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Fouling organisms in the port of Mar del Plata (Argentina). I. *Siphonaria lessoni*: ecological and biometric aspects

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Abstract

The present paper deals with ecological aspects of the pulmonate gastropod *Siphonaria lessoni* (Blainville, 1824), a common member of fouling communities in Mar del Plata's port (38°08′17″ S, 57°31′18″ W). Populations on colonized panels of an experimental raft were studied during three annual cycles, to determine feeding habits, growth and various factors which restrict their distribution on floating substrata. Although *S. lessoni* is harmless as a fouling organism, its grazing on the algal helt clears a part of the substratum's surface, which is then quickly colonized by truly aggressive organisms such as *Balanus amphitrite*.

Introduction

For a long time, economical considerations have made fouling a matter for study in many countries. The valuable information which has been gathered up to date has provided a better knowledge of these benthic communities and has helped to oppose their harmful effects. However, South American fouling communities were practically unknown before studies were commenced in Argentine ports during 1965.

Investigations made throughout three successive years (1966 to 1969) have provided a sound knowledge of fouling organisms, the annual settling cycles of the main species, trophic relationships, resistance to toxic substances, and other ecological aspects; this information has helped in the understanding of the colonizing processes and subsequent development on artificial substrata (Bastida, 1968a, b, 1969).

Parallel studies on special fouling species were also begun; some of these species were highly resistant to toxic paints, while others, although sensitive, were indirectly harmful (Bastida, 1969). Among the latter is found the pulmonate gastropod *Siphonaria lessoni*, the subject of this paper.

Siphonaria lessoni is a common limpet found on Argentina's rocky coast, and is a typical member of the Mar del Plata fouling communities. Up to the present time this species has been studied mainly from a taxonomical and zoogeographical point of view, although recently some of its ecological aspects have been considered (Hubendick, 1946, 1964; Olivier and Penchaszadeh, 1968).

Materials and methods

Fouling studies were made on an experimental raft placed in the port of Mar del Plata (38°08′17″ S, 57°31′18″ W), an important fishing and commercial centre in South America.

This harbour maintains a particular environment, with its own characteristics which have conditioned the settlement of special benthic communities, clearly differentiated from those inhabiting the surrounding areas. The most distinctive hydrographical characteristics of this port are: slight turbulence, slightly lower salinity than in neighbouring areas, lower pH, dissolved oxygen, and a high content of organic detritus. The temperature of the water varies within a range of about 15 C° annually, being slightly higher in summer and lower in winter than that of the water in the neighbouring areas (Figs. 1 and 2). Full details on the environmental characteristics of this port have been given in a previous paper (Bastida, 1968b).

The raft used for these investigations has metallic frames, each containing 4 vertical panels extending from the surface to about 2 m depth. The top panel (water-line panel) has only its lower $\frac{1}{3}$ submerged.

Biological samples were taken from 13 immersed frames provided with acrylic sanded panels. One of the immersed frames was taken out monthly for sampling, then cleaned and submerged again in order to check monthly settlement throughout the year. Of the remaining frames, one was removed each month in order to complete the record of a whole immersion year.

Although studies were made throughout three successive years, each year belonged to a specific cycle, as the raft had to be removed from the water once each year for repairs. The 3 cycles were as follows: first — 1 September, 1966 to 1 September, 1967; second — 1 October, 1967 to 1 October, 1968; third — 1 November, 1968 to 1 November, 1969.

The smallest limpets were measured in the laboratory with a graduated eye piece under a binocular microscope. The larger specimens were measured directly with calipers. Wet weight of each specimen was also obtained.

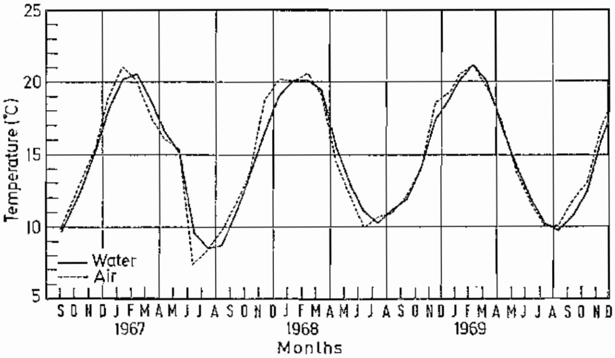

Fig. 1. Mean water and air temperature at the port of Mar del Plata, Argentina, September 1966/December 1969

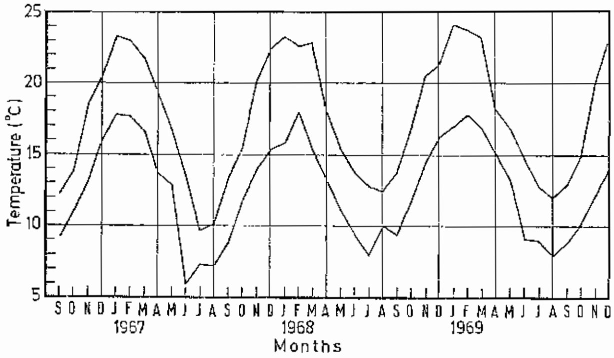

Fig. 2. Water maximum and minimum absolute temperatures at the port of Mar del Plata, Argentina, September 1966/December 1969

The habitat of *Siphonaria lessoni*

In a natural environment, *Siphonaria lessoni* is a very common species found on rocky substrata of varying hardness, from hard quartzite to the most brittle sedimentary rocks. The limpet is frequent on supra-littoral and mid-littoral levels, occurring on the former as a biological indicator and on the latter as an associated species of the *Brachydontes rodriguezi* — *Mytilus platensis* community (Olivier et al., 1966).

Recently, one of the authors of this paper observed, for the first time, this limpet on the infra-littoral level at several places in the Province of Buenos Aires. It was found at a depth of a few meters, down to the end of the shoreline of rocky formations. Specimens from this level were of regular size, and were covered with a thin layer of pink *Lithothamnium*.

In the port environment, the distribution of *Siphonaria lessoni* varies according to the steepness of the substratum. The distribution follows the same pattern as in natural environments on slight-slope bottoms. On vertical walls *S. lessoni* is confined mainly to the mid-littoral level, as low turbulence reduces the supra-littoral level to a minimum.

In the port mid-littoral level, *Siphonaria lessoni* is found associated with the *Balanus amphitrite* community, which displaces the characteristic *Brachydontes rodriguezi* — *Mytilus platensis* community of the natural areas adjacent to the harbour. In each case the distribution of *S. lessoni* is conditioned also by the presence of the algae on which it feeds.

When the investigations with the raft were begun in 1966, it was not expected that *Siphonaria lessoni* would colonize the panels, since these provided a floating substratum separated from the bottom, and it was not known at that time whether *S. lessoni* larvae are benthonic or planktonic. Later, as the first samples were taken, it was found that the species had successfully colonized the experimental surfaces, thus demonstrating the larvae to be planktonic.

The limpets distributed themselves especially along a narrow fringe on the water-line panels corresponding to an area subject to alternate emersion and exposure by the water due to the floating substratum. This fringe was always completely wet, and is homologous with the mid-littoral level of natural substrata, although these are not subject to tidal influences (Bastida, 1969). *Siphonaria lessoni* was not found on other panels at a deeper level, either as larvae, juveniles, or adults.

It is interesting that *Siphonaria lessoni* did not colonize the frames from a neighbouring experimental raft which were surrounded by a board about 50 cm high. This suggests that the veliger moves so near to the water surface that it cannot surmount a barrier and reach the panels beyond it. This observation was made in 1965 and, up to the present time, no limpet has been found inside the wooden frames. This also suggests the hypothesis that those specimens found on natural infra-littoral bottoms had first colonized the mid-littoral level, and later migrated deeper.

The colonization of artificial floating substrata

The analysis of the monthly panels for three cycles never showed any *Siphonaria lessoni*, despite the fact that larvae were frequently found in the plankton. This suggests that this species, like many others, only settles and develops on a substratum which is already inhabited by a community which has attained a certain degree of complexity and has already passed through certain developmental stages (Bastida, 1969). As these stages are so fleeting, it is not easy to identify them with accuracy. Nevertheless, it is possible to state that *S. lessoni* eventually reach a stage when they can afford suitable settling surfaces and an adequate trophic substratum which are of vital importance for the first developmental stages of this species.

Long-term panels did not provide proper conditions for the setting and development of this mollusk until after two months. It is only then that macrofouling is in full bloom, displacing the initial slime film, at the same time as a clear belt of algae is formed, especially during the summer.

Algae are of fundamental importance for the development of *Siphonaria lessoni*, insofar as they form the main feeding source. Limpets are always found above the algal belt, grazing only at the attachment base and not on the surface of the fronds.

Siphonaria lessoni was found to occupy only a very restricted fringe (less than 10 cm) above the algal belt and did not develop at higher levels. The few specimens found isolated at about 20 cm above this limit had died of dehydration. Undoubtedly, the algal belt is sufficient to supply the trophic needs of *S. lessoni*, and any displacements towards higher levels are limited by lack of food, insufficient humidity, and the lack of adequate shelter during periods of maximum dryness.

In contrast to its behaviour in natural environments, on the experimental raft *Siphonaria lessoni* did not penetrate deeper than the top border of the algal belt; accordingly, an experiment was performed by scraping the upper limit of the algae to an extent of approximately 5 cm width, that is to say a belt entirely submersed and never exposed to air. A short time later many limpets had migrated to the new deeper zone of the algal belt. This proves that *S. lessoni* move on the panel along the algal belt and can go deeper if the belt descends. They do not penetrate the actual belt itself, as the density of the algae and other organisms is so high that the limpets find no free setting surface.

Once the limpets settle and develop on the panels, they occupy practically the whole of the narrow zone which offers favourable living conditions, and no space is left for the development of new generations. Although evident recolonizing tendencies can be recognised (Figs. 3, 4, and 5), these cannot usually prosper owing to the lack of vital space.

Feeding habits

In order to determine the trophic spectrum of *Siphonaria lessoni*, a sample of all the specimens was examined microscopically, and the stomach contents and faeces observed. In all cases the digestive tract was full of food, which demonstrated that at least on our experimental substratum, *S. lessoni* undergoes no long fasting periods.

The trophic spectrum was composed chiefly of diatoms of various species (Table 1), chlorophytes — chiefly *Ulva lactuca* and *Enteromorpha intestinalis*, and rodophytes — genera *Polysiphonia*, *Ceramium* and *Bangia*, in proportion to their own settling and developmental cycles.

Other species of algae which make up the fouling communities were not found in the analysed gut contents, this is probably due to their relative scarcity and brief periods of settling.

As regards feeding on the higher algae, *Siphonaria lessoni* competes with *Idotea baltica* and *Sphaeroma* sp., although the latter mainly feed on organic detritus.

Cyrtograpsus angulatus and *C. altimanus* also feed to a certain extent on algae, but they are only present at certain seasons during the year, and their great motility allows them to explore deeper levels in search of other types of food.

As far as diatoms are concerned, *Siphonaria lessoni* has to compete especially with microfouling organisms, i.e., the harpacticoid Copepoda (*Tisbe furcata* and *Harpacticus* sp.), ciliated Protozoa, especially *Zoothamnium* sp., and the larvae of certain crustaceans.

Table 1. *List of diatoms in the trophic spectrum of Siphonaria lessoni*

Amphora sp.
Cocconeis sp.
Grammatophora sp.
Licmophora lyngbyei f. *elongata*
Licmophora lyngbyei f. *abbreviata*
Licmophora lyngbyei f. *minor*
Navicula spp.
Nitzschia closterium
Nitzschia longissima
Pinnularia sp.
Plagiogramma sp.
Pleurosigma sp.
Synedra affinis
Coscinodiscus sp.
Melosira sulcata

Although grazing by *Siphonaria lessoni* is very intense, it is unable to deplete the algal belt, as the growth and repopulation rhythm of the algae is extraordinarily high.

As phytobenthos on experimental panels is so abundant and competition for food so scarce, it can be inferred that the density of *Siphonaria lessoni* populations is not limited by the quantity of food available. The real limiting factor is lack of space, since the limpets live one beside the other along the higher border of the algal belt, preventing the access of other individuals to the food line.

In some experiments, 75% of the limpets were removed from experimental panels before replacing them in the raft. During the following months it was observed that the growth rate of the remaining specimens had increased and their size compared favourably with that of limpets on undisturbed panels. This is readily explained by the ready access to the algal belt of the limpets on the panels with only few specimens.

Morphological characteristics of *Siphonaria lessoni* shells and their variations

Other authors (Olivier and Penchaszadeh, 1968) have already drawn attention to the variations in the shape of *Siphonaria lessoni* shells induced by different ecological factors. Two extreme forms have been described: high shells with a remarkable apex curvature, and flat shells only slightly curved.

It is usually thought that, in *Siphonaria*, as in other patelliform mollusks, the type with a high shell is found where the limpets are exposed to drought and slight water movements, whereas the flat varieties occur where there is a high degree of humidity and water turbulence (Orton, 1933; Moore, 1934; Olivier and Penchaszadeh, 1968).

The environmental conditions in the port area and the characteristics of the experimental raft made it possible to demonstrate the factors which really condition the form of the *Siphonaria lessoni* shells, thus disproving the opinions expressed hy other authors on this subject.

Specimens derived from our experimental panels were of the high shell type and, although these occurred with certain degree of variation, none of the flat-shelled type ever appeared. As these limpets were never exposed to dessiccation, humidity was obviously not a determinant for high or flat shells; thus, a reasonahle explanation is that the high shell variety inhabits regions such as the port of Mar del Plata where the water is calm. Similar conditions can be found where there is a high degree of turbulence, but where adequate protection for the limpets is available. Flat shells, therefore, appear to be an adaptation to resist the fierce onslaught of waves in turbulent areas without protection. Of course variations in form may also be due to genetic factors as has been shown to be the case in other gastropods (Struhsaker, 1968).

Another characteristic of *Siphonaria lessoni* is the presence of radial ribbing on the surface of the shell. Specimens from rocky shores and the walls or piers of the port have strongly marked ribs. On the other hand, limpets from the experimental panels had very lightly marked ribbing, the shells being almost smooth.

As the experimental raft was always floating in the middle of the port, the absence of ribbing might have been caused by the exposure to the constant currents set up by the tidal flow. Such constant friction could cause a smoothing of the shells of *Siphonaria lessoni* which, due to the lack of turbulence in the port, are thinner than the shells of specimens found in other areas.

Growth

Size-age relationship

The growth curve of *Siphonaria lessoni* was obtained from monthly size-frequency distributions.

Such distributions arose from samples taken during the three annual cycles under consideration. It was observed that those corresponding to the 1966/1967 period showed the highest numerical representation in all sizes (Fig. 3). The samples obtained from the other periods, 1967/1968 (Fig. 4) and 1968/1969 (Fig. 5) did not display this characteristic; thus, the analysis on modal displacements and the calculation of each mode mean size was made using samples from the 1966/1967 cycle.

The first stage in obtaining the size-age relationship was an analysis of the decomposition in normal components using the successive differences method (Tanner, 1959) in each of the polymodal frequency distributions in order to obtain the mean size in each mode. All the modes were plotted, using size as ordinate against time (represented in days) as abscissa. Those modes which seemed to come from the same growth group joined each other, forming chains in such a manner that each represented a specific growth brood.

As a non-analytical method was used to obtain the polymodal decomposition, only those modes which, without any douht, displayed successive displacements, were joined. Some modes remained unjoined hecause there was only slight evidence that they belonged to the same group and also because, in this kind of distribution, there may exist modes which are not strictly structural, these latter arising as a consequence of the semi-graphic decomposition method and through certain unavoidable errors in the measurements.

The growth rate was calculated for each growth brood taking the difference in size between each consecutive mode in chains, divided by the corresponding time interval. This rate, between contiguous modes, was considered as the growth rate corresponding to the mean length of both modes.

In the growth equation, parameters were obtained (Gulland and Holt, 1959) by the following relation:

$$\frac{L_2 - L_1}{T_2 - T_1} = K\left(L_\infty - \frac{L_1 + L_2}{2}\right) \qquad (1)$$

$$t_0 = t - \frac{1}{K}\ln\left(\frac{L_\infty}{L_\infty - L_t}\right) \qquad (2)$$

where

L_2 is the length of a specimen in each mode of the chain;

L_1 is the length of a specimen in the following mode;

$T_2 - T_1$ is time interval (days) between both modes;

K is catabolism coefficient;

L_∞ is asymptote length;

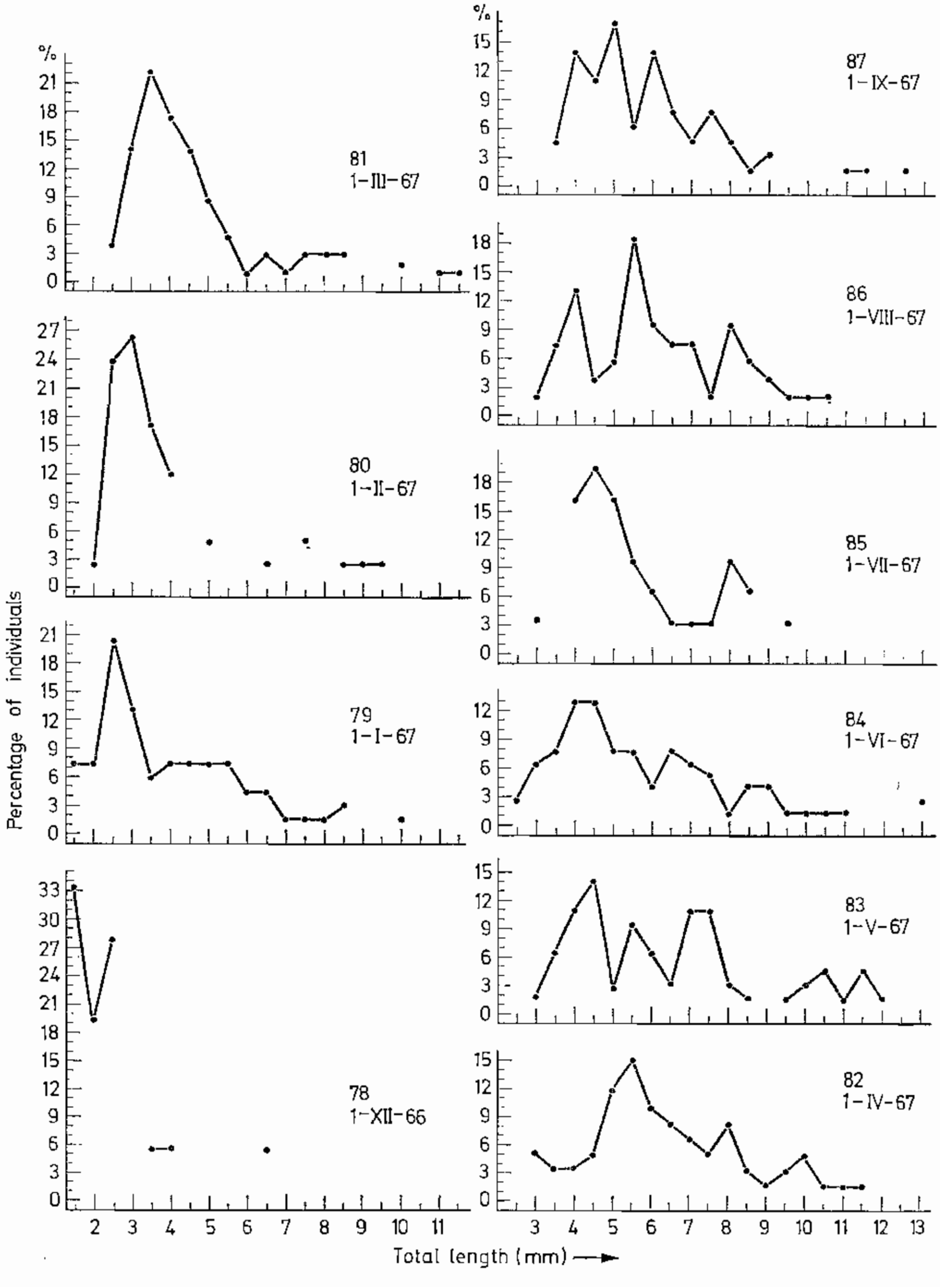

Fig. 3. *Siphonaria lessoni*. Size-frequency distribution. First cycle

t_0 is the hypothetic age of specimen for length 0. Values of

$$\frac{L_2 - L_1}{T_2 - T_1} \text{ and } \frac{L_1 + L_2}{2}$$

came from data in Table 2, and were then used to adjust the line (1), by the minimum quadratic adjustment method, obtaining the following values:

$K = 0.0042$;

$L_\infty = 24.97$ mm;

$t_0 = -5$ days.

Finally, the resulting growth equation is:

$$L_t = 24.97\,[1 - e^{-0.0042\,(t+5)}] \tag{3}$$

$$\frac{L_2 - L_1}{T_2 - T_1} = -\,0.0042\left(24.97 - \frac{L_2 + L_1}{2}\right) \tag{4}$$

$$\frac{L_2 - L_1}{T_2 - T_1} = 0.1049 - 0.0042\,\frac{L_2 + L_1}{2}\,. \tag{5}$$

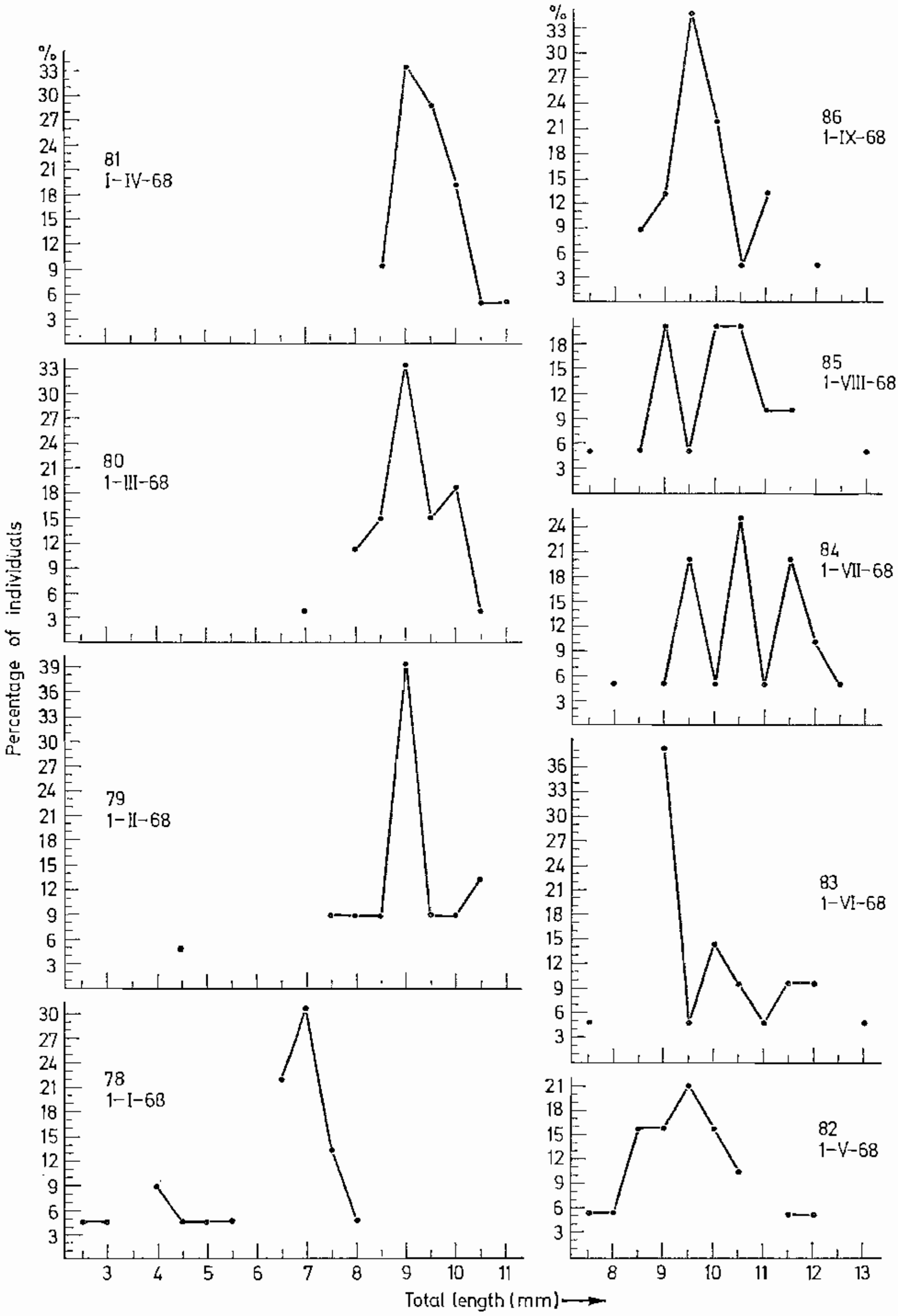

Fig. 4. *Siphonaria lessoni*. Size-frequency distribution. Second cycle

Expression (4) shows immediately the mean time that each specimen takes to pass from one size group to the following, and (5) shows the growth rate for any size at any interval.

Fig. 6 shows the growth curve corresponding to Eq. (3).

It is interesting to note that, according to the data obtained from the growth curve (cycle 1966/1967) a

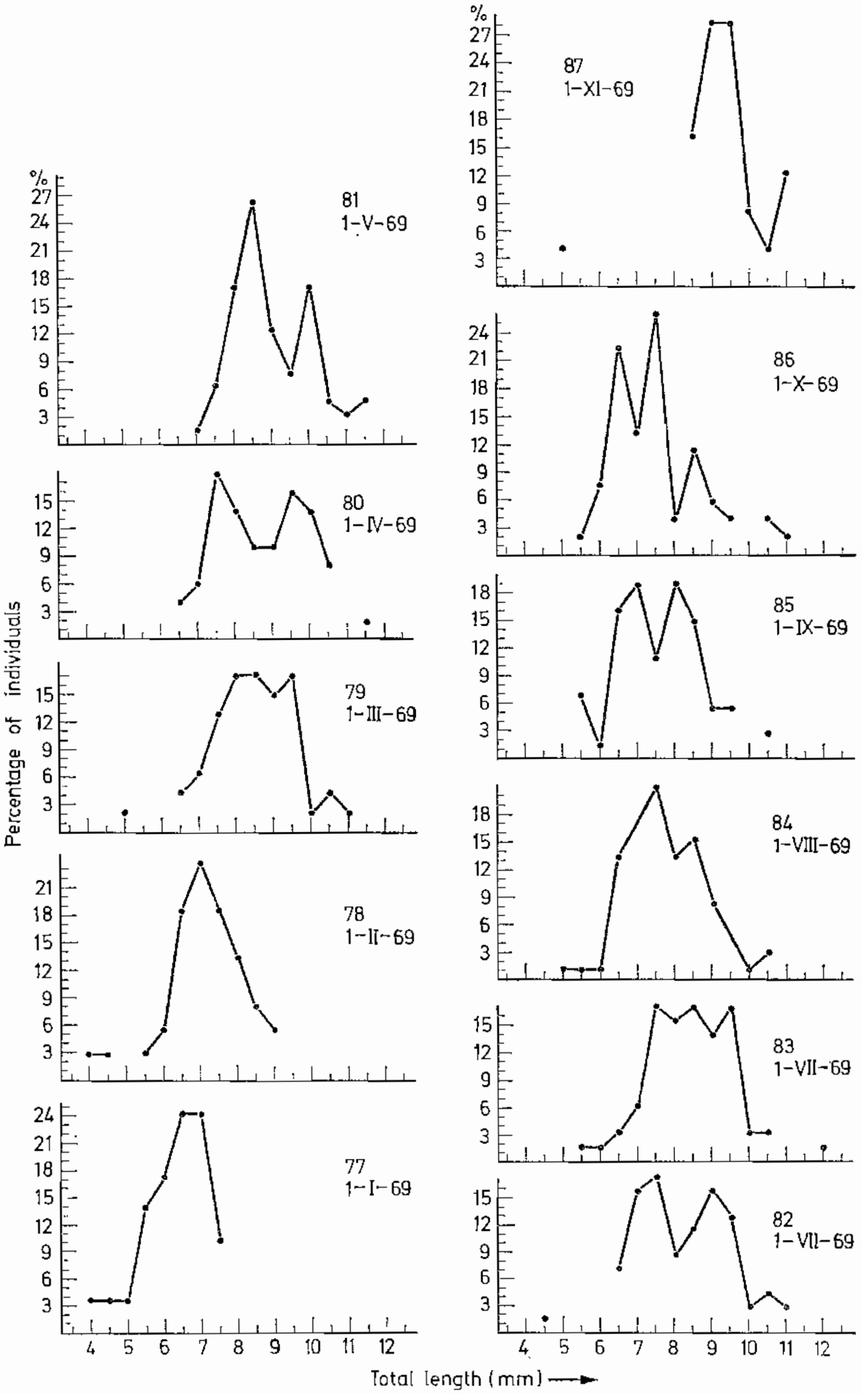

Fig. 5. *Siphonaria lessoni*. Size-frequency distribution. Third cycle

specimen reaches the size of about 4 mm in approximately 30 days after settlement. These values coincide with the findings obtained from the experimental panels, where the maximum size (4.6 mm) occurred in specimens about 1 month old (November).

Growth rates in the 1967/1968 and 1968/1969 cycles of young samples was higher because settling had occurred during the hottest month (January), the temperature compared with that of the first cycle being 5 C° higher. The influence of temperature on

Table 2. *Siphonaria lessoni. Modal means in mm obtained with the successive differences method for each of the polymodal size-frequency distributions. Values in brackets represent percentage of the total of each normal component*

Date	Days (partial)	Days (whole)	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
1. XII. 66 Panel 78			1.4 (63 %)	2.33 (24 %)	3.75 (12 %)		
1. I. 67 Panel 79	31	31		2.5 (46 %)	4.6 (39 %)	8.3 (4 %)	
1. II. 67 Panel 80	31	62		2.8 (83 %)			
1. III. 67 Panel 81	28	90		3.5 (85 %)	7.0 (14 %)		
1. IV. 67 Panel 82	31	121		3.0 (10 %)	5.47 (64 %)	8.0 (13 %)	9.9 (12 %)
1. V. 67 Panel 83	30	151		4.35 (41 %)	5.5 (16 %)	7.2 (26 %)	9.9 (11 %)
1. VI. 67 Panel 84	31	182		4.3 (64 %)	6.75 (20 %)	8.8 (15 %)	
1. VII. 67 Panel 85	30	212	2.6 (3.8 %)	4.5 (75 %)		8.18 (19 %)	
1. VIII. 67 Panel 86	31	243		3.8 (28 %)	5.5 (50 %)	8.1 (21 %)	
1. IX. 67 Panel 87	30	273	4.1 (28 %)	4.85 (28 %)	6.0 (24 %)	7.5 (13 %)	8.8 (3 %)

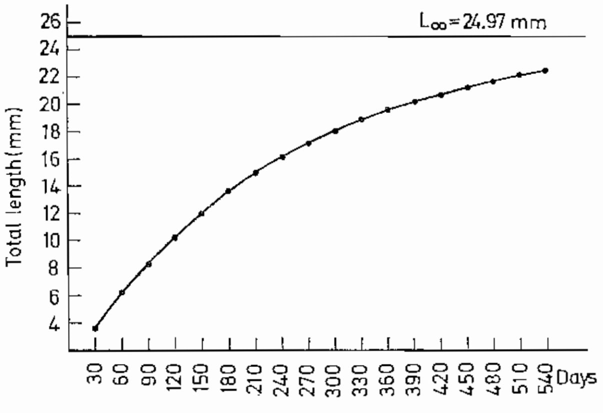

Fig. 6. *Siphonaria lessoni.* Growth curve

the growth of this species is very marked, as in the case of most organisms in the port of Mar del Plata (Bastida, 1968a, b).

As the size of the specimens increases, their growth rate slows; thus, it takes 25 days to increase from 5 to 7 mm, 32 days to increase from 9 to 11 mm and 62 days from 13 to 15 mm, etc.

The adjustment of the line (1) gave an asymptote length of 24.97 mm. Sizes varied from 20.0 to 24.9 mm in a group of 8 specimens taken from a floating substratum immersed for two consecutive years. As it is known that *Siphonaria lessoni* does not colonize a substratum which has been submerged for less than 1 month, it is possible to affirm the specimens mentioned were 23 months old at the most.

Special environmental conditions in the port area such as abundance of phytobenthos and scarce trophic competition are obvious reasons which account for the accelerated growth rhythm in *Siphonaria lessoni*, in comparison with the neighbouring natural zones.

In order to determine the age of the specimens, they were examined for growth rings. In small limpets, certain markings of doubtful validity were observed, tbese had disappeared in the larger specimens owing to smoothing of the shells in most cases; in the remaining specimens pertinent observations and measurements were made. It was thus possible to ascertain the fact that the first ring is not annual, as has been suggested by earlier authors (Olivier and Penchaszadeh, 1968), but corresponds to a period not longer than 90 days. Subsequent, unclear, markings appeared after short and somewhat variable intervals.

The difficulty in making a correct identification of the rings, make it impossible to relate them to the outstanding biological processes of this mollusk's life, thus, the study of the rings was considered useless for the analysis of this species and its age determination.

Length-weight relationship

Every specimen obtained during the 1968/1969 cycle was weighed. With the figures obtained, an attempt was made to discover a length-weight relationship using a weight regression model. The monthly relationships are shown in Table 3.

Finally, by using the data obtained over the 12 month period, a general weight regression relationship was obtained [Table 3, Eq. (6)]. A large variation was clearly observed on the logarithmic regression slope.

Table 3. *Siphonaria lessoni. Monthly and general length-weight relationships*

Panel 77	$\ln P = -3.2525 + 3.5190 \ln L$	$N = 29$
Panel 78	$\ln P = -1.6756 + 2.6843 \ln L$	$N = 38$
Panel 79	$\ln P = -1.3826 + 2.6622 \ln L$	$N = 48$
Panel 80	$\ln P = -1.7714 + 2.7728 \ln L$	$N = 51$
Panel 81	$\ln P = -2.3109 + 3.0357 \ln L$	$N = 65$
Panel 82	$\ln P = -1.0130 + 2.3898 \ln L$	$N = 69$
Panel 83	$\ln P = -1.9671 + 2.9138 \ln L$	$N = 65$
Panel 84	$\ln P = -2.9130 + 3.2116 \ln L$	$N = 105$
Panel 85	$\ln P = -2.4951 + 3.1142 \ln L$	$N = 75$
Panel 86	$\ln P = -1.7475 + 2.7251 \ln L$	$N = 54$
Panel 87	$\ln P = -4.3504 + 3.7863 \ln L$	$N = 24$

General regression:

$\ln P = -2.6539 + 3.0855 \ln L$ (6) $N = 623$

Variance analysis of (6):

$F = 4704$ $F_{0.01}$ (621:1)

Length-width relationship

The length and width of each specimen was measured in order to find out if there was any definite relationship between them.

Simple observation of the data showed an apparent linearity of the relation, but taking into consideration a possible allometric phenomenon, it was decided to analyse the data in greater detail.

Specimens from the samples were grouped in different size ranges. Analysis of each group showed the best method of plotting to be neither a straight line nor a continuous curve, but rather 4 consecutive intersecting straight lines, each corresponding to the size range with a maximum correlation coefficient. This can be seen in Table 4 where $x =$ length, $y =$ width, $r =$ correlation coefficient.

Simple calculation of the slope of these lines did not give a clear idea of allometry in growth. But when the theoretical value of the width corresponding to the given length of each range was calculated from each of the straight lines, it was observed that they increased according to the size range of the sample up to a length of 11 mm, remaining constant for the larger sizes. It is, therefore, possible to infer that at least for the experimental panels, *Siphonaria lessoni* presents characteristic allometric features up to a size of 11 mm, and from then on tends to be isometric.

An attempt was also made to try and determine the supposed allometry through the $y = bx^{\alpha}$ relationship, in which for any value for α different from 1, growth was considered allometrical. In this case the value for α was 0.88, which appears to prove that the slight allometry obtained with the former model seems valid.

The model using the relation $y = bx^{\alpha}$ evidently obscures the growth variations in the different sizes, since the relationship is not appreciably adjusted to real data.

Table 4. *Siphonaria lessoni. Length-width relationships in different size ranges*

Size ranges: from 3.95 to 7.00 mm

$r = 0.9648$ $y = 0.6114 + 0.5750\,x$

Size ranges: from 7.00 to 9.00 mm

$r = 0.8191$ $y = 0.4372 + 0.6432\,x$

Size ranges: from 9.00 to 12.00 mm

$r = 0.7900$ $y = 3.0190 + 0.3888\,x$

Size ranges: from 11.00 to 24.00 mm

$r = 0.9700$ $y = -2.2257 + 0.8165\,x$

The role of *Siphonaria lessoni* as a fouling organism

Most of the studies of fouling organisms have been made on directly harmful species. There is a large number of organisms which are resistant to toxic paints and destroy a film of paint during their development (barnacles, tube worms, etc.) and there are others which do not alter the substratum but increase the friction resistance of floating objects in their passage through the water (ascideans, algae, etc.).

Nevertheless, there are other organisms worthy of special attention which, although they have no directly harmful action, play an important part in the economy of the fouling community by forming a fundamental trophic base. On the other hand, there are species which create suitable conditions for the settlement of other organisms which are definitely harmful. This is precisely the case with *Siphonaria lessoni* (Fig. 7).

This limpet, when grazing, reduces the algal belt, thus leaving exposed surfaces free for settling and further development of species such as *Balanus amphitrite*. This barnacle, like many others, is very harmful, since it destroys the protective film of paint on floating substrata and exposes the surface to corrosion.

It is necessary to emphasize the fact that, if it were not for the action of *Siphonaria lessoni*, *Balanus*

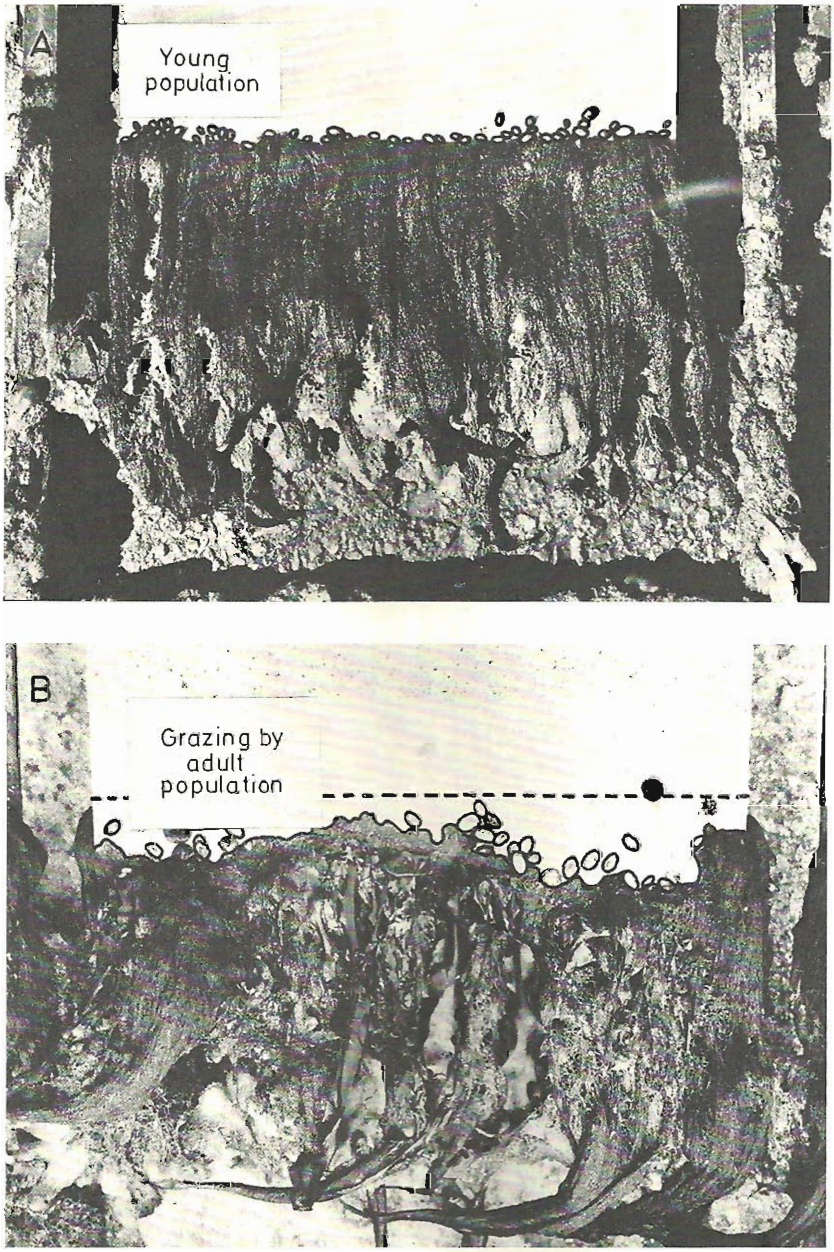

Fig. 7. Water-line panels colonized by *Siphonaria lessoni*. Upper: young population, on the top limit of the algal belt. Lower: grazing effects by an adult population; dotted line indicates original limit of algal belt

amphitrite could not reach this level, since the substratum is totally occupied by the algal belt which, because of its density, is practically impenetrable.

Moreover, the harmful action of barnacles is increased because the water lines of vessels, just as the water-line panels on experimental rafts, have no toxic paints, thus the surface of the substratum is entirely exposed to the attack of the organisms.

Tests made on floating structures treated with antifouling paints show that *Siphonaria lessoni* is very sensitive to the action of poisonous substances, in common with the majority of mollusks. It has been proved that asphaltic paint is highly harmful to the development of this species, especially in the case of young specimens.

Summary

1. In the Buenos Aires Province, Argentina, *Siphonaria lessoni* has been mentioned only from supra-littoral and mid-littoral rocky bottoms. After

diving searches it was found to be present also at infra-littoral levels.

2. The substratum slope plays an important role in *S. lessoni*'s vertical distribution. Specimens on a perfectly vertical substratum are limited to the mid-littoral bottoms.

3. In its natural environment, *S. lessoni* integrates the mid-littoral *Brachydontes rodriguezi — Mytilus platensis* community, although in the harbour area, it is generally associated with a community where *Balanus amphitrite* is the dominant species.

4. Since *S. lessoni* was able to colonize a floating substratum, it is obvious that the larvae have planktonic habits. It was also proved that veligers are distributed near the water surface, down to almost 50 cm depth.

5. *S. lessoni* larvae start attaching to the experimental substratum at the beginning of the second month of immersion. That is, after the community has passed through certain successional stages.

6. *S. lessoni* settled exclusively on the upper panel of the experimental raft, above the algal-belt's higher limit. Dispersion above this level is limited by food shortage, low humidity and the absence of a proper shelter in the periods of acute dryness. If the algal belt edge sinks, the limpets are able to reach lower levels.

7. The *S. lessoni* trophic spectrum is made up of diatoms species, Clorophyta (*Ulva lactuca* and *Enteromorpha intestinalis*), and Rodophyta (*Polysiphonia*, *Ceramium* and *Bangia*).

8. Since phytobenthos is very abundant and since *S. lessoni* has a low trophic competition, it is assumed that its population density is not regulated by the amount of food, but by the possibility of free access to such food.

9. The *S. lessoni* growth-curve equation obtained by the modal displacement of monthly length-frequency distribution, previously decomposed in normal components (structural modes) is:

$$L_t = 24.97\ [1 - e^{-0.0042\,(t+5)}]\,.$$

10. The sample's wet weight is related to its length by the equation: $\ln P = 2.6539 + 3.0855 \ln L$.

11. The best adjustment of length and width data obtained in this study is given by the 4 straight lines belonging to 4 consecutive size ranges, instead of an even and continuous curve $y = bx^{\alpha}$ type which is less sensitive than the former. Proportions between theoretical values allowed the detection of a slight allometry up to 11 mm length.

12. The rings found in *S. lessoni* shells correspond to very short time intervals (first ring is present within 90 days). The growth rings are considered useless for the study of this mollusk's growth due to the difficulty in identifying them exactly and of relating them to any characteristic biological process in its life.

13. Harbour-area environmental conditions and experimental raft characteristics suggest that the shell-shape variations are correlated with turbulence, without any consideration to degree of humidity. High-type shells are, in general, found in low turbulence areas and flat ones in zones directly exposed to wave action.

14. Although *S. lessoni* is not an aggressive species, it is an important fouling organism. Its grazing activity reduces part of the surface occupied by the algal belt, leaving clean areas which are easily colonized by *Balanus amphitrite*, a very harmful species.

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