NON-DESTRUCTIVE SAMPLING TECHNIQUES FOR THE RAPID ASSESSMENT OF POPULATION PARAMETERS IN ESTUARINE SHORE CRABS

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Abstract
Retrieving burrowing shore crabs to obtain information regarding their morphological attributes is often difficult and results in significant disturbance and habitat modification. A simple, rapid and non-destructive sampling method was proposed for indirectly estimating crab abundance, morphology and mass through the counting of burrow numbers and their diameter. Measurement of the number of crab burrows was found to correlate with crab abundance via both excavation and video observation techniques. Burrow diameters of individuals were also correlated with carapace width and body mass. Measuring burrow opening diameters along with the number of holes allows an indirect estimate of morphology and mass, which increases the information gained through such rapid sampling techniques and allows assessment of both structural and functional processes at the population level which may be affected through anthropogenic disturbance.

Keywords: biometry, *Heloecius cordiformis,* non-destructive sampling, rapid assessment techniques, Semaphore crab.

Introduction

The ocypodid crab, *Heloecius cordiformis*, Decapoda: Brachyura: Ocypodidae: Heloeciinae, Milne Edwards, 1852 (Turkay, 1983; Fielder & Greenwood, 1985), is among the most abundant and conspicuous representatives of epifaunal assemblages within temperate mangrove systems in Australia. These organisms hold a prime position in detritus based food chains (MacFarlane et al., 2000). Semaphore crabs are primarily deposit feeders (microphagous) sifting organic matter and mangrove detritus from sediment. They also possess well-developed mandibles for consumption of larger plant and animal material (macrophagous) (Maitland, 1990). These organisms assist in carbon/nutrient cycling and export, and in turn provide energy for higher trophic level consumers (Camilleri, 1992). These fauna are thus integral in mangrove system structure, health and function (Hutchings & Recher, 1983).

The species lives in large groups, at high densities, in semi-permanent burrows (Yates, 1978). Highest numbers are present on the middlittoral zone (Griffin, 1971; Maitland, 1990). Natural densities of crabs range from approximately 7-44 crabs m^2, dependant on sediment type and other environmental variables (Warren, 1990a). The number of burrows provides an accurate estimate of abundance for this species. Correlations between the number of burrows per m^2 and the number of individuals are high ($r = + 0.96$, $p<0.05$) (MacFarlane et al., 2000). Warren (1990a) also observed high correlations between apparent abundance and the number of holes($r = + 0.84$, $p<0.01$).

H. cordiformis maintain and actively defend individual burrows in sediment for long periods of time, indicating their site-specific nature and burrow ownership (Griffin, 1965, 1968). Most activities are performed at, or near, the entrances to burrows. (Warren & Underwood, 1986). Burrows function as a refuge from environmental stressors and predation, for defence of territories and sometimes as a centre for courtship and copulation (Griffin, 1968; Warren & Underwood, 1986; Warren, 1990b).

The Semaphore crab is easy to identify, maintains a close association with the burrow, and exhibits a strong relationship between the burrow number and crab abundance. As such, monitoring burrow densities may possibly be employed as a rapid, non-destructive sampling surrogate for the estimation of abundance for this species.

When crabs are disturbed, they immediately retreat into resident burrows. Thus retrieving crabs to obtain information regarding their morphological attributes is often difficult and results in significant disturbance and habitat modification. Crab burrow diameters have, however, been found to be closely correlated with morphological attributes such as the carapace length for other ocypodids (Takeda & Kurihara, 1987; Lourenco et al.2000). Measuring burrow diameters along with burrow density may be an appropriate and non-invasive technique for estimating the species morphological attributes indirectly

Thus the aims of the current study were to evaluate the non-destructive sampling techniques of counting burrows and measuring burrow opening diameters for the rapid estimation of *H. cordiformis* abundance, morphology and mass. Specifically to:

1. evaluate the accuracy of crab burrow numbers as an indicator of crab abundance by capture and observation methods.

2. assess whether morphological attributes such as the carapace width and total body mass may be predicted from the burrow diameter.

Methods

Assessment of the correlation between number of crab burrows and abundance in *H. cordiformis*

During September 1997, 50, 1m^2 quadrats at eight locales in Hawkesbury River Catchment (Cowan and Berowra Creeks) with different densities of crabs were sampled for number of crab burrows and number of individuals (for location descriptions see MacFarlane et al., 2000). An incoming tide was chosen for sampling as crabs tend to repair their burrows and maintain close proximity to burrows at this time. When approached, crabs tend to retreat into their burrows or neighbouring burrows to a depth of only a few centimetres and can be easily excavated using a trowel.

A second technique was used to estimate abundance. Digital video image of crabs within a 0.25m^2 field of view were recorded at a distance of one metre by a digital video camera (Sony, Digital Handicam VX-700) mounted on a tripod. The number of burrows and emergent crabs were recorded for 25 separate samples of 20 minute duration each. Digital video image samples were scored by viewing on computer, with assisted software (IBM compatible, DVD-Raptor, Frame-Grabber software). Values were converted to abundance and burrows per m^2.

Assessment of the correlation between crab burrow diameter, morphology and biomass in *H. cordiformis*

50 individuals from Apple Tree Bay, Cowan Creek, Hawkesbury River, were measured for burrow diameter (mm), carapace width (mm), and wet weight (g) during September 1997. Measurements were taken to the nearest 0.1mm using digital vernier callipers and data logger (Digimatic, Mitutoyo, Japan). Weights were obtained using an electronic field balance to the nearest 0.1 g (PT120, Sartorius, Germany).

Statistical analysis

Relationships between the number of crab burrows/m^2 and number of individuals/m^2, burrow diameter (mm) and carapace width (mm), and carapace width (mm) and total body mass (mm) were examined using bi-variate linear regressions in the multiple regression module of STATISTICA®.

Results

Correlation between crab burrows and abundance in *H. cordiformis*

On average, over 90% of crabs were recovered. The number of burrows was closely correlated with the number of resident individuals excavated (Figure 1a).

Number of crabs/m^2 = (number of burrows/m^2 x 0.83) + 0.26 (r^2 = 0.94).

The number of burrows was also closely correlated with the number of resident individuals via video observation (Figure 1b).

Number of crabs/m^2 = (number of burrows/m^2 x 0.91) + 2.28 (r^2 = 0.87).

Correlation between crab burrow diameter, morphology and biomass in *H. cordiformis*

Burrow diameter was found to be an accurate predictor of carapace width. As burrow diameter increases, so too does the individuals carapace width (Figure 1c).

Ln carapace width (mm)+ 1 = (ln crab burrow diameter (mm)+ 1 x 1.00) + 0.07(r^2 = 0.83).

Carapace width and body mass have a strong linear relationship for the species. As carapace width increases, body mass of individuals increases (Figure 1d).

Ln body mass of individual (g) + 1 = (ln carapace width (mm) + 1 x 2.95) – 9.46 (r^2 = 0.86).

Average carapace width and total mass were 15.3 ± 2.3 mm and 2.3 ± 1.1g for males and 14.3 ± 2.5 mm and 1.6 ± 0.9 g for females respectively (mean ± SE).

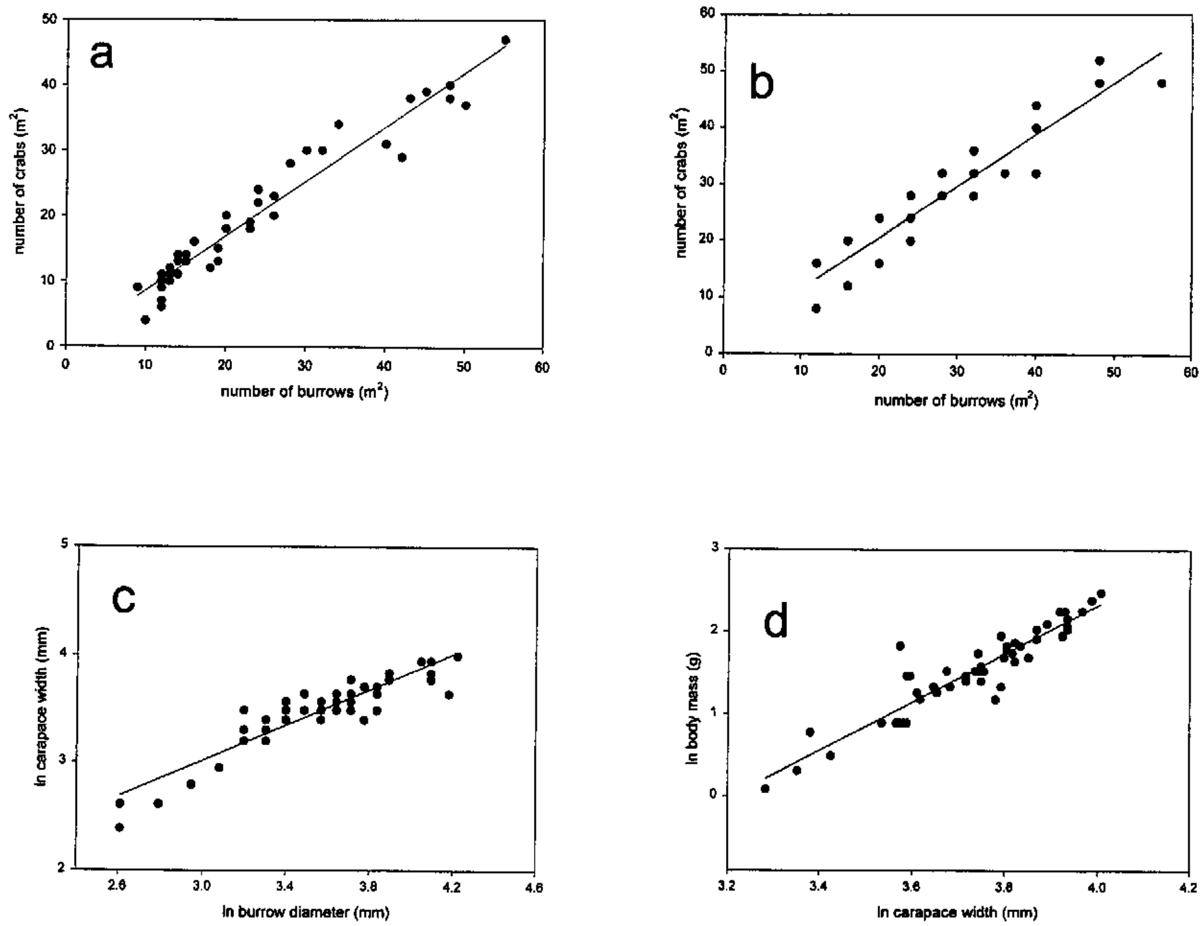

Figure 1: Significant relationships between burrow numbers and diameter, abundance and morphological attributes in *H. cordiformis*. Adjusted determination coefficients (r^2) and significance level (p) of bivariate regression models are given. The relationship between (a) the number of burrows and number of crabs per m^2 by retrieval, $r^2 = 0.94, p<0.01$ (n = 50); (b) the number of burrows and number of crabs per m^2 by video observation, $r^2 = 0.87, p<0.01$ (n = 25); (c) the ln burrow diameter (mm) and ln carapace width (mm), $r^2 = 0.83, p<0.01$(n= 50); (d) ln carapace width (mm) and ln body mass (g), $r^2 = 0.86, p<0.01$ (n =50).

Discussion

Crab burrow numbers were found to be an accurate indicator of crab abundance by both capture and video observation methods. Strong relationships were observed via both techniques, with abundance increasing with burrow density. Similarly, regression relationships suggest the morphological attributes carapace width and total body mass may be predicted from the burrow diameter. Thus the biometric regression models presented may be employed to estimate abundance, carapace width and mass, merely by counting burrows and measuring their diameter.

The measurement of crab burrows provides not only information on structural attributes of a population such as abundance and density, but also indirectly estimates other attributes of resident individuals such as carapace width and body mass. From these measurements, inferences may be made regarding population level processes such as the identification of age cohorts, recruitment and biomass that contribute to both population and community functioning. Counting crab burrows and measuring their opening diameter is a non-destructive technique, which generates minimal disturbance, and is a technique that may be readily collected by the non-specialist.

Rapid bio-assessment methodologies are designed to provide information on the ecological integrity of systems and identify impacts on biological communities in a cost effective and efficient manner, and may be performed and interpreted by non-specialists (Resh et al, 1995). Changes in relative abundances of *H.cordiformis* have been linked with anthropogenic impacts including boardwalk construction (Kelaher, 1998; Skilleter and Warren, 2000), and contaminant loadings in sediments (MacFarlane, et al., 2000). Similarly, burrow counts for other species in the genus *Ocypode* have been found to provide an accurate indication of human impacts on exposed sandy beaches (Barros, 2001). Measuring burrow opening diameters along with the number of holes increases the information gained through such rapid assessment techniques and allows comment on not only structural, but also functional processes at the population level which may be affected through anthropogenic disturbance (Fairweather, 1999).

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References

Barros, F. (2001). Ghost crabs as a tool for rapid assessment of human impacts on exposed sandy beaches. *Biological Conservation*. 97: 399-404.

Camilleri, J.C. (1992). Leaf-litter processing by invertebrates in a mangrove forest in Queensland. *Marine Biology*. 114: 139-145.

Fairweather P.G.(1999). Determining the 'health' of estuaries: Priorities for ecological research. *Australian Journal of Ecology*. 24: 441-51.

Fielder, D.R. & Greenwood, J. G. (1985). The systematic position *Heloecious cordiformis* (Milne Edwards, 1837) as revealed by larval morphology. *Crustaceana*. 48, 244-48.

Griffin, D.J.G. (1965). The behaviour of shore crabs. *Australian Natural History* 15, 87-91.

Griffin, D.J.G. (1968). Social and maintenance behaviour in two Australian ocypodid crabs (Crustacea : Brachyura). *Journal of Zoology London*. 156, 291-305.

Griffin, D.J.G. (1971). The ecological distribution of graspid and ocypodid shore crabs (Crustacea : Brachyura) in Tasmania. *Journal of Animal Ecology*. 40, 597-621.

Hutchings, P., & Recher, H. (1983). The faunal communities of Australian mangroves. In: H.J.Teas (Ed.). *Tasks for Vegetation Science (Vol. 8)*. Junk Hague. pp 103-110.

Kelaher, B.P., Underwood, A.J., & Chapman, M.G. (1998). Effects of boardwalks on the semaphore crab, *Heloecius cordiformis* in temperate urban mangrove forests. *Journal of Experimental Marine Biology and Ecology*. 227, 281-300.

Lourenco, R., Paula, J. & Henriques, M. (2000). Estimating the size of *Uca tangeri* (Crustacea: Ocypodidae) without massive crab capture. *Scientia Marina*. 64: 437-439.

MacFarlane, G.R., Booth, D.J., & Brown, K.R. (2000). The Semaphore crab, *Heloecious cordiformis:* bioindication potential for heavy metals in estuarine systems. *Aquatic Toxicology*. 50: 153-166.

Maitland, D.P. (1990a). Feeding and mouthpart morphology in the semaphore crab *Heloecious cordiformis* (Crustacea : Brachyura). *Mar. Biol.* 105, 287-296.

Resh, V.H., Norris, R.H., & Barbour, M.T.(1995). Design and implementation of rapid assessment approaches to water resource monitoring using benthic macroinvertebrates. *Australian journal of Ecology*. 20: 108-121.

Skilleter, G.A., & Warren, S. (2000). Effects of habitat modification in mangroves on the structure of mollusc and crab assemblages. *Journal of Experimental Marine Biology and Ecology*. 244, 107-129.

Takeda, S. & Kurihara, Y. (1987). The distribution and abundance of *Helice tridens* (De Haan) burrows and substratum conditions in a northeastern Japan saltmarsh (Crustacea: Brachyura). *Journal of Experimental Marine Biology and Ecology*. 107:9-19.

Turkay, M. (1983). The systematic position of an Australian mangrove crab, *Heloecious cordiformis*. *Memoirs of the Australian Museum*. 18, 107-111.

Warren, J.H. (1990a). The use of open burrows to estimate abundances of intertidal estuarine crabs. *Australian Journal of Ecology*. 15, 277-280.

Warren, J.H. (1990b). Role of burrows as refuges from subtidal predators of temperate mangrove crabs. *Marine Ecology Progress Series*. 67: 295-299.

Warren, J.H., & Underwood, A.J. (1986). Effects of burrowing crabs on the topography of mangrove swamps in NSW. *Journal of Experimental Marine Biology and Ecology*. 102: 223-235.

Yates, R.W. (1978). *Aspects of the ecology and reproductive biology of crabs in a mangrove swamp at Patonga, N.S.W.* MSc. Thesis. University of Sydney.