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Some studies on the growth of early post-larvae of Nephrops norvegicus (L.) reared from the egg

by

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SUMMARY

The growth rate of 42 artificially reared post-larvae of Nephrops norvegicus was followed individually during some months in 1974. The average duration of each stage increased with age and the increment per moult in carapace length was found to be just under 1 mm. The average carapace and total lengths were determined for each stage and the increment per moult in percentage of pre-exuvial lengths was estimated.

The post-larvae were fed mostly alive animals as small benthonic amphipods and isopods, the size of which was selected according to the stage of the Nephrops individuals.

Regeneration of lost appendices was normally verified after two moults, although after the first moult they were already present in a reduced size.

Experiments with purified water were carried out and the efficiency of a biological filter within the rearing units was tested.

INTRODUCTION

The growth rate of the post-larval and juvenile stages of Nephrops norvegicus is particularly difficult to follow because young individuals are very seldom caught in nature.The smallest Nephrops ever captured were reported by HILLIS (1972) and measured 4 mm of carapace length. The growth of early post-larval stages resulting from larvae caught in the plankton was also given by HILLIS (1971).

In the artificial culture of Nephrops (FIGUEIREDO, 1971) and (FIGUEIREDO and VILELA, 1972) some post-larval stages were obtained in laboratory experiments and they survived for about three months. Later experiments on artificial rearing (FIGUEIREDO, 1975) produced a greater number of post-larvae, the growth of which is reported in the present paper.

METHODS

The growth of 42 artificially reared post-larvae metamorphosing between 12 March and 6 April 1974 was followed individually in beakers of 400 ml until the third post-larval stage was reached; they were then transfered to beakers of 1000 ml. Seawater recirculated in the laboratory and treated with a biological filter was used to fill the beakers. The temperature of the water varied between 16º and 20º C, following the air temperature of the room. An unexpected increase to 23-24º C occurred on the 21st and 22nd of May causing the death of most individuals. The results for post-larvae living after that date may have been influenced by possible physiological disturbances during those days.

The salinity of the water was maintained between 32% and 33% and in all cases a continuous air supply was furnished.

Nephrops of the first post-larval stage were given Crangon crangon eggs as food. During the following stage also small amphipods and isopods were given and during the last ones only living amphipods of larger sizes were furnished. When Crangon eggs were given the water in the beakers was changed daily to prevent fouling of the water. When alive animals only were furnished as food the water was changed every second day. In all cases small fronds of Fucus spiralis and 2-3 ml of a pure phyto plankton culture, usually Nannochloris sp (?), were added whenever the water was changed.

Measurements of both total and carapace lengths were taken on the exuviae with an eyepice micrometer fitted to a binocular microscope. The total length was measured from the tip of the rostrum until the posterior margin of the telson, setae excluded, and the carapace length was taken from the eye soket to the middle point of the posterior margin of the cephalotorax. Very often the exuviae were eaten and some were found so damaged that they could not be measured. Measurements on alive animals were excluded due to the frailty of the young animals.

RESULTS

1. Growth and biometric relation

Annex Table A includes the data of 42 Nephrops post-larvae showing total and carapace lengths at successive stages and duration of each stage. As stated above, this paper deals mainly with the results obtained before the incident with the increased temperature which occurred on 21-22 May. The mortality until this time was 54.7%, possibly due in part (21.4%) to contamination of the water when the substitution of Cratgon eggs, which are merely seasonal, by the flesh of the Crangon itself was tried. This occurred between 8 and 11 April.

The 45.3% survival suffered presumably from the two-days increase of temperature and died successively of during the following days. There were, however, three exceptions (Nºs 1, 12 and 22 in Annex Table A) one of which lived until November and attained a total length of 32 mm (10 mm of carapace length) at its 7th post-larval stage. Bearing in mind that these failures in the artificial rearing were partly responsable for the mortality, it seems nevertheless of some interest to estimate the percentage of the individuals that reached the first four post-larval stages and average duration of each stage. These figures are reported in Table I.

TABLE I - Percentage of individuals that reached the successive post-larval stages and average duration of each stage.

	% Post-larvae	Average duration (days)
Pl 1	100.0	16.2
Pl 2	35.7	19.9
Pl 3	28.6	20.8
Pl 4	11.9	26.6

It will be noticed that there is an increase of the average duration of each successive stage. The average of total and carapace lengths for each stage are shown in Table II. Only one post-larva in stage 5 could be measured, the figures in brackets.

TABLE II - Growth of early post-larvae of <u>Nephrops norvegicus</u>.

	Average total length (mm)	Number of observations	Average carapace length (mm)	Number of observations
Pl 1	13.16	37	4.03	41
Pl 2	15.70	15	4.97	17
Pl 3	17.91	12	5.81	14
Pl 4	21.28	5	6.71	6
Pl 5	(22.6)	(1)	(7.3)	(1)

The average total and carapace lengths reached are plotted against time in Fig. 1. The average total length increment per moult lies roughly between 2 and 3 mm and the average carapace length increment is just under 1 mm. The increment in total and carapace lengths, as a percentage of the pre-exuvial dimensions, are shown in Table III.

TABLE III - Average increment per moult, in percentage of pre-exuvial lengths of early post-larvae of Nephrops norvegicus.

Moult	Average increment in			
	Total length (%)	Number of observations	Carapace length (%)	Number of observations
Pl 1 - Pl 2	14.83	12	22.58	16
Pl 2 - Pl 3	18.25	7	19.96	9
Pl 3 - Pl 4	10.53	3	8.50	3

Since the perfect extension of the abdomen is generally difficult to obtain the measurement of the total length is somewhat approximative. This measurement is also less frequent because the tip of the rostrum and the telson may sometimes be damaged. In order to facilitate the use of the carapace length as a standard measurement, a relation has been worked out between carapace and total lengths, expressed by the following equation:

$$TL = 2.899\ Cl + 1.387 \qquad r = 0.979$$

This correlation was obtained by measuring of 70 exuviae, part of them belonging to successive stages of the same individual. All but one (the Pl 5 reported in Table II) are listed in Annex Table A. The estimated values are plotted in the graphic of Fig. 2.

2. Regeneration

When metamorphosing some post-larvae loose one or both of their big claws and often also one or more pereiopods. Normally one single moult is sufficient to start regeneration of the appendices, but these do not reach the normal size until the young *Nephrops* have performed at least a second moult.

Here is refered a particular case of regeneration of the telson. An abnormal larva of stage II (FIGUEIREDO, 1975) found some difficulty in moulting into larval stage III due to a deformity of its furca which was twisted near the bifurcation. Just after moulting the furca was carefully cut off in order to facilitate the following moult, the metamorphosis. This occurred in a normal way and within the expected period of time, but the post-larva had a small bourgeon on the right angle of the distal margin of the telson. This, however, disappeared when the post--larva moulted into post-larval stage 2.

3. Feeding and behaviour

In previous experiments the post-larvae were given minced flesh of mussels and cockles in addition to *Crangon* eggs. In the present experiments small amphipods and isopods were for the first time used as food and they proved to be very adequate since the young *Nephrops* enjoy chasing alive animals and breaking them with their claws. However, the size of the food-animals had to be carefully chosen in order to be compatible with the size of the *Nephrops*. After the first post-larval stage only very small amphipods or isopods measuring about 2 mm were furnished, alternatively with *Crangon* eggs. To post-larval stage 3 bigger individuals ($\pm$ 3 mm) were given and were often successfully consumed. Post-larvae having only one claw had less capability to catch living animals; to them additional food consisting of *Crangon* eggs was daily furnished. Some individuals lost both their claws as they metamorphosed and had therefore to be fed *Crangon* eggs only. Usually after two moults the claws were regenerated and they coult then be fed also amphipods and isopods. In post-larval stage 4 bigger amphipods and isopods ranging from 4 to 5 mm were given..Finally, after post-larval stage 4 only rather big amphipods measuring more than 5 mm were furnished. Amphipods were on the whole more readily eaten than isopods, very probably due to the curling of the last ones.

Very often also great part of the Fucus spiralis fronds provided to the beakers was consumed. In the feeding experiments it was noticed that the activity and pigmentation of the post--larvae were greatly increased when living animals were given as food. The pigmentation was more reddish in some parts of the carapace and claws as compared with post-larvae fed Crangon eggs only.

Chasing activities take place on the bottom of the vessel, the post-larvae behaviour being in this case very similar to that of the adults. During a great part of the time, however, the post-larvae typically swim fast round and up and down the vessel.

4. Water treatment

The water used in the culture beakers was kept in a well aereated closed circulating system of 360 l capacity, and was treated by means of kind of a biological filter This was quickly developed by the activity of benthonic amphipods and isopods which fed upon fronds of the brown seaweed Fucus spiralis Air was provided to the water thus permitting aerobic bacteriae to oxidize the waste products excreted by the amphipods and isopods into inorganic compounds which were quikly incorporated by added phytoplankton forms. An intensive primary production occurred allowing the development of a micro-community consisting mainly of copepods, small worms and protozoans. This community concentrates as a fine substrate on the bottom of the aquarium and can easely be maintained in full activity within the recirculating water system, acting as a biological filter.

Two rearing experiments were carried out adding a small amount of this fine living substrate to the water in the beakers, in order to determine the purifying capacity of the filter. Crangon flesh and eggs were daily furnished to the post-larvae and were never removed. The water was changed at intervals of 5-6 days only and no signs of fouling had ever occurred. The two post-larvae lived 46 and 52 days under these conditions and the causes of their death were respectively difficulties at the moult and the mentioned incident with increased temperature.

DISCUSSION

The average increments per moult, given in percentage of the pre-exuvial lengths, does not differ substancially from those reported by HILLIS (1971). The increase per moult in carapace length (just below 1 mm) agrees with that estimated by FARMER (1973). According to this author young Nephrops up to 14 mm of carapace length belong to year class 0 and had moulted about 10 times. This is also in agreement with the present results since the oldest Nephrops obtained lived for about 8 months and measured 10 mm of carapace length when it died at its 7th post-larval stage.

The results of the present experiments show that much has yet to be done to improve the survival of the post-larval stages of Nephrops under laboratory conditions. Light conditions, insufficient food and space limitations may negatively influence the growth rate, which on the other hand may be artificially accelerated by temperatures higner than those found in the natural environment.

The deaths of several individuals at a temperature of about 23-24º C, but the survival around 20º C shows a letal level for post-larvae of Nephrops somewhat above 20º C.

Rearing post-larvae in beakers was facilitated by the use of the biological filter, as described above. The stabilization of the filter was obtained in a short time and this result may be of some value for future large-scale experiments. Chemical and bacteriological analysis are at present being carried out in order to evaluate the efficiency of the filter.

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A N N E X – T A B L E A

Total and Carapace Length, in mm., of Nephrops post larvae at successive stages and duration (D), in days, of each stage.

Nº	Date Metamorphosis	Pl 1 TL	Pl 1 CL	Pl 1 D	Pl 2 TL	Pl 2 CL	Pl 2 D	Pl 3 TL	Pl 3 CL	Pl 3 D	Pl 4 TL	Pl 4 CL	Pl 4 D	Date of Death
1	12.3	14.5	4.4	17	16.1	5.0	18	–	–	20	–	7.0	34	4.11
2	13.3	13.0	4.0	(26)	–	–	–	–	–	–	–	–	–	8.4
3	16.3	13.0	4.0	14	–	–	18	17.2	6.0	20	20.5	6.3	18	26.5
4	19.3	13.2	4.2	(14)	–	–	–	–	–	–	–	–	–	2.4
5	21.3	12.8	4.1	24	14.5	4.5	17	–	–	20	20.0	6.4	(2)	23.5
6	21.3	13.0	4.0	(8)	–	–	–	–	–	–	–	–	–	30.3
7	22.3	–	–	15	17.0	5.3	17	20.9	6.5	20	23.5	7.5	(10)	23.5
8	26.3	14.2	4.3	21	15.6	[illegible]	(5)	–	–	–	–	–	–	21.4
9	27.3	14.0	4.5	(15)	–	–	–	–	–	–	–	–	–	11.4
10	30.3	12.9	3.9	15	14.8	4.6	20	16.5	5.6	(19)	–	–	–	23.5
11	31.3	14.0	4.0	16	15.2	4.9	18	20.0	5.9	19	20.0	6.2	(1)	24.5
12	31.3	13.0	3.7	13	–	–	18	17.3	5.6	19	–	–	20	24.9
13	31.3	12.8	3.8	16	15.5	4.9	19	18.1	5.6	(18)	–	–	–	23.5
14	1.4	–	3.8	13	–	4.9	20	–	–	16	22.4	7.0	(3)	23.5
15	1.4	13.2	3.9	17	13.5	4.5	2.5	–	–	(4)	–	–	–	17.5
16	1.4	13.7	4.0	(9)	–	–	–	–	–	–	–	–	–	10.4
17	1.4	13.6	4.7	15	16.5	5.4	(28)	–	–	–	–	–	–	14.5
18	1.4	13.6	4.2	(16)	–	–	–	–	–	–	–	–	–	17.4
19	1.4	–	3.7	17	–	–	20	17.0	5.5	(15)	–	–	–	23.5
20	2.4	13.7	4.3	15	16.0	5.2	26	18.8	6.0	(15)	–	–	–	28.5
21	2.4	13.1	4.1	(22)	–	–	–	–	–	–	–	–	–	24.4
22	2.4	–	4.0	14	16.2	5.0	23	–	6.0	33	–	–	27	21.8
23	2.4	12.5	3.7	(14)	–	–	–	–	–	–	–	–	–	16.4
24	2.4	13.0	4.2	(7)	–	–	–	–	–	–	–	–	–	9.4
25	2.4	14.0	4.2	(7)	–	–	–	–	–	–	–	–	–	9.4
26	2.4	13.5	4.0	20	–	–	22	15.5	5.1	(8)	–	–	–	22.5
27	2.4	–	4.1	16	17.5	5.6	(11)	–	–	–	–	–	–	29.4
28	2.4	13.0	4.5	(30)	–	–	–	–	–	–	–	–	–	2.5
29	2.4	12.5	3.9	14	15.7	5.0	16	–	6.0	(20)	–	–	–	22.5
30	2.4	12.0	3.6	17	–	5.2	(32)	–	–	–	–	–	–	21.5
31	2.4	12.8	3.8	(16)	–	–	–	–	–	–	–	–	–	18.4
32	2.4	12.0	3.7	(2)	–	–	–	–	–	–	–	–	–	4.4
33	2.4	12.0	3.8	(15)	–	–	–	–	–	–	–	–	–	17.4
34	2.4	14.0	4.3	(2)	–	–	–	–	–	–	–	–	–	4.4
35	3.4	12.6	4.0	15	15.0	4.5	19	16.3	5.5	(18)	–	–	–	24.5
36	3.4	12.3	3.8	(6)	–	–	–	–	–	–	–	–	–	9.4
37	3.4	12.5	4.0	(6)	–	–	–	–	–	–	–	–	–	9.4
38	3.4	12.8	3.6	(5)	–	–	–	–	–	–	–	–	–	8.4
39	3.4	14.0	4.6	(2)	–	–	–	–	–	–	–	–	–	5.4
40	5.4	12.8	4.1	16	–	–	20	17.8	5.7	(13)	–	–	–	29.5
41	5.4	14.4	4.4	17	16.5	5.2	23	19.6	6.4	(16)	–	–	–	31.5
42	6.4	12.8	4.1	(3)	–	–	–	–	–	–	–	–	–	9.4

Figures in brackts correspond to the number of days the post-larvae have beenin a stated stage until they died.

FIG: 1 – Post – Larval Growth Of *Nephrops Norvegicus.*
Average Total Length [●] and Average Carapace Length [X]
Are plotted against time.

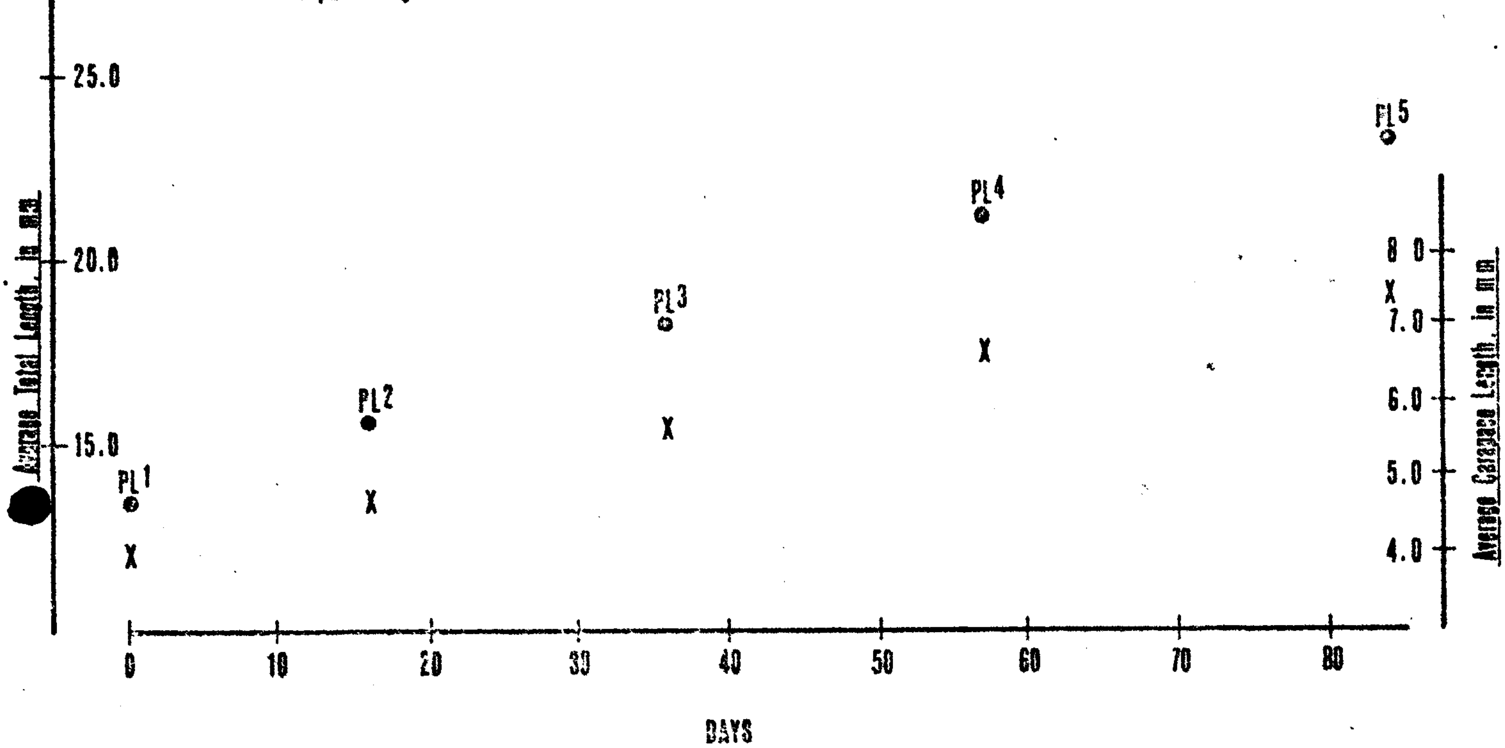

FIG: 2 – Correlation Between Total and carapace lengths of early post – larvae
[Stages 1 TO 5] of *Nephrops Norvegicus.*