Southeast Asian and Caribbean Cenozoic Reef-coral diversity and the importance of large new collections

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Analysis of specimen-based compilations of reef-coral species occurrences indicate widely differing Late Oligocene to Recent histories of coral reef ecosystems in Southeast Asia and the Caribbean. Caribbean reef ecosystems were altered by regional extinction during the Oligocene/Miocene and the Pliocene/Pleistocene (Budd 2000; Klaus et al. 2011). The Oligocene/Miocene extinction was associated with the collapse of reef building in the region, but contrary to expectations, the Pliocene/Pleistocene extinction is associated with regional reef recovery (Johnson et al. 2008). The depauperate extant Caribbean biota includes survivors of this extinction, and very few new species have appeared since.

Contrary to the Caribbean record, SE Asian reef ecosystems were apparently not strongly altered by extinction events (Fig. 1). In this study, we make use of the collections of fossil corals from the region held by NCB Naturalis (Leloux & Remena 2007) that were mainly collected as part of geological resource mapping in modern-day Indonesia and Malaysia during the late nineteenth and earliest twentieth centuries. The NCB collections include coral collections from 210 localities, with a total 1459 specimens, 1320 of which have been identified to species-level during the past century. We have attempted to bring species-level identifications up to date through examination of material and via species-level taxonomic revision, resulting in a reduction of species names applied from 305 to 271. However, this taxonomic revision had limited impact on the observed pattern of taxonomic turnover, suggesting that the observed pattern is in part controlled by uneven sampling intensity.

Stratigraphic ages of samples were also revised based on examination of associated larger benthic foraminifera (Fig. 2). Revised ages are now available for 79 sampling localities represented in the NCB collections. Age assignments changed in both position of midpoint and precision. Adjustments in midpoint were up to 17 Million years (from an Early Miocene to Pliocene age), but the distribution of changes is symmetrical about zero with a mean of 0.05 million years. As for the taxonomic revision, applying an updated stratigraphy had little effect on the observed pattern of faunal turnover.

These analyses suggest that in Southeast Asia, the Late Oligocene and Early Miocene is an interval of increased diversification (Fig. 2) that coincides with an expansion in coral-reef

Fig. 1: Turnover rates for reef-coral species estimated using the collections of Cenozoic fossil corals from Indonesia in the collections of NCB Naturalis. Estimates are sub-epochs bins using weighted methods (Johnson & Jackson 2000). A. Species richness including both range-through (light shading) and observed (dark shading) richness within each bin, B. the number of samples with age assignments crossing the bin, C. Numbers of first occurrences, and D. last occurrences within each bin.
development in the region (Wilson 2008). No intervals of accelerated extinction have yet been discovered in the Southeast Asian Neogene, suggesting that the high diversity of the regional reef biota is a function of continuous diversification. These results suggest that the regional response of coral reef ecosystems to global environmental change is strongly modulated by regional historical factors. Attempts to understand long-term global patterns of diversity and ecosystem distributions are enhanced by analysis of variation at non-global scales.

![Graph showing changes in the midpoint of ages assigned to coral samples from the collections of NCB Naturalis. New ages obtained after examination of associated larger benthic foraminifera.]

Fig. 2: Changes in the midpoint of ages assigned to coral samples from the collections of NCB Naturalis. New ages obtained after examination of associated larger benthic foraminifera.

New initiatives that are currently in progress include study of large new collections from well localized samples within well-resolved stratigraphic frameworks including a study of a new Late Oligocene biota from Malaysian Borneo (McMonagle et al. 2011) and the Throughflow Marie Curie Initial Training Network, a large-scale collaborative project supported by the European Union to study the Miocene shallow marine ecosystems of East Kalimantan (http://ipaeo.org/throughflow). The throughflow project includes partners from 9 institutions in Europe and Indonesia, including a range of sub-projects designed to independently reconstruct the geological, environmental, and biotic history of the Indonesian Throughflow (ITN) within a well constrained stratigraphic framework. This project has completed two 5-week long field seasons in East Kalimantan and is currently processing samples. Access to this much needed new information will allow for the first time a rigorous analysis of changing patterns of reef-coral diversity in the Neogene of SE Asia.