The Reproduction and Recruitment of the sand dollar *Arachnoides placenta* (L.) (Echinoidea: Echinodermata) from differing habitats on the North Queensland coast

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Abstract

The reproductive periodicity, recruitment and population studies of the intertidal Indo-Pacific echinoid, *Arachnoides placenta* (Linnaeus), were investigated from April 2001 to September 2002 at sites along 650km of the north Queensland coast, Australia. Three locations were sampled, comprising Mission Beach; Pallarenda Beach Townsville; and the Mackay region. *A. placenta* is a dominant macro-organism at all sites sampled, individuals of all sizes are found across the entire stretch of the beach terrace but are rarely evenly distributed, displaying a preference for pools and ripples containing wet sand. Despite patchiness a significant decrease in density downshore was observed in 11 / 17 transects laid at Pallarenda Beach, 2001 (p = <0.05). Significant differences in density were observed between all sites (p = 0.000) and even over distances of metres (p = 0.006). A maximum density of 88 individuals m^{-2} was recorded at Mackay in 2002.

There was also clear temporal and spatial variation in the size-frequency of the population at Pallarenda Beach and significant differences in test diameter between sites (p = 0.000) which clearly shows no effect of latitude on test diameter. At Pallarenda Beach test diameter was observed to increase with distance downshore in 13 / 17 transects. Test diameter at Bucasia Beach, Mackay on the contrary decreased with distance downshore. No relationship between test diameter and population size was observed.

Significant differences in population density and size-frequency data even over scales of just metres suggest that discrete differences in abiotic or biotic factors, particularly sediment grain size, moisture and protection from wave action, between sites are enough to produce significant variations between populations.

Growth of *A. placenta* from settlement demonstrates an s-shaped growth curve that is typical of a number of echinoid species. From a size of approximately 10mm growth assumes a linear phase which slows at a size of 25mm, at which size individuals are estimated to be 3 or 4 years old.

The reproductive periodicity of *Arachnoides placenta* exhibited an overall seasonal cycle with a period of gamete growth and accumulation from December to February culminating in a March to May main spawning period. Gametogenic patterns at Pallarenda Beach indicate the breeding season of *A. placenta* coincides with the start of a decline in sea water temperatures that occurs from March (26 – 28 ^{o}C) which

reaches a minimum over the months of June – August (22 – 24 ^{o}C). Partial spawning was observed in some individuals to June/July with a few spawning until September at Pallarenda Beach, indicating the continuation of spawning until temperatures reached a minimum. Over the range studied, *A. placenta* experienced similar annual air/sea water cycles and relatively comparable rainfall cycles. Air temperatures varied a maximum of ±8 ^{o}C from those of Townsville, possibly accounting for minimal differences in gametogenesis between sites. Spawning was only synchronous between males and females during months of the major spawning period (March to July), during which female gonads returned to the recovering condition within a month or less of spawning. From July to November no female gonads were in the late mature stage and a very slow rate of gametogenesis was observed. In males, 30-100% of individuals in all populations had ripe gonads throughout both years except June and September 2002 in Mackay. A percentage of all male gonads were always in the spent stage, indicating recovery takes longer than a month.

Significant numbers of newly settled recruits occur within the sediment from March – May at all sites, which strongly correlates with the timing of the annual gametogenic cycle of adults. The density of recruits downshore at Pallarenda Beach in 2001 demonstrate a clear patchy distribution, however a significant decrease in individuals downshore was observed in three out of six months of sampling ($p = <0.05$). Newly settled recruits prefer the middle to lower section of the beach terrace until a size of around 10mm is reached, when these individuals show a preference for the inhabiting the upper –middle section of the beach terrace. Such size-related positions on the beach terrace point to optimal grain-size preference possibly related to feeding and movement. There does not appear to be an adult-larval attraction during settlement.