Vol. III - N° 5 - pp 63 - 71 25 - 9- 1954

M. S. D. N. S.

SERVIÇO NACIONAL DE MALÁRIA
Diretor: Dr. MANOEL FERREIRA

PUBLICAÇÕES AVULSAS
DO
INSTITUTO AGGEU MAGALHÃES

Recife (Pe.) BRASIL

THE INFLUENCE OF INFECTION WITH *SCHISTOSOMA MANSONI* ON SURVIVAL OF *AUSTRALORBIS GLABRATUS**

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In many of the endemic foci of schistosomiasis in the vicinity of Recife, Brazil, the water level of the snail habitats has an annual flutuation, and many habitats are without water for a long period every year. The snails in these localities must be able to survive out of water for a considerable time in order to continue to populate these places.

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*The study was conducted at the Instituto Aggeu Magalhães by the Laboratory of Tropical Diseases of the National Institutes of Health, U. S. Public Health Service under the sponsorship of the Pan American Sanitary Bureau in cooperation with the Divisão de Organização Sanitaria and the Serviço Nacional de Malária do Departamento Nacional de Saúde of Brazil.

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While studying the relation between the snail, *Australorbis glabratus*, and its parasite, *Schistosoma mansoni*, in Brazil, we became interested in learning whether infected snails die before uninfected snails when they are kept out of water. The results of experiments designed to investigate this matter are presented here.

Apparently some species of larval trematodes do little or no serious damage to their snail host and do not seem to shorten the snails life [Rees (1931), Mattes (1936), Rankin (1939), and Rothschild (1941 and 1942)]. On the other hand, some trematode species appear to damage their snail hosts seriously and may cause premature death. Sewell (1922), Lund (1934), Porter (1938), Rankin (1939), and Cort et al. (1941a, 1941b, in press) have observed that certain trematodes other than the schistosomes of man may damage their snail hosts. The deleterious effect of schistosome parasites of man on their snail hosts has been mentioned by various workers. Cort (1920) found that *Oncomelania nosophora* infected with *Schistosoma japonicum* were less resistant to desiccation than uninfected snails and that the cercariae were injured and sometimes killed when the snails were dried. Gordon, Davey and Peaston (1934) noted that *Planorbis pfeifferi* infected with *Schistosoma mansoni* had a higher death rate than uninfected snails. Barlow (1935) presented evidence that during the winter closure in Egypt, the drying of the snails resulted in a decrease in the relative number of infected snails. Porter (1938) also found that infected snails were less hardy than uninfected snails. Brumpt (1941) observed that *Australorbis glabratus* infected with *Schistosoma mansoni* were apparently less resistant to desiccation.

FIELD OBSERVATIONS

In June, 1953 a collection of 89 *Australorbis glabratus* was taken from a small pool near Paulista, Pernambuco, a known focus of schistosomiasis. All were uninfected. On August 10, 257 snails of about the same size were taken from the same pool. One was infected with *Schistosoma mansoni*. On September 14, the collection was repeated and of 145 snails, 81, or 56 percent, were infected. Apparently these represented a large, new influx of infections into a relatively stable snail population.

After September 14, the water level of the pool fell gradually and on October 8 when the next collection was made, there was no standing water though the soil was very wet. From the surface of the wet soil under grass and dead leaves, 231 snails were collected. None was infected. Two additional collections were made under essentially the same conditions on October 14 and November 4. Out of 277 snails none was infected. The snails in these last

three collections were obviously of the same population that was sampled on September 14. Thus, after the water disappeared no infected snails were found although previously they had been very numerous. This failure to find infections in the survivors after the pool lost its water prompted an inquiry into the phenomena which occur when *Australorbis glabratus* infected with *Schistosoma mansoni* are removed from the water.

LABORATORY OBSERVATIONS

Five laboratory experiments give data on the ability of *Australorbis glabratus* infected with *Schistosoma mansoni* to survive out of water.

Experiment 1. — Seventeen infected and 25 uninfected *A. glabratus* collected from Bairro Novo, Olinda, Pernambuco, were placed in an unglazed clay jar at 6 to 27° C. and approximately 90 percent relative humidity. All the snails were about the same size and apparently about the same age. After seven days, 9 of the infected snails and all the uninfected snails were alive. After 16 days 3 of the infected snails and 20 of the controls were alive.

Experiment 2. — Nine infected and 39 uninfected *A. glabratus* collected from Arruda, Recife, were put in an unglazed clay jar at 26 to 27° C. and about 90 percent relative humidity for six days. Two of the infected snails and all the uninfected snails survived.

Experiment 3. — Eighteen infected and 25 uninfected *A. glabratus* collected from Água Fria, Recife were put in an unglazed clay jar at a relative humidity of about 90 percent and 27° C. After nine days, 9 of the 18 infected and 24 of the 25 uninfected snails were alive. Of the surviving infected snails, 8 shed cercariae when put in water for the viability test.

Experiment 4. — Fourteen infected and 15 uninfected *A glabratus* collected from Arruda, Recife were put in an unglazed clay, jar at about 90 percent humidity and 27° C. After 28 days, all the infected snails were dead and 14 of the 15 uninfected snails were alive.

Experiment 5. — In a large collection of adult *A. glabratus* from a pool in Paulista, Pernambuco, about half of the snails were found to be infected with *S. mansoni*. The infected snails were put in one half of a large wooden box containing moist soil, and the uninfected snails were put in the other half. Every snail was in contact

with the soil surface. The temperature was about 27° C. The relative humidity at the soil surface could not be determined with accuracy, but no doubt it was very high at first, and as the soil was allowed to dry, it fell to the laboratory humidity which was about 70 percent in the terminal part of the observation period. After 15 days, 97 snails from each group were removed from the box and put in water to test for viability. This same procedure was repeatted after 30, 45, and 60 days with approximately the same number of snails. The results appear in Table 1 and Figure 1. It may be noted that only 36 (37 percent) of the snails were alive in the infected group after 15 days whereas almost all the controls were alive. At 30, 45, 60 days the percentages of living infected snails were 28, 29, and 29. Thus the proportion did not change appreciably after the 30th day. Very few uninfected snails died during the 60 day period.

TABLE 1

EXPERIMENT 5. SURVIVAL OF INFECTED AND UNINFECTED AUSTRALORBIS GLABRATUS WHEN REMOVED FROM THE WATER

TIME OUT OF WATER (DAYS)	INFECTED SNAILS			UNINFECTED SNAILS		
	No EXAMINED	ALIVE		No EXAMINED	ALIVE	
		No.	%		No.	%
15	97	36	37	97	95	98
30	97	27	28	97	91	94
45	97	28	29	97	89	92
60	94	27	29	93	86	92

Experiment 6. — Thirty *A. glabratus* in a collection of 358 large specimens from Arruda, Recife were infected with *S. mansoni*. The infected snails were placed in an unglazed clay jar and 213 uninfected snails of the same collection were placed in an identical clay jar. Both jars were kept on a laboratory bench top under identical conditions at a temperature of about 27° C. and a relative humidity of about 90 percent. The snails were checked repeatedly for 216 days and the number of survivors noted. The results appear in Table 2 and Figure 1. It should be noted that after 20 days, almost all the uninfected snails were still alive, but only one third of the infected snails were alive. From the 20th day to the 82nd day, there was only one death in the infected group, and a few died among the uninfected snails. Thereafeter many deaths

FIGURE 1

SURVIVAL OF INFECTED AND UNINFECTED *AUSTRALORBIS GLABRATUS* WHEN KEPT OUT OF WATER

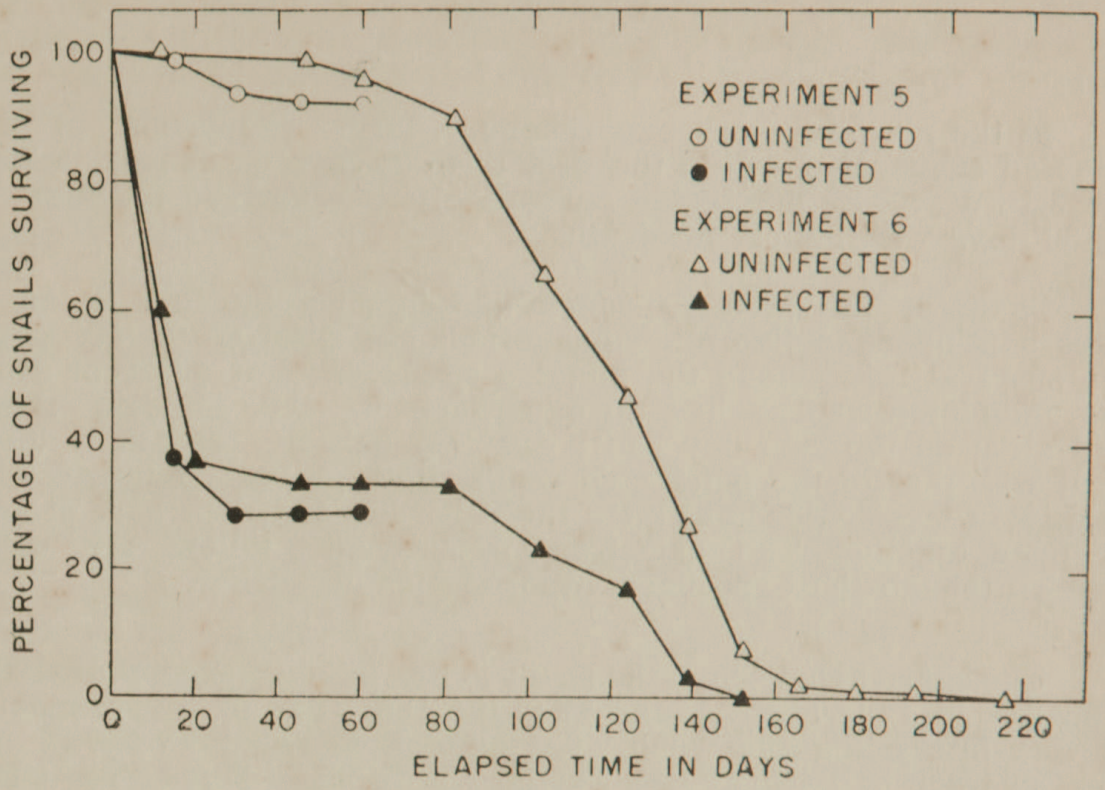

TABLE 2

EXPERIMENT 6 SURVIVAL OF INFECTED AND UNINFECTED AUSTRALORBIS GLABRATUS IN MOIST CLAY JARS WITHOUT WATER

GROUPS	ORIGINAL NUMBER OF SNAILS	PERCENTAGES OF SNAILS SURVIVING												
		ELAPSED TIME (DAYS)												
		12	20	46	60	82	103	124	138	152	165	179	193	216
INFECTED SNAILS	30	60	37	33	33	33	23	17	3	0	0	0	0	0
UNINFECTED SNAILS	213	99	-	98	96	90	66	47	27	7	2	1	1	0

occurred in both groups. All snails of the infect edgroup were dead in 152 days and almost all the controls in 165 days.

DISCUSSION

In the six laboratory experiments a large proportion of the infected snails died within the first 15 to 20 days or at least before the 30th day. The uninfected controls always survived the first 15 to 30 days with almost no deaths.

Snails of the infected groups that survived the first 20 to 30 days continued to live for long periods and after 20 to 30 days, the survival rate among the infected snails was not different from the uninfected snails. Thus in experiment 6, the infected snails still alive on the 20th day had a survival pattern essentially identical with that of the uninfected snails. Both groups continued with relatively few deaths until after the 82nd day and then both groups declined together. The data from experiment 5 follow the same pattern though the experiment was terminated earlier.

The survival pattern of the snails in the infected groups after the 15th day in experiment 5 and after the 20th day in experiment 6 is very interesting and would be difficult to explain were it not for the work of Barbosa and Coelho (1953). They found that when snails harboring mature infections with *Schistosoma mansoni* were kept out of water, the snails which did not die lost their infections during the first 20 to 22 days. Therefore, those "infected" snails that survived out of water for more than 20 or 22 days no longer contained viable schistosome larvae, and being without infection, they had about the same survival pattern thereafter as the "uninfected" group.

It should be pointed out that in none of the laboratory experiments were the snails exposed to severe desiccation. Actually in five of the six experiments, the relative humidity was maintained at a high level. Therefore, the early deaths in the infected groups cannot be simply attributed to dehydration, since at the humidities used in the experiments there was too little time for extensive water loss. Perhaps, the infected snails were in a precarious temporary equilibrium with their parasite infections. The denial of water and of the opportunity to feed may have upset the balance unfavorably and led to the death of most of the snails.

It is apparent, then, that when infected *Australorbis glabratus* are removed from water two related phenomena act to eliminate

infections with *S. mansoni* from the surviving snails. First, a majority of the infected snails die within about 20 days. Secondly, those that do not die during this period lose their chistosome infections. The result is that snails surviving out of water for approximately 20 days may be expected to be free from infection. This was found to be the case in the area described earlier in which a snail population that was heavily infected was deprived of water and soon thereafter was free of infections.

On the basis of these experiments, one may conclude that in the field, in Pernambuco, *Australorbis glabratus* which survive out of water for more than 20 days will probably be free of infection with *S. mansoni*. Perhaps the same may be expected in other parts of the world where *S. mansoni* occurs. Barlow (1935) and Brumpt (1941) have presented evidence tending further to justify this view.

SUMMARY

Evidence is presented to show that *Australorbis glabratus* infected with *Schistosoma mansoni* die in much greater numbers than uninfected snails when the snails are removed from the water. A large number of deaths occurred within the first 20 to 30 days, but thereafter deaths in the «infected» group were no more frequent than in the uninfected group.

Snails with mature *S. mansoni* infections which survive more than 20 days out of water are known to lose their infections.

Thus, when infected snails are removed from the water two phenomena act to eliminate the infections: first, most of the snails die within about 20 days and second, the remainder lose their infections.

SUMÁRIO

Australorbis glabratus, infestados por *Schistosoma mansoni* e conservados fora d'agua, morrem em muito maior número do que os não infestados. O maior número de mortes ocorre dentro dos primeiros 20 a 30 dias, porém, daí por diante, as mortes no grupo infestado não foram mais frequentes do que no grupo dos não infestados.

É sabido que os caramujos com infestação madura e conservados fora d'agua, quando sobrevivem mais de 20 dias, perdem a infestação.

Assim, quando os caramujos são removidos d'agua dois fenômenos contribuem para eliminar as infestações; em primeiro lugar, a maioria morre dentro de 20 dias e, em segundo lugar, os restantes perdem a infestação.

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