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## Coral Disease Prevalence on Scleractinian Corals at Prigi Bay, Trenggalek, East Java

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**Abstract.** Coral disease prevalence is defined as the ratio of diseased coral colonies to total colonies in a certain place. Coral community health is determined by measuring coral colony health using an index based on the percentage of diseased coral colonies within a quadrat transect. Disease in coral can be triggered by environment factors. Declining seawater quality leads to stress of the coral host and faster growth of pathogens both in the water and the body of the corals, caused coral disease. Prigi Bay is a heavily used area that has valuable ecosystems including coral reefs; however, nowadays the high level of anthropogenic activities in this bay is becoming a threat to coral health. The aim of this research was to examine the coral disease prevalence in Prigi Bay. Three stations were selected as coral disease monitoring stations: Patuk Sewu, Watu Lunyu, and Damas. In total, we surveyed 5,057 coral colonies. The highest coral disease prevalence was found at the Patuk Sewu station (17.23%), while at the Watu Lunyu and Damas stations prevalence was 3.31% and 3.15%, respectively. High coral disease prevalence in Patuk Sewu may cause by the abundance of explained growth anomalies (EGA). EGA is strongly correlated with water quality, which has been associated with the kinds of disease observed. Since Prigi Bay is in the utilization zone, with a busy fishing port and fish processing industries that are likely sources of pollution which could influence water quality and the health of the environment. Coral disease prevalence in Prigi Bay can be considered as high, and future research should focus on other aspects of coral condition and the stressors affecting corals.

### 1. Introduction

Disease on scleractinian corals is one factor causing a decline in live coral cover by 50% in the Indo-Pacific area, which has been mostly attributed to a number of factors such as marine pollution, overfishing, nutrient enrichment, sedimentation, and tourism activities [1–4]. In the last decade, about 0.3% (275 million) of the 7.3 billion world population lived within 30 km of coral reef areas [5]. Prigi Bay area is in a utilization zone with a Nusantara Fishing Port situated in the northern part of Prigi Bay. During 2014, about 709 fishing vessels of various sizes (from less than 10 GT to 30 GT) anchored in Prigi Bay. These vessels frequently pass over the coral reef area around the periphery of Prigi Bay, causing mechanical damage (breakage) to coral colonies. Other threats include fishing activities by local fisherman and tourism activities.

Administratively, Prigi Bay is in Watulimo district, Trenggalek Regency, East Java Province, Indonesia. The Bay covers an area of 3,380 ha and comprises 21% of the total area of Trenggalek

Regency [6]. The local conditions in Prigi Bay are similar to many other regions in Indonesia, being influenced by the west and east monsoons. The west monsoon brings a lot of rain from the south-west to the southeast during December to February each year. Conversely, from June to August the wind comes from the southeast bringing dry air masses to the north-west. High fresh water input from rainfall increases the stress on corals; it has been reported that rainfall has a significant correlation with coral health because it can change the sea surface temperature, result in greatly increased nutrient loads from terrestrial sources and decrease the penetration of sunlight into the water column [7].

In this research we used the criteria in [8] to describe types of coral disease as follow: tissue loss from predation; tissue loss non-predation (coloured band diseases); tissue loss non-predation (no overlying band of floured material); tissue discoloration (white); tissue discoloration (non-white); growth anomalies; compromised health; and diseases in other reef organisms. Eight of those categories can be caused by various factors or pathogenic agents such as bacteria and virus.

Many human activities in the coastal area have impacts which can increase the number of coral disease types and their prevalence. Anthropogenic activities can change the environmental conditions, potentially disturb coral immune systems, change the number and type of microbes in the host coral and alter the ambient physic-chemical seawater properties experienced by the corals. This study used the coral disease index to evaluate the health condition of coral colonies in the Prigi Bay area.

## 2. Research Method

### 2.1. Time and Study Site

Field surveys were conducted in Prigi Bay from March to May 2017, during the first monsoonal transition period (between the west and east monsoons). Coral disease prevalence data were collected at three stations (stations 1-3): (1) Patuk Sawu (111°44'32"S; 08°19'17"E); (2) Watu Lunyu (111°44'40"S; 08°19'01"E); and (3) Pantai Damas (111°41'45"S and 08°19'23"E) (Figure 1).

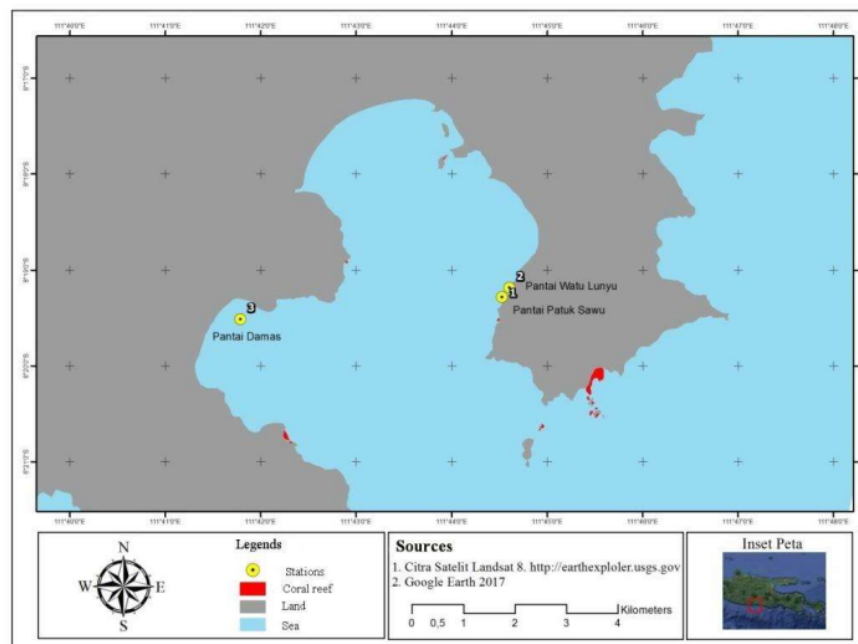
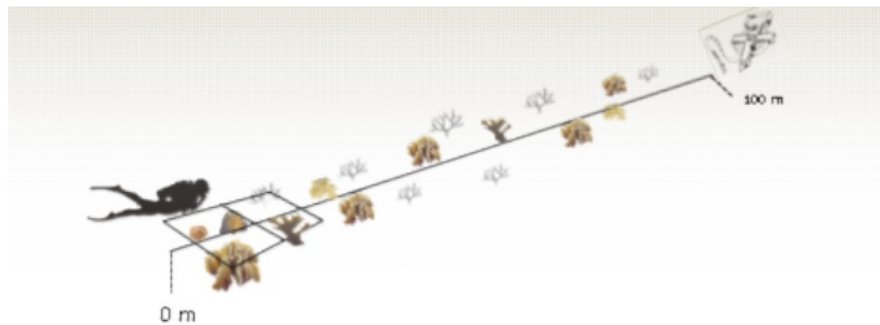


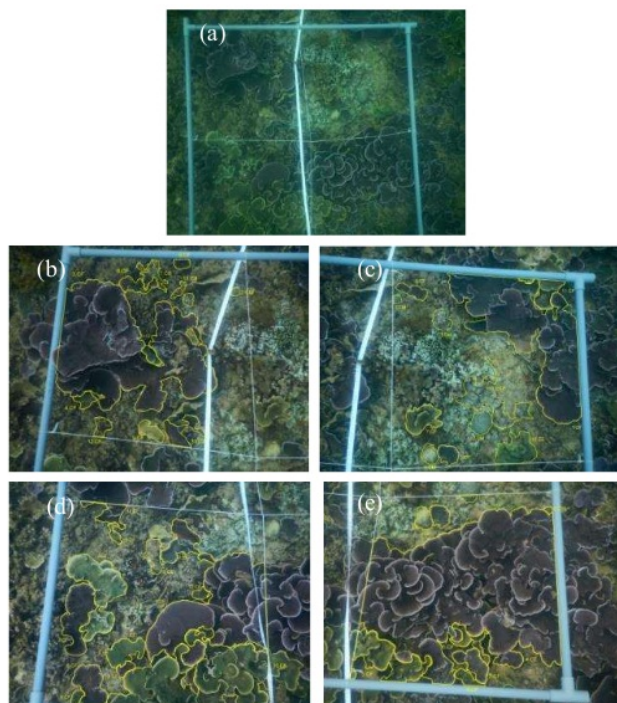
Figure 1. Map of the three coral disease survey stations around Prigi Bay

### 2.2. Disease prevalence data collection

Field surveys to collect coral disease prevalence data were conducted by using belt transects 1 m wide x 100 m long [8]. Coral disease data were recorded along these transects at each station. Quadrats were used to obtain coral taxon (genus) and disease data. The 1m<sup>2</sup> quadrats were divided into four 50x50 cm sub-transects. The corals in each sub-transect were photographed using an underwater camera (Canon PowerShot G-16, Japan) at a high-resolution setting (4000 x 2248 pixels). Each coral colony within the quadrats was then counted, identified to genus level and noted as healthy or diseased coral. The protocol of photographic data collection is described in figure 2 and 3.



**Figure 2.** Survey technique for collecting coral disease prevalence data using photo quadrats (1m<sup>2</sup>) set along a 100 m line transect.



**Figure 3.** Survey protocol using the photo transect (quadrat) method:  
a. placing the quadrat  
b-e: photographs of the four sub-quadrats.



2.3. Disease Identification

Figure 3 shows an example of the protocol used to collect coral disease data in the field, the first step was photographed whole quadrat transect (1x1 m) then continued took detail of coral colonies at each sub-transect to make detail of coral colonies. The high-resolution photographs taken in the field were edited to enhance brightness and correct the colour bias (enhancing red colour and reducing the blue colour) due to the light penetration underwater. The program ACD See Pro 8 was used before corals were identified and resulted in more natural coloration of the corals. All gross disease lesions on coral colonies were identified using the protocol developed by the Global Environment Facility (GEF) and World Bank Coral Disease Working Group [9].

14 Data Analysis

The prevalence of coral diseases was calculated by counting of number diseased coral colonies divided by all coral colonies within the belt transect at each station (equation 1) [10]:

$$P = \frac{a}{A} \tag{1}$$

8 where:

- P = Coral disease prevalence
- a = number of diseased coral colonies in the quadrat transect
- A = Total number of coral colonies within the quadrat transect

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3. Results and Discussion

3.1. Coral disease Prevalence

Coral disease prevalence was 17.23 %,at Station 1 (Patuk Sawu) while station two (Watu Lunyu) and station 3 (Damas) had similar prevalences (3.31 % and 3.15 %). The disease infected 6 coral genera: *Porites*, *Galaxea*, *Favites*, *Coelastrea*, *Pavona*, *Montipora*, and *Acropora*. *Coelastrea* (63.04 %) had the highest disease prevalence, followed by *Galaxea* (19.05 %) and *Porites* (8.89 %). No disease was observed on eleven coral genera: *Pocillopora*, *Lobophyllia*, *Merulina*, *Hydnophora*, *Sandalolitha*, *Fungia*, *Leptastrea*, *Favia*, *Cyphastrea*, *Turbinaria*, and *Astreopora* (Figure 4).

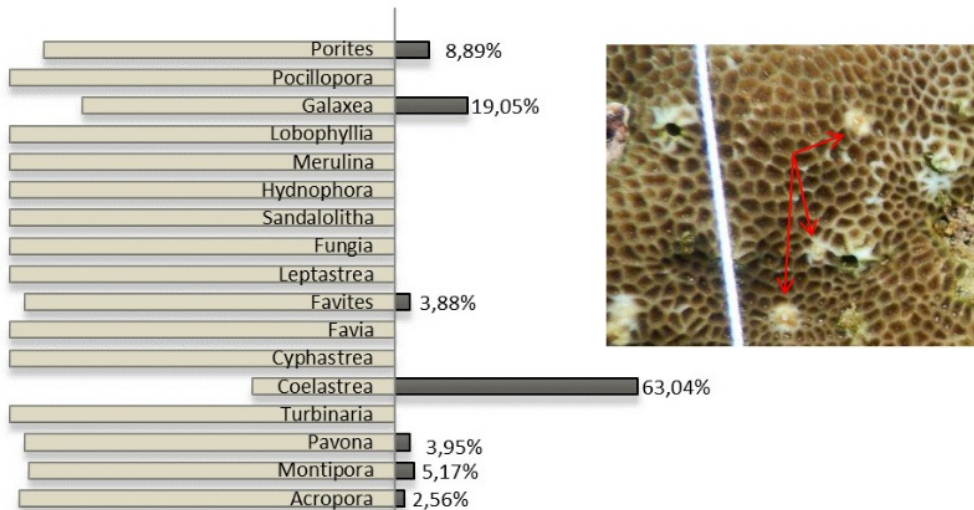
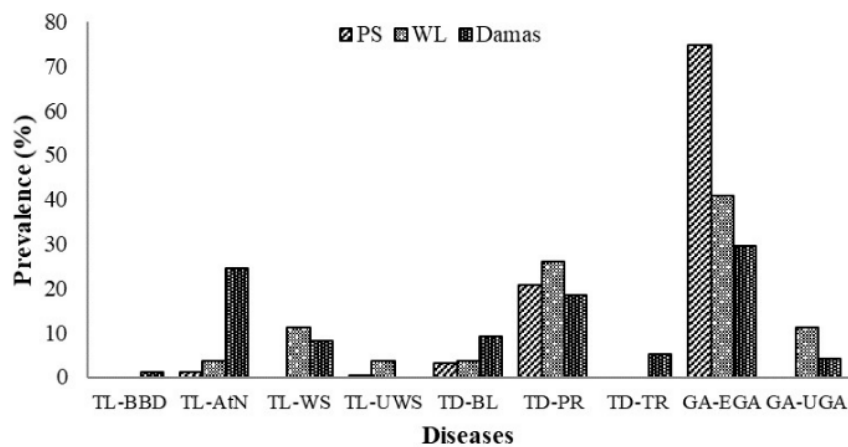


Figure 4. Disease prevalence by coral genus: pale grey = no disease; dark grey = disease present. Insert: explained-growth anomaly (EGM) on a *Coelastrea* colony.

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Figure 5 shows the types of coral disease observed in Prigi Bay. There were 9 types of disease, with the most prevalent being EGA (74.71, 40.74 % and 29.59 % at St 1, St 2 and St 3, respectively). The highest coral disease prevalence was on the massive coral *Coelastrea* (Figure 4). Growth anomalies are described as a circle or focal area where the polys diverge from the normal type or size of polyp. They are caused by infestation with polychaetes, bivalves, sponges and other bio-eroding organisms. Infestation of these invertebrates in the coral skeleton results in a discoloration of the coral polyps surrounding the focal point (infestation site). [11] identified about 18 species as borers in coral colonies in Ko Chang, Thailand, with the five-dominance species being *Leiosolenus lima*, *Lithophaga teres*, *Coralliophaga coralliophaga*, *Botula cinnamomea*, and *Gastrochaena cuneiformis*. The massive forms of the genera *Porites* and *Coelastrea* commonly suffer from this type of disease [10,11]. The main causes of growth anomalies in *Coelastrea* colonies at the study sites were barnacles and bivalves.



**Figure 5.** Coral disease prevalence by disease type. Site codes: PS = Patuk Sawu; WL = Watu Lunyu. Disease codes: TL = tissue loss; TD = tissue discoloration; GA = growth anomaly; BBD = black band disease; AtN = atramentous necrosis; WS = white syndrome; UWS = ulcerative white syndrome; BL = bleaching; PR = pigmentation response; TR = trematodiasis; EGA = explained-growth anomaly; UGA = unexplained-growth anomaly.

Barnacles are invertebrates that live in the sea, where their lives go through two stages: planktonic larvae and adult stages (attached phase) [12]. According to [13], barnacles belonging to the *Darwiniella* are often found in many massive coral colonies. The growth of barnacles on the coral surface can interfere with coral health because it can inhibit the coral skeleton deposit process. Barnacles can also weaken a coral colony, caused an elevated risk of mechanical breakage of the coral. This condition is also one of the main reasons for the lack of success in some coral rehabilitation processes [14].

The high prevalence of growth anomalies due to barnacles is thought to be related to the high prevalence of barnacles attached to the ships that often dock in the Bay, especially near station 1, including docking for leisure activities because this area is a tourist destination. The sessile barnacles carried on these vessels can release juveniles anywhere the ship passes. This hypothesis is supported by [15], who found that the distribution of barnacles in the sea can be supported by strong currents, waves, turbulence, and shipping lanes. [1] reported that the utilization area had a three-fold prevalence of coral disease compared to a protected area, and that the increase appeared to be caused by recreational activities in the water such as snorkelling and diving. Other factors that are likely to have contributed to the high coral disease prevalence at station 1 were high sedimentation and turbidity, as

this station is situated near to an estuary that receives a substantial sediment load of terrestrial origin. The intensive *in-situ* study in Montebello and Barrow Islands, Northwest Australia found a 2.5-fold increase in white syndrome prevalence associated with increased sediment loading and turbidity [16].

Excessive enrichment with nutrients such as nitrogen and phosphorus (eutrophication) over a long time period tends to increase disease and bleaching prevalence [17]; high levels of nutrients in seawater affect the microbial community in the coral tissue layers and can cause stress symptoms in coral colonies. The combination of elevated nutrients and increased sea surface temperature can act in synergy to increase the negative effect on coral health and result in declining coral abundance [14,16]. Nutrients from terrestrial sources, including sewage, can deliver large numbers of pathogens such as *Aspergillus sydowii*, and *Serratia marcescens* that are now thought to be responsible for the white pox disease of corals [16]. In addition, many microbes can become more virulent at higher sea surface temperatures. The surface mucopolysaccharide layer (SML) can harbour coral pathogens. Under normal conditions, this outer layer with its microbial community will protect the coral from pathogens coming from outside of the coral; disturbances to these communities due to environmental factors (high temperature and nutrients) can lead to disease in corals [14].

#### 4. Conclusion

The average prevalence of coral disease in Prigi Bay was 7.9%. This number is similar to but towards the higher end of the prevalence range reported from other regions, such as Australia (5%), Philippines (8%), and Palau (5%). Disease prevalence can reflect the environmental conditions in a given area, where high prevalence is generally related to a high level of environmental stressors acting on the coral reef. The high explained growth anomaly (EGA) prevalence in certain massive corals in Prigi Bay (especially the genus *Coelastrea*) indicates that stressors might include sedimentation and nutrient enrichment.

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