criteria. Trees derived from the molecular data set were compared with those from the set of 36 morphological characters previously analysed. Estimates of phylogeny were found to be significantly different between the molecular and the morphological data set and possible causes for incongruence, such as the coding of inapplicable characters in morphology and a very reduced set of taxa in the molecular analysis, are discussed. The position of Colossendeidae was a major cause of conflict, being supported as a relative of Ammotheidae by morphological characters but appearing closely related to Callipallenidae and Nymphonidae with DNA data. With the molecular characters, *Austrodecus* is identified as a basal taxon for the rest of the pycnogonids included, differing from its close relationship to ammotheids shown by morphology. Using morphological data, the family Ammotheidae appeared as paraphyletic as did Callipallenidae. *Pallenopsis* was related to *Anoplodactylus* according to DNA but not morphology. Although

no clear pattern of overall relationships among sea spiders is yet defined, several patterns useful for future systematic work have been noted. New sets of characters and compilation of data from all available sources will probably provide a better picture. Ontogenetic transformation could give some insights into character evolution, and knowledge of ecological traits is needed to complement morphological observations. A collection of fresh material of numerous species of sea spiders from the Great Barrier Reef and other localities of Queensland was useful for the phylogenetic analyses and also contributed to the knowledge of the marine fauna of Australia. Thirty-three species of tropical shallow-water sea spiders collected from the Queensland coast, the Great Barrier Reef and the Coral Sea are reported here. Among these were six undescribed species in the genera *Austrodecus*, *Anoplodactylus* and *Pycnogonum*, and other nine species, mostly of Indo-West pacific distribution not previously recorded for Australia.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PUBLICATIONS

Based on the work of this thesis, the following papers have been accepted or submitted to scientific journals for publication :

Arango CP. 2001. Sea spiders (Pycnogonida) from the Great Barrier Reef, Australia, feed on fire corals and zoanthids. Memoirs of the Queensland Museum 46:656.

Arango CP. 2000. Three species of sea spiders (Pycnogonida) from Santa Marta, Colombian Caribbean. Boletin de Investigaciones Marinas y Costeras 29:59-66.

Arango CP. In press. Morphological phylogenetics of sea spiders (Arthropoda, Pycnogonida). Organisms Diversity and Evolution.

Arango CP. In press. Sea spiders from the Great Barrier Reef area: New species, new records and ecological annotations. Journal of Natural History.

Arango CP. Molecular approach to the phylogenetics of Pycnogonida (Arthropoda) using nuclear ribosomal DNA and morphology. Submitted to Molecular Phylogenetics and Evolution.

Arango CP and Brodie GD. In press. Observations of predation on the tropical nudibranch *Okenia* sp. by the sea spider *Anoplodactylus longiceps* Williams (Pycnogonida, Arthropoda). The Veliger.

Lee A. C. and Arango CP. Two new species and other records of sea spiders (Pycnogonida, Arthropoda) from tropical North Queensland, Australia. Submitted to Memoirs of the Queensland Museum.

Statement on sources

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

Claudia P. Arango

23rd May 2002
Date