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Determination of the Growth Parameters of the *Anadara cornea* R. 1844 Population by the Bhattacharya Method in the Eastern Black Sea

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Abstract: *Anadara cornea* is going to be one of the target species of the dredging fishery along the continental shelf of the Turkish Black Sea coast. Although it has not been exploited yet, studies on the distribution, growth and meat quality have been carried out. In this study, growth parameters were estimated after determining the cohorts by the "Bhattacharya" method. Four year classes were distinguished and using the corresponding lengths of these, von Bertalanffy growth parameters and the length - weight relationship were found to be L_{∞}=75.24 mm, K= 0.370 and t_0= -0.103 and W= $0.0015L^{2.619}$, respectively.

Key Words: *Anadara cornea,* growth parameters, Bhattacharya method, eastern Black Sea.

Doğu Karadeniz'deki Akmidye (*Anadara cornea,* R. 1844) Populasyonunda Büyüme Parametrelerinin Bhattacharya Yöntemi ile Belirlenmesi

Özet: *Anadara cornea* Doğu Karadeniz balıkçılığı için en önemli potansiyel türlerden biridir. Henüz ticari olarak değerlendirilmemesine rağmen, dağılımı, büyüme ve et kalitesi üzerinde bazı araştırmalar yapılmıştır. Bu çalışmada, Bhattacharya yöntemine göre incelenen örneklerin 4 yaş sınıfından oluştuğu belirlenmiş ve büyüme parametreleri L_{∞} = 75.24 mm, K= 0.370 ve t_0= -0.103 şeklinde tahmin edilmiştir. Boy-ağırlık ilişkisi W= $0.0015L^{2.619}$ şeklindedir.

Anahtar Sözcükler: *Anadara cornea,* Büyüme parametreleri, Bhattacharya yöntemi, Doğu Karadeniz.

Introduction

Increasing efforts are being made by the nations of the Black Sea Basin to assess the ecological problems of the Black Sea and to find urgent solutions. Therefore the number of studies on marine ecology have continuously increased, focused mainly on fish species which are economically more important than other organisms.

There are a limited number of studies on benthic fauna in the eastern Black Sea. Therefore, there is a great need to study benthic species to determine their role in the ecosystem and look for ways of exploitation for the fishing industry. Recently some studies have been carried out on *Rapana thomasiana* and *Anadara cornea* concerning distribution, stock abundance, meat yield etc. (1, 2, 3). They are both endemc species of the Indo-Pacific region and were estimated to have been introduced to the Black Sea by accident in the ballast tanks of commercial trade vessels (1, 2). They seemed to be well adapted and distributed almost thorughout the continental shelf of the Black Sea. But *Anadara cornea* has not reached commercial size yet (3, 4).

Marine bivalve molluscs of the family *Arcidae* are very common in many tropical, subtropical and warm temperate areas. *Anadara granosa, A. subcrenata, A. broughtoni, A. antiquata,* and other species of this genus are harvested on a commercial basis intensively in countries such as Malaysia, Thailand, Japan and South Korea (5, 6).

Anadara cornea is a potential resource organism for the fisheries of Turkey as it can be fully exported. Therefore, studies before the exploitation phase are essential to understand the stock size, distribution, growth and recruitment rate, i.e. proper management of the stock. In this study the major growth parameters of the Black Sea *Anadara cornea* population were estimated using length classes since data on age-length were not available.

Materials and Methods

In this study, length frequency data obtained in extensive surveys in the eastern Black Sea during 1993-1994 were used for the application of Bhattacharya's

Age	N	Length	Weight	Length*	Weight*
1	75	25.02	6.98	21.25	6.88
2	746	41.34	26.29	37.94	25.66
3	379	50.47	44.37	49.48	45.28
4	114	58.83	64.05	57.44	65.42

Table 1. Mean shell length (mm) and live weight (g) of *A. cornea* estimated by the Bhattacharya and von Bertalannfy* methods.

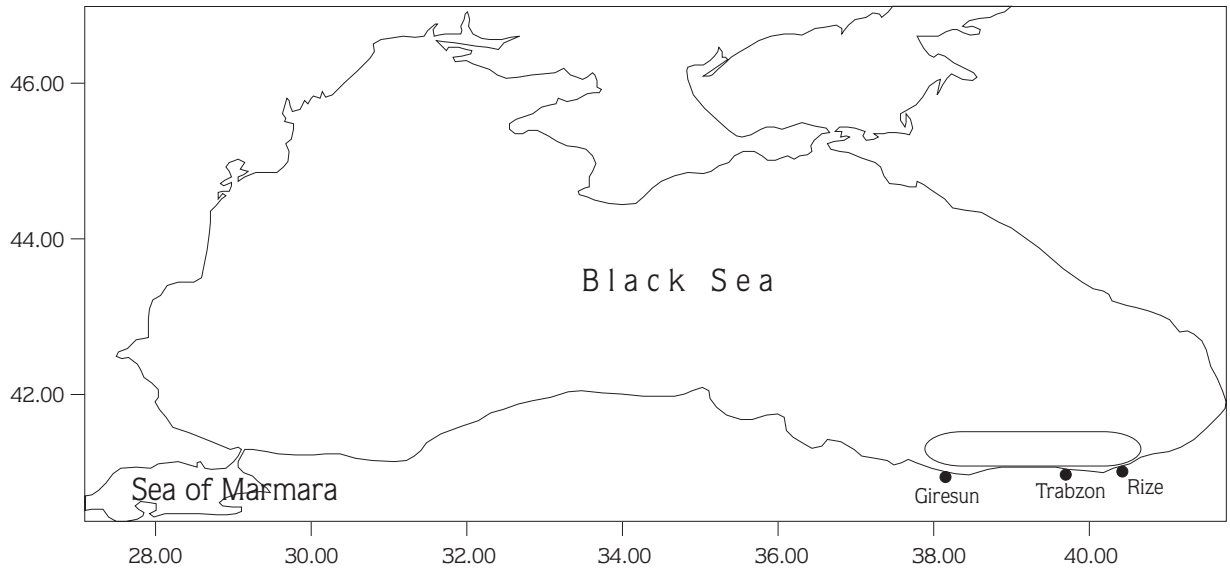

Figure 1. Study area.

method (3, 4). Data were obtained from the samples taken with a dredge at depths of 10-15 m off the coast from Giresun to Rize (Fig. 1).

Dredges with mouth dimensions of 3 m, height of 0.4 m and mesh size of 22 mm were similar to those used by fishermen. After cleaning the mud and other organisms such as Balanus sp., the length, width and thickness of the shells were measured to the nearest 0.05 mm with callipers while live weights were determined to the nearest 0.1 g (7, 8) (Fig. 2).

Age determinations can easily be made in some species of molluscs by direct observation of the shells without any treatment (9, 10) while the shells of some species (e.g. *A. cornea*) need to be studied in thin sections microscopically. Due to the difficulties of the expensive and labour intensive direct ageing method, it appears necessary to develop alternative approaches. One of the most convenient methods is the length based method developed by Bhattacharya. The model derives the number of year classes in the whole sample using length-frequency data. The Bhattacharya Method (11, 12) implemented in the LFSA computer program was employed to split the composite distribution of length into separate normal distributions, so as to identify different cohorts contained in the samples. The mean length of components derived from the Bhattacharya method were plotted against time series to obtain the assumed cohorts using modal progression analyses (13). In this study, 1 mm length groups were used for the application of the model using the FISAT package programme (14, 18).

The length-weight relationship was derived by applying the equation $W= aL^b$, where a and b are the coefficients calculated by the least squares method (12, 19). The age-length relationship was determined using the equation of von Bertalanffy;

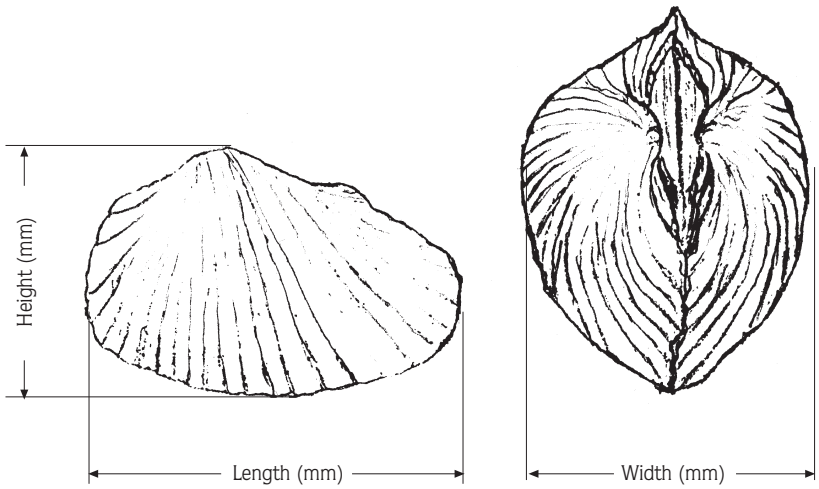

Figure 2. Shell measurements of *A. cornea*.

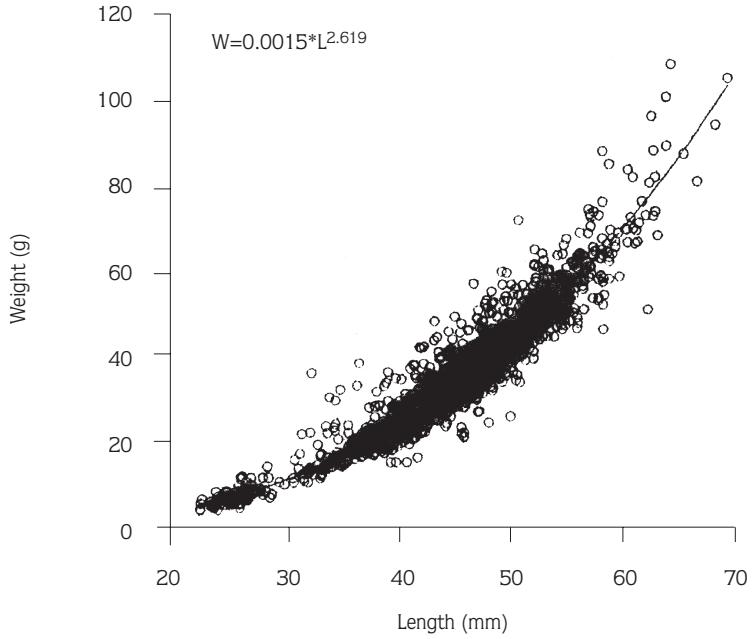

Figure 3. Length-weight relationship in *Anadara cornea* population.

$$L_t = L_\infty (1-e^{-k(t-to)})$$

were L∞: asymptotic length, K: growth coefficient, t_o: age at which the length is assumed to be zero theoretically (14, 19, 20).

Results

Data collected from 1314 *Anadara* specimens were used to determine the growth parameters. The length-weight relationship was derived as $W= 0.0015xL^{2.619}$ (Fig. 3).

By using the Bhattacharya method for the length frequency data, four year classes were determined (Table 1, Fig. 4). According to the results of the previous studies (2, 3), the first age group corresponds to 1^+ and there was no individual representing age 0^+.

The reason for this was either the selectivity of the dredge mesh size used or differences between the young and adults in settlement depth and material.

After applying the method, it was found that the differences between the observed and calculated length and weight values were not statistically significant. In other words, this method can be used without a

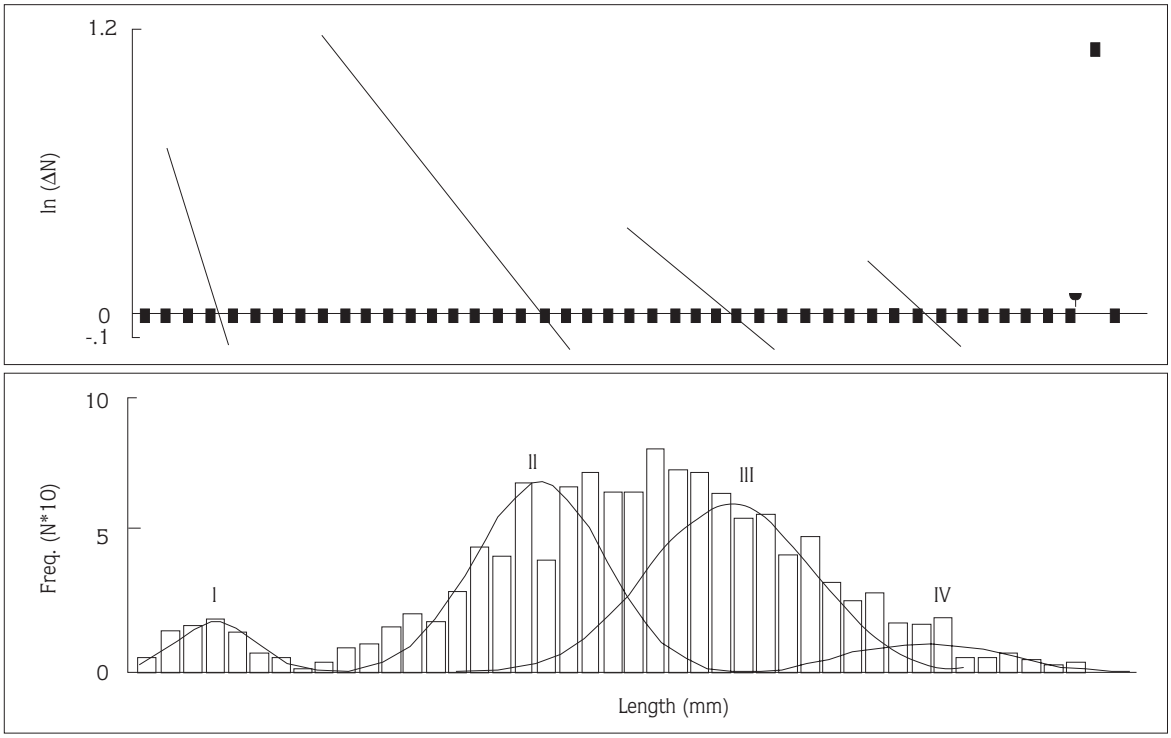

Figure 4. Year classes derived by the Bhattacharya method.

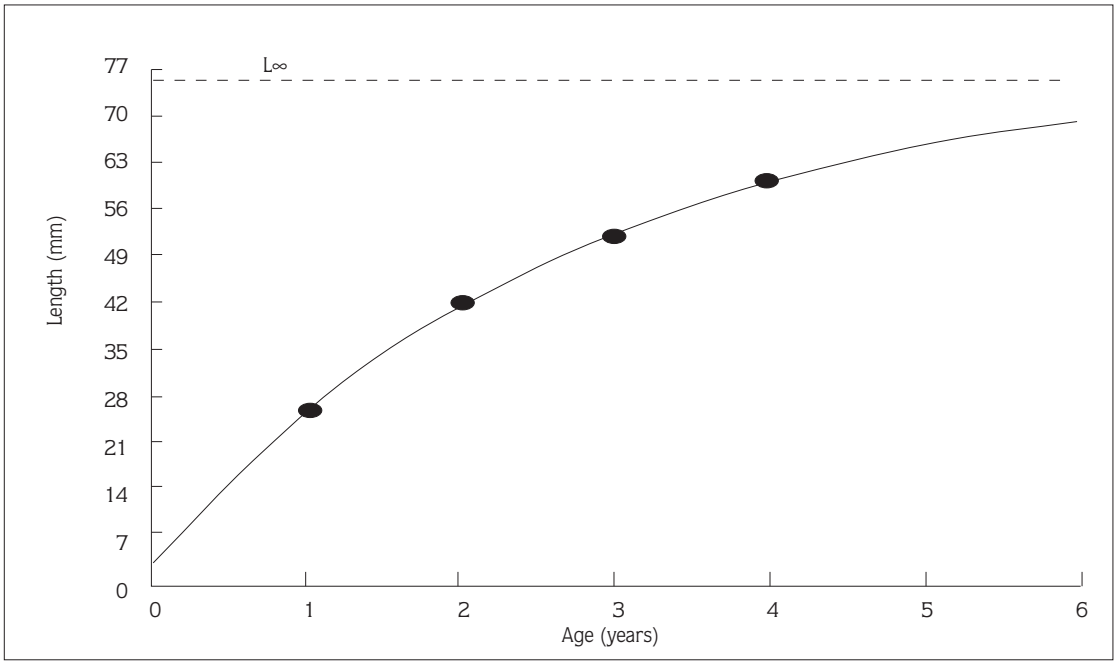

Figure 5. Age-length relationship.

Table 2. Parameters of length-weight relationship of *Anadara cornea* and some members of the same genus.

Species	Area	Length range	a	b	Authors
A. granosa	India	20-63 mm	$1.339*10^{-3}$	2.645	Narasimham (23)
A. granosa	Malaysia	0.75-3.2 cm	0.245	3.295	Broom (5)
A. granosa	Thailand	-	0.364	3.043	Boonruang and Janekarn*(5)
A. g.bisenensi	Korea	-	$4.327*10^{-4}$	2.937	Yoo*(5)
A. broughtoni	Korea	-	$3.245*10^{-3}$	2.440	Yoo*(5)
A. subcrenata	Japan	-	0.236	3.286	Ting et al.*(5)
A. subcrenata	Korea	3.0-4.5 cm	0.871	2.285	Yoo*(5)
A. senilis	East Africa	2-8 cm	$0.239*10^{-4}$	2.686	Wolff (24)
A. cornea	Turkey	2.5-6.9 cm	$3.30*10^{-3}$	2.581	Şahin (3)
A. cornea	Turkey	2-6.9 cm	$1.5*10^{-3}$	2.619	This research

* Cited in Broom (5)

Table 3. Some parameters of growth for some *Anadara* species i.e., (K) $L\infty$.

Species	Area	K	$L\infty$	Authors
A. granosa	Malaysia	1.01	44.4	Broom*(5)
A. granosa	Malaysia	0.62	49.6	Pathansali*(5)
A. g. bisenensis	Japan	0.24	73.3	Cahn*(5)
A. subcrenata	Japan	0.68	53.6	Kusukaba*(5)
A. rhombea	India	0.46	90.2	Narasimham (21)
A. granosa	India	0.58	73.4	Narasimham (22)
A. granosa	Phillippines	1.84	36.9	Vakily (17)
A. cornea	Turkey	0.37	75.2	This research

*Cited in Broom (5)

significant statistical bias. By applying the output data of the method, the von Bertalanffy growth equation and the parameters for age-length relation were estimated as L_∞ = 75.24 mm, K= 0.370 and t_0 = -0.103 (Fig. 5).

Discussion

Growth is expressed as length, weight and volume in molluscs as well as other living organisms. Growth is mainly related to the quality and quantity of food which is assimilated from the environment and the energy provided by the nutrients. It has been reported that models used for many fish species could also be used for bivalves (12, 14).

It is generally known that many marine organisms have a sigmoidal curve for weight and length growth and there are many bivalvia species exhibiting a similar growth tendency. It has been suggested that this type of curve may be used to explain the growth of most lamellibranchiata such as *Anadara cornea.* But it is not wise to use this method for individuals with a shell length smaller than 1/3 of the maximum length in that sample (16). In another study, it was reported that this curve cannot be used for *Anadara gronasa* which has a length less than 1/3 of its maximum size (21, 22).

The comparisons of the parameters of the length-weight equation between various species of the genus *Anadara* are given Table 2.

It has been reported that coefficients of b varied between 2.286 and 3.295 and the value of b in this study was found to be within this range. These data imply that *Anadara cornea* has a similar growth pattern to other species of Anadara.

Samples were collected with dredges, mesh size 22 mm. Due to the relevant selectivity, individuals greater than 22 mm length were abundant. Values of L_{∞}, K and t_o were derived using the ages and corresponding average lengths and compared with other species from the same genus (Table 3). Although all the species used in the comparison are endemic species of the warm seas in Far East countries the growth performance of *A. cornea* seemed to be considerably higher than that of the others. Evaluation of the growth pattern of the members o f the genus Anadara showed that estimation of the year classes can be reliable. For example, *A. granosa* raised in bottom cages in India has a similar growth performance to *A. cornea* (21, 22).

This study shows that the Bhattacharya method gives reliable results for an *A. cornea* population when ageing is not possible or is difficult. In addition, frequent and abundant sampling to reflect all the life stages after recruitment and then estimation of the cohorts can be used directly for population analyses.

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