The Highest Southern Latitude Record of A Living Tridacna gigas

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THE HIGHEST SOUTHERN LATITUDE RECORD OF A LIVING *TRIDACNA GIGAS*

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INTRODUCTION

Tridacna gigas (Linnaeus), growing to over 1 m in length and weighing up to 200 kg (Lucas, 1988), is the largest extant representative of the Bivalvia. This familiar and charismatic taxon, found throughout the Pacific region, is a well recognized, important and iconic component of coral reef communities (Rosewater, 1965; Yonge, 1981). Despite its iconic status, the species is under threat due to over-harvesting and habitat destruction, and is listed as "vulnerable" on the IUCN's red list of threatened species (IUCN, 1983; Juinio et al., 1989; Hviding, 1993; Munro, 1993; Lucas, 1994).

Like hermatypic scleractinians, *T. gigas* has a symbiotic relationship with photosynthetic dinoflagellate algae, and it is this relationship that has allowed it to obtain its huge size (Schneider, 1998). Because of this similarity to corals, members of the Tridacninae, including *T. gigas*, have been used as a proxy to assess the health of coral reef settings (Aharon, 1991; Pätzold et al., 1991) and for reconstructing paleoclimates at a high-resolution (Ahron, 1983, 1991; Aharon & Chappell, 1986; Watanabe & Oba, 1999). Previous paleoclimate studies have concentrated on shell chemistry, as *T. gigas* calcifies in isotopic equilibrium with surrounding seawater (Watanabe et al., 2004). However, as temperature is a major control on distribution, with previous studies determining that shell growth is impossible below 19.2°C and optimum growth occurs in regions where the temperature is above 25°C for much of the year (Lucas et al., 1989), presence/absence of the taxon can also be an indicator of paleotemperature.

The above factors make understanding the modern distribution of *T. gigas* vitally important, as it has implications for conservation of the species and both current and future studies of the effects of changing climate on tropical reef ecosystems. Given the strict ecological control on its distribution (temperature limited), *T. gigas* is an obvious candidate to identify and evaluate the possible influence of changing climate on coral reef communities.

MATERIAL AND METHODS

Previously Known Distribution

The geographic range of *T. gigas* is poorly constrained, and the southern extent of the species is unknown. Based upon the distribution map provided by Lucas (1988: 22) the southernmost occurrences of *T. gigas* occur on the Great Barrier Reef and its distribution should extend below the Tropic of Capricorn (23°26.366'). However, Lucas (1988) provides no specific occurrences and notes that the species is "nearly extinct or recently extinct over a considerable part of the range". Most occurrences recorded in the literature for the Great Barrier Reef are largely confined to the northern portion of the reef (less than 20°S) with few records of this taxon at latitudes greater than 19°S (Fig. 1). Braley (1987a, b), reported no living individuals south of 19°33'S in a census of *T. gigas* populations on the Great Barrier Reef. Ayling & Ayling (1986), in their survey of biodiversity of the southern Great Barrier Reef, recorded *T. gigas* in the north-easterly part of the Swain Reefs and at Elusive Reef (21°4.777'S). They specifically list *T. gigas* as absent from sampled sites in the southern-most part of the Great Barrier Reef, such as Heron Island and other Capricornia section reefs (Ayling & Ayling, 1986, Table 13). The Global Biodiversity Information Facility (GBIF) database lists no records of *T. gigas* south of 21°44'S and all of the southern-most specimens recorded represent single disarticulated valves of deceased individuals of indeterminate age (I. Loch pers. comm.) Therefore, no records exist in the literature of live individuals in the southern part of the Great Barrier Reef, south of the Capricorn Channel.

Location

Heron Reef, part of the Capricorn-Bunker group, is located just south of the Tropic of Capricorn, and 85 km north-east of Gladstone, central

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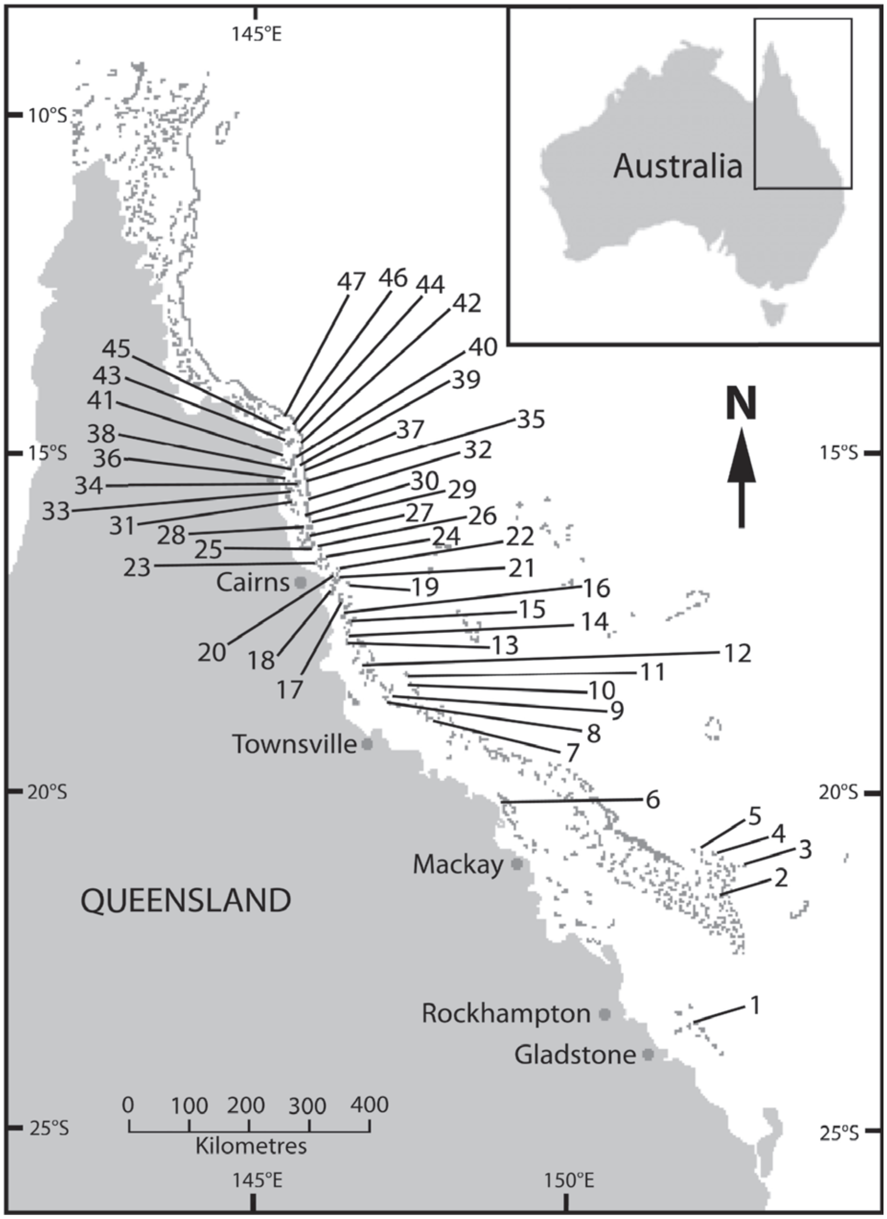


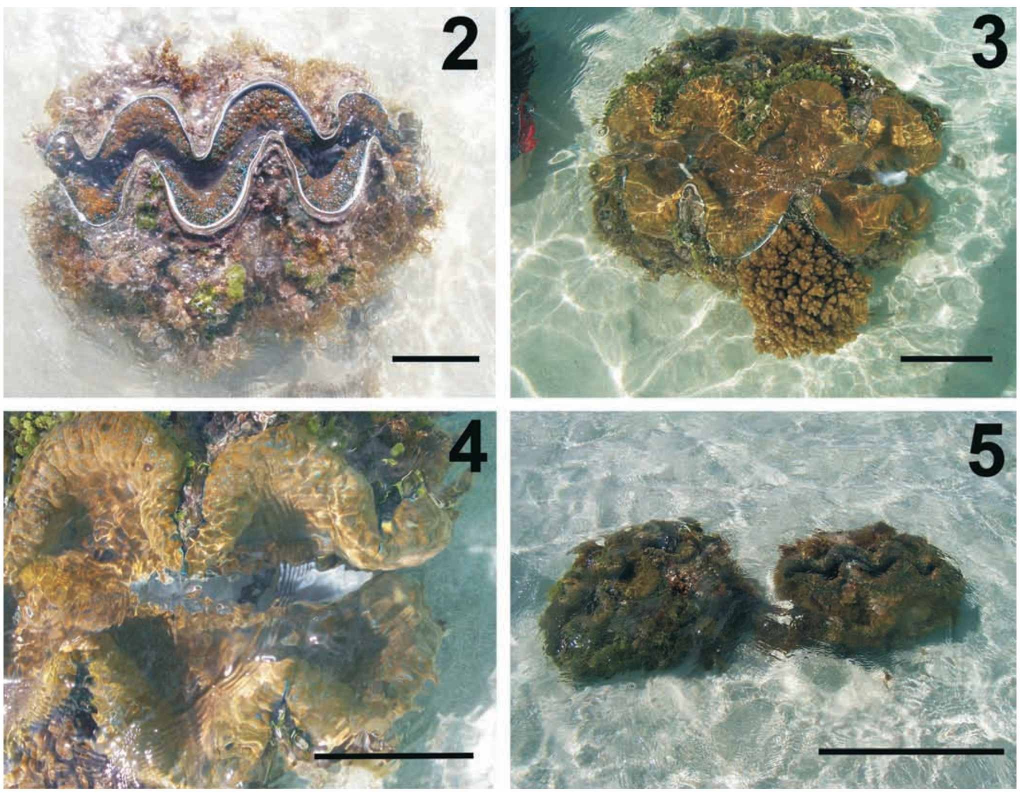
FIG. 1. Occurrences of *Tridacna gigas* on the Great Barrier Reef, based upon data published by Braley (1984), Ayling & Ayling (1986), Braley (1987a, b), Global Biodiversity Initiative Fund Portal (accessed 2008) and this study. 1. Heron Island, 2. Frigate Cay, 3. Elusive Reef, 4. 20-396 Reef, 5. 20-394 Reef, 6. Hayman Island, 7. Broadhurst Reef, 8. Lodestone Reef, 9. John Brewer Reef, 10. Dip Reef, 11. Myrmidon Reef, 12. Brook Island Reef, 13. Barnard Island, 14. Feather Reef, 15. Wardle Reef, 16. Peart Reef, 17. Russell Island, 18. High Island, 19. Channel Island, 20. Fitzroy Island, 21. Northwest Reef, 22. Flynn Reef, 23. Green Island, 24. Arlington Reef, 25. Upolu Reef, 26. Michaelmas Reef, 27. Batt Reef, 28. Opal Reef, 29. Tongue Reef, 30. St Crispin Reef, 31. Hope Island, 32. Escape Reef, 33. Cowlishaw Reef, 34. 15-043 Reef, 35. Ribbon Reef No. 5, 36. Egret Reef, 37. Ribbon Reef No. 6, 38. Boulder Reef, 39. Williamson Reef, 40. Forrester Reef, 41. Low Wooded Island, 42. Two Island, 43. Martin Reef, 44. Macgillivray Reef, 45. Lizard Island, 46. Carter Reef, 47. Day Reef.

Queensland, Australia. Heron Reef is approximately 27 km^2 in area, with Heron Island, a carbonate sand cay, located at the western end. A central lagoon dominates much of the reef (17 km^2) with the remainder of the reef consisting of shallow-water reef flat. Ambient water temperature varies between 20°C to 26°C.

RESULTS AND DISCUSSION

In April 2008, during a survey of the southern Heron Island reef flat, part of the Capricorn-Bunker group, four living specimens of *T. gigas* were discovered at 23°26.778'S. These specimens had been previously noted by one of the authors (Bagnato), who was unaware of their significance, and so had not officially recorded them. These specimens are the southernmost specimens of *T. gigas* ever recorded.

The Heron Island specimens are assigned to *T*. *gigas* based upon their large size, between 71 and 80 cm in length. This is well in excess of the maximum size of the next largest member of the genus *Tridacna*, *Tridacna derasa*, which reaches shell lengths of up to 60 cm (Lucas, 1988). The Heron Island specimens also exhibit shell thickening at the umbo, have a brown mantle with blue-green eyespots and have elongate, triangular projections present along the upper margin of the valve, all features that characterize *T. gigas* (Lucas, 1988) (Figs. 2–5).



FIGS. 2–5. *Tridacna gigas* individuals found at Heron Island. Orientations based upon Yonge (1953). FIG 2: Ventral view of *T*. *gigas* from Heron Island. Note the large size (see scale bar) and triangular projections present along the upper margin of the valve that are characteristic of the species (Lucas, 1988); FIG. 3: Ventral view of *T. gigas* from Heron Island. Note the *Stylophora* sp. colony growing on the shell. Based upon growth rates for *Stylophora pistillata* calculated by Loya (1976), this colony is between 12 and 14 years old; FIG. 4: Detail of Fig. 3, showing close-up of mantle, eyespots and inhalant siphon; FIG. 5: Two *T. gigas* from Heron Island growing in close proximity to one another. Scale bars are based upon measurements made in the field. Scale bars Fig. 2 = 20 cm; Fig. 3 = 10 cm; Fig. 4 = 20 cm; Fig. 5 = 70 cm.

All four individuals are located within a small (~12 m) area on the inner reef flat. The size of the Heron Island specimens is comparable to other adult individuals from the northern Great Barrier Reef (Ayling & Ayling, 1986; Braley, 1987a, b). Based upon growth rates for *T. gigas* calculated by Pearson & Munro (1991) the age of the Heron Island specimens is estimated at between 25 and 38 years. However, Pearson & Munro (1991) note that growth rates will be greater in warmer waters. Given that the sea surface temperatures at Heron Island are, on average, 2°C cooler than localities studied by Pearson & Munro (1991) (Lough, 1999), it is highly possible that the recorded specimens are much older.

The presence of *T. gigas* on Heron Island reef flat is surprising, given that sea surface temperatures in the area reach as low as 18°C (Lough, 1999), well below the temperature proposed for shell growth (Lucas et al., 1989). This is not the coldest water occurrence of the taxon, with higher latitude specimens of *T. gigas* recorded from Okinawa (Matsukuma, 2000), where sea surface temperatures reach as low as 17.5°C (Kanak & Tachihara, 2006). For over seven months of the year however, sea surface temperatures at Heron Island are below 25°C (Lough, 1999), much longer than at Okinawa (Kanak & Tachihara, 2006), and during the remaining five months, exceed 25°C for only very short periods (Lough, 1999). Previous work has proposed that 25°C is the optimum growing temperature for *T. gigas* (Lucas et al., 1989), and therefore the size of the Heron Island specimens would suggest that *T. gigas* is capable of growth in regions where average sea surface temperatures are lower than has been previously proposed.

As *T. gigas* can reach full sexual maturity in as little as four years (Fitt, 1991), and based upon the estimated ages of the Heron Island specimens, all four specimens are sexually mature. It is unclear, however, whether any of the four specimens have ever spawned. Fitt & Trench (1981) determined that spawning is not linked to temperature. Therefore, the comparatively cooler sea surface temperatures at Heron Island (Lough, 1999) should not preclude the Heron Island specimens from spawning. Searches of the reef flat both up-current and down-current of their location found no specimens of *Tridacna*, either juvenile or adult, that could be assigned to *T. gigas*. One of the authors (Bagnato) has conducted thousands of surveys of both Heron reef and lagoon over a period of decades and has never observed any other specimens of *T. gigas,* other than those recorded in this study. This suggests either the Heron Island specimens have never spawned, or that no viable offspring have been produced due to the small size of the population.

With no other specimens recorded or observed from the Heron Island Reef, either from reef flat or lagoonal settings, and no records of *T. gigas* from any other reefs in the Capricon-Bunker group, this would indicate two possibilities. Either the Heron Island specimens represent a remnant population or that that the source of the Heron Island *T. gigas* specimens is elsewhere. The authors recall that a single valve of *T. gigas* was once part of a display at the Heron Island Research Station and was supposedly obtained during construction of the Heron Island harbour in the 1960s. This potentially supports the possibility that a larger *T. gigas* population was once present on Heron Island, but with the current limited evidence it is impossible to be definitive.

If the Heron Island specimens are sourced from elsewhere, the closest live specimens of *T. gigas* recorded are from the northeastern part of the Swain Reefs (Ayling & Ayling, 1986), approximately 300 km north of Heron Island, and represent the most likely source. This trip includes crossing the Capricorn Channel, almost 120 km of open water that divides the southern Great Barrier Reef into two geomorphologically distinct reef systems (Kleypas & Burrage, 1994) and, at 200 m deep (Bostock et al., 2009), represents a distinct ecological boundary. As *T. gigas* reaches the pediveliger stage between 10–29 days after fertilization (Fitt & Trench, 1981), after which it becomes largely confined to the benthic zone, the Heron Island *T. gigas* specimens could potentially make this journey as part of the plankton. If true, this has implications for understanding genetic diversity and population dynamics of a variety of taxa in the southern Great Barrier Reef setting, as it suggests that free-swimming larvae produced by populations from Swain Reefs are able to colonize sites in the southernmost portion of the Great Barrier Reef, assuming they can survive the journey.

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