

**A STUDY OF THE BIOLOGY AND ECOLOGY OF
THE BLACK SPONGE *CHONDROSIA* SP.
COLONIZATION IN SEMPORNA ISLANDS,
AND ITS IMPACT
ON THE REEF ECOSYSTEM**



**BORNEO MARINE RESEARCH INSTITUTE
UNIVERSITI MALAYSIA SABAH
KOTA KINABALU
2007**

**A STUDY OF THE BIOLOGY AND ECOLOGY OF
THE BLACK SPONGE *CHONDROSIA* SP.
COLONIZATION IN SEMPORNA ISLANDS,
AND ITS IMPACT
ON THE REEF ECOSYSTEM**

AJIRIN @ ADRIAN ANGKAJI



PERPUSTAKAAN
UNIVERSITI MALAYSIA SABAH

UMS
UNIVERSITI MALAYSIA SABAH

**THESIS SUBMITTED IN FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE**

**BORNEO MARINE RESEARCH INSTITUTE
UNIVERSITI MALAYSIA SABAH
KOTA KINABALU
2007**

BORANG PENGESAHAN STATUS TESIS[®]

JUDUL : A STUDY OF THE BIOLOGY AND ECOLOGY OF THE BLACK SPONGE *CHONDROSIA* SP. COLONIZATION IN SEMPORNA ISLANDS, AND ITS IMPACT ON THE REEF ECOSYSTEM.

IJAZAH : SARJANA SAINS (SAINS MARIN).

SESI PENGAJIAN : 1998-2006

Saya, AJIRIN @ ADRIAN ANGKAJI mengaku membenarkan tesis Sarjana ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Universiti Malaysia Sabah.
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian saya.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara Institusi Pengajian Tinggi
4. TIDAK TERHAD.



Disahkan oleh

UNIVERSITI MALAYSIA SABAH

(Penulis: AJIRIN @ ADRIAN ANGKAJI)

ANITA BINTI ARSAD
PUSTAKAWAN KANAN
UNIVERSITI MALAYSIA SABAH

(TANDATANGAN PUSTAKAWAN)

Alamat:

UNIVERSITI MALAYSIA SABAH
JALAN TUNABALU
84000 KANAR, SABAH

(Penyelia: Prof. Dr. Hj. Ridzwan Abdul Rahman)

Tarikh: 8 Ogos 2007

Tarikh: 13.09.07 2007.

CATATAN: [®] Tesis dimaksudkan sebagai tesis Ijazah Doktor Falsafah dan Sarjana secara penyelidikan atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau laporan Projek Sarjana Muda (LPSM)

DECLARATION

The materials in this thesis are original except for quotations, excerpts, summaries and references, which have been duly acknowledged.



AJIRIN @ ADRIAN ANGKAJI

PS98-001-053

18 JUNE 2007



UMS
UNIVERSITI MALAYSIA SABAH

ABSTRACT

A STUDY OF THE BIOLOGY AND ECOLOGY OF THE *CHONDROSIA* SP. COLONIZATION IN SEMPORNA ISLANDS, AND ITS IMPACT ON THE REEF ECOSYSTEM

This study involved carrying out research into the biology and ecology of an invasive species of sponge called the black sponge from 1999 to 2004. The aim was to investigate its impact on the reef ecosystem and consider the implications of the infestation on reef management. The sponge was found to be locally common at depths between 2.0 - 20.0 m during surveys carried out in the initial phase (Phase I) of the Semporna Islands Project, in Sabah, Malaysia. It occurs as a thin film growing over rock, rubble and dead corals, leaving only isolated patches and certain dead corals uncovered. It is particularly common at Bodgaya West reef, Maiga South and Maiga West reefs. This phenomenon has not previously been described for the area and it was for this reason that a study on its biology and ecology was carried out. The research included identifying the black sponge, comparing results of Line Intercept Transect (LIT) method surveys and studying the spread of the sponge over different substrata. It was found that the black sponge can move over the substratum at rates of 1.8 – 1.9 mm² per day. The fastest spread occurred where the sponge was growing over the dead part of live hard coral or other non-living substratum. The fastest spread rates recorded were over terracotta brick where the sponge grew at an average of 1.9 mm² per day, and over dead coral where the sponge grew at 1.8 mm² per day. However, the area, which was initially dominated by the black sponge species, has been reduced year-by-year from 61% in 1999 to 3% in 2004. The black sponge was eventually identified and confirmed as an undescribed species of *Chondrosia* by a sponge expert Dr. Michelle Kelly and Dame Professor Patricia R. Bergquist, Emerita Professor, Department of Anatomy, School of Medical and Health Sciences, University of Auckland, New Zealand.

ABSTRAK

KAJIAN TERHADAP BIOLOGI DAN EKOLOGI CHONDROSIA SP. DI KEPULAUAN SEMPORNA DAN KESAN KEATAS EKOSISTEM TERUMBU KARANG

Kajian ini bertujuan untuk mengkaji biologi dan ekologi serta kesan jangka panjang terhadap ekosistem terumbu karang berikutan pertumbuhan meluas satu spesies span baru yang dikenali sebagai span hitam di pulau-pulau Semporna. Pertumbuhan meluas span hitam telah dikesan pada kedalaman 2.0 - 20.0 m ketika kerja-kerja penyelidikan awal terumbu karang Projek Pulau-Pulau Semporna (fasa I) di Semporna, Sabah bermula. Span hitam yang menyerupai filem hitam nipis, tumbuh di atas serpihan terumbu karang mati, walaupun bukan keseluruhannya. Span hitam ini boleh ditemui dengan banyak di bahagian Barat Pulau Bodgaya, Selatan dan Barat Pulau Maiga. Kajian terperinci terhadap pertumbuhan span hitam ini amat penting kerana tidak ada kajian mahupun laporan tentang kewujudan fenomena sebelum ini. Oleh itu kajian terperinci telah dijalankan secara tidak langsung dari tahun 1999 hinggalah 2004. Ini melibatkan kerja-kerja pengenalpastian spesies span hitam, perbandingan terhadap peratusan pertumbuhan span hitam menggunakan teknik Line Intercept Transect (LIT), kadar pertumbuhan span hitam menggunakan video digital serta mengukur kadar pertumbuhan dari masa ke semasa. Kawasan kajian ini merupakan antara kawasan yang teruk di tumbuhi oleh span hitam. Kadar pertumbuhan spesies ini juga menunjukkan bahawa spesies ini boleh bergerak dan tumbuh keatas sesuatu substrat mati pada kadar 1.8mm persegi/hari hingga 1.9mm² /hari. Kadar pertumbuhan tercepat direkodkan pada terumbu karang mati iaitu pada kadar 1.8 mm² / hari diikuti pada bata merah, 1.9 mm² / hari. Walau bagaimana pun, kajian berterusan dari tahun 1999 hingga 2004 menunjukkan penurunan peratusan span hitam di kawasan kajian dari 61% kepada 3%. Secara keseluruhannya kajian terperinci terhadap fenomena ini amat penting terutama sekali dalam pengurusan terhadap ekosistem terumbu karang dalam jangka masa panjang. Hasil dari kajian, span hitam tersebut akhirnya dikenalpasti sebagai satu spesies baru dalam genus Chondrosia sp. oleh pakar Span Dr. Michelle Kelly dan Professor Patricia R. Bergquist, Emeritas Professor, Jabatan Anatomi, Sekolah Sains Perubatan dan Kesihatan, Universiti Auckland, New Zealand.

ACKNOWLEDGEMENTS

I wish to extend my sincere thanks my supervisors, Prof. Dr. Ridzwan Abd. Rahman and Prof. Dr. Salem Mustafa (Director of Borneo Marine Research Institute) for their help, guidance and continuous encouragement during the course of this study.

I am particularly grateful to my co-supervisors Dr. Elizabeth Wood & Dr. Frances Dipper (Marine Conservation Society) for their help, guidance, commented, edited the drafts of this report, and giving me a big opportunity to further my studies in University Malaysia Sabah during the Semporna Islands Project 1998-2000.

I am also very grateful to Dr Michelle Kelly, NIWA, and Dame Professor Patricia R. Bergquist, Emeritas Professor, Department of Anatomy, School of Medical and Health Sciences, University of Auckland, New Zealand for helping me to identify sponge species.

I also would like to thank Dr. Majaji for her help in thesis correction, Dr. Charles Vairappan for his help in Scanning Electron Microscope (SEM), Mr. Julian Rangsangan for the histological studies in Universiti Malaysia Sabah, and Dr. David A Johnston, researcher in Parasite Genome Analysis, Biomedical Parasitology Division, Department of Zoology, Natural History Museum London. I also would like to thank the Sabah Parks Department and WWF Malaysia (Sabah) for giving me permission to conduct and to carry out continues this study. I am not forgetting to Sabah Parks Staff in Semporna, for their help during the course of this study.

This study would not have been completed without the support, patience and understanding of my wife Elve, my son Alvin and daughter Valentyna and my parents. To them, I am very much indebted.

CONTENTS

	Page
ABSTRACT	I
ACKNOWLEDGEMENTS	iii
LIST OF FIGURES	iv
LIST OF TABLES	xi
CHAPTER 1: INTRODUCTION	
1.1 Background	1
1.2 Aims and Objectives	3
CHAPTER 2: LITERATURE REVIEW	
2.1 General biology and morphology of sponges	5
2.2 Skeleton	6
2.3 Longevity, size and growth rate of sponges	8
2.4 General ecology and habitats of sponges	9
2.5 Reproduction	10
CHAPTER 3: METHODS	
3.1 Study area	12
3.2 Distribution of the 'black sponge' and selection of study sites.	12
3.3 Line Intercept Transect (LIT) Method	14
3.4 Identification of the black sponge	16
3.4.1 Collection and Preservation	
3.4.2 Laboratory Examination	
3.5 Spread rate observations	18
3.6 Spread and colonization rate observations of black sponge over live hard coral	18
3.7 Spread and colonization of black sponge on the dead part of live hard coral	21
3.8 Spread and colonization of black sponge on clean terracotta brick	23
3.9 Scraped and re-scraped experiment	23
3.10 Estimation of the black sponge colonies spread rate	24
3.11 Extent of Infestation	25
3.12 Statistical analysis	25
3.13 Management strategies	25
CHAPTER 4 : RESULTS AND DISCUSSION	
4.1 Sponge Taxonomy	26
4.1.1 Systematics Summary	27
4.1.2 Guide to Identification (Boury-Esnault and Lopes 1985)	27
4.1.3 Description of genus <i>Chondrosia</i> (Adapted from Boury-Esnault and Lopes, 1985)	27

4.1.4	Description of the unidentified species of <i>Chondrosia</i> sp.	30
4.1.4.1	Locality and habitat	30
4.1.4.2	Shape and size	30
4.1.4.3	Colour	30
4.1.4.4	Surface	31
4.1.4.5	Texture	31
4.1.4.6	Histology	31
4.1.4.7	Skeleton	33
4.1.4.8	Associations with other organism	34
4.2	Distribution and Abundance	38
4.2.1	The status of <i>Chondrosia</i> sp. in terms of percentage cover in 1999	38
4.2.2	The status of <i>Chondrosia</i> sp. in terms of percentage cover between 1999 to 2004 in Bodgaya West (black sponge site)	42
4.3	Spread Rates	45
4.3.1	Spread and colonization of <i>Chondrosia</i> sp. on live hard corals	45
4.3.1.1	<i>Diploastrea heliopora</i> border	46
4.3.1.2	<i>Favia rotumana</i> and <i>Favia</i> sp. border	46
4.3.1.3	<i>Porites</i> sp. border	47
4.3.2	Spread and colonization of <i>Chondrosia</i> sp. on the dead parts of live hard coral	56
4.3.3	Spread and colonization of <i>Chondrosia</i> sp. on terracotta brick	56
4.3.4	Scraped and re-scraped experiments over <i>Chondrosia</i> sp.	57
4.3.5	Average spread rates	57
4.3.6	Others	57
4.3.7	Discussion	70
4.4	Possible Cause(s) of Colonization and Regression	72
CHAPTER 5: CONCLUSION AND RECOMMENDATION		
5.1	Management strategies	80
5.2	Conclusion	80
<i>Appendix I: Sites Surveyed Within the Tun Sakaran Marine Park</i>		82
<i>Appendix II: Statistical Analysis</i>		84
<i>References</i>		86

LIST OF FIGURES

FIGURE	CONTENTS	PAGE
Figure 1.1	Sabah Map – Research Location	4
Figure 2.1	A , siliceous spicules (oxeas) glued together at their tips with spongin to form a network in <i>haliclona rosea</i> . B , spongin fibers with embedded siliceous spicules (oxeas) form a reinforced network in endectyon. (Adopted from: " <i>Porifera</i> " and " <i>Placozoa</i> " in http://64.78.63.75/samples/04BIORuppertInvertebrateZoology7ch5.pdf)	7
Figure 2.2	Porifera: body wall and skeleton of calcifying sclerosponge (demospongiae: ceratoporellidae). The calcareous exoskeleton is secreted by the basal exopinacoderm and contains embedded siliceous spicules. siliceous spicules also occur in the mesohyl of the living tissue. (Adopted from: " <i>Porifera</i> " and " <i>Placozoa</i> " in http://64.78.63.75/samples/04BIORuppertInvertebrateZoology7ch5.pdf)	7
Figure 3.1	Semporna Islands Reef (Recently gazetted Tun Sakaran Marine Park in June 2004)	13
Figure 3.2	Line Intercept Transect (LIT) method	14
Figure 3.3	Border between black sponge and live hard coral <i>Diploastrea heliopora</i> (13 July, 1999)	19
Figure 3.4	Border between black sponge and <i>Favia rotumana</i> . A piece of string (marked with white dot-line) was used as a mark around between the two colonies (21 July, 1999)	19
Figure 3.5	Border between black sponge and <i>Porites</i> sp. (13 July, 1999)	20
Figure 3.6	Border between black sponge and <i>Porites</i> sp. (13 July, 1999)	20
Figure 3.7	The spread of black sponge over dead parts of <i>Diploastrea heliopora</i> (Observation I: 13 July, 1999)	21
Figure 3.8	The spread of black sponge over dead parts of <i>Diploastrea heliopora</i> (Observation II: 13 July, 1999)	22
Figure 3.9	The spread of black sponge over dead parts of <i>Diploastrea heliopora</i> (Observation III: 13 July, 1999)	22
Figure 3.10	The brick laid vertically on the top of the black sponge colonies (22 February, 2000)	23

- Figure 3.11 A colony of *Porites* sp. with the area that had been scraped clean shown by the dotted white line. 24
- Figure 3.12 Estimation of the area covered by the black sponge colony using grid system 24
- Figure 4.1 *Chondrosia*. A, *In situ* photograph of a Mediterranean specimen of *Chondrosia reniformis* (J. Vacelet slide collection) Scale bar: 0.5 cm. B, microphotograph of histological slide from the Lendenfeld collection in the BMNH 96.11.5.109 (abbreviations: CO cortex; CH choanosome; sp: foreign spicule; arrow: cribriporal chone) Scale bar: 400 μ m. (Taken From ORDER CHONDROSIDA BOURY-ESNAULT & LOPES, 1985. FAMILY CHONDRILLIDAE GRAY, 1872 NICOLE BOURY-ESNAULT Université de la Méditerranée, Centre d'Océanologie de Marseille, Station marine d'Endoume, UMR CNRS 6540, rue de la Batterie des Lions, 13007-Marseille, France (esnault@com.univ-mrs.fr)) 28
- Figure 4.2 Fluorescent *in situ* hybridization with the universal Probe EUB338 in thin sections of the sponge *Chondrosia reniformis*. Each bright signal can be assigned to a single bacterial cell (Taken from Osinga, *et al.* 2001) 29
- Figure 4.3 SEM micrograph (PELDRI-dried) of the tissue of the coralline demosponge *Vaceletia crypta* from reef caves of the Great Barrier Reef (Northern Australia). Within the mesohyl mobile sponge cells are visible (S). Bacteria (B) are abundant in the mesohyl, most of them are *Vibri* o-types. C = canal, CHC = choanocyte chamber, PA = endopinacocyte (cell lining the internal surfaces). (Taken from Osinga, R. *et al.* 2001) 29
- Figure 4.4 *Chondrosia* sp. A: *In situ* photograph of a specimen of *Chondrosia* sp. From underwater close-up photograph (by Frances dipper) Abbreviation: **OSC**, osculum and semi-thin section microphotograph of histological slide showing. B: **CO** cortex, **CH** choanosome (40 X) C: **CC** Choanocyte chamber, **ca** Canal (200 X). 32
- Figure 4.5 A: Photomicrograph from SEM of spongin fibers by the incorporation of foreign material (8.00 K X), B: A Close-up SEM photomicrograph (40.00 K X) of spongin fibers. 33
- Figure 4.6 SEM micrograph of a diatoms magnification = 188 X; 20 μ m, slime growing under the surface of *Chondrosia* sp.. Predominant diatoms are species of *Amphora*. 35
- Figure 4.7 A close-up SEM photomicrograph of diatoms *Amphora* sp. magnification = 1.50 K X, 10 μ m. 36

Figure 4.8	A close-up SEM photomicrograph of diatoms <i>Amphora</i> sp. magnification = 2.50 K X, 2 μ m;	36
Figure 4.9	A close-up SEM photomicrograph of diatoms <i>Amphora</i> sp. magnification = 4.00 K X, 2 μ m.	37
Figure 4.10	A close-up SEM photomicrograph of diatoms <i>Amphora</i> sp. magnification = 10.00 K X, 1 μ m.	37
Figure 4.11	Other sites of the reefs investigated within the Tun Sakaran Marine Park	40
Figure 4.12	Reef check summary of the 9 study sites at 3 metres	41
Figure 4.13	Reef check summary of the 9 study sites at 10 metres	41
Figure 4.14	Change in percentage cover of the black sponge <i>Chondrosia</i> sp. at Bodgaya West site	42
Figure 4.15	Photographs showing the growing margins of <i>Chondrosia</i> sp. and live <i>Diploastrea heliopora</i> , and the minimal changes over a period of 361 days (Depth 4.3m)	48
Figure 4.16	Photographs showing the growth of <i>Chondrosia</i> sp. over dead parts of the coral <i>Favia rotumana</i> (d), which had been probably killed by crown-of-thorns starfish <i>Acanthaster planci</i> .	49
Figure 4.17	A) Crown-of-thorns (COT) Starfish <i>Acanthaster planci</i> eating coral on the Bodgaya West reef (April, 25 2000) (B) Coral killed by COT C) live coral, and D) the same coral after attack by COT (The death of the coral allowed the <i>Chondrosia</i> sp. to colonize).	50
Figure 4.18	Growth rate observation on <i>Favia</i> sp. Figure (D) shows rapid growth of <i>Chondrosia</i> over the dead part of the coral, which had probably been killed by crown-of-thorns starfish <i>Acanthaster planci</i> (BS: Black sponge)	51
Figure 4.19	Photographic record of the movement of <i>Chondrosia</i> on <i>Favia</i> sp. The sponge had receded in Nov 1999 grown back slightly in Jan 2000 and then receded again in April 2000.	52
Figure 4.20	Photographs showing the growth of <i>Chondrosia</i> . over the live part of <i>Porites</i> sp. followed by overgrowth by a fast growing encrusting sponge <i>Acervochalina confosa</i> (greeny black) (3.8m depth)	53

Figure 4.21	The percentage cover of <i>Acervochalina confosa</i> . over a period of 286 days on <i>Porites</i> sp. fig A is an original photograph taken underwater, B is a sketch from photographsto show the growth of the <i>Acervochalina confosa</i> (see table 4.3 for the area cover in cm ² /day).	54
Figure 4.22	Growth rate summary of <i>Acervochalina confosa</i> - another species of encrusting sponge over the <i>Chondrosia</i> sp to date.	55
Figure 4.23	Photographs showing the spread of <i>Chondrosia</i> over dead parts of <i>Diploastrea Heliopora</i> (Experiment A), (figure 4.24 and table 4.4)	58
Figure 4.24	Spread rate over 280 days mesured (using grid system) as change in percentage cover of <i>Chondrosia</i> sp. on the dead part <i>Diploastrea heliopora</i> (refer to table 4.4 and figure 4.25)	59
Figure 4.25	Growth rate summary of <i>Chondrosia</i> in cm ² within 223 days over the dead part of <i>Diploastrea heliopora</i> .	60
Figure 4.26	B & C – Photographs showing the growth of <i>Chondrosia</i> sp. on dead parts of <i>Diploastrea heliopora</i> .	61
Figure 4.27	Photographs showing the spread of black sponge on a clean terracotta brick. This experiment was started on February 22 nd 2000 (A-I & AII) and the vertical growth rate was taken. Figure B shows that the <i>Chondrosia</i> had grown 1.45cm upright after 22 days (B-I & B-II) and 2.10cm after 35 days (CI-CII). It had grown vertically to 3.6 cm after 63 days (D-1 & DII). (Please refer to table 4.5 & Figures 4.28 and 4.29)	62
Figure 4.28	Photograph shows that the brick was completely covered after nine months	63
Figure 4.29	Change in percentage cover of the <i>Chondrosia</i> sp. over the terracotta brick over 63 days (Please refer to table 4.5 & figure 4.30)	64
Figure 4.30	Spread rate summary of <i>Chondrosia</i> sp. on the brick experiment over 63 days.	65
Figure 4.31	(A) The area within the white dotted line had previously been scraped out with a knife. (B) The drawing shows the cover by <i>Chondrosia</i> sp. on the scraped area in experiments E1 and E2.	66

Figure 4.8	A close-up SEM photomicrograph of diatoms <i>Amphora</i> sp. magnification = 2.50 K X, 2 μ m;	36
Figure 4.9	A close-up SEM photomicrograph of diatoms <i>Amphora</i> sp. magnification = 4.00 K X, 2 μ m.	37
Figure 4.10	A close-up SEM photomicrograph of diatoms <i>Amphora</i> sp. magnification = 10.00 K X, 1 μ m.	37
Figure 4.11	Other sites of the reefs investigated within the Tun Sakaran Marine Park	40
Figure 4.12	Reef check summary of the 9 study sites at 3 metres	41
Figure 4.13	Reef check summary of the 9 study sites at 10 metres	41
Figure 4.14	Change in percentage cover of the black sponge <i>Chondrosia</i> sp. at Bodgaya West site	42
Figure 4.15	Photographs showing the growing margins of <i>Chondrosia</i> sp. and live <i>Diploastrea heliopora</i> , and the minimal changes over a period of 361 days (Depth 4.3m)	48
Figure 4.16	Photographs showing the growth of <i>Chondrosia</i> sp. over dead parts of the coral <i>Favia rotumana</i> (d), which had been probably killed by crown-of-thorns starfish <i>Acanthaster planci</i> .	49
Figure 4.17	A) Crown-of-thorns (COT) Starfish <i>Acanthaster planci</i> eating coral on the Bodgaya West reef (April, 25 2000) (B) Coral killed by COT C) live coral, and D) the same coral after attack by COT (The death of the coral allowed the <i>Chondrosia</i> sp. to colonize).	50
Figure 4.18	Growth rate observation on <i>Favia</i> sp. Figure (D) shows rapid growth of <i>Chondrosia</i> over the dead part of the coral, which had probably been killed by crown-of-thorns starfish <i>Acanthaster planci</i> (BS: Black sponge)	51
Figure 4.19	Photographic record of the movement of <i>Chondrosia</i> on <i>Favia</i> sp. The sponge had receded in Nov 1999 grown back slightly in Jan 2000 and then receded again in April 2000.	52
Figure 4.20	Photographs showing the growth of <i>Chondrosia</i> . over the live part of <i>Porites</i> sp. followed by overgrowth by a fast growing encrusting sponge <i>Acervochalina confosa</i> (greeny black) (3.8m depth)	53

Figure 4.21	The percentage cover of <i>Acervochalina confosa</i> . over a period of 286 days on <i>Porites</i> sp. fig A is an original photograph taken underwater, B is a sketch from photographsto show the growth of the <i>Acervochalina confosa</i> (see table 4.3 for the area cover in cm ² /day).	54
Figure 4.22	Growth rate summary of <i>Acervochalina confosa</i> - another species of encrusting sponge over the <i>Chondrosia</i> sp to date.	55
Figure 4.23	Photographs showing the spread of <i>Chondrosia</i> over dead parts of <i>Diploastrea Heliopora</i> (Experiment A), (figure 4.24 and table 4.4)	58
Figure 4.24	Spread rate over 280 days mesured (using grid system) as change in percentage cover of <i>Chondrosia</i> sp. on the dead part <i>Diploastrea heliopora</i> (refer to table 4.4 and figure 4.25)	59
Figure 4.25	Growth rate summary of <i>Chondrosia</i> in cm ² within 223 days over the dead part of <i>Diploastrea heliopora</i> .	60
Figure 4.26	B & C – Photographs showing the growth of <i>Chondrosia</i> sp. on dead parts of <i>Diploastrea heliopora</i> .	61
Figure 4.27	Photographs showing the spread of black sponge on a clean terracotta brick. This experiment was started on February 22 nd 2000 (A-I & AII) and the vertical growth rate was taken. Figure B shows that the <i>Chondrosia</i> had grown 1.45cm upright after 22 days (B-I & B-II) and 2.10cm after 35 days (CI-CII). It had grown vertically to 3.6 cm after 63 days (D-1 & DII). (Please refer to table 4.5 & Figures 4.28 and 4.29)	62
Figure 4.28	Photograph shows that the brick was completely covered after nine months	63
Figure 4.29	Change in percentage cover of the <i>Chondrosia</i> sp. over the terracotta brick over 63 days (Please refer to table 4.5 & figure 4.30)	64
Figure 4.30	Spread rate summary of <i>Chondrosia</i> sp. on the brick experiment over 63 days.	65
Figure 4.31	(A) The area within the white dotted line had previously been scraped out with a knife. (B) The drawing shows the cover by <i>Chondrosia</i> sp. on the scraped area in experiments E1 and E2.	66

- Figure 4.32 The average spread rate comparison of *Chondrosia* sp. 67
- Figure 4.33 Photographs showing the growth of *Chondrosia* sp on the Bodgaya West reef. It is growing over or around the following: (a) *Dysidea* sp., (b) Small *Turbinaria* sp. Plate and *Stylophora mordax*, (c) *Favites* sp. (d) live sea squirts, (e) Hard Coral, (f) Brain Coral. 69
- Figure 4.34 A group of black damselfish seems to feed on the *Chondrosia* sp. colony. 77



UMS
UNIVERSITI MALAYSIA SABAH

Figure 4.21	The percentage cover of <i>Acervochalina confosa</i> . over a period of 286 days on <i>Porites</i> sp. fig A is an original photograph taken underwater, B is a sketch from photographsto show the growth of the <i>Acervochalina confosa</i> (see table 4.3 for the area cover in cm ² /day).	54
Figure 4.22	Growth rate summary of <i>Acervochalina confosa</i> - another species of encrusting sponge over the <i>Chondrosia</i> sp to date.	55
Figure 4.23	Photographs showing the spread of <i>Chondrosia</i> over dead parts of <i>Diploastrea Heliopora</i> (Experiment A), (figure 4.24 and table 4.4)	58
Figure 4.24	Spread rate over 280 days measured (using grid system) as change in percentage cover of <i>Chondrosia</i> sp. on the dead part <i>Diploastrea heliopora</i> (refer to table 4.4 and figure 4.25)	59
Figure 4.25	Growth rate summary of <i>Chondrosia</i> in cm ² within 223 days over the dead part of <i>Diploastrea heliopora</i> .	60
Figure 4.26	B & C – Photographs showing the growth of <i>Chondrosia</i> sp. on dead parts of <i>Diploastrea heliopora</i> .	61
Figure 4.27	Photographs showing the spread of black sponge on a clean terracotta brick. This experiment was started on February 22 nd 2000 (A-I & AII) and the vertical growth rate was taken. Figure B shows that the <i>Chondrosia</i> had grown 1.45cm upright after 22 days (B-I & B-II) and 2.10cm after 35 days (CI-CII). It had grown vertically to 3.6 cm after 63 days (D-1 & DII). (Please refer to table 4.5 & Figures 4.28 and 4.29)	62
Figure 4.28	Photograph shows that the brick was completely covered after nine months	63
Figure 4.29	Change in percentage cover of the <i>Chondrosia</i> sp. over the terracotta brick over 63 days (Please refer to table 4.5 & figure 4.30)	64
Figure 4.30	Spread rate summary of <i>Chondrosia</i> sp. on the brick experiment over 63 days.	65
Figure 4.31	(A) The area within the white dotted line had previously been scraped out with a knife. (B) The drawing shows the cover by <i>Chondrosia</i> sp. on the scraped area in experiments E1 and E2.	66

LIST OF TABLES

TABLE	CONTENTS	PAGE
Table 3.1	Sample from LIT data form	15
Table 3.2	Substratum categories and abbreviations	15
Table 3.3	Summary of histological procedure	17
Table 4.1	Measurements of percentage cover at 3 m and 10m depth by different benthic categories at 9 study sites within the Tun Sakaran Marine Park.	39
Table 4.2	(Two-Way ANOVA) – Temporal Change In the relative abundance of each Benthic category within six years of Monitoring (1999-2004)	44
Table 4.3	Spread of encrusting sponges <i>Acervochalina confosa</i> over <i>Chondrosia</i> within 245 days (please refer to figure 6.6 & 6.7)	55
Table 4.4	Spread rate (area covered in sq. cm) of <i>Chondrosia</i> sp. over the dead part of <i>Diploastrea heliopora</i> to date using grid system.	60
Table 4.5	Spread rate of <i>Chondrosia</i> sp. over the brick to date in sq cm over a period of 63 days.	65
Table 4.6	Growth rate of <i>Chondrosia</i> sp. over the scraped and re-scraped area of a dead part of <i>Porites</i> sp., calculated using a grid system.	67
Table 4.7	Average spread rate comparison of <i>Chondrosia</i> sp. over; A-dead part of <i>Diploastrea heliopora</i> B-terracotta brick; C- <i>Acervochalina confosa</i> over the <i>Chondrosia</i> sp., D-Scraped and re-scraped area of dead part of <i>Porites</i> sp.	68

CHAPTER 1

INTRODUCTION

1.1 Background

Coral reefs are among the most biologically diverse marine ecosystems with high biological diversity on earth (English *et al.* 1997), rivalled only by the tropical rainforests on land. Coral reefs deserve protection for their intrinsic natural value, and for their importance to humans. People obtaining part of the protein in their diet from coral reefs are estimated to number in tens of millions (Salvat, 1992). Coral reefs not only contribute directly to human livelihoods but also indirectly, for example as a main food supplier for both oceanic and inshore pelagic fishes (Birkeland, 1997), which are utilized by fishers throughout the world.

Importantly, some of the economic, fishing and recreational resources of tropical areas around the world depend upon healthy coral reef systems. However, there is now widespread concern about threats facing reefs, which are affecting their sustainability and biodiversity. These threats and documented impacts are due to a variety of factors, which fall within two categories: natural disturbances and anthropogenic (man-made) disturbances. Although natural disturbances may cause severe changes in coral communities, anthropogenic disturbances have been linked to major and widespread degradation of reefs and their resources. Hodgson (1999), refers to "coral reef health" as a general concept to a balance in the ecosystem that might be shifted by human activities.

The proposed Semporna Islands Park, covering an area of 350 sq. km, is situated off the east coast of Sabah (figure 1.1). The natural resources of the proposed park are of considerable biological, social, cultural and economic value, and the reefs and islands have a natural beauty and interest that provide enormous potential for eco-tourism. The coral reefs are of particular significance because of their high biodiversity, unique species and value to local communities (Wood, 1998).

The Semporna Islands Project (SIP) began in 1998 under the leadership of Dr. Elizabeth Wood, Coral Reef Conservation Officer of the Marine Conservation Society, UK. It is a collaborative venture between the Marine Conservation Society (MCS), Sabah Parks, WWF Malaysia and Nature Link. The project was funded by the European Community under its global environment budget line. The aim of the project was to produce a plan for effective management and to ensure a healthy future for the area by safeguarding livelihoods, promoting sustainable use of natural resources and encouraging environmentally-sensitive development (Wood, 1998).

During the surveys carried out in the initial phase of the project, one of the reef sites investigated (Bodgaya West) was found to be severely affected by a black organism of uncertain identity that grew as a very thin film over rock, rubble and corals, leaving only isolated patches and certain corals uncovered (Wood, pers. Comm.). It was confirmed to be black sponge following examination of specimens at the Natural History Museum London, and by Dr. Michelle Kelly, a sponge expert from the Marine Ecology and Aquaculture Group, National Institute of Water and Atmospheric Research (NIWA), New Zealand.

This sponge infestation had not previously been reported for the area, or from elsewhere in Sabah, but was clearly having a profound effect on the reef. Research into the phenomena of ecological significance is vital, and it was for this reason that a decision was made to carry out a full investigation of the biology and

ecology of the sponge. The study was also important because this area is a proposed marine park, and particular management strategies may be required for the affected reef.

1.2 Aims and Objectives

The overall aim of this project was to carry out research into the biology and ecology of the black sponge, investigate its impact on the reef ecosystem and consider the implications of the infestation on reef management. The specific objectives of this research were to:

1. Describe the sponge and determine its identity.
2. Map the main area on Bodgaya West reef covered by the black sponge and investigate its occurrence elsewhere in the proposed Park and on adjacent reefs.
3. Determine how fast the sponge grows and spreads over the reef.
4. Determine the impact of the sponge infestation by investigating which reef organisms are being smothered and which are apparently able to withstand the spread of the sponge .
5. Consider whether particular management strategies may be required for the affected reef.

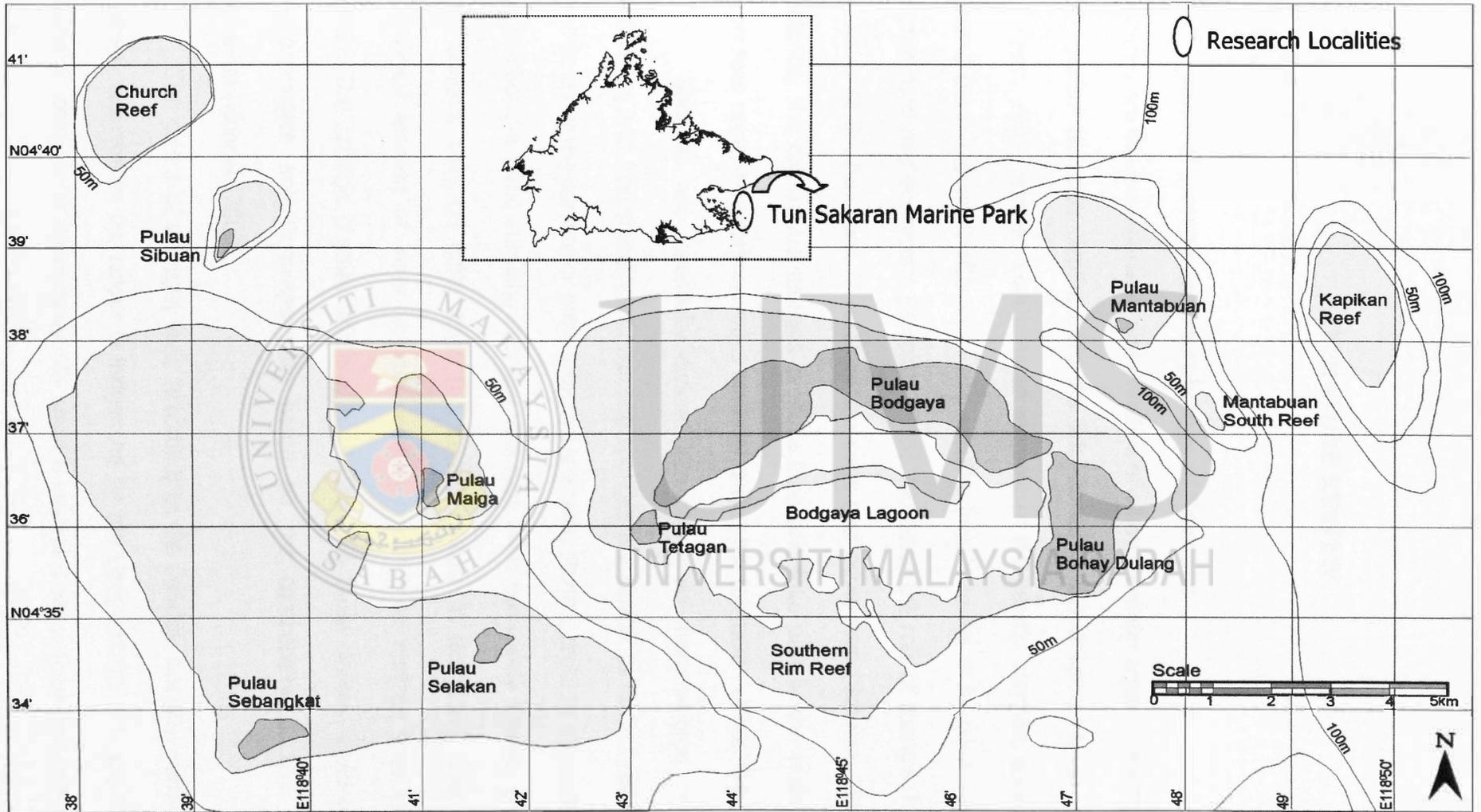


Figure 1.1: Sabah Map – Research Location

CHAPTER 2

LITERATURE REVIEW

2.1 General Biology and Morphology of Sponges

Sponges are the most ancient, and primitive of all multicellular aquatic animals. They are present at water depths from the tidal zones to the deepest regions (abyss) (Sorokin, 1993; Hooper, 2000). As an element of the sessile benthos, sponges are second most important after coral and zoantharians in terms of functions and roles on the coral reef ecosystem (Sorokin, 1993). Moreover the role of sponges is similar to some of the functions of coral on the coral reef ecosystem (Sorokin, 1993). For instance, the calcareous sponges produce lime and take part in the reef-building processes cementing carbonaceous material during the formation of reef-flat rocks.

Sponges are essentially divided into two main morphological categories encrusting and free standing. Encrusting sponges are similar to moss because they tend to cover the surface or grow attached to shells, stones, rocks or any solid object on the bottom. Free standing sponges, the type most commonly known, grow into odd shapes, may be quite large (up to two meters in diameter), and have a significant amount of inner volume compared with their surface area (Hayden, 1999). The sponge phylum Porifera, is divided into three classes: Calcispongiae, Hyalospongiae and Demospongiae, based on the composition of the skeletal elements (Hooper, 2000).

The colour of sponges vary according to the species, but also varies within species. Sometimes the colour is influenced by the depth where it is growing. For instance, deep-water sponges usually show a neutral drab or brownish colour, while

shallow-water sponges are generally brightly coloured, ranging from red, yellow, and orange to violet and occasionally black (Hooper, 2000). Certain sponges (e.g. the *Verongida*), contain what are known as aerophobic pigments that darken upon contact with air (Hooper, 2000). Some species of sponges such as the Family Spongilidae are often greenish because green algae live in symbiotic relationship within them, and others are violet or pinkish, because they harbour symbiotic blue green algae (Hooper, 2000).

2.2 Skeleton

Most sponges live in moving water and support themselves with a well-developed skeleton. The skeleton of the sponges are formed by units called spicules which are either scattered throughout the sponge or united to form fibres. Spicules are classified as megascleres, which function in support, and microscleres which function in protection and aid in support (Hooper, 2000). In most species of sponges, spongin and spicules occur together. As shown in figure 2.1 A, spongin welds together the tips of spicules to form a skeletal network. Figure 2.1 B, spicules are embedded into spongin fibres themselves. Some species of sponges lack spicules, but secrete organic spongin. For example, in some species of demosponges (*Scleresponges*), the siliceous spicules are secreted in the mesohyl (Figure 2.2).