Turk J Zool
27 (2003) 339-343
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Population Parameters of the Pearl Oyster *Pinctada radiata* (Leach) in Qatari Waters, Arabian Gulf.

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Received: 27.07.2002

Abstract: The pearl oyster, *Pinctada radiata*, represents the most abundant marine bivalve species in Qatari waters. The population parameters of this species were investigated and compared to those obtained previously from both the Mediterranean and Red seas. Four age groups with mean lengths of 56.75, 65.84, 77.54 and 84.66 mm were obtained for P. radiata from Qatari waters. The values of asymptotic length, Brody's growth coefficient and growth performance index were 132.18 mm, 0.34 y^{-1} and 1.77 respectively, while the total mortality coefficient equals 2.47 y^{-1}. The morphometric relationship between the total weight and dorso-ventral measurement was determined to be $W = 0.0002606\ (DVM)^{2.90707}$.

Key Words: Qatari waters, Pearl oyster, *Pinctada radiata*, age, growth, mortality and recruitment pattern

Arap Körfezi'nin Katar Sularında İnci İstiridyesinin *Pinctada radiata* (Leach) Populasyon Parametreleri

Özet: İnci istiridyesi (*Pinctada radiata*), Katar sularında en bol bulunan midye türüdür. Bu nedenle, bu türe ait populasyon parametreleri incelenmiş ve Akdeniz ile Kızıldeniz'de daha önceden yapılmış araştırmaların sonuçlarıyla karşılaştırılmıştır. Katar sularındaki inci istiridyelerinin ortalama boyları sırasıyla 56.75, 65.84, 77.54 ve 84.66 mm olan dört yaş grubu (kohort) saptanmıştır. Toplam ölüm katsayısı (Z) 2.47 $yıl^{-1}$ eşiken; sonuşmaz (asimptotik) boy (Ls), Brody'nin büyüme katsayısı (K) ve büyüme performansı indeksi (s) değerlerinin sırasıyla 132.18 mm, 0.34 $yıl^{-1}$ ve 1.77 olduğu belirlenmiştir. Dorsoventral uzunluk ve toplam ağırlık arasındaki morfometrik ilişki $W = 0.0002606\ (DVM)^{2.90707}$ ile ifade edilebilmiştir.

Anahtar Sözcükler: Katar suları, İnci istiridyesi, *Pinctada radiata*, yaş, büyüme, ölüm, stoğa katılım modeli

Introduction

Pearl oyster resources in many countries have been exploited for pearl production. In the past, pearl fishing in the Arabian Gulf was large and represented about 80% of the world's production of natural pearls (Al-Matar et al., 1993a). Some scientific attention has been given with regard to pearl oyster fishing in Kuwait (Al-Matar et al., 1983; Al-Matar et al., 1993a; Al-Matar et al., 1993b) and on its biology in Bahrain (Khamdan, 1988; Al-Sayed et al., 1993; Qureshi et al.,1993). Al-Matar *et al* (1983) estimated the seasonal growth parameters in asymptotic length (L_∞), Brody's growth coefficient (K) and (t_o) for *Pinctada margaritifera* in Kuwait waters by using the ELEFAN technique of Pauly and David (1981). Sims (1990) determined L_∞ and K in wild stocks of *Pinctada margaritifera* off Cook Island. Beaumont and Khamdan (1991) and Al-Sayed et al. (1993) studied the morphometric characters in population differentiation of pearl oyster *Pinctada radiata* from around Bahrain. Yassien (1998) and Yassien et al. (2000) studied the population structure of the wild stock of *Pinctada radiata* from both the Red and Mediterranean seas, respectively.

Qatari waters are rich in pearl oyster beds (more than 80) famous for their excellent pearls. It is distinguished by the presence of different species of pearl oyster. *Pinctada radiata* represents about 95% of the total oyster catch, while *Pinctada margaritifera* and *Pteria marmorata* represents about 5% (Mohammed, 1994). The lack of biological, population structure and fishery management compelled us to study this important edible marine bivalve in Qatari waters.

Materials and Methods

The specimens were collected from Qatari oyster beds (lat 25°19'60"N, long 52°03'52"E) by scuba divers and the associated fouling cleaned off. For each individual, shell height (dorso-ventral measurement), shell length (anterior-posterior axis), shell width and hinge length were measured to the nearest millimeter by vernier calipers. The total weight for each individual was weighed to within 0.001 g. Length frequency analysis was applied using modal progression analysis (MPA), and the Bhattacharya method (Bhattacharya, 1967) to assess the age groups. The estimation of von Bertalanffy growth parameters for length was performed using FiSAT software (Gayanilo et al., 1995). The Wetherall method (Wetherall, 1986) was used to estimate L_∞ and the value of the total mortality caefficient (Z)\K from pooled samples in a time series of length frequency data; where K was determined using ELEFAN I.

The growth performance index (Φ`) was estimated by applying the equation derived by Munro and Pauly (1983) in the form of $\Phi` = \log_{10} (K) + 2 \log_{10} (L_\infty)$, where L_∞ and K are the growth parameters.

A morphometric relationship between the dorso-ventral measurement (DVM) and the total weight was calculated according to the equation derived by Le Cren (1951), $W = aL^b$ where W is the total weight in grams, (L) is the DVM in millimeters, and (a) and (b) are constants.

Z was determined by applying the linearized length converted catch curve method (LLCCCM) of Pauly (1983).

The recruitment pattern was obtained by projecting the length frequency data with constant class size backward onto the time axis using the growth parameters L_∞ and K to show the number of recruitment pulses per year (Pauly, 1986b) by normal separation.

Results and Discussion

Growth parameters

A length frequency sample of 566 specimens collected from Qatari waters, in the Arabian Gulf was incorporated in the FiSAT software (Gayanilo et al., 1995) to apply MPA and the Bhattacharya method (Bhattacharya, 1967). This method split the composite distribution into four separate age groups with mean lengths of 56.75, 65.84, 77.54 and 84.66 mm respectively (Fig. 1).

Narayanan and Michael (1968) studied the growth in shell height DVM of the pearl oyster *Pinctada fucata* (=*Pinctada radiata*) reared in the Gulf of Kutch, India, based on growth rings and found that oysters grew to 44.1, 61.7, 76.2, 81.6, 85.2 and 86.6 mm at the end of years one through six respectively; the second, third and fourth age groups are comparable with those of the present study. Chellam (1987), while tracing the growth forms of *Pinctada fucata* in Tuticorin harbor, found the

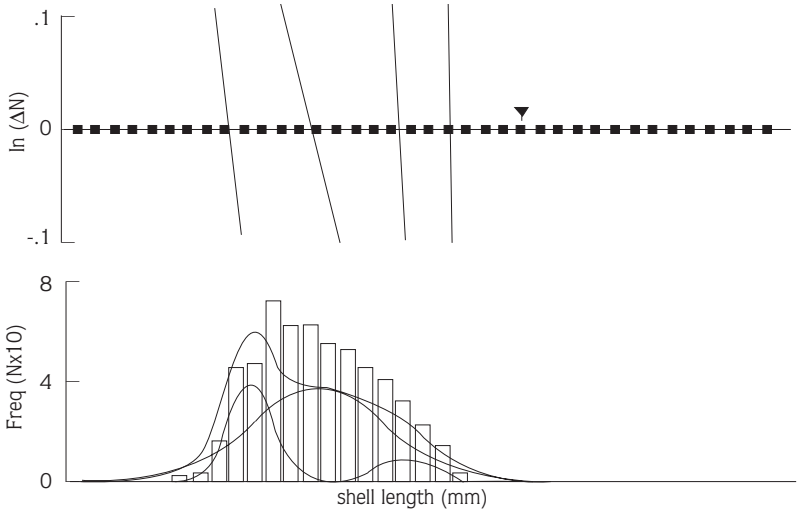

Figure 1. Observed age groups using Bhattacharya's method for *Pinctada radiata* collected from the Qatari waters.

spat attained a size of 47.0, 64.5 and 75.0 mm shell height at the end of the first, second and third years respectively. The second and third age groups are also in agreement with those of the present study. In Japan, Wada (1990) found that the average shell height for 5-year-old *Pinctada fucata* was 46.4 mm (1st year), 58.2 mm (2nd year) and 72.7 mm (3rd year). The maximum size recorded was about 100.0 mm over a 10-year lifespan. Mohammed (1994) calculated the mean size in shell height (= DVM in the present study) of five different age groups of *Pinctada radiata* in Qatari waters using age frequency distribution, based on growth rings. They were 63.4, 67.4, 76.3, 81.7, and 92.1 mm respectively. In his study, the mean length obtained for the first age group is high but those obtained for the second, third and fourth age groups are comparable with those of the present study.

Yassien (1998) identified six cohorts with mean lengths of 20.3, 47.9, 66.4, 78.8, 87.0 and 91.7 mm respectively for the wild population of *Pinctada radiata* in the Red Sea and the largest specimen had a length of 93.2 mm. He suggested that the first cohort represents the 0 age group. Yassien et al. (2000) estimated four age groups for *Pinctada radiata* from the Mediterranean with mean lengths of 23.9, 43.3, 54.5 and 60.8 mm respectively, and the maximum observed length was 64.0 mm.

Estimation of L_∞ and Z/K

In the method of Wetherall (1986), the cutoff length used was 93.75 mm and data corresponding to class mid-length of 93.75 mm onwards were only used in the regression as they represent the fully recruited specimens (Fig. 2). The alignment of points on the straight line was quite satisfactory with a good coefficient of correlation (r = 0.852). The following estimates are obtained: L_∞ = 132.218 mm and Z/K = 0.419, and the resultant K = 0.34 y^{-1}.

Mohammed (1994) estimated L_∞ for *Pinctada radiata* in Qatari waters as 107.0 mm by using a Ford-Walford plot for back-calculated growth rings, and K as 0.2497 y^{-1}. Yassien (1998) calculated L_∞ = 9.574 cm and Z/K = 4.723 for *Pinctada radiata* in the Red Sea. He found that K equals 0.414 y^{-1}. Yassien et al. (2000) estimated L_∞ as 6.918 cm, and Z/K as 5.415 for *Pinctada radiata* in the Mediterranean Sea and K value as 0.56 y^{-1}. Comparing the abovementioned parameters with those in the present work, it can be seen that there

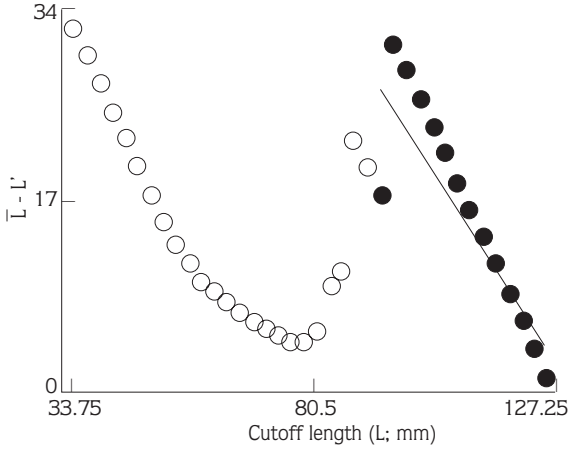

Figure 2. Wetherall plot to estimate L_∞ and Z/K for *Pinctada radiata* from Qatari waters.

is no definite pattern for the parameters estimated by different authors and the results diverge between different authors in different areas. These differences can be explained by the different methods applied for age determination; they also can be explained by the different survival strategies and ecological factors present at different latitudes.

Growth performance index

The Φ` may be equal within species or between closely related taxa and between different stocks of the same species (Moreau et al., 1986). The $\Phi$` of *Pinctada radiata* in Qatari waters according to the formula of Munro and Pauly (1983) equals Φ` = 1.77. Table 1 shows the difference in the value of $\Phi$` for the *Pinctada radiata* in different areas. The Φ` is higher than that reported by Mohammed (1994), Yassien (1998) and Yassien et al., (2000). Comparative growth studies can be used to investigate the effects of various factors such as pollution, environmental stress hazards and different habitats.

Length-weight relationship

Morphometric relationships are used to differentiate between genetic groups, where the length-weight relationship is required in population dynamics and fisheries stock assessment, since the rate of increase in weight reflects how the ecological factors of a habitat affect the animal which lives in it. Figure 3 shows the relationship between the DVM and W of *Pinctada radiata* from Qatari waters and the resultant formula is: $W = 0.0002606\ (DVM)^{2.90707}$ with a regression coefficient of 0.8586.

Table 1. Growth parameters in length of *Pinctada radiata* from different areas.

Area	L_∞ (cm)	K y^{-1}	Φ`	Reference
Qatar	10.70	0.25	1.456	Mohammed (1994)
Red Sea	10.23	0.41	1.637	Yassien (1998)
Mediterranean	6.92	0.56	1.428	Yassien et al. (2000)
Arabian Gulf	13.20	0.34	1.770	Present study

Table 2. Constants of the length-weight relationship of *Pinctada radiata* in different areas.

Area	a	b	Author
Red Sea	0.000372	2.2050	Mohammed (1997)
Qatar	0.000490	2.1980	Mohammed (1997)
Red Sea	0.110500	3.0005	Yasasien (1998)
Mediterranean	0.321000	2.7760	Yassien et al. (2000)
Arabian Gulf	0.000261	2.9071	Present study

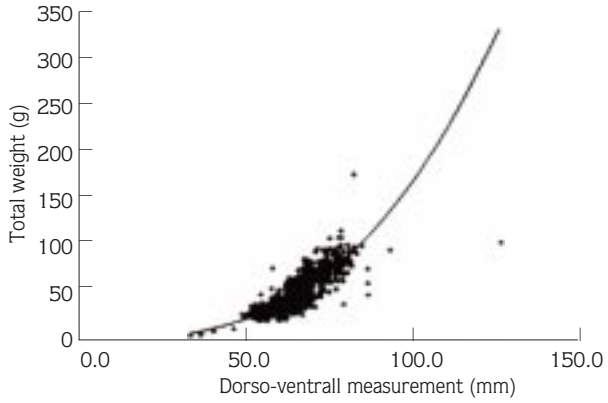

Figure 3. Length-weight relationship of the pearl oyster *Pinctada radiata* in Qatari waters.

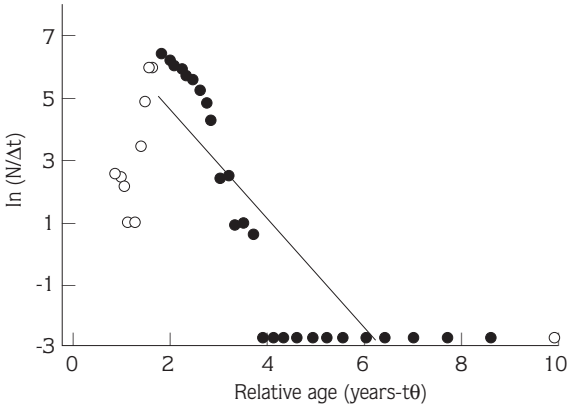

Figure 4. Length converted catch curve to estimate total mortality coefficient (Z).

This relationship was isometric as the slope value, 2.907, was not significantly different from the isometric value, $p < 0.1$. Table 2 summarizes the reported estimates of the length-weight relationship of *Pinctada radiata* in different areas.

Mortalities

In the length converted catch curve, Figure 4, the straight-line regression was fitted to the points of length 60.0 to 125.0 mm of the plot. The slope of the fitted line equals - Z = 1.74 and the regression equation is Ln (N/Δt) = 8.31-1.74 t (r = 0.848)

Yassien (1998) estimated that Z = 2.47 y^{-1} for *Pinctada radiata* collected from the Red Sea. Alagarswami and Chellam (1977) stated that the problems of fouling and boring organisms are probable causes of mortality in pearl oysters observed at different ages.

Recruitment pattern

This pattern reconstructs the recruitment pulses from a time series of length frequency data to determine the number of pulses per year and the relative strength of each pulse. The recruitment pattern or pulses is extended over the year, as shown in Figure 5, suggesting semi-continuous breeding. Chellam (1987) in Indian waters and Al-Sayed et al. (1993) in Bahrain waters recorded continuous spawning in *Pinctada radiata* with peaks in hot seasons. Al-Matar et al. (1993b) observed spawning evidence in May (could be extended to September) in Kuwait. Yassien (1998) suggested that the spawning season of *Pinctada radiata* from the Red Sea is prolonged and hence the recruitment pattern extends throughout the year.

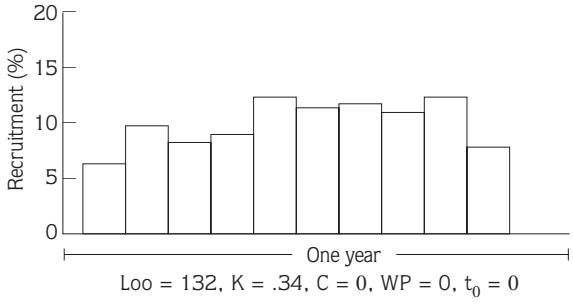

Figure 5. Recruitment pattern of *Pinctada radiata* from Qatari waters, Arabian Gulf.

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