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Exceptional biodiversity of the cryptofaunal decapods in the Chagos Archipelago, central Indian Ocean

Catherine E.I. Head[a,b,c,*], Michael B. Bonsall[a,d], Tom L. Jenkins[e,a], Heather Koldewey[b,f], Morgan S. Pratchett[g], Michelle L. Taylor[h,a], Alex D. Rogers[a]

[a] Department of Zoology, South Parks Road, University of Oxford, Oxford OX1 3PS, UK
[b] Zoological Society of London, Conservation Programmes, Regents Park, London NW1 4RY, UK
[c] Linacre College, St Cross Road, Oxford, OX1 3JA, UK
[d] St Peter's College, New Inn Hall Street, Oxford, OX1 2DL, UK
[e] Department of Biosciences, College of Life and Environmental Sciences, University of Exeter, Exeter EX4 4QD, UK
[f] Centre for Ecology & Conservation, University of Exeter Cornwall Campus, Penryn, Cornwall TR10 9FE, UK
[g] ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD 4811, Australia
[h] School of Biological Sciences, University of Essex, Wivenhoe Park, Colchester CO4 3SQ, UK

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ABSTRACT

The Chagos Archipelago is geographically remote and isolated from most direct anthropogenic pressures. Here, we quantify the abundance and diversity of decapod crustaceans inhabiting dead coral colonies, representing a standardised microhabitat, across the Archipelago. Using morphological and molecular techniques we recorded 1868 decapods from 164 nominal species within 54 dead coral colonies, but total species estimates (Chao1 estimator) calculate at least 217 species. Galatheids were the most dominant taxa, though alpheids and hippolytids were also very abundant. 32% of species were rare, and 46% of species were found at only one atoll. This prevalence of rarer species has been reported in other cryptofauna studies, suggesting these assemblages maybe comprised of low-abundance species. This study provides the first estimate of diversity for reef cryptofauna in Chagos, which will serve as a useful baseline for global comparisons of coral reef biodiversity.

1. Introduction

There have been various predictions regarding the number of marine species on Earth, spanning several orders of magnitude (Grassel and Maciolek, 1992; May, 1994). One of the most recent estimates suggests that there are ~2.2 million eukaryotic marine species, with < 10% having been described (Mora et al., 2011a). Among marine systems, coral reefs account for < 0.2% of the ocean floor, yet are recognised as the most biologically diverse marine ecosystem (Sala and Knowlton, 2006), with global coral reef species richness estimates of 830,000 multi-cellular plants and animals (Fisher et al., 2015). Coral reef invertebrate species richness, described to date, is estimated at 168,000 species (Ruppert et al., 2004; Stella et al., 2011a), far surpassing the number of fish species (~5000 species; Bellwood et al., 2012) and reef-building corals (700 species; Veron, 2000). The majority of these reef invertebrates are small and cryptic, often referred to as the cryptofauna, and live within the reef framework itself (Reaka-Kudla, 1997; Plaisance et al., 2011). The cryptofauna contains many poorly-known groups and are hard to sample as a result of their small and cryptic nature (Plaisance et al., 2009). Hence this component of biodiversity is understudied and further research is needed to improve species diversity estimates for several specific groups (Reaka-Kudla, 1997; Small et al., 1998; Plaisance et al., 2009). However, in recent years there have been several large-scale initiatives undertaken, such as the Census of Marine Life (http://www.creefs.org) and the Moorea Biocode Project (http://bscit.berkeley.edu/biocode), which have emphasised the importance of documentation of small and understudied organisms such as invertebrate and microbial species.

Approximately 20% of reef invertebrates are crustaceans, making them one of the most speciose groups on coral reefs (Plaisance et al., 2011 and Stella et al., 2011). Crustacea play a major role in the trophic dynamics of detrital-based food webs on coral reefs and are an extremely important link between primary production and higher consumers, as well as contributing to microbial- and detrital-based food webs (Enochs and Manzello, 2012a; Kramer et al., 2014). Overall, energetic transfer by coral reef crustaceans is estimated to average 0.066 g

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* Corresponding author at: Department of Zoology, South Parks Road, University of Oxford, Oxford OX1 3PS, UK.
E-mail address: catherine.head@zoo.ox.ac.uk (C.E.I. Head).

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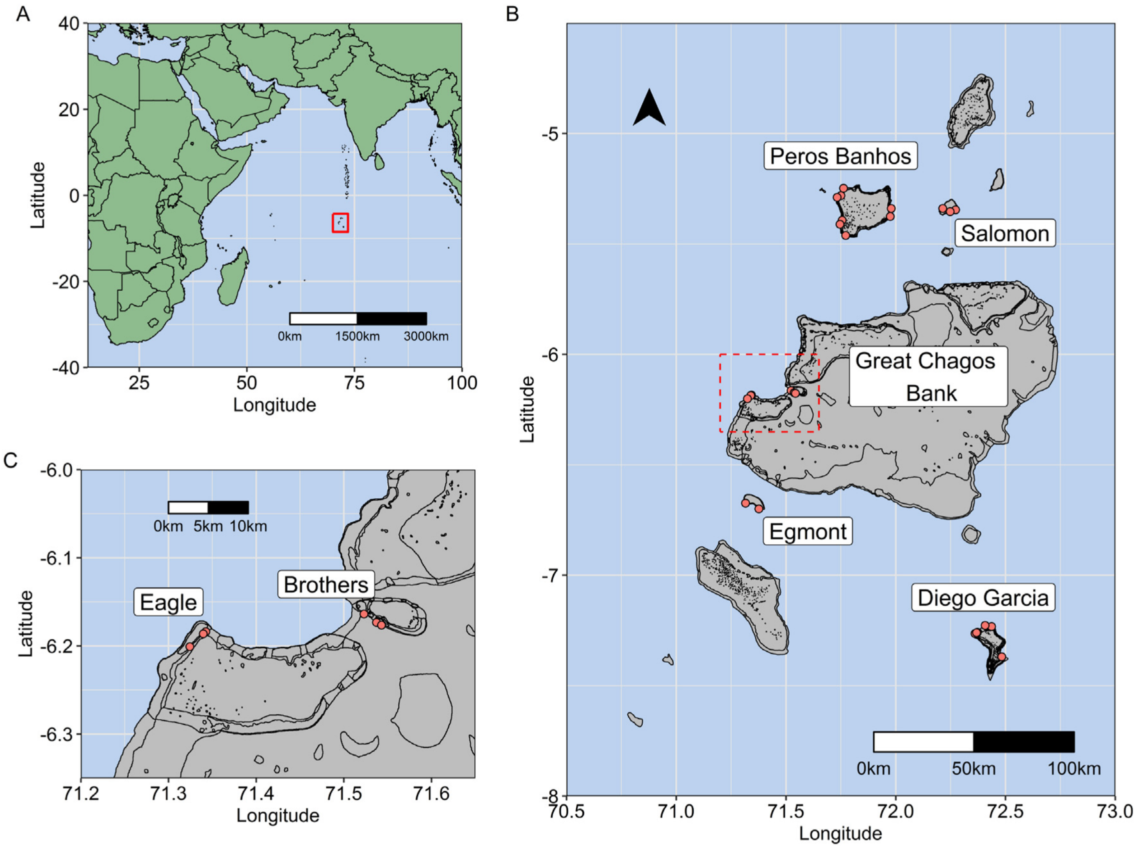

Fig. 1. The Chagos Archipelago; **(a)** illustrates the location of the Chagos Archipelago, **(b)** illustrates the atolls in the Archipelago with red circles representing the 25 sites where dead coral colonies were collected (*n* = *54*) on the 2012 and 2013 expeditions. Two coral colonies were collected at each site except at the three sites at Salomon Atoll where three coral colonies were collected at two of the sites and four colonies at the remaining site, **(c)** a close up of Eagle and Brothers Islands (part of the Great Chagos Bank) shows the distribution of the six sites around these two islands. In **(b)** and **(c)** the grey areas depict the submerged and unsubmerged atolls and banks. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

wet weight $m^{-2}d^{-1}$ (Kramer et al., 2014), comparable to productivity and transfer by fishes (0.20 g wet weight m − 2 d − 1; Depczynski et al., 2007). Crustacea are considered one of the most important dietary components of reef fish assemblages because 70% of reef fish are invertivores, and 60% of invertivores prey predominantly on benthic Crustacea (Williams and Hatcher, 1983; Randall et al., 1997; Froese and Pauly, 2014). In addition, decapods also have important functional roles in maintaining coral reef health with species cleaning fish of parasites, e.g. cleaner shrimp (Becker and Grutter, 2004), and some species defending coral colonies from predators and clearing excess sediment preventing smothering of coral polyps, e.g. *Trapezia* crabs (Pratchett, 2001; McKeon and Moore, 2014).

Crustaceans inhabit all reef microhabitats and are major components of invertebrate assemblages within live corals, dead corals, coral rubble, the epilithic algal matrix (Kramer et al., 2013), and sand (Kramer et al., 2014). Of these microhabitats, dead coral colonies have been identified as the most biodiverse habitats (Enochs, 2012; Kramer et al., 2014). This is probably because of the structural relief of the coral still remaining intact to provide habitat and shelter from predators, in comparison to the lower structural complexity of other microhabitats, such as sand and coral rubble. The heterogeneity of the benthic substrata increases on dead branching coral compared to live coral as sessile organisms, such as Porifera and Ascidiacea, colonise recently dead corals providing a variety of niches for motile cryptofauna (Enochs and Manzello, 2012b), resulting in higher biodiversity through complementarity and facilitative interactions (Hooper et al., 2005). In addition, the productivity of the complete faunal assemblage of dead coral colonies is estimated to be up to 149 g Ash-free Dry Weight (AFDW) $m^{-2} yr^{-1}$ (Kramer et al., 2014), suggesting this microhabitat is one of the most productive in the world, surpassed only by Californian macrophyte detritus and mussel beds in the Wadden Sea (Asmus, 1987; Taylor, 1998).

The greatest threat to natural biodiversity across all ecosystems is ongoing degradation and loss of critical habitats (e.g., Brooks et al., 2002; Waycott et al., 2009), which is being increasingly caused and compounded by global climate change (Mantyka-Pringle et al., 2012). This is especially acute for tropical coral reefs (Burke et al., 2011) which are impacted by multiple stressors including unsustainable and destructive fishing practices, sedimentation and pollution from coastal and maritime activities, and biological outbreaks of crown-of-thorns sea stars. These direct impacts are taking place against a background of increasing global climate change affects, such as mass coral bleaching events, eroding the resilience of reef ecosystems (e.g. Pandolfi et al., 2003; Harborne et al., 2017; Hughes et al., 2017). For instance, the Great Barrier Reef lost over 50% of it coral cover from 1985 to 2012 which has been further compounded by the 2015–2016 global mass bleaching event (D'eath et al., 2012; Hughes et al., 2018).

Despite the demonstrated importance of coral reef decapod assemblages there is little information on how decapod, or indeed cryptofauna communities, are affected by human-induced stressors (But see Coles, 1980, Tsuchiya, 1999, Idjadi and Edmunds, 2006, Leray et al., 2012). In other ecosystems, pollutants have been shown to impact abundance and diversity of decapods. For example, decapod communities on deep offshore banks suffered a dramatic decrease in both abundance and diversity following an oil spill, hypothesised to be a result of cascade effects from seaweed loss (Felder et al., 2014). Whilst, in a macrotidal estuarine environment an increase in species richness and abundance of mysid and caridean decapods over a 26-year study