

Widespread Occurrence of Coral Growth Anomalies in the Republic of Maldives

Chiara Bises ^{1,2,*}, Inga Dehnert ^{1,2}, Greta Aeby ³, Michelle Dennis ⁴, Jacopo Gobbato ^{1,2}, Jessica Hodge ⁵, Miriam Staiger ⁶, Federica Siena ^{1,2}, Paolo Galli ^{1,2,7} and Simone Montano ^{1,2,7,*}

- ¹ Department of Earth and Environmental Sciences (DISAT), University of Milano—Bicocca, Piazza della Scienza, 1, 20126 Milano, Italy; inga.dehnert@unimib.it (I.D.); jacopo.gobbato@unimib.it (J.G.); federica.siena@unimib.it (F.S.); paolo.galli@unimib.it (P.G.)
 - ² MaRHE Center (Marine Research and High Education Center), Magoodhoo Island, Faafu Atoll 12030, Maldives
 - ³ Department of Biological and Environmental Sciences, Qatar University, Doha 2713, Qatar; greta@hawaii.edu
 - ⁴ Department of Biomedical and Diagnostic Sciences, University of Tennessee College of Veterinary Medicine, 2407 River Drive, Knoxville, TN 37996, USA; mdenni12@utk.edu
 - ⁵ Maldives Underwater Initiative, Six Senses Laamu, Laamu Atoll 15090, Maldives; jess.hodge@sixsenses.com
 - ⁶ The Manta Trust, Maldives Manta Conservation Programme, Olhuveli Island, Laamu Atoll 15090, Maldives; miriam.staiger@mantatrust.org
 - ⁷ NBFC (National Biodiversity Future Center), 90133 Palermo, Italy
- * Correspondence: c.bises@campus.unimib.it (C.B.); simone.montano@unimib.it (S.M.)

Abstract: In the last decades, there has been a concerning increase in the frequency and severity of coral disease outbreaks on a global scale, resulting in significant damage to the coral reef ecosystem and biodiversity. Growth anomalies (GAs) have been increasingly observed, with significantly higher occurrences in larger and older coral colonies compared to their smaller counterparts. However, there is a notable lack of knowledge and reports regarding growth anomalies in the Maldivian region. Here, we provide the first evidence of four distinct growth anomalies on three coral species, respectively on *Acropora* sp., *Montipora* sp., and *Pachyseris speciosa*, observed across four different locations across three atolls within the Maldivian Archipelago.

Keywords: coral diseases; coral reefs; Indo-Pacific Ocean; skeletal tissue anomalies



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Coral reefs are experiencing a rapid and significant decline in biodiversity, primarily attributed to the consequences of climate change, disease outbreaks, and pollution resulting from human activities [1]. In recent times, there has been an alarming increase in the frequency and intensity of coral disease outbreaks worldwide, causing significant damage to coral reef diversity and communities. This phenomenon has resulted in enhanced susceptibility among coral hosts, expanded pathogen range, and increased pathogen survival and disease transmission [2,3]. Among the most widespread, but less known, coral diseases are the anomalous growth forms, commonly known as growth anomalies (GAs) [4], observed with increasing frequency and severity on stony corals [5,6].

The aetiology of growth anomalies is still under investigation [7,8]. However, studies have established that, in some coral species, the prevalence of growth anomalies are correlated with anthropogenic stressors and extreme temperature conditions [9]. Even though the causes are still unknown, genetic predisposition, UV radiation, and infectious agents have all been suggested [4].

Generally, GAs have been observed on larger and older colonies relative to smaller colonies, as growth abnormalities usually are a chronic disease which can accumulate through time [10], although they can be transitory in some coral species [11].

Growth anomalies have significant implications for the morphology [12,13] and biological functioning of coral colonies, leading to restricted reproductive capabilities [5,14,15], diminished feeding capacities [16,17], and compromised defences against external agents [18,19]. Furthermore, *Acropora*, *Montipora*, and *Porites* are the most frequently reported as being affected by GAs [16,20], suggesting a notable susceptibility of these genera to the development of growth abnormalities. Nonetheless, it remains unclear whether the prevalence of GAs within these genera is primarily influenced by their dominance within coral reefs or if it signifies a distinct susceptibility inherent to each genus.

Herein, we report a widespread occurrence of growth anomalies found in the Republic of Maldives. While tumours seemed uncommon in the region, coincidental observations during other underwater studies or activities, such as the ones here reported, began to occur more frequently. In particular, GAs on coral colonies were observed on different islands' reefs: Adanga ($3^{\circ}08'19.9''$ N $73^{\circ}00'30.6''$ E) and Magoodhoo ($3^{\circ}4'49.08''$ N $72^{\circ}57'57.19''$ E) in Faafu Atoll; Falumafushi house reef in the Gaafu Alif Atoll ($0^{\circ}40'07.1''$ N $73^{\circ}26'05.3''$ E); Olhuveli house reef in the Laamu Atoll ($1^{\circ}48'57.7''$ N $73^{\circ}24'15.6''$ E). The growth anomalies were found on three coral species (*Acropora* sp., *Montipora* sp., and *Pachyseris speciosa*) at different depth and zonation on the reefs: at the edge of the flat and front reef in the first 3–4 m (Figure 1a,b) and in different depths on the slope; respectively, 5–6 m (Figure 1c,d), 12–13 m (Figure 1e,f), and 9–10 m (Figure 1g,h).

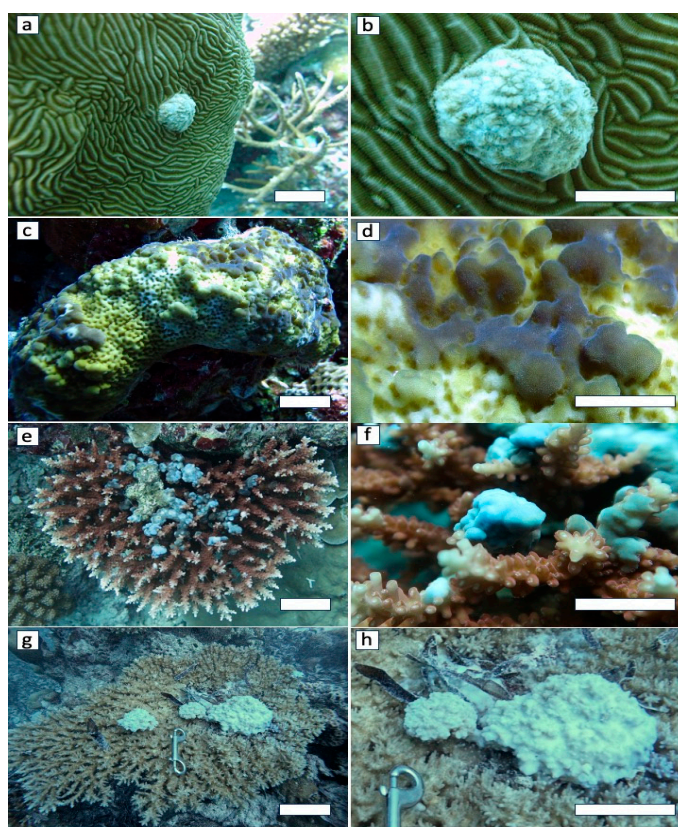


Figure 1. (a) Nodular growth anomalies on *Pachyseris speciosa*; (c) bosselated growth anomalies on *Montipora* sp.; (e) umbonate growth anomalies on *Acropora* sp.; (g) nodular growth anomalies on *Acropora* sp.; closer view of growth anomalies on *Pachyseris speciosa* (b); on *Montipora* sp. (d); on *Acropora* sp. (f); on *Acropora* sp. (h) (Scale bars: (a,b,e,f) 2 cm; (c,d) 1 cm; (g,h) 5 cm).

Grossly, a GA appears as a discrete mass of abnormal skeleton and thin tissue of various shapes, with colour different to the rest of the colony. Following the classification of Ricci et al. (2022) [21], shape is further characterised as a nodular formation (Figure 1a,b,g,h), isolated to a coalescing and rounded bosselated shape (Figure 1c,d) with an undulating

surface and umbonate (Figure 1e,f) with a smooth and rounded shape. The location of growth anomalies on colonies varied, having no obvious common position on the colony. Notably, this is the first report of GAs on *Pachyseris speciosa*.

Finally, despite coral diseases having been extensively studied and found in the Maldives [22,23], no growth anomalies were previously reported. There is still lack of information regarding the prevalence of these anomalies in the reef; however, the growing interest in the subject may suggest an increasing frequency or an enhanced ability to recognise them.

Therefore, the lack of knowledge of growth anomalies in this region of the Indo-Pacific emphasises the need for conducting investigations to assess their presence, prevalence, distribution, and pathology to better understand their ecology and potential causes.

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