

RELATIONSHIP BETWEEN THE MEDUSAE *AURELIA AURITA*
LAM AND ZOOPLANKTON IN ELEFSIS BAY
(SARONIKOS GULF, GREECE)

By

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ABSTRACT

The present study examines the influence of *Aurelia aurita* Lam. on the zooplankton abundance in the dystrophic ecosystem of the Elefsis Bay (Saronikos Gulf, Greece).

Copepods and cladocerans constituted almost 90% of the total zooplankton population. High jellyfish biomass was noted during early summer and this seems to be responsible for the reduction of food supply, having a feedback effect. The massive death of jellyfish that was noted during late summer was attributed to the lack of available food rather than to other natural causes.

INTRODUCTION

The mass occurrence of jellyfish in several Mediterranean regions has attracted the interest of scientists (ROTTINI-SANDRINI & STRAVISI, 1981; ROTTINI-SANDRINI & AVIAN, 1983; AXIAK, 1983; GOY, 1983; GOMOIU, 1980; SHUSHKINA & MUSAYEVA, 1983). However, the ecological role of jellyfish in the marine ecosystem and their patchy distribution and growth rates (all influenced by a variety of environmental factors) have been neglected, except for few studies (MALEJ, 1982; LINDAHL & HERNROTH, 1983; FEIGENBAUM & KELLY, 1984). Quantitative data on a larger scale exist for *Aurelia aurita* Lam. (YASUDA, 1968; 1969; 1970; MOLLER, 1980a; HERNROTH & GRONDAHL, 1983; MOLLER, 1983; 1984, HERNROTH & GRONDAHL, 1985).

In Greece, *A. aurita* can be found in large numbers in Elefsis Bay (PAPATHANASSIOU *et al.*, 1986), a semi-closed bay near the industrial area of

Athens, which is subjected to both urban and industrial pollution (Fig. 1). Elefsis Bay is relatively small (surface of 67 square kilometers and a volume of 1.3 km³) and shallow (a mean depth 15m and a maximum 33m) and can be considered a natural aquarium for the development of *A. aurita* (PANAYOTIDIS *et al.*, 1985; 1986).

Recent studies of the abundance of this species in the area showed that the life cycle of *A. aurita* is annual in Elefsis Bay and that the population was growing until June/July, after which a sharp decline was observed during August-September (PAPATHANASSIOU *et al.*, 1987). A massive occurrence of *A. aurita* is not unusual in the Mediterranean Sea, but there is no data available in the literature. Similar abundance changes have been reported from other seas such as the Kiel Bight in the Federal Republic of Germany (MOLLER, 1980a), Urazoko Bay in Japan (YASOUDA, 1968) and in Gullmar Fjord in Western Sweden (HERNROTH & GRONDAHL, 1983; 1985). The following paper studies the abundance of *A. aurita* with a view to explain the trophic dependence of this species on phytoplankton and zooplankton.

MATERIALS & METHODS

Monthly oceanographic cruises were carried out from January 1984 to December 1985 and several environmental factors were measured (sea

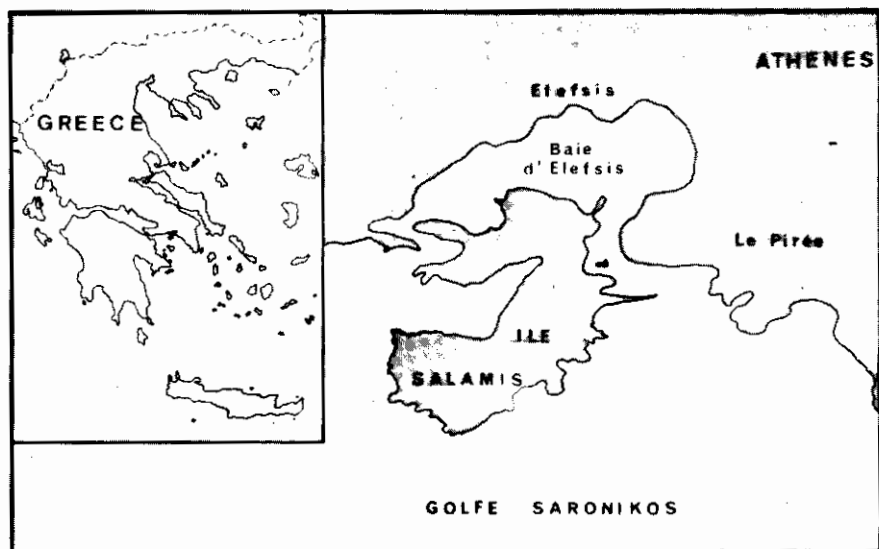


Fig. 1 The sampling area in Saronikos Gulf.

water temperature; salinity and underwater light intensity).

Chlorophyll-a values, from three depths (0, 10 and 20 m) were measured using a «Turner» fluorometer as this has been suggested by YENTCH & MENZEL (1963) and subsequently modified by HOLM-HANSEN *et al.*, (1965).

Zooplankton samples were collected by double oblique hauls, simultaneously with the medusae sampling, using a WP-2 plankton net with 200 µm mesh size equipped with an «Hydrobios» flowmeter. Samples were then preserved in 4% neutralised formalin. Two subsamples were obtained using a Folsom plankton splitter. One of these was used to evaluate the biomass, following Lovegrove's method (1966). The other subsample was used to determine the different taxonomic groups.

The medusae were sampled by double-oblique hauls at a ship's speed of 2 to 3 knots, using a plankton net 2.5m long with 1m mouth opening and 1.5mm and/or 2.0mm mesh size (MOLLER, 1980-a). These types of nets were chosen after proving to be very efficient in trials with various other types since clogging of the nets could be avoided, especially in a eutrophic environment such as the Elefsis Bay (FRILIGOS, 1981; 1982; GOTSIS-SKRETAS, 1985). Both nets were equipped with other «Hydrobios» flowmeters.

All measurements of the umbrella diameter (to the nearest cm) were carried out on board, while the medusae were still alive. The medusae were then transported to a 2 litre volumetric cylinder and their actual volume was noted since a rough estimate of the jellyfish biomass can also be calculated using the volume of the jellyfish (MOLLER, 1983; PAPATHANASSIOU *et al.*, 1986).

The jellyfish biomass values were calculated using the experimental formula $G=0.0971 \times D^{2.68}$, where G=wet weight (in g) and D=umbrella diameter (in cm), which is very close to Kerstan's (1977) formula. The relation between dry weight and wet weight was found to be at the level of 4%.

The double-oblique sampling procedures employed in Elefsis Bay for both zooplankton and medusae, were deployed, from the surface water layer to a depth of 10m, on account of the shallow waters that were in the area and the unfavorable light conditions in the deeper layers.

RESULTS

The sea water temperature and the light intensity during the period of study are shown in Table 1. The salinity did not change enough to be considered significant for the scyphomedusae abundance, varying between 38.1 and 39.1 ppt.

For both years the light intensity had the maximum value during Au-

gust. At the same time a very distinct thermocline from May to August can be observed.

It is worth noticing that, throughout the year, at 20 m depth light loses more than 90% of its surface intensity (Table 1).

The standing stock of the zooplankton population, the chlorophyll-a values together with the *A. aurita*'s biomass within the period of two years (January 1984 to December 1985), are shown in Table 2. From Table 2 the chlorophyll-a has the maximum value during January 1985 followed by the next two months with a zooplankton peak. Another high chlorophyll-a value was also noted during December 1985, while a smaller but equally distinct peak was observed during March 1985. As far as the zooplankton biomass is concerned the great variations observed during the year were the result of the differentiation of the zooplankton composition. High values that were observed during the winter (January to April) were the result of the mass appearance of *Acartia clausi* which represents the 95-99% of the total zooplankton population. On the contrary, during the summer months (May to October), there was a high percentage of small sized cladocerans (mainly *Penilia avirostris* and *Evadne tergestina*) which due to their small weight account for the low biomass values (Fig. 2). It is interesting also to note that the medusae biomass reached the maximum value during late spring-summer with decreasing numbers there on until the next year. It should be mentioned that the small values on the medusae biomass, observed for winter, account for the presence of numerous but small sizeephyrae (Table 2).

DISCUSSION

The results suggest that the jellyfish population influences to a large extent the energetics of the dystrophic ecosystem of Elefsis Bay.

Similar studies by MOLLER (1978; 1980a; 1980b) and SHUSKINA & MUSAYEVA (1983) on *A. aurita* in the Kiel Bight and the Black Sea respectively, have reviewed and emphasized the significance of this species of scyphomedusae in relation to other planktonic organisms as predators and competitors of fish larvae. Fish larvae predation by medusae has also been reported in the offshore waters of British Columbia, Canada (ARAI & HAY, 1982).

A. aurita was considered to be an omnivorous feeder with an estimation of daily food requirement for a 100g *A. aurita* to be nearly 10mg dry weight (KERSTAN, 1977 - cited from MOLLER, 1980a). Even though all the above are based on rough estimates and not on actual feeding rates, the results that were obtained for Elefsis Bay justified the speculations, that a reduction in the zooplankton standing stock could, due to predation and/or natural causes, have a feedback effect on the development of the jellyfish population. Similar suppositions have been made by MOLLER (1983) for the Baltic

Table 1: Sea-water temperatures and underwater light intensity in the Elefsis Bay.

Depth (m)	Temperature (°C)			Light intensity (%)		
	0	10	20	0	10	20
1984						
JANUARY	12.1	12.1	12.2	100	10	2
FEBRUARY	-	-	-	-	-	-
MARCH	12.3	12.4	12.7	100	10	7
APRIL	16.2	14.2	15.3	-	-	-
MAY	-	-	-	-	-	-
JUNE	23.4	21.6	16.0	100	10	2
JULY	23.7	23.7	15.7	-	-	-
AUGUST	24.6	24.3	17.0	100	20	2
SEPTEMBER	23.6	23.6	23.6	100	10	3
OCTOBER	21.2	21.2	21.3	100	7	1
NOVEMBER	18.3	18.3	18.3	-	-	-
DECEMBER	14.3	14.2	14.1	100	8	1
1985						
JANUARY	11.6	11.6	11.6	100	3	0
FEBRUARY	10.3	10.1	10.1	100	3	1
MARCH	12.9	11.4	11.2	100	7	0
APRIL	16.4	15.2	13.4	100	2	0
MAY	21.6	20.3	13.3	-	-	-
JUNE	25.0	21.3	14.3	100	3	0
JULY	26.6	24.9	16.7	100	15	2
AUGUST	25.5	24.5	14.4	100	36	6
SEPTEMBER	22.3	22.3	22.3	100	8	1
OCTOBER	18.7	18.4	18.2	100	8	0
NOVEMBER	-	-	-	-	-	-
DECEMBER	15.4	15.3	15.3	100	12	1

Sea. HUNTLEY & HOBSON (1978) found that the feeding of leptomedusae could reduce herbivore populations and thus allowed a second spring bloom in the fjord of British Columbia, Canada.

Generally, the *A. aurita*'s diet mainly includes zooplankton, while the importance of phytoplankton and protozooplankton in the medusae diet is small (GOMOIOU, 1980). On the other hand the quantitative role of the dissolved organic matter is not clear at present, even though there is an indication of organic matter uptake by *A. aurita* (DUGDALE *et al.*, 1985). Although the phytoplankton contribution as a food source for *A. aurita* in Elefsis bay has not been studied in great detail, it is known that the greatest zooplankton biomass was observed one month before the highest increase in the bell diameter of the medusae (March-April) (PAPATHANASSIOU *et al.*, 1987). This implies a high degree of dependence between the zooplankton population and the medusae. The increasing food availability during this

Table 2: Chlorophyll-a zooplankton biomass and biomass of the *A. aurita* population in the Elefsis Bay.

	Chl-a mg/l	Zooplankton Biomass mg/m ³	<i>A. aurita</i> Biomass mg/m ³
1984			
JANUARY	-	100.8	< 100*
FEBRUARY	-	-	-
MARCH	-	12.1	< 100*
APRIL	-	30.2	< 100*
MAY	-	5.7	293
JUNE	2.96	15.0	1670
JULY	2.85	11.4	1463
AUGUST	1.45	7.8	< 100*
SEPTEMBER	2.48	42.6	< 100*
OCTOBER	4.08	7.4	< 100*
NOVEMBER	3.12	61.4	< 1*
DECEMBER	3.65	2.9	< 1*
1985			
JANUARY	10.70	16.2	< 100*
FEBRUARY	5.39	471.2	< 100*
MARCH	9.66	117.9	< 100*
APRIL	2.44	53.5	1516
MAY	7.37	9.0	2200
JUNE	-	4.7	1100
JULY	2.58	3.8	1000
AUGUST	1.52	29.2	< 10*
SEPTEMBER	-	3.6	< 1*
OCTOBER	2.19	1.5	< 1*
NOVEMBER	-	12.3	< 1*
DECEMBER	8.59	4.1	< 1*

*The symbols < 1, < 10 and < 100 represent the different order of magnitude for the jellyfish biomass. The actual numbers do not contribute anything on this study.

period seems to play a significant role in the increase of the medusae population.

The decline of the jellyfish population during late summer could be connected with the food supply. The qualitative zooplankton analysis during this period supports this postulation since a lot of small sized cladocerans do not seem to have these biomass values that were needed to develop the crucial biomass for the continuation and development of the jellyfish population. In similar studies, LINDAHL & HERNROTH (1983) suggested that scyphomedusae in Western Sweden can «regulate» the pelagic ecosystem during the summer with a sharp reduction in zooplankton standing stock.

Another factor which could influence and regulate the abundance of *A. aurita* is the phytoplankton, since it could control the zooplankton standing

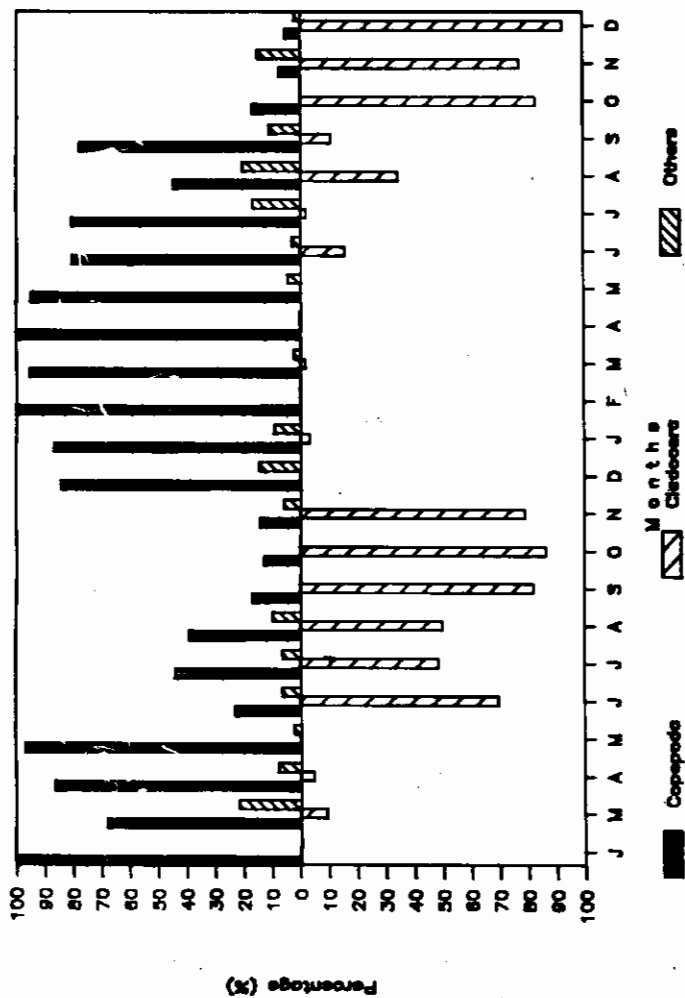


Fig. 2. Fluctuations (%) of the major zooplanktonic groups.

stock through the prey-predator relationship. The results of the present study showed that generally, from June to September, low values of chlorophyll-a could develop periods of food shortage for the zooplankton standing stock since there is a decline in *A. clausi* population with the rising of cladoceran population (SIOKOU-FRANGOU & ANAGNOSTAKI, 1985).

Similar changes in the lower Chesapeake Bay food chain were observed by FEIGENBAUN & KELLY (1984).

MOLLER (1980a) reported three reasons for the death of *A. aurita* in the Kiel Bight: genetical determination, starvation and parasitization. In the Elefsis Bay parasites in the population were never observed and it is possible to claim that the medusae die of senescence after reproduction. However, in the greater area of the Saronikos gulf, the large *A. aurita* specimens which should be over a year old and were occasionally observed during spring time, suggest that the senescence after reproduction, although valid, is not the main reason for the massive death which occurred in Elefsis Bay. A shortage in food during the period of expansion by the jellyfish population could play a very important role.

In conclusion, the low zooplankton biomass during the summer months seems to be one of the main reasons for the unfavorable conditions for the development of *A. aurita* population, which consequently leads to the massive death of jellyfish in the area.

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