Volume 1, No.1, September 2013, Pages 51-58

Environmental Studies of Persian Gulf

journal home page: espg.pgu.ac.ir

Growth, Mortality and Stock Abundance of Venerid Bivalve, *Paphia cor* from Iranian Coastal Waters of Bushehr, Persian Gulf

Nassir Niamaimandi*

Iran Shrimp Research Institute, Bushehr, Iran.

ARTICLE INFO

Article History:
Received
May 5, 2013
Accepted
August 29, 2013

Keywords:
Growth parameters
Abundance
Bivalve
Paphia cor
Bushehr
Persian Gulf

ABSTRACT

In this study, population dynamics of venerid bivalve *Paphia cor* was investigated for a one-year period (2008-2009) in Bushehr shoreline areas (50˚ 40´ E- 29˚ 14´N) to estimate the stock abundance, growth parameters and natural mortality. Sampling was carried out bi-monthly by transects at random direction and zigzag pattern with duplicated quadrate (0.25 m2). The length frequency was used to estimate the growth and natural mortality parameters using LFDA statistical software. Sediment (µ), salinity (ppt) and water temperature (°C) were also sampled and measured. The Von Bertalanffy growth parameters were estimated as K = 0.8 $year^{-1}$, $L\infty$ = 55 mm and t_0 = -0.45 $year^{-1}$. Estimated natural mortality rate and maximum age (T_{max}) were 0.57 $year^{-1}$ and 50 months respectively. The mean (±SE) stock abundance of *P. cor* was 10.5±0.9 shells/m^2, with the maximum in February and the minimum in November. The mean value of water temperature and salinity were 25.2 °C (SD = 1.6) and 42 ppt (SD = 1.4) respectively. The bottom sediment grain sizes consisted of gravel (>2000 µ), sand (2000-62.5 µ), silt (62.5-2.0 µ) and clay (<2.0 µ). The results showed that the water temperature and sediment types affected the growth and existence of *P. cor* in the studied area.

1 INTRODUCTION

Bushehr coastal waters have a variety of marine organisms that can be used as food. They are also important to the commercially fish species. The shells are one of these species that are not directly used by the local people but they constitute one of the main food sources of some of the valued fishes in this area. Since 1996 due to the improvement in shrimp culture in Bushehr area some of the species, such as Solenspp. are used and harvested for the cultured shrimp. Further, habitat of some species such as *Paphia cor* is located in the shrimp pond drainage waters.

Approximately, 20,000 species (Pearse et al., 1987) of marine bivalves exist worldwide, so this class offers a rich diversity of lifestyles. There are relatively sparse studies of the bivalves in the Iranian shores of the Persian Gulf. The first published work on the shells was conducted by Issel (1865). Following that studies in the Persian Gulf area continued by Martens (1874), Melvill (1940), Biggs (1957),

*Corresponding author: nmaimandi @yahoo.com

Smyth (1972), Hasan (1994) and Hosseinzadeh et al. (2001). Most of these studies have focused on shell identification. According to the available literature, in the Arabian side of the Persian Gulf some of the mollusks involving bivalves have been studied by a small number of conchologists (Biggs and Grantier, 1960; Basson et al., 1977, and Sharabati, 1981). Oliver and Glover (1996) reported that genus Paphia in the Arabian Sea contains taxa belonging to the subgenera Protapes and Paratapes. Five taxa are recognized of which four are distinguished at the species level with the fifth given sub-species status only.

Study of the growth parameters is essential for modeling population dynamics of the bivalves, which, in turn, is crucial to support exploitation and management and also to propose effective measures for the protection of the species (Laudien et al., 2003; Peharda et al., 2007; Katsanevakis, 2007).

The purpose of the present study was to estimate the growth parameters and abundance of P. cor population in the shoreline of Bushehr located in northern part of the Persian Gulf.

2 MATERIALS AND METHODS

The study was conducted in the shallow intertidal zone of Bushehr (50´ 40°E and 29´ 14° N), where the tide ranged from 0.1 to 1.0 m (Fig. 1). Random sampling transects were used in a ziz-zag form to ensure representative coverage of all shell beds. For each transect, P. cor was counted and the samples were collected from two to three quadrates (0.25 m^2) during the low tide. To compare seasonal differences, samples for the abundance estimation were collected during warm (i.e. September and November) and cold (i.e. February) months. In each month, 30 to 35 quadrates were sampled.

The abundance of clams were first averaged by quadrate to give an average abundance per transect. Following formula was used for the estimation of abundance (King, 2006).

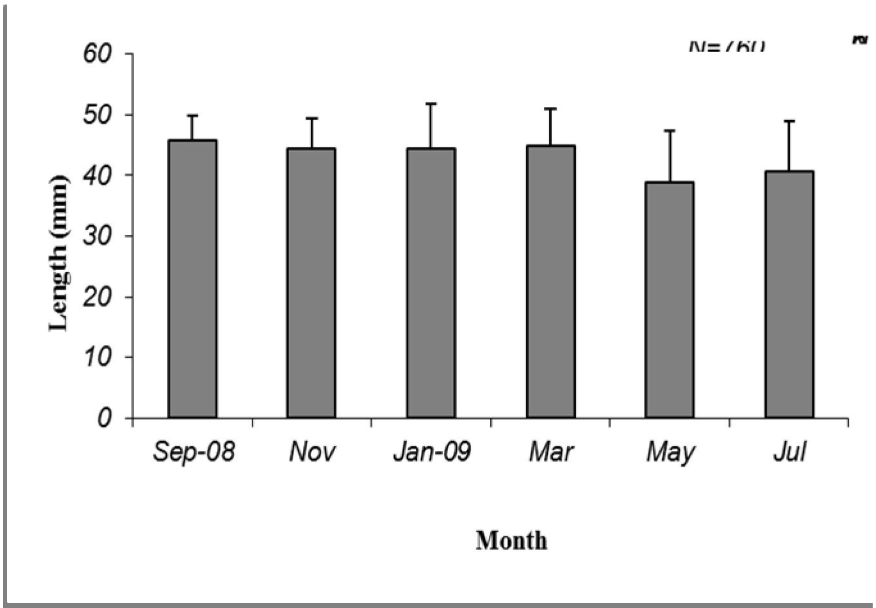

Fig. 1. Average total length of *Paphia cor* (n = 760) sampled from Bushehr waters, Persian Gulf (2008-2009).

Where $\overline{X}$ is the mean number of the samples per quadrate and n is the number of quadrates sampled.

Sampling for the estimation of growth parameters was conducted bimonthly. For each individual, shell length (anterior-posterior axis) was measured to the nearest millimeter using vernier calipers. The values of asymptotic length ($L\infty$), growth coefficient (K) and age at zero size (t_0) were estimated using LFDA software (Version 0.5).

The growth performance index (Ǿ) was estimated following the formula by Pauly and Munro (1983).

$$Ǿ = \ln K + 2 \ln L\infty$$

Natural mortality (M) was obtained using the method described by Taylor (1960) for bivalves.

$$M = 2.996/A_{0.95}$$

Where $A_{0.95}$ is the 95 percentile of the asymptotic length.

Longevity estimates (T_{max}) were calculated by using the inverse of the von Bertalanffy equation (King, 2006).

$$Tmax = t_0 - (l/k) \ln [1 - (Li/L\infty)]$$

Where Li is arbitrarily considered equal to 99% of the asymptotic length

$$T_{max} = t_0-(3/K)$$

Three random surface sediment samples (0-20 cm) were collected from the sampling area inhabited by the *P. cor* using Van Veen grab. Folk (1980) method was used for sand fraction. Salinity and water temperature were also measured.

3 RESULTS

The total average length of the shells are presented in Fig. 1. As can be seen, the average minimum and maximum length occurs in May (45.7 mm ± 4.2) and September (38.9 mm± 8.4) respectively.

Total length frequency of 760 specimens obtained during this study is presented in Fig. 2. Clam length ranged from 16 to 58 mm, with maximum frequency at ranges of 48-51 mm.

The length frequency curve is shown in Fig. 3 to illustrate the suitable seasonal growth curve. To find the growth curve by maximum number of peaks, different lengths were

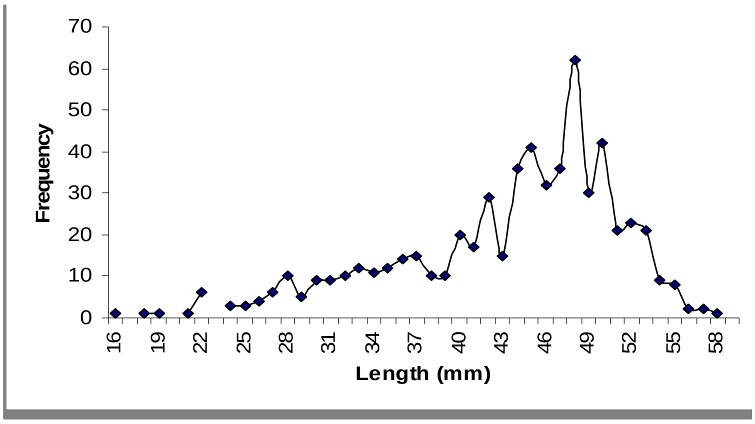

Fig. 2. Length frequency distribution of *Paphia cor* from Bushehr waters, Persian Gulf (2008-2009).

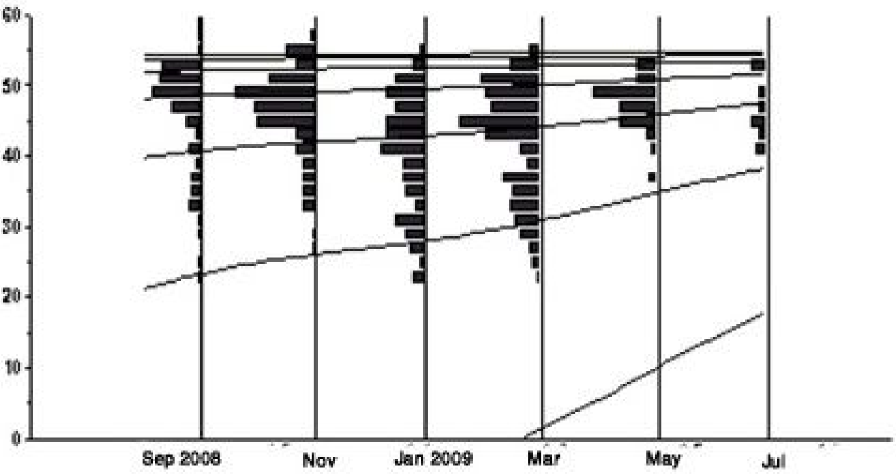

Fig. 3. Length frequency curve for *Paphia cor* in Bushehr waters, Persian Gulf (2008-2009).
$L\infty$ = 55 mm, K = 0.8 year^{-1}, t_0 = -0.45 year^{-1}.

subjected to the goodness-of-fit tests by assessing the ratio ESP/ASP (Rn). Amplitude of oscillation (C) and winter point (WP) were assumed equal to 0.5 and 0.1, respectively. This curve corresponds to asymptotic length ($L\infty$= 55 mm), growth coefficient (K = 0.8 year^{-1}) and age at zero length (t_0 = -0.45 year^{-1}).

The mean number of clam per m^2 in the hot months (September and November) is from 8.7 to 6.3. The mean number of individuals has increased to 10.8 clams per m^2 in the cold month (February) of the year, with an average abundance of 10.5 (SE = 0.9) per m^2 (Table 1).

Table 1
Mean of *Paphia cor* individuals per m^2 found in Bushehr study area, Persian Gulf (2008-2009).

Month	Studied area (m^2)	Mean No. individuals per m^2
Sep 2008	2	8.7
Nov 2008	2	6.3
Feb 2009	1.75	10.8
Mean(±SE)		10.5 (±0.9)

The soil (or sediment) analyses (Table 2) showed that the sediment contained 11.5% clay, 54.6% silt, 32.74% sand and 1.11% gravel.

During different months of sampling, the salinity and temperature were measured (Table 3). Results showed the highest salinity measured as 43 ppt in September and the lowest in June with the least fluctuation. Mean water temperature ranged between 15ºC and 35ºC, with the maximum in June and the minimum in January.

Natural mortality (M) was estimated using Taylor (1960) formula from estimated asymptotic length of $L\infty$ = 55mm.

Table 2
Sediment composition (% by weight) in coast of Bushehr, Persian Gulf (2008-2009).

Sediment type	Particle size (µ)	Percent
Clay	<2.0	11.55
Silt	2.0-62.5	54.60
Sand	62.5-2000	32.74
Gravel	>2000	1.11

Table 3
Average salinity (ppt) and water temperature (°C) during different months in Bushehr, Persian Gulf (2008-09)

Months	Temperature (°C)	Salinity (ppt)
September	33	43
November	25.5	42.5
February	15	45
March	18	43
May	25	39.5
Jun	35	40
Mean	25.2	42
S.D	±1.6	±1.4

The following result was obtained:

$$M = 2.996 / 5.22 = 0.57$$

The value of growth performance index (Ǿ) was calculated using Pauly and Munro (1983). The following result was obtained:

$$Ǿ = \ln 0.8 + 2\ln 55 = 7.79$$

Maximum age (T_{max}) was derived from parameters of $L\infty$, K and $t_0$was obtained from the growth curve. The result is as follows:

$$T_{max} = - 0.45 – 3/0.8 = 4.2$$

4 DISCUSSION

In the present study, biomass measurements obtained showed that the abundance was the greatest in the cold month of February and the lowest in hot months (i.e. September and November). Large and older clams are visible in the September and November (hot months) and the smaller newly recruited clams appear as a new cohort in January and March (cold months). The observed monthly variation of *P. cor* may be due to the environmental conditions.

Ecological factors are important in the distribution and abundance of a species, and interactions among species should be (theoretically) stable in a locale if the environment is uniform (Bourne, 1968). Bivalves inhabit a temperature ranging from ⁻1.8ºC in polar waters to >30 ºC in tropical seas, and a salinity ranging from fresh water to hyper saline waters (Morton, 2000). The relations between the environmental conditions and growth of the invertebrates were determined by Wanink and Zwarts (1993). Environmental conditions play an important role in the growth of the bivalve mollusks (Littlewood, 1988). Temperature drop could reduce the metabolism of the clams and hence rate of the shell formation (Ardial, 1993).

Predation is another factor which may limit the growth of the invertebrates. Some of the predators (e.g. birds or fishes) select the largest or the smallest size classes from many of their prey species (Zwarts & Drent, 1981; Sutherland 1982; Zwarts and Esselink, 1989). In the studied area, bivalves are the main food of some of the fishes, family Sparidae, specifically Acanthopagrusberda and Sparidentex hasta (Niamaimandi, 1991). The main source of high natural mortality for *P. cor* can be predation by these species. Selecting feeding grounds with relatively large or small prey may be highly important for the predators food intake (Wanink and Zwarts, 1993), while they may severely deplete their areas from larger (i.e. older) or smaller (i.e. juvenile) species. Growth rate directly sets the time at which a species reaches the lower threshold size of acceptance for the predators (Zwarts and Wanink, 1984). In species with a calciferous exo-skeleton, such as *P. cor*, growth rate also determines the period during which an animal is ingestible to waders. When a bivalve has reached a size greater than the width of the predators gape, and the predators are not using a technique to separate the flesh from the shell, so it is safe from the predation (Zwarts and Blomert, 1992; Zwarts et al., 1992). Thus, growth rate appears to be a key factor in estimating the harvestable bivalves' fraction for waders.

In the studied area, high and the length compositions were obtained; however, they do not seem to cover the lower length range and this could indicate that *P. cor* smaller than 16 mm was not presented in the survey area. The gradual shift to the right of length-frequency distributions of *P. cor* may be inhibited, and the observed mean growth will be lower than the actual growth of the individuals.

More than 88 percent of the bottom sediment in the study area included silt (54.60%) and sands (32.74%). This sediment type characterizes the habitat of this species. This physical condition may influence the limitation of *P. cor* abundance and distribution in the Bushehr coastal area. Sediment type may be another important factor regulating feeding and growth of the invertebrates (McClusky and Elliott, 1981; Newell and Hidu, 1982).

P. cor has been identified in the Oman coastal area and Arabian Sea (Oliver and Glover, 1996); however, there is no data on the growth or other biological parameters of this species in the Persian Gulf and Oman sea area and basically published data on *P. cor* are limited.

Numerous factors such as salinity, light, current speed, exposure to high-energy environments, exposure to siphon-cropping, population density, and genotype have been noted to affect the growth of marine invertebrates (Seed, 1980). The interrelationships between many of these variables make it difficult to isolate the most important factors. But it seems that at least two factors of temperature and sediment types affected the growth and existence of *P. cor* in the studied area. Also, this area is exposed to the drainage waters of shrimp farms. Thus, pollution of this area can limit and reduce the reproductivity and juvenile survival.

The potential presence of pollutants from shrimp ponds should also be investigated. Also, the prey-predation relationship is one of the important keys that can clear the obscure information on the survival and growth of the P. cor in the Bushehr coastal area.

ACKNOWLEDGEMENTS

This work was funded and supported by Bushehr Fisheries Department (Shilat). Appreciation is extended to the managers of Shilat and Iranian Fisheries Research Institute (IFRO) for their support. The author also thanks A. Ansari, R. Gholamnezhad, K. Khorshidian and G. Izadpenahi for their contributions to this research.

REFERENCES

Ardila, J. P. (1993). Growth patterns in the shells of *Amiantis umbonella*: Records of 1991 Persian Gulf oil spill. *M Sc Thesis, University of Wales*, 30pp.

Basson, P. W., Buchard, J. E., Hardy, J. T. and Price, A. A. G. (1977). Biotopes of the western Persian Gulf. *Maritime life and environments of Saudi Arabia. Department of loss prevention and environmental affairs. Aramco, Dhahran*. 284p.

Biggs, H. E. G. & Grantier, I. (1960). A preliminary list of mollusca of RasTanura. Persian Gulf. *J. Conch. Land.*, Vol. 24, No. 11, pp. 387-392.

Biggs, H. E. J. (1957). Littoral collection in the

Persian Gulf. *J. Conch. London*, Vol. 24, pp. 270-275.

Bourne, N. (1968). Clam research in British Columbia. *Proc. Shellfish. Assoc.*, Vol. 59, 10p.

Hasan, A. K. (1994). A taxonomic review of the bivalve and gastropod mollusc fauna along the Saudi intertidal zone of the Persian Gulf. *J. Kau. Mar. Sci.*, Vol. 7, pp. 245-253.

Houseinzadeh, H., Daghoghi, B., & Rameshi, H. (2001). Atlas of the Persian Gulf mollusks. *Iranian Fisheries Research Organization Press., Tehran*., 208 pp.

Issel, A. (1865). Catalogo del molluschi raccolti della Missione Italiana in Persia. Mem. *Dellereale academia dellascienze di Torino*, Ser. 2, 23pp.

Katsanevakis, S. (2007). Growth and mortality rates of the fan mussel Pinna nobilisin Lake Vouliagmeni (Korinthiakos Gulf, Greece): a generalized additive modelling approach. *Mar Biol*, Vol. 152, pp. 1319–1331.

Laudien, L., Brey, T. & Arntz, W. E. (2003). Population structure, growth and production of the surf clam Donaxserra (Bivalvia, Donacidae) on two Namibian sandy beaches. *Estuar. Coast. Shelf. Sci*., Vol. 58, pp. 105–115.

Littlewood, D. T. J. (1988). Subtidal versus intertidal cultivation of Crassostrearihzophorae. *Aquaculture*, Vol. 72, pp. 59-71.

Martens, S. (1874). Ueber voderasiatische conchylien nach den sammlugen des prof, Hausnechtcassel. *Verlag. Von. Theodor. Fisher*. 102 pp.

McClusky, D. S. and Elliott, M. (1981). The feeding and survival strategies of estuarine molluscs. In: N.V. JONES & W.J. WOLFF. Feeding and survival strategies of estuarine organisms. *Plenum Press, New York*, pp. 109-121.

Melvill, J. C. (1940). Description of twenty-three species of gastropoda from the Persian Gulf, Gulf of Oman and Arabian Sea. *Proc. Malac. Soc. London*, Vol. 6, pp. 51-60.

Morton, B. (2000). The biology and functional morphology of Fragumerugatum (Bivalvia: Cardiidae) from Shark Bay, Western Australia: the significance of its relationship with entrained zooxanthellae. *J. Zool*. Vol. 251, pp. 39–52.

Newell, C. R. & Hidu, H. (1982). The effects of sediment type on growth rate and shell allometry in the soft shelled clam Myaarenaria. *J. Exp. Mar. Biol. Ecol*. Vol. 65. pp. 285-295.

Olive, P. G. & Glover, E. (1996). Paphia (Protapes) (Bivalvia: Veneroidea) in the Arabian Sea, with the descripiton of a new species. *Journal of Conchology*, Vol. 35, No. 5, pp. 389-405.

Pearse, V., Pearse, J., Buchsbaum, M., & Buchsbaum, R. (1987). Living Invertebrates. *Blackwell Scientific Publications, Boston, USA*., 249 pp.

Peharda, M., Richardson, C. A., Mladineo, I., Popovi´c, Z., Bolotin, J., & Vrgo´c, N. (2007). Age, growth and population structure of *Modiolus barbatus* from the Adriatic. *Mar Biol*, Vol. 151, pp. 629–638.

Powell, E. N. & Cummins, H. (1985). Are molluscan maximum life spans determined by long-term cycles in benthic communities? *Oecologia*, Vol. 67, pp. 177–182.

Schone, B. R., Fiebig, J., Pfeiffer, M., Gle, R., Hickson, J., Johnson, A. L. A., Dreyer, W., & Oschmann, W. (2005). Climate records from a bivalve Methuselah (Arcticaislandica, Mollusca; Iceland). *Paleogeogr. Paleoclimat. Paleoecol.*, Vol. 228, pp. 130-148.

Seed, R. (1976). Ecology. In: B. L. Bayne. Marine mussels: their ecology and physiology. *International Biological Programme 10. Cambridge University Press, Cambridge*, pp. 13- 65.

Sharabati, D. P. (1981). Saudi Arabian seashells, selected Red Sea and Persian Gulf mollusks. *Royall SmeetS Offset. Netherlands*. 119pp.

Smythe, K. (1972). Marine mollusca from Bahrain Island, Persian Gulf. *J. Conch*. pp. 491-496.

Sutherland, W. J. (1982). Do oystercatchers select the most profitable cockles? *Anim. Behav.*, Vol. 30. pp. 857-861.

Wanink, J. H., & Zwarts, L. (1993). Environmental effects on the growth of the intertidal invertebrate and some implications for foraging wades. *Netherlands Journal of Sea Research*. Vol. 31, No. 4, pp. 407-418.

Zwarts, L., & Drent, R. H. (1981). Prey depletion and the regulation of predator density: oystercatchers (*Haematopus ostralegus*) feeding on mussels (*Mytilus edulis*). In: N.V. Jones and W.J. Wolfe. Feeding and survival strategies of estuarine organisms. *Plenum Press, New York*, pp. 193-216.

Zwarts, L., & Esselink, P. (1989). Versatility of male curlews *Numenius arquata* preying upon *Nereis diversicolor*. deploying contrasting capture modes dependent on prey availability. *Mar. Ecol. Prog.*, Ser. 56, pp. 255-269.

Zwarts, L., & Wanink, J. H. (1984). How oystercatchers and curlews successively deplete clams. In: P.R. Evans, J.D. Coss-Custard and W.G. Hale. Coastal waders and wildfowl in winter. *Cambridge University Press, Cambridge*, pp. 69-83.

Zwarts, L., & Blomert, A. M. (1992). Why knot *Calidris canutus* take medium-sized *Macoma balthica* when six prey species are available. *Mar. Ecol. Prog.* Ser. 83, 113-128.

Zwarts, L., Blomert, A. M., & Wanink, J. H. (1992). Annual and seasonal variation in the food supply harvestable by knot *Calidris canutus staging* in the Wadden Sea in late summer. *Mar. Ecol. Prog*. Ser. 83; 129-139.