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INFLUENCE OF INFESTATION AND OTHER FACTORS UPON THE RESPIRATION OF THE SNAIL, *AUSTRALORBIS GLABRATUS*

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INTRODUCTION

Australorbis glabratus is the intermediate host of the Trematode, *Schistosoma mansoni,* and as such is of considerable importance medically. In addition to the important field work that is presently underway in the campaign against schistosomiasis, it is essential that investigations of a fundamental nature be carried out in the laboratory on both the host snail and the parasite to provide more complete knowledge of the physiological processes of the animals concerned. With such information one can then better understand the fundamentals of the transmission of the disease and produce a more effective control.

The respiratory metabolism of *Australorbis* is little known. Earlier work on the subject has been confined to two studies by von

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Brand and coworkers concerning the relation of size, temperature, starvation and oxygen tension to respiration (von Brand, Nolan and Mann, 1948) and the influence of a number of potential molluscacides upon respiratory rate (von Brand, Mehlman and Nolan, 1949).

The present report is of a preliminary nature, being part of a more complete investigation of the biology of *Australorbis* now planned and being executed at the Instituto Aggeu Magalhães. We present here the results of some studies on the influence of infestation, light, salinity and starvation upon the respiratory rate, and considerations of the relation of the shell and respirable tissue to the animal as a whole.

MATERIALS AND METHODS

The animals used in these experiments comprise two groups of *Australorbis glabratus*. The infested animals were collected from Peixinhos in Olinda, Pernambuco, the first week of June, 1951 and kept in glass aquaria in the laboratory. The waters from which the snails were obtained were of pH 7.1 and 7.2, 29-31°C, and salinity of 34 to 46 p.p.m. (as NaCl). The animals ranged in weight from 200 to 700 milligrams and in age were less than 6 months. In the laboratory they were kept in water having average values of pH 7.4, temperature 25°C, 02 0.57%, and 12 p.p.m. NaCl, in association with *Elodea* in the aquaria. They were fed upon lettuce. The infestation of these animals averaged 19.63% for *Schistosoma mansoni*, and 8.97% for other trematodes.

The non-infested animals were reared in the laboratory in cement tanks in water of pH 7.3 to 7.6,12 p.p.m. NaCl and 25°C temperature. They averaged 5 months in age, ranging in weight from 200 to 1200 milligrams. They were fed on various aquatic plants *(Clorophyces, Eichornea, Nymphea)*. The original stock from which these animals were derived was obtained from the Rio Tapado, in Olinda, where the water averaged 30°C and in salinity ranged from 140 to 170 p.p.m. NaCl. Except for the animals used is the starvation experiments, animals fresh from the tanks or aquaria were used for the daily experiments.

In some experiments animals suspected of infestation were used. These were subjected to examination after the experimental run. Infestation was determined roughly by exposing the animals to light, which causes emission of cercariae. If cercariae were not noticed following this procedure, the animals were removed from the shell and the hepatopancreas examined microscopically for cercariae. Removal of the animal from the shell, whether for examination or experiment, was accomplished by crushing the shell gently between two microscope slides and picking away the pieces of shell from the nude animal, taking care not to tear the tissues.

The respiration was measured by volumetric microrespirometers

of two types. Where great sensitivity was required (as for a single nude animal) the original respirometers described by Scholander (1942) and Scholander and Edwards (1942) were used with some modification. Were less accuracy was needed the more simple, plastic respirometers devised by Scholander (1950) were used. The snails were contained in the bottom of the experimental vials and partially covered with tank or aquarium water. Carbon dioxide was absorbed by Ascarite (NaOH and CaO on asbestos) contained in a square of cloth in a small section of plastic tubing suspended from the oxygen port. No precautions were taken to maintain constant temperature in the water baths in which the respirometers were immersed as the temperature of the room and baths never fluctuated more than 0.5° per day and was usually constant within 0.1° for 3 to 4 hours at a stretch.

RESULTS

1. Influence of infestation upon respiratory rate:

The primary consideration of the investigation was that of the influence of infestation upon the respiratory rate of the snails. The results are given in Tables 1, 2, and 3, and Figure 1.

The individual respiratory rates of 26 snails were determined first. As indicated in Figure 1 and Table 1, there appeared to be a slight difference between the infested and non-infested animals, i.e. the infested animals appeared to be in the upper range of Q02's at a given weight. However, one must bear in mind the small number (7) of infested animals tested.

TABLE ONE

RELATION OF RESPIRATORY RATE OF *AUSTRALORBIS* TO SIZE AND INFESTATION

Fresh weight (mgms)	02 consumption mm3 02/mgm/hr.	Condition
189.1	0.0969	negative
200.2	0.1357	negative
224.1	0.1002	negative
230.5	0.0772	negative
235.6	0.1210	negative
251.3	0.1046	negative
255.9	0.0744	negative
259.0	0.0876	negative
260.2	0.0907	negative

263.6	0.1025	negative
286.6	0.0847	negative
321.6	0.0791	negative
326.7	0.0795	negative
400.2	0.0786	infested
449.4	0.0716	negative
452.0	0.0652	infested
458.2	0.0694	negative
495.8	0.0952	infested
507.1	0.0640	infested
508.4	0.0451	negative
509.9	0.0736	infested
517.5	0.0809	infested
545.9	0.0494	negative
554.9	0.0547	negative
558.8	0.0470	negative
578.1	0.0331	negative
663.6	0.0329	negative
684.0	0.0407	negative
690.5	0.0762	infested
919.8	0.0232	negative
1128.5	0.0254	negative

To check these results, the respiration of 10 infested and 10 non-infested animals was measured in the plastic respirometers, 5 animals to each vial. As may be seen in Table 2, there appeared to be little difference between the two groups.

TABLE TWO

INFLUENCE OF INFESTATION OF RESPIRATORY RATE OF *AUSTRALORBIS*

Condition	nº of animals	mm3 02/mgm fresh/hr.
infested	5	0.0842
infested	5	0.1365
negative	5	0.1265
negative	5	0.0802

A further test was made by determining the oxygen consumption of nude animals both individually and en masse. These results are shown in Table 3. It will be seen that there is little difference between infested and non-infested animals, on the basis of both fresh and dry weight.

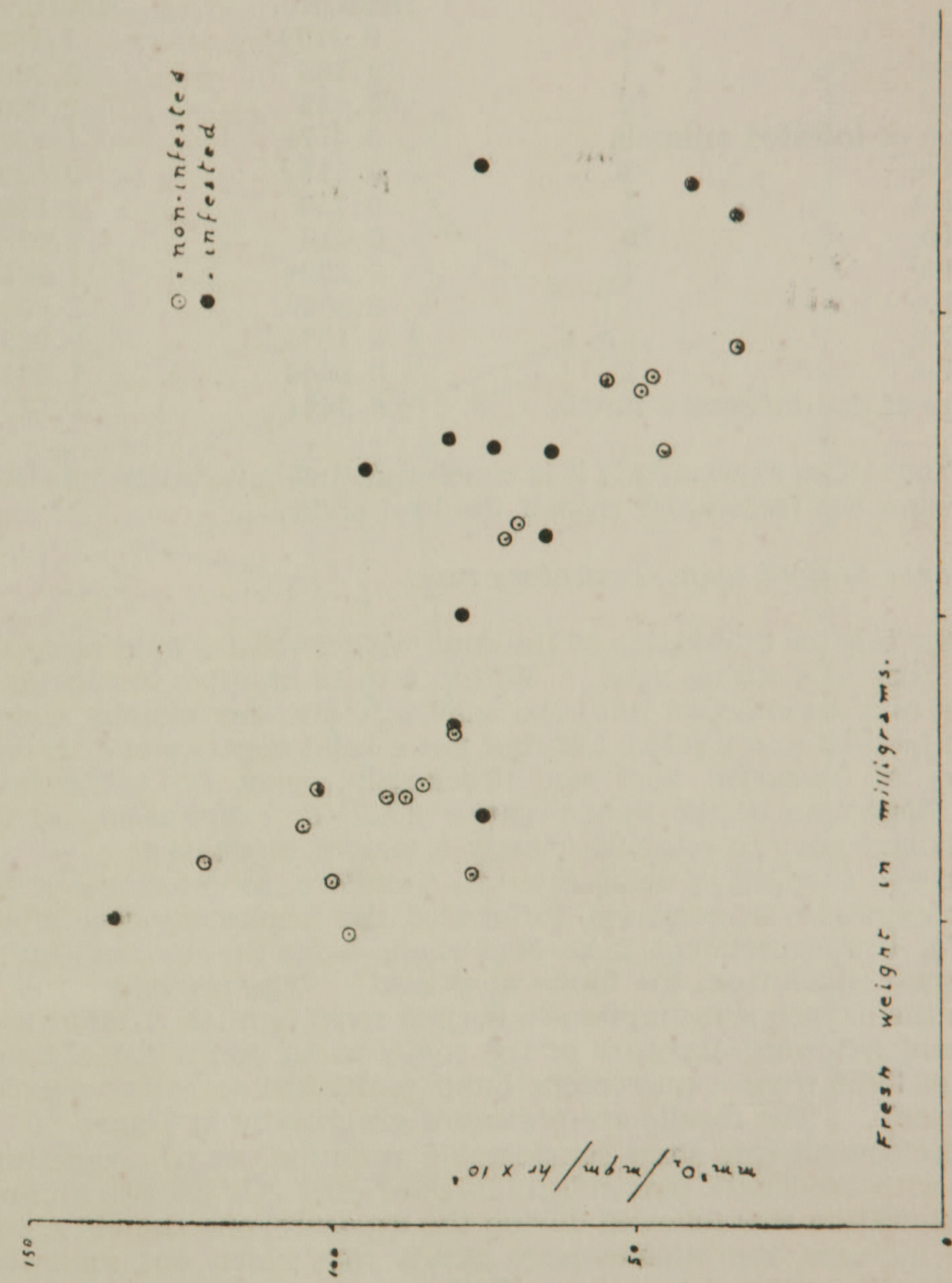
○ : non-infested
● : infested
mm³ O₂ / mgm / hr x 10
Fresh weight in milligrams.
150
100
50
200
400
600

Figure 1

TABLE THREE

INFLUENCE OF INFESTATION OF RESPIRATORY RATE OF *AUSTRALORBIS* OUT OF SHELL

Condition	nº of animals	mm3 02/mgm fresh/hr.	mm3 02/mgm dry/hr.
infested	1	0.2169	1.168
infested	1	0.288	2.080
infested	10	0.452	2.060
average of infested animals		*0.4171*	*1.821*
negative	1	0.1157	0.522
negative	1	0.230	1.899
negative	10	0.416	2.025
negative	1	0.2924	1.905
negative	1	0.3049	2.090
negative	1	0.1570	0.582
negative	1	0.3049	1.272
average of non-infested animals		*0.3691*	*1.783*

From these experiments it is concluded that infestation has little influence on the respiratory rate of the host snail.

2. Influence of light upon respiratory rate:

One test for infestation of the snail with cercariae is to place the snail in front of a strong light. Within 5 to 10 minutes thousands of cercariae may be expelled from the snail into the surrounding water. This can be used as a positive test, but not a valid negative one, as non-expulsion of cercariae does not necessarily mean no infestation. Further dissection of the light-negative snail for examination of the organs is necessary to establish clearly a lack of infestation.

It was thought of some interest, therefore, to determine if the light, or expulsion of cercariae, influenced the respiratory rate of the snail. For this experiment 3 infested snails from the aquaria, and 2 non-infested snails from the tanks were used. The procedure was to measure the oxygen consumption in normal room light for 1 hour, then during and following exposure of the snails to an additional 125 foot candles of light from a microscope lamp (sufficient to cause emission of cercariae). The results are portrayed graphically in Figure 2.

The control rate show considerable variation, as was sometimes the case with the snails, particularly infested ones. Of the two animals whose respiration was followed during the exposure, one showed a considerable increase, the other a more steady rate which was somewhat higher than the normal average. Following removal of the light the rate was higher in all snails than before or during exposure, possibly a shock reaction. Except in one animal the rate subsequently decreased to a rate lower than the initial one. As both the infested and non-infested animals showed a change in the light it is concluded that the

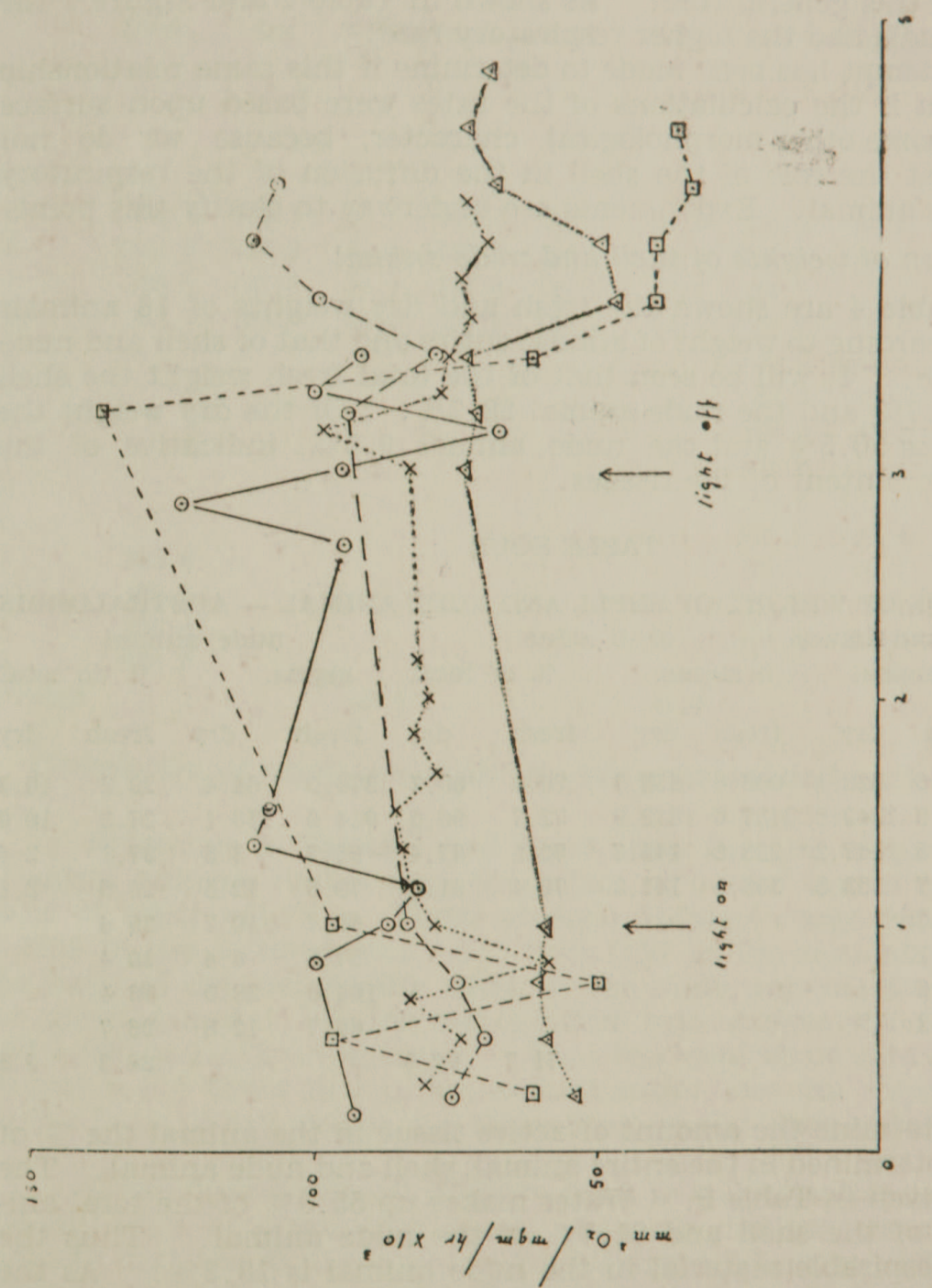
mm³ O₂ / mgm / hr x 10³
150
100
50
0
1
2
3
5
Time in hours
No light
Light
No light

Figure 2

exposure to light, and not necessarily the emission of cercariae, caused the increase in respiration.

3. Correlation of size and respiratory rate:

In the animal kingdom in general the respiratory rate is higher per unit weight for immature animals than for mature animals, and higher for small than for large mature animals. *Australorbis* is no exception to this general rule. As shown in Table 1 and Figure 1 the smaller animals had the higher respiratory rate.

No attempt has been made to determine if this same relationship would obtain if the calculations of the rates were based upon surface (W2/3), or some other morphological character, because we do not known as yet the role of the shell in the diffusion of the respiratory gases in this animal. Experiments are underway to clarify this point.

4. Correlation of weights of shell and nude animal:

In Table 4 are shown the fresh and dry weights of 18 animals analysed according to weight of animal entire and that of shell and nude animal alone. It will be seen that of the total fresh weight the shell averages 71.7% and the nude animal 28.3%. Of the dry weight the shell averages 90.5% and the nude animal 9.5%, indicative of the higher water content of the tissues.

TABLE FOUR

CORRELATION OF WEIGHT OF SHELL AND NUDE ANIMAL — **AUSTRALORBIS**

nº animals	shell and tissues mgms.		shell alone mgms.		% of total		nude animal mgms.		% do total	
	fresh	dry	fresh	dry	fresh	dry	fresh	dry	fresh	dry
6	1282.6	623.1	908.6	558.7	70.8	89.7	374.0	64.4	29.2	10.3
6	3351.8	1349.0	2437.6	1212.9	72.7	90.0	914.0	136.1	27.3	10.0
1	320.5	147.2	233.8	143.7	72.9	97.4	96.7	3.5	27.1	2.6
1	387.7	153.8	308.1	141.3	79.4	91.9	79.6	12.5	20.6	8.1
1	235.6						69.7	10.7	29.6	
1	189.1						57.5	8.4	30.4	
1	286.6						104.0	28.0	36.4	
1	260.2						69.7	12.8	26.7	
average					71.7	90.5			28.3	9.5

To determine the amount of active tissue in the animal the % of water was determined in the entire animal, shell and nude animal. The results are given in Table 5. Water makes up 55.9% of the total animal, 44.8% of the shell and 81.7% of the nude animal. Thus the amount of respirable material in the nude animal is 18.3%. As the nude animal averages 28.3% of the total fresh weight, and the amount of respirable material in only 18.3% one can calculate that only 5.2% of the entire animal is composed of respirable tissue, assuming the shell to be metabolically inert.

TABLE FIVE

CORRELATION OF WET AND DRY WEIGHTS IN AUSTRALORBIS

n° animals	whole animal			shell			nude animal			
	fresh	dry	%H20	fresh	dry	%H20	fresh	dry	%H20	% respirable tissue
6	1282.6	623.1	51.4	908.6	558.7	38.6	374.0	64.4	82.8	17.2
6	3351.8	1349.0	60.0	2437.6	1212.9	50.3	914.2	136.1	85.1	14.9
1	320.5	147.2	54.1	233.8	143.7	38.5	86.7	3.5	96.0	4.0
1	387.7	153.8	60.2	308.1	141.3	54.1	79.6	12.5	84.3	15.7
1							77.5	10.7	85.2	14.8
1							82.7	10.0	87.9	12.1
1							169.3	37.3	78.0	22.0
1							126.3	17.4	86.2	13.8
10							1147.8	251.8	78.1	21.9
10							962.9	197.4	79.5	20.5
1	235.6						69.7	10.7	84.7	15.3
1	189.1						57.5	8.4	85.4	14.6
1	286.6						104.0	28.0	73.1	26.9
1	260.2						69.7	12.8	81.6	18.4
average			55.9			44.8			81.7	18.3

5. Correlation of respiratory rate of entire animal and nude animal:

Reference to Tables 1 and 3 will show that the respiratory rates of entire animals lie between the values of 0.1357 and 0.0232 on the basis of fresh weight. Those of nude animals range from 0.452 to 0.2169 in the infested and 0.416 to 0.1157 in the non-infested. On the basis of dry weight the Q02's of the nude animals average 1.821 for infested and 1.783 for non-infested with ranges of 2.080 to 1.168 and 2.090 to 0.522 respectively. Thus the respiratory rate of the nude animal is 5.5 times that of the animal entire, and the respiratory rate on the basis of dry weight 4.6 times that on the basis of fresh weight.

These figures suggest that the shell, in its protective role, impedes the diffusion of respiratory gases, although preliminary experiments indicate that the shell may have a relatively high permeability. The question of whether or no the shell plays an active part in metabolism remains unanswered. However, the following suggest that there may be some oxidation due to the shell.

The respiration of 4 animals was measured by individuals and

the Q02 calculated on the basis of the total fresh weight (Table 6). Then the animals were dissected from the shell and the oxygen consumption of the nude animals measured. The theoretical Q02 that would be expected on the basis that only the nude animal portion used the oxygen in the original experiment was then calculated for each animal. The resulting theoretical figures are higher than the measured figures, suggesting that some oxidation may be due to the shell.

TABLE SIX

INFLUENCE OF SHELL ON RATE OF RESPIRATION AUSTRALORBIS

measured weight whole animal mgms	measured weight nude animal mgms	measured respiration whole animal mm3 02/ mgm/hr.	measured respiration nude animal mm3 02/ mgm/hr.	calculated respiration of respirable tissue of whole animal mm3 02/ mgm/hr.
235.6	69.7	0.1210	0.2924	0.4106
189.1	57.5	0.0969	0.3049	0.3191
286.6	40.0	0.0847	0.4075	0.5807
260.2	69.7	0.0907	0.3049	0.3386

6. Group effect:

It has often been observed that the respiration of animals measured in a group is less than the sum of the rates of the animals when measured individually. This is very true, of course, in homeometabolic animals which utilize huddling as a means of conserving heat. The phenomenon has been observed also, however, in invertebrats.

In one experiment on *Australorbis* the oxygen consumption was determined of 5 animals in one experimental vial and subsequently that of the 5 animals individually. Although the difference is not great, it will be seen in Table 7 that the average of the individual respiratory rates is higher than that of the group of animals, and that the lowest individual rate of oxygen consumption is also higher than that of the group. Thus *Australorbis* demonstrates the "group effect" to a slight degree.

TABLE SEVEN

"GROUP EFFECT" IN *AUSTRALORBIS*

5 animals in one vial mm3 02/mgm/hr.	same 5 animals measured individually mm3 02/mgm/hr.
0.0802	0.1210
	0.0969
	0.0847
	0.0907
	0.1007
	average 0.0988

7. Influence of starvation on respiratory rate:

It was noticed that animals which had been out of the tank for one day appeared to have a lower rate of oxygen consumption than fresh animals. To determine the influence of starvation two groups of animals were kept unfed and their oxygen consumption followed for some days. That of the first group is presented in Table 8.

In the first group the oxygen consumption dropped rapidly within the 1st 3 days to almost 1/2 the original rate, then in the next two days decreased only slightly. In the 2d group the results were variable. The animals generally showed no change or an increase the 1st day followed by a decrease thereafter. One can conclude from these experiments only that starvation causes a non-specific decrease in oxygen consumption.

TABLE EIGHT

INFLUENCE OF STARVATION UPON THE RESPIRATION OF **AUSTRALORBIS**

Animal number Data	A mm3 02/ mgm/hr.	mgms	B mm3 02/ mgm/hr.	mgms	C mm3 02/ mgm/hr.	mgms	D mm3 02/ mgm/hr.	mgms
15 June	0.1025	263.6	0.1002	224.1	0.1046	251.3	0.1237	200.2
18 June	0.0680	267.7	0.0606	246.5	0.0390	222.7	0.0733	215.7
20 June	0.0631	265.4	dead		dead		0.0657	208.9

8. Influence of salinity on rate of oxygen consumption:

The snails have been collected in waters of salinity up to 170 p.p.m. NaCl. It was observed by the collectors that in water of

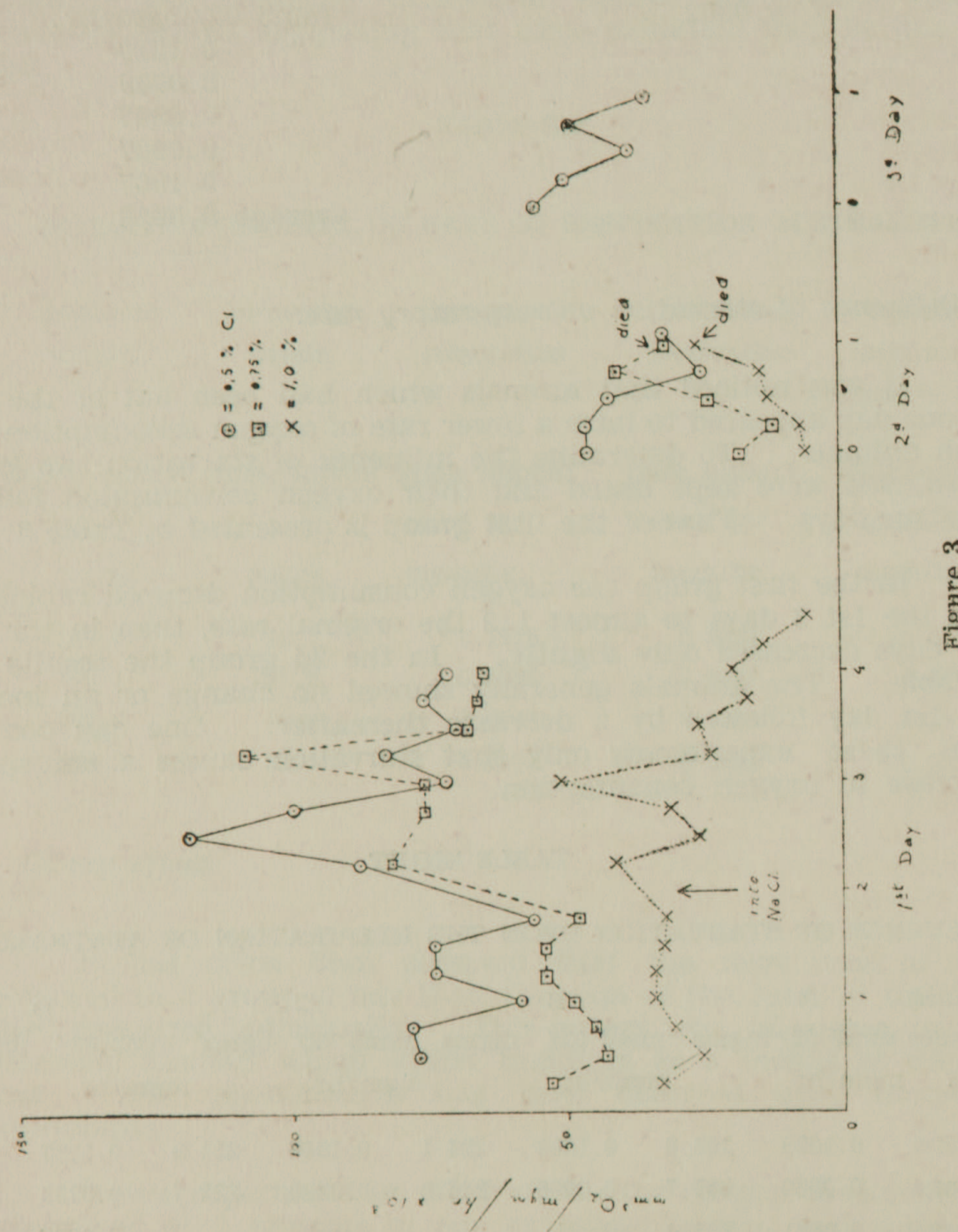

Figure 3

high salinity the snails were dead. It has further been observed that certain varieties or species appear to be more resistant to salinity than others, and that this may be an important factor in distribution. Thus it was considered to be of some importance to initiate experiments on the influence of salinity on rate of oxygen consumption.

Two groups of snails were used; the first group at 0.3, 0.5 and 0.7% and the 2d group in 0.5, 0.75 and 1.0% NaCl.

In the first experiment (table 9) all three animals showed an immediate increase in oxygen consumption when placed in the cloride solutions. In the 0.3 and 0.7% solutions the initial rise was followed by a rapid decrease until within 1 to 2 hours the rate was lower than the original. The animals were left in the saline solutions overnight and their rates determined again the following day. The snail in 0.7% NaCl was dead. The other 2 animals were alive and respiring at a rate equal to about the lowest level of the previous day. Two days later the 0.5% was still alive and respiring at a rate slightly lower than normal.

In the 2d experiment (figure 3) the animals again showed an immediate increase when placed in the saline solutions. The animal in 0.5% returned to a normal rate within 1 hour. The snail in 0.75% NaCl maintained a higher than normal rate for 2 hours, and when examined after the experimental run was found to be partially retracted within the shell. The animal in 1.0% NaCl decrease its oxygen consumption within two hours to a very low rate (about one tenth the original) and was seen to be retracted into the innermost whorls. Eighteen hours later the oxygen consumption was measured once more. That of the animal in 0.5% was only slightly less than normal. The rates of other 2 animals were extremely low. Following the experiment (20 hours in saline) the animal in 0.75% NaCl eliminated large quantities of haemoglobine and soon was dead. The other animal died during the day. On the 3d day the animal in 0.5% was still alive and respiring at the same rate as on the 2d day.

TABLE NINE

INFLUENCE OF SALINITY UPON THE OXYGEN CONSUMPTION OF *AUSTRALORBIS GLABRATUS*

animal nº	A	B	C
solution	0.3% NaCl	0.5% NaCl	0.7% NaCl
time	mm3 02/mgm/hr	mm3 02/mgm/hr.	mm3 02/mgm/hr.
19 June 51 — in tank water — control			
15 mins.	0.0406	0.0513	0.0272

30	0.0408	0.0487	0.0242
45	0.0438	0.0487	0.0241
60	0.0336	0.0278	0.0333
75	0.0414	0.0471	0.0291

19 June 51 — in experimental solutions

15 mins.	0.0795	0.1656	0.0374
30	0.0373	0.1341	0.0647
45	0.0612	0.0823	0.0486
60	0.0411	0.0730	0.0486
75	0.0452	0.0766	0.0286
90	0.0278	0.0489	0.0333
105	0.0222	0.0553	0.0438
120	0.0271	0.0610	0.0165

20 June 51 — 18 hours in the solutions

15 mins.	0.0253	0.0272	dead
30	0.0382	0.0358	
45	0.0230	0.0284	
60	0.0259	0.0209	
75	0.0276	0.0218	
90	0.0266	0.0240	

22 June 51 — 66 hours in experimental solution

15 mins.	dead	0.0389
30		0.0265
45		0.0316
60		0.0315

From these preliminary experiments it appears that *Australorbis* from Olinda is quite sensitive to cloride of low concentrations. These experiments confirm the findings of Dr. Frederico Simões Barbosa (personal communication) who found that above 0.5% NaC1 changes occur in the snails that may result in death, and that at 1.0% haemoglobin is expelled accompanying the bursting of the animal.

DISCUSSION

The most important consideration of the experiments here reported are the influence of infestation and the factors related to it upon

the oxygen consumption of the snail. From the results obtained from both the entire animal and the animal without the shell, it would appear that infestation of the snail with cercariae of *Schistosoma* does not influence the respiratory rate. It will be noticed that the smaller animals were not infested, i.e. in our experiments the animals smaller than 400 mgms. were negative. Although the stages of infestation were uncontrolled, the size range of the infested animals used was considerable so it is presumed that there is no gross relation of stage of infestation and respiration of host. These results agree well with the laboratory and field observations that the infested snails appear to live quite well, exhibiting a behavior no different from that of the uninfested animals.

An interesting corollary to this finding is the fact that light influences the oxygen consumption of the snail, but the influence appears to be independent of the emission of cercariae as evidenced by the fact that the non-infested animals showed the same effect as the infested animals in the light.

In the few experiments reported herein it was found that *Australorbis* is quite sensitive to cloride, showing a respiratory effect at concentrations above 0.5% NaCl, and decrease oxygen consumption followed by death and liberation of haemoglobin at concentrations between 0.7% and 1.0%. It would be of some interest to relate these results with the distribution of the snails and the influence of such factors as backwash of the sea into the streams from which the snails are obtained. One might expect to find specific and racial difference in the snails in their distribution in relation to salinity.

The results confirm and extend the findings of von Brand, Nolan and Mann (1943) on the relation of weight to respiratory rate. In general it was found that the smaller animals have a higher rate of oxygen consumption on a unit weight basis. As von Brand et al used smaller animals it was necessary to extrapolate from our curve to compare the absolute rates. By so doing it was found that the Q02's determined in the present group of snails from Olinda are on the same level as those reported by von Brand from Venezuela.

There has been always some question concerning the weight basis for the calculation of the unit respiratory rate. von Brand has shown that on the basis of W1.0 there is a decrease in oxygen consumption but that the decrease is not apparent on the basis of W2/3, i.e. surface. Until we know more about the sites of diffusion, permeability of shell and role of the shell, if any, in respiration we feel that there is no point in applying the "surface law" to these animals. Our measurements show that the shell makes up the major portion of the weight of the animal (71.7% of fresh weight, 90.5% of dry weight) and hence, if the shell is inactive in respiration, one should base the calculations upon the weight of the nude animal. As 81,7% of the nude animal is water and only 18.3% active tissue one should actually

base the calculations upon only 5.2% of the weight of the entire animal. The oxygen consumption of the nude animal is 5.5 times that of the animal in the shell, no doubt due to the greater availability of oxygen to the respiring tissues, indicating again, that until we have more information concerning the shell we should base our calculations upon the active tissue of the animal out of the shell.

The rate of oxygen consumption becomes much reduced in starvation. As found by von Brand and coworkers, in one experiment our snails showed an initial rapid decrease followed by a more gradual decline. The more variable results in the 2d experiment can permit us to conclude only that there is an unspecified decrease in oxygen consumption during starvation. However, the results imply that comparable results in experiments can be obtained only by using fresh animals for each experiment.

A further caution implied by the results obtained above is that of comparing animals measured in a group with those measured individually. *Australorbis,* like other animals reported in the literature, exhibits the "group effect", hence mass experiments with this animal should be subject to some careful consideration.

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SUMMARY

The oxygen consumption of infested and non-infested *Australorbis glabratus,* from Olinda, Pernambuco, has been determined in relation to several factors. Analyses have also been made of the relation of shell to nude animal.

Infestation of the snail by cercariae of *Schistosoma mansoni* has no influence of the host oxygen consumption, whether the snail is in or out of the shell.

Exposure to light sufficiently strong to cause emission of cercariae causes an increase in oxygen consumption of both infested and non-infested snails.

The rate of oxygen consumption of the smaller animals in higher than that of the larger ones on the basis of unit weight. The oxygen consumption of the animal out of the shell is 5.5 times that within. The Q02 on the basis of dry weight is 4.6 times that on the basis of

fresh weight. Assuming the shell to be inert, only 5.2% of the entire animal is composed of respirable tissue.

The rate of oxygen consumption of animals determined individually is higher than that of animals en masse, indicating that *Australorbis* exhibits the "group effect".

During starvation the oxygen consumption of the snails is decreased considerably in the first 2-3 days, then more gradually thereafter.

Immersion of the snails in waters of salinity from 0.3 to 1.0% (NaCl) causes an immediate increase in oxygen consumption. In 0.3 and 0.5% NaCl the rate returns to normal within a few hours. Concentrations above 0.5% cause gross disturbances in respiration within a few hours and death within a few days.

SUMÁRIO

O consumo de oxigênio de *A. glabratus* de Olinda (Pe.), foi determinado em animais infestados e não-infestados, em relação a alguns fatôres. Observações também foram realizadas sôbre animais inteiros e sôbre aquêles desprovidos de casca.

Nenhuma influência sôbre o consumo de oxigênio do animal com casca ou sem ela, tem a infestação do caramujo pelas cercarias de *S. mansoni*.

A exposição à luz suficientemente forte para causar a emissão das cercarias provoca um aumento no consumo do oxigênio, tanto nos caramujos infestados como nos não-infestados.

O consumo de oxigênio dos animais menores é mais alto do que o dos maiores, tomando por base a unidade de pêso. Nos animais fora da casca o consumo é de 5.5 vezes mais do que o dos animais íntegros. O Q02 em relação ao pêso do animal sêco é 4.6 vezes o encontrado para o pêso total. Admitindo que a casca seja inerte sòmente 5.2% do animal inteiro é constituído de tecido que respira.

O consumo de oxigênio dos animais tomados individualmente é mais alto do que em conjunto, indicando que o *Australorbis* apresenta "efeito de grupo".

Durante o jejum o consumo de oxigênio dos caramujos, sofre diminuição considerável nos primeiros 2 a 3 dias, tornando-se, em seguida, gradualmente mais lento.

A imersão dos caramujos em água de salinidade de 0.3 a 1.0% (NaCl) produz um aumento imediato no consumo de oxigênio. Nas soluções de 0.3 a 0.5% a intensidade volta ao normal em poucas horas. As concentrações acima de 0.5% provocam graves perturbações na respiração em poucas horas e a morte em alguns dias.

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