

Santo

The Natural History of

edited by
Philippe Bouchet, Hervé Le Guyader, Olivier Pascal



PATRIMOINES NATURELS

PUBLICATIONS SCIENTIFIQUES DU MUSÉUM
IRD ÉDITIONS
PRO-NATURA INTERNATIONAL

The Santo 2006 expedition was organized,
with the support, among others, of

ΣΝ / *SNf* STAVROS NIARCHOS FOUNDATION

FONDATION
TOTAL



and



Santo

The Natural History of

edited by

Philippe Bouchet, Hervé Le Guyader & Olivier Pascal



Institut de recherche
pour le développement



Contents

Foreword by Edward Natapei, Prime Minister of Vanuatu	10
Introduction. The Natural History of Santo: An Attempt to Bridge the Gap between Academic Research and Conservation and Education	11
Vanuatu in the South Pacific	13
Benoît Antheaume	
ESPIRITU SANTO IN SPACE AND TIME	17
coordinated by Bruno Corbara	
The Late Quaternary Reefs	19
Guy Cabioch & Frederick W. Taylor	
The Holocene and Pleistocene Marine Faunas Reconsidered	25
Pierre Lozouet, Alan Beu, Philippe Maestrati, Rufino Pineda & Jean-Louis Reys	
Geography of Santo and of the Sanma Province	34
Patricia Siméoni	
Drainage, Hydrology and Fluvial Geomorphology	46
James P. Terry	
The Climate of Santo	52
James P. Terry	
Large-scale Climatic and Oceanic Conditions around Santo	57
Christophe Maes & David Varillon	
A Brief History of Biodiversity Exploration and Scientific Expeditions on and off the Island of Santo	62
Bruno Corbara & Bertrand Richer de Forges	
Deforestation on Santo and Logging Operations	67
Rufino Pineda	
The Impact of WWII on Infrastructures and Landscape	69
Laurent Palka & Rufino Pineda	
Conservation Efforts in Santo	71
Samson Vilvil-Fare	
VEGETATION AND FLORA	73
coordinated by Jérôme Munzinger & Porter P. Lowry II	
Exploration by the Santo 2006 Botany Team	75
Porter P. Lowry II & Jérôme Munzinger	
Principal Types of Vegetation Occurring on Santo	76
Jérôme Munzinger, Porter P. Lowry II & Jean-Noël Labat	
Phytogeographic Relationships	77
Gordon McPherson	
How Old are the Kauri (<i>Agathis microphylla</i>) Trees?	83
Jonathan Palmer	
The Flora of Santo	89
Some New, Characteristic or Remarkable Species	89
Gordon McPherson & Jérôme Munzinger	
Focus on Araliaceae:	
Several Genera Exemplify Santo's Melanesian Biogeographic Relations	90
Porter P. Lowry II & Gregory M. Plunkett	
Focus on <i>Geissois</i> (Cunoniaceae):	
Another Example of the Melanesian Connection	93
Yohan Pillon	
Focus on Pandans	94
Thomas Haevermans	
Focus on Orchids	97
Marc Pignal	

Focus on Palms	102
Jean-Michel Dupuyoo	
Focus on Ferns	105
Germinal Rouhan	
Focus on Bryophytes	110
Elizabeth A. Brown	
Fungi, the Forgotten Kingdom	113
Bart Buyck	
TERRESTRIAL FAUNA	117
coordinated by Bruno Corbara	
IBISCA-Santo Biodiversity Along an Altitudinal Gradient	119
Bruno Corbara on behalf of the IBISCA network	
Insects on Santo	123
Focus on Orthoptera	123
Laure Desutter-Grandcolas, Sylvain Hugel & Tony Robillard	
Termites in Santo: Lessons from a Survey in the Penaoru Area	128
Yves Roisin, Bruno Corbara, Thibaut Delsinne, Jérôme Orivel & Maurice Leponce	
Focus on Bees and Wasps	131
Claire Villemant	
Myrmecophily in Santo: A Canopy Ant-Plant and its Expected and Less Expected Inhabitants	143
Bruno Corbara	
Beetles in Saratsi Range, Santo	146
Alexey K. Tishechkin, Jürgen Schmidl	
Lepidoptera in Vanuatu: Fauna, Geography and the IBISCA-Santo Project	155
Roger L. Kitching	
Other Invertebrates	161
Diversity of Spiders	161
Christine Rollard	
Some Arthropods as Expressed in the Words of Penaoru Villagers	167
Bruno Corbara	
Indigenous Land Snails	169
Benoît Fontaine, Olivier Gargominy & Vincent Prié	
The Vertebrates of Santo	179
Terrestrial Bird Communities	179
Nicolas Barré, Thibaut Delsinne & Benoît Fontaine	
Amphibians and Reptiles	187
Ivan Ineich	
RIVERS AND OTHER FRESHWATER HABITATS	237
coordinated by Philippe Keith	
Freshwater Habitat Types	239
Philippe Keith & Clara Lord	
Freshwater Biota	242
Focus on Fish, Shrimps and Crabs	242
Philippe Keith, Clara Lord, Philippe Gerbeaux & Donna Kalfatak	
Focus on Aquatic Insects	251
Arnold H. Staniczek	
Focus on Freshwater Snails	257
Yasunori Kano, Elen E. Strong, Benoît Fontaine, Olivier Gargominy, Matthias Glaubrecht & Philippe Bouchet	

CAVES AND SOILS	265
coordinated by Louis Deharveng	
The Karst Team	267
Louis Deharveng & Anne-Marie Sémah	
Karst and Caves	269
Bernard Lips, Franck Bréhier, Denis Wirrmann, Nadir Lasson, Stefan Eberhard, Josiane Lips & Louis Deharveng	
Caves as Archives	278
Denis Wirrmann, Jean-Christophe Galipaud, Anne-Marie Sémah & Tonyo Alcover,	
Ni-Vanuatu Perception and Attitudes Vis-à-Vis the Karstic Environment	284
Florence Brunois	
Karst Habitats of Santo	288
Focus on Soils	288
Anne Bedos, Vincent Prié & Louis Deharveng	
Focus on Cave Terrestrial Habitats	296
Louis Deharveng, Anne Bedos, Vincent Prié & Éric Queinnec	
Focus on Guano	300
Louis Deharveng, Josiane Lips & Cahyo Rahmadi	
Focus on Blue Holes	306
Stefan Eberhard, Nadir Lasson & Franck Bréhier	
Focus on the Loren Cave	310
Franck Bréhier, Sephan Eberhard & Nadir Lasson	
Focus on Anchialine Fauna	312
Geoff Boxshall & Damià Jaume	
Karst Biota of Santo	316
Focus on Bats	316
Vincent Prié	
Fish and Shrimps of Santo Karstic Systems	323
Marc Pouilly & Philippe Keith	
Focus on Springtails	327
Louis Deharveng & Anne Bedos	
Focus on Microcrustaceans	331
Damià Jaume, Geoff Boxshall & Eric Queinnec	
MARINE ECOSYSTEMS	335
coordinated by Philippe Bouchet	
Benthic Algal and Seagrass Communities from Santo Island in Relation to Habitat Diversity	337
Claude E. Payri	
The Position of Santo in Relation to the Centre of Maximum Marine Biodiversity (the Coral Triangle)	369
Bert W. Hoeksema & Adriaan Gittenberger	
Focus on Selected (Micro)Habitats	373
Sulfide Rich Environments	373
Yasunori Kano & Takuma Haga	
Marine Interstitial	375
Timea Neuser	
Mangroves Environments of South East Santo	377
Jean-Claude Plaziat & Pierre Lozouet	
Focus on Selected Biota	383
Checklist of the Fishes	383
Ronald Fricke, John L. Earle, Richard L. Pyle & Bernard Séret	

Unusual and Spectacular Crustaceans	410
Tim-Yam Chan, Masako Mitsuhashi, Charles H.J.M. Fransen, Régis Cleva, Swee Hee Tan, Jose Christopher Mendoza, Marivene Manuel-Santos & Peter K.L. Ng	
The Marine Molluscs of Santo	421
Philippe Bouchet, Virginie Héros, Pierre Lozouet, Philippe Maestrati & Rudo von Cosel	
A Rapid Assessment of the Marine Molluscs of Southeastern Santo	431
Fred E. Wells	
Molluscs on Biogenic Substrates	438
Anders Warén	
Marine Partnerships in Santo's Reef Environments: Parasites, Commensals and Other Organisms that Live in Close Association	449
Stefano Schiaparelli, Charles Fransen & Marco Oliverio	
Seaslugs: The Underwater Jewels of Santo	458
Yolanda E. Camacho & Marta Pola	
MAN AND NATURE	465
coordinated by Michel Pascal	
Pre-European Times	467
Vertebrate Pre-Human Fauna of Santo: What Can we Expect to Find?	467
Joseph Antoni Alcover	
The Prehistory of Santo	469
Jean-Christophe Galipaud	
Introduced Biota	476
Overview: Introduced Species, the "Good", the "Worrisome" and the "Bad"	476
Michel Pascal, Olivier Lorvelec, Nicolas Barré, Michel de Garine-Wichatitsky & Marc Pignal	
Focus on Synanthropic Mammals	480
Olivier Lorvelec & Michel Pascal	
Focus on Feral Mammals	483
Michel de Garine-Wichatitsky & Anthony Harry	
Focus on Alien Birds	488
Nicolas Barré	
Focus on Introduced Amphibians and Reptiles	490
Olivier Lorvelec & Michel Pascal	
Focus on Introduced Fish	494
Philippe Keith, Clara Lord, Donna Kalfatak & Philippe Gerbeaux	
Focus on Alien Land Snails	495
Olivier Gargominy, Benoît Fontaine & Vincent Prié	
Endemic, Native, Alien or Cryptogenic? The Controversy of Santo Darkling Beetles (Insecta: Coleoptera: Tenebrionidae)	500
Laurent Soldati	
The Case of Two Invasive Species: <i>Mikania micrantha</i> and <i>Merremia peltata</i>	503
Marc Pignal	
Man Santo in his Environment	508
Food-Garden Biodiversity in Vanuatu	508
Sara Muller, Vincent Lebot & Annie Walter	
At the Junction of Biological Cycles and Custom: the Night of the Palolo	515
Laurent Palka	
Ni-Vanuatu Perceptions and Attitudes Vis-à-Vis Biodiversité	516
Florence Brunois & Marine Robillard	
THE SANTO 2006 EXPEDITION	523
The Santo 2006 Expedition from an Ethnologist's Point of View	525
Elsa Faugère	

The "Making of" Santo 2006 **529**
 Philippe Bouchet, Hervé Le Guyader, Olivier Pascal

Santo 2006 Expedition in the Classroom **549**
 Sophie Pons & Alain Pothet

Santo 2006 Expedition Participants List **550**

Acknowledgements **553**

Bibliography..... **557**

Addresses of the Authors..... **564**

FOCUS ON MICROCRUSTACEANS

The freshwater lakes, streams and rivers of oceanic islands are prone to be colonised by typically marine groups that seldom penetrate far inland on continental landmasses. The process of colonisation of these island habitats is presumed to have been facilitated by the reduced competition, if any, posed to the newcomers since the island hydrographic networks (inland water systems) have never been connected to the continents and are assumed to offer plenty of vacant niches. In addition, and since many oceanic islands are fringed by karstified zones consisting of fossil coral reef terraces that have been raised, their running waters typically exhibit raised calcium concentrations, which can lessen the osmotic barriers preventing colonisation by marine animals. A classic example of colonisation of island freshwaters by a typically marine taxon is the hermit crab *Clibanarius fonticola*. This is the only strictly freshwater anomuran crab known to science thus far, and dwells in karstic coastal springs and blueholes adjacent to the shore on the island of Espiritu Santo. The name of the species, *fonticola*, means living in springs, and refers to this unique aspect of its biology.

The exploration of Santo surface freshwater habitats undertaken in 2006 revealed a second example of the colonisation of island freshwater habitats by a predominantly marine group: this time an isopod belonging to the basically marine family Sphaeromatidae. Isopods are a diverse group of crustaceans containing terrestrial forms, such as woodlice, as well as freshwater and marine forms. Some species are even parasitic on shrimp hosts and exhibit highly modified body shapes. Most have

Damià Jaume, Geoff Boxshall, Eric Queinnec

dorso-ventrally flattened bodies but, like amphipods and tanaids, they belong to the Peracarida which are characterised by carrying their developing young in a ventral brood pouch.

The new species of Sphaeromatid was discovered in a karstic stream and associated cave sink located on a raised coral reef terrace about 390 m a.s.l. and covered by lowland rainforest. This site was situated near Butmas village, about 23.5 km inland from the east coast of the island. The Sphaeromatidae is a large family, currently comprising about 655 species, and the vast majority of these are marine.

The new species was named *Exosphaeroides quirosi* (Fig. 406) by two members of the expedition, Damià Jaume and Eric Queinnec in 2007. The name of the new species honours the Portuguese explorer Pedro Fernández de Quirós, who was the first European to reach the island on 1606, exactly 400 years before the date of our expedition.

This is a particularly exciting discovery because *Exosphaeroides quirosi* is the only truly freshwater sphaeromatid known to occur in the Pacific Islands outside of New Zealand. It is only the third species described in the genus *Exosphaeroides*, and the other two are known to live in brackish waters in New Zealand and in Easter Island.

Another important habitat to search for microscopic crustaceans is the subterranean waters. We were allowed to sample water from wells in villages around the islands of Santo and Malo and in most cases there were pumps so we were able to collect

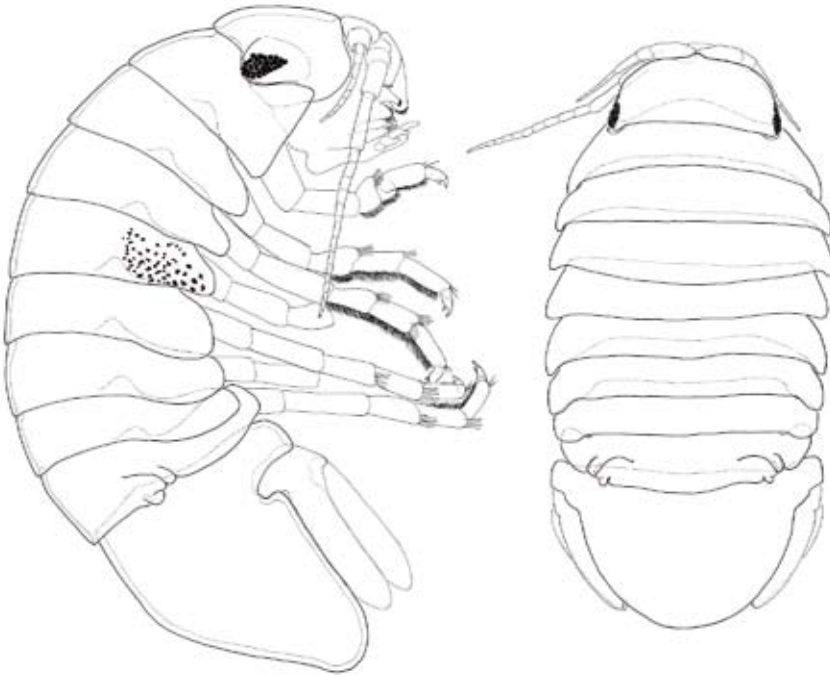


Figure 406: Adult specimens of *Exosphaeroides quirosi* shown in side view and dorsal view. These adults are about 11.5 mm in length. (Line drawings by Damià Jaume).

samples simply by pumping water through a hand held net (Fig. 407) supplied with a fine mesh that retained even minute crustaceans less than 1 mm in body length.

Around the Eastern and Southeastern coast of Santo, these wells provide access to parts of the anchialine aquifer fringing the island that otherwise could not be sampled for aquatic fauna. The most interesting



Figure 407: Filtering water from a pump near Matevulu. Using a fine mesh plankton net allowed us to catch interesting microscopic crustaceans.

discovery was a blind and unpigmented amphipod shrimp, possibly a new species of *Josephosella* belonging to the family Melitidae. It was collected in virtually fresh water, salinity was only 0.3 parts per thousand, at pumps in the villages of Natanara and Matevulu. It has not been fully studied yet, but apparently the same amphipod species was caught by Stephan Eberhard at Nanda Blue Hole at a depth 13 m, and also at the spring at Porpor, this time entangled in submerged tree roots.

Most of the pump samples taken around Santo also contained copepods, but they were particularly common at the pumps at Matevulu and Natanara. The copepods inhabiting subterranean waters are typically tiny, with a body length of around half a millimetre (0.5 mm). They have slender bodies and usually have short sensory antennae at the front of the head (Fig. 408). They are usually white and lack the single mid-dorsal eyespot present in forms living above ground.

Early developmental stages of copepods were also found in many pump samples. Copepod eggs hatch

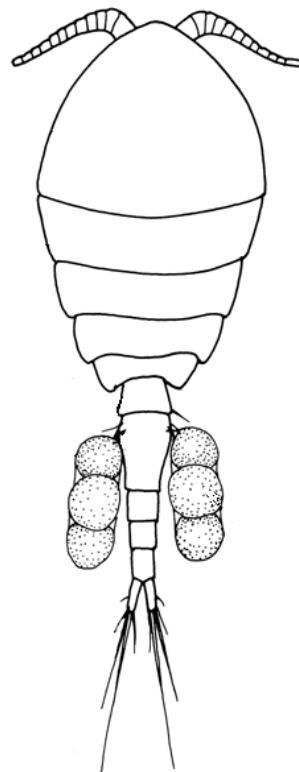


Figure 408: A typical copepod from the family Cyclopidae, shown in dorsal view. This is an adult female bearing a pair of egg sacs, each with only few eggs, as is typical for subterranean forms. This female is 0.6 mm long. (Line drawing by Geoff Boxshall).

as nauplii, a tiny swimming larval stage with only three pairs of limbs (unlike the 12 pairs of limbs present in the adult). Like all arthropods, copepods moult as they develop and grow up to become adults, and they typically add one pair of limbs at each moult until the adult total of 12 pairs is reached. The presence of larvae representing different stages of the life cycle indicates that there are viable populations of the microcrustaceans living in the subterranean waters.

The subterranean copepod fauna of the southeastern coast is quite diverse, consisting of at least two different species of the family Cyclopidae and three different species of the order Harpacticoida. All of these species are probably new to science. Only one species of the Cyclopidae has previously been reported from the island of Santo, and that was not a subterranean form. It was *Bryocyclops anninae* and was found back in 1927 from water caught in empty coconut shells collected near Hog Harbour. This tiny species has an adult body length of 0.4 mm and was first described from Java in Indonesia. We were unable to find this same species again, perhaps because the original collections were made during February and we were collecting in September. However, we did find other members of the Cyclopidae in several

surface streams and swamps on Santo and Malo. We collected species of the genera *Mesocyclops* and *Eucyclops* in various localities on both islands and these are still being studied.

In addition to the amphipod *Josephosella* and the cyclopid copepods, other samples taken at pumps contained representatives of different types of crustacea. One pump sample taken just east of Luganville contained two specimens of an unidentified microparasellid isopod, although this time water was slightly brackish with a salinity of 1.10 parts per thousand. Finally, another pump in the same area rendered a single specimen of a juvenile tanaid. Because it is a juvenile it is not possible to identify or describe the species until more material becomes available, but the discovery is remarkable because the water was virtually fresh (salinity only 0.4 parts per thousand). The Tanaidacea is a strictly marine group with only a handful of species ever reported from fresh water anywhere. Interestingly, we can mention here that another tanaidacean has just been collected from a cave stream of the coastal Maros karst in Sulawesi, in running fresh water. This new species has been recently described as a new species of *Pseudohalmyrapseudes*, a genus with four species reported from freshwater habitats on Pacific Islands.

Santo

The Natural History of

The islands of the Pacific are renowned for the high levels of endemism of, and threats to, their unique faunas and floras. Espiritu Santo, affectionately known simply as Santo, is an island of superlatives: the largest and highest in Vanuatu, Santo is an extraordinary geographical and cultural microcosm, combining reefs, caves, mountains, satellite islands, and a history of human habitation going back 3 000 years. In the spirit of famous voyages of discovery of the past, the Santo 2006 expedition brought together over 150 scientists, volunteers and students originating from 25 countries. With contributions by more than 100 authors, *The Natural History of Santo* is a lavishly illustrated homage to the biodiversity of this "planet-island". Bridging the gap between scientific knowledge and conservation and education, *The Natural History of Santo* was written with local stakeholders as well as armchair naturalists from all over the world in mind.

Les îles du Pacifique sont célèbres pour le très haut niveau d'endémisme et la grande vulnérabilité de leurs faunes et de leurs flores. L'île d'Espiritu Santo, ou Santo, cumule les superlatifs : la plus grande et la plus haute du Vanuatu, Santo est un extraordinaire microcosme géographique et culturel, avec récifs, grottes, montagnes, îles et îlots satellites, et une occupation humaine qui remonte à 3 000 ans. Renouant avec l'esprit des "Grandes Expéditions Naturalistes", l'expédition Santo 2006 avait mobilisé sur le terrain plus de 150 scientifiques, bénévoles et étudiants de 25 pays. Petit tour de force éditorial avec plus de 100 auteurs, ce *Natural History of Santo* est un éloge de la biodiversité de cette "île-planète". À la fois beau livre richement illustré et bilan des connaissances scientifiques, *The Natural History of Santo* se veut un outil de connaissance pour sa conservation durable. Il s'adresse autant aux acteurs locaux du développement et de l'éducation qu'aux naturalistes du monde entier.



Institut de recherche
pour le développement



ISSN 1281-6213

ISBN MNHN: 978-2-85653-627-8
ISBN IRD: 978-2-7099-1708-7



9 782856 536278

Prix : 59 € TTC