This article was downloaded by: [University of Bath]

On: 13 February 2014, At: 17:10

Publisher: Taylor & Francis

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK

Journal of Natural History

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tnah20>

Population structure and breeding biology of the hairy crab *Pilumnus vespertilio* (Fabricius, 1793) (Crustacea: Brachyura: Pilumnidae) in southern Mozambique

Carlos Litulo^a

^a Departamento de Ciências Biológicas, Faculdade de Ciências, Universidade Eduardo Mondlane, Maputo, Mozambique

^b Departamento de Ciências Biológicas, Faculdade de Ciências, Universidade Eduardo Mondlane, Caixa Postal 257, Maputo, Mozambique E-mail:

Published online: 21 Feb 2007.

To cite this article: Carlos Litulo (2005) Population structure and breeding biology of the hairy crab *Pilumnus vespertilio* (Fabricius, 1793) (Crustacea: Brachyura: Pilumnidae) in southern Mozambique, *Journal of Natural History*, 39:17, 1359-1366, DOI: [10.1080/00222930400010070](https://doi.org/10.1080/00222930400010070)

To link to this article: <http://dx.doi.org/10.1080/00222930400010070>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms &

Population structure and breeding biology of the hairy crab *Pilumnus vespertilio* (Fabricius, 1793) (Crustacea: Brachyura: Pilumnidae) in southern Mozambique

CARLOS LITULO

Departamento de Ciências Biológicas, Faculdade de Ciências, Universidade Eduardo Mondlane, Maputo, Mozambique

(Accepted 26 August 2004)

Abstract

The population structure and reproduction of *Pilumnus vespertilio* were studied for the first time in Mozambique. Random samples of crabs were taken monthly from January to December 2002 from a pebble area of Inhaca Island, southern Mozambique. A clear sexual dimorphism was observed in the present population with males reaching greater sizes than females. Sex ratio was female-biased, and the monthly size–frequency distributions were often bimodal. The annual reproductive cycle of *Pilumnus vespertilio* was continuous with peaks of breeding in summer. Results suggest that embryonic development may be synchronized within the population as a result of the very high reproductive activity observed in summer. Juveniles are recruited mostly in winter in the study area.

Keywords: *Breeding biology, Inhaca Island, Mozambique, Pilumnus vespertilio, population structure, sex ratio*

Introduction

Reproduction is the main mechanism to maintain species proliferation and continuity and, in brachyuran crabs is extremely diversified, ultimately shaped to maximize egg production and offspring survivorship (Hartnoll and Gould 1988). The determination of breeding periods is governed by a complex interaction of endogenous and exogenous factors, allowing both intra- and inter-specific variations regarding the duration of the reproductive season (Sastry 1983). Generally, peaks of higher breeding activity may be associated with variations of temperature, salinity, oxygen, food availability, photoperiod, rainfall, among others (Meusy and Payen 1988; Costa and Negreiros-Fransozo 2003; Litulo 2004).

Reproductive periods of brachyuran crabs have been frequently described and vary from seasonal to continuous patterns (Pinheiro and Fransozo 2002). It is assumed that the variations verified in the breeding patterns are often related to fluctuations observed in the

Correspondence: Carlos Litulo, Departamento de Ciências Biológicas, Faculdade de Ciências, Universidade Eduardo Mondlane, Caixa Postal 257, Maputo, Mozambique. E-mail: Litos@imensis.net

environmental conditions, latitudinal position and intertidal distribution of species which varies from region to region (Emmerson 1994; Yamaguchi 2001a, 2001b), or to biotic factors such as seasonal planktonic food, which is essential for larval development (Paula et al. 1998; Litulo 2004).

Despite the abundance of published literature on the reproductive biology of many brachyurans (e.g. Meusy and Payen 1988; Perez 1990; Emmerson 1994, Rodriguez et al. 1997), very little is known about the reproductive biology of tropical brachyurans (Emmerson 1994; Leme and Negreiros-Fransozo 1998; Oshiro 1999).

Pilumnus vespertilio (Fabricius, 1793) is one of the most abundant crabs in the tidal areas of Inhaca Island, southern Mozambique. The first account on the ecology of *Pilumnus vespertilio* (Fabricius, 1793) was given by Clark and Paula (2003) who analysed its larval development. There are no published studies on the population biology and reproduction of *P. vespertilio* in East Africa. This paper describes the population structure and breeding biology of *Pilumnus vespertilio* from Inhaca Island, southern Mozambique, with emphasis on its size structure, sex ratio, breeding season and juvenile recruitment.

Materials and methods

Field sampling and laboratory analysis

This study was conducted from January to December 2002 during low tide in the exposed pebble area in front of the Marine Biological Station of Inhaca, Inhaca Island, southern Mozambique (26°00'S, 33°00'E). The climate at this location is a mixture of tropical and subtropical, partly influenced by the south-eastern trade wind, and a northerly monsoon, but also occasionally by strong and cold south-west winds or cyclones from the north-east. The winter (April to September) is usually cold and dry, while summer (October to March) is warm and rainy (Guerreiro et al. 1996; Paula et al. 1998). Guerreiro et al. (1996) and Paula et al. (1998) give detailed descriptions regarding the ecology, fauna and flora of the island.

Each month (during full moon), crabs were randomly collected through a catch-per-unit-effort performed by two people during a period of 1 h covering the same area of 300 m². Collected crabs were preserved in 70% ethanol until further analysis. In the laboratory, crabs were identified, sexed and measured for carapace width (CW) using a vernier calliper (± 0.05 mm) or with the aid of a compound microscope equipped with a calibrated ocular micrometer.

Data analysis

The population size structure was analysed as a function of the size–frequency distribution of all individuals collected during the study period. Specimens were grouped in 3.0-mm size class intervals from 5.0 to 36.0 mm CW. The period of time when ovigerous females were found in the population was referred to as the breeding season (Diaz and Conde 1989; Costa and Negreiros-Fransozo 2003). Assessment of recruitment was based on the proportion of juveniles in the samples (individuals of both sexes smaller than the smallest ovigerous female collected). The chi-square test (χ^2) was used to evaluate the sex ratio and the overall size–frequency distributions were tested for normality using the Kolmogorov–Smirnov (Lilliefors) (*D*) test (Underwood 1997). The mean size of males and females was compared using the Mann–Whitney Sum test. Monthly estimates of the proportions of

juveniles were tested for correlation with temperature using Pearson's correlation (Underwood 1997). Average values of temperature were obtained at the local meteorological station (INAM, Instituto Nacional de Meteorologia). Mean $\pm$ standard error is presented through the text.

Results

A total of 930 individuals was collected during the study period: 375 males (40.3%), 359 non-ovigerous females (38.6%) and 196 ovigerous females (21.1%) (Table I). Males ranged from 5.0 to 31.2 mm CW (18.31 ± 5.67) and females from 5.67 to 28.9 mm CW (16.28 ± 7.43). Males were on average larger than females (Mann-Whitney Sum test, $P < 0.001$).

Figure 1 shows the size-frequency distributions for all sampled crabs. In both males and females, size-frequency distributions differed from normality (Kolmogorov-Smirnov Lilliefors test, $D_{\text{males}} = 0.09984$, $P < 0.05$; $D_{\text{females}} = 0.06598$, $P < 0.05$) as well as from asymmetry (t -test for $H_0: \gamma = 0$: $g_{\text{males}} = -0.496$, $t = 4.41$; $g_{\text{females}} = -0.182$, $t = 3.65$, $P < 0.05$) (Figure 1). Males had a bimodal distribution with prevalence of specimens (modal size) measuring 5.0–10.0 mm CW and 17.0–25.0 mm CW whereas females had a unimodal size-frequency distribution (20.0–25.0 mm CW), respectively.

Monthly size-frequency distributions were generally uni- or bimodal (Figure 2) and juveniles were found year-round, with higher incidence in winter. Pearson's correlation analyses indicate that the relative frequency of juveniles was negatively correlated with mean air temperature ($r = -0.61$, $P < 0.05$) (Figure 3).

The overall sex ratio (1:1.48) was significantly different from the expected 1:1 proportion (χ^2 -test, $P < 0.05$) and was female biased during most parts of the study (Table I).

Ovigerous females were recorded during all months throughout the year, showing continuous reproduction with high percentages of occurrence in January, March, October, November, and December (Table I). The size of the smallest ovigerous female collected

Table I. Total number of *Pilumnus vesperilio* (Fabricius, 1793) specimens collected at Inhaca Island, southern Mozambique.

Month	Males		Non-ovigerous females		Ovigerous females		Total n	Sex ratio (M:F)
	n	%	n	%	n	%		
January ^a	33	43.42	20	46.51	23	53.49	76	1:1.31
February ^a	20	35.08	19	51.35	18	48.65	57	1:1.85
March ^a	15	29.41	16	44.44	20	55.56	51	1:2.4
April ^a	19	35.18	21	60.0	14	40.0	54	1:1.84
May ^a	30	42.86	30	75.0	10	25.0	70	1:1.33
June	57	50.89	48	87.27	7	17.27	112	1:0.96
July	48	45.28	53	91.38	5	8.62	106	1:1.21
August ^a	17	18.28	72	94.74	4	5.26	93	1:4.47
September ^a	29	33.72	40	70.28	17	29.82	86	1:1.96
October ^a	52	60.46	13	38.23	21	61.76	86	1:0.65
November	39	48.15	15	37.71	27	64.29	81	1:1.10
December ^a	16	27.59	12	28.57	30	71.43	58	1:2.63
Total ^a	375	40.32	359	64.68	196	35.31	930	1:1.48

n , number of individuals. ^aSignificant difference from the expected 1:1 ratio (χ^2 -test, $P < 0.05$).

Figure 1. *Pilumnus vespertilio* (Fabricius, 1793). Overall size–frequency distributions of all individuals collected at Inhaca Island.

was 15.1 mm CW. All individuals of a smaller size than this were considered to be juveniles.

Discussion

Population structure

The global size–frequency distributions for both sexes of *Pilumnus vespertilio* at Inhaca Island were found to be different, with males having a bimodal and females a unimodal distribution, and both skewed to the left. This type of distribution has been reported by several authors (Diaz and Conde 1989; Spivak et al. 1996; Flores and Paula 2002). As stated by Thurman (1985), the size–frequency distribution of a population is a dynamic characteristic that can change throughout the year as a result of reproduction and rapid recruitment from larvae. Poisson-like size–frequency distributions can be found in certain situations due to seasonal mortality pulses and behavioural differences in harsh environmental conditions (Thurman 1985; Underwood 1997).

Sexual dimorphism was observed in the present population, with males reaching larger sizes than females. Lopez Greco et al. (2000) and Mantelatto et al. (2003) suggest that females may have lower somatic growth than males because they concentrate their energetic budget for gonad development, a fact that may lead them to have a lower somatic growth than observed in males. Moreover, males reach larger sizes due to copulation with more than one female, since larger males have greater chances of obtaining females for copulation, and win intra-specific fights (Wada et al. 2000).

Monthly size–frequency distributions were either uni- or bimodal throughout the study period. This pattern has been attributed to migration (Leme and Negreiros-Fransozo 1998; Flores and Negreiros-Fransozo 1999), differential mortality (Diaz and Conde 1989) and

Figure 2. *Pilumnus vesperilio* (Fabricius, 1793). Monthly size-frequency distributions. White bars, males; grey bars, non-ovigerous females; black bars, ovigerous females.

Figure 3. *Pilumnus vespertilio* (Fabricius, 1793). Association between monthly juveniles (crabs of both sexes <15.1 mm CW) with temperature at Inhaca Island, southern Mozambique.

growth rates (Costa and Negreiros-Fransozo 2003). According to Zimmerman and Felder (1991), differences in the monthly size–frequency distributions are typically found in species that produce several clutches per season.

In this study, the overall and monthly sex ratios were female-biased. Deviations from the 1:1 ratio might result from sexual differences in the spatio-temporal distribution and mortality of organisms (Lardies et al. 1998; Wada et al. 2000), sex reversal, differential life span, migration, longevity of each sex, food restriction, utilization of different habitats, and growth rates (Wenner 1972). Emmerson (1994) and Lardies et al. (2004) suggest that deviations from the 1:1 ratio can internally regulate the size of a population by affecting its reproductive potential. Additionally, lunar phases and intertidal zonation are known to be determinants for sex ratio variation in brachyuran crabs (Emmerson 1994).

Breeding biology

The study of breeding in Crustacea can facilitate the understanding of the adaptive strategies and reproductive potential of a species and its relationship with the environment and other species. In the case of brachyurans, the breeding patterns are a result of a trade-off between growth and reproductive processes.

The annual reproductive cycle of *P. vespertilio* at Inhaca Island was continuous throughout the year, with peaks of occurrence of ovigerous females in the warmer months. This condition has been reported in several brachyurans (e.g. Thurman 1985; Diaz and Conde 1989; Perez 1990; Zimmerman and Felder 1991; Negreiros-Fransozo et al. 2002). It is generally suggested that near the tropics reproduction occurs year-round because environmental conditions are generally favourable for feeding, gonad development and larval release (Cobo 2002; Pinheiro and Fransozo 2002).

Females of *Pilumnus vespertilio* showed a strong reproductive activity with high percentages of egg-bearing females occurring in summer. This suggests that the present

species has a rapid embryonic cycle with an incubation period of less than a month (between 20–25 days) and settlement takes place immediately after the hatching of the larvae in the area. This ensures constant larval supply in the area, which may determine some aspects of population dynamics such as settlement of megalopae, and juvenile recruitment, which may contribute to the maintenance of population size.

Juvenile recruitment was constant throughout the year as a result of the high reproductive activity observed in the population. Looking at Figure 3, it can be seen that juveniles recruit to the adult population during the colder months, a period when reproductive activity is decreasing. Fransozo et al. (1999) reported the same pattern. According to these authors, timing is the ultimate factor affecting breeding, allowing larvae to encounter adequate food supplies for development. Furthermore, breeding in summer, when temperatures are higher and phytoplankton more abundant, would shorten development time and reduce larval predation (Emmerson 1994). This seems to apply for the population of *P. vespertilio* from Inhaca Island since according to Paula et al. (1998), the favourable period for phyto- and zooplankton abundance in the island occurs from September to November and March due to nutrient accumulation in Maputo Bay along the rainy season.

Acknowledgements

I would like to thank the Marine Biological Station of Inhaca Island (EBMI) for support and especially Sergio Mapanga for tireless help. Thanks are due to the National Institute of Meteorology for providing the environmental data. Daniela Abreu, Juan Antonio Baeza and Winston D. Emmerson provided helpful suggestions on an earlier draft of the manuscript. Thanks are also extended to two anonymous referees for useful comments that improved this manuscript.

References

- Clark PF, Paula J. 2003. Descriptions of ten Xanthoidean (Crustacea: Decapoda: Brachyura) first stage zoeae from Inhaca Island, Mozambique. *Raffles Bulletin of Zoology* 52:323–378.
- Cobo VJ. 2002. Breeding period of the spider crab *Mithraculus forceps* (A. Milne Edwards) (Crustacea, Majidae, Mithracinae) in the southeastern Brazilian coast. *Revista Brasileira de Zoologia* 19:229–234.
- Costa TM, Negreiros-Fransozo ML. 2003. Population biology of *Uca thayeri* Rathbun, 1900 (Brachyura, Ocypodidae) in a subtropical South American mangrove area: results from transect and catch-per-unit-effort techniques. *Crustaceana* 75:1201–1218.
- Diaz H, Conde JE. 1989. Population dynamics and life history of the mangrove crab *Aratus pisonii* (Brachyura: Grapsidae) in a marine environment. *Bulletin of Marine Science* 45:148–163.
- Emmerson WD. 1994. Seasonal breeding cycles and sex ratios of eight species of crabs from Mgazana, a mangrove estuary in Transkei, Southern Africa. *Journal of Crustacean Biology* 14:568–578.
- Flores AAV, Negreiros-Fransozo ML. 1999. On the population biology of the mottled shore crab *Pachygrapsus transversus* (Gibbes, 1850) (Brachyura, Grapsidae) in a subtropical area. *Bulletin of Marine Science* 65:59–73.
- Flores AAV, Paula J. 2002. Population dynamics of the shore crab *Pachygrapsus marmoratus* (Brachyura: Grapsidae) in the central Portuguese coast. *Journal of the Marine Biological Association of the United Kingdom* 82:229–241.
- Fransozo A, Bertini G, Correa MOD. 1999. Population biology and habitat utilization of the stone crab *Menippe nodifrons* in the Ubatuba region, São Paulo, Brazil. *Crustacean Issues* 12:275–281.
- Guerreiro J, Freitas S, Pereira P, Paula J, Macia A. 1996. Sediment macrobenthos of mangrove flats at Inhaca Island, Mozambique. *Cahiers de Biologie Marine* 37:309–327.
- Hartnoll RG, Gould P. 1988. Brachyuran life history strategies and the optimisation of egg production. In: Fincham AARainbow PS, editors. *Aspects of decapod crustacean biology* Oxford: Clarendon Press. p 1–9. (Symposia of the Zoological Society of London; 59).

- Lardies MA, Rojas JR, Wehrtmann IS. 1998. Breeding biology of the snapping shrimp *Betaeus emarginatus* inhabiting a rock pool environment in central-southern Chile (Decapoda: Caridae: Alpheidae). *Ophelia* 49:221–231.
- Lardies MA, Rojas JM, Wehrtmann IS. 2004. Breeding biology and population structure of the intertidal crab *Petrolisthes laevigatus* (Anomura: Porcellanidae) in central-southern Chile. *Journal of Natural History* 38:375–388.
- Leme MHA, Negreiros-Fransozo ML. 1998. Reproductive patterns of *Aratus pisonii* (Decapoda: Grapsidae) from an estuarine area of São Paulo northern coast, Brazil. *Revista de Biologia Tropical* 46:673–678.
- Litulo C. 2004. Reproductive aspects of a tropical population of the fiddler crab *Uca annulipes* (H. Milne Edwards, 1837) (Brachyura: Ocypodidae) at Costa do Sol Mangrove, Maputo Bay, southern Mozambique. *Hydrobiologia* 525:167–173.
- Lopez Greco LS, Hernandez JE, Bolanos J, Rodriguez EM, Hernandez G. 2000. Population features of *Microphrys bicornutus* Latreille, 1825 (Brachyura, Majidae) from Isla Margarita, Venezuela. *Hydrobiologia* 439:151–159.
- Mantelatto FLM, Faria FCR, Garcia RB. 2003. Biological aspects of *Mithraculus forceps* (Brachyura: Mithracidae) from Anchieta Island, Ubatuba, Brazil. *Journal of the Marine Biological Association of the United Kingdom* 83:789–791.
- Meusy J-J, Payen GG. 1988. Female reproduction in malacostracan Crustacea. *Zoological Science* 5:217–265.
- Negreiros-Fransozo ML, Fransozo A, Bertini G. 2002. Reproductive cycle and recruitment period of *Ocypode quadrata* (Decapoda, Ocypodidae) at a sandy beach in south-eastern Brazil. *Journal of Crustacean Biology* 22:157–161.
- Oshiro LMY. 1999. Aspectos reprodutivos do caranguejo guaia, *Menippe nodifrons* Stimpson (Crustacea, Decapoda, Xanthidae) da Baía de Sepetiba, Rio de Janeiro, Brazil. *Revista Brasileira de Zoologia* 16:827–834.
- Paula J, Pinto I, Guambe I, Monteiro S, Gove D, Guerreiro J. 1998. Seasonal cycle of planktonic communities at Inhaca Island, southern Mozambique. *Journal of Plankton Research* 20:2165–2178.
- Perez OS. 1990. Reproductive biology of the sandy crab *Matuta lunaris* (Brachyura: Calappidae). *Marine Ecology Progress Series* 59:83–89.
- Pinheiro MAA, Fransozo A. 2002. Reproduction of the speckled swimming crab *Arenaeus cribrarius* (Brachyura: Portunidae) on the Brazilian coast near 23°30'. *Journal of Crustacean Biology* 22:416–428.
- Rodriguez A, Drake P, Arias AM. 1997. Reproductive periods and larval abundance patterns of the crabs *Panopeus africanus* and *Uca tangeri* in a shallow inlet (SW Spain). *Marine Ecology and Progress Series* 149:133–142.
- Sastry AN. 1983. Ecological aspects of reproduction. In: Vernberg WB, editor. *The biology of Crustacea*. Volume 8, Environmental adaptations New York: Academic Press. p 179–270.
- Spivak ED, Anger K, Bas C, Luppi TA, Ismael D. 1996. Size structure, sex ratio and breeding season in two intertidal grapsid crab species from Mar Chiquita lagoon, Argentina. *Neritica* 10:7–26.
- Thurman CL. 1985. Reproductive biology and population structure of the fiddler crab *Uca subcylindrica* (Stimpson). *Biological Bulletin* 169:215–229.
- Underwood AJ. 1997. *Experiments in ecology: their logical design and interpretation using analysis of variance* Cambridge: Cambridge University Press. 504p.
- Wada S, Ashidate M, Yoshino K, Sato T, Goshima S. 2000. Effects of sex ratio on egg extrusion and mating behaviour of the spiny king crab *Paralithodes brevipes* (Decapoda: Lithodidae). *Journal of Crustacean Biology* 20:479–482.
- Wenner AM. 1972. Sex ratio as a function of size in marine Crustacea. *American Naturalist* 106:321–350.
- Yamaguchi T. 2001a. The breeding period of the fiddler crab *Uca lactea* (Decapoda, Brachyura, Ocypodidae) in Japan. *Crustaceana* 74:285–293.
- Yamaguchi T. 2001b. Incubation of eggs and embryonic development of the fiddler crab, *Uca lactea* (Decapoda, Brachyura, Ocypodidae). *Crustaceana* 74:449–458.
- Zimmerman TL, Felder DL. 1991. Reproductive ecology of an intertidal brachyuran crab *Sesarma* sp. (nr. reticulatum), from Gulf of Mexico. *Biological Bulletin* 181:387–401.