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CORAL REEFS: A BRIEF REVIEW

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ABSTRACT

Coral reefs are often referred to as the ocean's rainforests and serve as a refuge with high gross primary productivity. They provide structural heterogeneity to a wide variety of creatures and provide numerous other ecological products and services. Coral reefs that have developed over the last half-million years are being jeopardised by coral loss and the related modification of reef habitats, which are risking the structure and function of coral reef ecosystems. They are valuable social, economicand environmental assets, but the diversity, frequency, and magnitude of human influences on them are increasing to the point that they are threatened globally. The resilience of the reefs is eroding to the point where it can no longer recover from recurring disruptions. Given these dangers and the value of coral reefs to humans and marine biodiversity, this papergives an overview of the types of corals, their organisation, formation, theories, zones of the reefs, biodiversityof coral reef ecosystems and their associated threats.
Keywords: Biodiversity, coral reefs, marine, ecosystem, polyps, threats

INTRODUCTION

Coral reefs are diverse aquatic ecosystems that exist worldwide. Although occupying less than 0.1% of the Earth's ocean surface, these regions sustain a wide variety of marine organisms, such as fish, mollusks, crustaceans, Echinoderms the sponges, tunicates, or, and other Cnidarian constituting at least 25% of the overall marine population. Coral reefs are raised structures mostly made of limestone, with an upper layer composed of calcium carbonate formed by the actions of numerous species, mainly corals(Vaughan, 1971). The Fiji islands in the Pacific Ocean and the coral islands in the Bahamas Island region are often recognized as the most prestigious.Bermuda is a coral island characterized by structures constructed from coral segments. Long-lived corals from the wild allow for historical growth pattern studies (De'ath et al., 2009; Lough, 2011). The calcification of coral skeletons from 328 colonies of the gigantic coral Porites in Australia's Great Barrier Reef has decreased by 14.2% since 1990. This occurrence is unparalleled in the past 400 years on the Great Barrier Reef(D'Olivo et al., 2013).Corals help produce coral reefs. Polyploid coelenterates with a secreted skeleton live alone or in colonies. Most of them are Anthozoa, although others are Hydrozoa. Phase-shifts from one durable species assemblage to another are common on coral reefs and other ecosystems due to human impacts (T. P. Hughes et al., 2010).The

foundation for coping with ecological shocks, future changes, and uncertainty is provided by the incorporation of the role that human activity plays in the creation of ecosystems into management for greater resilience (Bellwood et al., 2004).

I. CATEGORIES OF CORALS

- **Hydrozoa Coral**: The Hydrocorallina order, which includes species such as Millepora and Stylasterina, among others, is colonial and produces huge calcareous exoskeletons. These organisms are part of the order. In addition to other types of corals, these corals are found in reefs that are made up of corals.
- **Anthozoan Coral:** Different species of corals are formed by individuals belonging to different orders of the class Anthozoa, such as:
- One of the representatives of the Order Alcyonacea is soft coral, which is a member of the well-known genus Alcyonium, sometimes known as "Dead man's finger."
- The colonial coral known as Tubipora, sometimes known as organ pipe coral, are members of the Order Stolonifera. These corals are red in color.
- Within the Order Coenothecalia, there is only one genus known as Heliopora, which is more generally referred to as blue coral.
- Gorgonacea, which may include sea fans or horny corals within its order.
- The aforementioned corals are together referred to as octocorallian corals.
- Members of the stony coral or real coral classification are included in the Order Madreporaria. The majority of them are colonial types, although some of them are solitary or isolated. These corals, along with the other types of soft corals, are the primary contributors to the formation of coral reefs. It is also possible to refer to them as hexacorallian corals.

II. CORAL ORGANIZATION

- **Coral skeleton:** A corallite is the skeleton of a single piece of coral. It is a skeletalstructure made of calcium carbonate that is producedby the outer layer of skin.The corallite of every individual polyp within a colonial coral combines to form a solid structure known as corallium. The cup-shaped corallite consists of a base plate and a cup wall, which is alternatively referred to as the theca. Sclerosepta, which are vertical ridges or septa that extend from the theca to the center of the cup, line the cavity of the cup. By fusing the interior extremities of the Sclerospeta, an asymmetrical central skeletal structure called a columella is formed.
- **Coral Polyps:**Approximately one centimeter in length, the coral organism is a miniature anthozoan polyp. An oral disc bearing tentacles in a cycle of six is absent, and a pedal disc is absent as well. Siphonoglyphs are absent from the pharynx. Escaping the upper portion of the polyp, the mesenteries adhere to the hexamerous structure. Muscle development is inadequate.

III. FORMATION OF CORALS

- Planula larvae transform into coral polyps when they mature and commence secreting protheca, which are skeletal rudiments.Its basal plate form is initially secreted by the ectoderm. Simultaneously, the polyp, situated at the apex, is encased in a thecal wall comprising the rim, while the larva develops radial folds that secrete septa. Gradually, supplementary skeletal material is incorporated into the interstices of the septa. Alternating with the mesenteries of a living coelenterate are typically the septa of the skeleton.

- **Solitary Corals:** Caryophyllia, Flabellum, and Fungia, among others, are solitary or cup corals. The corallite skeleton is disc-like, cup-shaped, or mushroom-shaped, with a diameter ranging from 5 mm to 25 cm. It frequently lacks a theca.
- **Colonial corals:** A plate-like, hemispheric, cup-shaped, or vase-shaped skeleton comprises the majority of stony coral's composition. Acropora, Oculina, Favia, Madrepora, Meandrina, among others, are typical examples. The colony is generated asexually from a solitary polyp that was produced sexually. The polyp resides on the calcareous skeleton's surface. Diverse forms of colonies are generated by the method of asexual blossoming. Certain colonies exhibit branching. For instance, Acropora and stag horn coral consistently maintain a primary polyp atop the colony, flanked by lateral branches. Meandrina polyps and the theca converge in the brain coral, inhabiting valleys that are delineated by ridges on the corallium's surface.

IV. FACTORS INFLUENCING CORAL GROWTH

- The optimal growth environment for corals is within a minimum depth of 100 feet in the sea. • A minimum temperature of 22ºC is required.
- The process of photosynthesis in symbiotic algae necessitates exposed light. Therefore, optimal coral growth takes place in the photic zone of the marine environment(Done et al., 2003).
- They are unable to flourish in areas with limited sunlight and die in total absence of light.
- Freshwater and excessive precipitation is lethal to corals.
- Corals are present at depths below 50 meters; however, they do not form the reefs.
- Their distribution is restricted to mild, shallow water.
- Continents and island shores are within their range. •
- They contain zooxanthellae (dinoflagellates), the presence of which facilitates the formation of the coral's skeleton by aiding in the removal of H_2CO_3 produced as a consequence of $CaCO_3$(Falkowski et al., 1993; Jaap, 2000).
- Potable water that has been agitated is necessary.

V. TYPES OF CORAL REEFS

Fringing Reefs: Bordering reefs are coral reefs at the southern shoreline of a volcanic island or a continental area. A bordering reef is a narrow strip of coral that stretches from the shoreline to a distance of about ¼ mile. It is characterized by a prominent reef edge where the most vigorous coral growth takes place, as well as a slightly lower and relatively flat surface. The reef flat located between the forward and the beach primarily consists of coral sand, muck, deceased corals, and miscellaneous debris. The outermost beach of the island has the potential to integrate with the flat area of the reef that is already there, which includes a slope towards the sea where coral develops up to a depth of 20 fathoms. Coral reefs of this nature are abundant in the East Indies.

Barrier Reefs: These reefs look like bordering reefs but are farther from the coast. The lagoon separating the barrier reef from the land can be half a mile to 10 miles wide. The 10–50-fathom depth is suitable for navigation. Ships can enter barrier reefs by "passes" or "passages". The entire island may be surrounded by barrier reefs. An exemplary instance is the "Great Barrier Reef" located in Australia, spanning over 1200 miles in length and extending up to 90 miles from the coastline.

Atoll Reef: Atoll reefs act like barrier reefs but lack a lagoon island. The largest atoll is 40 miles wide. They can exhibit a circular, ring-like, or horse-shoe shaped form. The channels, although few are accessible, might either be entire or fractured. The outer side of the reef gradually descends into the depths of the ocean, exhibiting a tranquil demeanor.

VI. FORMATION OF CORAL REEF

The exoskeletons of stone corals form the calcareous framework of coral reefs, which are also quite rich in organic material, especially in the upper levels where the corals grow. Coral reefs are underwater formations composed of calcium carbonate structures that result from the accumulation of skeletal remains and shells of marine organisms. After the glaciers melted, sea levels rose, and the continental shelves were flooded, creating the vast majority of the coral reefs that can be seen today.As a result, most modern coral reefs are younger than 10,000 years old. As the communities settled on the shelves, the reef grew in height, matching the rising sea levels. Reefs that experienced insufficient vertical growth are referred to as drowned reefs (Sorokin, 2013).They were submerged in a vast expanse of water, with inadequate illumination. Coral reefs predominantly occur in the abyssal zone, which is far off from continental shelves. They are frequently observed around oceanic islands and developing into atolls. The majority of these islands are predominantly shaped by volcanic activity, whereby geological forces have uplifted the deep-sea flora to the surface(Nakamura & Nakamori, 2007).

The majority of coral reefs consist primarily of coral skeletons, predominantly derived from complete coral colonies. Aragonite is generated when several chemical components found in corals are absorbed into the calcium carbonate deposits.However, the existence of shell fragments and the remains of calcareous algae, such as the green segmented species Helimeda, can strengthen the reef's ability to withstand storms and other possible dangers.

VII. THEORIES OF THE ORIGIN OF CORAL REEFS

Various theories were suggested to clarify the process of atoll and reef formation. The genesis of reefs cannot be fully explained by any single theory. Multiple processes likely operate concurrently in the construction of reefs.

Darwin Theory:In 1842, Charles Darwin published his inaugural monograph titled "The Structure and Distribution of Coral Reefs." Charles Darwin (Darwin, n.d.)developed his idea about the formation of atoll reefs. Three steps were identified by Darwin's theory as the creation of an atoll.

When an active volcano island sinks both its bottom and the ocean floor, a shallow lagoon usually forms between the main reef and the island. This is the first stage of the process.

The modest bordering reef grows into a larger barrier reef that is farther from the beach as the land continues to sink. This barrier reef also encompasses a larger and deeper lagoon within its boundaries.

The island eventually vanishes beneath the ocean, and the barrier reef changes into an atoll featuring an exposed lagoon. This idea was supported by American geologist Dana.

Murray's Theory: Murray asserts that reef formation is the result of the sea floor being raised, which can occur due to subsea volcanic eruptions or the accumulation of skeletal remains of minute planktonic organisms that reside near the surface and descend upon decomposition. Coral started proliferating on the platform once it had attained an optimal vertical distance, ultimately ascending to the top of the structure.

Submerged Bank Theory: Scientists have recently postulated that coral organisms develop to construct reefs on pre-existing flat surfaces, either while the substrate is submerged or afterward. This phenomenon is

caused by the erosion and denudation of an island, which occur both above and below the water's surface. The builder will create an atoll by totally replacing an island with a plateau that is submerged in water.

Daly Glacial Control Theory: Daly was the one who initially proposed this theory. According to him, the formation of the polar ice caps, which are over a mile thick and spread across the entire planet, occurred during the most recent glacial epoch.Consequently, the water level decreased by a minimum of 150 feet, exposing numerous flat platforms composed of accumulated sediment and mud. The low temperature of the island acted as a barrier to the development of coral reefs, which prevented their expansion.As a consequence of the ice's thawing, the sea level rose and the platform became increasingly submerged. The sea temperature has increased to more than 10 degrees Celsius, making it appropriate for the growth of coral. It is projected that the global sea level is increase by 3.2 millimetres a year (from 1993 to 2010) as a consequence of the warming of the ocean, which causes an increase in volume, and the melting of land ice. (Impacts, 2014).

Consequently, the prevailing theories at present are the complementary submerged bank theory and Daly's theory, which are currently the most popular theories, even though Darwin's hypothesis continues to receive a lot of support.

VIII. ZONES OF CORAL REEF

- Ecosystems that are found on coral reefs are composed of three separate zones, each of which represents a different form of habitat.
- I. The Fore Reef, II. The Reef Crest, and III. The Back Reef, also known as the Reef Lagoon.
- Moyle and Cech identified six zones, however the majority of reefs only contain a few of these zones.
- All three zones are physically and ecologically connected:
- **Reef Surface**: The shallowest depth on the reef. It is susceptible to the fluctuations in tidal levels and surges. Frequently, water is agitated. A plethora of light is available in this area to support photosynthetic organisms.
- **The off-reef floor:**It consists of the reef's encircling shallow seafloor. This zone is characterized by continental margin reefs.
- **Reef drop off:** It is fifty meters deep and is home to numerous reef species. This zone primarily affects the reefs that encircle atolls and oceanic islands.
- **The reef face:** It is the region situated higher than the reef floor or reef slides. The most varied region of the reef**.**
- **The reef flat:** The bottom is composed of sand.
- **The reef lagoon:** It is a completely contained location, resulting in an area that is less susceptible to wave effects.

IX. BIODIVERSITY

Coral reefs are extraordinarily productive ecosystems that sustain an extensive diversity of living species and ecosystems and a variety of maritime habitats. (Pandolfi et al., 2003; Pörtner et al., 2014).These habitats support a diverse array of organisms including sponges, cnidarians, crabs, echinoderms, sea turtles, sea snakes, fish, and seabirds. Mammals are few, except dolphins that visit.

Algae: They are the predominant organisms found in the reefs. Reefs are susceptible to the invasion of algae. The cause of this issue is mostly attributed to the depletion of fish populations owing to excessive fishing and the excessive supply of nutrients resulting from the discharge of sewage and chemical fertilizers from coastal development in the vicinity. Algae can deplete the oxygen available to corals, resulting in their reduced state and ultimately causing destruction to the

reef. Grasses, coralline algae, and macroalgae make up the algal community.

Sponges:For the coral reef ecosystem to work, sponges are essential. Coral reefs produce organic matter through the metabolism of algae and coral. After sponges break down the organic matter, tiny particles are released into the water for green algae and corals to absorb.

Fishes: Coral reefs have a high level of piscine biodiversity. Coral reefs are home to over 4000 fish species. The cause of this variation is unknown. Coral reefs may produce 35 metric tons of fish each square kilometer yearly(R. N. Hughes et al., 2014).

Invertebrates: The coral skeletal substrate is inhabited by a variety of invertebrates known as "Cryptofauna." These invertebrates either bore into the skeleton or reside in existing gaps and fissures.The organisms that excavate tunnels in the rock include sponges, clamshell Mollusks, and sipunculans. The reef ecology consists of a diverse array of organisms, particularly crabs and polychaetes.

Sea birds: The coral reef system plays a vital role as home for several seabird species. The Midway Atoll in Hawaii harbors around 3 million seabirds, comprising 1.5 million *Laysan albatrosses*, or two-thirds of the worldwide population, and one-third of the global population of black-footed albatrosses. Each species of seabird exhibits a unique nesting site within the atoll. Midway is home to a total of 17 species of seabirds. Marine bird species, including egrets, gannets, and pelicans, predominantly rely on reef fish as their primary food source.

Other: Sea snakes have a diet that consists solely of fish and their eggs. Several terrestrial reptiles occasionally inhabit reefs, including monitor lizards, marine crocodiles, and semi-aquatic snakes. Hawkbill sea turtles mostly consume sponges as their main source of food.

X. THREATS TO CORAL REEFS

Coral reefs face several threats from a variety of reasons. Global mortality is occurring. Rough approximations indicate that almost 10% of the coral reefs worldwide have perished. Approximately 60% of the Earth's coral reefs are in jeopardy as a result of detrimental human activities. Ocean acidification, a phenomenon known as the change in pH of surface water, has occurred over the past century. The rapid advancement of technologies for discovering and utilizing the biological and mineral resources found in deep-sea ecosystems has increased the negative effects caused by human activities(Freiwald et al., 2004; Ramirez-Llodra et al., 2010). In South East Asia, the health of the reefs is under significant jeopardy, with 95% of them being vulnerable to local risks (Caldeira & Wickett, 2003). By 2030, it is anticipated that 90% of the reefs will be vulnerable to both human activity and climate change.

- Mining for coral, runoff from farms and cities, organic and inorganic contaminants, excessive blasting fishing, and various diseases are only a few of the many threats to coral reefs.
- • Building a channel and channeling it to the islands • Increase in ocean temperature as a result of global warming • Elevation of sea level • Alteration in water acidity levels owing to ocean acidification • Release of greenhouse gases into the atmosphere • Rapid growth of population along the coastline • Encroachment of non-native species

XI. MAJOR CORAL REEFS OF THE WORLD

- **The Great Barrier Reef:** The Great Barrier Reef is the most extensive coral reef system globally, consisting of around 2900 distinct reefs and 900 islands, spanning across a distance of

2600 km along the coast of Queensland, Australia.

- **The Mesoamerican Barrier Reef System:** Stretching for one thousand kilometers from Island Contoy at the point of the Yucatan Peninsula to the Bay Islands of Hondurus, this reef is the second largest in the world.
- **The New Caledonia Barrier Reef**spanning 1500 kilometers, is the second-longest double barrier reef in the world.
- **Andros, Bahamas Barrier Reef:** This reef ranks third in size globally.
- **Red Sea:**A 6000-year-old fringing reef(Stone, 1995).
- **Florida Reef Tract:** The largest continent-wide US reef.
- **Pulley Ridge:** Florida's deepest photosynthetic reef.

XII. CORAL REEFS IN INDIA

- Coral reefs are a highly old and vibrant ecosystem found in India. Indeed, they are.
- **Andaman and Nicobar Islands**: Most of the 500 Bay of Bengal islands' Fringing and Barrier reefs are rich in biodiversity.
- **Gulf of Kutch**: is all fringing reef. Wide temperature range and high salinity reduce reef development. Their biodiversity is lower. Marine National Park covers the Gulf of Kutch.
- **Gulf of Mannar and Palk Bay**: A surrounding reef with 21 islands runs from Rameshwaram to Thoothukudi.
- **Lakshadweep**: Approximately thirty-six coral atolls are known to exist, with ten of them being populated.

CONCLUSION

Coral reefs offer a unique ecological habitat for both stationary and moving creatures. They have gained widespread notoriety due to their emphasis on ecotourism and fishing amenities, efforts to limit coastal erosion, and the presence of breathtaking natural wonders. Based on fossil evidence, corals appear to have a higher propensity for extinction than certain associated organisms, whose habitat demands may have been less stringent. With the global expansion of coral restoration initiatives, there is an increasing need to enhance sophisticated monitoring techniques for reef restoration beyond post-restoration surveillance. Metabolic monitoring has the potential to be extensively implemented in the realm of coral restoration. Monitoring changes in benthic composition that occur simultaneously with coral restoration progress could provide crucial information to restoration practitioners, researchers, and stakeholders.

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