Fecundity of *Eriphia gonagra* (Fabricius, 1781) (Crustacea, Brachyura, Xanthidae) in the Ubatuba region, São Paulo, Brazil

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Abstract

The objective of this study was to determine the fecundity of *Eriphia gonagra* using the number of eggs laid by female crabs. A total of 92 female crabs was analyzed. Specimens of *E. gonagra* were collected monthly for two years (1996-1997), on the rocky shore of Praia Grande, Ubatuba, São Paulo. The mean carapace width for ovigerous crabs was 28.4 ± 6.11 mm, the mean egg diameter was 0.466 ± 0.031 mm, and the mean brood size was 15,362 ± 8,002 eggs per female. The number of eggs was directly proportional to the carapace width, which seems to be the general trend among brachyurans. *Eriphia gonagra* reproduced year-round, with well-distributed spawning periods. This reproductive strategy is assumed to contribute to the establishment and colonization of this species on rocky shores.

Key words: Fecundity, *Eriphia gonagra*, Crustacea, Brachyura, Xanthidae.

Introduction

Estimates of fecundity and knowledge of reproductive periodicity are crucial to proper understanding of the population dynamics, determination of management strategies and to optimize the exploitation of commercially important species (Perkins, 1971; Campbell and Eagles, 1983 and Kennelly and Watkins, 1994).

Sastry (1983) noted that fecundity analysis includes estimating not only the number of eggs produced by each female, but also the rate at which the eggs are produced over a period of time or during the female's lifespan. However, many authors define fecundity by the total number of eggs laid by a female of a given species, during a single spawning and over a certain time period of the reproductive cycle (Bourdon, 1962; Du Preez and Mclachlan, 1984; Melville-Smith, 1987; Branco and Avilar, 1992; Negreiros-Fransozo *et al.*, 1992; Costa and Negreiros-Fransozo, 1996).

The body size of a female crab is the principal determinant of reproductive output. The weight of the egg mass is apparently limited to 10% of the body weight, because of the small space available in the cephalothoracic cavity to accommodate the gonads (Hines, 1982).

Many investigators have reported on the relationship between fecundity and female body size (Prager *et al.*, 1990; Shields *et al.*, 1991; Reid and Corey, 1991; Haddon, 1994). Different aspects of fecundity have been treated by other workers: Somerton and Meyers (1983) that studied the fecundity differences between primiparous and multiparous females; Jewett *et al.* (1985), with the size at sexual maturity; Batoy *et al.* (1987) about breeding season and sexual maturity; Campbell and Fielder (1988) studied egg extrusion and egg development and Hines (1988) with the reproductive output. In Brazil, the fecundity of brachyurans has been studied by Ogawa and Rocha (1976), Pinheiro and Fransozo (1995), Reigada and Negreiros-Fransozo (1995), Mantelatto and Fransozo (1997), Santos and Negreiros-Fransozo (1997) and Leme and Negreiros-Fransozo (1998).

The fecundity of the crab *Eriphia gonagra* has not yet been studied. Previous reports on this species have dealt with recruitment (Góes and Fransozo, 1997a), relative growth (Góes and Fransozo, 1997b), heterochely (Góes and Fransozo, 1998), sex ratio (Góes and Fransozo, 2000) and morphological aspects of the size at female maturation (Góes and Fransozo, 2001). We now report an analysis of the fecundity of *E. gonagra*, which was estimated by counting the number of eggs laid by each female, during a single spawning, over a certain period of time in its reproductive cycle.

Material and Methods

Specimens of *E. gonagra* were collected monthly from January 1996 through December 1997 along the rocky coast of Praia Grande (23^0 28'02" S and 45^0 03'35" W), at Ubatuba, São Paulo, Brazil (Figure 1). In the laboratory, the animals were counted, their carapace width (CW) was measured, and the CWs were arranged according to Sturges (1926) in size classes over a range of 4.2 to 50.2 mm, with an interval of 4.2 mm.

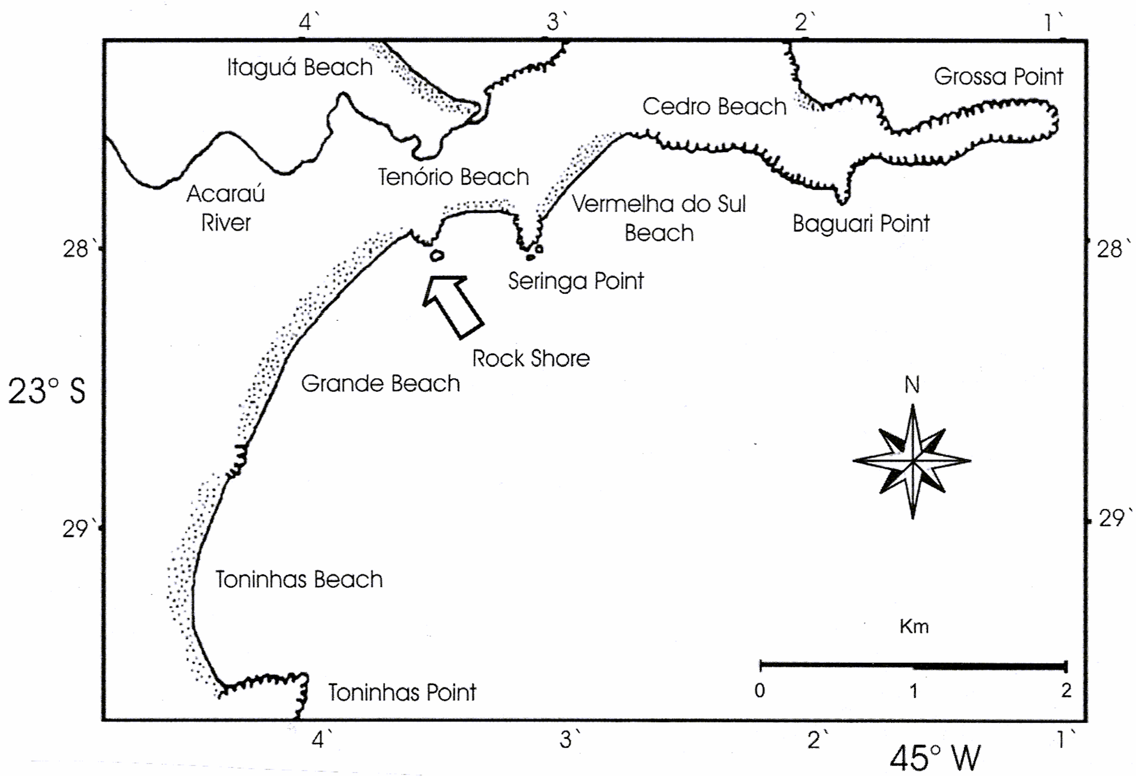

Figure 1: Map of the study area.

The pleopods of the females with eggs were cut at their base, and a subsample of ten eggs was taken, to determine the egg diameter. The remaining eggs were fixed in 70% ethanol. The fixed eggs were classified as: 1) initial stage: the eggs are orange and this color becomes more intense after fixation, indicating high yolk content; 2) intermediate stage: the fixed eggs are light brown, and the compound eyes of the embryos can be observed by a microscope; 3) final stage: the fixed eggs are black, and the well-developed zoeae can be observed through the transparent outer egg membrane, by a microscope.

For measurements of egg diameter, 92 egg masses were used, including 56 masses in the initial stage, 24 in the intermediate stage and 12 in the final stage. To estimate fecundity, 90 ovigerous females were used, 73 in the initial stage and 17 in the final stage.

The eggs were separated from the pleopods by washing them with a solution of 0.033 to 0.06% sodium hypochlorite. Each egg mass was counted using a Motoda subsampler (1959).

The regression relationships between the carapace width (CW) and the total number of eggs (NE), number of initial eggs (NIE), final (NFE) and the weight of the egg mass (WE) were calculated. The weight of the egg-bearing female (WF) was related to the NE, NIE and NFE, and the WE to NE. For these regressions we used the power function $y=ax^b$, which seemed to be the best correlation between the variables.

The data for CW vs. NE, WF vs. NE and WE vs. NE, for eggs in the initial and final conditions, were compared by covariate analysis, ANCOVA (Zar, 1999). To check for a possible difference in seasonal egg production during the sample period, we performed an analysis of variance, ANOVA (Sokal and Rohlf, 1995; Zar, 1999).

Results

The smallest ovigerous female was 17.7 mm CW, and the largest was 43 mm. The mean CW was 28.4 ± 6.1 mm.

For the 92 egg masses analyzed, egg diameter ranged from 0.407 to 0.599 mm. The mean diameter was 0.466 ± 0.031 mm. The values in the three embryonic developmental stages were analyzed by the Kruskal-Wallis test. The resulting groups, isolated by the Dumm test, are shown in Table I.

The number of eggs ranged from 2,720 to 36,192, with a mean of 15,362 ± 8,002. The eggs were distributed in their respective size classes (Table II).

The best correlation in the fecundity analysis was by the power function ($y=ax^b$), which always showed the best relationship. Figure 2 shows the regression of CW vs. NE, and Figure 3 the regression of CW vs. NIE and NFE. The ANCOVA test showed no significant difference between the initial and final stages for both equations $\{F(1;87) = 0.55; p>0.05\}$.

Table I: *Eriphia gonagra*. Minimum, maximum and mean size of the diameter of eggs in the embryonic developmental stages (N= number of females with eggs).

EGG STAGE	N	EGG DIAMETER (mm)				
		Minimum	Maximum	Mean	Median	SD
INITIAL	56	0.407	0.481	0.452	0.450 **a**	0.017
INTERMEDIATE	24	0.439	0.535	0.475	0.471 **b**	0.020
FINAL	12	0.470	0.599	0.516	0.503 **b**	0.041

Table II: *Eriphia gonagra*. Minimum, maximum and mean number of eggs of the females in the respective size classes (N= number of females with eggs).

CLASSES	N	NUMBER OF EGGS			
(mm)		Minimum	Maximum	Mean	SD
16.6 ---] 20.8	12	2,720	6,208	4,737	1,128
20.8 ---] 25.0	16	3,744	15,552	9,262	3,616
25.0 ---] 29.2	22	8,512	21,856	14,303	3,920
29.2 ---] 34.4	24	10,784	27,792	18,340	4,983
34.4 ---] 37.6	10	19,552	32,640	24,078	3,948
37.6 ---] 41.8	3	20,480	36,192	28,245	7,857
41.8 ---] 46.0	3	29,904	35,488	32,384	2,843

Figure 4 shows the WF vs. NE relationship, which was strongly positively correlated, with $r^2 = 0.86$. The ANCOVA test showed no significant difference $\{F\ (1;87) = 3.88;\ p>0.05\}$ between the weight of the female and eggs, either in the initial or the final stages (Figure 5).

For CW vs. WE there was a strong positive correlation ($r^2 = 0.77$), as shown in Figure 6. However, plotting WE vs. NIE and NFE we obtained two different equations (Figure 7). For this correlation, the ANCOVA test showed a significant difference $\{F\ (1;87) = 7.33;\ p \leqslant 0.05\}$ between the weight of egg mass and the eggs in the initial and final stages.

Figure 8 shows the distribution of the number of eggs produced during each season, in both years. These data were plotted in box-plots according to Tukey (1977).

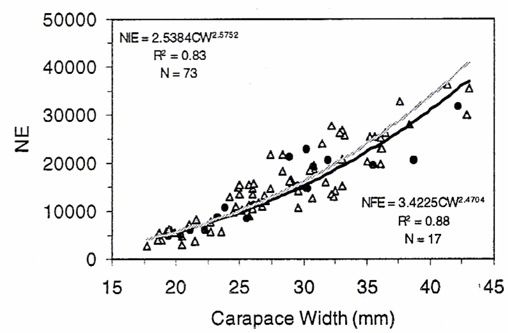

Figure 2: *Eriphia gonagra.* Regression between the carapace width (CW) and the total number of eggs (NE).

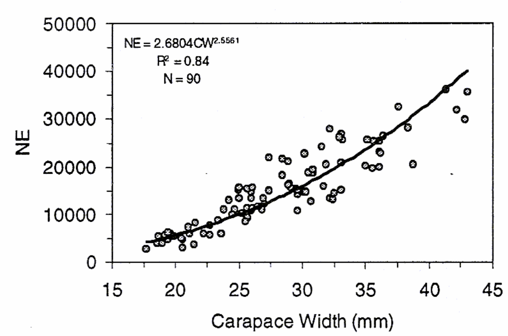

Figure 3: *Eriphia gonagra.* Regression between the carapace width (CW) and the number of eggs in the initial developmental stage (NIE).

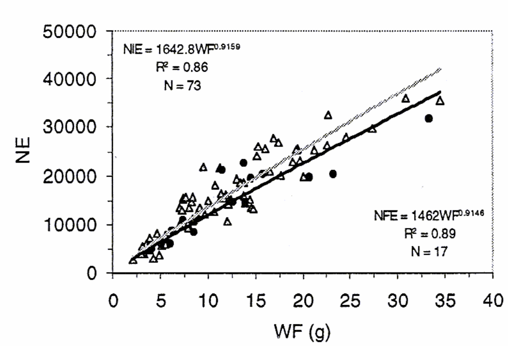

Figure 4: *Eriphia gonagra.* Regression between the weight of the female (WF) and the total number of eggs (NE).

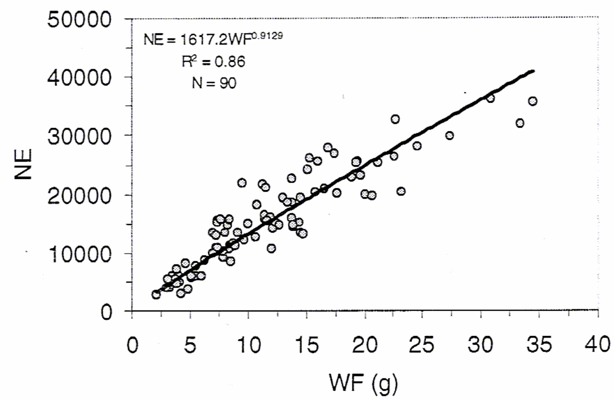

Figure 5: *Eriphia gonagra.* Regression between the weight of the female (WF) and the number of initial eggs (NIE = gray triangle) and final eggs (NFE = black circle).

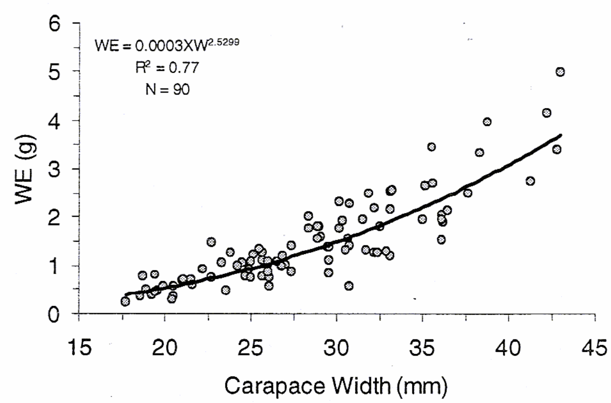

Figure 6: *Eriphia gonagra.* Regression between the carapace width (CW) and the weight of the egg mass (WE).

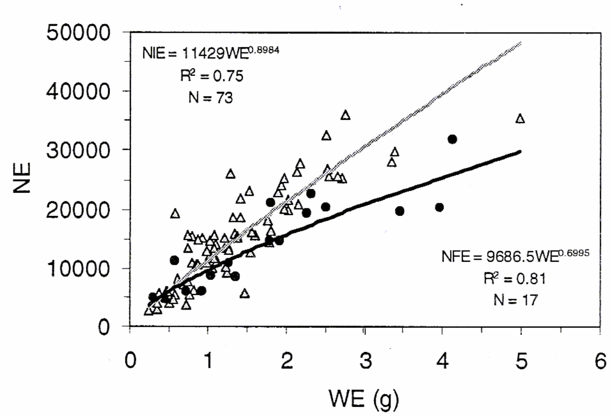

Figure 7: *Eriphia gonagra.* Regression between the weight of the egg mass (WE) and the number of initial eggs (NIE = gray triangle) and final eggs (NFE = black circle).

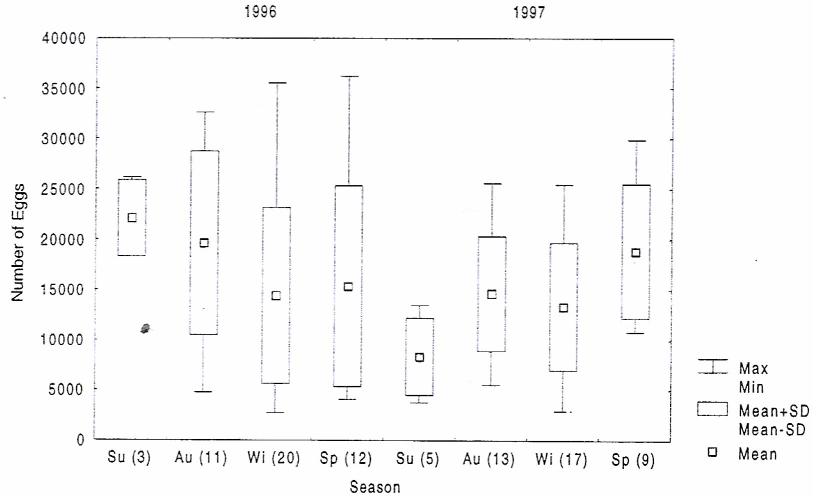

Figure 8: *Eriphia gonagra.* Number of eggs produced, by season (central square = mean; N = number of individuals analyzed in each season).

Discussion

Knowledge of the size of the smallest ovigerous female of a given species during its seasonal cycle is essential to estimate the species' sexual maturity. The smallest ovigerous female of *E. gonagra* (17.7 mm) found in this population agreed with the size at which this crab reaches sexual maturity, as determined by Góes and Fransozo (1997 b), and with the physiological sexual maturity (Góes, 2000).

Our measurements for *E. gonagra* revealed that the mean egg diameter increased slightly during the development of the embryos. The increase in egg size results both from embryonic growth and from water intake by osmosis during the later stages (Hattori and Pinheiro, 2001).

Several authors studying the fecundity of crabs have expressed concern about using only eggs in the initial stages. However, in the present study, as regards the regression between the carapace width and the number of eggs, there was no significant difference in the equations for eggs in the initial and final stages. In this case, it was possible to infer that the concern of many researchers about not counting eggs in the final stages, because of possible losses during development, should be borne in mind, but that losses apparently did not affect the results. In our analysis, it was possible to use a single equation to indicate the fecundity of *E. gonagra.*

From the results for the mean number of eggs in *E. gonagra* by size class, we inferred that larger females produce more eggs. This is in agreement with the results of Warner (1977), Du Preez and Mclachlan (1984), Campbell and Fielder (1988), Hines (1988), Branco and Avilar (1992), Reigada and Negreiros-Fransozo (1995), Costa and Negreiros-Fransozo (1996), Mantelatto and Fransozo (1997) and Leme and Negreiros-Fransozo (1998).

For *E. gonagra*, in regard to the regression between WF vs. NIE and WF vs. NFE, it was possible to say that there was no loss of eggs. This is clear from the strong positive correlation found for both equations, and also from the lack of significant statistical differences. It is possible that at certain times the female may eliminate and eat some eggs, for instance when she is under stress, as in the laboratory environment. The eggs are fixed on the pleopods and it was very difficult to separate them; in many cases it was necessary to use additional sodium hypochlorite. For these reasons, we believe that there was no significant egg loss. In many species of crabs, the large number of eggs is closely related to evolutionary mechanisms, mostly in respect to larval survival during development.

There was a significant difference between the equations for the regressions of WE vs. NIE and WE vs. NFE. This difference may be related to an increase in the diameter of eggs, caused by the development of the larvae and by water intake, rather than to a possible loss of eggs during the time required for the larvae to hatch.

We collected ovigerous females at all seasons of the year. During the autumn, winter and spring there was a wider range in the number of eggs. Because of the small number of females sampled in the summer, one might conclude, erroneously, that there was a difference between summer and other times of year. However, the statistical tests showed no significant difference among seasons in both years. This lack of seasonal differences is expected for species with continuous reproduction, like *E. gonagra* (Góes, 1995). This reproductive pattern is common in tropical and subtropical climates, where most females spawn over a long period, sometimes with peaks in some months or seasons (Goodbody, 1965; Ahmed and Mustaquim, 1974).

Analysis of the numbers of eggs of several species from different brachyuran families revealed a wide variation (2,560 to 433,888). This wide range in the number of eggs extruded may result from the many biological and ecological factors affecting the life cycle of each species. Table III shows the ranges in mean sizes of eggs of different species in different families. For *E. gonagra*, the mean sizes of all animals and the means of number of eggs produced were strongly correlated, $r^2 = 0.80$.

The mean carapace width and the number of eggs were strongly and positively correlated in different families of crabs, indicating that fecundity is closely related to the size of the animal. This suggests that two crabs of different families, with about the same carapace width, may have different fecundities; this may be related to the size of eggs, resulting in a longer or shorter larval development. On the other hand, it is possible to find animals from the same species, of about the same size, which show a wide range of fecundity. According to Reigada and Negreiros-Fransozo (1995) and Costa and Negreiros-Fransozo (1996), such a wide range may result from many factors, such as latitudinal differences, season, available food and the reproductive period of each female, and whether the estimate was made from the first, second or third hatch in the cycle.

In *E. gonagra*, it was common to observe females of about the same size with different numbers of eggs. This phenomenon has been observed previously in brachyurans. For instance, Mantelatto and Fransozo (1997), working with *Callinectes ornatus*, emphasized that this difference may be a function of multiple spawnings and also of the existence of more than one reproductive cycle annually.

For xanthids, some reports have indicated that the number of spawnings during a single intermolt period may vary. For *Neopanope sayi*, Swartz (1978) reported one or two spawnings. Porter (1960) found that *Menippe mercenaria* may spawn four times in each intermolt period. Vannini (1987) observed that *E. smithi* spawns more than twice per intermolt period; however, Tomikawa and Watanabe (1992) reported that this species always spawns once per intermolt period, although some individuals are able to spawn twice.

For *E. gonagra*, we infer that there is more than one spawning, because of the differences found in the CW vs. NE relationship for females of the same size. However, additional laboratory analyses are necessary to confirm this.

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Table III: Comparison of the mean fecundity in some brachyuran species.

Family / Species	Author (s) (Year)	Carapace width (mm)			Fecundity (Number of eggs)		
		Min.	Max.	Mean	Min.	Max.	Mean
Grapsidae							
Aratus pisonii	Leme and Negreiros-Fransozo (1998)	15.0	24.3	19.6 *	7,448	27,343	15,197
Pachygrapsus gracilis	Furtado-Ogawa and Rocha (1976)	5.5	11.8	7.9	1,340	14,996	4,756
P. transversus	Furtado-Ogawa and Rocha (1976)	6.0	15.4	10.6	1,436	22,314	9,222
Calappidae							
Hepatus pudibundus	Reigada and Negreiros-Fransozo (1995)	32.0	65.0	48.5 *	-	-	75,614
Portunidae							
Callinectes ornatus	Mantelatto and Fransozo (1997)	46.0	61.0	52.6	56,817	379,815	171,570
Ovalipes catharus	Haddon (1994)	46.0	107.0	76.5 *	82,000	683,000	360,000 *
O. ocellatus floridanus	Reid and Corey (1991)	45.2	60.9	52.0	119,437	345,958	196,789
Portunus gibbesii	Reid and Corey (1991)	26.0	31.9	29.3	55,774	206,644	151,491
P. ordwayi	Reid and Corey (1991)	14.6	22.1	19.9	16,015	59,014	45,046
P. spinicarpus	Reid and Corey (1991)	16.4	23.2	18.7	12,574	75,115	32,204
P. spinimanus	Reid and Corey (1991)	-	38.9	47.42	190,774	564,101	433,888
Xanthidae							
Eriphia smithii	Tomikawa and Watanabe (1992)	25.1	52.6	38.8 *	5,926	73,501	39,713 *
Eurypanopeus abbreviatus	Furtado-Ogawa and Rocha (1976)	6.2	10.4	8.6	919	4,408	2,560
Platyxanthus patagonicus	Carsen et al. (1996)	42.7	70.1	55.6	32,105	165,826	97,736
Eriphia gonagra	Present study	17.7	43.0	28.4	2,720	36,192	15,362

* Estimated in these studies from the simple mean.

References

Ahmed, M. and Mustaquim, J. 1974. Population structure of four species of porcellanid crabs (Decapoda: Anomura) occurring on the coast of Karachi. Marine Biology, 26: 173-182.

Batoy, C. B.; Samargo, J. F. and Pilapil, B. C. 1987. Breeding season, sexual maturity and fecundity of the blue crab, *Portunus pelagicus* (L.) in selected coastal waters in Leyte and vicinity, Philippines. Annals of Tropical Research, 9: 157-177.

Branco, J. O. and Avilar, M. G. 1992. Fecundidade em *Callinectes danae* (Decapoda, Portunidae) da lagoa da Conceição, Florianópolis, Santa Catarina, Brasil. Revista Brasileira de Zoologia, 9 (3/4): 167-173.

Bourdon, R. 1962. Observations préliminares sur la ponte des Xanthidae. Bulletin de l'Académie et Société Lorraine des Sciences, 2: 3-28.

Campbell, A. and Eagles, M. D. 1983. Size at maturity and fecundity of rock crabs, *Cancer irrroratus*, from the Bay of Fundy and southwestern Nova Scotia. Fishery Bulletin, 81 (2): 357-362.

Campbell, G. R. and Fielder, D. R. 1988. Egg extrusion and egg development in three species of commercially important portunid crabs from S. E. Queensland. Proceedings of the Royal Society, 99: 93-100.

Carsen, A. E.; Kleinman, S. and Scelzo, M. A. 1996. Fecundity and relative growth of the crab *Platyxanthus patagonicus* (Brachyura: Platyxanthidae) in Patagonia, Argentina. Journal of Crustacean Biology, 16 (4): 748-753.

Costa, T. M. and Negreiros-Fransozo, M. L. 1996. Fecundidade de *Callinectes danae* Smith, 1869 (Crustacea, Decapoda, Portunidae) na região de Ubatuba (SP), Brasil. Arquivos de Biologia e Tecnologia, 39 (2): 393-400.

Du Preez, H. H. and Mclachlan, A. 1984. Biology of the three spot swimming crab, *Ovalipes punctatus* (De Haan) III. Reproduction, fecundity and egg development. Crustaceana, 47 (3): 285-297.

Furtado-Ogawa, E. and Rocha, C. A. S. 1976. Sobre a fecundidade de crustáceos decápodos marinhos do Estado do Ceará, Brasil. Arquivos de Ciências do Mar, 16: 101-104.

Góes, J. M. 1995. Biologia populacional de *Eriphia gonagra* (Fabricius, 1781) (Crustacea, Decapoda, Xanthidae) na região de Ubatuba, SP. M.Sc. Dissertation Universidade Estadual Paulista, "Campus" de Botucatu, SP, 123 pp.

Góes, J. M. 2000. Biologia do caranguejo *Eriphia gonagra* (Fabricius, 1781) (Crustacea, Brachyura, Xanthidae) na região de Ubatuba, São Paulo. Doctoral thesis Universidade Estadual Paulista, "Campus" de Botucatu, SP, 175 pp.

Góes, J. M. and Fransozo, A. 1997a. Recrutamento de *Eriphia gonagra* (Fabricius, 1781) (Crustacea, Brachyura, Xanthidae) na região de Ubatuba, São Paulo, Brasil. Zoea, 4 (2): 66.

Góes, J. M. and Fransozo, A. 1997b. Relative growth of *Eriphia gonagra* (Fabricius, 1781) in State of São Paulo, Brazil. Nauplius, 5 (2): 85-98.

Góes, J. M. and Fransozo, A. 1998. Heterochely in *Eriphia gonagra* (Fabricius, 1781) (Crustacea, Decapoda, Xanthidae) of the rocky coast from Praia Grande, Ubatuba (SP), Brazil. Biotemas, 11 (1): 71-80.

Góes, J. M. and Fransozo, A. 2000. Sex ratio analysis in *Eriphia gonagra* (Crustacea, Decapoda, Xanthidae). Iheringia, Porto Alegre, (88): 151-157.

Góes, J. M. and Fransozo, A. 2001. Aspectos morfológicos do caranguejo *Eriphia gonagra* (Fabricius, 1781) (Crustacea, Brachyura, Xanthidae) do costão rochoso da Praia Grande, Ubatuba, São Paulo, Brasil., Anais do IX Congresso Latino-americano sobre Ciências do Mar.

Goodbody, I. 1965. Continuous breeding in populations of two tropical crustaceans, *Mysidium columbiae* (Zimmer) and *Emerita portoricensis* Schmidt. Ecology, 46 (1 & 2): 195-197.

Haddon, M. 1994. Size-fecundity relationships, mating behaviour, and larval release in the New Zealand paddle crab, *Ovalipes catharus* (White 1843). New Zealand Journal of Marine and Freshwater Research, 28: 329-334.

Hattori, G. Y. and Pinheiro, M. A. A. 2002. Fecundity and embryology of *Pachycheles monilifer* (Dana, 1852) (Anomura, Porcellanidae) at Praia Grande, Ubatuba, SP, Brazil. Nauplius, 9 (2): 97-109.

Hines, A. H. 1982. Allometric constraints and variables of reproductive effort in brachyuran crabs. Marine Biology, 69: 309-320.

Hines, A. H. 1988. Fecundity and reproductive output in two species of deep-sea crabs, *Geryon fenneri* and *G. quinquedens* (Decapoda: Brachyura). Journal of Crustacean Biology, 8 (4): 557-562.

Jewett, S. C; Sloan, N. A. and Somerton, D. A. 1985. Size at sexual maturity and fecundity of the fjord-dwelling golden king crab *Lithodes aequispina* Benedict from northern British Columbia. Journal of Crustacean Biology, 5 (3): 377-385.

Kennelly, S. J. and Watkins, D. 1994. Fecundity and reproductive period, and their relationship to catch rates of spanner crabs, *Ranina ranina*, off the east coast of Australia. Journal of Crustacean Biology, 14 (1): 146-150.

Leme, M. H. de A. and Negreiros-Fransozo, M. L. 1998. Fecundity of *Aratus pisonii* (Decapoda, Grapsidae) in Ubatuba region, State of São Paulo, Brazil. Iheringia, (84): 73-77.

Mantelatto, F. L. M. and Fransozo, A. 1997. Fecundity of the crab *Callinectes ornatus*, 1863 (Decapoda, Brachyura, Portunidae) from the Ubatuba region, São Paulo, Brazil. Crustaceana, 70 (2): 214-226.

Melville-Smith, R. 1987. The reproductive biology of *Geryon maritae* (Decapoda, Brachyura) of south west Africa / Namibia. Crustaceana, 53 (3): 259-275.

Motoda, S. 1959. Devices of simple plankton apparatus. Memoirs of the Faculty of Fisheries, Hokkaido University, 7 (1/2): 73-94.

Negreiros-Fransozo, M. L.; Fransozo, A.; Mantelatto, F. L. M.; Nakagaki, J. M. and Spilborghs, M. C. F. 1992. Fecundity of *Paguristes tortugae* Schmitt, 1933 (Crustacea, Decapoda, Anomura) in Ubatuba (SP), Brazil. Revista Brasileira de Biologia, 52 (4): 547-553.

Ogawa, E. F. and Rocha, C. A. S. 1976. Sobre a fecundidade de crustáceos decápodos marinhos do Estado do Ceará, Brasil. Arquivos de Ciências do Mar, 16 (2): 101-104.

Perkins, H. C. 1971. Egg loss during incubation from offshore northern lobsters (Decapoda: Homaridae). Fishery Bulletin, 69 (2): 451-453.

Pinheiro, M. A. A. and Fransozo, A. 1995. Fecundidade de *Pachycheles haigae* Rodrigues da Costa, 1960 (Crustacea, Anomura, Porcellanidae) em Ubatuba (SP), Brasil. Revista Brasileira de Biologia, 55 (4): 623-631.

Porter, H. J. 1960. Zoeal stage of the stone crab, Menippe mercenaria Say. Chesapeake Science, 1:168-177.

Prager, M. H.; McConaugha, J. R.; Jones, C. M. and Geer, P. J. 1990. Fecundity of blue crab, *Callinectes sapidus*, in Chesapeake Bay: biological, statistical and management considerations. Bulletin of Marine Science, 46 (1): 170-179.

Reid, D. M. and Corey, S. 1991. Comparative fecundity of decapod crustaceans, II. The fecundity of fifteen species of anomuran and brachyuran crabs. Crustaceana, 61 (2): 175-189.

Reigada, A. L. D. and Negreiros-Fransozo, M. L. 1995. Fecundidade do caranguejo *Hepatus pudibundus* (Herbst, 1785) (Crustacea, Decapoda, Calappidae) em Ubatuba (SP), Brasil . Arquivos de Biologia e Tecnologia, 38 (2): 661-668.

Santos, S. and Negreiros-Fransozo, M. L. 1997. Fecundity in *Portunus spinimanus* Latreille, 1819 (Crustacea, Brachyura, Portunidae) from Ubatuba, São Paulo, Brazil. Interciencia, 22 (5): 259-263.

Sastry, A. N. 1983. Ecological aspects of reproduction, 179-270. In: Vernberg, F. J. and Vernberg, W. B. (ed.). The Biology of Crustacea: Environmental Adaptations. New York, Academic Press, Inc. V. 8, 383 p.

Shields, J. D.; Okazaki, R. K. and Kuris, A. M. 1991. Fecundity and the reproductive potential of the yellow rock crab *Cancer anthonyi*. Fishery Bulletin, 89 (2):299-305.

Sokal, R. R. and Rohlf, F. J. 1995. Biometry: the principles and practice of statistics in biological research. W. H. Freman, New York, 887 p.

Somerton, D. A. and Meyers, W. S. 1983. Fecundity differences between primiparous and multiparous female Alaskan tanner crab (*Chionoecetes bairdi*). Journal of Crustacean Biology, 3 (2): 183-186.

Sturges, H. A. 1926. The choice of a class interval. Journal of the American Statistical Association, 21: 65-66.

Swartz, R. C. 1978. Reproductive and molt cycles in the xanthid crab *Neopanope sayi* (Smith, 1869). Crustaceana, 34 (1): 15-32.

Tomikawa, N. and Watanabe, S. 1992. Reproductive ecology of the xanthid crab *Eriphia smithii* Mcleay. Journal of Crustacean Biology, 12 (1): 57-67.

Tukey, J. W. 1977. Exploratory data analysis. Addison-Wesley, Reading, 668 p.

Vannini, M. 1987. Notes on the ecology and behaviour of the pebble crab *Eriphia smithi* Mcleay (Decapoda Brachyura). Monitore Zoologico Italiano, suppl. 22 (21): 383-410.

Warner, G. F. 1977. The biology of crabs. Elek Science, London, 202 p.

Zar, J. H. 1999. Biostatistical analysis. Prentice-Hall, Upper Saddle River, 941 p.

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