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Effect of Water Quality on the Fecundity and Body Size of *Sphaeroma serratum* (Crustacea: Isopoda)

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ABSTRACT. *Sphaeroma serratum* was found to vary in the maximum length attained in pereonal width and fresh body weight in response to water pollution. In Sphaeromatids from polluted site, the body size (Length × average pereonal width) and wet weight were significantly lower than those collected from the clean site.

The number of eggs contained in the marsupia of ovigerous females increases with body size. However, the actual number of eggs is dependent upon the water quality, there being more eggs in the marsupia of all sizes of ovigerous females from clean site than those of the polluted site.

Ovigerous females from the polluted site, kept in clean water, produced F_1 generation which, when grown in clean water, showed a significant increase in body size and weight. F_1 generation males, derived from the clean water site females and grown up in clean or polluted water, showed a significantly greater increase in width (for any given body length) in clean water than they did in polluted water.

Fecundity and body size, using methods described in this study might be a useful bioassay technique for measuring pollution in natural waters.

Introduction

Sphaeroma serratum occurs in a wide variety of habitats but in most cases, it is commonly found under intertidal and shallow-water stones, empty mollusk shells, rocky intertidal coasts and upper shores crevices[1-4]. *S. serratum* is very tolerant to desiccating conditions and can tolerate brackish water[5].

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Despite the widespread occurrence of *S. serratum*, little work has been done on the biology of this species. Hostlandt[6], showed that the main factor limiting the northern extention of *S. serratum* may be low temperature which possibly inhibited ovarian development; Harvey[7], studied the life cycle of *S. serratum* in Britain, she found, *S. serratum* has a short breeding period restricted to the warmest months of the year; Charmantier[5], found that the ionic regulation of *S. serratum* was affected by changes in the salinity and temperature.

Numerous experiments have been reported in the literature concerning the effects which various pollutants have on the survival of individuals species. However, few workers have attempted to evaluate the effect of total water quality on the growth of individuals within a population. Stebbing[8], found that, colonies of marine hydroid *Companularia flexousa* produced different growth patterns and frequencies of gonozooids when subjected to water of different qualities in the laboratory; Aston and Milner[9], found that the longest individuals of some crustacean species were associated with location exhibited the heaviest organic pollution loads; Tolba and Holdich[10], found that *Asellus aquaticus* was found in large number in locations at River Trent which was characterized by heavy pollutant loads.

Fortunately, *S. serratum* was found in large numbers at two lakes in Egypt, Lake Qarun[11;12;4] and Lake Timsah[7;4]. Lake Qarun is one of many enclosed inland lakes in Egypt, and it is far away from the Red Sea as well as Mediterranean Sea. *Sphaeroma serratum* has been transported to Lake Qarun from Mediterranean Sea with algae and water used during fish restocking exercises[11]. Lake Qarun represents a relatively clean site because it has no effluents and it is far away from any industrial development. On the other hand, *S. serratum* occurs commonly in the hypersaline lagoons associated with the Suez Canal, such as, Bitter Lakes; Timsah Lake and Manzala Lake[13,14]. The occurrence of *S. serratum* at Lake Timsah is about thought to be due to migration. Lake Timsah represents a relatively polluted lake, since it receives plenty of industrial discharges such as oil, hydrocarbons, toxic substances from the ships which pass through Suez Canal regularly[15;13;16].

The body length has been extensively used for assessing isopods growth[9,17-19]. However, length is not always the best measure of 'size' because when isopods moult they usually increase in width as well as length, and the weight increases over the inter moult period. It will be shown in this paper that water pollution affects the weight and body size (length × average pereonal width) of *S. serratum* – water of poor quality depressing these parameters. A number of workers listed above have reported a positive relationship between the length of ovigerous females of *S. serratum* and the number of eggs initially contained within the marsupium. However, individuals of the same length do not necessarily have the same size of marsupia, as it is also dependent upon their width. Therefore, the relationship between body size and egg number was examined at both study areas.

The present study was undertaken to assess the effect that water quality has on the size and fecundity of post- marsupial stages of *S. serratum*.

Material and Methods

Samples of *S. serratum* were collected monthly from August 1982 to September 1985 from Lake Qarun and Lake Timsah (Fig. 1). The two lakes, as it has been shown by Dawood[16]; Lashin[20]; Holdich and Tolba[4] in Table 1, exhibit different degrees of water quality.

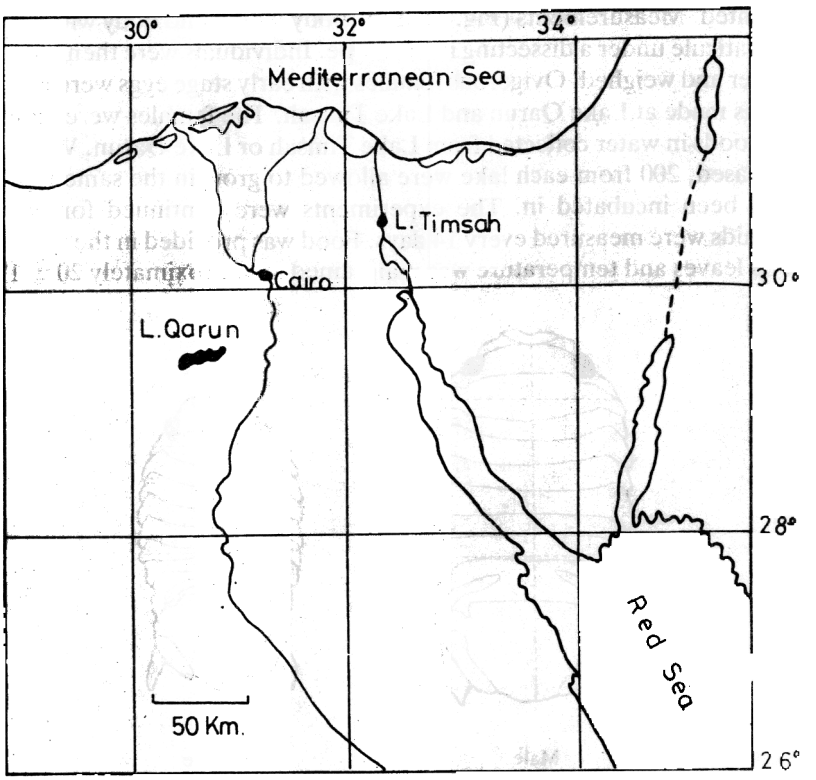

FIG. 1. Map of Egypt showing the geographical position of Lake Timsah and Lake Qarun.

TABLE 1. Mean values and ranges of selected variables in water from Lake Qarun (A) and Lake Timsah (B) from September 1982 to August 1985.

	S‰	pH	NO_3	Cl	Cu	Pb	DO	BOD	Temp.	P	Hard.	
Min.	19.34	7.4	0.12	11.0	0.01	0.1	8.5	1.5	16	0.45	1000	
Max.	36.5	9.1	0.70	20.7	0.10	0.2	9.4	6.4	33	0.70	4000	A
Mean	29.80	8.0	0.21	13.0	0.05	0.15	9.0	3.6	25.5	0.49	2794	
Min.	29.36	7.8	0.10	16.8	0.10	0.20	4.5	2.1	15.0	0.60	2000	
Max.	41.70	9.5	0.85	23.7	0.20	0.35	8.0	7.5	30.5	0.85	4500	B
Mean	35.5	8.4	0.35	20.2	0.15	0.25	6.6	5.5	22.4	0.58	3311	

At least 200 individuals of *S. serratum* were collected from both lakes by washing submerged stones randomly chosen by the reach of hand. These were rinsed with lake water in large plastic dishes and *Sphaeroma* were eventually collected using a small brush. Specimens were then transported in sufficient amounts of the same water to the laboratory. In the laboratory, each sphaeromid longer than 3 mm, below which it is difficult to separate the sexes, was staged: male, non-ovigerous females or ovigerous females. The number of eggs in the marsupia of the ovigerous females were counted. Measurements (Fig. 2) of the body length and body width were made using a graticule under a dissecting microscope. Individuals were then blotted dry on filter paper and weighed. Ovigerous females with early stage eggs were isolated from collections made at Lake Qarun and Lake Timsah. The females were allowed to incubate broods in water collected from Lake Timsah or Lake Qarun. When juveniles were released, 200 from each lake were allowed to grow in the same type of water they had been incubated in. The experiments were continued for 90 days and sphaeromids were measured every 14 days. Food was provided in the form of decaying moris leaves and temperature was maintained at approximately 20 ± 1°C.

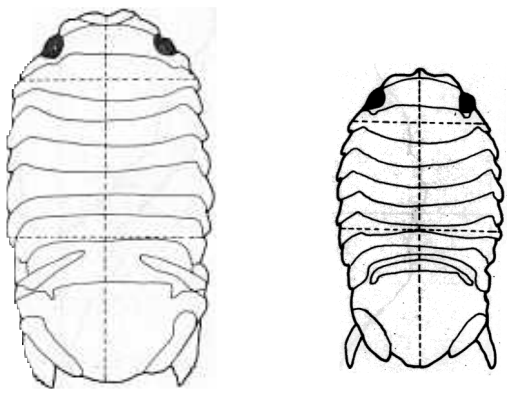

FIG. 2. Diagram to show the way of taking length and width measurements.

Physico-chemical parameters listed in Table 1 were measured monthly at the two lakes throughout the study period using the same equipments outlined by Tolba and Holdich[10].

Separate regression analyses were carried out for all measurements of the body length/width, body size/wet weight and body size/egg number relationships using the standard equation :

$$Y = A + BX$$

where Y is the length or body size, A the calculated Y intercept, and B the slope.

Results

A. *The relationship between body length and pereonal width*

It can be seen, from Fig. 2 that the maximum pereonal width of males and females occurs at different levels, being at pereonite 6 in females and pereonite 7 in males. The minimum width was across pereonite 1 in both sexes.

If body lengths are plotted against the mean width of pereonites one and seven for males and pereonites one and six for females there is an obvious increase in width with an incresae in body length (Fig. 3). However, if the regression lines are compared for animals from Lake Qarun and Timsah Lake there is a significant increase ($P < 0.001$) for the male data, and also for the female data, although the difference between males and females is not so clear cut. Therefore, both males and females of any given length over 3 mm from Lake Qarun are not therefore to be regarded as a good measure of the size of an sphaeromid. The body size (length times average pereonal width) is used in future comparison.

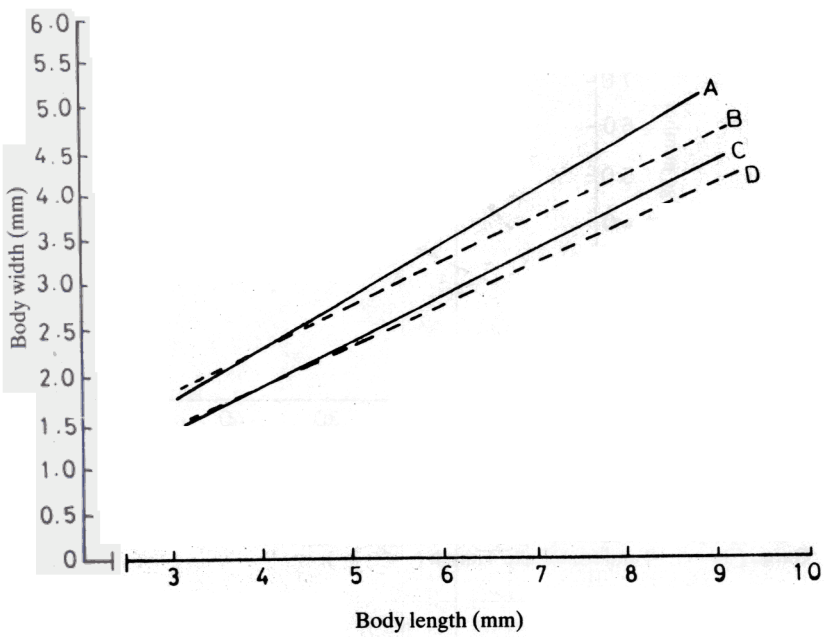

FIG. 3. Regression lines of body length against body width of *S. serratum*. (A), females; (B), males from Lake Qarun; (C), females (D), males from Lake Timsah.

Regression data :

(A). $Y = 0.21 + 0.15\ X$
(B). $Y = 0.53 + 0.16\ X$
(C). $Y = 0.27 + 0.24\ X$
(D). $Y = 0.30 + 0.16\ X$

B. The relationship between body size and number of marsupial eggs

It is expected that long ovigerous females will have a larger marsupium than short individuals. Measuring the length only, however, may hind the fact that females which have the same length may be of different width; wider females may, therefore, have a larger marsupium and so be able to incubate more eggs. If egg number is plotted against the body size, there is an increase for every size of females (Fig. 4). However, if the regression lines for the two lakes are compared then it can be seen that egg number varies considerably. All sizes of ovigerous females from the Lake Timsah water, have significantly lower egg number ($P < 0.001$) than those found at Lake Qarun.

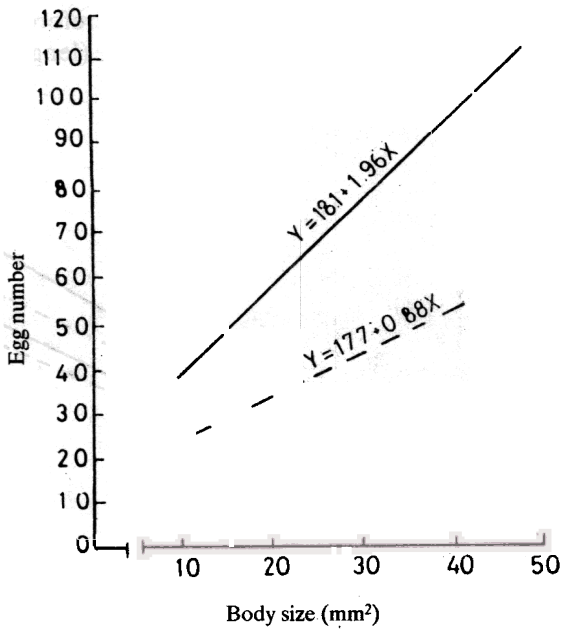

FIG. 4. Regression lines of egg number against body size of ovigerous females of *S. serratum* from Lake Qarun (————) and from Lake Timsah (– – – –).

C. The relationship between body size and wet weight

Even though animals may appear to have similar body size, their weight may differ due to a number of internal factors, *e.g.* the reproductive state, the quality of their food, whatever they have eaten recently or not and disease. In addition, external factors, such as water quality may also have an effect. When the wet weight of *S. serratum* males is plotted against body size, there is a linear relationship (Fig. 5).

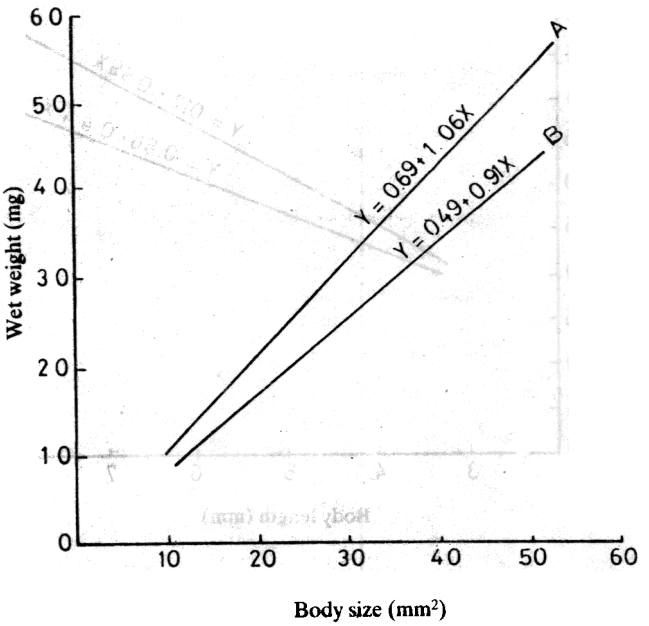

FIG. 5. Regression lines of wet weight against body size of male *S. serratum* from Lake Qarun (A) and from Lake Timsah (B).

Sphaeroma serratum from Lake Qarun shows a positive increase in wet weight with every increase in body size, that for males being larger than those for females (Fig. 5). However, individuals from Lake Timsah show a such smaller increase (Fig. 5). It also can be seen that the differences in weight between males for the two lakes are significant ($P < 0.001$).

D. The effect of water pollution on F_1 individuals

In order to assess the effect of clean and polluted water on the growth of *S. serratum*, a number of ovigerous females were transferred from Lake Timsah (polluted) and kept in Lake Qarun water (clean) through their brooding periods. When F_1 generation resulting from these females was grown up for 90 days in Lake Qarun water, they showed a significant increase in body size and body weight compared with individuals collected from the field from Lake Timsah (Fig. 6). This is particularly noticeable in larger individuals from Lake Timsah ($P < 0.001$). To show that water pollution affects growth, in term of width, individuals derived from Lake Qarun water were grown in clean or polluted water at the same temperature ($20 \pm 1°C$). When mean pereonal width is plotted against body length, there is a significant difference ($P < 0.001$) in the growth of sphaeromatids from the two lakes; width being depressed in those growing in polluted water (Fig. 6).

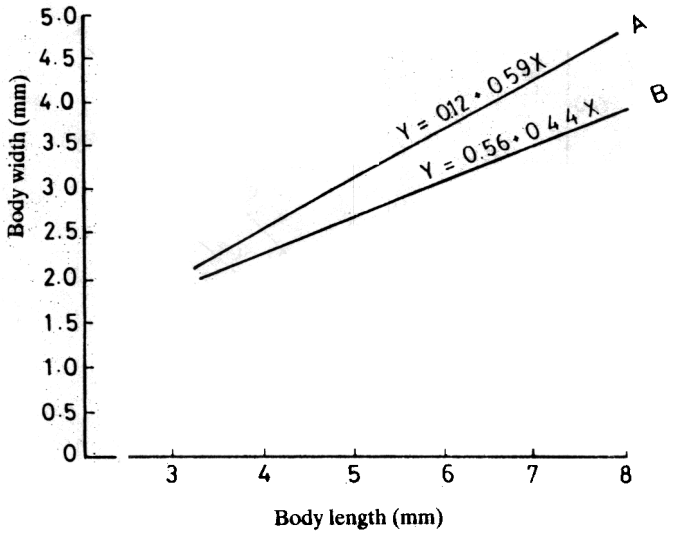

FIG. 6. Regression lines of body width against the body length of F_1 generation of males derived from Lake Qarun females and grown up in Lake Qarun water (A), and grown up in Lake Timsah water (B), at 20 ± 1°C.

Discussion

Two implications are apparent from the results obtained in the present study. Similar to those results obtained by Tolba and Holdich[10] for the isopod *Asellus aquaticus*. Firstly, as mentioned in the introduction, many workers have used body length to assess growth in *S. serratum*[5;2], and they have made comparisons between their populations. It has been shown in the present study that, in a fairly small geographical area of Egypt, the body size and weight of individuals of the same length differ significantly. Therefore, any further studies should include other parameters besides length to obtain a true indication of 'growth'. Secondly, the quality of the water in which population of *S. serratum* lives affects their growth and fecundity of females. In this study, the effects of total water pollution has been examined, but the effects of organic pollution and that of toxicants in the water have been not distinguished. The clean lake which was examined regularly (Lake Qarun), contained large amounts of decaying natural vegetation and agriculture irrigation but the level of toxicants, such as, copper and lead, was very low. The population densities of *S. serratum* at Lake Qarun were lower than those of Lake Timsah (polluted lake) [Unpubl. Obs.]. Individuals were larger and ovigerous females produced large number of broods.

Biological oxygen demand, salinity, level of phosphate, chloride, copper and lead, all tended to be higher in Lake Timsah than in Lake Qarun. Oxygen level was fairly high and pH levels were normal around 7.2 at both lakes.

Lake Timsah contained high densities of *S. serratum* possibly due to the amount of food. Barbary[21] found that, the amount of diatoms and filamentous algae in Lake Timsah water was significantly higher than that at Lake Qarun water; and may be also due to lack of competitors and predators. However, individuals at Lake Timsah tended to be smaller, and females collected from Lake Qarun carried more eggs than those of the same size females collected from Lake Timsah, although females from Lake Qarun were younger than those from Lake Timsah. On the other hand, increased organic matter may provide more food for *S. serratum* in Lake Timsah but the actual amount of growth attained by this isopod may be less than they are capable of; as shown by our transfer experiments. This suggests that other factors, such as heavy metals, may be depressing growth in organically polluted lake Timsah.

According to Aston and Milner[9] and Tolba and Holdich[10], high temperature may bring forward sexual maturity in *Asellus aquaticus* by diverting energy from growth to egg production, but may also have the effect of making animals smaller due to the fact that more energy has to be utilized for activity and maintenance at higher temperatures. It seems likely that if more energy is being utilized for activity and maintenance and less for growth, then less may be available for egg production, thus resulting in smaller broods as found in the present study for *S. serratum*. It could be concluded that, the smaller size of *S. serratum* from Lake Timsah may be due to thermal pollution which probably acts synergistically with certain chemical pollutants which exist in Lake Timsah water, thus, having a greater effect than Lake Qarun water.

There was a significant difference between growth in term of width for clean Lake F_1 individuals grown in clean and polluted water. Barbary[21] found that the developmental rates, over a range of temperatures, were similar for *S. serratum* eggs from clean and polluted lakes when they were grown in clean water (when clean lake eggs were transferred to polluted water they reacted by developing at a faster rate – presumably a response to environmental stress). However, in the field, the post- marsupial stages of Lake Timsah sphaeromatids may well develop faster in Lake Timsah water than in Lake Qarun water, but the actual amount of growth they achieve is significantly less.

Acknowledgements

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تأثير تلوث المياه على الخصوبة والحجم لحيوان : الاسفيروما سرأتم (قشريات : متماثلة الأرجل)

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المستخلص . وجد في هذا البحث أن كلًا من طول حيوان الاسفيروما سرأتم وعرضه ووزنه قد تأثر بتلوث المياه إذ إن حجم (الطول × متوسط العرض) الحيوانات التي جمعت من المياه الملوثة ووزنها كانا أقل بكثير من حجم الحيوانات التي جمعت من المياه النقية ووزنها .

من المعلوم ، أن عدد البيض في جيب التحضين للإناث يزداد بزيادة حجم الإناث ولكن في هذا البحث وجد أن العدد النهائي للبيض في الإناث يعتمد اعتمادا رأسيا على درجة تلوث المياه التي تعيش فيها ؛ حيث وجد أن عدد البيض في الإناث ذات الحجم الواحد أكثر في الإناث التي جمعت من المياه النقية .

ولقد وجد أن الإناث التي جمعت من المياه الملوثة وتركت في مياه نقية أنتجت صغارا وعندما نمت هذه الصغار في مياه نقية أظهرت ازديادًا ملحوظا في الحجم والوزن خاصة في الذكور التي أظهرت ازديادا ملحوظا في العرض إذا ما قورنت بتلك التي نمت في المياه الملوثة .

يمكن باستخدام خصوبة الإناث وحجم الجسم الطريقة المشار إليها في متن هذا البحث قياس تلوث المياه بالطريقة البيولوجية .