Using Statolith Composition to Determine Migration patterns in the box jelly *Chironex fleckeri*

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Kingford, MJ, Mooney CJ. (2012). Sources and movements of *Chironex fleckeri* medusae using statolith elemental chemistry. Hydrobiologia 690(1) : 269-277.

The box jellyfish *Chironex fleckeri* is a common predator in Australian waters. As active hunters, these highly venomous jellyfish interact not only with their small crustacean prey but also with human bathers—encounters that have, over the last century, led to dozens of deaths (Bentlage et al. 2009). In spite of the threat they pose to humans, little was known about the migratory patterns of these organisms except that they tend to move from low to high salinity areas as they mature (Hartwick 1991). Mooney & Kingsford (2010) aimed to better understand the life history and migration of Chironex by using chemical analysis of the body to deduce the characteristics of waters they had traveled through.

Their experimental approach was based on the fact that the statolith, the calcium sulfate ball used by *Chironex fleckeri* for orientation, has a chemical composition that could provide information about the box jellyfish's migratory habits. The core of the statolith forms within rhopalia at the onset of metamorphosis from polyp to medusa. This core is continuously added to by the secretion of calcium sulfate layers as the organism matures (Boese et al 2011). As with any tissue development, statolith growth involves the uptake of nutrients from the environment that reflect environmental conditions at the time of its formation. In this case, the incorporation of the trace element strontium (Sr) into calcareous structures had been shown to vary as a function of salinity, whereas the incorporation of calcium (Ca) was independent of salinity. The ratio of these two elements therefore provides an indication of the salinity of *C. fleckeri*'s habitat when that layer of the statolith was formed (Mooney and Kingsford 2012).

In order to estimate salinity exposure in wild-caught animals, statoliths were taken from jellies collected from 5 regions along the northern Australian coast, encompassing a wide range of salinities. These statoliths were studied using a procedure, LA-ICPMS, that combines laser light and mass spectrometry to analyze the chemical composition of small portions of the statolith. This procedure had been used successfully in studies of fish otoliths to determine migration routes (Brown et al 1994). Mooney and Kingsford (2012) used this method to discern gradients of chemical change between the innermost core of the statolith, which reflected the salinity of the medusa's birthplace, to the outermost edges, which reflected the salinity of the organism's most recent environment. As predicted, LA-ICPMS revealed significant differences in Sr:Ca ratios between center and edge, indicating a change in salinity during a given organism's lifetime as it moved between estuarine and littoral marine environments (Fig. 3a).

However, statoliths from different individuals revealed variation in their travel paths: while some moved to more saline waters, others were captured in water that was significantly less saline than where they had become a medusa (Fig. 3b). Moreover, examination of the statoliths revealed that polyps had lived in a much greater range of salinities than previously known. The authors concluded that suitable nursery habitats for *C. fleckeri* likely included a broad range of salinities, involving not only estuaries but also coastal environments and even calmer marine littoral waters (Mooney and Kingsford 2012).

Even more interesting was the pattern of variation in chemical composition of the statolith on a shorter time scale. Between the core and the edge of the statolith, a new layer of calcium sulfate may be added each day, providing a way to estimate daily movements as *C. fleckeri* moves between regions of varying salinity. Among individuals, these data showed extreme day-to-day salinity variation reflecting the organism's travels in and out of estuaries, river plumes, and beach zones. This record was consistent with results from previous studies by Kingsford in which *C. fleckeri* was observed to travel between environments at intervals of a few days in search of food. Data from this experiment suggest that the cubozoans make such migrations repeatedly (Mooney and Kingsford 2012).

Although these data show that cubozoans can experience a vast range of water salinities, they do not indicate the distance travelled between locations. One practical application of this research would be to develop a model that could be used to identify the likely location of different salinity waters and, by extension, the recent geographical movements of animals. Such data could be used to track the movement of individual medusae over their life history, allowing biologists to study the movements of *C. fleckeri* and to learn more about the long distance migratory patterns and distributions of the species.

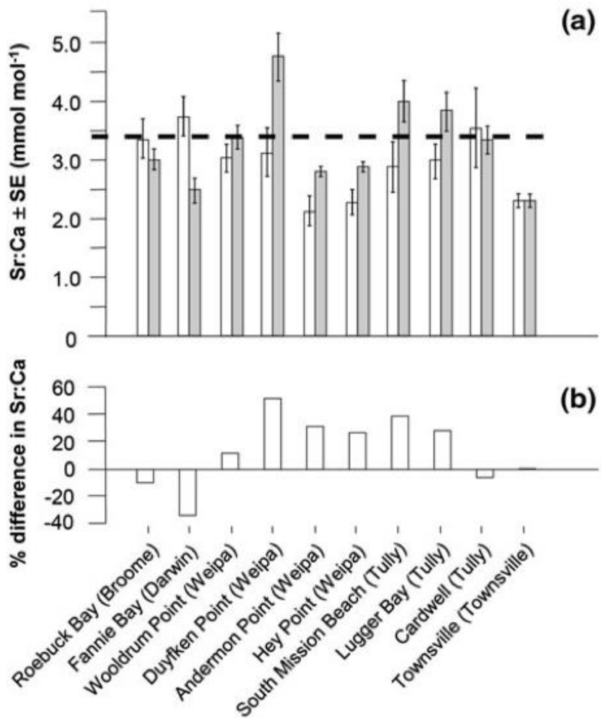

Fig. 3 **a** Mean Sr:Ca ratios ± SE in *Chironex fleckeri* medusa statoliths among sites between core (*white bars*) and edge (*grey bars*) zones relative to a salinity of 34 (*dashed line*), *n* varied: $3 \leq n \leq 5$; **b** percentage difference in Sr:Ca ratios from core to edge zones of statolith, positive indicates change from lower to higher ratios; negative indicates from higher to lower ratios

Other Literature Cited

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