Phuket mar. biol. Cent. Res. Bull. **65**: 55–60 (2004)

DO DIAMETERS OF BURROWS AND FOOD PELLETS PROVIDE ESTIMATES OF THE SIZE STRUCTURE OF A POPULATION OF *DOTILLA MYCTIROIDES* AT THE SAND-FLATS OF AO TUNG KHEN, PHUKET?

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ABSTRACT: *Dotilla myctiroides* (Milne Edwards), the soldier crab, is a deposit feeder that burrows in sand flats and forms food pellets after the extraction of nutrients from sediments. Burrow diameter, food pellet diameter and carapace morphometric dimensions (carapace width, carapace length and carapace depth) of *D. myctiroides* were measured at the sand flats of Ao Tung Khen, Phuket, Thailand in September 2001. Regression results showed that food pellet diameter and burrow diameter were strongly positively related: average food pellet diameter = 0.776 + 0.221 (Burrow diameter) (r^2 = 0.79). All three simple linear regressions showed that crab carapace length, carapace width and carapace depth were positively related to burrow diameter with $r^2 = 0.83$. Of the three morphometric measurements, carapace length accounted significantly ($p = 0.030$) for most of the variability in burrow diameter in the multiple regression analysis. The simple linear regression for this relationship was: Burrow diameter = – 0.081 + 1.309 (Carapace length) and $r^2 = 0.89$. These results indicated that both burrow diameter and food pellet diameter were closely related to the size of the crab, especially carapace length, suggesting that food pellet diameter and burrow diameter could be used as estimates to the size structure of the population, without massive excavation and undue disturbance to the habitat.

INTRODUCTION

Ocypodid crabs of the genus *Dotilla*, found in the Indo-Pacific region, typically prefer sandy substratum to muddy shores. They can be generally found at the lower regions of sandy shores (MacNae and Kalk, 1962; Silas and Sankarankutty, 1967; McIntyre, 1968; Hartnoll, 1973; Hails and Yaziz, 1982; Matsumasa *et al.*, 1992). At low tide, it is common to find the large areas of the sandy shore strewn with excavated burrow pellets and discarded food pellets of *Dotilla* (Tweedie, 1950, 1952).

The biology of *Dotilla myctiroides* (Milne-Edwards) has been studied in India, Malaysia and Singapore by many researchers. Aspects studied included factors affecting the distribution of the species on the shore (Altevogt, 1957; McIntyre, 1968; Chee, 1983; Matsumasa *et al.*, 1992), mouth parts morphology (Chee, 1983; Vogel, 1984), growth and reproduction (Hails and Yaziz, 1982) and behaviour (Tweedie, 1950, 1952; MacNae and Kalk, 1962; Takeda *et al.*, 1996). In Thailand, Bradshaw (1997a, 1997b) studied the bioturbation activities of *D. myctiroides* from Ao Tung Khen in relation to the taphonomy of reefs. She reported a density of 90.6 ± 18.2 m^{-2} (n = 31) but did not conduct any study on population aspects of *D. myctiroides*.

To date, no published population study on size structure has been reported on *D. myctiroides* in tropical sandy shores. These spherical ocypodid crabs are very elusive to capture as they are able to scurry into their burrows at the slightest movement. Thus, for highly mobile intertidal macrofauna, biodiversity and population studies usually involved digging up sizeable areas in order to capture all the individuals within the quadrats. Vohra (1971) excavated up to a depth of 5 cm whereas Frith *et al*. (1976) and Frith and Brunenmeister (1983) went as deep as 25 cm in their collection of macrofauna. This sampling method is extremely invasive as it would require

excavations of substantial areas and volumes of the intertidal, thereby disturbing the habitat to a great extent.

We propose that population studies of this soldier crab could be made less invasive in that the diameters of the burrow and food pellets could be used to provide us with an indication of the size structure of the crab population. If these variables are highly correlated with crab morphometry, then they could be used to estimate the population size structure.

The objective of the study was to determine the relationship between crab size and burrow diameter by indirectly establishing (1) the relationship between food pellet diameter and size of crab; (2) the relationship between burrow diameter and crab size.

MATERIALS AND METHODS

This study was conducted in September 2001 at Ao Tung Khen, Phuket, Thailand. Eighty burrows of *Dotilla myctiroides* were randomly selected on the sand flat at the bay during low tide. Burrow diameters were measured to the nearest 0.01 mm with a pair of digital vernier calipers (Mitutoyo). Ten food pellets associated with each of the burrows were randomly selected and the diameters of these pellets similarly measured with the digital vernier calipers.

The measurements of another 29 burrow diameters together with morphometric measurements of the crab occupant were also recorded. Morphometric measurements recorded were: carapace width, carapace length and carapace depth. This indirect method was used as it was extremely tedious to both measure burrow diameter and capture the respective burrow occupant effectively.

Statistical analyses

Food pellet diameters (n = 10) associated with each burrow were averaged and mean values regressed against burrow diameter to determine the relationship between the two variables. Burrow diameter was regressed with (1) carapace width; (2) carapace length; (3) carapace depth individually to determine the relationship between the variables respectively using MINITAB (1998). A multiple regression was carried out with burrow diameter as the dependent variable and carapace width, carapace length and carapace depth as the predictor variables using MINITAB (1998).

RESULTS

The minimum and maximum burrow diameters obtained in the two parts of the study were similar in range (Table 1). A wide range of crab sizes (Table 1) were also sampled in order to cover as large a proportion of the size structure range of the population as possible. Average food pellet diameter for 80 burrows ranged from 1.75 mm to 5.29 mm with a mean of 3.05 ± 0.86 mm (Table 1).

There was a strong positive relationship between the average food pellet diameter and burrow diameter (Fig. 1, Average food pellet diameter = 0.776 + 0.221 (Burrow diameter); $r^2 = 0.79$). Individual regressions of burrow diameter against the three crab morphometric measurements yielded similarly strong positive relationships (Figs. 2a–c), with r^2 values of more than 0.8 for all three regressions. Regression equations for carapace width, carapace length and carapace depth were as follows:

(a) B.D. = 0.234 + (1.506 x Carapace width)
r^2 = 0.86
(b) B.D. = –0.081 + (1.309 x Carapace length)
r^2 = 0.89
(c) B.D. = 0.147 + (1.478 x Carapace depth)
r^2 = 0.83
(B.D. = Burrow diameter)

When all three variables were used, results of the multiple regression analysis showed that the variable, carapace length, was the most significant one of the three to account for variability in burrow diameter (Table 2). The equation was: Burrow diameter = –0.104 + 1.08 (Carapace length) + 0.299 (Carapace width) – 0.026 (Carapace depth), with $r^2 = 0.89$.

Table 1. Minimum, maximum and mean values of burrow diameter, average food pellet diameter and *Dotilla myctiroides* morphometric measurements.

Variable	n	Minimum (mm)	Maximum (mm)	Mean ± S.D.
Burrow diameter	80	4.85	17.10	10.30 ± 3.44
Average food pellet diameter	80	1.75	5.29	3.05 ± 0.86
Burrow diameter	29	4.76	18.36	9.53 ± 3.82
Carapace width	29	3.28	10.49	6.17 ± 2.35
Carapace length	29	3.95	12.97	7.34 ± 2.75
Carapace depth	29	3.46	10.54	6.35 ± 2.36

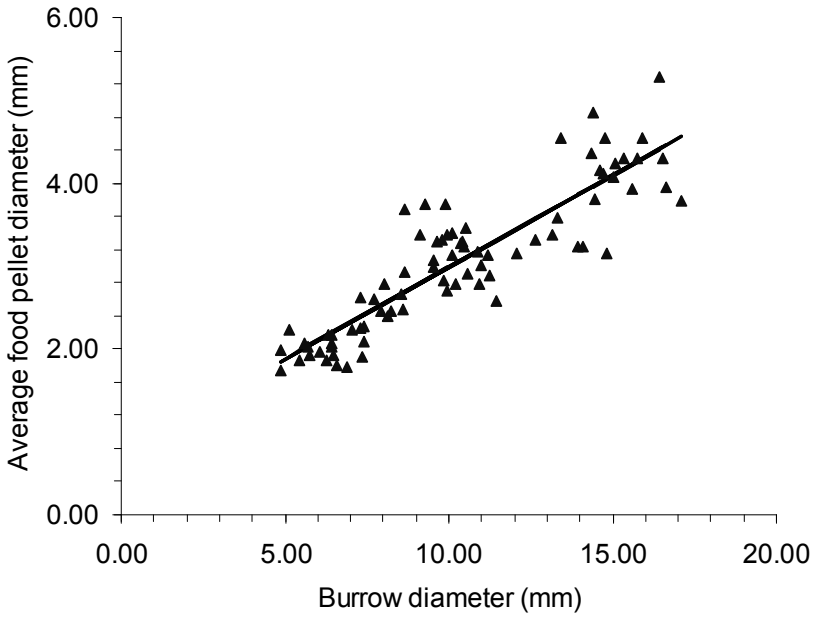

Figure 1. Regression of average food pellet diameter against *Dotilla myctiroides* burrow diameter (n = 80) at Ao Tung Khen, Phuket.

DISCUSSION

Bradshaw (1997a) reported an average burrow diameter of 7.5 ± 3.5 mm for 27 burrows of *D. myctiroides*, ranging from 5 to 16 mm, that she measured using a ruler at Ao Tung Khen. Results from our study showed that the mean burrow diameter of 109 burrows (combining the data from the two parts of the study) was 10.09 ± 3.55 mm, much larger than that reported by Bradshaw (1997a). This difference could be attributed to our large sample size as compared with that of Bradshaw's study.

The regression analyses showed that strong relationships existed between food pellet diameter, burrow diameter and crab morphometric measurements. These results indicated that both burrow diameter and food pellet diameter were closely related to the size of the crab, especially carapace length. The carapace of *D. myctiroides* is almost spherical in shape. Thus, it is not surprising that all three carapace morphometric measurements were highly significant in determining the burrow diameter. However, since *D. myctiroides* usually enters the burrow sideways, it is logical that burrow diameter was most significantly related to crab carapace length.

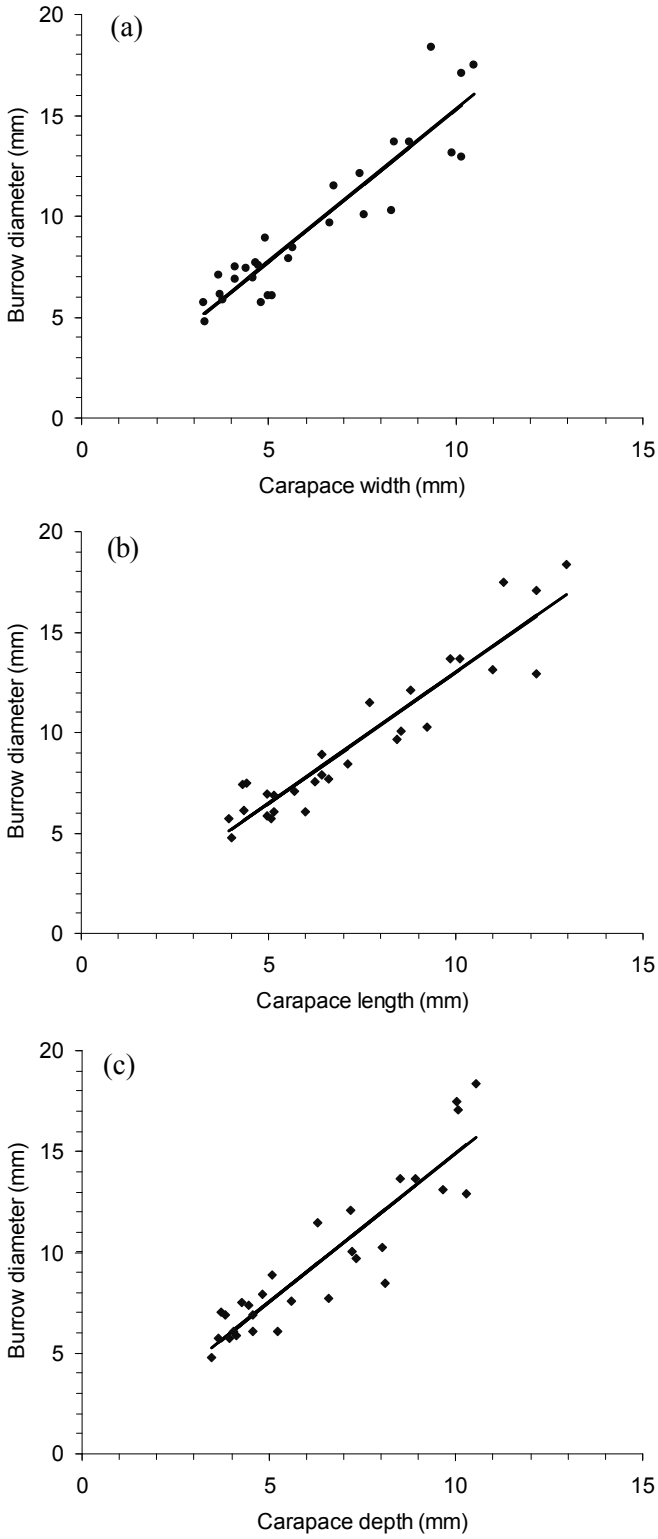

Figure 2. Regression of burrow diameter against *Dotilla myctiroides* (a) carapace width; (b) carapace length; (c) carapace depth (n = 29) at Ao Tung Khen, Phuket.

Table 2. Results of multiple regression of burrow diameter against *Dotilla myctiroides* morphometric measurements. (* = significant).

Predictor variable	Coefficient	t	p
Constant	–0.104	–0.14	0.887
Carapace width	0.299	0.67	0.510
Carapace length	1.083	2.29	0.030*
Carapace depth	–0.026	–0.06	0.951

It has been documented that the burrowing and feeding activities of *Dotilla* crabs can be seen extensively at low tides (see Tweedie, 1950, 1952). At Ao Tung Khen, with densities as high as 90 crabs per m^2 (as cited by Bradshaw, 1997a), one can only imagine the extent of disturbance if a proper quantitative population size structure study were to be conducted. Thus, as our results indicated that food pellet diameter and burrow diameter were closely related with crab size, we propose that these parameters could be used as estimates to the size structure of the population, without massive excavation and undue disturbance to the habitat. Of the two variables, burrow diameter would probably give the better estimate as the r^2 was slightly higher (0.89 cf. 0.79). The empirical formula that can be used for the calculation of crab size would be: Burrow diameter = –0.081 + (1.309 x Carapace length), as these variables were the most strongly related.

ACKNOWLEDGEMENTS

The authors thank the PMBC for the warm hospitality and comfortable accommodations during their stay in Phuket, 2001. Appreciation goes to PMBC staff, Somchai Bussarawit for arranging all the necessary logistics for field work at Ao Tung Khen. Field assistance from Joshua Wong and Edwin Cho are also gratefully acknowledged. This research was partially supported by an NIE/NTU Research Grant (RP 19/97 LSL) to the second author.

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Manuscript received: May 2003
Accepted: October 2003