Short Communication

The Coral Triangle Initiative: what are we missing? A case study from Aceh

Edi Rudi, Stuart J. Campbell, Andrew S. Hoey, Nur Fadli, Matthew Linkie and Andrew H. Baird

Abstract The Coral Triangle Initiative is an ambitious attempt to conserve the marine biodiversity hotspot known as the Coral Triangle. However, the reef fauna in many nearby regions remains poorly explored and, consequently, the focus on the Coral Triangle risks overlooking other areas of high conservation significance. One region of potential significance, Aceh, Indonesia, has not been visited by coral taxonomists since the Dutch colonial period. Here we document the species richness of scleractinian corals of Pulau Weh, Aceh. We also compare the species richness of the genus *Acropora* at 3–5 sites in each of nine regions in Indonesia and Papua New Guinea. Although dominated by widespread Indo-Pacific species, the coral fauna of Pulau Weh is also the eastern and western boundary for many Indian Ocean and Pacific Ocean species, respectively. We identified a total of 133 scleractinian species, of which three have been previously recorded only in the western Indian Ocean and five are presently undescribed. The mean species richness of the *Acropora* at Pulau Weh is similar to regions within the Coral Triangle. This high species richness plus the high proportion of endemics suggests that the Andaman Sea is of similarly high conservation value to the Coral Triangle. We suggest that an international initiative similar to the Coral Triangle Initiative is required to conserve this region, which includes the territorial waters of six countries.

Keywords Aceh, biodiversity, conservation, coral reefs, Coral Triangle Initiative

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The terrestrial fauna and flora of South-East Asia has been a source of inspiration for biogeography since the field was founded following Alfred Russell Wallace's voyage through the Malay Archipelago in the 19th century (Wallace, 1869). Many marine organisms, including corals and reef fish, also have their global centre of diversity in South-East Asia (Veron, 1995; Roberts et al., 2002). More recent compilations of the global scleractinian and reef fish fauna have revealed a hotspot within South-East Asia now called the Coral Triangle (Allen, 2008; Veron et al., 2009), bounded by the Philippines to the north, the Solomon Islands to the east and Bali to the west (Fig. 1). Veron et al. (2009) further divided the Coral Triangle into 16 ecoregions, each with > 500 scleractinian species. The Coral Triangle contains a total of 605 scleractinian species, 76% of the world's total, including c. 15 (2.5%) endemic to the area (Veron et al., 2009). The reefs of the Coral Triangle are also amongst those most threatened globally by human activities such as destructive fishing and pollution (Todd et al., 2010; Fisher et al., 2011). Consequently, the protection of this hotspot of biodiversity is one of the major goals of marine conservation (Clifton, 2009).

The Coral Triangle Initiative is a collaborative conservation project that includes the governments of Indonesia, Malaysia, the Philippines, Papua New Guinea, Timor Leste and the Solomon Islands (Clifton, 2009). Areas outside the Coral Triangle, however, are important given the regional variation of the scleractinian fauna within Indonesia (e.g. Wallace, 1999) but may be overlooked with such intense focus on the Coral Triangle (Fisher et al., 2011). Sumatra, although part of Indonesia, is not considered part of the Coral Triangle and is therefore not a focus of the Initiative. In particular, the province of Aceh, in northern Sumatra, is likely to be of high biogeographical significance because of its position at the junction of the Andaman Sea, the Indian Ocean and the Straits of Malacca (Brown, 2007). Because of political instability over most of the last 150 years Aceh remains almost completely unexplored scientifically (Brown, 2007). Neither Veron (2000) nor Wallace (1999) examined material from Aceh and to the best of our knowledge the area has not be visited by a coral taxonomist since the Dutch colonial period. Consequently, we have a poor understanding of the scleractinian fauna of this region. Data deficient areas, such as Aceh, the Andaman and Nicobar Islands, and the Mergui Archipelago in Myanmar,

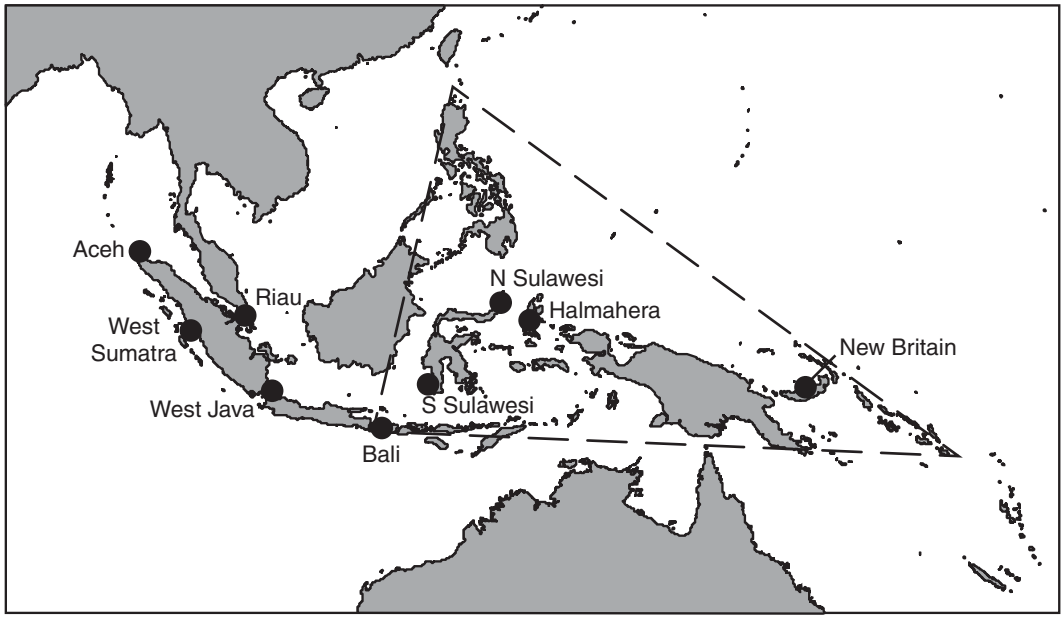

FIG. 1 Indonesia and Papua New Guinea, showing the Coral Triangle and the location of the nine regions used to compare the species richness of *Acropora*.

require biodiversity surveys to facilitate assessment of regional conservation priorities (Brown, 2007; Fisher et al., 2011).

The aim of this study is to describe the shallow water Scleractinia of Pulau Weh, Aceh, to facilitate an assessment of its conservation significance. A species list for Pulau Weh was compiled from 4–8 10-m line intercept transects at 11 sites in 2005 (Baird et al., 2005), six of which were resurveyed in November 2009. The list was supplemented with species encountered incidentally during these surveys. We also compare the species richness of the *Acropora* of Pulau Weh with another eight regions within Indonesia and Papua New Guinea, five of which are within the Coral Triangle. For this comparison the number of *Acropora* species was estimated in 40-minute haphazard swims at four sites on Pulau Weh in November 2009 and 3–5 sites in each of the further eight regions (Fig. 1). Sites in these eight regions were surveyed by AHB between 2001 and 2007. A one-way ANOVA followed by Tukey's post-hoc test was used to test for difference in the mean number of *Acropora* species among the regions. All data were collected by snorkelling, restricting the surveys to depths < 4 m. All species identifications where performed by AHB in the field, from images taken in the field, or from small samples of the colony skeleton with reference to Wallace (1999) and/or Veron (2000). All reference material for identifications is stored at the Centre for Marine and Fisheries Studies, Syiah Kuala University, Banda Aceh, Aceh, Indonesia.

The scleractinian fauna of Pulau Weh is unique, being a composite of widespread Indo-Pacific species (e.g. *Acropora hyacinthus*, *Acropora humilis*, *Acropora gemmifera*, *Acropora digitifera*), Indian Ocean species (e.g. *Acropora branchi*, *Acropora roseni*), Pacific Ocean species (e.g. *Acropora globiceps*, *Acropora lutkeni*, *Scapophyllia cylindrica*) plus locally abundant species found mainly in Indonesia (e.g. *Acropora pinguis*, *Acropora bifurcata*). A total of 133 hermatypic scleractinian species were identified, including three new records for the region (*A. branchi*, *A. roseni*, *Montastrea serageldini*) and five taxa potentially new to science (Appendix 1). Pulau Weh is the western boundary of 13 Pacific Ocean species and the eastern

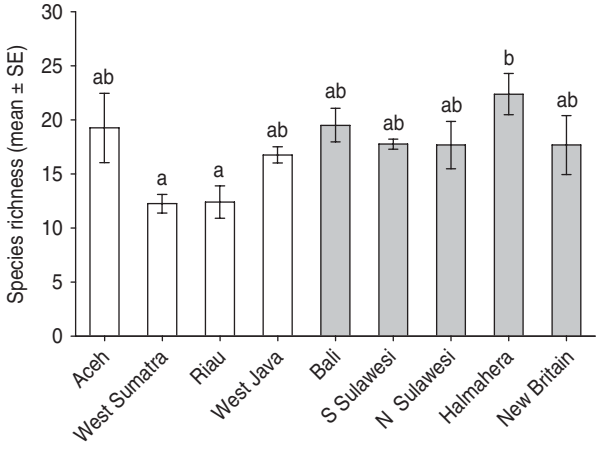

FIG. 2 Mean number of *Acropora* species per 10 m line intercept transect at nine regions in Indonesia and Papua New Guinea (Fig. 1). Sites within the Coral Triangle are in grey; sites outside the Coral Triangle are in white. An ANOVA indicated there were significant differences in the mean species richness among sites ($F_{(8, 30)} = 3.52$, $P = 0.005$). Letters indicate groups for which means are not significantly different, as determined by Tukey's post-hoc test.

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boundary of four Indian Ocean species (Appendix 1). Eight species are found only within the Indonesian archipelago (Appendix 1).

This species composition supports Wallace's (1999) description of a distinct Sumatran *Acropora* fauna but the presence of a number of Indian Ocean species and potential endemics suggest that the fauna of Aceh may be even more distinct. The high proportion of potential new species also supports Allen & Adrim's (2003) suggestion that the area is a distinct province in the Indo-Pacific. Both Veron (2000) and Wallace (1999) suggest there are many more species to be found in the area and Wallace & Muir (2005) described two endemic species at nearby sites in the Andaman Sea. Similarly, the genetic structure of the giant clam *Tridacna crocea* indicates that the western Sumatran population is distinct from other regions within Indonesia (DeBoer et al., 2008). Furthermore, the relative abundance of different strains of the coral symbiotic algae *Symbiodinium* in the Andaman Sea is suggestive of a distinct environmental and/or evolutionary history (LaJeunesse et al., 2010).

The diversity of the *Acropora* of Aceh is comparable with regions in the Coral Triangle. The mean number of *Acropora* species per transect at Pulau Weh was similar to five sites in the Coral Triangle and significantly higher than two other sites around Sumatra (Fig. 2). Surveys in Halmahera, in the heart of the Coral Triangle, with a larger geographical scale but similar sampling intensity, recorded 130 scleractinian species (Ardiwijaya et al., 2008), similar to the total of 133 recorded at Pulau Weh.

Hotspots of terrestrial biodiversity generally arise from aggregations of endemic species with narrow ranges. By prioritizing the conservation of such areas both biodiversity and genetic novelty are protected (Roberts et al., 2002). In the marine realm, however, areas of high species richness, such as the Coral Triangle, arise from the overlap of species with wide geographical ranges (Connolly et al., 2005; Veron et al., 2009). These species-rich areas often contain few endemics. Endemic species in the marine realm are generally more common in isolated regions, such as Hawaii and the Eastern Pacific (Bellwood & Hughes, 2001; Veron et al., 2009). Consequently, a focus only on areas of high species richness, such as the Coral Triangle, may not be an appropriate approach for the conservation of marine biodiversity, particularly if genetic novelty is also to be preserved (Baird et al., 2002). In the marine realm it will be necessary to conserve hotspots and areas with high numbers of endemics, such as Pulau Weh.

In conclusion, the scleractinian fauna of Pulau Weh is unique. It is distinct from other regions in Indonesia and probably has the closest affinity with reefs in the Andaman Sea. The high species richness plus the high proportion of endemics (c. 5%) indicates that the region is of high conservation value. If Pulau Weh is representative of the Andaman Sea an effort similar to that of the Coral Triangle Initiative will be required to conserve the reefs of this area, which include the territorial waters of India, Indonesia, Myanmar, Malaysia and Thailand.

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Appendix 1

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Biographical sketches

Edi Rudi's research interests include the biodiversity of reefs in Indonesia. Stuart Campbell has broad interests in conservation biology, with a focus on the marine realm in Indonesia. Nur Fadli's research interests include coral reef ecology. Andrew Hoey's research explores the functional importance of herbivorous fishes on coral reefs. Matthew Linkie has broad interests in conservation biology. Andrew Baird's research focus is the biogeography of the Scleractinia, in particular the genus *Acropora*. He has surveyed reefs in Indonesia from Sabang to Merauke.

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