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Transitional Waters Bulletin
TWB, Transit. Waters Bull. 4(2007), 1-8
ISSN 1825-229X, DOI 10.1285/i1825229Xv1n4p1
http://siba2.unile.it/ese/twb

RESEARCH ARTICLE

The growth of the bivalve *Abra segmentum* (Recluz, 1843) in two Mediterranean lagoons

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Abstract

1 - The growth of *Abra segmentum* was studied for nearly one year in two Mediterranean lagoons with different degrees of communication with the sea.

2 - Tsopeli, situated in Amvrakikos Gulf (Ionian Sea), is a brackish-water lagoon, with restricted water circulation, relatively isolated from the open sea. Vivari is situated in Argolikos Gulf (Aegean Sea), and has better communication with the sea. Both lagoons are shallow with muddy bottom and both are used for the extensive culture of fish.

3 - Differences in the populations of *A. segmentum* were found regarding intensity of recruitment and growth in the two lagoons: recruitment was higher and survival lower in Vivari, while growth was better in Tsopeli.

4 - Length frequency histograms showed that larger body-size classes prevailed in Tsopeli, as opposed to Vivari where smaller individuals dominated. Mean individual size of *A. segmentum* was higher in Tsopeli throughout the year.

5 - Predation may be important in structuring the populations, however, comparison with findings in the literature suggest that the degree of communication with the sea is a more important factor controlling growth of *A. segmentum*.

Keywords: *Abra segmentum*, growth, lagoons, Amvrakikos Bay, Mediterranean Sea.

Introduction

The bivalve *Abra segmentum* extends from the Mediterranean and the Black Sea to the Atlantic coasts of Morocco and France. A common species in Mediterranean coastal lagoons, it is considered as a characteristic species of littoral eurythemal and euryhaline lagoons (Pérès, 1967; Glémarec, 1964; Charles et al, 1996). In Greece it has been found in the Messologhi lagoon (Nicolaidou et al, 1988), in Amvrakikos Gulf (Nicolaidou and Karlou, 1983; Nicolaidou and Kostaki-Apostolopoulou, 1988) in Gialova lagoon (Koutsoubas et al 2000) and in the lagoons of Evros Delta (Kevrekidis and Koukouras, 1992; Mogias and Kevrekidis, 2005).

A. segmentum can tolerate a wide range of salinities, from 3psu to 41psu (Marazanof, 1969). In their study of *A. segmentum*, in another lagoon of Amvrakikos, Nicolaidou and Kostaki-Apostolopoulou (1988) suggested that its growth rate is related to the salinity range. Bachelet et al (1986), investigating the demographic characteristics of seven species of *Abra* indicated the role of environmental constraints on the life strategies of the species.

The present study examines the growth of *Abra segmentum* in two Mediterranean lagoons with different degree of communication with the sea, therefore with different ranges of environmental conditions.

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Materials and Methods

Description of sampling sites

Tsopeli lagoon (Fig. 1) is situated in the semi-enclosed Amvrakikos Bay, Ionian Sea, in the vicinity of Louros River. It communicates with Amvrakikos Bay only through an opening approximately 5m wide. Amvrakikos itself has a poor water exchange with the Ionian Sea through a narrow channel, 800m wide and 12m deep (Panayotidis et at, 1994). This makes Tsopeli well isolated from the open sea. A series of radiating dykes further restrict the renewal of water (Reizopoulou et al, 1996). The lagoon covers an area of 1km^2 and its depth ranges from 0.2 to 1.5m. The bottom is muddy, covered in most parts by *Zostera noltii* but green algae, such as *Ulva sp.* and *Enteromorpha sp.*, were also noted. At the times of sampling temperature ranged from 8^{0}C to 29^{0}C and salinity from 21psu to 38psu.

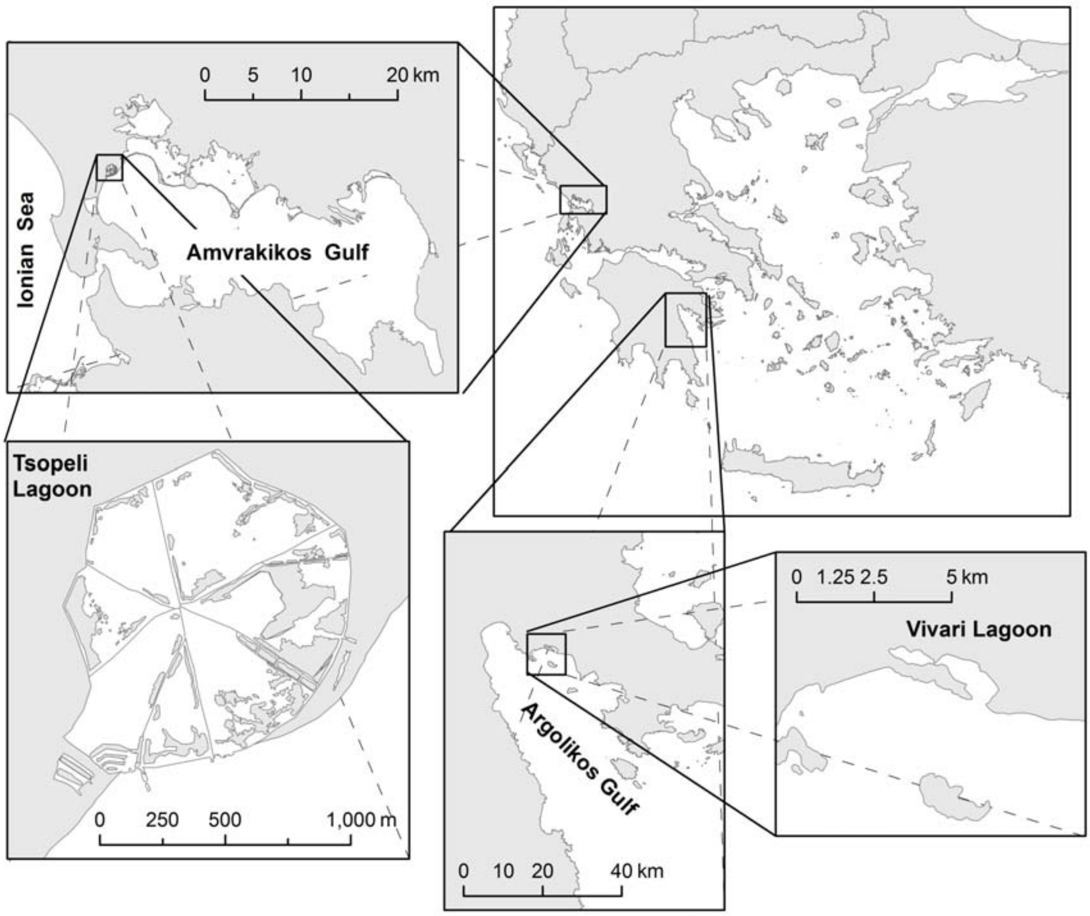

Figure 1. The two study sites: Tsopeli Lagoon in Amvrakikos Gulf (Ionian Sea) and Vivari Lagoon in Argolikos Gulf (Aegean Sea).

Vivari lagoon (Fig. 1) is situated in Argolikos Bay, Aegean Sea. It is approximately half the size of Tsopeli. It has better communication with the marine environment and the circulation of water in the lagoon is unprohibited. Both temperature and salinity were higher than in Tsopeli and they ranged from 12^{0}C to 34^{0}C and from 29 to 40psu respectively. The sediment was muddy. *Zostera sp*. was also reported from the area but had disappeared prior to the time of sampling.

Both lagoons are used for the extensive culture of various species of mullet and eels. Small amounts of gilthead (*Sparus aurata*), bass (*Dicentrarchus labrax*) and sole (*Solea vulgaris*) are also caught.

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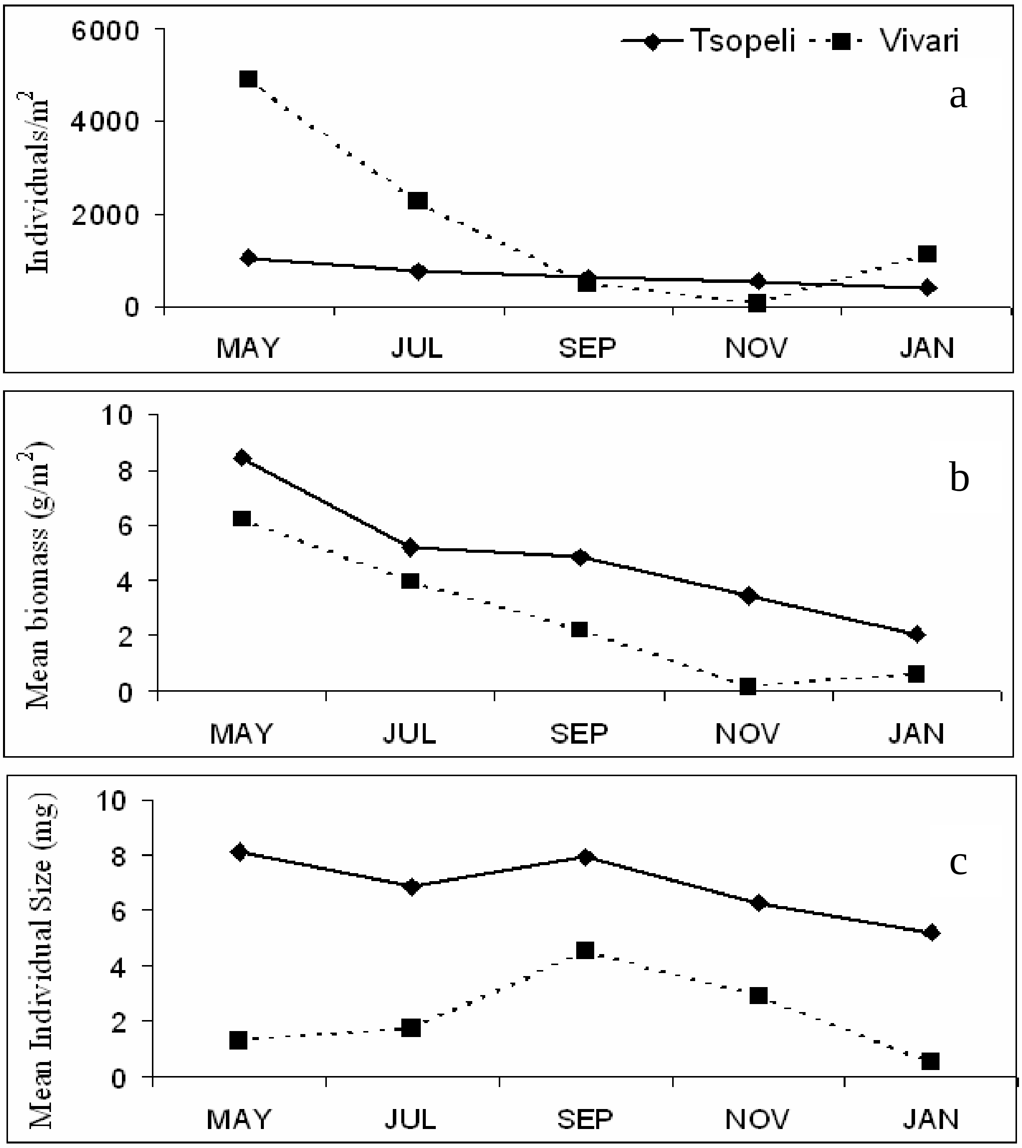

Figure 2. a. Mean density, b. Biomass and c. Mean individual weight of *Abra segmentum* in the two lagoons.

Sampling and laboratory methods

The lagoons were sampled at approximately bimonthly intervals from May 1990 to January 1991. After this time access to the lagoons was prohibited because of restocking. Three replicate samples were collected at each of six stations in Tsopeli and four in Vivari, distributed all over the lagoons, using a Ponnar grab which sampled 0.05m^2 of the bottom. The samples were sieved through a 1mm mesh sieve and preserved in 4% formalin.

The shell length (posterior to anterior end) in the larger specimens was measured to the nearest 0.05mm with a pair of sliding callipers. Animals smaller than 4mm were measured under a microscope fitted with a graticule. For the estimation of dry weight (W) the shells of the bivalves were decalcified in 20% hydrochloric acid. Individuals were dried to constant weight at 105^{0}C for 48 hours.

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Results

The temporal variations of density of *Abra segmentum* in the two lagoons are shown in Figure 2a. Highest density was recorded in the spring in both lagoons, but in Vivari it was almost five times higher (1041 individuals/m^2 in Tsopeli and 4887 individuals/m^2 in Vivari). The population declined much faster in Vivari and reached 58 individuals/m^2 in November. In Tsopeli, the lowest density (398 individuals/m^2) was observed in January. The changes in population biomass with time (Fig. 2b) followed those of the density. However, the biomass in Tsopeli was always much higher than in Vivari, which suggests that the animals in Vivari were much smaller. This is demonstrated in Figure 2c, which shows the mean individual weight of *A. segmentum* in the two lagoons at each sampling time. In Tsopeli, the mean weight ranged from 5.19mg in January to 8.10mg in May while in Vivari it ranged from 0.55mg in January to 4.55mg in September.

The size frequency distribution of *A. segmentum* in the two lagoons is shown in the histograms of Figure 3. In Tsopeli, all sizes from 3 to 19mm were represented practically throughout the year, while in Vivari only small sizes, from 3 to 10mm, were present. Influx of young animals occurred in May in both lagoons. In Tsopeli, the numbers dropped drastically in July, but the decline of the population was not so dramatic after that, since a large percentage (approximately 30%) of small individuals appeared again in September. From that time on the population consisted of two cohorts. In Vivari, a winter recruitment occurred between November and January. By then, the summer recruitment had almost disappeared completely, thus, only one cohort was present throughout the year.

Discussion

Comparison of the demographic characteristics of the *A. segmentum* populations in the two lagoons showed that the population in Vivari consisted of one cohort (as opposed to two in Tsopeli), had a much higher recruitment followed by a high mortality and a smaller growth in individual size. Low food availability should not be considered responsible for the low growth rate of the deposit feeder *A. segmentum* since sediment organic carbon is higher in Vivari (6.7%) than in Tsopeli (5.3%). One possible explanation for the observed differences in the population size structure is predation, which would be more intense in Vivari due to the lack of vegetation. The latter would provide shelter from the fish predators, which are basically visual hunters (Arntz and Brunswig, 1975; Arntz and Finger, 1981; Rainer, 1985). The observed small size could either be caused by preferential predation of larger specimens or by very heavy predation, to which prey organisms adapt by producing more young.

Although predation must be an important factor in structuring the populations, it cannot be the only one responsible for the small individual size. If that were the case, at least a few specimens of *A. segmentum* would be expected to survive and reach a larger size. However, larger specimens were never found, neither alive nor dead as empty shells. It seems therefore, that *A. segmentum* in Vivari never grows to a larger size than the observed.

Small size of *A. segmentum* in a fully marine environment has been found in Ria Formosa by Sprung (1994a) who pointed out that some characteristics of the species, namely the size of the specimens and the appearance of one generation per year, were similar to those of the intertidal species *Abra tenuis* (Bachelet, 1989; Bachelet et at, 1986). This is also true for the population of Vivari, where, as in the Ria Formosa, the morphological characteristics correspond to *A. segmentum*.

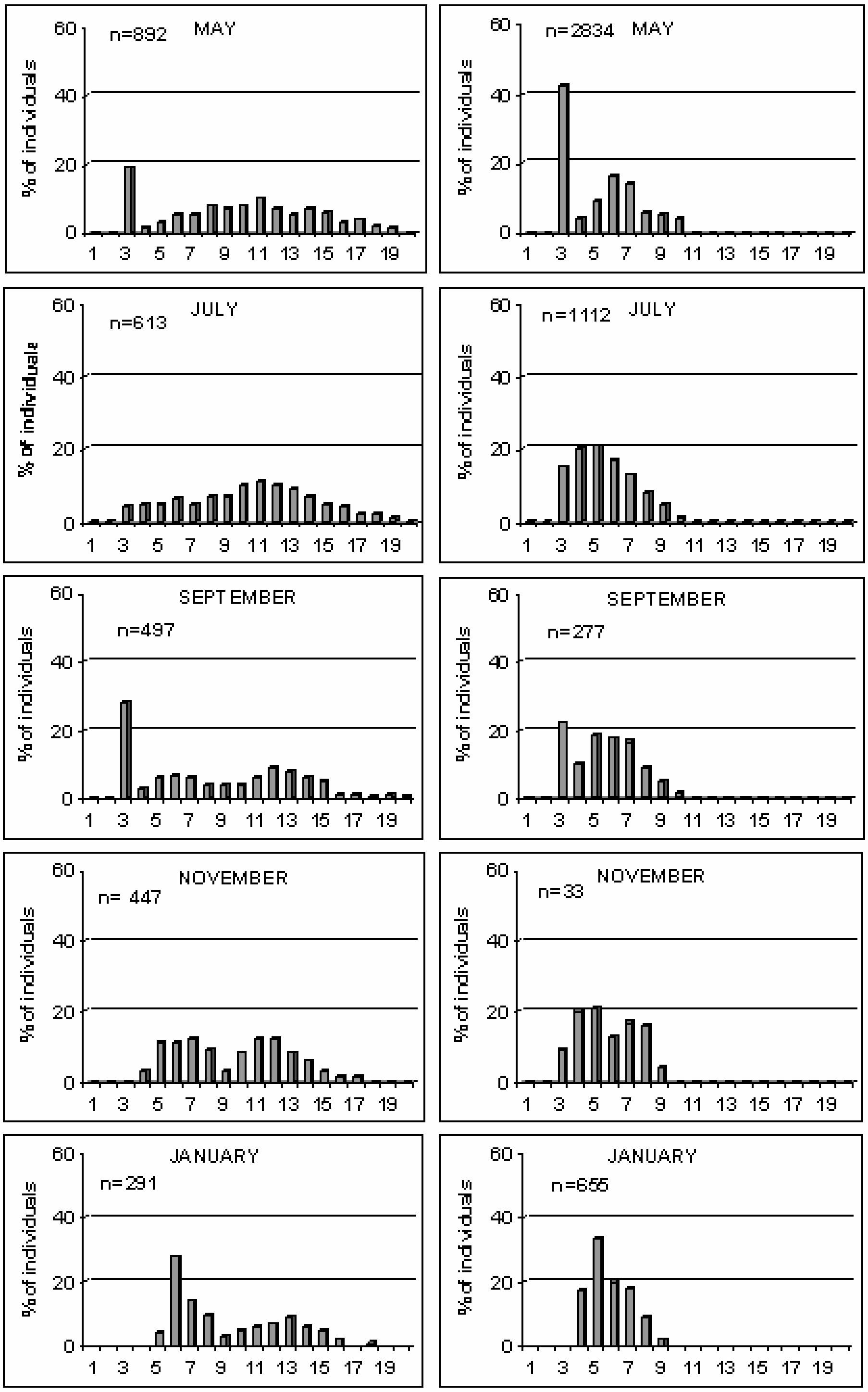

Figure 3. Length frequency distributions of *Abra segmentum* in the two lagoons.

Table 1 summarises the available information on the maximum size and the number of cohorts of *A. segmentum* in various areas. Indeed, smaller sizes are found in Vivari and Ria Formosa both of which have good communication with the sea. Sprung (1994b) mentions that in Ria Formosa there is a "rather intense exchange of 50-75% of the water mass during each tide". At the other extreme, a maximum size of 20mm (Kevrekidis and

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Koukouras, 1992) was observed in "an isolated channel representative of the inner regions of the Evros Delta".

Two different modes of life have been reported for *A. segmentum*. Bachelet et al (1986) describe a population with two generations per year, longevity of two years and development including a short pelagic and a long meiobenthic phase. The population of Ria Formosa (Sprung, 1994a) showed one generation per year, life span of one year, with direct development (no pelagic larvae) and a short meiobenthic phase. It is possible that under different environmental conditions *A. segmentum* adopts different life strategies, unless it is another case of sibling species as those described for other bivalves (Seed, 1992) or other animal groups such as polychaetes, (Kruse and Reise, 2003) and decapods (Macferson and Machordon, 2005). It is an interesting question, which merits further investigation, by examining the life history of the species, together with its genetic constitution, in lagoons with varying degrees of confinement.

Table 1. Characteristics of *A. segmentum* in various areas of its distribution

Area	Salinity range psu	Cohorts/ year	Max size mm	Authors
Prevost St 16 (Outer station)	30-38	2	9	Guelorget and Mayer, 1981
Prevost St 3 (Inner station)	17-40		13	Guelorget and Mayer, 1981
Golf du Morbihan			16	Denis, 1981
Lagunes de Certes (Subtidal)		2		Bachelet et al, 1986
Mazoma	14-37	2	18	Nicolaidou and Apostolopoulou, 1988
Evros Delta (Inner Delta)	24-36	2	20	Kevrekidis and Koukouras, 1992
Ria Formosa (Intertidal)	36-37	1	9	Sprung, 1994
Tsopeli (Confined)	21-38	2	19	Present paper
Vivari (Open)	29-40	1	9	Present paper

Conclusions

Comparison of the growth of *Abra segmentum* in two lagoons with different communication with the sea showed that:

1. the species reached a larger size in the most isolated lagoon.
2. recruitment was higher and survival lower in the most exposed lagoon.
3. Comparison with findings in the literature suggests that confinement is the most important environmental factor controlling growth of *A. segmentum*.
4. It is proposed that *A. segmentum* may adopt different strategies under different environmental conditions.

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Acknowledgements

Thanks are due to the Fishermen's Co-operative of Preveza for their assistance with sampling.

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