DOI: 10.21276/ijabpt.2016.7.3.15

INTERNATIONAL JOURNAL OF APPLIED BIOLOGY AND PHARMACEUTICAL TECHNOLOGY

www.ijabpt.com ISSN : 0976-4550

Volume-7, Issue-3, July-Sept-2016 Coden IJABFP-CAS-USA Copyrights@2016

Received: 10th June 2016 *Revised: 2nd July 2016* *Accepted: 2nd July 2016*

Research article

HYDROLITHON (FOSLIE) FOSLIE (HYDROLITHOIDEAE, CORALLINACEAE) FROM SHALLOW REEFS OF SOUTH ANDAMAN, INDIA

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ABSTRACT: The present paper deals with the first detailed taxonomic account on the coralline algal genus *Hydrolithon* from the shallow reefs of the South Andaman, India. The genus *Hydrolithon* is belonging to the subfamily Hydrolithioideae under corallinacaeae family of the phylum Rhodophyta. It is one of the most dominant coralline algal genus of this area and it is represented by three species i.e. (*H. onkodes, H. samöense and H. munitum*). Out of three, one species i.e. *H. munitum* is first time recorded from the India while the other two species (*H. onkodes* and *H. samöense*) are known form the other parts of India but they are also first time recorded from the study area. The present study provides details of the morphological and anatomical characters, including keys to species of this genus. The significance of crustose coralline algae (CCA) has also been highlighted with respect to new recruitment of corals in South Andaman.

Key words: *Hydrolithon*, Coralline algae, Reefs, Andaman.

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INTRODUCTION

Andaman and Nicobar Islands are characterized by rich coral reef biodiversity which have been well studied over the years (Pillai 1983, 1996; Turner et al. 2001; Venkataraman et al. 2003; Saxena et al. 2008; Raghuraman et al. 2013). Coralline algae is also well represented among coral reefs of this area. Though they are important bulk producers and consolidators of the reef in most tropical and subtropical areas yet from the Andaman Sea, they have been poorly studied and understood. Coralline algae are very important components of coral reef ecosystems (Björk et al.1995; Vermeij et al. 2011) where they play a major role in the carbon and carbonate budgets (Payri et al. 2001; Farr et al. 2009; Littler and Littler 2013). They not only cement reefs but also act as a very important substrate for the settlement and growth of coral larvae (Morse et al. 1994; Erwin 2008; Littler and Littler 2013) and other benthic organisms (Daume et al.1999; Naylor 2006; Farr et al. 2009). They also helps in the recovery and restoration of coral reef systems relatively quickly, since some thin forms of crustose coralline algae (CCA) accelerate colonization and chemically attract and facilitate survival of coral larvae over them (Morse et al. 1994; Harrington et al. 2004).

However, despite the fact that they are important constituents of this area, they have remained unstudied. Previous works on Indian coralline algae include Ganesan (1962); Desikarchary and Ganesan (1967); Krishnamurthy and Joshi (1970); Krishnamurthy (1980); Krishnamurthy and Jayagopal (1985 a, b, 1987 a-d); Silva et al. (1996) and Desikachary et al. (1998).

These workers have extensively studied coralline algae of the India, especially of its east and west coasts and provided basic data for understanding coralline algal biodiversity of India. But after these pioneering efforts, no serious attempt has been made to understand the taxonomic composition of this algal group and their significance with respect to coral reefs. In recent years, nomenclature and systematics of the coralline algae have also undergone major changes. Consequently, many taxa have been transferred to different genera and/or subfamilies and/or families and many have been found to be of uncertain taxonomic affinities. Harvey et al. (2003)*;* Bailey et al. (2004); Le Gall and Saunders (2007); Le Gall et al. (2010) have reclassified coralline algae on the basis of genomic analysis. Except Jagtap (1997), no systematic records of living coralline algae from the coral reefs of the Andaman and Nicobar Islands are available. He reported *Metamastophora flabellata* from the coral reef of Great Nicobar Island. In the light of limited amount of data on coralline algae, the present study provides useful taxonomic information about genus *Hydrolithon* (that belongs to the subfamily Hydrolithioidea of the Family Corallinaceae) and its importance in coral reefs. The aim of this paper is to provide morphological, anatomical and reproductive account of *Hydrolithon* and distinguish three species in light of modern taxonomic concept.

The genus *Hydrolithon* has undergone several taxonomic revisions (Kato et al. 2011). Kato and Baba in Kato et al. (2011) recently separated it from subfamily Mastophoroideae to include in a new subfamily Hydrolithoideae for this genus within Family Corallinaceae. *Hydrolithon* differs from the closely related genus *Porolithon* only in its trichocyte arrangement characterized by large and tightly packed horizontal fields that lack vegetative filaments between the individual trichocytes occurring in the Porolithon genus (Kato et al. 2011). Seven species of *Hydrolithon* (i.e. *H. krusadiense, H. onkodes, H. craspedium, H. reinboldii, H. iyengarii, H. verrucosum and H. samöense*) are known from the Tamilnadu, Gulf of Mannar and Lakshadweep of India.

MATERIALS AND METHODS

Coralline algal samples were collected from intertidal and sub-tidal areas of coral reefs from North Bay, Marina Park, Burmanullah, Chidiyatapu, Wandoor and Hut Bay of the South Andaman District (Fig. 1). These samples were collected from rocks and dead corals in shallow reefs less than 5m in depth. Small pieces of samples were taken and decalcified with the help of dilute acid (HNO_3). Sections were made with the help of microtome and observed under microscopes to study the characters of reproductive and vegetative structures and cells to identify species.

RESULTS

Three species of *Hydrolithon* were identified from the algal samples collected from the six study areas. The description of the genus *Hydrolithon* followed by the description of the three species are given below.

Systematic Description

Division Rhodophyta Wettstein, 1901
Class Rhodophyceae Rabenhorst, 1863
Order Corallinales Silva and Johansen, 1986
Family Corallinaceae Lamouroux, 1812
Subfamily Hydrolithoideae Kato and Baba in Kato et al., 2011
Genus ***Hydrolithon*** (Foslie) Foslie, 1909

Plants calcified, encrusting, warty or lumpy, attached to various substrates or free-living as rhodoliths; non-geniculate. Structure pseudoparenchymatous; internal organization dorsiventral; construction monomerous ordimerous. Cells of adjacent filaments joined by cell-fusions, secondary pit connections absent. Epithallial cells terminate filaments at the thallus surface, distal walls rounded or flattened but not flared. Trichocytes present or absent, if present arranged in horizontal fields, horizontal/vertical rows or occurring singly, either at the thallus surface or buried within the thallus.

Tetrasporangia and bisporangia formed in uniporate conceptacles. Tetrasporangia and bisporangia formed across the whole chamber floor orperipheral to a central columella. Gametangia and carposporangia formed in uniporate conceptacles.

Key to species of *Hydrolithon*

1. Core filaments non-coaxial, multilayered, trichocytes commonly present as horizontal rows in the thallus (Pl. 1, figs. 1-4) ……*H. onkodes*
2. Core filaments non-coaxial, multilayered, trichocytes present singly in the thallus (Pl. 1; figs. 5-6; Pl. 2, figs. 1-3) ……..……*H. samöense*
3. Core filaments non-coaxial, multilayered, trichocytes present singly or rows in the thallus (Pl. 2, figs.4-7) ..…… ……*H. munitum*

Hydrolithon onkodes (Heydrich) Penrose and Woelkerling, 1992
(Pl. 1; figs. 1-4)
Lithothamnion onkodes Heydrich, 1897, p. 6, pl. 1.
Goniolithon onkodes (Heydrich) Foslie, 1898, p. 8.
Lithophyllum onkodes (Heydrich) Heydrich, 1901, p. 529-545.
Porolithon onkodes (Heydrich) Foslie, 1909, p. 57.
Spongites onkodes (Heydrich) Penrose and Woelkerling, 1988, p. 159, figs.10-14.
Hydrolithon onkodes (Heydrich) Penrose and Woelkerling, 1992, p. 834, figs. 4, 5.

Plants non-geniculate, encrusting to substrate by cell adhesion, thallus 1.1mm thick. The internal thallus construction monomerous. The core region is non-coaxial and cells 6–8µm long and 6–8µm in diameter. Peripheral filaments are comprised of rectangular cells that measure 9–11µm long by 6–7µm in diameter. Peripheral filaments are terminated by a single layer of rounded to flattened epithelial cells. Cells of adjacent filaments are joined by cell fusions, secondary pit connections have not been observed. Trichocytes common, occurring in horizontal rows/fields in the thallus surface, commonly becoming buried within the thallus. Gametangial plants were not observed. Tetra/bisporangial conceptacles are uniporate and flush with the surrounding thallus surface. The base of the pore canal is surrounded by a ring of enlarged cells, these cells do not project into the pore canal. Mature tetra/bisporangial conceptacles measure 360–400µm in diameter and 120–130µm in height. The conceptacle chamber lacks a central columella and zonately divided tetra/bisporangia are scattered across the chamber floor.

Hydrolithon samöense (Foslie) Keats and Chamberlain, 1994
(Pl. 1; figs. 5-6; Pl. 2, figs. 1-3)
Lithophyllum samöense Foslie, 1906, p. 20.
Hydrolithon samöense (Foslie) Keats and Chamberlain, 1994, p. 15.

Plants non-geniculate, encrusting to substrate by cell adhesion, thallus 1.5mm thick. The internal thallus construction monomerous. The core region is non-coaxial and comprises rectangular cells that are 10–12µm long and 6–8µm in diameter. Peripheral filaments composed of e cells 6-7µm long by 3–5µm in diameter. Peripheral filaments are terminated by a single layer of rounded to flattened epithelial cells. Cells of adjacent filaments are joined by cell fusions, secondary pit connections have not been observed. Trichocytes occurring singly in the thallus surface, commonly becoming buried within the thallus.
Male conceptacles uniporate, spermatangial filaments unbranched, arising only from the conceptacle floor. Chambers up to 160µm in diameter and up to 120µm high. Female carpsporangial/conceptacles uniporate and flush with the surrounding thallus surface. Carposporophytes developing within female carpogonial conceptacles. The base of the pore canal is surrounded by a ring of enlarged cells, these cells do not project into the pore canal. Mature female/carpsporangial conceptacles measure 150–160µm in diameter and 100-110µm in height. The conceptacle chamber lacks a central columella and carpospores are scattered across the chamber floor.

Hydrolithon munitum (Foslie and Howe) Penrose, 1996
(Pl. 2; figs. 4-7)
Lithophyllum munitum Foslie and Howe, 1906, p. 132.
Hydrolithon munitum (Foslie and Howe) Penrose, 1996, p.263.

Plants non-geniculate, encrusting to warty, protuberances 2.5-3.0mm long. The internal thallus construction monomerous. The core region is non-coaxial and comprises rectangular cells that are 5–10µm long and 4–5µm in diameter. Peripheral filaments are comprised of elongate cells that measure 10-16µm long by 4–6µm in diameter. Peripheral filaments are terminated by a single layer of rounded to flattened epithelial cells. Cells of adjacent filaments are joined by cell fusions, secondary pit connections have not been observed. Trichocytes present singly or rows in the thallus. Gametangial plants were not observed. Tetra/bisporangial conceptacles are uniporate and flush with the surrounding thallus surface. The base of the pore canal is surrounded by a ring of enlarged cells; these cells do not project into the pore canal. Mature tetra/bisporangial conceptacles measure 200–210µm in diameter and 60-70µm in height. The conceptacle chamber lacks a central columella and tetra/bisporangia are scattered in floor.

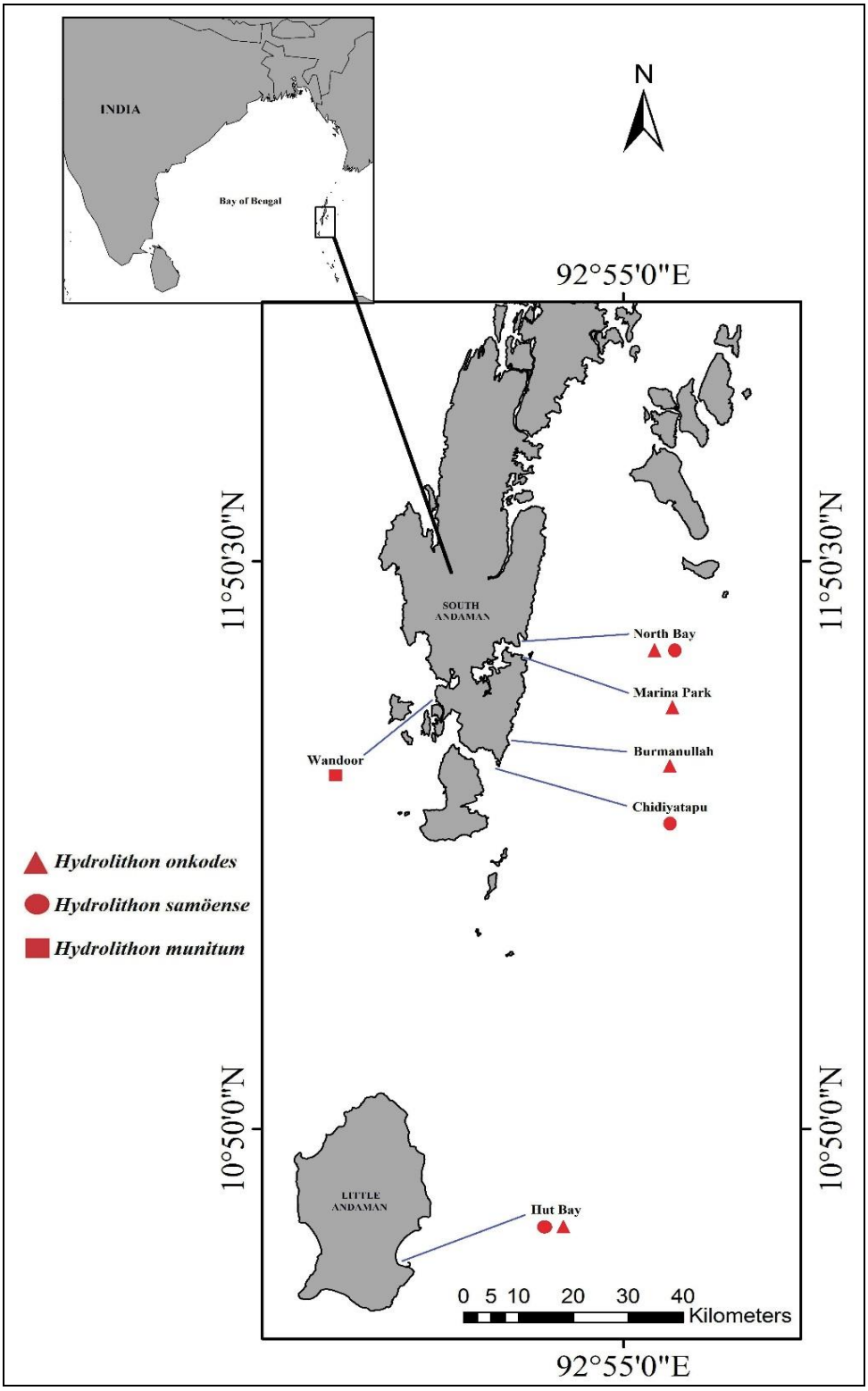
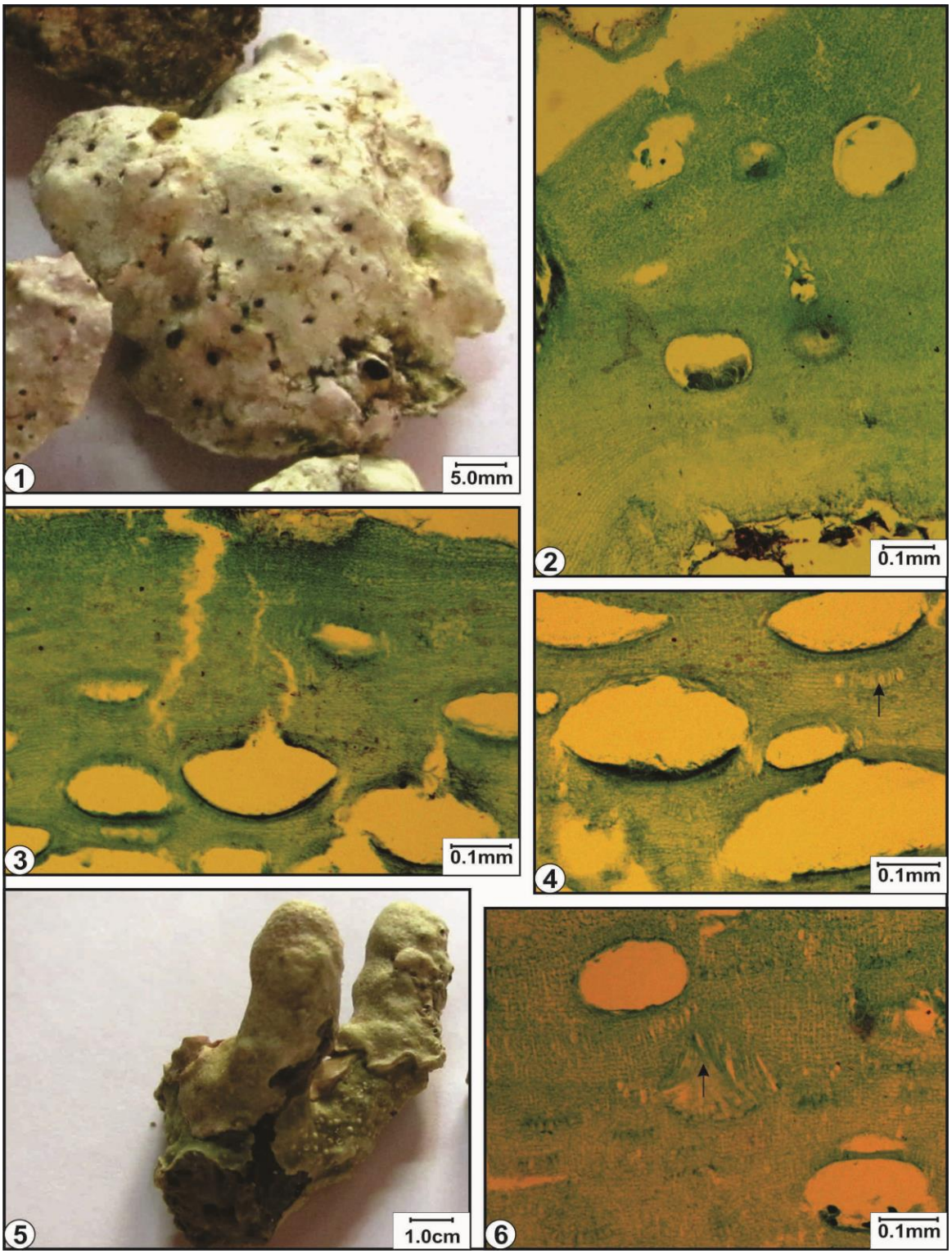


Figure 1. Location of the study sites and distribution of *Hydrolithon* species in the South Andaman, India.



Figs. 1-4. *Hydrolithon onkodes*, Fig. 1. Encrusting growth-form of *Hydrolithon onkodes*, Figs. 2, 3. Thallus showing uniporate conceptacle, Fig. 4. Thallus with conceptacles and row of trichocytes (indicated by an arrow). Figs. 5, 6. *Hydrolithon samöense*, Fig. 5. Encrusting growth-form of *Hydrolithon samöense*, Fig. 6. Male conceptacles/spermatangial filaments (indicated by an arrow).

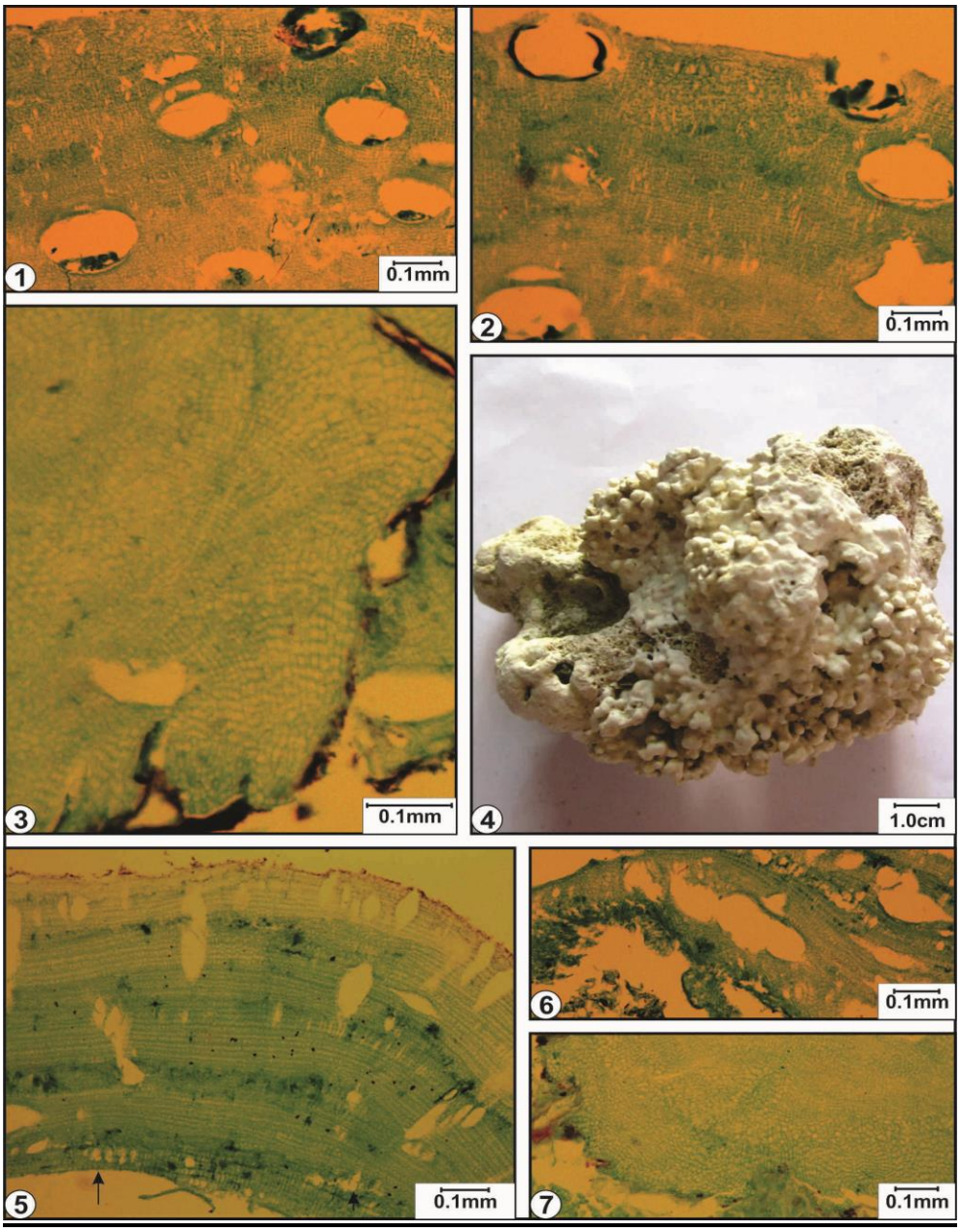


Plate II: Figs.1-3. *Hydrolithon samöense,* Figs. 2, 3. Uniporate female/carpsporangial conceptacles with carpospores, Fig. 3. Non-coaxial core filaments and peripheral filaments of monomerous construction, Figs. 4-7. *Hydrolithon munitum,* Fig. 4. Encrusting to warty growth-form of *Hydrolithon munitum*, Fig. 5. Peripheral filaments show trichocytes (indicated by an arrow), Fig. 6. Uniporate tetra/bisporangial conceptacles, Fig. 7. Peripheral and non-coaxial core filaments of the thallus.

DISCUSSION

The coralline algal genus *Hydrolithon* is one of the most important components of coral reef ecosystems in the Andaman area. But the biodiversity of its species in this area is poorly known. However, in spite of abundance of its representatives in India, it has not been properly studied; except Desikarchary and Ganesan (1967) and Krishnamurthy and Jayagopal (1985, 1987) no previous work on *Hydrolithon* from the Andaman and Nicobar area is available. The present study is therefore significant and throws light on biodiversity of this genus of this area. Three species of the genus *Hydroliothon* are identified from six different stations of the Andaman area. These are *H. onkodes* from the Marina Park, North Bay, Burmanullah and Hut Bay, *H. samöense* from Hut Bay and North Bay, and *H. munitum* from the Wandoor only of the South Andaman (Fig. 1).

Out of these, one species, i.e. *H. munitum* is first time recorded from India, while the other two species (*H. onkodes* and *H. samöense*) are known from other parts of India, they are first time recoded from the study area. This study is still continuing, and it is expected that more species will be identified in near future, which will indicate true taxonomic composition of *Hydrolithon* in the Andamans Sea.

Morse et al. (1994) reported settlement and metamorphosis of larvae of the scleractinian coral *Agaricia humilis* in response to chemosensory recognition of a morphogen on the surface of *Hydrolithon boergesenii* and other CCA. Different species of *Hydrolithon* have been studied to understand larval settlement of corals by various workers over the years (Raimondi and Morse 2000, Harrington et al. 2004). In this study *Hydrolithon* spp. present in shallow water of the study areas are playing a vital role in recruitment of *Acropora* spp. as well as other coral species especially in Marina Park and Hut Bay. The average water temperature and salinity of these water are 30±1.5 and 33±1.4 respectively. Malakar and Venu (2015) reported that CCA was playing an important role in recovery of corals (especially *Acropora* spp.) in South Andaman after mass bleaching of corals in 2010. *Hydrolithon* is one of the most common species of CCA in shallow waters of South Andaman. The significance of *Hydrolithon* and other CCA in the sustainability of shallow water reef needs to be studied in details.

CONCLUSION

This study reports three new species of *Hydrolithon* from Andaman and Nicobar Islands of India and also highlights the significance of the genus with respect to shallow water coral reefs of the region. Further research is necessary to study taxonomy of other CCA species and understand their role in reef ecology.

ACKNOWLEDGEMENT

The authors are thankful to the Forests Department for giving permission to carry out surveys in South Andaman. Department of Ocean Studies and Marine Biology, Pondicherry University and Department of Botany, University of Lucknow are gratefully acknowledged for providing facilities for the research. The first author acknowledges the fellowship received from the University Grants Commission under the Rajiv Gandhi National Fellowship Scheme to carry out this study which is a part of PhD research work.

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ISSN : 0976-4550

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