Extended geographic distribution of several Indo-Pacific coral reef diseases

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ABSTRACT

Other than coral bleaching, few coral diseases and diseases of other reef organisms have been reported from Japan. This is the first report of lesions similar to *Porites* ulcerative white spots (PUWS), brown band disease (BrB), pigmentation response (PR), and crustose coralline white syndrome (CCWS) for this region. To assess the health status and disease prevalence, qualitative and quantitative surveys were done in March and September 2010 on two reefs of the Ginowan-Ooyama reef complex in Okinawa, and two protected reefs off Zamani island in the Kerama MPA complex, 40 km west of Okinawa Island. Overall, mean disease prevalence was higher in Ginowan-Ooyama (9.7 ± 7.9%) compared to Zamami (3.6 ± 4.6%). *Porites lutea* was most affected by PUWS at Ooyama (23.1± 10.4 vs. 4.5 ± 5.2%). These results significantly expand the geographic distribution of PUWS, BrB, PR and CCWS in the Indo-Pacific, indicating that the northern-most coral reefs in the western Pacific are susceptible to a higher number of coral diseases than previously thought.

OBJECTIVES AND METHODS

Diseases of corals and other reef organisms are more commonly found in tropical regions where their impact has increased in the last decades with significant mortalities and coral community structure changes in many Caribbean and Indo Pacific coral reefs (Green and Bruckner 2000; Willis et al. 2004; Harvell et al. 2007, Miller et al. 2006; Weil et al. 2009; Weil and Rogers 2011). Few reports come from northern- and southern-most coral reef communities in both the Atlantic-Caribbean (Weil et al. 2002, Francini-Filho et al. 2008), and the Indo-Pacific (Yamashiro et al. 2000, 2004; Yamashiro & Fukuda 2009; Irikawa 2006, Irikawa et al., 2011, Dalton and Smith 2006). The most developed and diverse (415 spp) coral reefs of Japan are located in three groups of islands which form the Ryukyu archipelago (< 27˚ N), to the south of the main island of Japan (Fig.1). These highly diverse and extensive coral communities thrive mostly due to the warm waters of the Kuroshio current flowing from the south (Nishihira 2004). Few diseases have been reported for these communities (Sato 2006; Casareto 2008). The goals of this study were to characterize the status of coral diseases in reefs of two localities in the Ryukyu archipelago, Okinawa Island (exposed to human induced disturbances) and the Kerama Islands, 40 km west from Okinawa main island (without human disturbances)

To assess number of diseases, species affected, and prevalence of diseases affecting corals and other important benthic components (soft corals, sponges, crustose coralline algae, etc.), qualitative observations were conducted during the Spring (March of 2010), and quantitative surveys were done during the Summer (September 2010) at two geographically distant localities in the Ryukyu Island system: (a) the un-protected Ginowan-Ooyama deep (17-45m deep) reef complex located nearby Naha city, Okinawa, and (b) the Zamami reefs, located in the Kerama Islands, 40 km west of Naha, which is a Marine Protected Area (MPA) with low human impact (Fig. 1). Three 50 x 2 (100m²) belt-transects (N=6 per locality) were deployed between 7.4 and 9.6 m deep in each of the two Zamani reefs and between 9.6 and 10.5m deep in each of the two Ginowan-Ooyama spur-and-groove reefs. In March 2010, a one-hour SCUBA dive was conducted at each reef. Starting at the base of the reef (or 25m maximum depth), and slowly swimming up in a long zig-zag patterns following the contour of the reef, colonies were carefully checked in as many habitats as possible, tallied and photographed when disease signs, uncommon coloration patterns, lesions or scars were observed. Soft corals and crustose coralline algae (CCA) were also checked during these surveys.

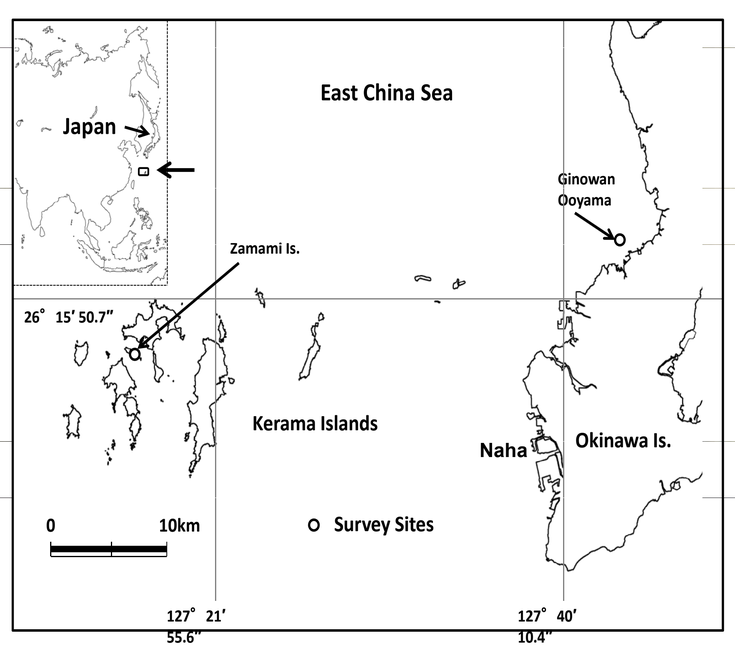

Figure 1: Map showing the localities and the approximate location of the reefs surveyed in the Ryukyu archipelago system, southern Japan. Several reefs surrounding Zamami islands, (1,000 residents and 90,000 tourists). Zamami Islands are 40 km away from severely disturbed area. The Ginowan-Ooyama reef complex is located in front of densely-populated areas (500,000 residents and 10 million tourists) including Naha, Okinawa's capital city.

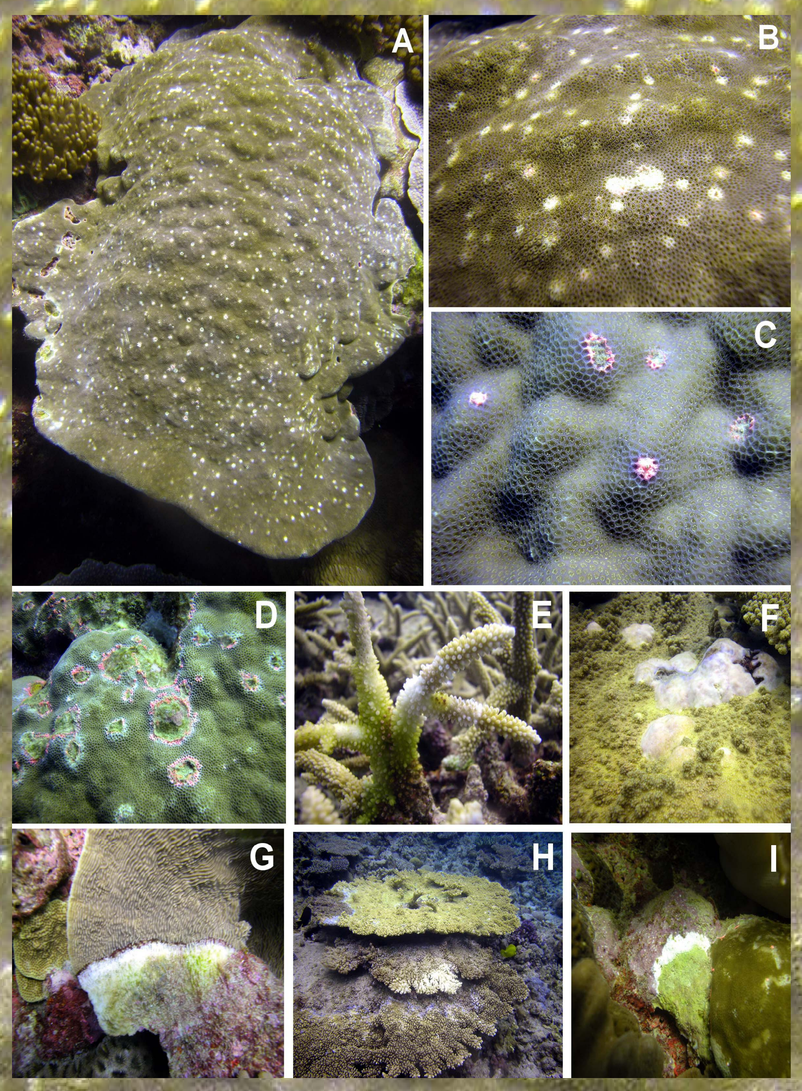

Figure 2. Photographs of newly found and already reported coral reef diseases in Japan reefs. Colonies of *P. lutea* showing signs of PUWS (A,B); pigmentation responses expressed as pink spots and pink lines on *Porites* colonies (C,D), brown band-like disease signs on *A. nobilis* (E), growth anomalies on *A. cytherea* (F), black band disease on *Pachyseris speciosa* (G), white syndrome on *A. florida* (H), and crustose coralline white syndrome on an unidentified coralline algae (I). (Photos E. Weil).

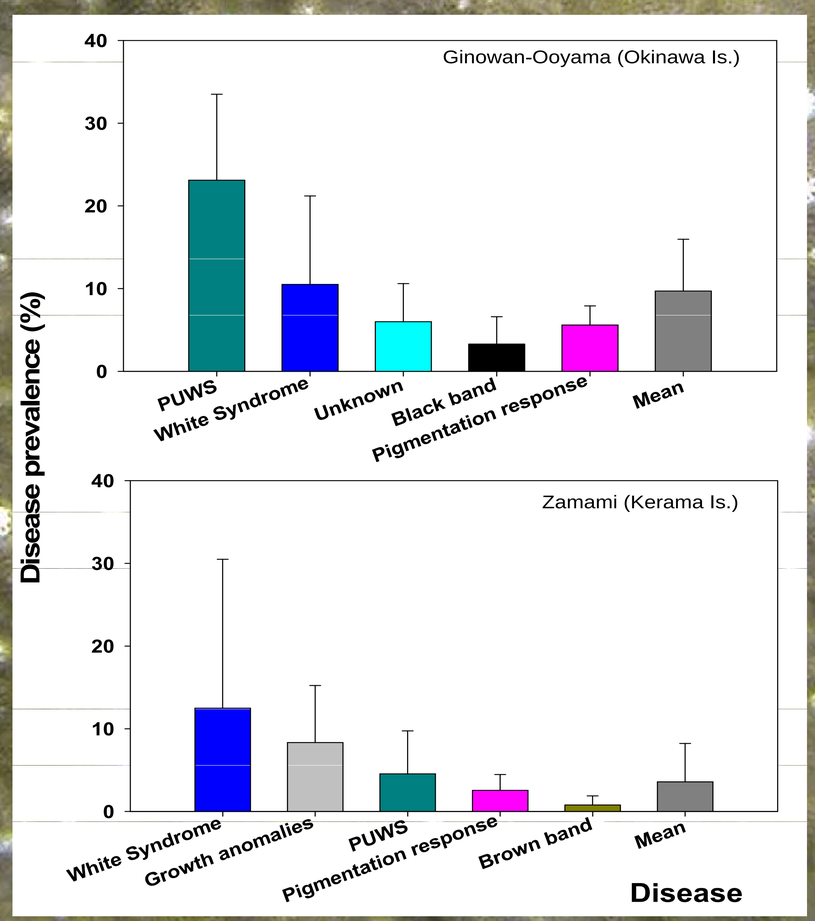

Figure 3. Mean disease prevalence in the main species affected in the two localities. Color bars correspond to coral genera/species (Top figure - Ginowan-Ooyama reefs– Dark grey = *Porites lutea*, blue= *Oxypora lacera*, red= *Pachyseris speciosa*. Bottom figure – Zamani reefs - Dark grey = *Porites lutea*, magenta= *Acropora cytherea*, mild blue= *Acropora nobilis*). Mean overall disease prevalence was significantly higher in the Ginowan-Ooyama reef complex exposed to human disturbance.

Disease condition	Abundance	Localities	Geographic distribution	Potential cause	Sources
GA	+++	+++	Indo-Pacific	Fungi, endolithic algae, virus, aging	Yashimiro (2004), Irikawa (2006), Irikawa et al. (2011)
PPBD (trematodiasis?)	++	++	Hawaii	Trematode larvae (*Podocotyloides* sp.)	Yashimiro (2004)
WS	++	++	Indo-Pacific	*Vibrio* sp. Apoptosis	Casareto (2008)
PUWS	++	++	Indo-Pacific	*Vibrio* sp	This study
BrB	+	+	Indo-Pacific	Ciliate	This study
BBD	++	++	Indo-Pacific	Cyanobacterial mat	Yashimiro (2004)
PR	+++	++	Indo-Pacific	Unknown	This study
CCWS	++	++	Indo-Pacific	Unknown	This study
Compromise health (CH)	++	+++	Indo-Pacific	Environmental/biological stressors	This study
Bleaching (BL)	++	+++	Indo-Pacific	Environmental stressors	Yamasato (1981)
White spots (focal bleaching)	+	+	Indo-Pacific	Environmental stressors ?	Yamashiro and Fukuda (2009)

Table 1. Summary of coral diseases, their relative abundance (+++ = high number of colonies affected; ++ intermediate; += few colonies affected) and number of localities (+++ = many; ++ few; += rare) reported from this study and from other reports (in parenthesis) in Japan. Potential causative agents include information on potential pathogens and other causes identified in studies from other geographic localities that may not be listed in the sources and that need verification.

RESULTS AND DISCUSSION

A higher than expected number of coral colonies were observed with disease signs during the Spring 2010 surveys, when water temperatures were in the low 20's. Four new syndromes constitute new reports for Japan: *Porites* ulcerative white spots (PUWS), brown band disease (BrB), pigmentation response (PR), and crustose coralline white syndrome (CCWS), significantly expanding their geographic distributions.

The overall mean disease prevalence was higher in the Ginowan-Ooyama complex (9.7 ± 7.9%) compared to the protected Zamami Islands (3.6 ± 4.6) (Fig. 2a, b). White syndrome (WS) mostly affected *Acropora cytherea* (12. 5 ± 18%) in Zamami and *Oxypora lacera* (10.2 ± 10%) in Ooyama. Growth anomalies (GA) and BrB were only observed on *A. cytherea* (8.3 ± 6.2%) and *A. nobilis* (0.8%) at Zamami. Black band disease affected *Pachyseris speciosa* (6 ± 4.6%) in Ooyama only. Pigmentation responses (PR) were common in massive *Porites* in both localities (2.6 ± 1.9 and 5.6 ± 2.3% respectively). Crustose coralline white syndrome (CCWS) was observed in both localities (Table 1, Fig. 2, Fig.3).

Other organisms observed with disease signs included the soft coral *Lobophyton* sp. which had several colonies with extensive bleached areas, loss of structure and areas with decomposing tissues. Several crusts of crustose coralline algae (CCA) were observed with thin ring-like white bands separating healthy looking tissues from dead areas (Fig. 2i), similar to those described as crustose coralline white syndrome (CCWS) in many localities in Caribbean and the Indo Pacific (Weil 2004; Weil and Jordán-Dahlgren 2005; Ballantine et al. 2005, Weil et al. 2006; Vargas-Angel 2010). Scars and irregular areas devoid of live tissue consistent with signs of recent predation by *Acanthaster planci* and *Drupella* spp. were also observed in the reefs surveyed. Snails were found under the colonies or nearby, but sea stars were not observed.

Overall, our results indicate that the northern-most coral reefs in the Pacific are susceptible to a higher number of coral diseases than previously thought and that greater effort to investigate these phenomena must be addressed. This is especially true for the southern-most coral reefs of Japan which seem to be experiencing significant increases in the number and prevalence of some of the most damaging diseases in the Indo-Pacific region. Further research is needed to identify the putative pathogens for these conditions in Japan, their host ranges, virulence, vectors and reservoirs.

More continuous quantitative surveys are needed to compare the spatial distribution and variability of the different diseases, establish baseline prevalence levels for the most damaging conditions, characterize their seasonal dynamics, assess co-variation with environmental parameters, and the short and long term impact (mortality, loss of fecundity, etc.) each disease condition is having at the population level of the affected species, and at the coral community level in the different reef localities

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