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THE JELLYFISH *AURELIA AURITA* (CNIDARIA: SCYPHOMEDUSAE): ITS LIFE HISTORY STRATEGY, MIGRATION ACTIVITY AND ITS IMPACT ON THE ZOOPLANKTON COMMUNITY OF SUEZ CANAL, EGYPT

HAMED A. EL-SEREHY

Suez Canal University, Faculty of Science, Marine Science Department, Ismailia, Egypt

Keywords: Gelatinous plankton, Life span, Grazing Impact, Migration, Red Sea, Mediterranean, Suez Canal

ABSTRACT

Suez Canal is the main connecting link between the Red Sea in the south and the Mediterranean in the north. It crosses different lakes on its route from Port Said on the Mediterranean Sea to Port Suez on the Red Sea. Jellyfishes form a major part of the macro-plankton of the canal. The role of jellyfishes in general and *Aurelia aurita* (Linnaeus, 1881) in particular in marine ecosystem of the Suez Canal is of interest not only biologically but also socio-economically. During the present study, the life history of the common jellyfish *A. aurita* (Linnaeus) in the canal was investigated by monthly sampling over 24 month period from September 1999 to December 2001. Young medusae of 2-3 cm diameter occur from February/March. Growth was rapid. Some specimens of this cohort reach 16 cm and spawn by March/May and then decrease in size or die. Others reach a maximal size of 10 cm by September, when spawning takes place. A few number of mature individuals remain after spawning in the next year and decrease in size. Release of ephyrae seams to be induced by a lowering of ambient environmental temperature to below 16 ^{O}C, with peak of release occurring in December/February. A drop in temperature may be the cue for strobilation in the canal. *A. aurita* (Linnaeus) seems to be an immigrant plankter to the Suez Canal, and much interest was focused upon which end of the canal these organisms invading the opposite sea. However, the canal with its lakes should also be considered as a substantial permanent habitat in its own right, and one can not consider the canal only as a funnel or corridor through which animals pass like ships from one sea to the other. *A. aurita* (Linnaeus) enters Suez Canal from the south via water currents; to do so it would need to be carried the 20 km or so along the canal from the Gulf of Suez into the Bitter Lakes, then pass across these lakes before being carried the further 12 km or so along the canal into Timsah Lake. Transport of *A. aurita* (Linnaeus) southward along the canal from Mediterranean is unlikely to take place during most seasons of the year against water flow, but is possible only during the brief period of reversal of flow. Because the main part of the 80 km or so from the Red Sea is canalized, passive transport of *A. aurita* (Linnaeus) by water currents from the north could occur within a week even at the low speed of ½ km/hour. Moreover, conditions on the migratory route of Suez Canal, in either direction, are likely to determine the success of passive transport of *A. aurita* (Linnaeus). Preliminary analysis of predation rate indicates that the immigrant *A. aurita* (Linnaeus) may lead to a sharp decrease in the density of the cyclpoid *Oithona nana* (Giesbrecht, 1892); the calanoid *Paracalanus crassirostris* (Dahl, 1894) and the harpacticoid *Euterpina acutifrons* (Dana, 1848) during winter and spring, but does not markedly affect the other copepods, which remain abundant throughout the year. Because of this and because of the heavy predation of *A. aurita* (Linnaeus) on diatom grazer copepods, large quantities of diatoms remain on the bottom of the canal, decompose, and are mineralized by bacteria. As a result, only a small portion of the primary production is transferred to fish production in the Suez Canal.

E mail: hel_serehy@yahoo.com

INTRODUCTION

The Suez Canal is the main link between the Mediterranean Sea and Red Sea. It lies between longitudes 32º 20΄ and 32º 35΄ E and latitudes 29º 55΄ & 31º 15΄ N. On the route from Port Said on the Mediterranean Sea to the Suez Port on the Red Sea, the Suez Canal has been dug out, only about 70 km of the Canal were dug out in dry land, while the rest of the waterway was crossing a series of lakes and swamps (from the north: Manzalah Lake, Ballah Bypass, Timsah Lake, and the two Bitter Lakes) (Por, 1978). The 45 km through Manzalah Lake were deepened in the shallow lake, with the excavated earth forming two dams which contain the Canal. By this, the eastern end of Manzalah Lake has been cut off from the main lake.

In the earlier years after its opening in 1869, the canal had a navigational depth of 8 m and surface width of 59-98 m (Luksch 1898; Morcos 1971/1972). However; successive projects to widen and deepen the canal have brought its depth to 10-23 m and its surface width to 135- 345 m (Por, 1978; El-Serehy & Sleigh 1993 and El-Serehy *et a*l. 2000 a & b).

The role of jellyfish and other gelatinous plankton in marine ecosystem is of interest not only biologically but also socio-economically. Aspects requiring further research include reproductive behaviour, factors leading to large standing stocks and mass occurrences, rapid growth rate, impact of predation rate, and their detrimental effects on coastal industrial activities including tourism (Yasuda 1988). In Suez Canal during spring and autumn, mass occurrences of *Aurelia aurita* (Linnaeus, 1881) periodically cause serious problems for net fishing.

The present research investigates the environmental factors affecting the life strategy of *Aurelia aurita* (Linnaeus) and its impact as a predator on the marine planktonic community in the Suez Canal. In order to obtain basic information on the life history of *A. aurita* (Linnaeus) in the canal, growth pattern and reproductive strategy were investigated over 24 – month period starting in September 1999.

MATERIALS AND METHODS

Aurelia aurita (Linnaeus) were sampled monthly using a conical net with an 80-cm mouth diameter (3 mm mesh aperture) from September 1999 to December 2001 at six stations in Suez Canal. The selected six stations are Suez, Little Bitter Lake, Great Bitter Lake, Timsah Lake, El Qantara and Ras EL Ech (Fig. 1). Samples were taken at almost the same time of day between 1000 h and 1300 h. The net was towed horizontally in the surface layer for 5 minutes at approximately 2 knots with a RGS flowmeter attached to the mouth of the net. The depth of all the fixed stations was shallow, ranging from 10 m to 23 m. Surface and bottom water temperature were measured during sampling. Additional samples of *A. aurita* (Linnaeus) were occasionally taken whenever they aggregated at the surface, in order to obtain sufficient individuals for analyses of growth pattern. Bell diameter, sex, and wet weight of *A. aurita* (Linnaeus) were measured and the presence of planula larvae in the pits of the oral arms was checked on all live material immediately after sampling. Measurements of the bell diameter, to the nearest 1.0 mm, were made by placing the specimen on a scale with the dorsal side down to flatten out the bell. Sex was identified by the basal form of the oral arms (Russel, 1970). Wet weight was measured after external water was soaked up rapidly by blotting paper. Ephyrae and young medusae without sexual characteristics on the oral arms were not sexed, nor some adult medusae which lacked oral arms after reproduction. Standing stock of *A. aurita* (Linnaeus) was expressed by the number of individuals and also by wet weight m^{-3}. Cohort analyses of the bell diameter histograms were made according to Cassie (1954) and Taylor (1965).

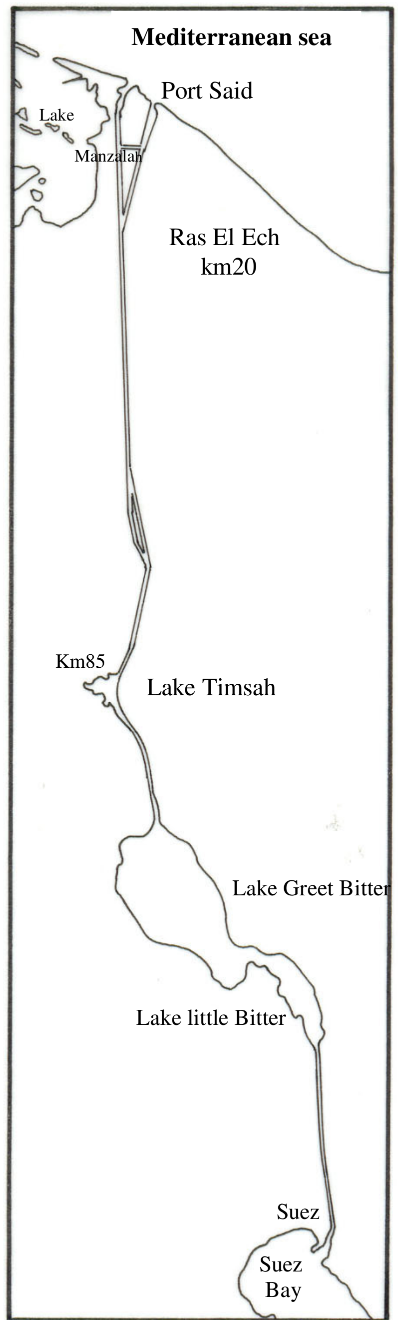

Figure (1): A map of the Suez Canal showing the six sampling locatities of Suez, Little Bitter Lake, Great Bitter Lake, Lake Timsah, El-Qantara and Ras El-Ech

RESULTS

Figure (2) shows the monthly records of average water temperature at the surface and bottom in the Suez Canal during the period of the present study as average values of the six fixed stations. The water of the canal is well mixed in all months except June to September, when thermal stratification occurs. All stations showed more or less similar temperature pattern. Maximum surface water temperature was 31 °C in August and 15.0 °C during January.

Monthly changes of the standing stock of *A. aurita* (Linnaeus) over the 24-month period indicated that both the number of individuals and wet weight were high in April 2000 (being 0.3 individuals m^{-3} and 70.0 g wet wt m^{-3}). Although both the number of individuals and biomass varied in each year they did not show any discernible seasonal pattern (Figs. 3 and 4). Monthly size-frequency distributions of the bell diameter generally showed a broad distribution with several size groups at any one time (Fig.5).

The data indicated that ephyrae of 0.1-0.3 cm bell diameter appeared in December/February 2000 and young medusae of 2-3 cm in February/March. Growth seemed rapid. Most specimens of this cohort reach 16 cm and spawn by March/May and then decrease in size or die. Others reach a maximal size of 10 cm by September, when spawning takes place. A few numbers of mature individuals remained after spawning to the next year of 2001 but decreased in size.

The mean sex ratio was approximately 1:1 throughout the sampling period, with only minor fluctuations. The minimal bell diameter size of females with planula larvae was 5.0 - 5.5 cm, and planula larvae were observed on the oral arms throughout certain months of the year.

DISCUSSION

In the present study, ephyrae appeared in December/February and young medusae occurred from February/March, which may assume that strobilation occurs in winter. Kakinuma (1962) showed that lowering of the temperature from 25 °C to 15 °C caused maximum strobilation for specimens sampled from Mutsu Bay, Japan. In Gullmar Fjord, Sweden, the ephyrae were most abundant in October and November when the temperature at 20 m deep dropped from 15 to 5 °C (Hernorth and Grondahl, 1983 and 1985). Thus it is inferred that strobilation of *A. aurita* (Linnaeus) becomes most active after periods of falling temperature in winter, and that environmental conditions during the polyp stage may be the underlying causes of mass occurrences. The ephyrae grow to adult medusae with a maximum bell size within 2-3 months, then decrease or die.

Generally, the reduction *i.e.* decrease in size is a common phenomenon in *A. aurita* (Linnaeus), both in the sea and in aquaria. Möller (1980) found that bell diameter reduced by 13-18 % from August to September after sexual reproduction. Hamner and Jenssen (1974) found that starvation also led to shrinkage where adult medusae reduced by 70 % in bell diameter after 100 day starvation, but medusae markedly increased in size again when fed.

The life history strategy of *A. aurita* (Linnaeus) in the Suez Canal is different from that in Tokyo Bay, Japan (Omori *et al*. 1995). In Tokyo Bay, ephyrae appeared in March and grew to young medusae in April and to adults of 25 cm by July/August. In Keil Bight, Germany, ephyrae grow to young medusae of 1.0 cm bell diameter by late April, and to the adults of 25 cm in August, and then undergo reduction (Möller, 1980). In Urazoko Bay Japan, young medusae appeared in May and reached a maximal size of 20 cm in April/May of the next year (Yasuda, 1971). In Tomales Bay, California, there are two different life history patterns. One is annual, in which the young medusae grow rapidly, mature in mid-summer and die, whereas the other pattern shows continuous growing until winter, with spawning in the next year (Hamner and Jenssen, 1974). These differences reflect the wide capability of *A. aurita* (Linnaeus) to alter their life strategy depending on environmental conditions.

The jellyfish *A. aurita* (Linnaeus) recorded in the present study occurred in the canal in one or more of the stations sampled, and it would appear to survive there during spring in high numbers. But how did this species originally come to the canal, and is this zooplankter annually re-introduced at self-sustaining isolated populations?. Migration may take place by passive transport by currents (common for holoplanktonic organisms and meroplanktonic larvae of benthic forms), by other animals or man; and by active migration (common for larger active animals). *A. aurita* (Linnaeus) most likely enters the Suez Canal in water currents; to do so from the south it would need to be carried the 20 km or so along the canal from the Gulf of Suez into the Bitter Lakes, then passes across the Bitter Lakes before being carried the further 12 km or so along the canal into Timsah Lake. Transport of *A. aurita* (Linnaeus) southward along the canal from Mediterranean is unlikely to take place during most seasons of the year against water flow, but is possible only during the brief period of reversal of flow. Because the main part of the 80 km or so from the Red Sea is canalized, passive transport of *A. aurita* (Linnaeus) by water currents from the north could occur within a week even at the low speed of ½ km/hour. Moreover, conditions on the migratory route of Suez Canal, in either direction, are likely to determine the success of passive transport of *A. aurita* (Linnaeus), because this species seems to thrive better in spring and autumn than in winter and summer, thus it is more likely to has been derived from the Red Sea via water currents rather than Mediterranean against the water currents. The success of the *A. aurita* (Linnaeus) to inhabit the canal ecosystem suggests that the Suez Canal ecosystem is able to contain at least some self sustaining isolated population of zooplankton species, which may reflect the fact that the Suez Canal is a habitat in its own and should not consider as a funnel or corridor through which jellyfish medusae pass like ships from one end to the other.

A. aurita (Linnaeus) eats any meso and macro-zooplankters available as prey (Omori *et a*l. 1995). Occasional examinations of the food pouch of *A aurita* (Linnaeus) from Suez Canal revealed that they ingest virtually any zooplankters in the field, including ciliates and copepods. Considering their abundance and rapid growth, the impact of predation of *A. aurita* (Linnaeus) on zooplankton must be significant and may lead to change in the structure of planktonic food web in Suez Canal, as suggested in other areas (e.g. Möller,1980; Lindahl and Hernroth, 1983; Omori *et al*. 1995). However, quantitative data on predation by *A. aurita* (Linnaeus) are scarce (Båmstedt, 1990; Olesen *et a*l. 1994). The fluctuation of the zooplankton community in the Suez Canal has recently been compiled (El-Serehy *et al.* 1999; 2000 & 2001). Net zooplankton was dominated by the cyclpoid *Oithona nana* (Giesbrecht, 1892); the calanoid *Paracalanus crassirostris* (Dahl, 1894) and the harpacticoid *Euterpina acutifrons* (Dana, 1849). These three copepod species were abundant from May to July, but sharply decreased from December to April. The average abundance for the three species was 5590, 438 and 496 ind. m^{-3}, respectively while the maximum was 26357 ind m^{-3} in July for the cyclpoid *Oithona nana* (Giesbrecht); 3104 ind. m^{-3} in June for the calanoid *Paracalanus crassirostris* (Dahl) and 3826 ind. m^{-3} in June for the harpacticoid *Euterpina acutifrons* (Dana). A scenario of the impact of predation by *A. aurita* (Linnaeus) on cyclpoid *Oithona nana* (Giesbrecht); calanoid *Paracalanus crassirostris* (Dahl) and harpacticoid *Euterpina acutifrons* (Dana) in the Suez

Canal can be drawn based on the previous information. A sharp decrease in the density of the three copepod species with rapidly increasing predation and growth rates of *A aurita* (Linnaeus) in winter and spring is anticipated. Other copepods, which remain abundant throughout the year in the Suez Canal did not markedly be affected. Because of this and because of the heavy predation of *A. aurita* (Linnaeus) on diatom grazer copepods, large quantities of diatoms remain on the bottom of the canal, decompose, and are mineralized by bacteria. As a result, only a small portion of the primary production is transferred to fish production in the Suez Canal.

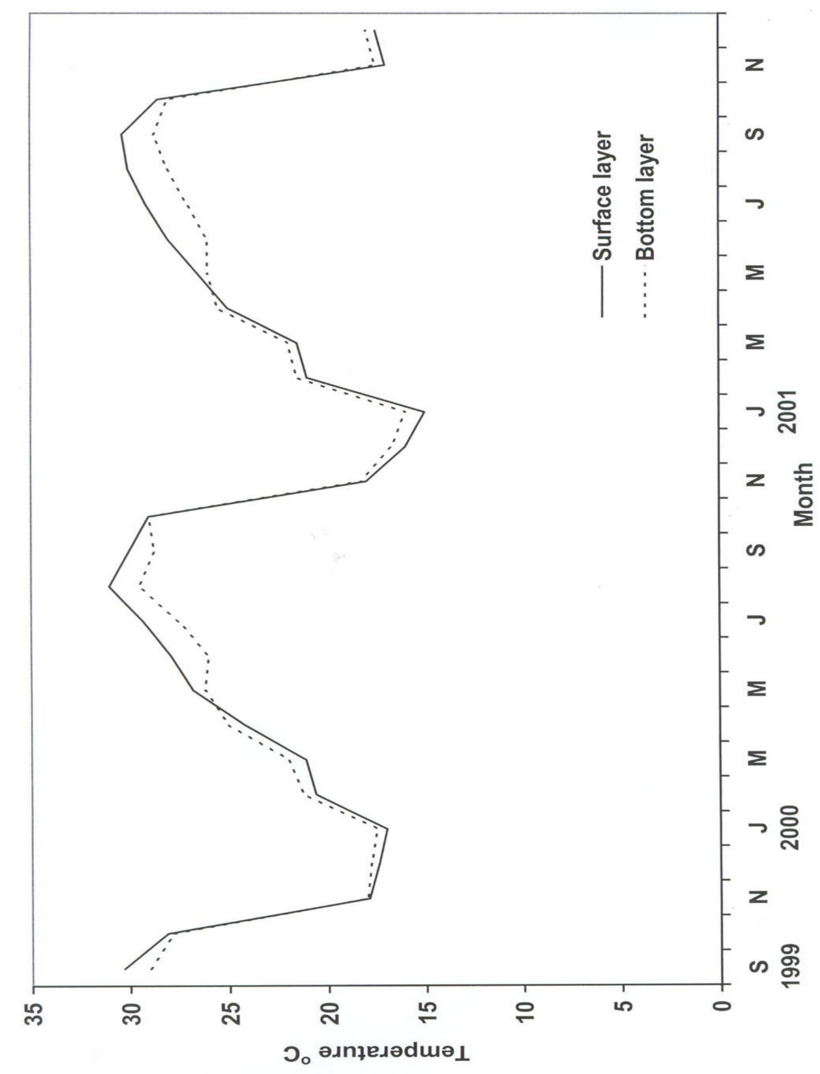

Figure (2): Monthly records of average water temperature at the surface and bottom of the Suez Canal from September 1999 to December 2001.

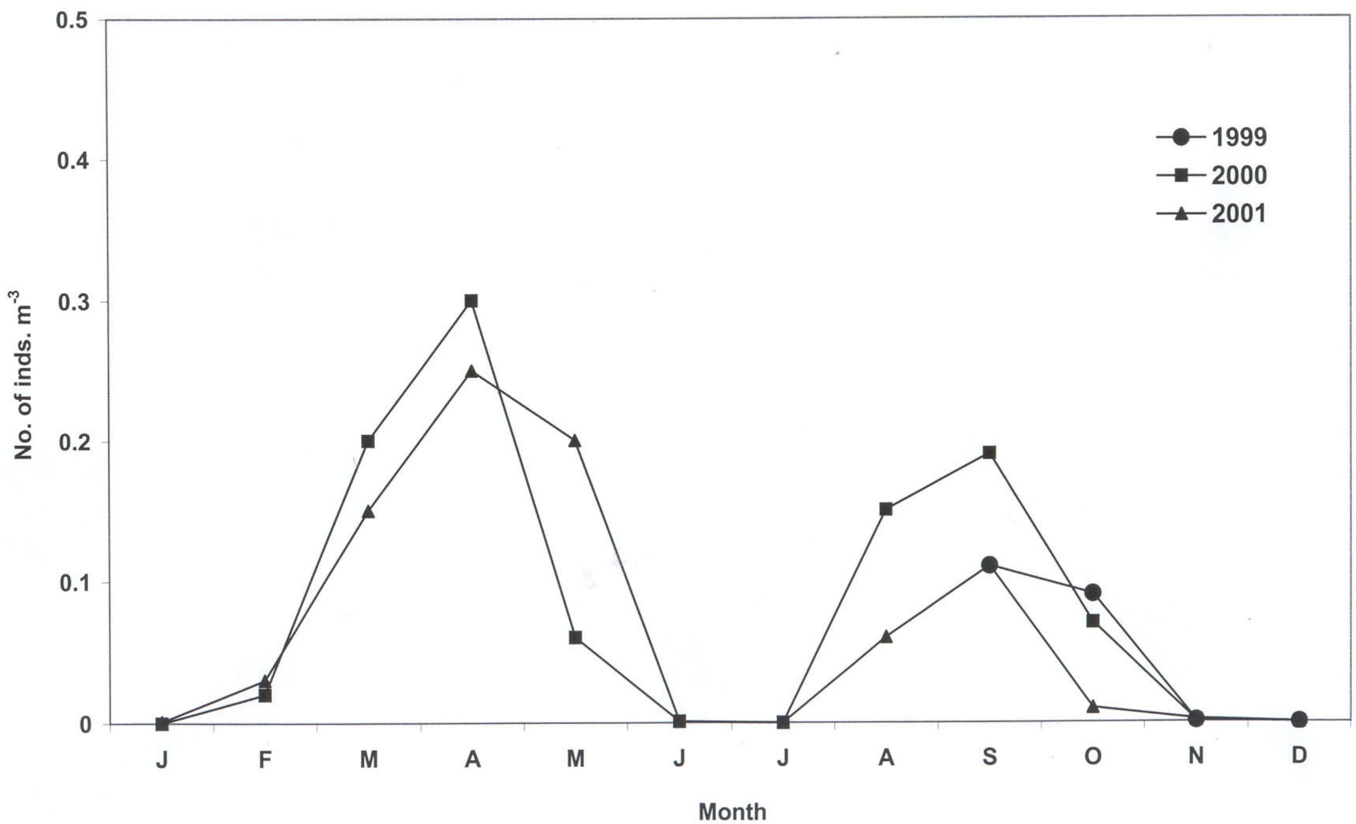

Figure (3): Monthly records of the number of individuals m^{-3} of *Aurelia aurita* (Linnaeus) as average values of the six fixed stations

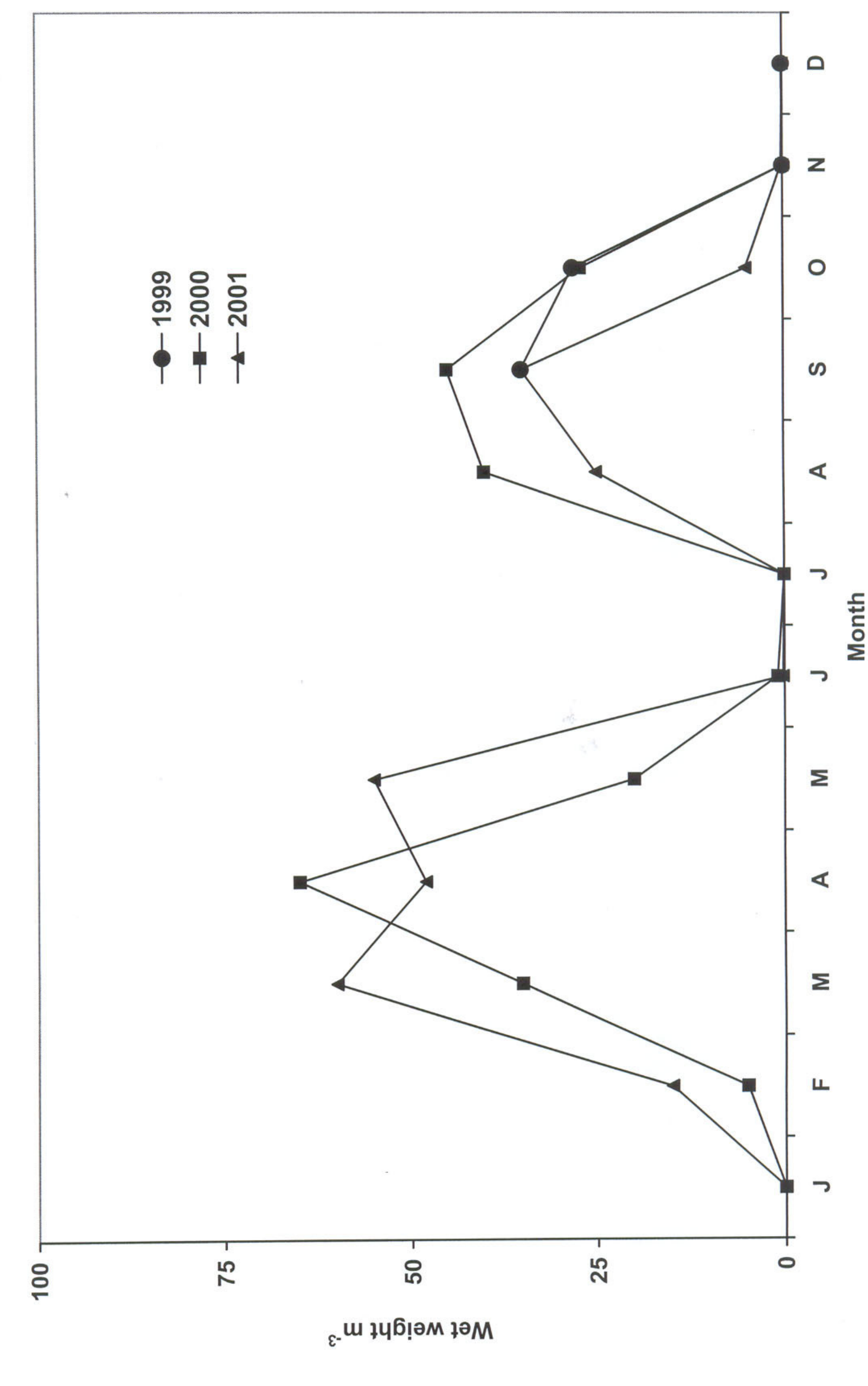

Figure (4): Monthly records of wet weight m-3 of *Aurelia aurita* (Linnaeus) as average values of the six fixed stations.

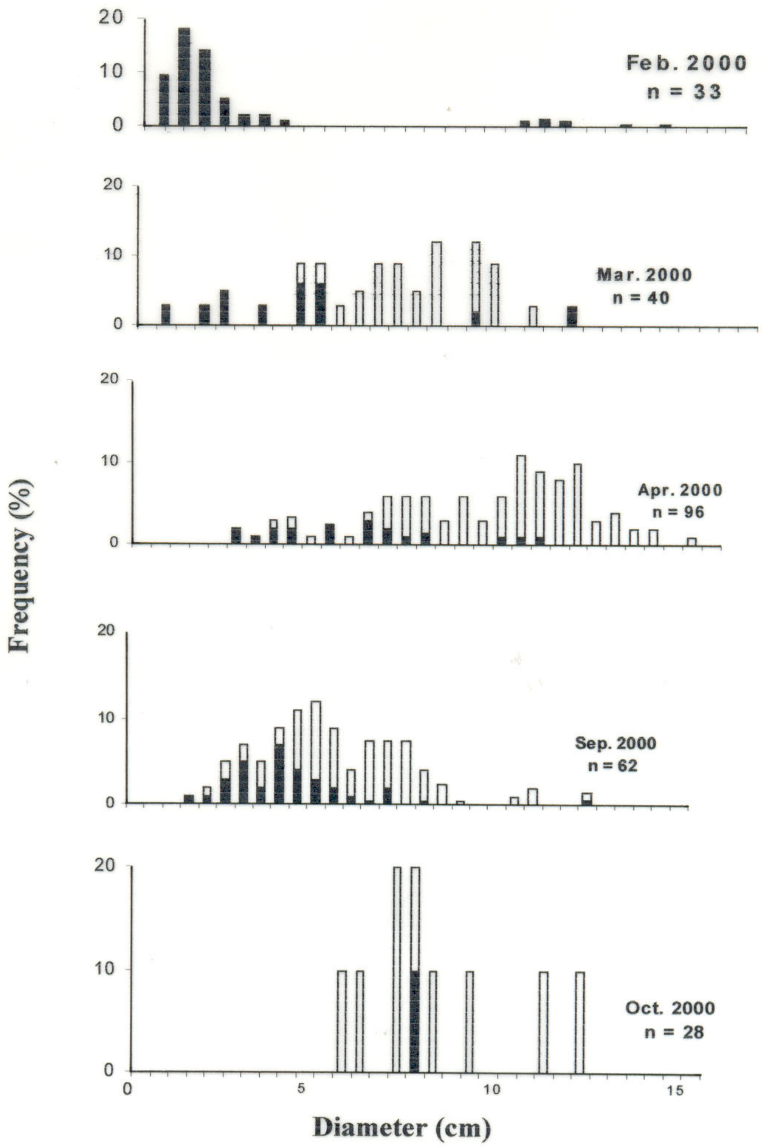

Figure (5): Percentage frequency distribution of the bell diameter in cm of *Aurelia aurita* (Linnaeus). Percentage of individuals in which sex was not determined is indicated by solid shading. Histograms are not shown for months with 15 individuals.

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