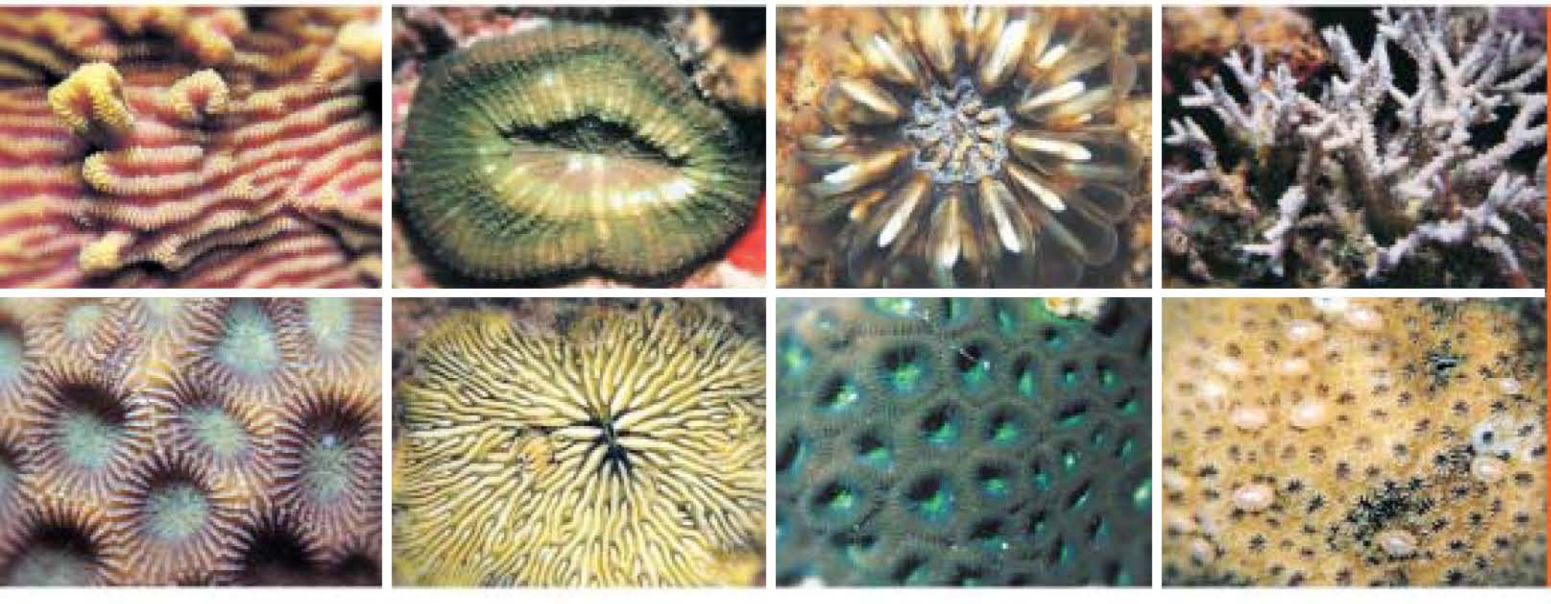
Training Manual on Corals Taxonomy in Southeast Asia



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Training Manual on Corals Taxonomy in Southeast Asia

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FOREWORD

The Training Manual on Corals Taxonomy in Southeast Asia is an offshoot of the Training Workshop on Coral Taxonomy held at the Universiti Sains Malaysia in Penang on 4-8 December 2010. The training session formed part of the series of workshops under the Japan-ASEAN Integration Fund project "Taxonomic Capacity Building and Governance for Conservation and Sustainable Use of Biodiversity" implemented by the ASEAN Centre for Biodiversity.

The objectives of the workshop were to upgrade the skills of the participants in coral taxonomy; introduce advanced taxonomic methodologies to the participants; and provide hands-on experience. The participants were from the ASEAN Member States. The workshop was made possible by Japan's Ministry of the Environment, the ASEAN Centre for Biodiversity and Universiti Sains Malaysia.

This manual was prepared based on the lecture notes presented by the trainers during the workshop. It provides methodology on sampling specimens and identifying features of the main group of reef building corals.

Most of the photographs and drawings used in this manual were taken from Veron (2000) *Corals of The World* and Walace (1999) *Staghorn Corals of the World*. Some of the photos were contributed by Dr. Hironobu Fukami.

This manual is envisioned to encourage researchers and students to develop a better understanding of the diversity of coral fauna associated with tropical coral reefs. It is hoped that this will inspire a new generation of coral taxonomists as the world needs them to contribute to the sustainable management and conservation of biodiversity.

MESSAGE

Prof. SHUKRI MUSTAPA KAMAL
Deputy Vice Chancellor
for Academic and International Affairs
Universiti Sains Malaysia

It is my pleasure to welcome you to the "Training Workshop on Coral Taxonomy" at Universiti Sains Malaysia.

We are well aware that human activities especially in our coastal areas deeply affect the natural environment. The lack of hard scientific information is a glaring handicap in our understanding and prediction of the impacts of these activities. As the human population increases in our coastal cities and the use of our seas continues to escalate, the issue of sustainable use of these resources becomes more critical. Malaysia in particular relies heavily on its coastal living resources. It is important for us to understand the critical processes, status and diversity of these resources for us to be able to use them wisely.

We cannot take for granted that these resources will tolerate more of man's abuse. It is therefore essential that in our desire to sustain or even improve our natural ecosystems, we emphasize the fundamental knowledge required to understand these living worlds – the knowledge of taxonomy. In order to understand the corals we first have to know them.

The training workshop on coral taxonomy is timely. Coral reefs are one of the most endangered living systems on earth today. Global warming, rise in sea temperatures and widespread bleaching of corals are now familiar topics making headlines across the globe. These headlines come in different guises - changing weather patterns, freak storms, failed crops and the crash in fisheries.

We rely heavily on our scientists to advise us on what to do to remedy this situation and to prepare for the future. Many of these issues cannot be solved by one nation. It is no accident that we gather the young brains from ten nations to be with us today in this workshop in hopes that they will continue in this mission to improve the future of our seas.

As a premiere research university in this country, the Universiti Sains Malaysia is proud to co-host this meeting with the ASEAN Centre for Biodiversity and the Ministry of Environment of Japan.

Our appreciation goes to the local secretariat whose hard work has made this event possible.

May you have a successful workshop and may your stay here be a pleasant one.

Thank you.

MESSAGE

Mr. RODRIGO U. FUENTES
Executive Director
ASEAN Centre for Biodiversity

The dynamic growth of the ten ASEAN Member States, China, Japan Korea (ASEAN + 3) in recent years has increased the pressure on their natural resources. Human activities, the driving force behind the regional growth, threaten biological resources. Lack of scientific information on biodiversity in this region is a crucial issue in the assessment and prediction of biodiversity changes, caused mainly by the lack of taxonomic capacity in data collection and analysis. The lack of trained human resources and the inadequate capacities on taxonomy in the ASEAN Member States have been identified as an obstacle in meeting their commitments to the Convention on Biological Diversity (CBD).

Adequate taxonomy is also one of the fundamental tools required for the global community to be able to implement the Millennium Development Goals and the development targets from the World Summit for Sustainable Development. Without adequate long-term investment in the human, infrastructural (including important biological collections) and information resources necessary to underpin the science of taxonomy, the now well-recognized taxonomic impediment will continue to prevent adequate implementation of sound, scientifically-based and sustainable environmental management and development policies.

To respond to the challenge of inadequacy in taxonomy, the ASEAN Centre for Biodiversity and the Ministry of the Environment of Japan, through the Japan-ASEAN Integration Fund, launched the *"Taxonomic Capacity Building and Governance for Conservation and Sustainable Use of Biodiversity Project"*. At the project inception workshop held in Manila on 31 August – 1 September 2010, the participating ASEAN Member States identified three training concerns, one of them on the taxonomy of corals.

The ASEAN region is home to 34 percent of the world's coral reefs. While we host the largest coral reef areas in the world, we also have the highest rate of loss, which today stands at 40 per cent. Our rich coral reef systems are increasingly at risk due to a number of culprits such as human activities and climate change.

Through this workshop, we brought together young scientists from all over the region to be involved in corals taxonomy. We believe that this is a crucial initial step towards the protection and conservation of one of man's natural heritage – the corals reefs.

We call on the younger generation to explore taxonomy. Taxonomists, like many endangered species, are not increasing in numbers. There is a dire need to revive interest in taxonomy. The diminishing status of this science and profession is crippling the ASEAN Member States' and other Asian countries' capacity to effectively catalogue our biological resources.

We have to admit that while we have identified thousands of species, we know only a fraction of the species on earth. There is still so much out there. It is important to note that the groups that are the least-known are often those with the most potential for discovery of products that are useful to humankind.

This is where taxonomy comes in. It is not there to simply name and identify species. It can be a useful tool to improve knowledge, which can then lead to the efficient use and protection of biodiversity. Taxonomic information provides insights that are used by ecologists and management authorities to understand species distributions, untangle species interactions and ecosystem structure, rank and justify conservation areas, and plan restoration efforts.

Let us all keep in mind that without knowledge and understanding of species, it would be difficult to plan and implement biodiversity conservation efforts.

Thank you.

MESSAGE

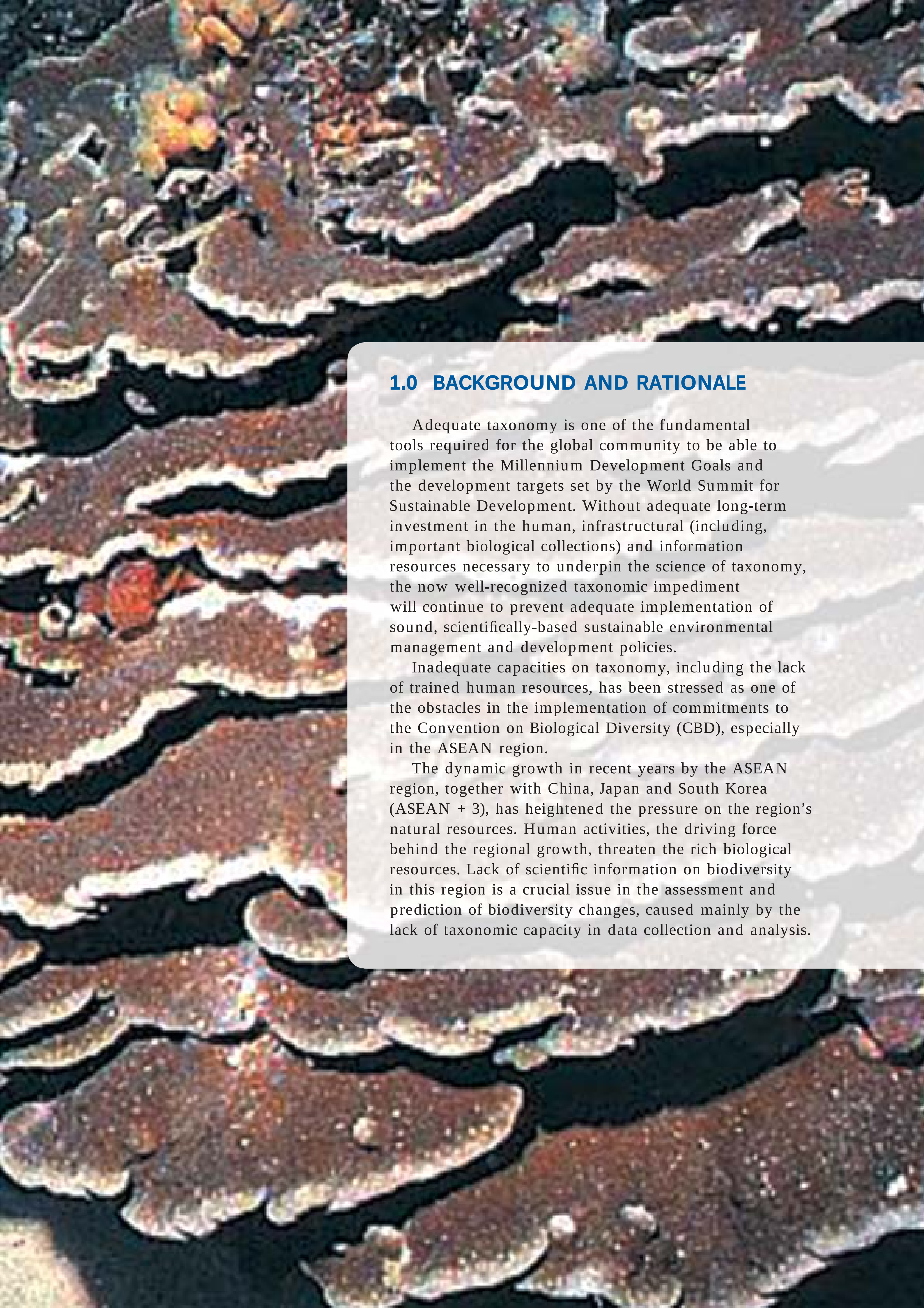
Mr. TOMOO MIZUTANI
Director, Biodiversity Center of Japan
Ministry of the Environment, Japan

The Southeast Asian region includes the highest coral diversity in the world known as the Coral Triangle area. Yet coral reefs and related ecosystems in the region are under serious threats mainly due to rapid increase of human pressures and demands on coastal resources together with recent mass coral bleaching events caused by increased water temperatures. These evidences have been continuously stressed in the CBD. One of the obstacles identified under the Global Taxonomy Initiative (GTI) was the lack of trained human resources and inadequate capacities on taxonomy.

The regional needs assessment conducted in 2009 as part of the ESABII – a new regional initiative aimed at developing biodiversity information system and raising taxonomic capacity in the region – revealed that capacity building of coral taxonomy is one of the priority areas to be addressed. From these backgrounds, a joint training workshop on coral taxonomy has been proposed as part of ESABII Work Plan 2010-2011 by the Japanese Ministry of the Environment together with the ASEAN Centre for Biodiversity funded by the Japan-ASEAN Integration Fund (JAIF).

This five-day training workshop held in Universiti Sains Malaysia aims to provide upgraded skills and hands-on experiences on advanced taxonomic methodologies to selected young scientists from the ASEAN Member States.

The ESABII programme and its partners will continue to provide these taxonomic training opportunities in the region to contribute to achieving the goals of the CBD.



1.0 BACKGROUND AND RATIONALE

Adequate taxonomy is one of the fundamental tools required for the global community to be able to implement the Millennium Development Goals and the development targets set by the World Summit for Sustainable Development. Without adequate long-term investment in the human, infrastructural (including, important biological collections) and information resources necessary to underpin the science of taxonomy, the now well-recognized taxonomic impediment will continue to prevent adequate implementation of sound, scientifically-based sustainable environmental management and development policies.

Inadequate capacities on taxonomy, including the lack of trained human resources, has been stressed as one of the obstacles in the implementation of commitments to the Convention on Biological Diversity (CBD), especially in the ASEAN region.

The dynamic growth in recent years by the ASEAN region, together with China, Japan and South Korea (ASEAN + 3), has heightened the pressure on the region's natural resources. Human activities, the driving force behind the regional growth, threaten the rich biological resources. Lack of scientific information on biodiversity in this region is a crucial issue in the assessment and prediction of biodiversity changes, caused mainly by the lack of taxonomic capacity in data collection and analysis.

Decision IX/22 of the 9th Meeting of the Conference of the Parties to the CBD (COP-9) urged Parties to promote and carry-out the Programme of Work for the Global Taxonomy Initiative (GTI) through coordination of implementation with existing national, regional, sub-regional, and global initiatives, partnerships and institutions; designation of national GTI focal points; provision of updated information about legal requirements for exchange of genetic/biological specimens and about current legislation and rules for access and benefit-sharing; and initiatives in setting up national and regional networks to aid the Parties in their taxonomic needs in implementing the CBD.

To push the GTI programme of work, a series of GTI workshops were conducted in various venues: Central America and Africa in 2001, Asia in 2002, and Asia-Oceania in 2004 (Wilson et al., 2003; NIES, 2005). However, as far as the CBD Secretariat is concerned, the 2002 GTI Workshop is the First GTI Regional Workshop followed by the Second GTI Regional Workshop for Asia-Oceania in 2004.

It is in this context that the project entitled *"Taxonomic Capacity Building and Governance for Conservation and Sustainable Use of Biodiversity"* proposed by the ASEAN Centre for Biodiversity (ACB) was approved by the Japan-ASEAN Integration Fund (JAIF) in July 2010. A similar taxonomic capacity building project was also planned by the Biodiversity Center of Japan's Ministry of the Environment. These two projects were offshoots of the *ASEAN+3 Regional Workshop on Global Taxonomy Initiative* held in May 2009 and adopted as activities under the 2010-2011 Work Plan of the East Asia and Southeast Asia Biodiversity Information Initiative (ESABII).

The Ministry of the Environment of Japan is also planning to conduct taxonomic capacity building training workshops in accordance with the ESABII Work Plan 2010-2011. As a joint activity, the collaboration between ESABII and the ACB-JAIF project is evident in this training workshop.

2.0 OBJECTIVES OF THE TRAINING WORKSHOP

The training workshop was aimed at capacitating participants in the rigors of taxonomy, especially on the corals group. Specifically, the training workshop:

- introduced the participants to the reef-building corals, specifically the Phylum Cnidaria, Class Anthozoa, and Order Scleractinia;
- familiarized the participants with the general biology of these reef-building corals;
- upgraded the taxonomic skills of the participants on the methods of morphological observation, sample collection, processing and managing, and photography of corals;
- introduced the participants to advanced taxonomic methodologies such as molecular techniques, photo-identification, and use of the Internet; and
- provided hands-on experience on museum collections management, cataloguing and storage.

3.0 ORGANIZATION OF THE TRAINING COURSE

The training course was organized by the ASEAN Centre for Biodiversity, the Ministry of the Environment of Japan/Japan Wildlife Research Center (JWRC), and the Universiti Sains Malaysia (USM). The training course was held at the Marine Science Laboratory, School of Biological Sciences of the USM, Pulau Pinang, Malaysia.

4.0 PARTICIPATION

Thirty participants represented the nine ASEAN Member States: Brunei Darussalam – 3, Cambodia – 4, Indonesia – 4, Lao PDR – 4, Malaysia – 3, Philippines – 3, Singapore – 4, Thailand – 4, and Viet Nam – 1. There were five resource persons: USM – 2, Japan – 2, and Thailand – 1; and ten observers: Japan – 2, Malaysia – 2, Indonesia – 1, and USM – 5; and four staff from the organizers: ACB – 3 and JWRC – 4.

The list of participants is presented in Appendix A.

5.0 THE TRAINING COURSE

The training course was organized into ten lecture sessions and ten laboratory/hands-on sessions. The topics of the lecture sessions are shown in the programme below:

DAY 1 (4 December 2010, Saturday)

08:30	Registration
09:00	Welcome address by Prof. Shukri Mustapa Kamal, Deputy Vice Chancellor (Academic and International Affairs), Universiti Sains Malaysia
09:20	Introduction and background by Mr. Kohei Hibino, Japan Wildlife Research Center; and Dr. Filiberto A. Pollisco, Jr., ASEAN Centre for Biodiversity
09:50	Group photo
10:00	Refreshment
10:30-10:40	Introduction of participants
10:40-12:00	**Lecture 1:** General taxonomy of animals
12:00-13:00	Lunch
13:00-14:30	**Lecture 2:** Basic taxonomy of corals
14:30-14:45	Break time
14:45-16:30	**Lecture 3:** Taxonomy of corals (families and genera) Part 1

DAY 2 (5 December 2010, Sunday)

08:30	Registration
09:00-10:30	**Lecture 4:** Taxonomy of corals (families and genera) Part 2
10:30-10:45	Break time
10:45-12:00	**Lecture 5:** Problems of coral taxonomy
12:00-13:00	Lunch

13:00-15:00	**Lecture 6:** Sample collection, processing and managing **Laboratory Work 1:** Sample collection, processing and managing
15:00-15:15	Break time
15:15-17:00	**Lecture 7:** Sample processing for advanced techniques (SEM Observation)
19:00	Group Dinner

DAY 3 (6 December 2010, Monday)

08:30	Registration
09:00-10:30	**Lecture 8:** General biology of reef building corals
10:30-10:45	Break time
10:45-12:00	**Laboratory Work 2:** Sample processing; observation of specimens identified by authorities
12:00-13:00	Lunch
13:00-15:00	**Laboratory Work 3:** Sample processing; observation of specimens identified by authorities (cont.)
15:00-15:15	Break time
15:15-17:00	**Laboratory Work 4:** Photographing samples, observation of specimens identified by authorities (cont.)

DAY 4 (7 December 2010, Tuesday)

08:30	Registration
09:00-10:30	**Lecture 9:** Advanced taxonomic methods (Molecular techniques)
10:30-10:45	Break time
10:45-12:00	**Laboratory Work 5:** Trial to identify specimens prepared in the workshop
12:00-13:00	Lunch
13:00-15:00	**Laboratory Work 6:** Trial to identify photo samples (Part 1)
15:00-15:15	Break time
15:15-17:00	**Laboratory Work 7:** Trial to identify photo samples (Part 2)

DAY 5 (8 December 2010, Wednesday)

08:30	Registration
09:00-10:30	**Lecture 10:** Museum collection management, cataloguing, storage
10:30-10:45	Break time

10:45-12:00	**Laboratory Work 8:** Writing description of a species
12:00-13:00	Lunch
13:00-15:00	**Laboratory Work 9:** Presentation of accomplishments
15:00-15:15	Break time
15:15-17:00	**Laboratory Work 10:** Presentation of accomplishments (cont.)
17:00-17:30	Closing Programme • Presentation of certificates of participation • Closing remarks
19:00-21:00	Group Dinner

At the end of the course, the participants presented their taxonomy assignments and their impressions. Most of the participants were able to identify their assigned coral species. The expert panel, composed of the trainers/resource persons, pointed out the errors in identifying the coral specimens.

6.0 OUTPUTS

The outputs of the training workshop were the following:

1. Skills of the participants in corals taxonomy upgraded
2. Advanced taxonomic methodologies introduced
3. Hands-on experience in collections management, cataloguing and storage provided

7.0 EVALUATION

At the beginning of the workshop, the participants filled out the pre-training evaluation form to determine their backgrounds, as well as their expectations. The pre-training evaluation form is shown below:

Taxonomic Capacity Building and Governance for the Conservation and Sustainable Use of Biodiversity

TRAINING WORKSHOP ON CORALS TAXONOMY
PRE-TRAINING EVALUATION

Instructions: Please fill out the following questions prior to attending the training session. We will refer to this form at the beginning of the training.

NAME:	
ORGANIZATION / AGENCY:	
COUNTRY:	
POSITION:	

What skills / knowledge / behavior do you want to develop by attending this training workshop?

What do you expect to see / hear / feel differently by developing the abovementioned skills / knowledge / behavior?

How will it benefit your job performance by developing the abovementioned skills / knowledge / behavior? (Be as specific as possible)

How do you want others to relate to you after attending the training workshop?

What do you feel you are currently <u>not achieving</u> due to under-developed abovementioned skills / knowledge / behavior?

What are your <u>personal learning goals</u>? What do you really want to learn from this training workshop? Be specific, with a maximum of 3.

What are your supervisor's expectations from your attendance to this training workshop?

What other expectations do you have of this training workshop? Please provide any other comments you would like to make prior to attending the training workshop.

Please send a completed copy of this form to the trainer one week prior to the course.

Many thanks for your assistance.

At the end of the workshop, the participants filled in the post-training evaluation form to determine the outcomes of the workshop in terms of knowledge gained by the participants, as well as their personal learning goals. The post-training evaluation form is shown below:

Taxonomic Capacity Building and Governance for the Conservation and Sustainable Use of Biodiversity

TRAINING WORKSHOP ON CORALS TAXONOMY
POST-TRAINING EVALUATION

Instructions: The Post-training Evaluation is in two (2) parts. Part I refers to the process and substance of the training workshop. Part II makes reference to the Pre-training Evaluation that has been previously filled-up by the trainee.

NAME:	
ORGANIZATION / AGENCY:	
COUNTRY:	
POSITION:	

PART I. PROCESS & SUBSTANCE OF THE TRAINING WORKSHOP

The Top 3 BEST training lectures for me were:

1.
2.
3.

Kindly check on the appropriate column to rate your BEST lecture / session.

		Excellent	Good	Fair	Poor
1.	My understanding of this lesson was:				
	The practicality of this lesson for my work is:				
	The instructor's knowledge of the subjects was:				
	The instructor's skill in presenting this lesson was:				
2.	My understanding of this lesson was:				
	The practicality of this lesson for my work is:				
	The instructor's knowledge of the subjects was:				
	The instructor's skill in presenting this lesson was:				

		Excellent	Good	Fair	Poor
3.	My understanding of this lesson was:				
	The practicality of this lesson for my work is:				
	The instructor's knowledge of the subjects was:				
	The instructor's skill in presenting this lesson was:				

Time Allotted

		More time spent on the subject	Less time spent on the subject	This was just right
1.	For this lesson I would like:			
2.	For this lesson I would like:			
3.	For this lesson I would like:			

Yes or No

		Yes	No
1.	This lesson was easy to understand		
	This lesson will help me in my daily job		
	I would like more lessons on this subject		
2.	This lesson was easy to understand		
	This lesson will help me in my daily job		
	I would like more lessons on this subject		
3.	This lesson was easy to understand		
	This lesson will help me in my daily job		
	I would like more lessons on this subject		

Which of the training lectures / sessions need to be further improved? Please elaborate which aspect needs to be given attention (time allotment, clarity of topic, instructor/trainer expertise, processes/methodologies used).

Kindly provide your recommendations to further improve the training lecture/session.

PART II. FROM PRE-TRAINING EVALUATION

What were your personal learning goals?

1.
2.
3.

Looking at each goal separately, list below the learning and results for each goals after attending the training.

1.
2.
3.

What was your biggest learning experience since attending the training?

What skills/knowledge/attitude do you have now, that you didn't have before attending the training? What can you do better after acquiring such skills/knowledge/behavior from the training workshop?

What changes will you do to apply what you have learnt from the training workshop into your day-to-day job? Please be specific.

What support do you need from your Supervisor and colleagues to make the above real for you in your job?

Do you have any other comments about the training workshop?

Please hand a completed copy of this form to the course Trainer one week after the course.

Many thanks for your assistance.

Most of the feedback centered on the relevance of the course to the participants' work. Many of the participants admitted they attended the course with little knowledge in coral taxonomy and were grateful for the enhanced skills resulting from the workshop.

8.0 Module

The training course was subdivided into ten lecture sessions and ten laboratory / hands-on sessions. The topics were:

1. General taxonomy of animals
2. General biology of reef building corals
3. Basic taxonomy of corals
4. Families and genera of corals – Part 1
5. Families and genera of corals – Part 2
6. Problems in coral taxonomy
7. Sample collections, processing and managing
8. Advanced taxonomic methods (molecular techniques)
9. Sample processing for advanced techniques (SEM)
10. Museum collection management, cataloguing and storage

8.1 Basic Taxonomy of Animals

What is taxonomy?

Humans generally categorize things using their common features and separating each of them into unique groups. Such grouping, based on common characteristics, is known as "classification". Taxonomy is a subject of biology that classifies organisms and makes taxonomic hierarchy systems based on common biological (mostly morphological) characteristics.

- There are three stages in taxonomy: ($\alpha \rightarrow \beta \rightarrow \gamma$)
  - α – Most primitive stage of taxonomy which recognizes species and gives scientific names based on description. This is the first step before step β.
  - β – A stage to analyze the phylogenetic relationship among taxa.
  - γ – Taxonomy pursues to understand mechanism that allows producing the biodiversity made through species identification and description.

Biological Species Concept

Species, the smallest unit in taxonomy, is a group of individuals that realistically or potentially crossbreed and reproductively isolate from other groups.

There is a limit to the biological species concept:

- Not applicable to species without sexual reproduction
- Not applicable to extinct species
- Not realized whether or not there is reproductive isolation among populations isolated geographically

The classification system was first proposed by Carl von Linné (or Carolus Linnaeus) hence called the Linnaean classification system.

Identification of Species

Names of the specimens collected are searched by referring to the Linnean classification system: a process called identification.

In the classification system, type specimen is pointed out for each species; its biological characteristics are described and published. After these steps, the species name becomes valid. If the specimen does not match the existing identification system, description of the new species needs to be done and added to the system.

International Code of Zoological Nomenclature (ICZN)

There is a strict rule in giving a scientific name to a certain taxon. All names given to a species are subjected to this code.

Binomial Name and Binomial Nomenclature

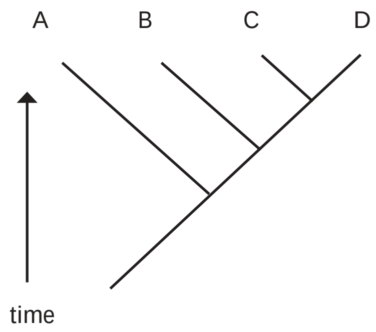
The method of describing species name was established by Carl von Linné when he published *Systema Naturae ver. 10* in January 1, 1758. He used “binomial name” in the publication. Under this system, each species has a generic name (noun) and a specific name (adjective). For example, the scientific name for common octopus is written as *Octopus vulgaris (*Cuvier, 1791).

Both the generic and specific names should be italicized and the first character in the generic name is in capital letter. After the binomial name, the author’s name and the year of nomination are added.

If one species has two scientific names, the name published earlier is considered valid and the latter name is treated as “synonym”. If two species have the same scientific name (homonym), the species described earlier holds the original name and the other will be given a new species name. If one species has two names with condition that the older name is never used for more than 50 years, the name will be declared invalid and the younger name will be used as the valid name.

Phylogenetic Tree

Phylogenetic tree or dendrogram is used to show evolutional history of organisms. Pioneered by E. Heckel when he formulated the idea from the origin of organisms, three major groups emerged (plant, animal and protozoa).



Taxa are arranged horizontally and time is arranged vertically. Upper area means it is close to present and lower area is in the past. Lines mean evolutional relationship where nearer to present and means relationship is tighter. Further explanation on phylogenetic tress can be obtained in the presentation included in Appendix B.

8.2 Coral Biology and Coral Ecology

General Coral Biology

- There are four 'biodiversity hotspots' in Southeast Asia: Indo-Burma, the Philippines, Wallacea, Sundaland.
- There are three ways of nutrient uptake by corals namely: direct feeding by the polyp, zooxanthellae-coral symbiosis, and nutrient absorption.
- Details of reef formation and coral nutrition are illustrated in Appendix C.
- Mass extinction and geological time in relation to corals are described in Appendix C.

Coral Ecology: An introduction to issues

- Coral growth is NOT equivalent to reef growth.
- Both coral growth and reef formation require different conditions:

Coral Growth	**Reef Formation**
Intermediate temperature	High temperature
Not full strength salinity	Full strength salinity
Hard substrate	Hard substrate
Lighted environment	Lighted environment
	Calcium carbonate ($CaCo_3$)

Sea level, sea surface temperature, sedimentation and acid acidification threats to the ecology of coral reef are further discussed in Appendix D.

8.3 Taxonomy of the Zooxanthellate Scleractinian Corals

Scleractinian Coral Notes

- Scleractinian corals are divided in zooxanthellate and azooxanthellate with both having around 750 species in each group.
- Most zooxanthellate corals are hermatypic (reef building) but also consist of some ahermatypic species (e.g. *Cladocora caespitosai*). Likewise, azooxanthellate have hermatypic species (e.g. *Tubastrea micranthus*) but in smaller number as compared to the larger group of ahermatypic species in azooxanthellate corals.
- Figure 1 shows the general structure of the polyp and underlying skeleton.

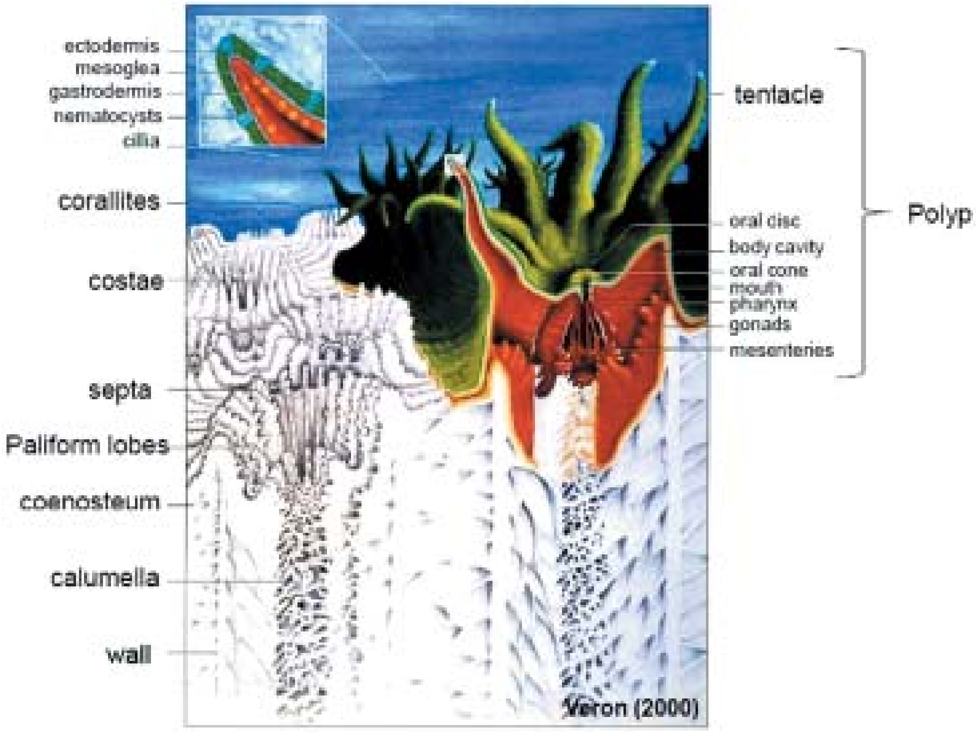


Figure 1. The general structure of polyp and underlying skeleton

Glossary of Coral Morphological Terms

- Corallite: the skeleton of an individual polyp
- Calice: the upper surface of a corralite bounded by the wall
- Corralum (plural: corolla): the skeleton of a colony

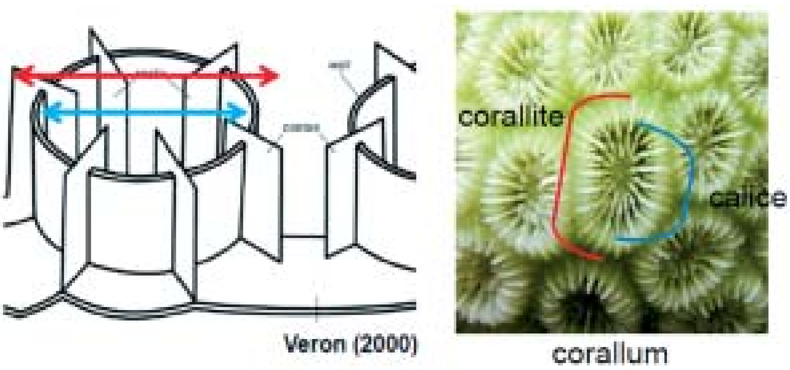


Figure 2. Diagram showing the difference of corallite, calice and corallum

- Septum (plural: septa): radial skeletal elements projecting inwards from the corallite wall
- Costa (plural: coastae): radial skeletal elements outside the corallite wall
- Wall (theca): the skeleton enclosing a calice

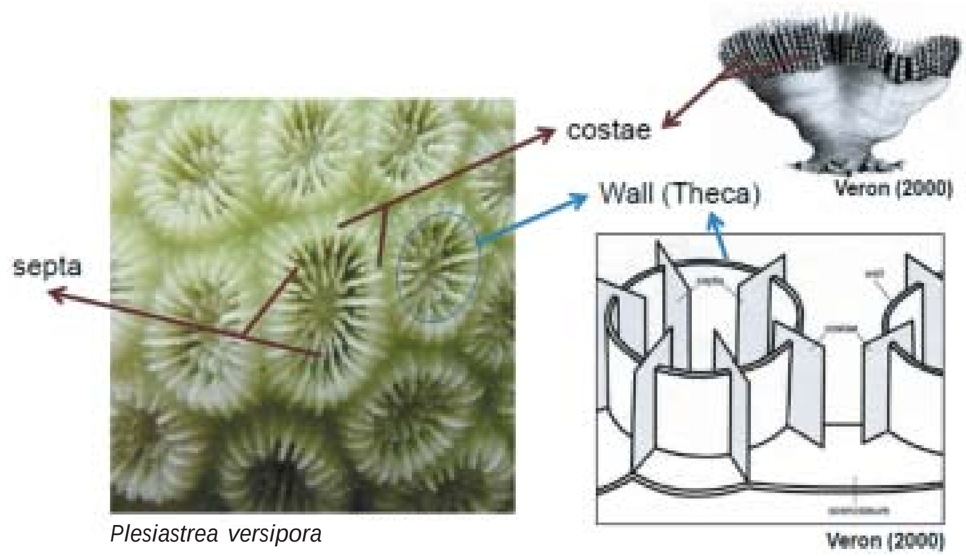


Figure 3. Diagram showing the difference of septum, costae and wall

- Paliform lobe: upright skeletal rods or plates at the inner margin of septa formed by upward growth of septum
- Pali: upright skeletal rods or plates at the inner margin of the septa formed by pourtàles plan fusions
- Coenosteum: horizontal parts between corallites
- Calumella (plural: calumellae): skeletal structures at the axis of corallites

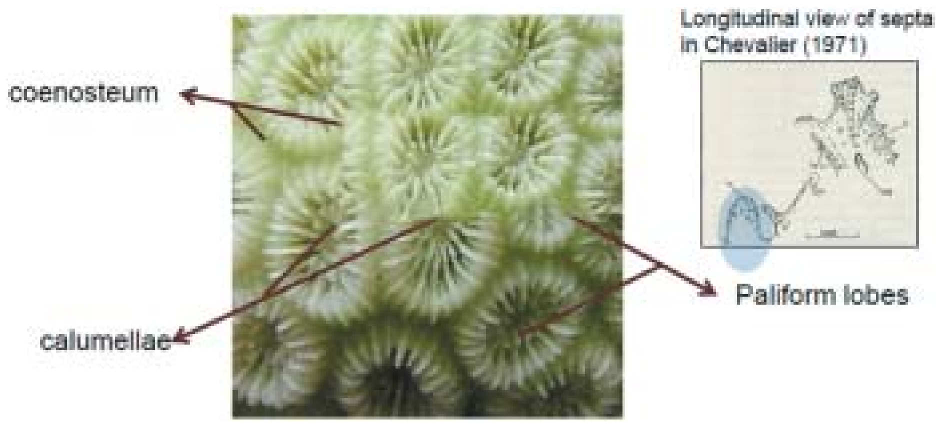


Figure 4. Diagram showing the difference of coenosteum, calumellae and paliform lobes

- Septo-costae: septa from one center to another, connected by septa-like structures
- Petaloid: septa with a flower-like appearance
- Synapticulae: horizontal rods between septa
- Collines: skeletal ridges composed of coenosteum which separate corallites

Colony Shape

Encrusting

Pavona explanulata

Montipora floweri

Columnar

Favia stelligera

Gonioastrea

Pavona clavus

Foliaceous, plates, fronds, laminase

Tubinaria mesenterina

Pavona cacutas

Leptoseris yabei

Branching, arborescent, ramose

Cyphastreadecadia

Acropora intermedia

Free living

Fungia scutaria

Trachyphyllia geofferoni

Solitary

Scolymia vitiensis

Cynaria lacrymalis

Massive submassive

Faviaspeciosa

Psammocora profundcella

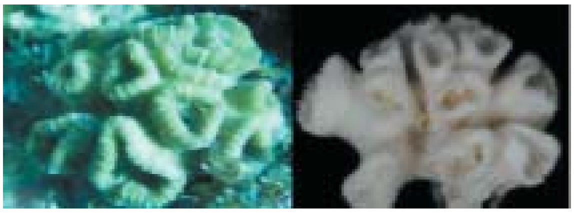
Arrangement of Corallites

Plocoid 

Notes:

- Colonies with conical corallites with their own walls
- Mainly in the genus *Favia*

Phaceloid 

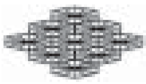


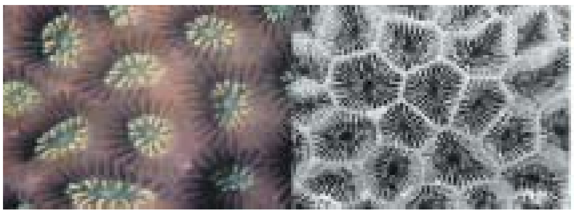
Caulastreatumida **(Family: Faviidae)**

Euphylliaparaglablescens **(Family: Euphylliidae)**

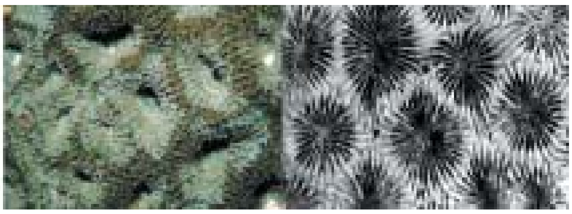
Notes:

- Colonies with corallites of uniform height and adjoined towards their base

Cerioid 



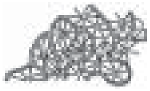
Gonioastrea aspera **(Family: Faviidae)**



Acanthastrea echinata **(Family: Musiidae)**

Notes:

- Colonies with corallites sharing common walls

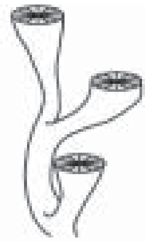
Meandroid 

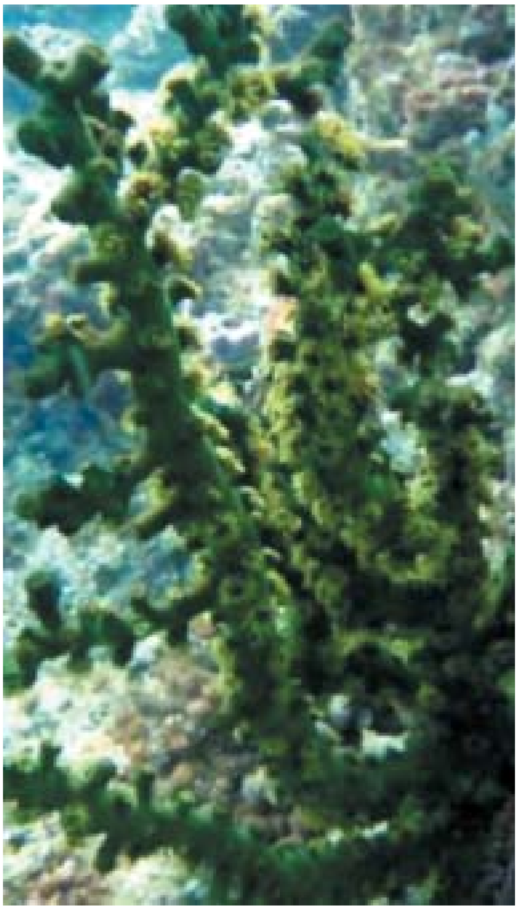
Gonioastrea australensis **(Family: Faviidae)**

Physogyra lichtensteini **(Family: Euphylliidae)**

Notes:

- Colonies with corallite mouths aligned in valleys

Dendroid 

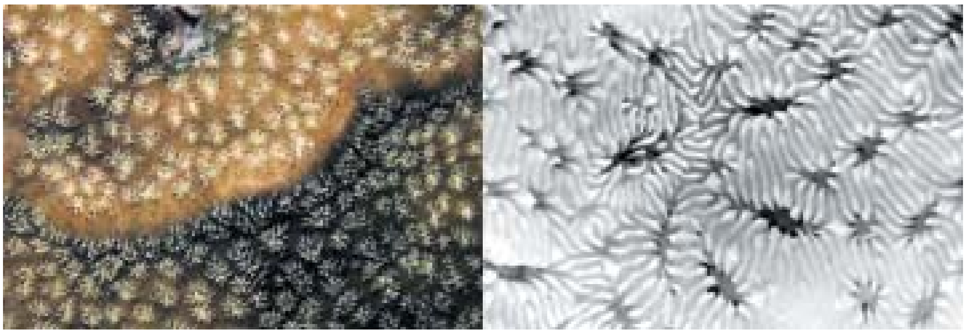


Dendrophylliidae

Notes:

- Spreading branches of single corallites

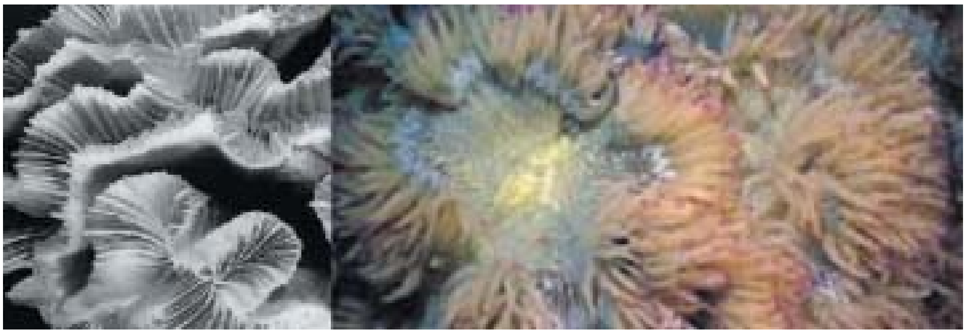
Thamnasterioid 



Notes:

- Corallites with confluent septa and lacking defined boundaries (septa-costae)

Flabello-meandroid



Catalaphyllia jardinei

Notes:

- Colonies with valleys that have completely separate walls
- Valleys have several mouths
- Seen in *Catalaphyllia* and *Lobophyllia*

8.4 Taxonomy of Corals (Families and Genera)

Notes on the Family Acroporidae

General Features

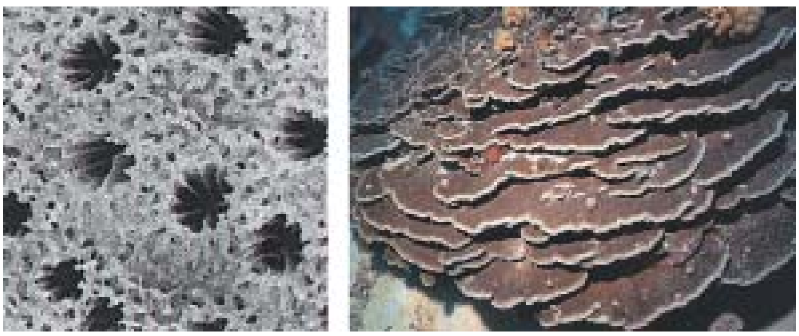
- Small corallites (except *Astreopora*)
- Lack of columellae (except *Astreopora*)
- Synapticulothecae
- Simple septa (no pattern of fusion)
- Extratentacular budding

Genus: *Anacropora*

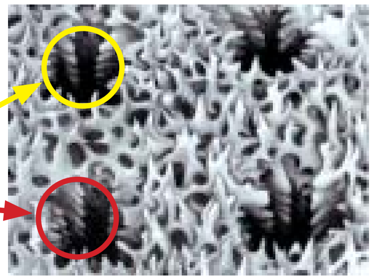
- Arborescent
- Thin tapered branches without axial corallite
- Radial corallite small, immersed
- Corallite walls and coenosteum porous
- Corallites often have projecting lower lips

Genus: *Astreopora*

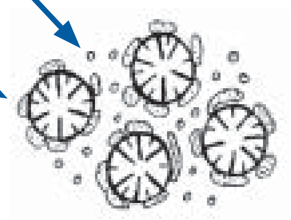
- Growth form: encrusting, massive, subramose and laminar
- Corallites are immersed or conical with short, numerous, neatly spaced septa
- Coenosteum: reticular and spinose surface



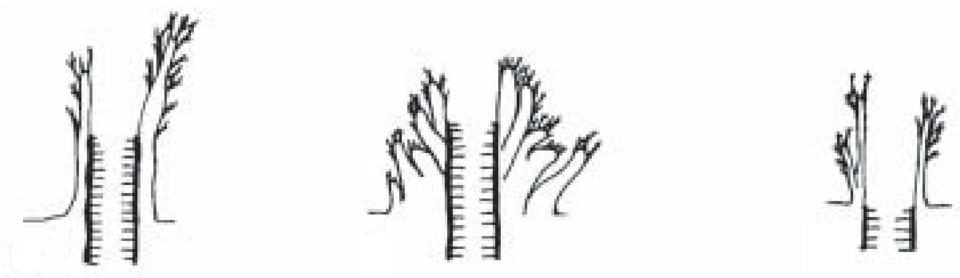
Genus: *Montipora*



- Growth form: foliaceous, encrusting, branching, branching with laminar base and massive/submassive
- Corallites are very small (<2mm)
- Walls of coenosteum are highly elaborated and porous
- Septa: inward projecting teeth (comb-like)
- Columellae is absent
- Thecal papillae and coenosteum papillae present



- Thecal papillae in three forms:

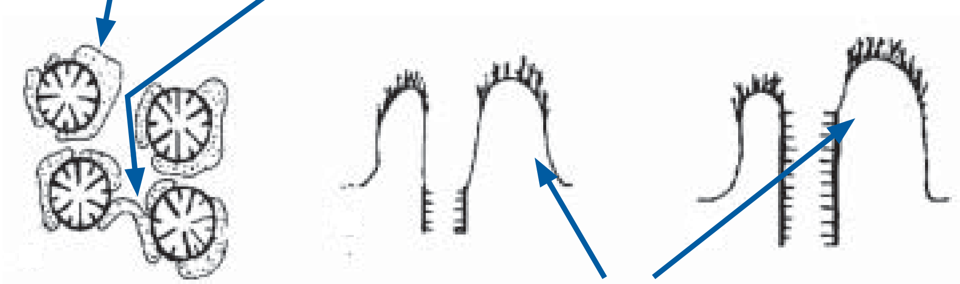


Simple papillae
Exsert corallite

Compound papillae
Exsert corallite

Simple corallite
Immersed corallite

- Thecal tuberculae and coenosteum named for the larger elaborations

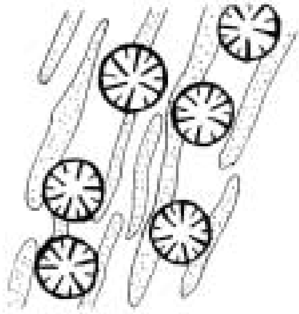
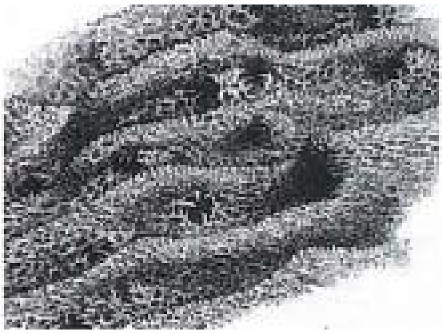


Thecal tuberculae

Immersed corralit

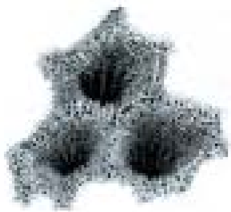
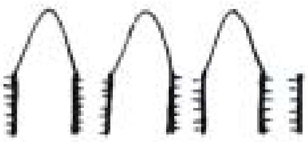
Exsert corallite

- Coenosteum tuberculae forming ridges

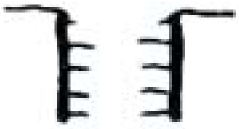
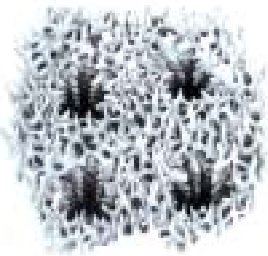



- Coenosteum tuberculae forming verrucae


- Foveolate corallites

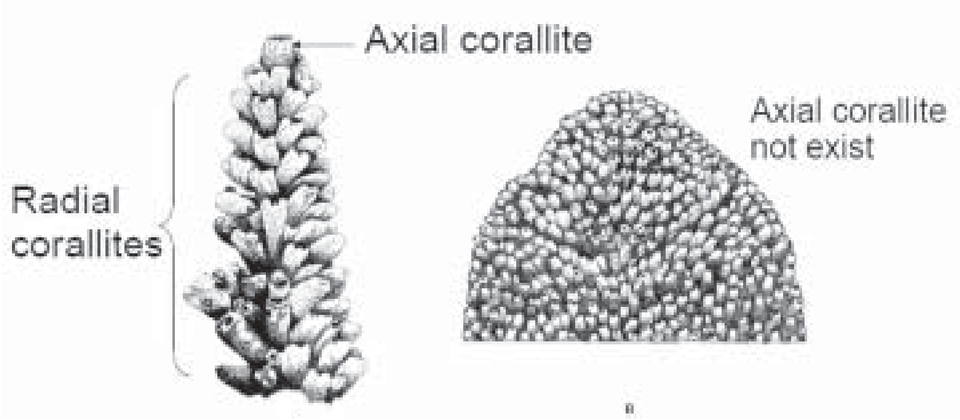



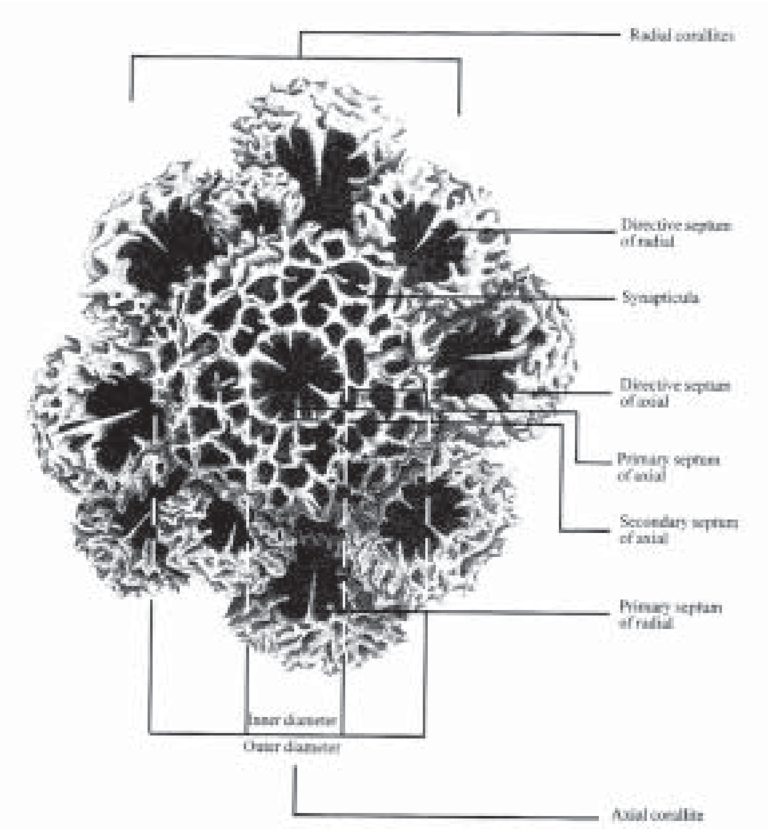

- Glabrous coenosteum with immersed corallites

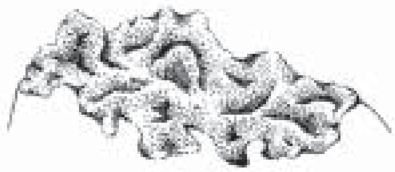

Genus: ***Acropora***

- Axial corallites (except a few spp.) and radial corallites



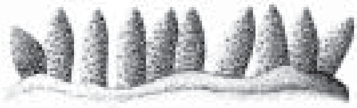


- Growth forms:



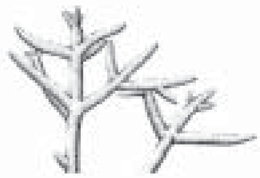
Encrusting (very rare)

Submassive



Digitate

Corymbose



Aborescent

Caepitose

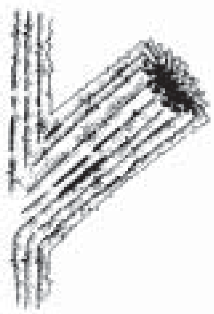
Aborescent table

Caepitose-corymbose

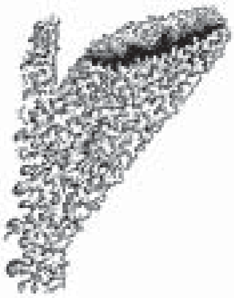
Hispidose

Tabulate (table)

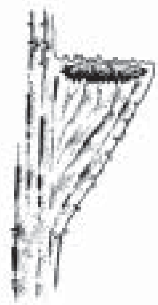
- Radial corallite



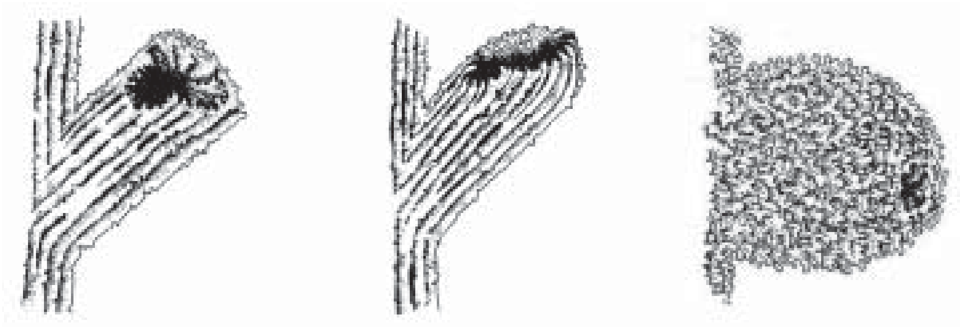
Tubular and round opening



Tubular and oblique opening



Appresed tubular



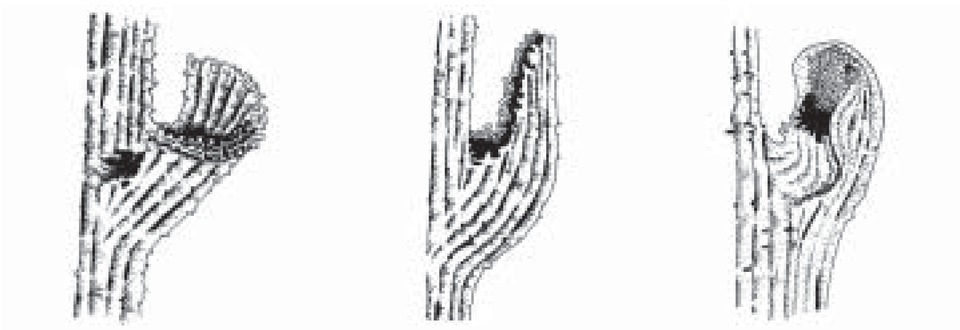
Tubular and dimidiate opening rounded tubular

Tubular and nariform opening

Nariform and elongate opening

Nariform and round opening

Labellete and rounded lip



Labellete and flaring lips

Labellete and straight lips

Cochleariform

Appressed tubular

Conical

Subimmersed

Immersed

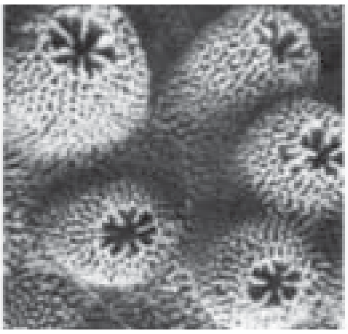
- Coenosteum types:

Reticulate will spicules all over

Costate on and between radial corallites

Costate or broken costate on radial corallites, reticulate with spinules between them

Dense arrangement of spinules on radial corallites, reticulate with spinules less densely arranged between them

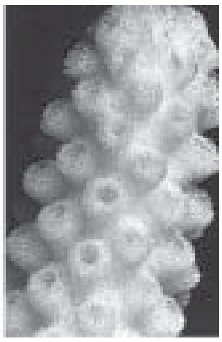


Dense arrangement of spinules

- Size of radial corallites

two different sizes

Different sizes



Uniform sizes

Notes on the Family Faviidae

General Features

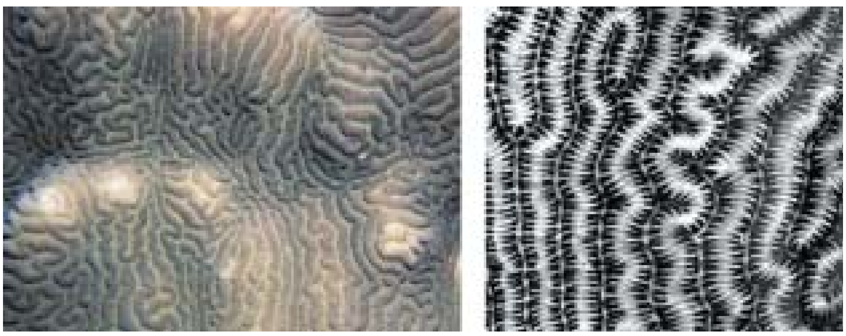
- The most number of genera in the Scleractinia
- Second to the Acroporidae in number of extant species
- All species are zooxanthellate
- Septa, paliform lobes, columellae and wall structures (when present), all appear to be structurally similar
- The vast majority of faviids are hermaphroditic broadcast-spawners. Only a few species are gonochoric. Planula brooding occurs in some species.
- A total of 24 genera and the most number of genera in the scleractinia
- A number of 15 genera are common in the Indo-Pacific

Genus: *Caulastrea*

- Colonies are phaceloid
- Corallites have numerous fine septa and well developed columellae
- Paliform lobes are absent
- Consists of five species

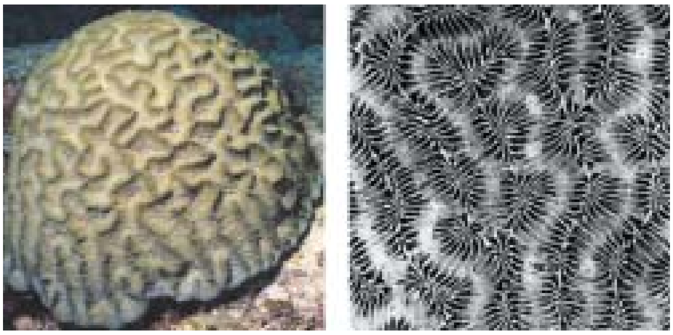
Genus: Leptoria

- Colonies are massive or encrusting with sinuous valleys
- Colonies are meandroid
- Neatly arranged equal septa and no paliform lobes
- Has the narrowest valleys (2-3mm)
- Consists of only two species



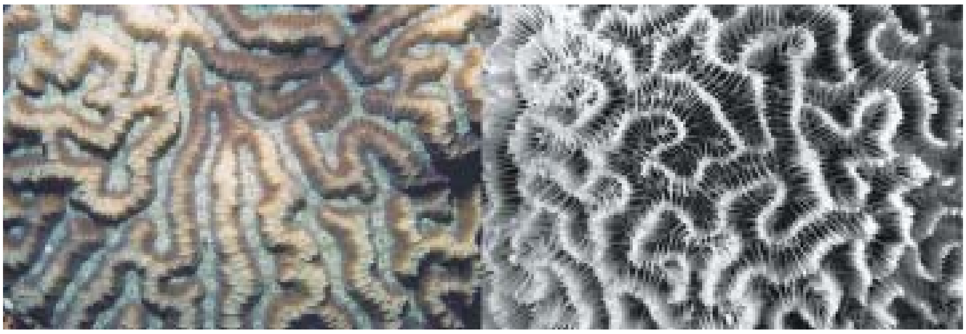
Genus: ***Oulophyllia***

- Colonies are massive and meandroid
- Composed or widest valleys (10-12mm)
- Poliform lobes are usually present
- Polyps are large and fleshy extended during night only

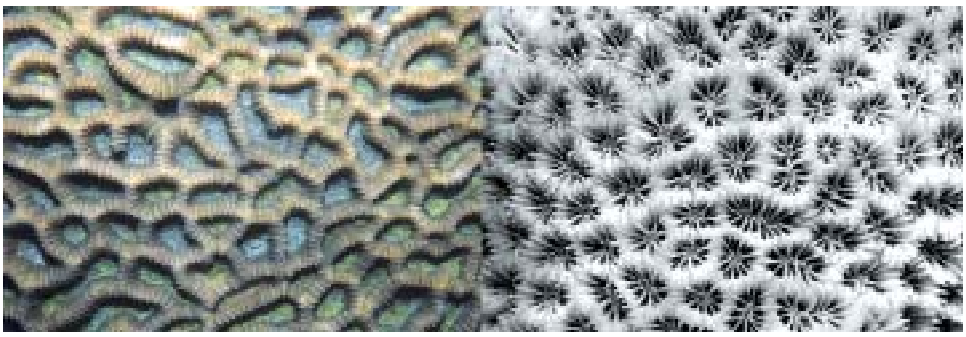


Genus: ***Platgyra***

- Colonies are massive and either flat or dome-shaped
- Corallites are meandroid but sometimes cerioroid
- Palifom lobes are not developed
- Mid-sized valleys (3-5mm)
- Septa are exsert and have ragged appearance
- Columellae are poorly developed
- Consists of 11 species



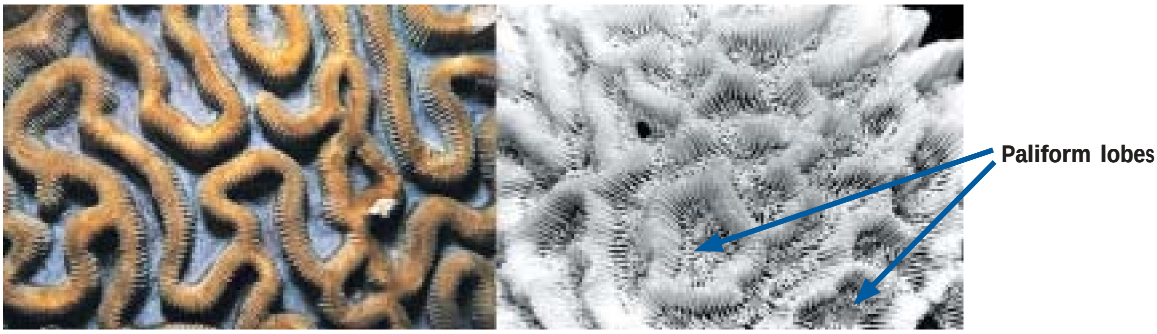
Platygyra daedalea



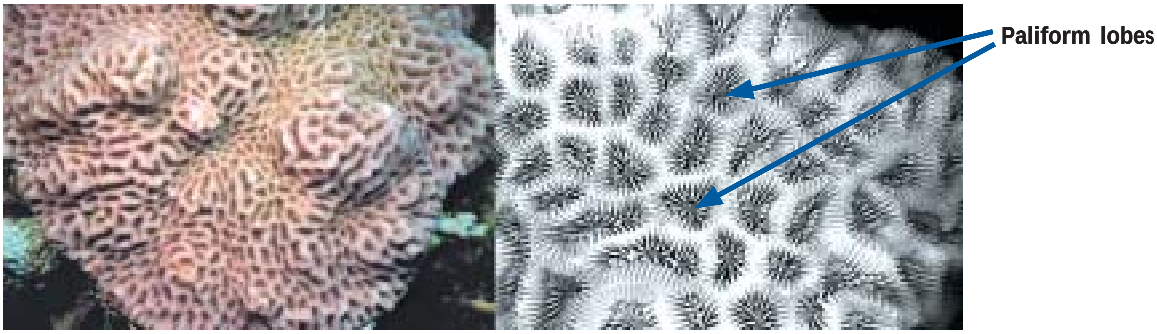
Platygyra pini **(A few species that form only short valleys)**

Genus: *Goniastrea*

- Colonies are massive and usually spherical/thick flat plates
- Three out of total 13 species form valley and meandroid
- Remaining ten species are cerioid
- Paliform lobes are well developed



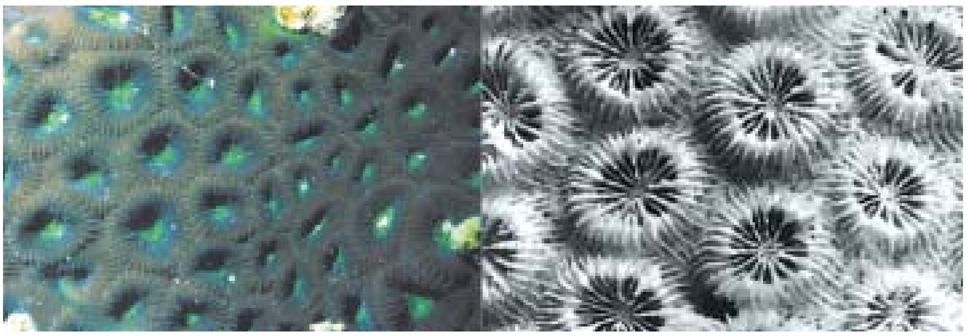
Goniastrea australensis



Goniastrea pectinata

Genus: *Favia*

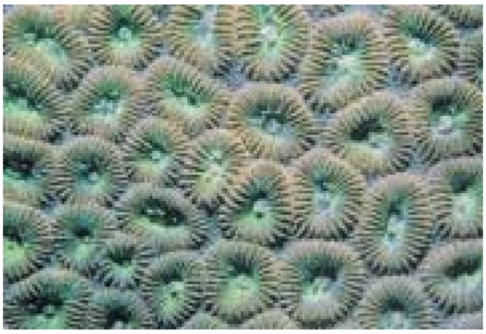
- Colonies are massive in either flat or dome-shaped
- Corallites are plocoid
- Intertentacular budding
- Very similar to genus *Montastraea* which has extratentacular budding
- Consists of 23 species



Favia speciosa

Genus: *Montastraea*

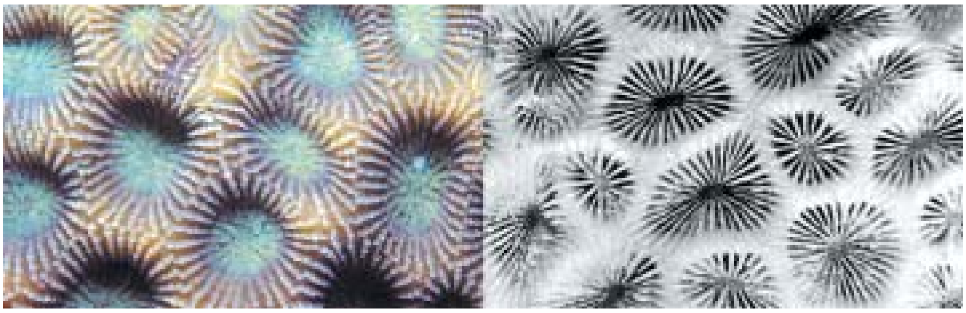
- Colonies are massive, either flat or dome-shaped
- Corallites are plocoid
- Daughter corallites formed by extratentacular budding
- Consists of 12 species



Montastraea magnistellata

Genus: *Favites*

- Colonies are massive, either flat or dome-shaped
- Cerioid colony
- No paliform lobes (differing characteristic for *Goniastrea*)
- Adjacent corallites mostly share common walls
- Consists of 16 species



Favites abdita

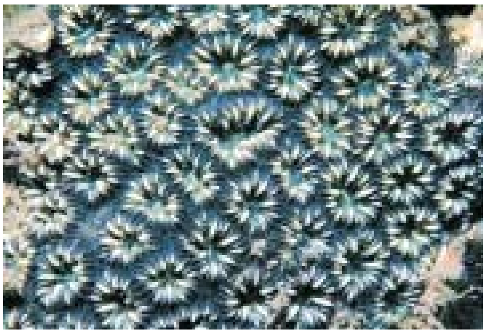
Genus: *Barabatoia*

- Colonies have tubular corallites which fuse irregularly
- Extratentacular budding
- Exsert corallites (differing characteristic from genus *Favia* and *Montastrae*a)

Barabattoia amicorum

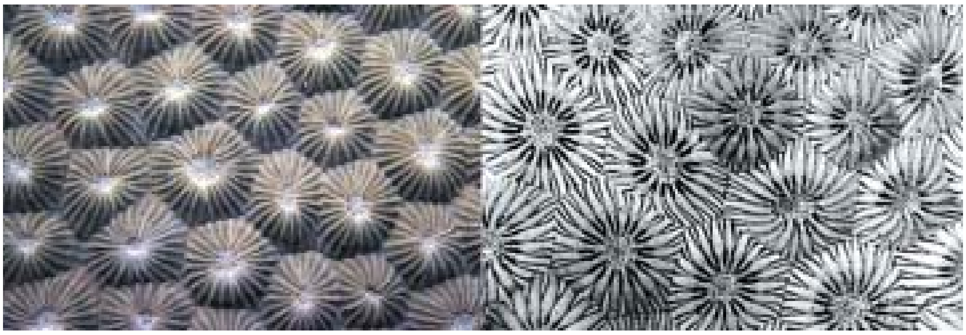
Genus: *Oulastrea*

- Only one species in this genus
- Distinctive black skeleton
- Species name: *Oulastrea crispate*



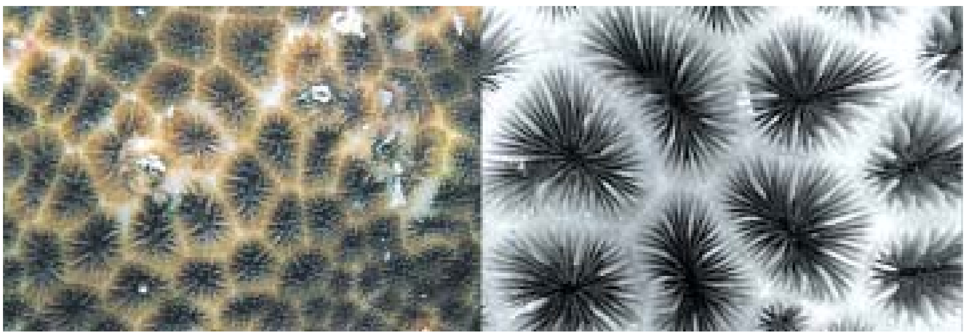
Genus: *Diploastrea*

- Only one species in this genus
- Very big characteristic corallites
- *Diploastrea heliopora*



Genus: *Leptastrea*

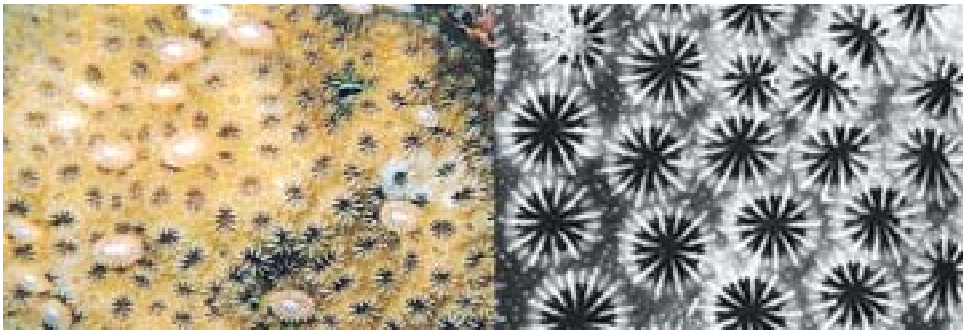
- Corallites are cerioid to subplocoid
- Costae are poorly developed or absent
- Septa have inward projecting teeth
- Columellae consist of vertical pinnules
- Consists of seven species



Leptastrea purpurea

Genus: *Cyphastrea*

- Colonies are massive or encrusting
- Corallites are plocoid
- Small corallite size (1-2mm)
- Costae are generally restricted to the corallite wall
- Consists of eight species



Cyphastrea chalcidium

Genus: *Echinopora*

- Plate-like colony
- Corallites are plocoid (except *E. fruticulosa* and *E. tiranensis* which form branches)
- Exsert septa and irregular
- Total of 12 species

Echinopora lamellose

Genus: *Plesiastrea*

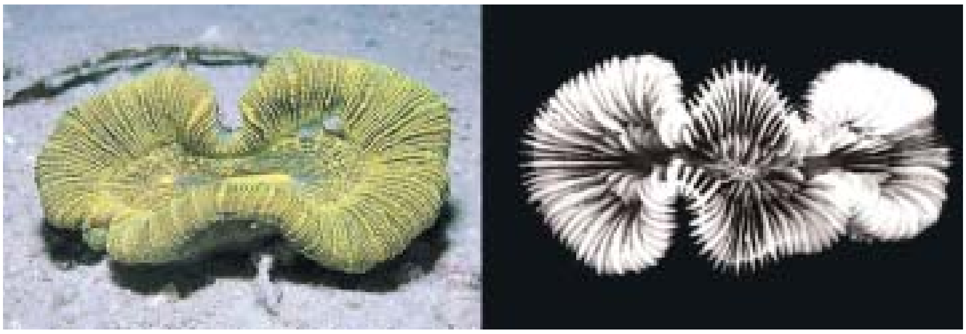
- Colonies are massive, rounded or flattened
- Corallites are small (2-4mm) and plocoid
- Extratentacular budding
- Paliform lobes well-developed (differing characteristic from genus *Cyphastrea*)

Plesiastrea versipora H. Fukumi

Notes on the Family Trachyphyliidae

General Features

- One genus, one species
- Colonies are flabello-meandroid and free-living
- Hourglass shape, up to 80 mm in length with one to three separate mouths
- Large regular septa and paliform lobes



Trachyphyllia geofferoni

Notes on the Family Merulinidae

General Features

- Can be found only in Indo-Pacific
- Total of five genera
- Skeletal structures are often faviid-like but are highly fused
- Without paliform lobes
- This family can be easily identified by the color and specific character
- There are no common characters among genera

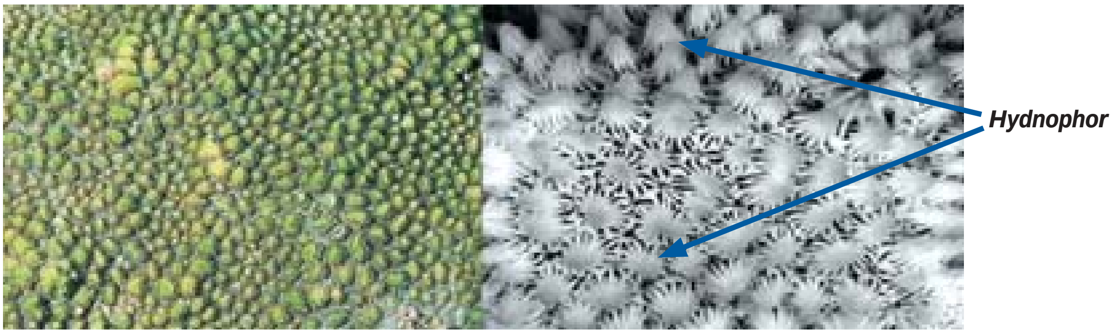
Genus: Merulina

- Partly encrusting and partly foliaceous colonies
- Colonies are pale-pink or pale-brown in color
- Surface structure is meandroid, with the calices arranged in rows
- Septa protrude and are closely packed
- Paliform lobes are well-developed
- Looks similar to *Goniastrea pectinata*
- Only three species in this genus

Merulina ampliata

Genus: *Hydnophora*

- Colonies are either branched or massive with tips of the monticules pale (hydnophore)
- The genus name is derived from prominent hydnophores, which are conical structures (projecting discontinuous cones) between the corallite centers
- Consists of six species



Hydnophora exesa

Genus: *Scaphophyllia*

- Colonies form massive, often columnar
- Valleys are meandroid, sinuous and parallel
- Generally uncommon, conspicuous
- Distinguishable from genus *Merulina* by parallel valleys and columnar colonies
- Only one species in this genus

Scapophyllia cylindric

Notes on the Family Pectiniidae

General Features

- Only five genera in this family all found in the Indo-Pacific
- Thick fleshy polyps which have a superficial resemblance to some faviids and mussids
- Calices are connected with neighboring calices by septo-costae
- Usually a center polyp is conspicuous

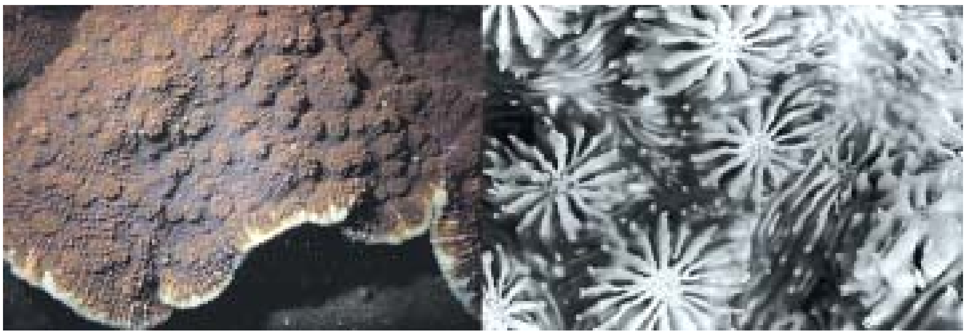
Genus: *Pectinia*

- Encrusting, foliaceous, or branching colonies
- Form semi-meandroid arrangement of thin leaves (wall-like costae), an important characteristic to this genus
- Calices are superficial and lack true walls
- Margins of septa and septo-costae are finely and irregularly serrated
- Consists of nine species

Pectinia lactusa

Genus: *Echinophyllia*

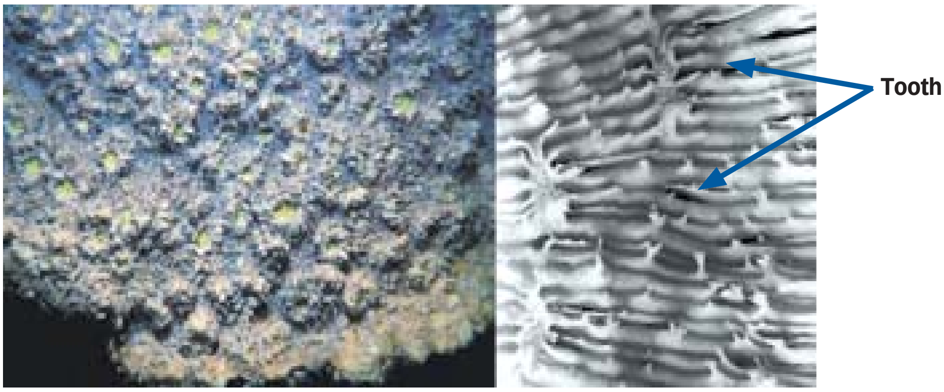
- Irregular foliaceous or encrusting growth form
- Corallites are round / oval and generally elevated several millimeters above the surface of the corallum (like plocoid). This character is distinctive for this genus.
- Paliform lobes are usually present
- Consists of eight species



Echinophyllia aspera

Genus: *Oxypora*

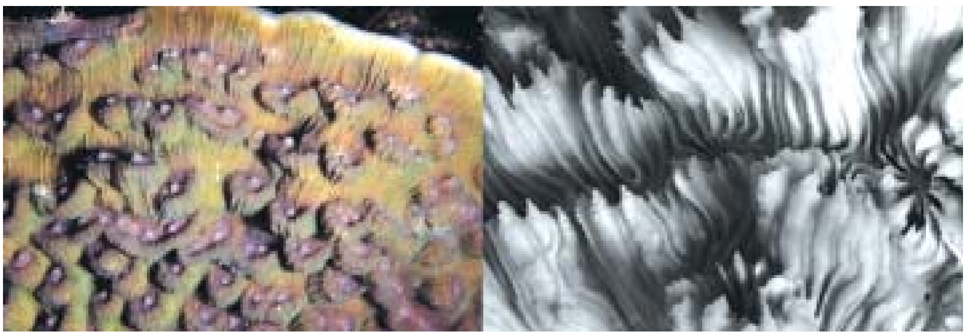
- Encrusting with free-foliaceous margins
- Fragile corallum
- The coenosteum is pitted
- Calices are superficially or slightly raised
- Small number of septo-costae (8-12)
- Costae are toothed
- Superficially similar to the Echinophyllia; it will be necessary to see the skeleton for identification
- Consists of four species



Oxypora lacera

Genus: *Mycedium*

- Foliaceous or semi-encrusting colonies
- Corallites are inclined, facing outwards to the edge of the colony margins. Important characteristic for this genus.
- Septa are numerous
- Very conspicuous and easily identified in the field
- Consists of five species



Mycedium elephantotus

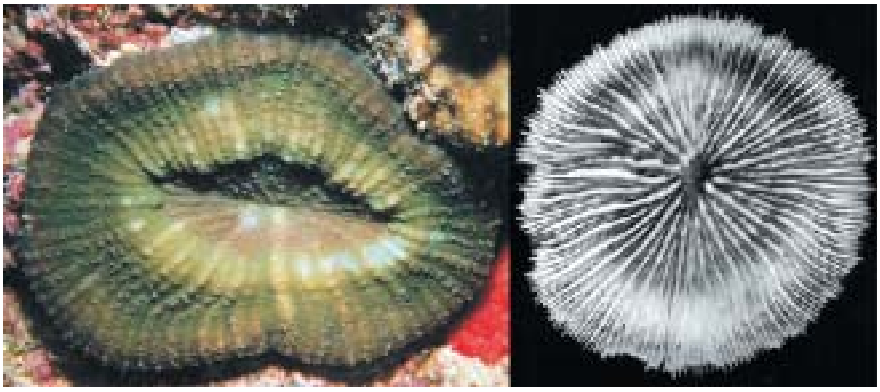
Notes on the Family Mussidae

General Features

- There are 13 genera (eight from Indo-Pacific, and four from Atlantic. One is common in both)
- Colonies are solitary or colonial
- Skeletal structures are solid
- Corallites and valleys are very large
- The septa have large teeth or lobes (in contrast to the smoother *Faviids*)
- Columellae and walls are thick and well developed with thick and fleshy polyps

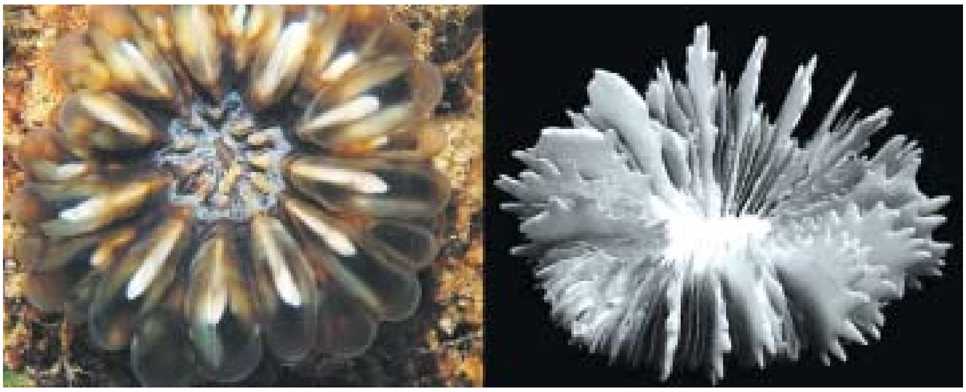
Genus: Scolymia

- Attached and solitary
- Flattened and disk-like
- About 3-14cm in diameter
- Septa are arranged in cycles
- Generally uncommon
- Consists of three species

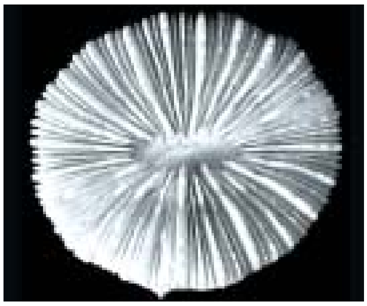


Genus: *Cynarina*

- Attached or free-living
- Solitary
- About 5-6cm in diameter
- First cycle of septa is strongly exserted and thickened
- Only one species for this genus *(Cynarina lacrymalis)*



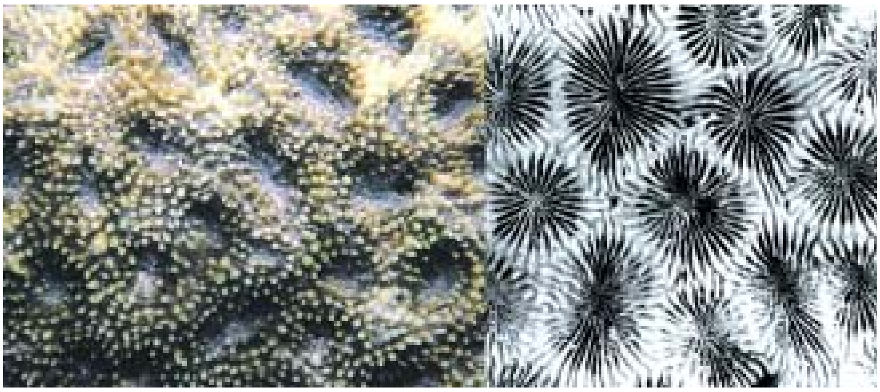
Genus: *Indophyllia*



- Free-living and solitary
- About 4.5 cm in diameter
- This, formerly thought long extinct, was rediscovered alive in Indonesia
- Very rare
- Only one species in this genus *(Indophyllia macassarensis)*

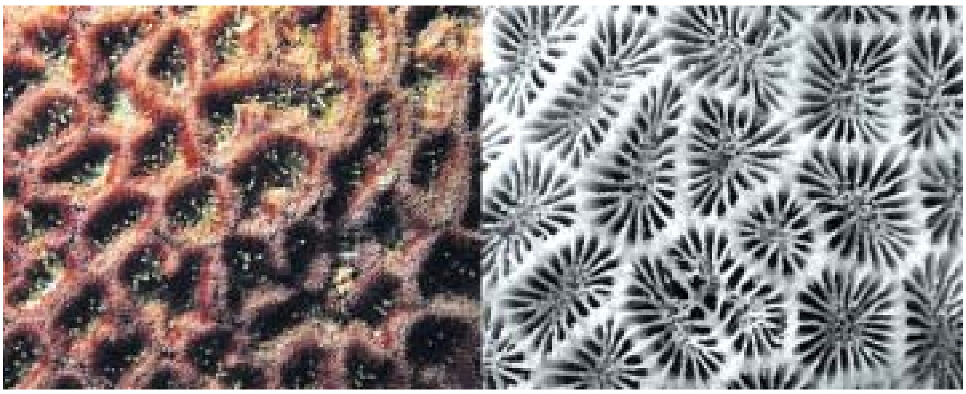
Genus: *Acanthastrea*

- Colonies are massive or encrusting and usually flat
- Corallite are circular or angular in shape and are cerioid or subplocoid
- Corallite size >8mm (characteristic differentiating from genus *Micromussa*)
- Septa are thickened at the wall and having tall teeth
- Consists of 12 species



Genus: *Micromussa*

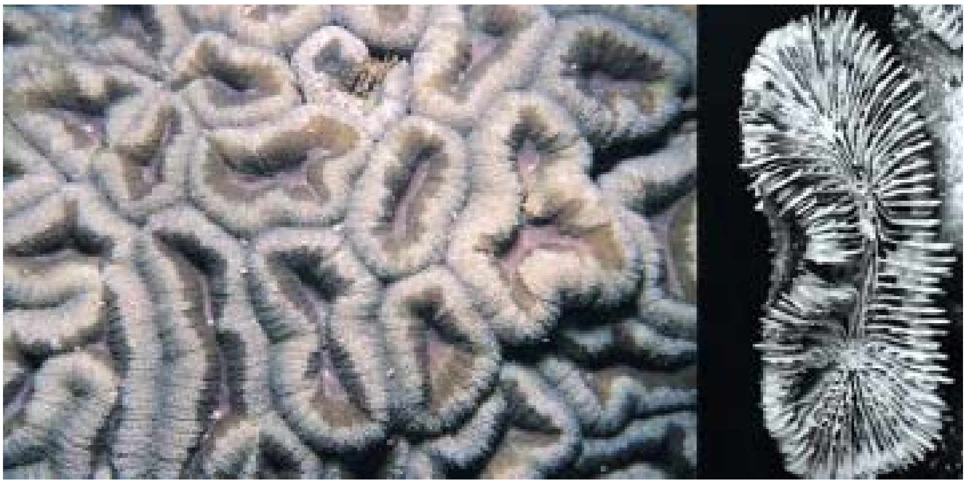
- Colonies are submassive or encrusting
- Cerioid corallites with circular or angular shape
- Size of corallite up to <8mm (characteristic differering from genus *Acanthastrea*)
- Septa are thickened at the wall and having tall teeth
- Consists of three species



Micromussa makusensis

Genus: *Lobophyllia*

- Colonies are phaceloid to flabello-meandroid (distinctive characteristic for this genus)
- Corallites valleys are large
- Septa are large with long teeth



Lobophyllia hemprichii

Genus: *Symphyllia*

- Colonies are meandroid (distinctive characteristic for this genus)
- Valleys are wide
- Groove usually runs along the top of the wall
- Large septa with teeth
- Consists of seven species

Symphyllia agaricia

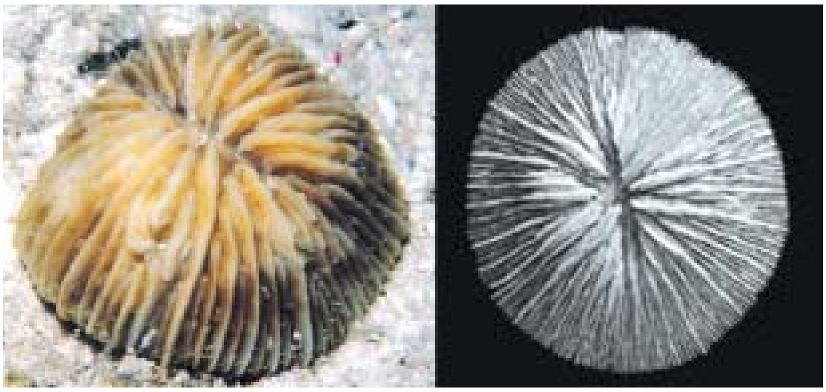
Notes on the Family Fungiidae

General Features

- Total of 13 genera in this family all found in Indo-Pacific known as mushroom corals
- Members are usually free-living, but some are attached even in their adult stages
- Septo-costae radiate from the mouth on the upper surface as septa and from the center of the under-surface as costae

Genus: *Cycloseris*

- Solitary, free-living, flat or dome-shaped
- Circular or slightly oval in outline with central mouth
- No pits on the undersurface
- Reach up to 10cm
- Septa have fine teeth and costae are also fine
- Restricted to reef environment and consist of 11 species in the genus



Cycloseris cyclolites

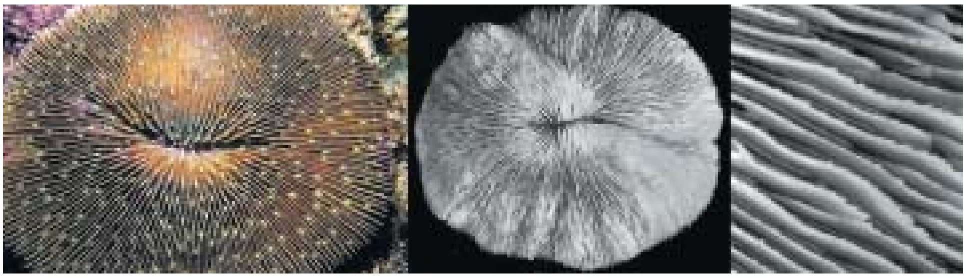
Genus: *Diaseris*

- Solitary and free-living polyps
- Fan-shaped segments with a mouth situated at the point of divergence of the segments
- Septa are thick with blunt teeth resembling rows of granules
- Consists of two species

Diaseris distorta

Genus: ***Fungia***

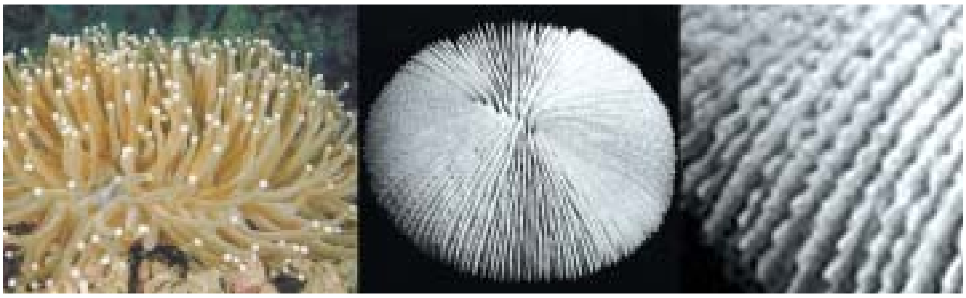
- Solitary and free-living
- Can reach 50cm in diameter
- Flat or dome-shaped with circular or elongate outline and a central mouth
- Septa with large or small, rounded and pointed teeth
- Costae with large spines in rows (distinctive characteristic of this genus)
- Existence of pits between costae (distinctive characteristic of this genus)
- Has 18 species in the genus



Fungia fungites

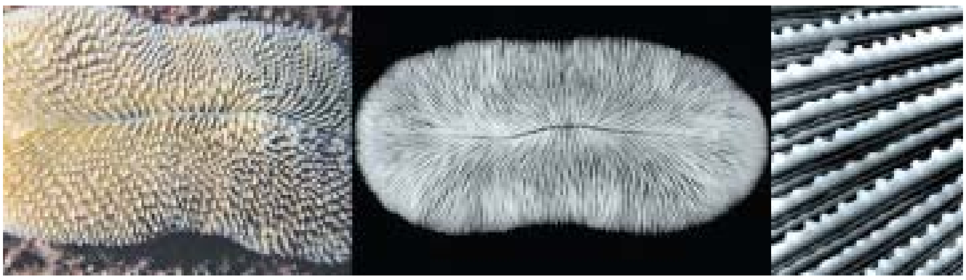
Genus: ***Heliofungia***

- Solitary and free-living
- Can reach 20cm in diameter
- Tentacles are usually over 5cm long
- Septa have large lobed teeth
- Only one species in the genus, *Helipfungia actiniformis*



Genus: ***Ctenactis***

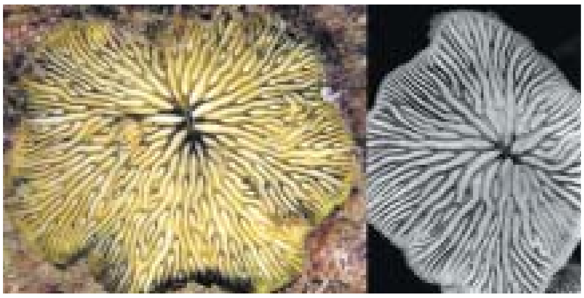
- Solitary and free-living
- Elongated shape reaching 50cm in diameter
- Lobed septal teeth
- A prominent central furrow which may have one to several mouths
- Consists of three species



Ctenactis echinata

Genus: *Cantharellus*

- Solitary and permanently attached to the substrate
- Rarely colonial
- Up to 20cm in diameter
- Septa are thick and alternate in five cycles
- Consists of three species



Cantharellus jebbi

Genus: *Herpolitha*

- Colonial and free-living
- Colonies are elongate with an axial furrow
- There is a central groove on the upper surface, along which is a series of conspicuous slit-like mouths
- Consists of two species

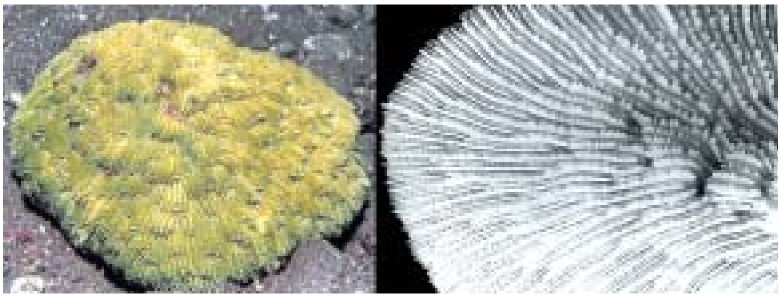
Herpolitha limax

Genus: *Polyphyllia*

- Colonial and free-living
- Elongate colonial coral
- Petaloid appearance of the calices
- With prominent tentacles
- Only one species in this genus *(Polyphyllia novaehinerniae)*

Genus: *Sandolitha*

- Free-living
- Colonies are heavily constructed
- Corallites are numerous, exsert
- Consists of three species



Sandolitha robusta

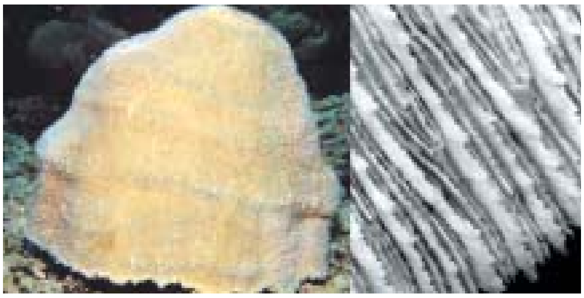
Genus: *Halomitra*

- Colonies are delicate and free-living
- Corallites are not exsert
- Distribution of corallites is loose
- Consists of three species

Halomitra clavator

Genus: *Zoopilus*

- Colonies are delicate and free-living
- The corallum is strongly domed
- Only one species in this genus *(Zoopilus echinatus)*



Genus: *Lythophyllon*

- Colonies are flat, attached and encrusting
- Consists of three species

Lithophyllon undalatum

Genus: *Podabacia*

- Colonies form explanate plates and attached
- Corallites are inclined towards the margins
- Consists of four species

Podabacia crustacean

Notes on the Family Siderastreidae

General Features

- Colonies are colonial, massive, or laminar
- Corallites are small, immersed and with numerous thickened septo-costae
- The septa are closely compacted and equally spaced
- The corallite walls are very poorly defined
- Only two genus is common in Indo-Pacific in total six genera

Genus: *Psammocora*

- The surface of the coral is smooth or granular
- Calices are closely packed and superficial, measuring about 1-2mm in diameter
- Septa are numerous and visible which may end in a wide, blunt monticule (thamnasterioid structure), giving a flower-like appearance (petaloid septa rather than terming them septo-costae)
- Corallite wall is absent or weak
- Consists of 12 species

P. suferficialis

P. profundacella

Benzoni et al. 2007

Genus: *Cosinaraea*

- Colonies are rough in surface structure
- Calices are crowded, have a shared rounded wall and are 2-7mm in diameter
- Septa are visible, granulated
- Columellae are papillose
- Species are often confused with those of *Psammocora*
- Consists of nine species

Cosinaraea columna

Benzoni et al. 2007

Notes on the Family Agariciidae

General Features

- Colonies are massive or laminar
- The corallites are usually highly modified and immersed with poorly defined walls formed by thickening of the septo-costae (thamnasterioid)
- Mainly gonochoric
- A total of six genera but five are common in Indo-Pacific

Genus: *Pavona*

- Colonies are foliaceous, encrusting, or massive
- Immersed calices are 2-3mm in diameter
- An important feature of this genus is the foliaceous species which are bifacial (corallites on both sides)
- Septa are visible with fine lines running from one calice center to the next (septo-costae)
- Intertentacular budding and consists of 15 species

Pavona cactus

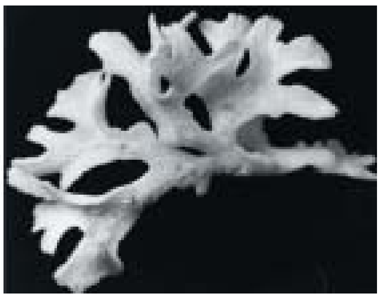
Pavona cactus

Pavona frondifera

Genus: *Leptoceris*

- Corallites are outwardly inclined (in some cases)
- Calices are usually present only on the upper surfaces
- Septo-costae are numerous, closely packed and unite adjacent corallites
- Columellae are weakly developed
- Nearly indistinguishable from *Pavona* but septa-costae of *Pavona* is finer than those in this genus
- Consists of 16 species

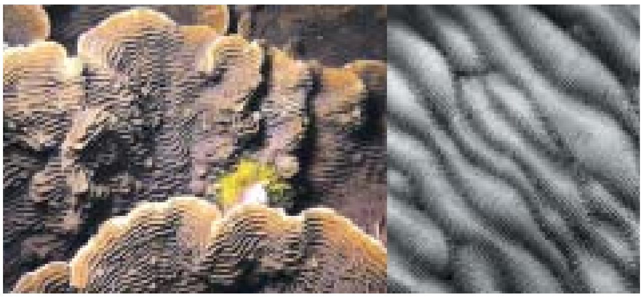
Leptoseris amitoriensis



Leptoseris papyracea

Genus: *Pachyseris*

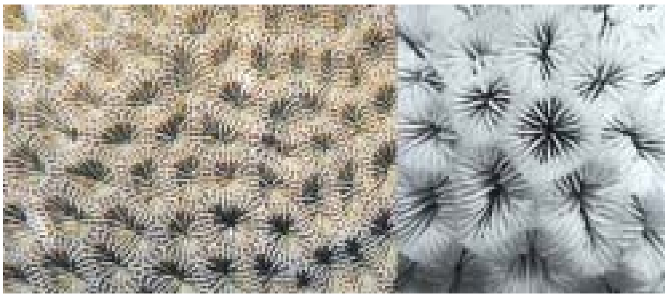
- Very easy to recognize
- Forms leafy, plate-like, encrusting, or massive colonies
- Upper surfaces are closely packed with ridges and valleys which are arranged in neat concentric rows
- Distances from mid-ridge to mid-ridge are usually 3mm and consists of five species



Pachyseris gemmae

Genus: *Coeloseris*

- Colonies are cerioid without columellae
- Septo-costae are joined at the top of the walls
- The top of the walls is rather flattened
- Superficially similar to *Goniastrea* (Faviidae)
- Only one species in this genus *(Coeloseris mayeri)*



Coeloseris mayeri

Genus: *Gardineroseris*

- Calices are polygonal, irregular
- Calices are closely packed with shared corallite walls that are prominent

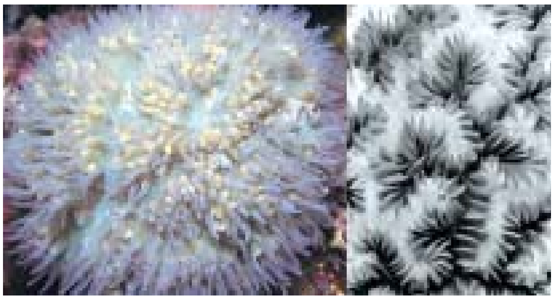
Notes on the Family Euphylliidae

General Features

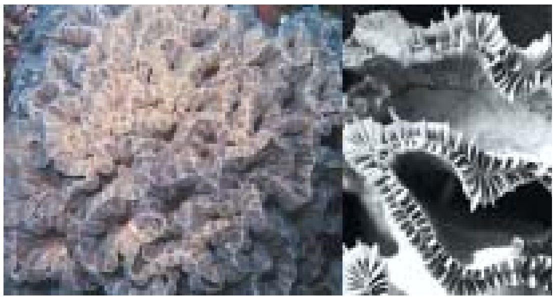
- Colonies are phaceloid, meandroid or flabello-meandroid with large, solid and widely spaced smooth septo-costae
- Corallite walls have a similar structure among genera and large fleshy tentacles are keys of genus identification
- Family was previously grouped in the family *Caryophyllida*e
- Members of the family are from genus *Euphyllia, Catalyphillia, Nemezophyllia, Plerogyra* and *physogyra*

Euphyllia sp

Catalyphyllia jardinei



Physogyra lichtensteini



Nemenzophyllia turbid

Plerogyra sp.

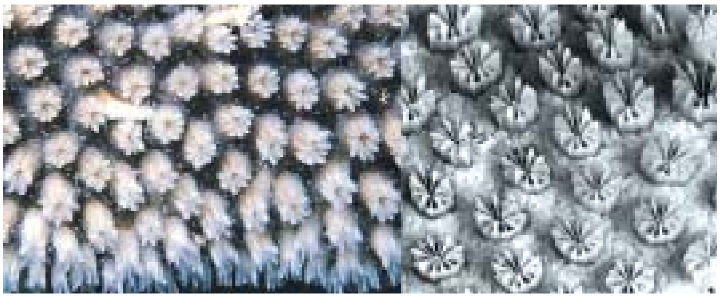
Notes on the Family Oculinidae

General Features

- This family is characterized by large upstanding calices
- In the Indo-Pacific, one zooxanthellate genus exists

Genus: *Galaxea*

- One of the easiest genera to recognize
- Corallites are distinct and rise at least 2mm and sometimes even 15mm above the coenosteum
- Corallite diameters may range from 1.5-8mm
- Septa are numerous, arranged in cycles, are strongly exserted, and protrude thin with sharp blades
- Septal margins are smooth, granular, or minutely dentate
- Coenosteum is free of septal structures
- Consists of seven species



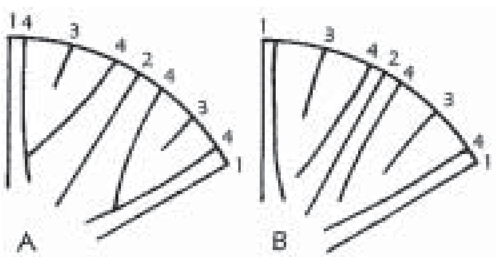
Galaxea astreata

Notes on the Family Dendrophyllidae

General Features

- Corallite walls are porous, usually composed of coenosteum
- Septa are fused in a distinctive pattern (Pourtalès plan), at least in immature corallites

Pourtalès plan

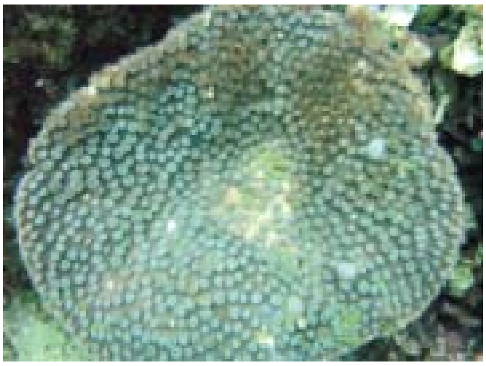


Wells (1956)

- Consists of zooxanthellate: four genera (azooxanthellate: 17 genera)

Genus: *Turbinaria*

- Colonies often form vase-shaped convolutions or spreading leaf-like fronds
- Corallites are round, immersed to tubular
- Porous wall surrounding the coesnosteum
- Consists of 11 species



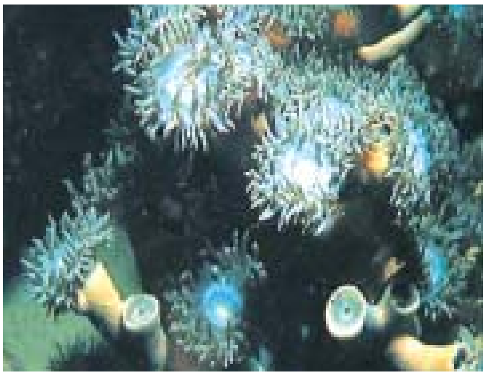
Genus: *Heteropsammia*

- Corals are free-living
- Commensal relationship with peanut worms
- Consists of three species

Heteropsammia cochlea

Genus: *Duncanopsammia*

- Colonies are composed of long tubular corallites
- Usually occurs in water over 20 metres deep
- Sole species in this genus: *Duncanopsammia axifuga*



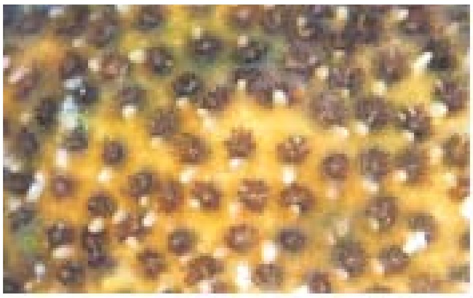
Notes on the Family Astrocoeniidae

General Features

- This family features style-like columellae and neatly arranged solid septa in 2-3 distinct cycles
- There are four genera
- Only one genera can be found in Indo-Pacific

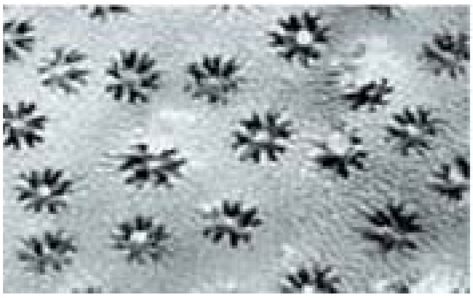
Genus: *Stylocoeniella*

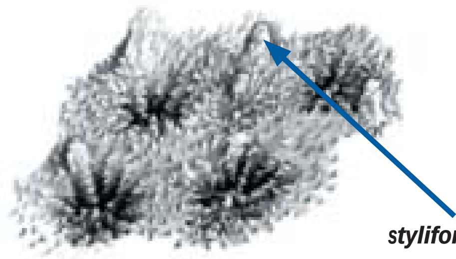
- Corallites are separated by coenosteum
- The upper outer edge of one of the primary septa of each corallite is raised and merges with the coenosteum to form a styliform pillar
- There are 12 septa arranged in two alternating cycles of six
- Consists of three species



S. amata

S. guentheri





Notes on the Family Pocilloporidae

General Features

- Colonies are generally ramose
- Corallites are plocoid to cerioid about 1-2mm across which arise from extratentacular budding
- Columellae: styliform (when present)
- Coenosteum is covered with spinules
- There are three genera in this family

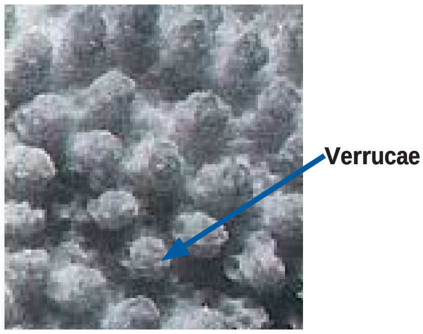
Genus: *Pocillopora*

- Corallites immersed on verrucae
- Colonies ranging from branching to submassive
- Septa reduced to rows of spines
- Columellae (if present) styliform
- Coenosteum covered with granules
- *Pocillopora damicornis* lacks true verrucae but with sub-branches resembling verrucae
- Consists of 17 species

Photos from Veron (2000)

P. meandrina

P. damicornis

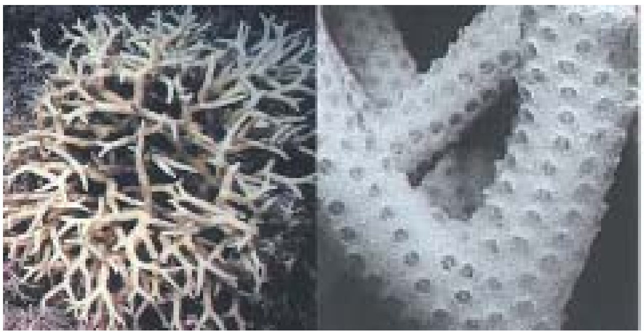


P. eydouxi

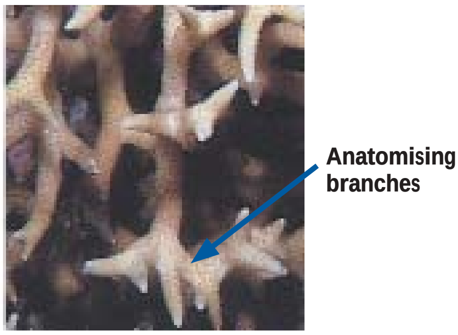
Genus: *Seriatopora*

- Colonies compact bushes with thin anatomising branches
- Corallites in neat rows along branches and may be slightly hooded
- Corallites are immersed and poorly developed internal structure
- Style-like columellae and coenosteum covered by fine spinules
- Consists of six species

Photos from Veron (2000)



Seriatopora hystix

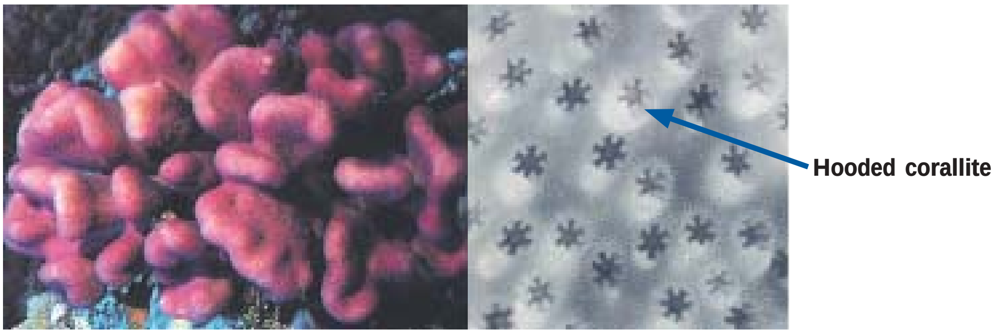


Seriatopora caliendrum

Genus: *Stylophora*

- Colonies are submassive and branching
- Branches short and seldom fused
- Corallites are immersed, conical and hooded
- Solid style-like columellae
- Coenosteum covered with fine spinules

Photos from Veron (2000)



Stylophora pistillata

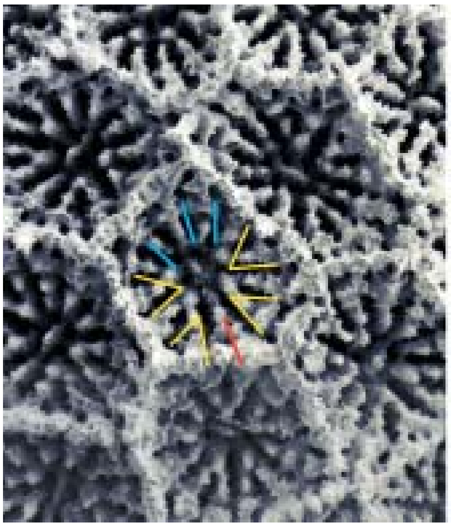
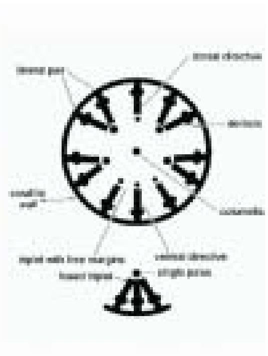
Notes on the Family Poritidae

General Features

- Growth form: massive/laminar/ramose
- Corallites are cerioid, small and compact
- Extratentacular budding
- Wall and septa are porous
- Coenosteum is poorly developed or absent
- There are six genera in this family
- Here only three major genera are shown because others are very rare

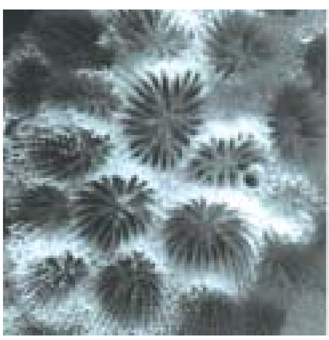
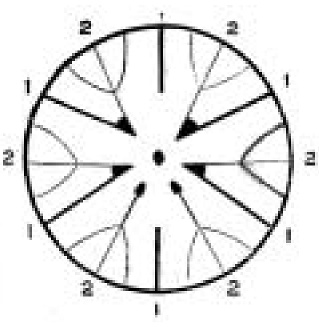
Genus: *Porites*

- Corallites are small (<2mm), immersed and filled with septa
- Coenosteum is poorly developed or absent

Genus: *Goniopora*

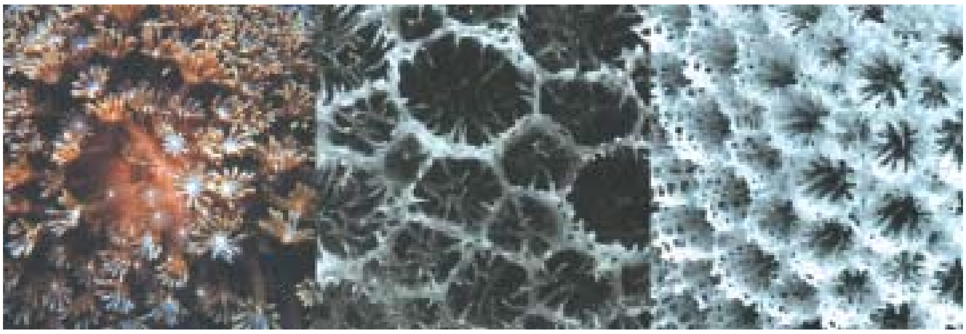
- Growth forms: massive, columnar, encrusting and branching
- Polyps are long, fleshy and 24 tentacles extended during day and night
- Septa with gonioporoid pattern
- Corallites ranging from 1.5 to 6mm in diameter and filled with compacted septa and columellae
- Corallites has thick but porous walls

Gonioporoid patterns of septa

Genus: *Alveopora*

- Polyps are large, fleshy and 12 tentacles extend during day and night
- Often the tentacles are with swollen knob-like tips
- Skeleton is extremely porous and light
- Septa is reduced to fine spines and may fuse at the deep centre to form tangle in the columellae
- Corallites ranging from 1.2-4.5 mm in diameter
- Corallite wall is lattice-like



8.5 Problems of Taxonomy of the Reef-building Corals

Identification of species

Species identification of corals is based on skeletal morphology. However, species identification is mostly subjective because species description lacks measurement of skeletal characters.

Showing many skeletal photos, the book *Scleractinia of Eastern Australia* published by Veron and others (1976-84) is one of the best publications on coral taxonomy. Books like this are no longer produced and are very difficult to come by.

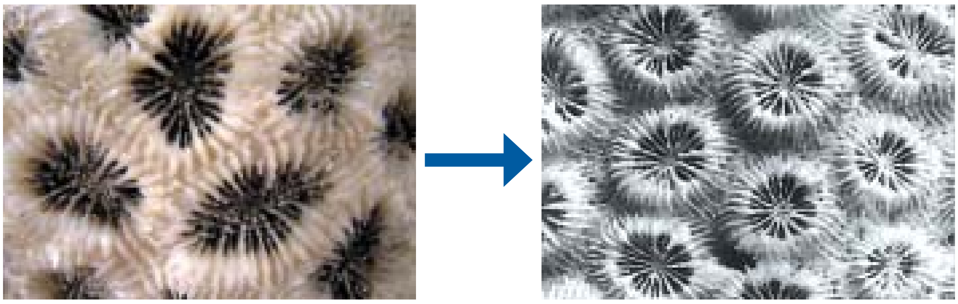
Recently, *Corals of the World* was published by Veron (2000). The three-volume set showed many pictures of the living specimens of almost all zooxanthellate coral species in the world. It is very useful in identifying specimens without looking at skeletons in many cases. However, several parts of this book do not observe and adhere to the rules of the International Code of Zoological Nomenclature (ICZN). For example, 100 new species were created in the book, but the new names were not indicated as being new.

According to ICZN, a new name published after 1999 is not made available unless it is explicitly indicated as being new. Therefore the book *Corals of the World* should be used and referred to with care.

Morphological variation and species boundaries

Type specimens are very important, but sometimes species which are recognized at present are different morphologically from their type specimens.

Type | **Veron (2000)**



Corallites are compact and not prominent | **Corallites are widely spaced and prominent**

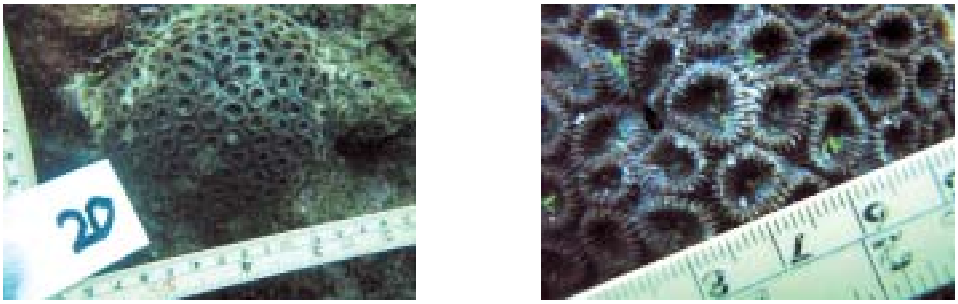
It is not easy to get information of type specimen because:

a) many types were lost during World War II
b) not many photos of them exist and explanations are short
c) many references are old and very difficult to obtain

8.6 Specimen Preparation Techniques for Identification

Step 1: Taking Photographs of Living Corals

Upon spotting a specimen, record the depth, time and type of environment (e.g. rocky, muddy, etc.) where the specimen is found. Take photo of the whole colony with a scale and tag. Then, take a close-up photo of the colony, together with a scale as shown in Figure 5.



a b

Figure 5. Photograph of the whole colony (a) and close-up of the colony (b)

If a photograph of a specimen is not taken in the field, take it upon returning to the laboratory. Immerse the specimen in water when taking photograph in the lab. It is best to avoid taking photos of the specimen on land because they look like different species as illustrated in Figure 6.

a b

Figure 6. Photograph of specimen from the same species taken on land (a) and underwater (b)

Step 2: Sample Collecting

After taking photographs, collect the sample with the aid of a hammer and chisel. Samples are best collected with minimum of 5cm in width and 5cm in height. But this is also very dependent on the size of the corallites. A sample collected must include several corallites for identification as shown in Figure 7.

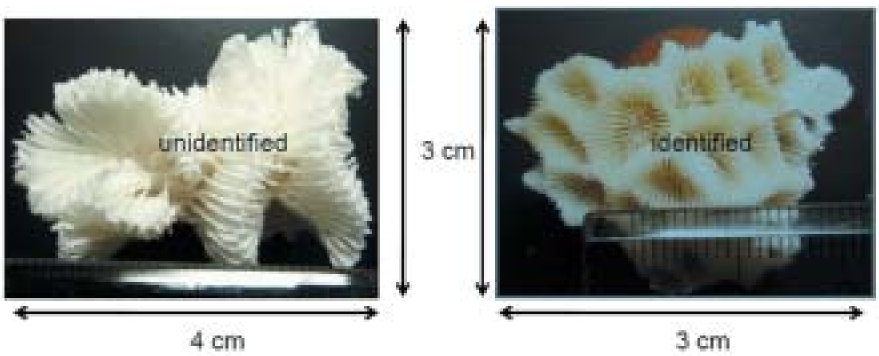


Figure 7. Collected samples of different sizes. It is important to include several corrallites within a sample to make correct identification. For *Acropora*, it is important to collect large enough size to determine the colony shape.

Step 3: Treatment of Samples Collected

Chip off a small piece of about 5 x 5 x 5mm of the sample for DNA analysis. Keep and immerse the small piece in either 99 per cent ethanol or Guanidine (CHAOS) solution. Bleach the whole specimen with domestic bleaching agent to remove all the tissues leaving only the skeletal, then wash the specimen with water and dry it. Figure 8 shows the overall process of treating the samples collected.

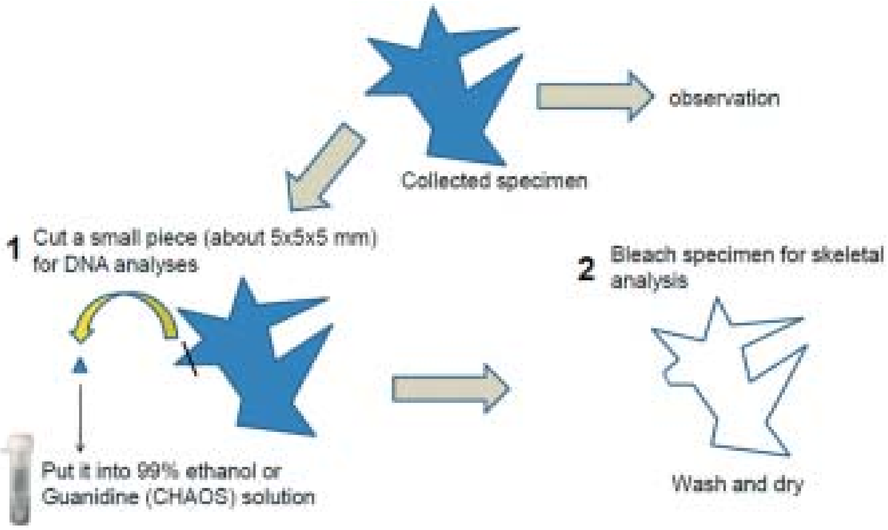


Figure 8. The process of treating samples collected

Step 4: DNA Extraction

If the DNA samples are preserved in 99 per cent ethanol solution, use the DNA extraction kit following procedures provided in the kit. Dry a small piece of coral inside draft for three to five hours before grinding them in a mortar and pestle. Place the grinded coral into a 1.5 ml microcentrifuge tube.

For samples preserved in CHAOS solution, apply phenol/choloroform extraction techniques before subjecting it to ethanol precipitation. Then, store the extracted DNA extracted in TE buffer under -20°C.

Step 5: Observation and Measurements of the Morphological Characters

Observe the colony shape and corallite structures (budding patterns, paliform lobes, septa, costae, callumellae). Then measure at least six mature corallites on several aspects, namely, corallites size, calices size, callumellae size and number of septa.

Step 6: Specimen Preparation for Scanning Electron Microscopy (SEM)

Cut the coral samples into small pieces. Immerse the coral samples in hypochlorite solution, clean with ultrasound, and rinse with distilled water before final drying.

For SEM method, dry and dehydrate the coral samples at 150°C for 24 hours. Then coat the samples with gold and examine with scanning electron microscopy.

8.7 Museum Collection, Management, Cataloging and Storing

An example of museum collection, management, cataloguing and storing of samples of coral is illustrated using the examples done at the Phuket Marine Biological Centre. Electronic cataloging must be done in line with manual cataloguing to safe guard data. Details can be found in the presentation slides in Appendix E.

APPENDICES

Appendix A

List of Participants

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Appendix B

Basic Taxonomy of Animals

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Some Good Textbooks on Invertebrate Zoology

– The Invertebrates (Bruska, Bruska and Haver) Sinauer Associates Inc; 2nd版 (2003/2/14) **ASIN:** 0878930973 ¥9,891

– Invertebrate Zoology (Ruppert, Fox and Barns) Academic Internet Publishers; 7th版 (2006/6/30) **ASIN:** 1428803610 ¥3,494

What is taxonomy?

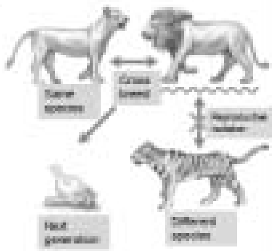
- Human naturally recognize some common future among different things, and try to separate them from others as a unique group.
- Such grouping based on common characteristics is "classification".
- Taxonomy is a subject of biology, classifying organisms and making taxonomic hierarchy system based on common biological (mostly morphological) characteristics.

3 stages in taxonomy

- There are 3 stages (α−, β−, γ−) in taxonomy.
- α-taxonomy is the most primitive stage; recognizing species, giving scientific name based on description. β or γ taxonomy cannot be done if α–taxonomy is not completed.
- β taxonomy is a stage to analyze phylogenetic relationship among taxa (species).
- γ taxonomy pursues to understand mechanism that allowed to produce the biodiversity recognized through α taxonomy.

Biological Species Concept

- The smallest unit in α taxonomy is "species".
- Biological species concept was proposed by A. Mayer as "species is a group of individuals that will realistically or potentially crossbreeds and reproductively isolated from other groups."
- Species can be established by biological criteria using above concept.



Sibling species・variety

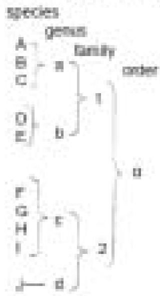
- In α taxonomy, morphology is the most important because recognized difference in morphology can be considered to have genetic background.
- However, there are two or more species that are reproductively isolated but morphologically identical. They are called sibling species.
- On the other hand, there are morphologically distinguishable but genetically identical species. They are called variety.

Limit of biological species concept

- Not applicable to the species without sexual reproduction.
- Not applicable to the extinct species.
- It is not realized whether or not there is reproductive isolation among populations isolated geographically.

Linnean Classification System

- Among many species, it is possible to classify them based on the common characters, and make a larger group step by step.
- Each rank of grouping is named taxonomic rank. Genus is higher than species, Family is higher than genus, order, class, phylum, kingdom so on.
- The each group of individuals at any rank is called taxon. Taxa is plural of taxon.
- This classification system is proposed by C. Linne.



Example of Linnean Classification System

Kingdom: Animalia
Phylum: Cnidaria
Class: Anthozoa
Order: Scleractinia
Family: Acroporidae
Genus: Acropora
Species: formosa

Freedom of higher taxonomic rank

- No biological criteria to define genus or higher taxonomic ranks.
- Taxonomists can make certain family consisting of some genera (β taxonomy) freely. It thus always is considered hypothesis.
- The hypothesis however is always under review whether or not that properly reflexes biological evolution.

Identification of species

- The first step you take after you collected a specimen is to find its species name referring Linnean classification system. This process is called identification.
- In the classification system, type specimen is pointed out for each species, its biological characteristics are described and published. After the steps, the species name becomes valid.
- If the specimen you have does not match to the existing classification system, you need to describe a new species and add the species name to the classification system.
- Such steps need to be continued until biodiversity will be fully described.

International Code of Zoological Nomenclature

- There is a strict rule to give a scientific name to a certain taxon.
- The rule is called "International Code of Zoological Nomenclature".
- The newest version (ver. 4) is published in January 1, 1999.
- Revision of this version is now under the way. For example, rules regarding electric publishing should be established.

Binominal name and binominal nomenclature

- The method to described species name is established by C. Linne when he published "Systema Naturae ver. 10" in January 1, 1758. He used "binominal name" in that publication.
- The method to make binominal name is called "binominal nomenclature system".
- Under binominal nomenclature system, each species has generic name (noun) and specific name (adjective).
- For example, binominal name of current human is *Homo sapiens* , which means intelligent human.

Binominal Nomenclature

- For example, the scientific name of common octopus is written as *Octopus vulgaris* Cuvier, 1797
- Both generic and specific names should be italicized. The first character of generic name must be capital letter.
- After binominal name, author name and year of nomination are added.
- Author means those who wrote a paper that first gave scientific name to the species.
- Year of nomination means the year when the paper is printed.
- If author name and year are in parentheses, the scientific name is not the same to the original.

Priority

- If one species has two scientific names, the name published earlier is considered valid. The latter species name is treated as "synonym".
- If two species have the same scientific name (homonym), the species described earlier holds the original name, and the other will be given a new species name.

arbitrage

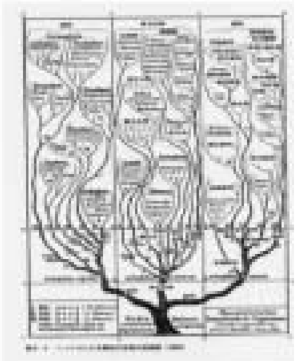
- If one species has two names, but the older name never used for more than 50 years, the name will be declared invalid, and the younger name will be used as valid name.

Phylogenetic Tree

- If evolutional theory is correct, the variety of organisms we see now must have a single origin.
- Phylogenetic tree or dendrogram is to show such evolutional history.

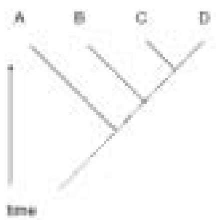
Heckel's tree

- E. Heckel invented the phylogenetic tree.
- His idea is that from the origin of organisms, three major groups (plant, animal and protozoa) first emerged.



The meaning of phylogenetic tree

- Taxa is arranged horizontally, and time is vertically.
- Upper area is close to now, lower area is the past.
- The lines mean evolutional relationships. If the branch is closer to now, the relationship is tighter.
- If all descendants from one origin is recognized as a taxon, it is called "clade". If a taxon does not cover all descendants, it is called "grade".



Three methods to make phylogenetic trees

- In conventional way, i.e. "evolutional taxonomy", sharing of characters that are considered to reflect evolutional history are considered important.
- In numerical taxonomy proposed by Sokal, weighing is not given to any characters, and phylogenetic tree will be constructed by multivariate analysis.
- Both have some defects.

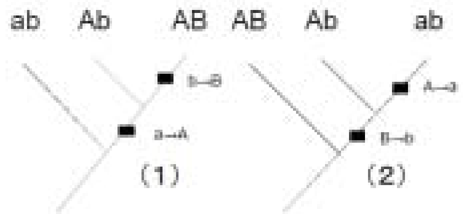
Cladistics

- The third, and highly evaluated system is called "cladistics".
- If two characters have the same origin, one character must have evolved from the other.
- The newly evolved character is called "apomorphic character", whereas the original character state is called "plesiomorphic character"
- In the cladistics, only commonness of apomorphic character (synapomorphy) is considered as a reason to recognize kinship of two taxa (sister group).

Justification of cladistics

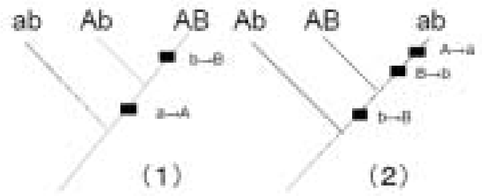
(1) Based on synapomorphic characters

(2) Based on synplesiomorphic characters



the principle of parsimony

（1） Based on synapomorphic characters (2 steps)
（2） Potential other phylogenetic tree (3 steps)



This concept is used in the molecular phylogeny.

Out group

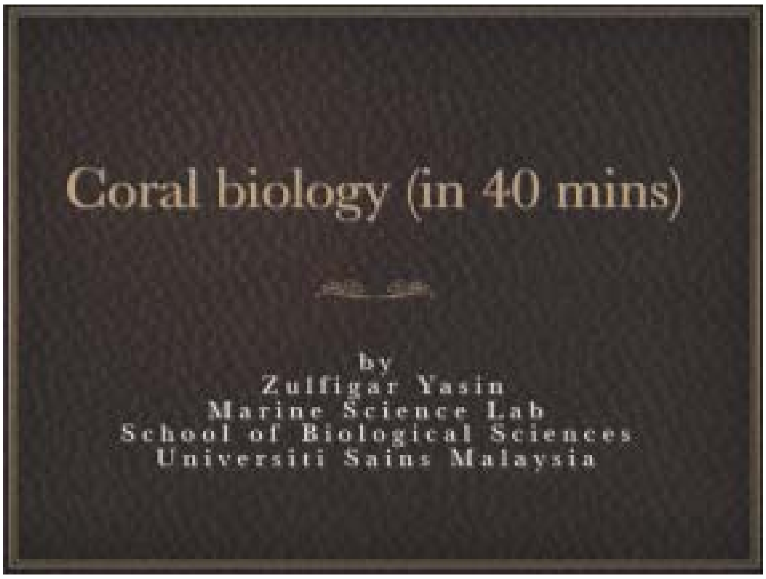
- If you cannot identify which is plesiomorphic, out group comparison is useful.
- A taxon outside your analysis has one of two character state, that is considered plesiomorphic.

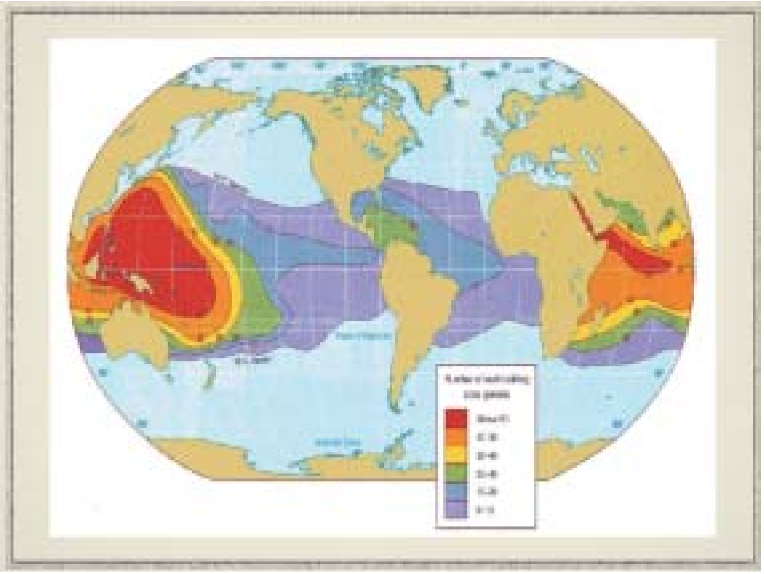
Practice

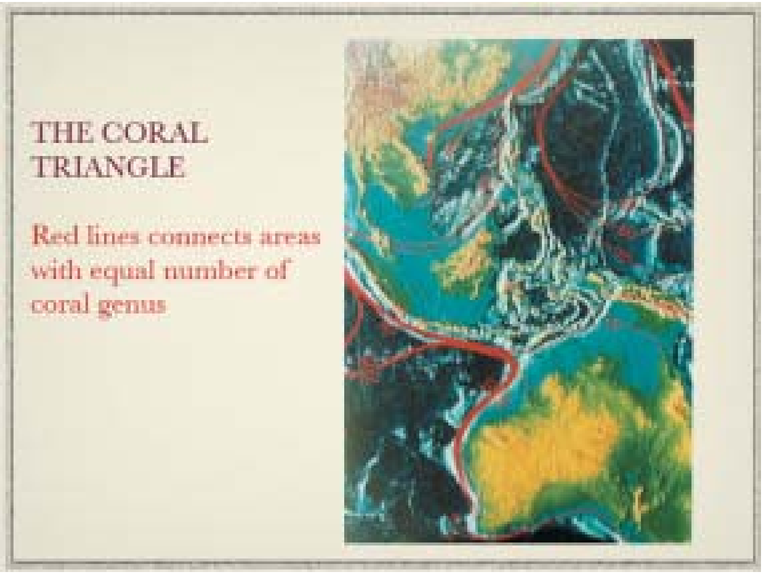
Make a phylogenetic tree based on the information below.

	Characters			
Species	A	B	C	D
W	2	2	2	2
X	1	1	1	2
Y	1	2	1	2
Z	1	2	2	2
Out group	1	1	1	1

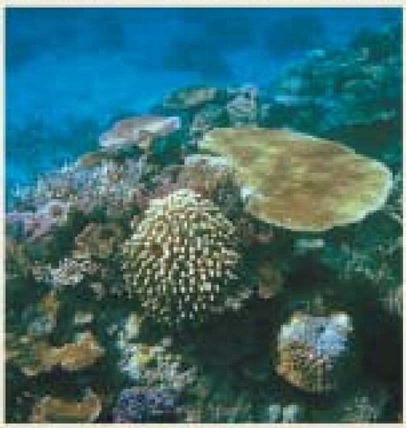
Appendix C


Coral biology (in 40 mins)
by
Zulfigar Yasin
Marine Science Lab
School of Biological Sciences
Universiti Sains Malaysia

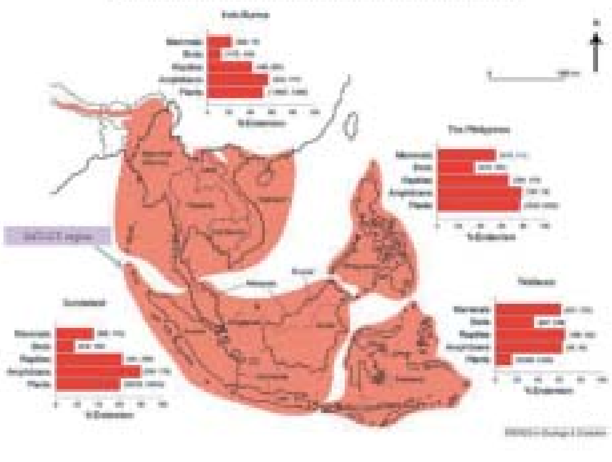


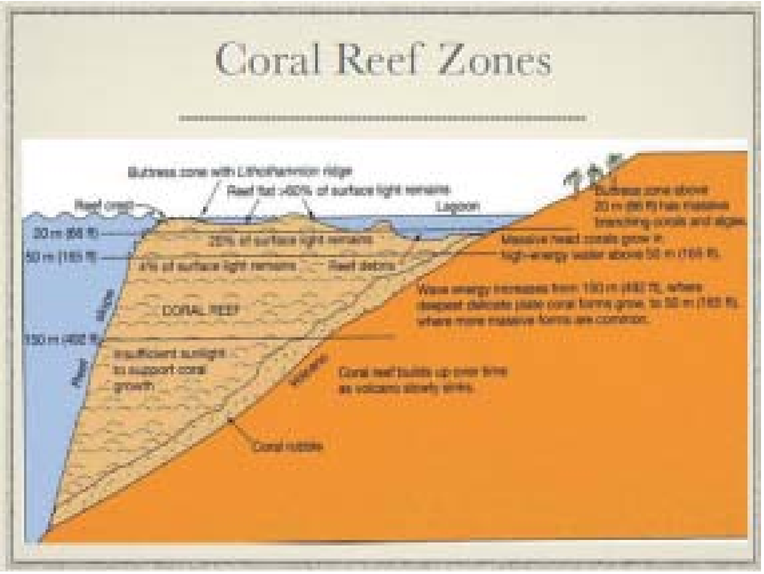

THE CORAL TRIANGLE
Red lines connects areas with equal number of coral genus

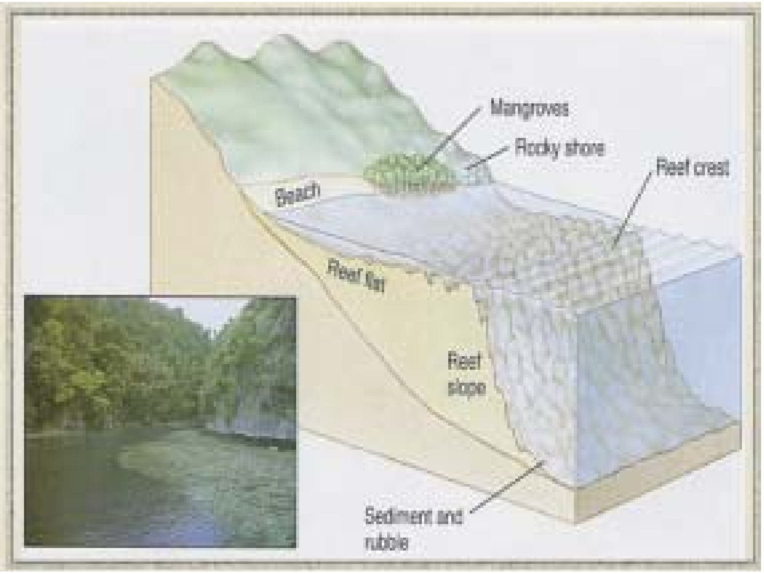
Hard (stone) coral diversity

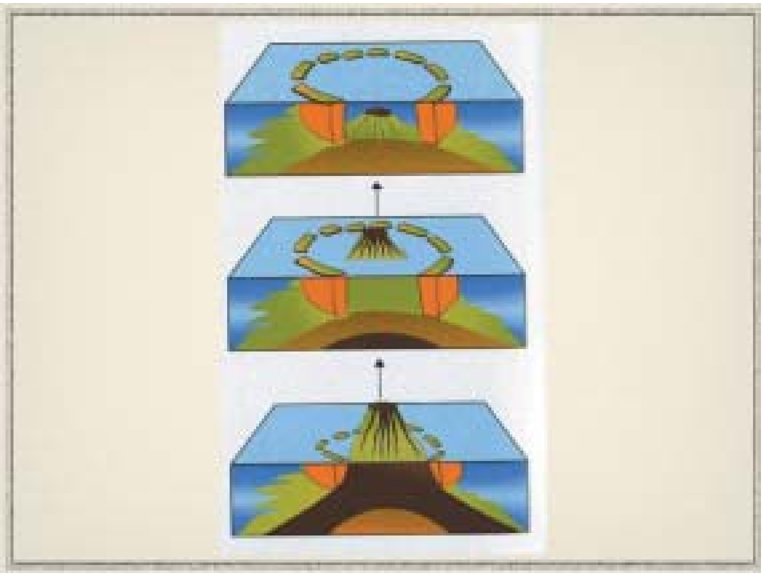


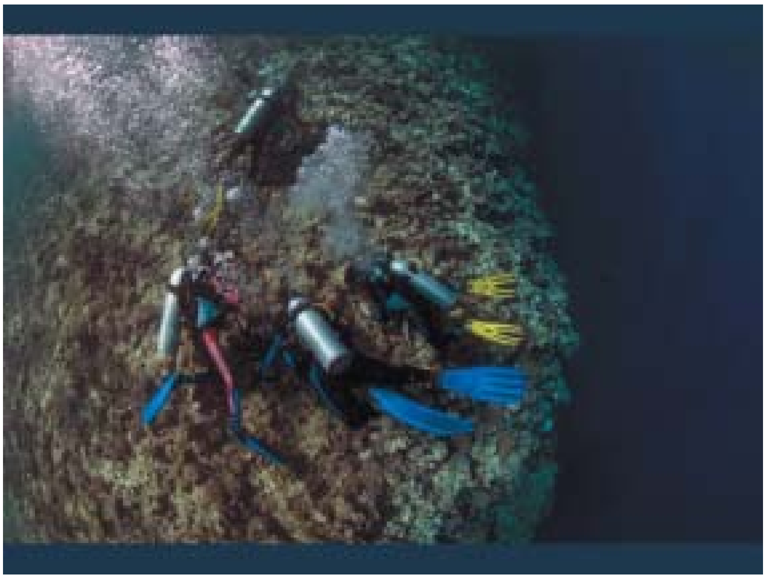
The four 'biodiversity hotspots' in Southeast Asia

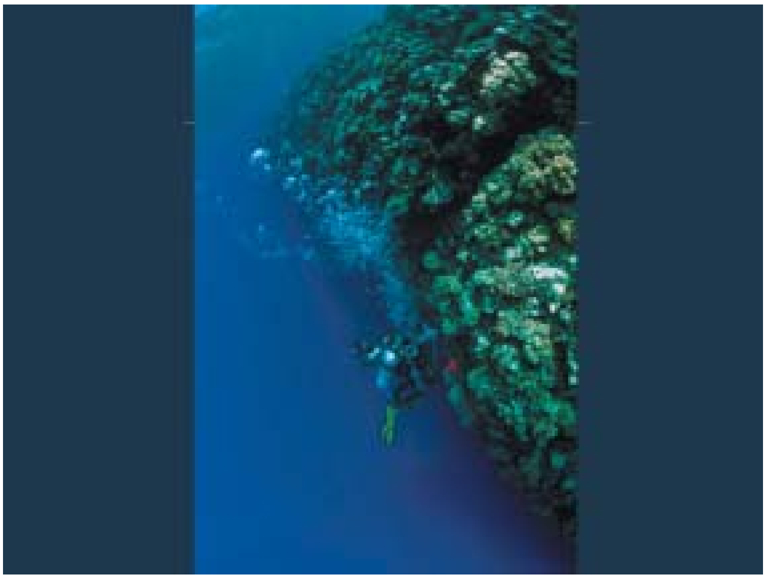


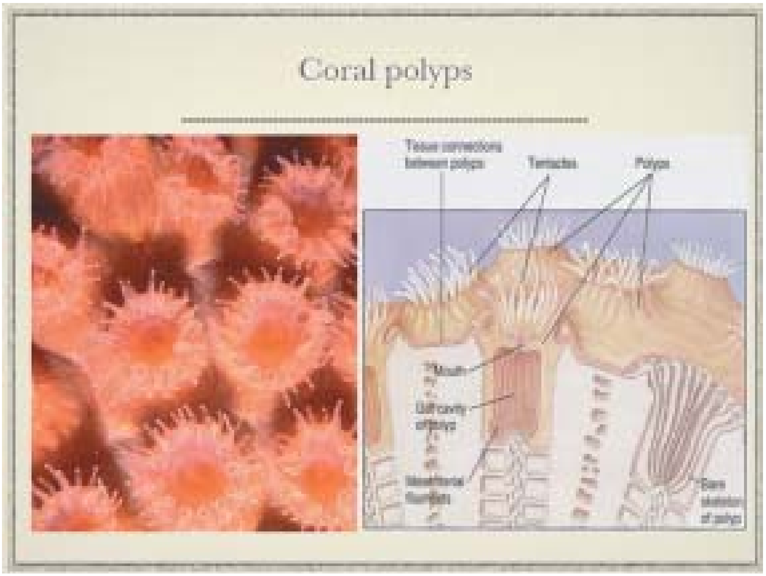

Coral Reef Zones
Lagoon
CORAL REEF
Coral rubble


Mangroves
Rocky shore
Reef crest
Beach
Reef flat
Reef slope
Sediment and rubble

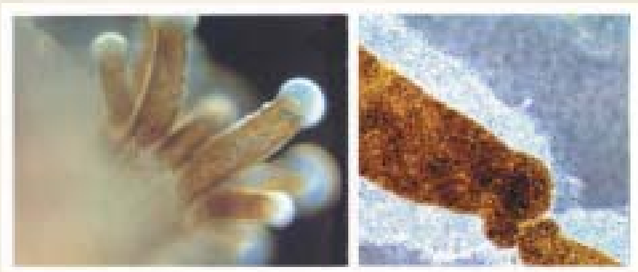


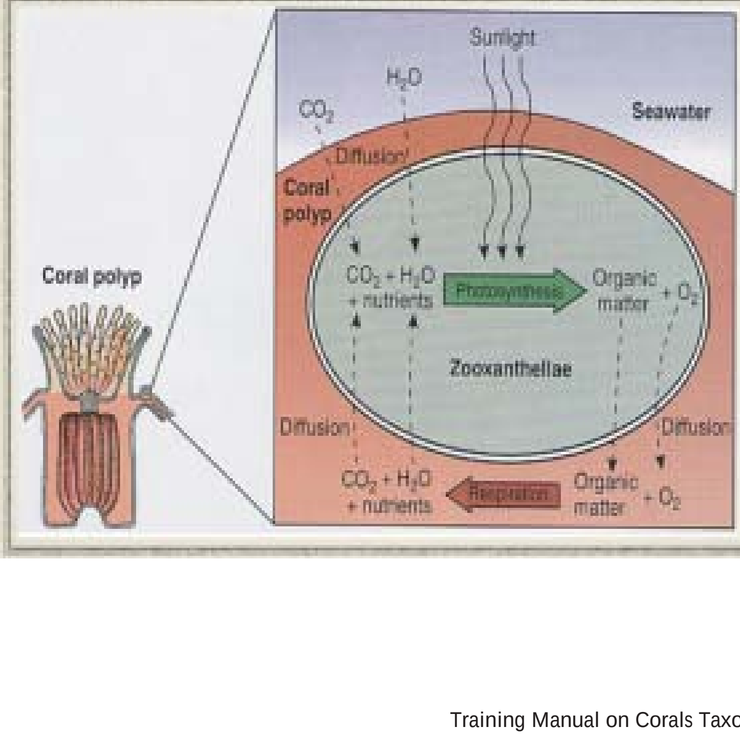





Coral polyps
Tissue connections between polyps
Tentacles
Polyps
Mouth


Coral nutrition on the reef
Coral nutrition
1. Direct feeding by the polyp
2. Zooxanthellae-coral symbiosis
3. Nutrient absorbtion



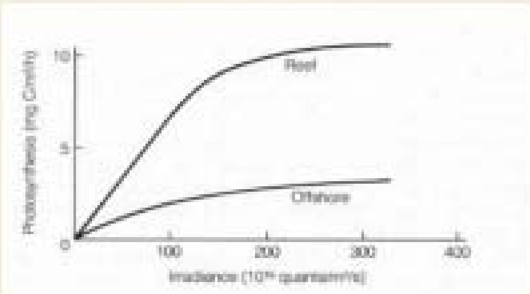

Sunlight
H_2O
CO_2
Seawater
Diffusion
Coral polyp
Coral polyp
$CO_2 + H_2O$ + nutrients
Photosynthesis
Organic matter + O_2
Zooxanthellae
Diffusion
Diffusion
$CO_2 + H_2O$ + nutrients
Respiration
Organic matter + O_2

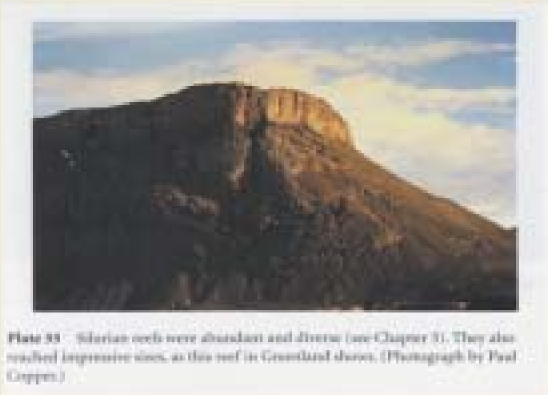
Primary productivity of the reef

Primary producers:

- 1. Zooxanthellae
- 2. Calcareous green and red algae
- 3. Algal fuzz
- 4. Phytoplankton

Productivity on and off the reef

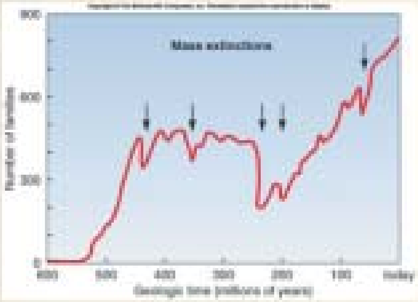




EXTINCTIONS AND GEOLOGICAL TIME

HISTORY OF LIFE

Families with mineralized hard parts through time



- Overall trend has been increase in diversity and abundance with time
- But have had major setbacks and reorganizations
- Have times at which up to 50% have died off
- To understand this have to look at the species level

SPECIES AND THE FOSSIL RECORD

Mass Extinctions

- Species subject to many environmental changes. Some survive others die out. Most species extinct. Only 0.1% around today.
- Each species is non recurring. Extinctions clear out living space for the surviving or new organisms.
- Constant elimination of the old and refilling of space by the new creates the incredible variety of life today.
- Background extinctions occur at a moderate rate. Mass extinctions fast but relatively uncommon.
- Following a mass extinction the Earth take on a completely different appearance as the survivors are joined by new species.

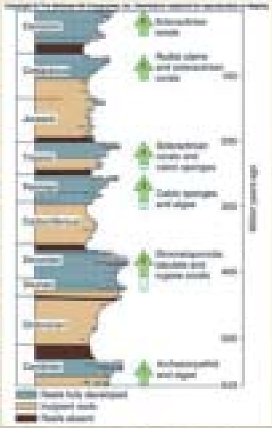
SPECIES AND THE FOSSIL RECORD

THE TROPICAL REEF EXAMPLE

Extinctions of the tropical reefs

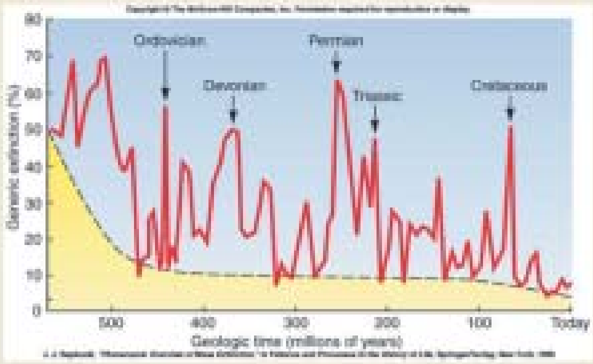
- A tropical coral reef.
- Today built by scleractinian (stony or hard) corals along with framework building.
- Created shelters where numerous other species survive.
- Fossil record shows how much these have changed through time.

SPECIES AND THE FOSSIL RECORD
THE TROPICAL REEF EXAMPLE
Geological column and reef building organisms



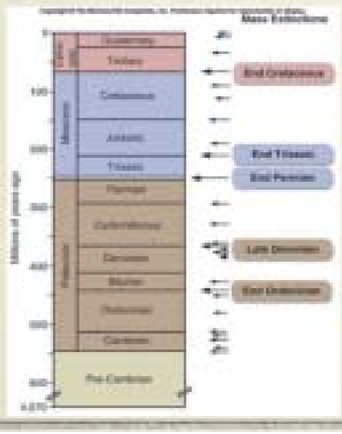
- Six major successions of reef building organisms.
- After each mass extinction of the entire reef, there was along period before other creature could fill the environmental void.
- Species are different in each reef phase.

MASS EXTINCTIONS: PHANEROZOIC
EXTINCTION PATTERNS
Marine invertebrates and protozoans versus time....



* Excursion correlate with divisions in geological time scale

MASS EXTINCTIONS: PHANEROZOIC
EXTINCTION PATTERNS
Geological time scale showing the mass extinctions



- Size of arrow indicates magnitude of extinction.
- Note how the largest ones correlate with the divisions in the geological time scale.
- Statistical analysis shows that every 100 million years have event that removes 65% of the species. Every 10 million years have an event that removes 30% of the species.

POSSIBLE CAUSES OF MASS EXTINCTIONS

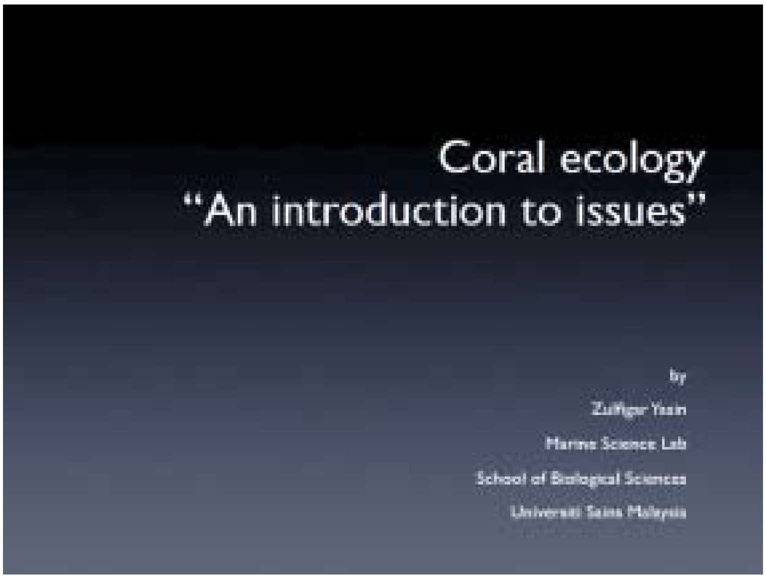
OVERVIEW

- Plate tectonics and Sea level changes
- Volcanic
- Climate change
- Extra terrestrial (Bolites)
- Biological
- Multiple causes (combination of the above)

RESEARCH ON THE SEAS AND ISLANDS OF MALAYSIA

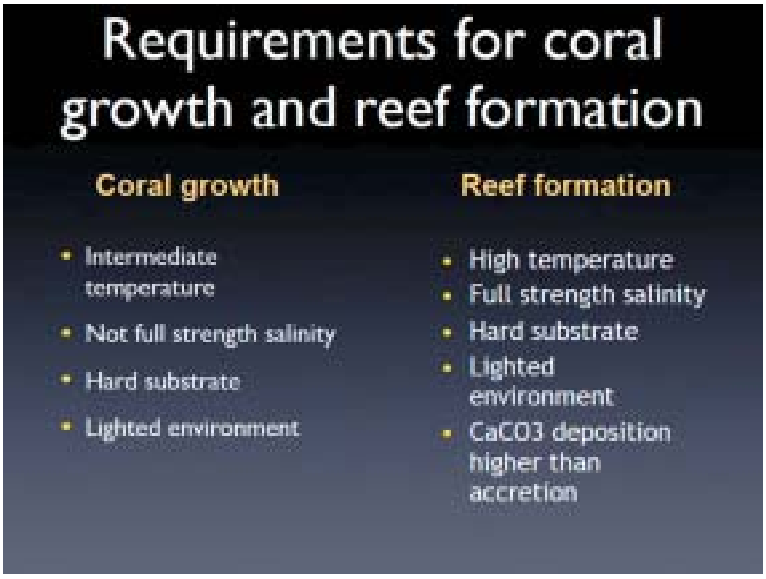
ROSES

Appendix D

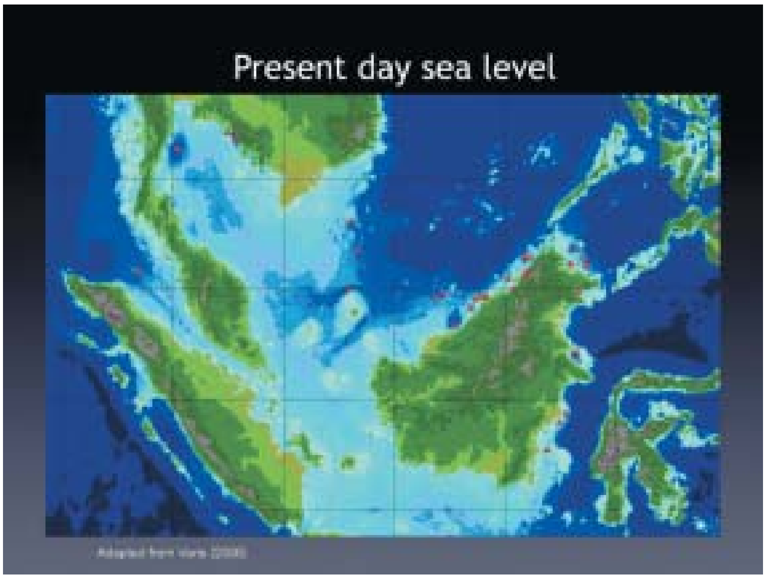


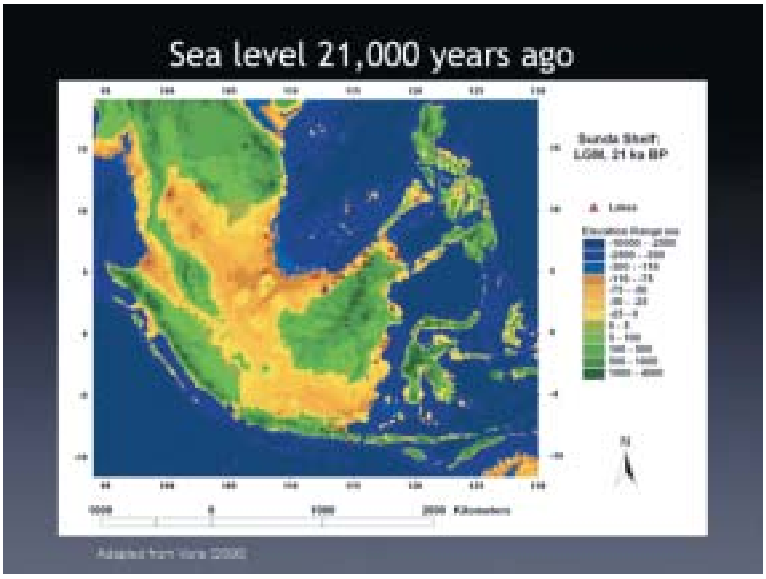
Coral ecology
"An introduction to issues"
by
Zulfigar Yasin
Marine Science Lab
School of Biological Sciences
Universiti Sains Malaysia

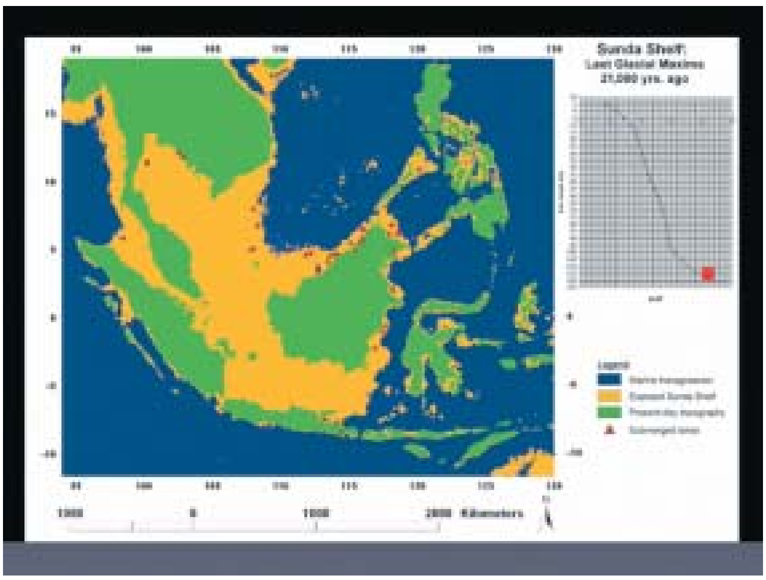
Please note:
Coral growth ≠ Reef growth



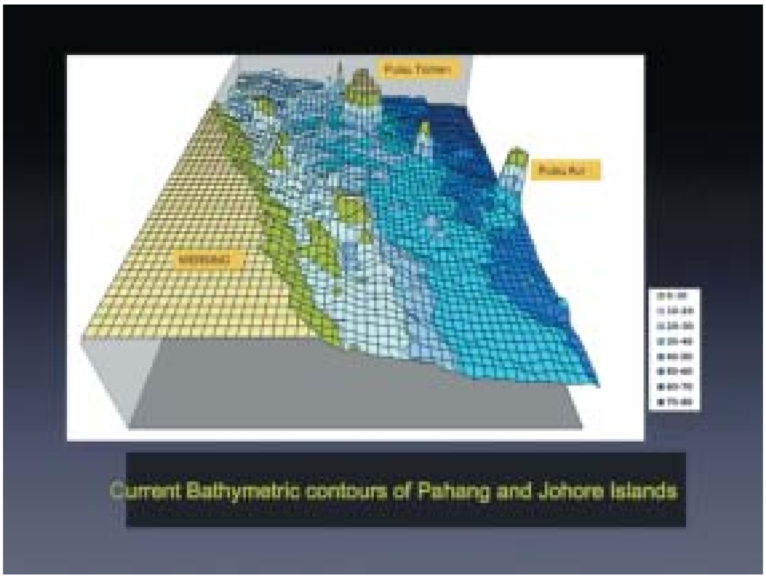
Requirements for coral growth and reef formation
Coral growth
Intermediate temperature
Not full strength salinity
Hard substrate
Lighted environment
Reef formation
High temperature
Full strength salinity
Hard substrate
Lighted environment
CaCO3 deposition higher than accretion

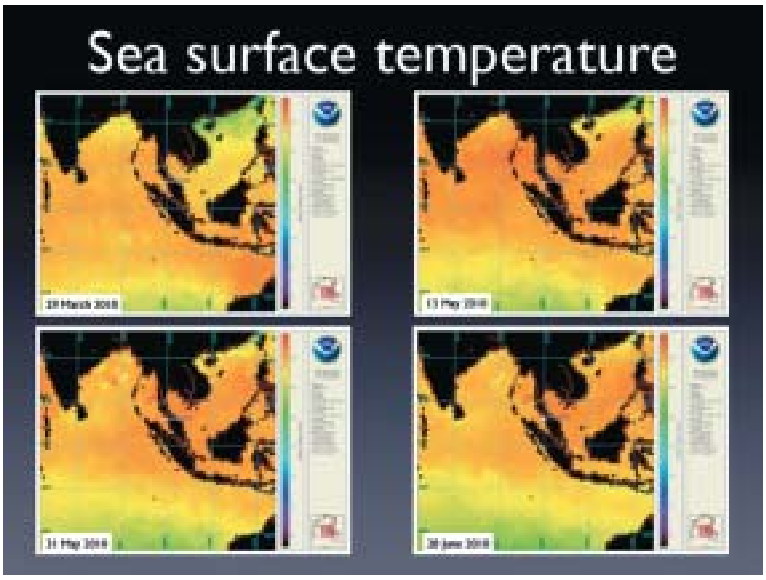

Present day sea level

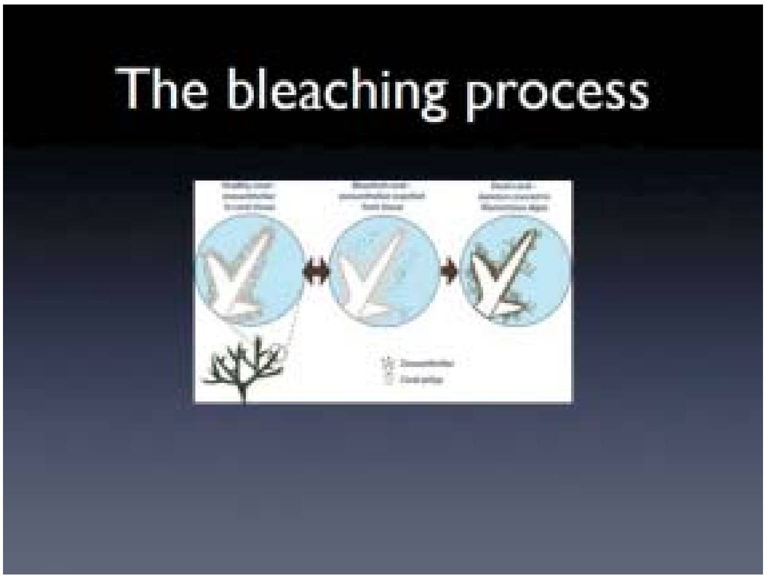

Sea level 21,000 years ago
Sunda Shelf:
LGM, 21 ka BP
Kilometers


Sunda Shelf:
Kilometers


The Pahang and Johore Islands


Current Bathymetric contours of Pahang and Johore Islands

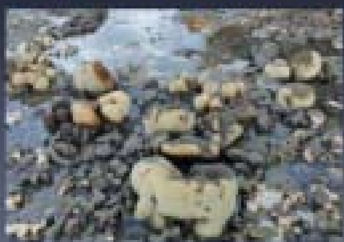

Sea surface temperature

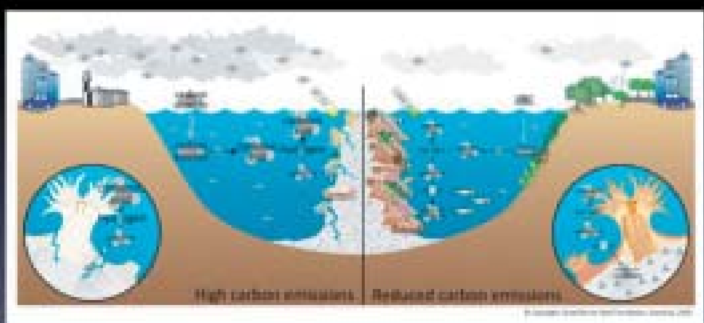

The bleaching process

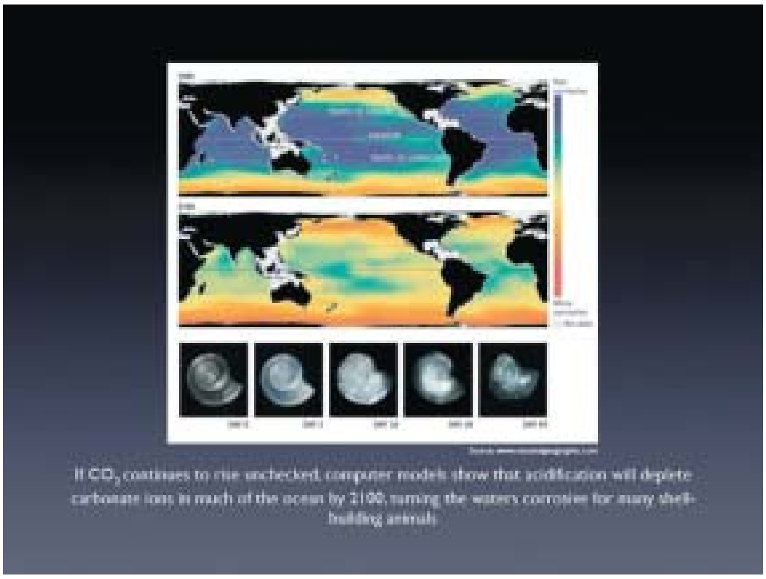

Healthy reef

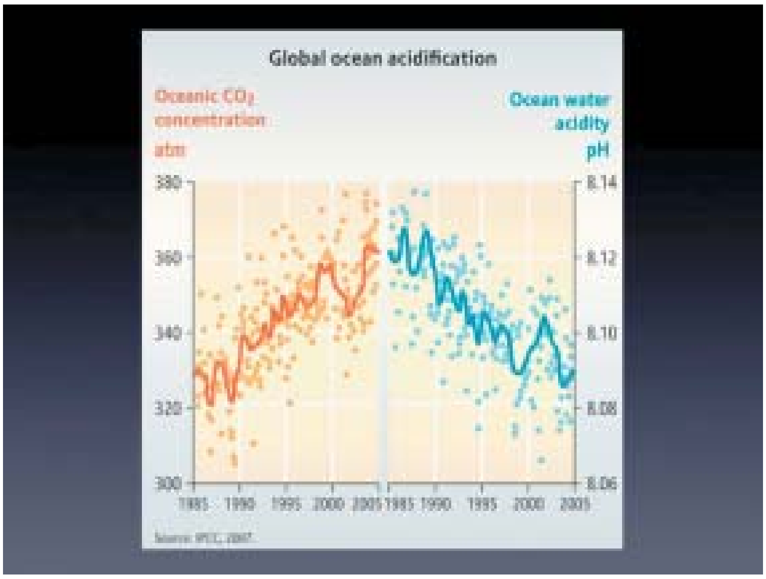
How sedimentation damage corals

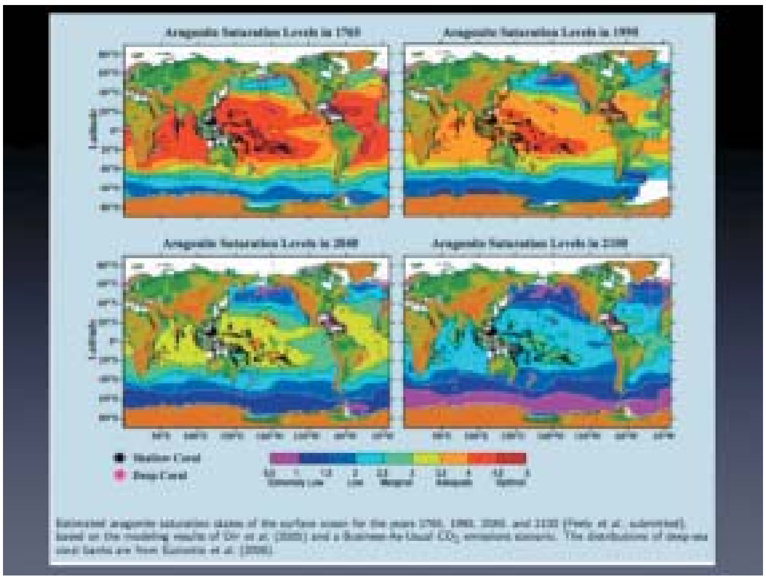
- Reducing light levels
- Smoldering of corals
- Intrinsic toxicity of sediment materials

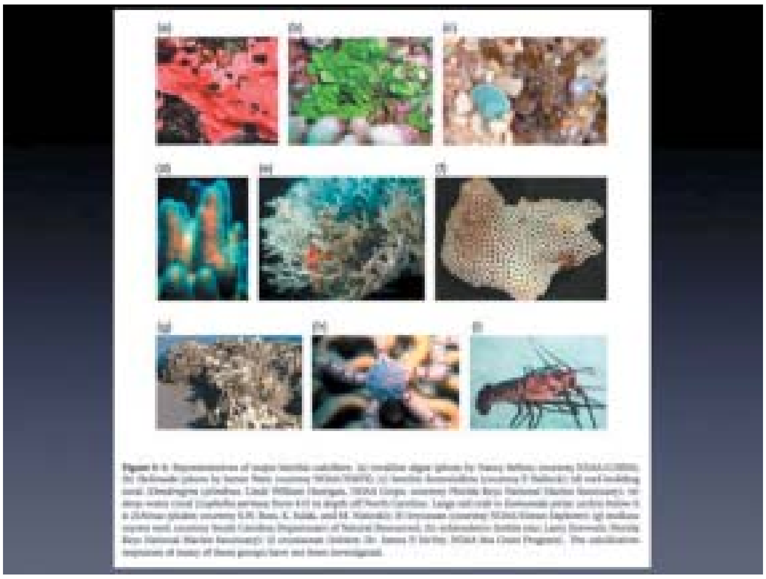




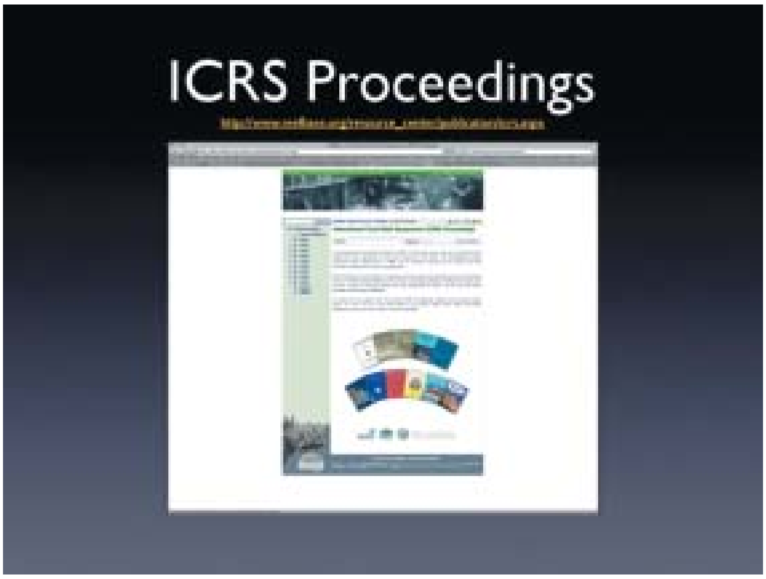

If CO_2 continues to rise unchecked, computer models show that acidification will deplete carbonate ions in much of the ocean by 2100, turning the waters corrosive for many shell-building animals


Global ocean acidification
Oceanic CO_2 concentration
atm
Ocean water acidity
pH
380
360
340
320
300
8.14
8.12
8.10
8.08
8.06
1985 1990 1995 2000 2005
1985 1990 1995 2000 2005
Source: IPCC, 2007.






7th Alexander von Humboldt International Conference


ICRS Proceedings


Reef Watch


ReefBase


Thank you

Appendix E

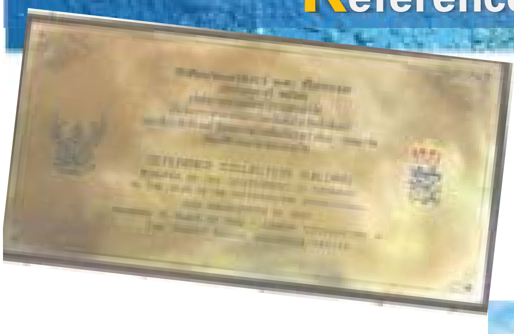

The PMBC Reference Collection:
Collection Management and Database
Charatsee Aungtonya
Phuket Marine Biological Center (PMBC)
Department of Marine and Coastal Resources (DMCR)
Ministry of Natural Resources and Environment
THAILAND
http://www.pmbc.go.th/pmbc_rc/


the 5th Thai-Danish Expedition in the Andaman Sea,
south-western Thailand in 1966
Thailand
Phuket
Sampling stations


Established since 11 October 1968 under a bilateral agreement between the governments of Thailand and Denmark after the 5th Thai-Danish Expedition in the Andaman Sea

PMBC was officially declared operational in April 1971. A reference collection was included in the PMBC activities from the beginning.

Reference Collection



The RC building donated by the Danish Government on the occasion of the Rattanokosin Bicentennial in 1983

Mission

- To carry out taxonomic research.
- To maintain various groups of marine flora and fauna in Thai waters.
- To facilitate visiting researchers in examination of identify their materials.
- To support education and raise public awareness of the need for conservation and the sustainable use of resources by encouraging public participation and network.

Reference Collection-Taxonomic Study

Dr. Somchai Bussarawit: fish, sea snake, cephalochordate, crustacean, echinoderm, mollusc (oyster), brachiopod

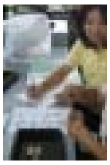
Dr. Charatsee Aungtonya: polychaetes

Ms. Wanida Onkaew: jelly fish

Mr. Rueangrit Promdam: crab

PMBC & DMCR–Biodiversity Research

Cnidaria: Anthozoa (hard coral)...........: Mr. Niphon Phongsuwan
Mollusca: Bivalvia....................................: Ms. Vararin Vongpanich
Mollusca: Cephalopoda...........................: Dr. Anuwat Nateewathana
Chordata (fish)...: Mr. Ukkrit Satapoomin
Chordata (sea turtle).............................: Mr. Supot Chantrapornsyl
Chordata: Cetacea (dolphin)..............: Ms. Kanjana Adulyanukosol
Chordata: Cetacea (whale).................: Dr. Kongkait Kittiwathanawong
Zooplankton..: Dr. Suree Satapoomin
Phytoplankton..: Ms. Jiraporn Charoenrattanaporn



Reference Collection-Taxonomic Network in Thailand

Prince of Songkla University, Songkhla
Algae & sea grasses.....................................: Assist. Prof. Dr. Anchana Prathep
Crustracea: Amphipoda................................: Ms. Koraon Wongkamhaeng
Curstacean: Tanaidacea.................................: Prof. Dr. Saowapa Angsupanich
Mollusca: Cephalopoda.................................: Dr. Jaruwat Nabhitabhata
Chordata (sea snakes).................................: Dr. Sansareeya Wangkulangkul

Phuket Rajabhat University, Phuket
Cnidaria: Anthozoa (soft coral)....................: Mr. Thanongsak Chanmethakul

Chulalongkorn university, Bangkok
Chordata: Cephalochordata (tunicate).........: Assist. Prof. Dr. Suchana Chavanich

Kasetsart University, Bangkok
Mollusca: Gastropoda..................................: Dr. Teerapong Duangdee

Burapha University, Chonburi
Echinodermata & Porifera (sponges)...........: Dr. Sumaitt Putchakarn

Walailak University, Nakhon Si Thammarat
Porifera (sponges)...: Dr. Udomsak Darumas

Reference Collection-Taxonomic Network in abroad

University of Aarhus, Denmark
Foraminifera..: Assoc. Prof. Dr. Tomas Cedhagen
Mollusca: Bivalvia; Sipuncula..........................: retirement Prof. Jørgen Hylleberg

Zoological Museum, University of Copenhagen, Denmark
Foraminifera; Mollusca: Cephalopoda;
Porifera (sponges).....................................: Assoc. Prof. Dr. Ole Secher Tendal
Annelida (Polychaeta).......................................: Assoc. Prof. Dr. Danny Eibye-Jacobsen

National University of Singapore, Republic of Singapore
Crustracea (crab)..: Assoc. Prof. Dr. Peter K.L. Ng

Australian Museum, Australia
Curstacean: Amphipoda....................................: Dr. Jim Lowry

Museum of Tropical Queensland, Australia
Curstacean: Isopoda...: Dr. Niel L. Bruce

Prince Hitachi (Japan)
visited PMBC Reference Collection in 1988

H.R.H. Princess Maha Chakree Sirinthorn
visited PMBC Reference Collection in 1988

Collections

1. Type Materials Collection
2. Marine Invertebrates Collection
3. Marine Invertebrates Collection: Cnidarians Collection
4. Marine Vertebrates Collection
5. Unsorted Specimens Collection

Type Materials Collection

- 412 records
- Including 209 new species (Holotype/ Allotype/ Paratype) from Thai waters (the Andaman Sea & the Gulf of Thailand)
- Protozoa (Granuloreticulosa), Annelida (Polychaeta), Arthropoda (Chelicerata & Crustacea), Chordata (Pisces), Echinodermata, Entoprocta, Mollusca (Bivalvia, Cephalopoda, and Gastropoda), and Platyhelminthes (Turbellaria)

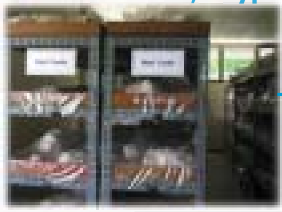
Marine Invertebrates Collection

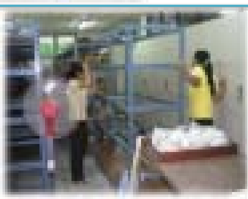
- Protozoa (Foraminifera & Myzozoa)
- Chromista (Ochrophyta: Subphylum Diatomeae & Phaeistia)
- Plantae (Bacillariophyta, Chlorophyta, Cyanophyta, Phaeophyta, & Rhodophyta (Algae) and Tracheophyta (sea grasses)
- Animalia (Annelida: Polychaeta; Arthropoda (Chelicerata and Crustracea), Brachiopoda (lamp- shells), Bryozoa, Echinodermata, Mollusca, Nemertea (ribbon- or proboscis-worms), Platyhelminthes, Porifera (sponges), Sipuncula and Prochrodates, i.e., Cephalochordata, Hemichordata, and Urochordata

Marine Invertebrates Collection

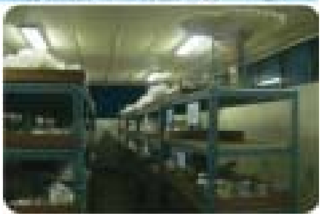
Marine Invertebrates Collection: Cnidarians Collection

Anthozoa, Scyphozoa, Hydrozoa, and Cubozoa





Marine Invertebrates Collection: Cnidarians Collection



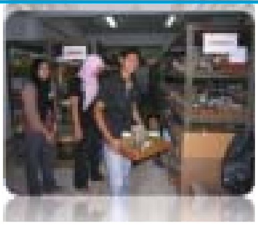
Marine Vertebrates Collection

Agnatha, Chondrichthyes, Osteichthyes, Testudines (sea turtle), Squamata (sea snake) and Cetacea (dolphin & whale)

Remarks: Cetacean (dolphin & whale) have been registered and catalogued at the PMBC Reference Collection, but they are deposited at PMBC Marine Endanger Species Museum.

Marine Vertebrates Collection

Unsorted Specimens Collection

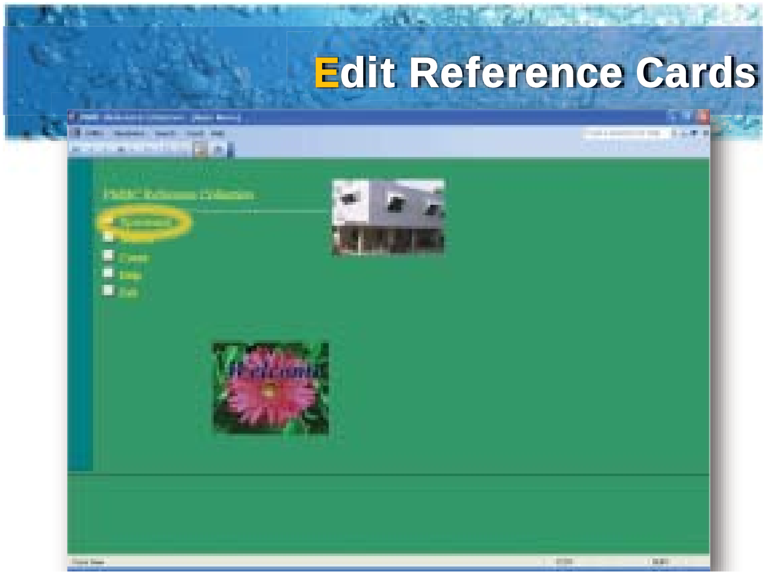


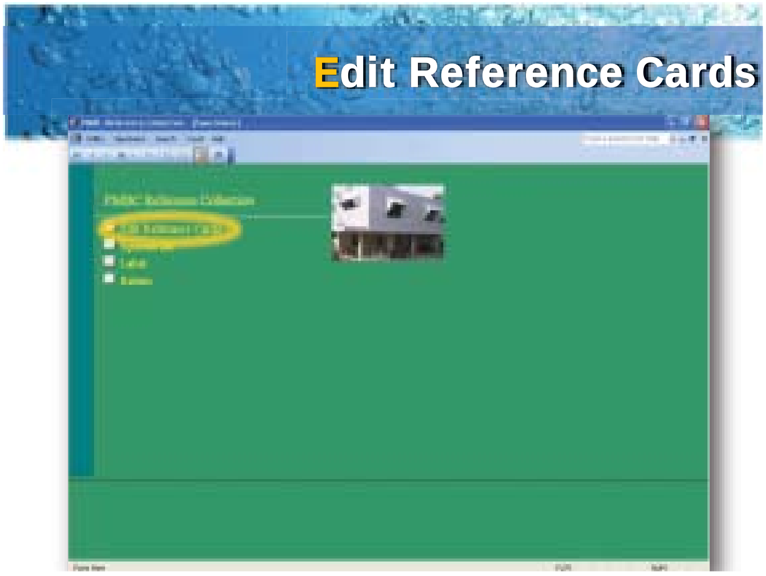
Unsorted Specimens Collection

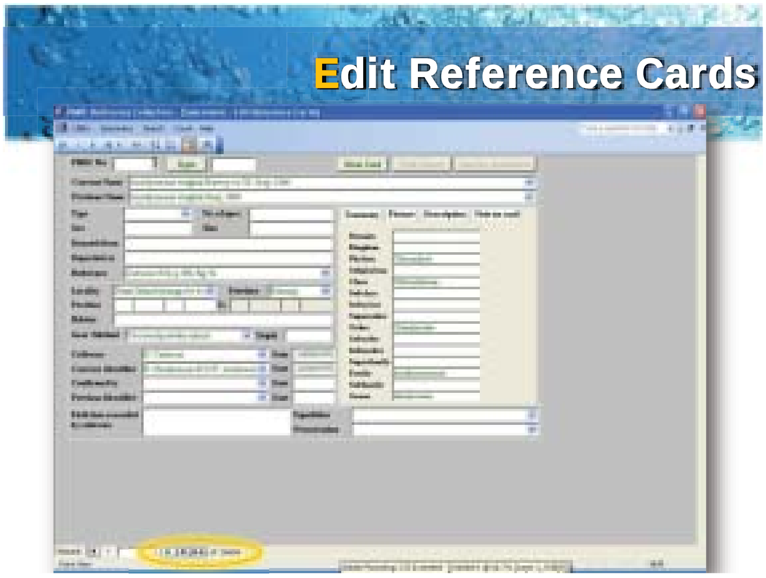
Registration Process

Registration Process: Registration Book

Registration Process: PMBC Reference Collection Database


Edit Reference Cards


Edit Reference Cards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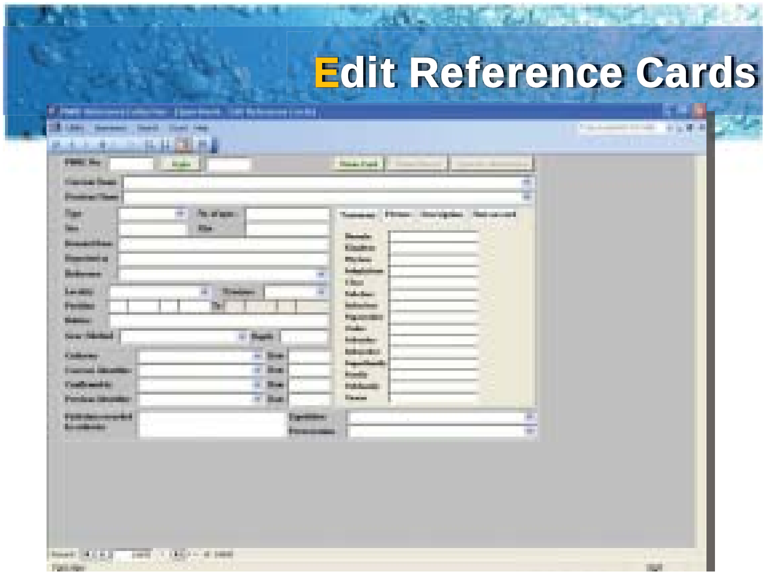
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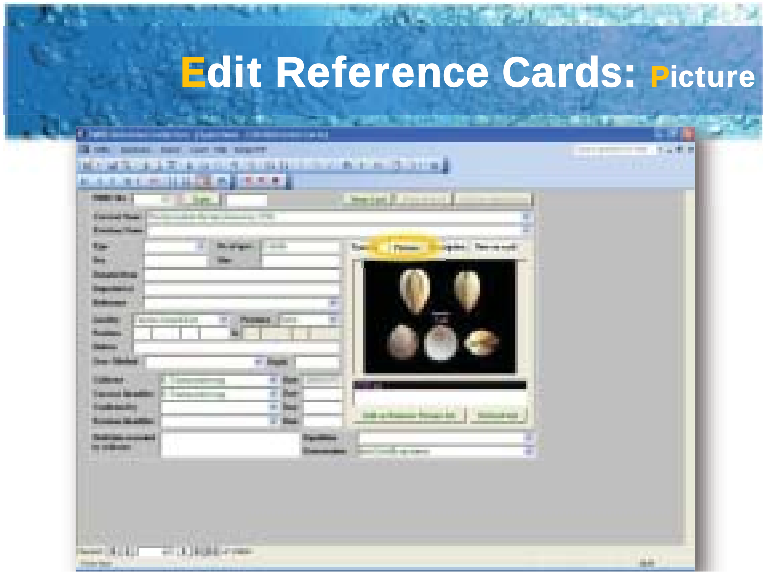
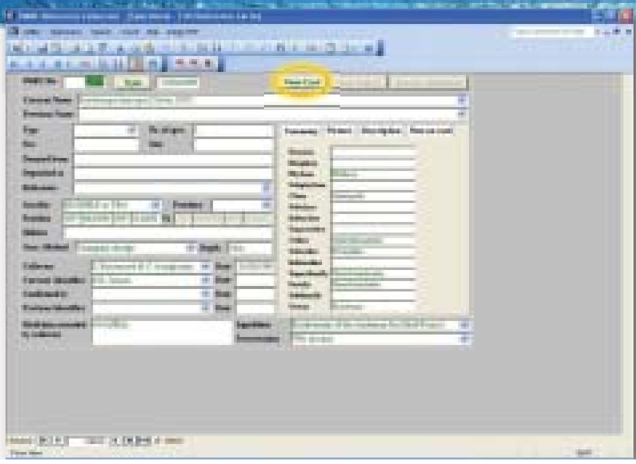
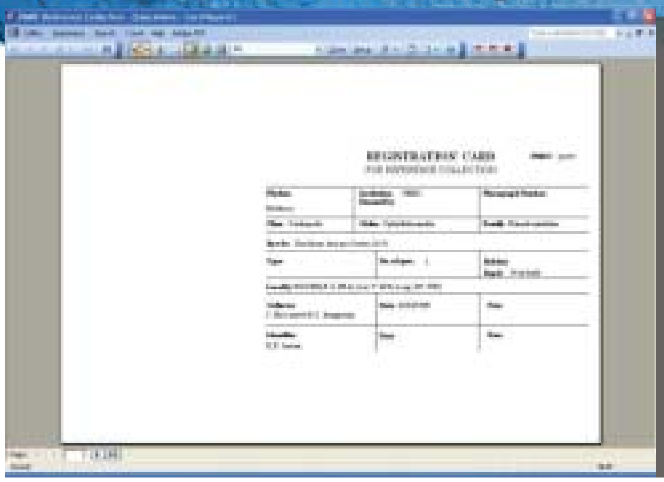

Edit Reference Cards: Picture


Edit Reference Cards: Picture preparation

Edit Reference Cards: Registration Card

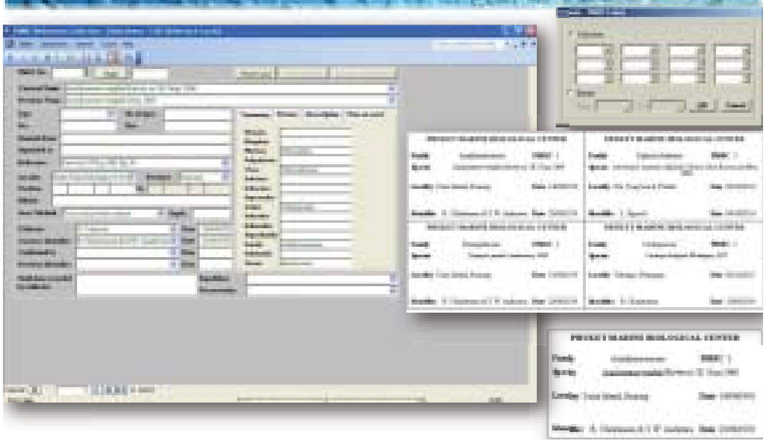


Edit Reference Cards: Registration Card



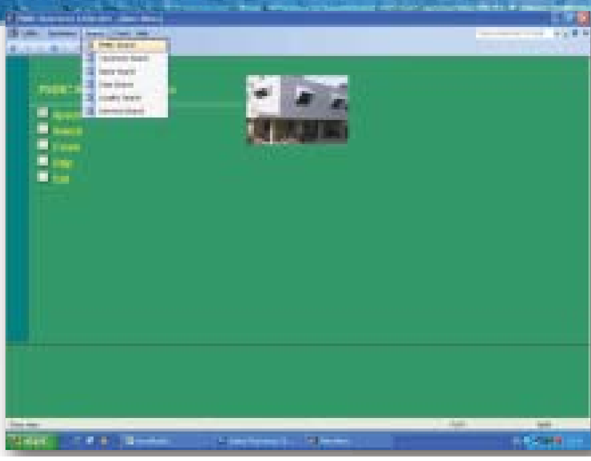
Registration Card Index

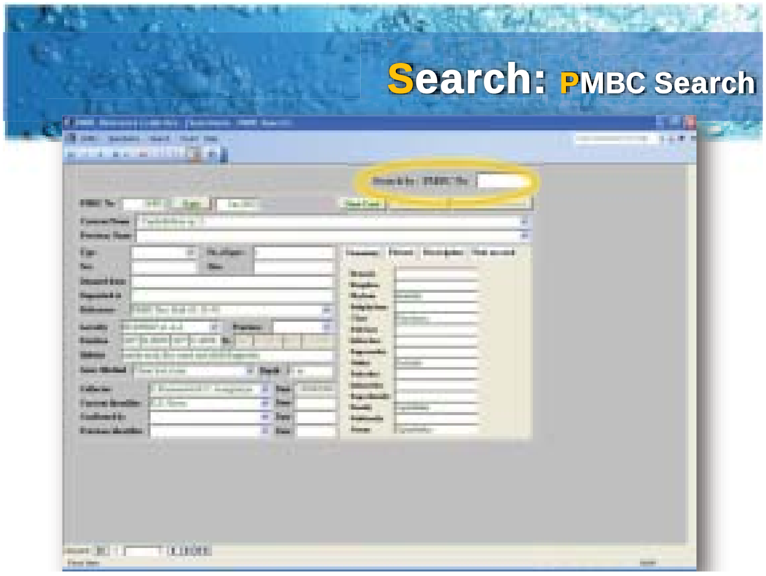
Edit Reference Cards: Label

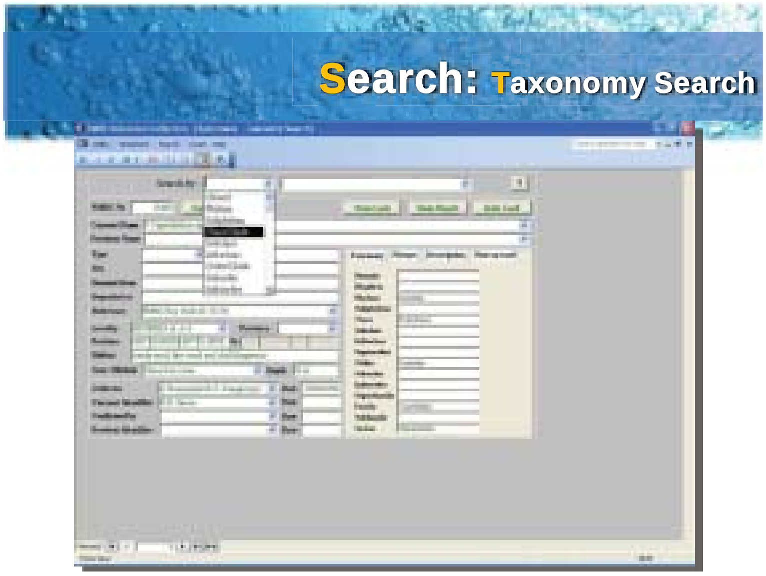


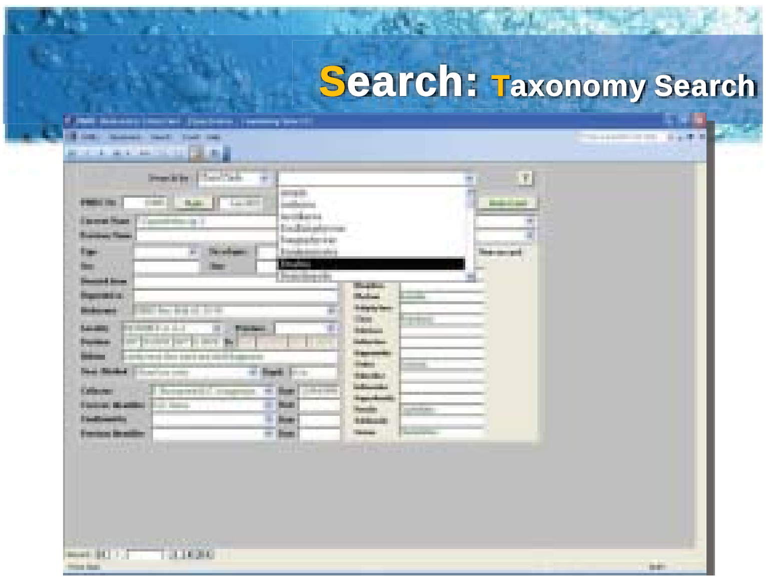
Label and Specimen

Search




Search: PMBC Search

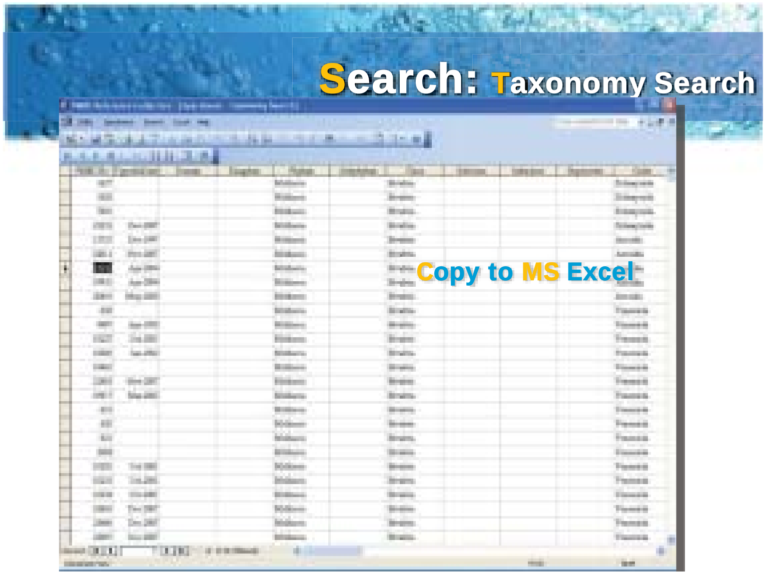

Search: Taxonomy Search

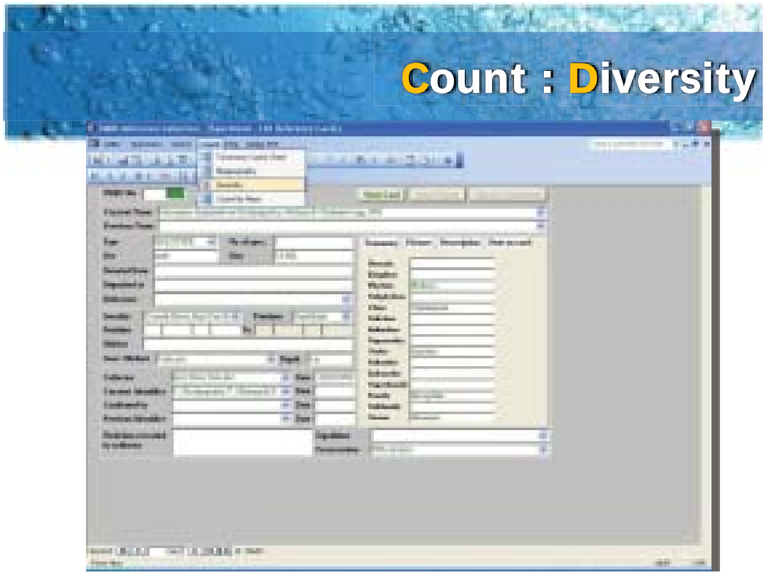

Search: Taxonomy Search


Search: Taxonomy Search

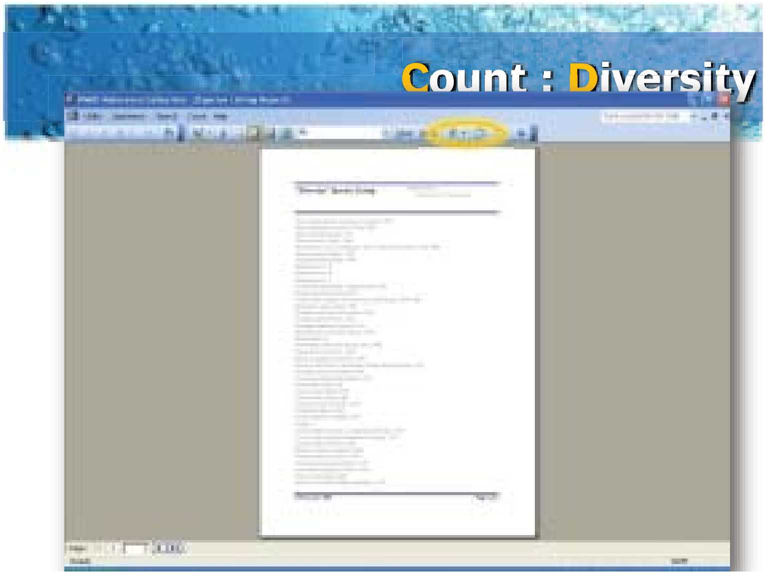

Search: Taxonomy Search
Report:
printout

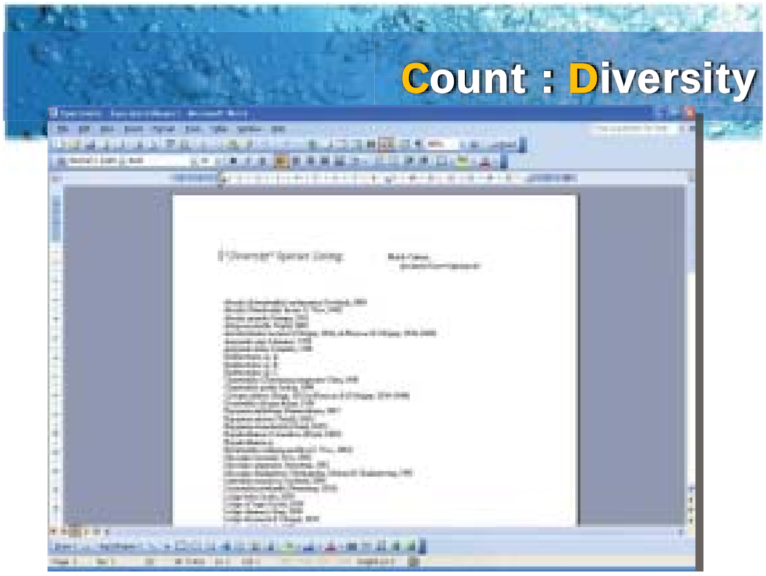

Search: Taxonomy Search

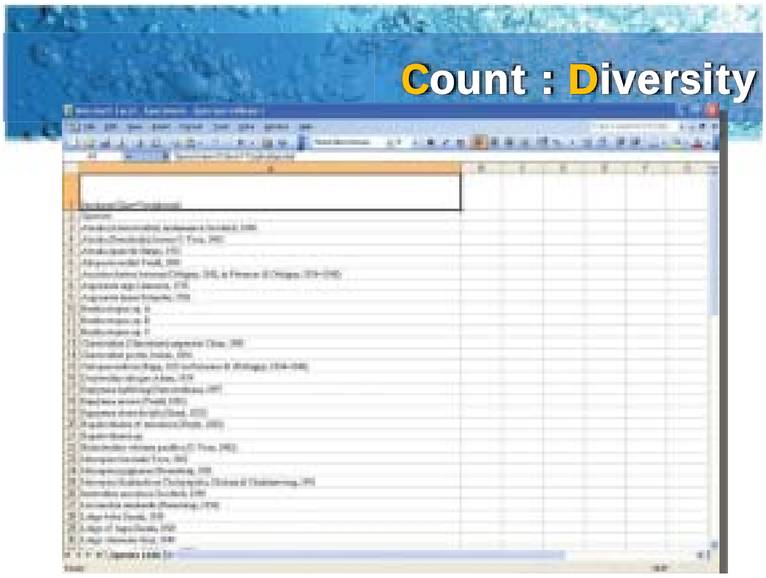

Search: Taxonomy Search
Copy to MS Excel


Count : Diversity

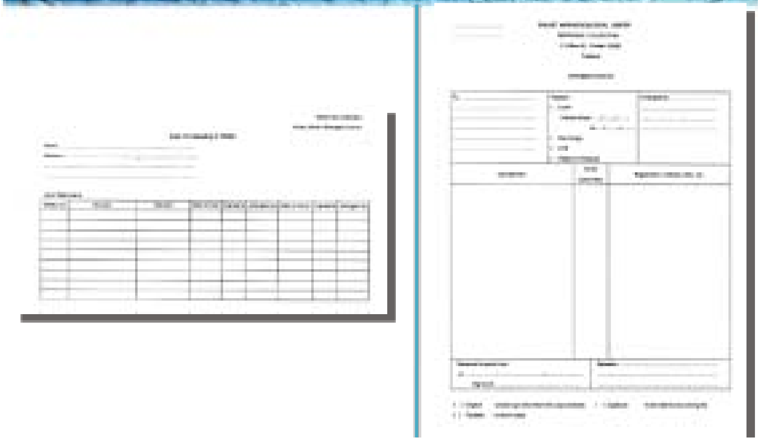

Count : Diversity


Count : Diversity

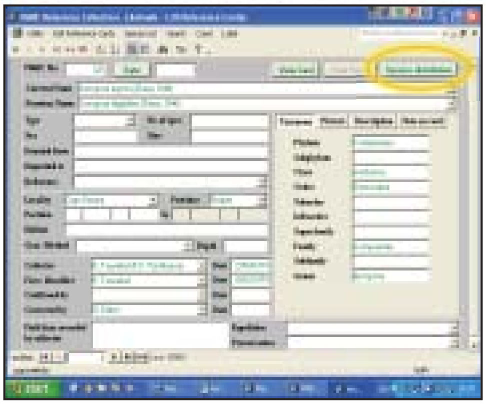

Count : Diversity


Count : Diversity

Loan

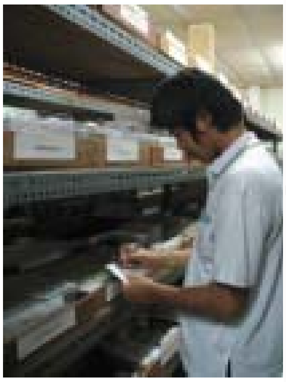


Edit Reference Cards: Species distribution



Edit Reference Cards: Species distribution

Annual maintenance



NOTES