

**JELLYFISH BIODIVERSITY AND HUMAN-
JELLYFISH CONFLICT IN SABAH, MALAYSIA**



CHUAN CHEE HOE

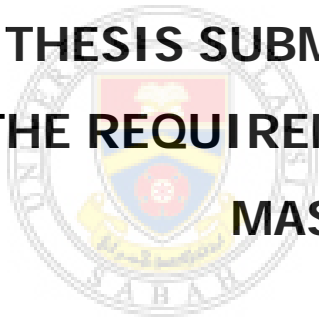
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**BORNEO MARINE RESEARCH INSTITUTE
UNIVERSITI MALAYSIA SABAH
2023**

**JELLYFISH BIODIVERSITY AND HUMAN-
JELLYFISH CONFLICT IN SABAH, MALAYSIA**

CHUAN CHEE HOE

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



UNIVERSITI MALAYSIA SABAH

**BORNEO MARINE RESEARCH INSTITUTE
UNIVERSITI MALAYSIA SABAH**

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UNIVERSITI MALAYSIA SABAH

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DECLARATION

I hereby declare that the work contained herein, submitted as a dissertation titled: Jellyfish Biodiversity and Human-Jellyfish Conflict in Sabah, Malaysia, for a Master's Degree in Science of Universiti Malaysia Sabah, is the result of my own investigations, work, and efforts, and that all references to the ideas, work and research of other researchers have been duly and specifically acknowledged.

16 November 2022

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CERTIFICATION

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*“Here’s a health to the all of you, and if I named you not,
Do not think for a moment it’s because you’re forgot.
I will treasure the memories as I call you my friends,
And I hope someday very soon we will all meet again.”*

Chuan Chee Hoe

16 November 2022



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ABSTRACT

Medusozoan jellyfish (Cnidaria) represent an important part of the ocean's ecosystem, and despite their wide-ranging impacts to human activities, relatively little knowledge is currently present on their population within the state of Sabah. In order to determine the species biodiversity and the impact that these jellyfish have to human health in the state, an assessment of jellyfish biodiversity was carried out. First, a literature review of jellyfish reports within the bodies of water surrounding Borneo from 1870-1970 was carried out in order to ascertain the potential species which may occur in Sabah waters. Next, the current biodiversity of jellyfish in the state was determined via the opportunistic sampling of jellyfish throughout February to April 2018 and 2020. Collected jellyfish samples were preserved at 7°C in 4% buffered formalin in seawater, and re-examination of previously unidentified jellyfish records was used to create an up-to-date collection of jellyfish species in the state. Finally, a record of serious and fatal jellyfish sting cases from 1991 to 2021 was also produced through reviewing reports in media, scientific literature, and reports from the medical sector. Historical records from 1870-1970 show that 162 species of jellyfish (99 hydrozoans, 57 scyphozoans and six cubozoans) were previously recorded in the study area. Next, the current jellyfish biodiversity of the state was expanded by new records of 11 species in addition to three unidentified species which had hitherto not been reported from the state. These jellyfish consist of three hydrozoan species, ten scyphozoan species and one cubozoan species, and their records expand the total number of species in the state to 25 in total. The large difference between the number of jellyfish species recorded in the present day compared to that in historical records suggest that the current records of jellyfish biodiversity in the state is highly underestimated, especially in the classes Hydrozoa and Cubozoa. Since 1991, there have been 36 cases of serious jellyfish envenomation in the state, with six resulting in fatality of the sting victim. Children are most at risk of developing serious symptoms. Cases of jellyfish stings were reported from all parts of the state. Sting events are more common from November to January; however, stings were reported year-round. Among the species known to occur in the state is the deadly box jellyfish *Chironex yamaguchii* Lewis & Bentlage, 2009, which has been implicated in multiple serious jellyfish stings and fatalities. Through this study, a list of jellyfish species which could occur in the state has been produced, as well as a checklist of jellyfish species currently known to occur within the state, with physical samples collected deposited for future reference. It was also found that harmful jellyfish pose a threat to coastal human populations throughout the state. More research on jellyfish needs to be prioritized, not only to determine the true biodiversity of jellyfish in the region and to identify and prepare for harmful jellyfish species, but also to raise public awareness of jellyfish-related risks and proper safety-seeking attitude in order to reduce the risk of jellyfish-human conflicts.

ABSTRAK

BIODIVERSITI UBUR-UBUR DAN KONFLIKNYA DENGAN MANUSIA DI SABAH, MALAYSIA

Ubur-ubur Medusozoa (Cnidaria) merupakan unsur penting ekosistem lautan sedunia dan boleh mencetuskan impak yang meluas terhadap kegiatan manusia. Namun, tahap ilmu tentang populasi ubur-ubur di negeri Sabah masih agak rendah. Bagi menentukan biodiversiti spesies, impak dan kesan ubur-ubur ini terhadap kesihatan manusia di negeri ini, penyelidikan biodiversiti ubur-ubur telah dijalankan. Pada mulanya, sorotan literatur laporan ubur-ubur di dalam badan air di sekitar Borneo dari 1870-1970 telah dilaksanakan untuk mengenali kewujudan spesies-spesies ubur-ubur yang berpotensi di perairan Sabah. Seterusnya, biodiversiti ubur-ubur yang wujud di negeri ini pada masa kini ditentukan melalui persampelan oportunistik ubur-ubur sepanjang Februari hingga April 2018 dan 2020. Sampel ubur-ubur yang dikumpul telah diawet pada suhu 7°C dalam 4% formalin ditimbang dalam air laut, dan pemeriksaan semula rekod ubur-ubur lepas yang tidak dikenal pasti sebelum ini sudah digunakan untuk mengemaskini senarai spesies yang ada di Sabah. Justeru, rekod laporan sengatan ubur-ubur yang serius dan menyebabkan maut dari 1991 hingga 2021 juga dihasilkan melalui semakan laporan media, kesusasteraan saintifik serta laporan sektor perubatan. Rekod sejarah dari 1870-1970 menunjukkan bahawa 162 spesies ubur-ubur (99 Hydrozoa, 57 Scyphozoa dan enam Cubozoa) telah direkodkan dari kawasan kajian sebelum ini. Di samping itu, biodiversiti ubur-ubur dalam negeri pada masa kini ini dapat diperkembangkan dengan rekod baharu 11 spesies yang berjaya dikenal pasti dan disahkan bersama 3 spesies yang tidak dikenal pasti. Ubur-ubur ini terdiri daripada tiga spesies Hydrozoa, sepuluh spesies Scyphozoa dan satu spesies Cubozoa, dan rekod mereka meningkatkan jumlah spesies di negeri ini kepada 25 secara keseluruhan. Perbezaan besar antara bilangan spesies ubur-ubur yang direkodkan pada masa kini berbanding dengan rekod sejarah menunjukkan bahawa rekod semasa biodiversiti ubur-ubur di negeri ini berkemungkinan terlalu rendah, terutamanya dalam kelas Hydrozoa dan Cubozoa. Sejak tahun 1991, sebanyak 36 kes sengatan dan 6 kematian telah direkod. Kanak-kanak merupakan golongan yang paling berisiko untuk mengalami gejala serius akibat sengatan ubur-ubur. Kes sengatan dilaporkan dari semua pantai Sabah dan berlaku sepanjang tahun, dengan lebih banyak kes pada bulan November hingga Januari. Antaranya merupakan spesies balung api *Chironex yamaguchii* Lewis & Bentlage, 2009 ditemui di Sabah, yang telah disahkan boleh menyebabkan maut. Kes sengatan tersebut berkemungkinan besar tidak dilaporkan akibat tahap kemajuan di luar bandar. Melalui penyelidikan ini, sebuah senarai spesies ubur-ubur yang boleh dijumpai serta yang telah dijumpai di perairan Sabah telah dihasilkan. Sampel-sampel fizikal juga telah disimpan untuk rujukan pada masa depan. Penyelidikan ini juga menentukan bahawa spesies ubur-ubur berbahaya telah menimbulkan ancaman kepada masyarakat persisiran pantai di seluruh negeri. Oleh itu, lebih banyak penyelidikan ubur-ubur perlu diutamakan supaya mengenal pasti keanekaragaman sebenar, dan dapat bersedia untuk menangani spesies yang berbahaya. Tahap kesedaran orang ramai tentang risiko ubur-ubur serta pengajaran atas langkah-langkah keselamatan perlu ditingkatkan untuk mengurangkan risiko konflik di antara ubur-ubur dan manusia.

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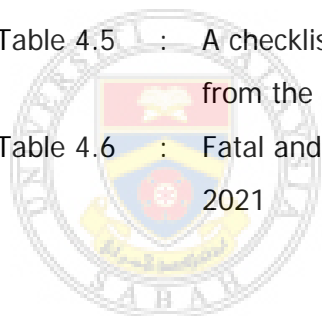
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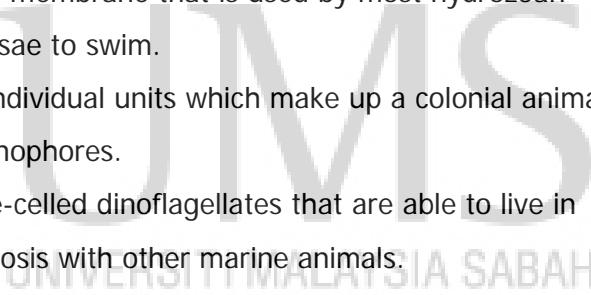


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LIST OF GLOSSARIES

- Bell - The umbrella-shaped main body of jellyfish.
- Benthic - Living or occurring near or on the seabed.
- Bract - A gelatinous, shield-like zooid.
- Cormidium - A single group of the repeating pattern of zooids which make up the siphosome of siphonophores.
- Ephyra - a free-swimming juvenile of the scyphozoan medusa, formed via strobilation
- Exumbrella - The upper surface of the jellyfish bell.
- Gastric saccules - Characteristic feature of chirodropid jellyfish, formed from diverticula of the central gastrovascular pouch.
- Gastrozooid - The zooid specialised for feeding in siphonophores.
- Gelata - Gelatinous zooplankton. Used as a collective noun to describe the polyphyletic assemblage of medusae, siphonophores, ctenophores, radiolarians, urochordates, molluscs, and worms that eke out a planktonic existence.
- Gonozooid - The zooid specialised for reproduction in siphonophores.
- Lappet - A fold or overhanging flap at the edge of the umbrella.
- Manubrium - An extension of the mouth in jellyfish. In Scyphozoa the oral arms originate from the manubrium.
- Medusa - The sexually mature free-living stage of the jellyfish. One of the two main body forms of cnidarians.
- Metagenesis - The alternation of generations between sexual and asexual reproduction.
- Monotypic - Only represented by one species.
- Nectophore - The zooid specialised for propulsion in siphonophores.
- Nematocysts - The stinging cell, found only in cnidarians.
- Pedalia - The gelatinous extensions on the four corners of cubozoan jellyfish from which the tentacles emerge from.
- Pelagic - Living or occurring near the surface of the ocean.
- Planula - The larval stage of the jellyfish, covered with cilia.

- Pneumatophore - The gas filled float found in certain groups of siphonophores.
- Polyp - The sessile stage of the jellyfish which reproduces asexually. One of the two main body forms of cnidarians.
- Polyphyletic - Organisms that are grouped together based on characteristics that do not imply that they share a common ancestor.
- Rhopalia - The sense organs of the jellyfish, the complexity of which depends on the type of jellyfish.
- Strobilation - Asexual reproduction by transverse division of the body into segments
- Subumbrella - The underside of the jellyfish bell.
- Velarium - A thin membrane that is used by cubozoan medusae for propulsion.
- Velum - A thin membrane that is used by most hydrozoan medusae to swim.
- Zoid - The individual units which make up a colonial animal like siphonophores.
- Zooxanthellae - Single-celled dinoflagellates that are able to live in symbiosis with other marine animals.



LIST OF ABBREVIATIONS

RNA	-	Ribonucleic Acid
BP	-	Blood Pressure
BSA	-	Body Surface Area
CPR	-	Cardiopulmonary resuscitation
GCS	-	Glasgow Coma Scale
GFP	-	Green Fluorescent Protein
HMS	-	His Majesty's Ship
HR	-	Heart Rate
IOC	-	Intergovernmental Oceanic Commission of UNESCO
LOC	-	Loss of Consciousness
mg	-	Milligram
mg/kg	-	Milligrams per kilogram
mmol	-	millimole
RECS	-	Remote Envenomation Consultancy Services
SIMCA	-	Sugud Islands Marine Conservation Area
SpO₂	-	Saturation of Oxygen measured by Pulse Oxymetry
UMS	-	Universiti Malaysia Sabah
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
USS	-	United States Ship
WESTPAC	-	Western Pacific

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Among the various denizens of the ocean, one of the most primitive and ancient lineages are the jellyfish. These gelatinous creatures have been drifting through the world's oceans since at least the Lower Cambrian period (541-484 million years ago), with the presence of fossilized medusae *Medusina radiata* and *Dactyloidites asteroides* being found in sedimentary rocks dating from that period (Walcott, 2011). Although the term jellyfish is sometimes used interchangeably with gelata to describe a wide range of animals from different phyla, namely those from Ctenophora (also referred to as comb jellyfish), Chordata (salps and sea squirts) and Cnidaria (stinging jellyfish), in this study, jellyfish will be defined as members of the Phylum Cnidaria that belong to the Subphylum Medusozoa.

The main distinguishing feature of jellyfish is their life history, which, as members of the subphylum Medusozoa are distinguished from other Cnidarians by having a free-living stage, called the medusa, which is absent from the other Cnidarians such as corals, sea anemones, gorgonians and myxozoans (Bridge et al., 1995). This leads to a unique life cycle, where there exists two adult body forms or life stages where reproduction occurs. This alternation of generations between an asexual phase and a sexual phase is known as metagenesis, and is present in all 5 classes of the Medusozoa in varying degrees (Arai, 1997). They also possess

umbrella-shaped bells in this medusa stage, which pulsate to move the animal through the ocean, as well as tentacles to catch and collect prey. As members of the Cnidaria, they are also characterised by their unique specialised cells called cnidocytes, which they have evolved for capturing prey. These cnidocytes contain a harpoon which is fired into the victim and delivers toxin, which weakens or kills the prey, allowing the jellyfish to hunt.

The subphylum Medusozoa consists of 4 classes, Hydrozoa, Scyphozoa, Cubozoa, and Staurozoa. Previously the class Polypodiozoa was also included in the subphylum (Evans et al., 2008), however, it has since been reclassified along with Myxozoa to form a clade which is sister to Medusozoa, one consisting of cnidarian obligate endoparasites (Okamura & Gruhl, 2016). Staurozoa, also known as stalked jellyfishes, is a class of about 50 or so species of jellyfish which differ from the other classes in that the members of the class do not have a free-swimming stage as in the other medusa jellyfish, but rather live a sedentary lifestyle attached to a substrate such as shells, rocks and algae (Miranda et al., 2018). The general body plan of the typical staurozoan is funnel-shaped, with a peduncle and pedal disk at one end of the animal which it uses to affix itself to the substrate.

The class Hydrozoa, on the other hand, is the most diverse of the medusozoan classes, containing over 3,700 valid species (Schuchert, 2022a). Members of the Hydrozoans are extremely varied in size, shape, and life cycle. For example, members of the Siphonophora are colonial organisms which among them contain some of the longest organisms known to man, *Praya dubia* (Quoy & Gaimard, 1833), which has been recorded to be as long as 40 m (Robison, 1995), while the anthothecate hydroid *Turritopsis dohrnii* (Weismann, 1883) is commonly known as the “immortal jellyfish” due to its ability to revert from the medusa stage back into the polyp stage when damaged, allowing individuals to effectively be biologically immortal (Kubota, 2011).

Meanwhile, members of the class Scyphozoa, or the “true jellyfishes” are the animals most often thought of when the word “jellyfish” comes to mind. This class contains around 200 extant species, split across 3 orders and 21 families (Daly et al., 2007). It is this class of medusozoans which contain the species which are most valuable economically, both for food and pharmaceutical reasons.

Finally, the jellyfish belonging to the class Cubozoa are among the most highly evolved examples of the phylum. Cubozoans are characterized by their box-like bell, and highly potent venom. The largest cubozoan species, *Chironex fleckeri* Southcott, 1956, has been implicated in the deaths of over 60 people in Australia since 1884 (Fenner & Williamson, 1996).

Since the early ages of written history, jellyfish have entwined themselves into mankind's collective mythology. The namesake of the adult jellyfish form, the medusa, takes its name from the fabled Greek Gorgon of the same name, as the jellyfish swimming in the water conjures up images of Medusa herself, whose severed head with the long snake hair trailing behind it inspired Linnæus to name the zoological class after her (Linnæus, 1758). The connection between Greek mythology and jellyfish extends further, as when Perseus slew Medusa by decapitation, out came from the severed neck her two sons, Pegasus; the winged horse, and Chrysáor; he who wields the golden sword. It is after Chrysáor that the genus *Chrysaora*, commonly called the sea nettles, is named after due to the golden colour that most members of the genus possess (Péron & Lesueur, 1809).

All throughout the world, jellyfish are in close contact with coastal human populations, leading to a great variety of names given to them. In Portuguese, the jellyfish is known as "a água-viva", or living water, which is an apt description of an animal that can consist of up to 95% water (Lowndes, 1942). This aspect of the jellyfish is also reflected in other similar languages. In New Zealand, jellyfish are known as "kakarū moana" in the native Māori language, which means the jelly of the ocean, while in Welsh slang, it has the amusing name of "pysgod wibbly wobbly," or the wibbly wobbly fish! Yet other names call upon the appearance of the jellyfish, like the Farsi "orus daryāyi," the bride of the water, referring to the long lacy arms which resemble a bridal veil, to the Malay "ubur-ubur," or torches. This may refer to the brilliant red oral arms of the flame jellyfish, *Rhopilema esculentum*, a common species in the Indo-Pacific region.

Still other names for jellyfish call out the result of brushing up against them while swimming in the ocean. In Malayalam, the jellyfish is known as "kadalchori," which directly translates to the sea itch. This is also reflected in the Mandarin "hǎizhē," or sea stinger, the name given to the flame jellyfish. In Spanish, they are