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SEASONAL STUDIES ON *TROPICORBIS CENTIMETRALIS* IN NORTHEASTERN BRAZIL (1)

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As part of a program designed to provide more information about the planorbid vectors of *Schistosoma mansoni* in Northeastern Brazil, extensive field observations were made on *Australorbis glabratus* and *Tropicorbis centimetralis* in their natural habitats near Recife, Pernambuco. Some of the data on *A. glabratus* have been described in the preceding paper (Olivier and Barbosa (1955), and that paper should be consulted for rainfall data, methods of study, etc. Data concerning *T. centimetralis* will be presented here.

Because of the pronounced seasonal rainfall cycle characteristic of Northeastern Brazil, the fresh-water snail habitats are subjected to much rain and high water during the rainy season which lasts from March or April to July or August. The remainder of the year is dry, and the water level of most of the

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snail habitats falls drastically. Many of the habitats are without standing water for from 5 to 7 months each year. The snails were studied both in habitats that are permanently wet and in those that dry annually. Many habitats were studied over a period of about two years, but since the observations made in all the localities cannot be presented, only those made in selected places considered to be typical will be described.

OBSERVATIONS ON TROPICORBIS CENTIMETRALIS FROM SALGADINHO, OLINDA

Salgadinho is a part of Olinda lying near the sea and is built to a large extent of land fill over a mangrove swamp. The area is only slightly above sea level, the soil is heavy and dense, and the drainage is poor. As a result, during the wet season there is standing water over much of the area not occupied by houses. The water ranges up to 30 cm. in depth in some of the pools, but for the most part it is very shallow. There is no shade except that afforded by the walls about the houses and the sparse weeds and grass that grow there.

In the dry season the water disappears from almost all the area, though small, fetid pools may persist near the walls where they are fed by effluent from the houses. Most of these pools dry before the end of the dry season. All are poor habitats for the snails, and snails were seldom found in them. When the water disappears from the fields the exposed soil becomes hard and dry and remains in this condition until the next wet season except that it is moistened from time to time by light rains. Most of the vegetation dies leaving large bare areas, but some of the weeds and grasses survive.

The snails were studied in four limited and distinct fields scattered among the houses in an area of about 10 hectares. Since the observations on the snails in the four fields did not differ greatly, only the first field will be dealt with in detail.

Field 1.

In the rainy season this area is a roughly circular pool about 15 meters across and up to 25 cm. deep. In the dry season, there is no water and the very sparse vegetation consists mostly of tussocks of the sedge, *Cyperus ligularis* L. which has stiff, rough-edged, erect, grass-like leaves standing close together.

The first collection from the field was made on December 17, 1952, after the pool had dried. Much of the area was barren, and the soil was hard and dry. No living snail was found on or in this soil, and the shells of dead snails were found only in small numbers in spite of the fact that there had been many living snails widely scattered in the pool before the water had disappeared. However, continued search revealed large numbers of living snails in the protection of the tussocks of *C. ligularis*. Both *T. centimetralis* and *Drepanotrema anatinum* were found in the leaf axils and on the humus and soft soil at the ground level in the tussocks. A total of 2,369 shells of *T. centi-*

metralis ranging from 2 to 10 mm. in diameter was collected. Of these, 648, from 2 to 8 mm. in diameter, harbored living snails. The snails were retracted about one-half whorl but did not appear to be severely desiccated. Apparently the tussocks offered protection from the heat of the sun, from excessive drying, and from the activities of predators such as chickens, pigs, and rats. (Data from this and all other collections made in Field 1 are presented in Table 1.)

Another similar collection was made on January 16, 1953. Again, no living snail was found in exposed locations, but numerous living snails of about the same size range as those collected on December 17 were collected from the tussocks of *C. ligularis*.

On April 10, there was no water in the field, but heavy rains fell after April 16 and the pool became flooded between April 20 and 25. The snails of the May 6 collection were all from 5 to 9 mm. in diameter. The central portion of each shell was dark brown, thick, and hard while the terminal portion was thin, fragile, and nearly colorless. The central portions of the shells had from 2.0 to 3.4 whorls (average 2.9) and fell within the size range of the snails collected during the dry season. The terminal portions of the shells ranged from 0.4 to 1.8 whorls (average 0.8) in size. These snails must have grown rapidly after the return of water since they had acquired up to 1.8 whorls of new shell in 16 days or less.

It was concluded that all these snails had survived the dry season and that the terminal portion of the shells had been added since the field had become flooded. It is notable that apparently only partly-grown snails survived the dry season. The snails found in the tussocks during the dry season were always medium-sized, and all those collected soon after the water returned had old shells, falling in the size range of the aestivating snails, to which new shell material had been added since the pool flooded.

On May 21, the collection contained many small snails which were entirely thin and fragile, as well as large old snails that had obviously survived the dry season. These small snails were judged to be members of a new snail generation produced after the field flooded. Some of the snails of the new generation had reached 6 mm. in diameter although the field had been flooded for only about one month.

On June 1, the old snails had grown to a maximum of 14 mm. but were collected only in small numbers. The impression was gained that they were dying out rapidly. The young snails of the new generation were very numerous and had reached a maximum of 9 mm. in diameter.

New snails continued to come into the pool throughout the remainder of the wet season since small snails with fragile shells were always found, though in variable numbers. The old snails continued to die off gradually, and by the end of the wet season the population consisted almost entirely of snails produced since the start of the wet season.

On September 14, the pool was reduced to about one-half of its previous area, but the snails were still numerous and active. Young snails were present though the majority were large and apparently mature.

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Table 1

Data from successive collections of *Tropicorbis centimetralis* made in Field 1, Salgadinho, Olinda

Date	Condition of field	Snail diameters in millimeters															Total	Mean
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Dec. 17, 52	Dry		5	92	173	187	142	31	18								648	4.8
Jan. 16, 53	Dry			1	135	201	72	14									423	4.9
May 6	Flooded					9	45	81	92	45							272	7.4
May 21	Flooded		42	75	73	55	12	1	6	5	4						273	4.0
Jun. 1	Flooded		2	5	24	38	47	45	27	20	9	4	2	1	1		225	6.6
Jun. 11	Flooded		7	28	35	32	40	50	35	26	15	14	13	2			297	
Jun. 26	Flooded		12	15	21	39	39	51	46	34	31	30	15	7			340	
Jul. 17	Flooded		1	1	11	41	34	86	101	81	49	22	4	2			433	
Aug. 1	Flooded			7	9	11	14	40	58	75	85	60	37	6		1	403	
Aug. 6	Flooded		27	12	11	17	20	37	50	73	50	25	11	3			336	
Aug. 17	Flooded			21	71	72	40	52	66	36	39	16	7	2			422	
Sept. 14	Drying		12	12	20	15	6	13	26	31	77	35	24	8	1		280	
Nov. 7	Dry			3	20	36	17	13	4	1							94	5.3
Dec. 1	Dry			3	11	28	43	20	12	1							118	5.9
Dec. 2	Dry			3	11	36	111	100	29	5	1						296	6.4
Apr. 13 54	Dry				2	9	14	13	2	2							42	6.2
Apr. 27	Flooded						14	42	47	15	5						123	7.6
May 4	Flooded						13	40	53	50	24	5					185	8.2
May 15	Flooded				5	9	19	29	32	31	32	25	6	1			189	8.4
May 22	Flooded				1	4	17	37	28	35	25	13	1				161	8.2
May 29	Flooded				12	18	18	26	34	43	32	9	5	2	1		200	8.0
Jun. 5	Flooded		1	3	25	32	13	30	35	49	35	12	3				238	7.5
Jun. 15	Flooded		9	23	30	45	59	55	30	15	21	12	5				304	6.4
July 1	Flooded			17	17	30	43	57	43	20	19		2				248	6.7
July 6	Flooded			2	4	21	39	64	44	25	22	8	3				232	7.4
Total																	6782	

OBSERVATIONS ON TROPICORBIS CENTIMETRALIS IN OTHER HABITATS

Numerous other observations were made on the habits and seasonal cycle of *Tropicorbis centimetralis* in the field. However, for various reasons, it was not possible to study the species intensively in other habitats. As a result, the information gained is more limited and fragmentary.

T. centimetralis in Iputinga, Recife.

Iputinga is a subdivision of Recife which is flat, low, and poorly drained. There are numerous depressions and ditches in the fields and among the houses and many of these harbor *T. centimetralis*. On the basis of observations made in this area over a period of 18 months, it was concluded that the seasonal cycle of the snails there is the same as that of the snails in Salgadinho.

T. centimetralis in habitats that do not dry.

T. centimetralis lives in ponds, lakes, ditches, and streams that do not dry. Numerous collections were taken from these permanently wet habitats. In general, it was found that reproduction in these places was more or less continuous throughout the year, but that there were important fluctuations in reproductive rate and population density not obviously related to season, climate, water level, etc. Collections made in the vicinity of Vitória de Santo Antão between October, 1952, and April, 1954, will illustrate this. Snails were taken from three locations, two in the river that flows through the town and one in a lake nearby (Lagoa Caiçara). The snails were numerous in all three localities in October, 1952. Shortly thereafter almost all the snails disappeared from the river, and they were relatively scarce in the lake. The snails continued to be scarce until June, 1953 when many snails were found in one of the two places in the river while the snails in the other two localities remained scarce. One month later the snails were numerous in all three localities. Occasional fluctuations in population density also occurred during the following year. These shifts were accompanied by shifts in the ratio of small to large snails and may have been due, in part, to variations in reproductive activity of the snails. On the other hand, the fluctuations were too great to be accounted for on this basis alone, and it is quite possible that epidemics of snail disease or temporary changes in the nature of the habitats may have contributed to the population crises.

DISCUSSION

Since there are marked seasonal changes in the habitats that dry annually, the snails in these localities undergo a marked seasonal cycle and

relatively clear-cut quantitative information concerning the seasonal fluctuations of the snail populations and the behavior of the snails could be obtained.

On the basis of the observations made in Salgadinho and confirmed by observations made in many other localities, the seasonal cycle of *T. centimetralis* in that type of habitat can be outlined.

At the end of the wet season, the snails are numerous and the population consists entirely, or almost entirely, of snails produced since the start of the wet season. Drying of the pools results in the death of all of the snails in exposed situations, but some snails avoid destruction if they happen to lie in the vegetation or debris which seems to protect them from excessive drying, predators, high temperatures, etc. Some of the snails in such situations may survive the long dry season of 5 to 7 months.

When the water returns, the surviving snails, which may be very few in number, grow rapidly and produce many eggs. Then, during the course of the wet season, these old snails die and are replaced by this new generation. One month after the pools are filled, some of the snails of the new generation may be 6 mm. in diameter and by 6 or 8 weeks after the return of the water, the new generation may be very numerous. Reproduction continues during the wet season, but it is not known if more than one generation is produced.

The life span of most of the snails is necessarily short. A large proportion of the snails alive at the end of the wet season die in the first weeks after the pools lose their water. Others die during the course of the long dry season and relatively few survive until the following wet season. Apparently, all those that survive the dry season were produced in the preceding wet season and so are relatively young. These snails grow rapidly in their second wet season, produce a new generation, and die. Their life span is probably not more than 15 or, at the most, 18 months.

The seasonal cycle of *T. centimetralis* in habitats that dry annually is not significantly different from that described for *Australorbis glabratus* by Olivier and Barbosa (1955). It is probable that *A. glabratus* is somewhat less resistant to drying than is *T. centimetralis* though this was not tested adequately. The latter tends to live in habitats that dry more thoroughly than those usually inhabited by *A. glabratus*, and their habitats tend to remain dry for a greater part of the year.

The data from the four fields in Salgadinho indicate that *T. centimetralis* may grow very rapidly in the field. Snails which survived the dry season reached maximal size soon after the fields became flooded. For instance, in Field 1, the old snails added up to 1.2 whorls of new shell between April 15 and May 4. Moreover, the young snails produced in April and May obviously grew at a rapid rate also, since the upper limit of their size distribution curve soon overlapped that of the parent snails. In the same field some of the snails of the new generation had reached 6 mm. in diameter one month after the pool flooded, and all the available evidence indicates that the snails may reach full size and development in not more then 4 to 6 months.

The reproductive potential of *T. centimetralis* is very great. The snail populations in Salgadinho fell to relatively low levels during the dry season, and consequently, after the pools flooded, the snail population was small for the first few weeks. Appearance of the new generation resulted in a rapid increase in the population density as indicated by the record from Field 3 where there was a seven-fold increase in about 4 weeks. Thus, the relatively small number of snails that survived the dry season had produced enough progeny to swell the population to an impressive degree. Comparable population increases were observed in the other three pools.

As stated earlier, the snails survive the dry season in the protection of vegetation and debris. The relative humidity is higher there than in exposed locations, and there is also protection against the sun's heat and against animals which might eat them. There was no evidence that the snails tend to enter the soil in order to avoid the consequences of the drought, and there was clear evidence that this is not necessary for their survival. Since the snails survived in protected locations that were probably somewhat humid throughout the dry season they were not necessarily subjected to severe desiccation, and there was no evidence from these studies that the species can withstand severe drying for extended periods.

In Salgadinho, only medium-sized snails were found alive during the dry season, and this suggests that the snails at the extremes of the size range are less successful in withstanding drought conditions. It is not known whether this is characteristic of the species in all habitats.

T. centimetralis living in permanent bodies of water apparently reproduce throughout the year, but there was evidence that they do not always reproduce at the same rate. Data on the life span and growth rate of these snails in permanent bodies of water were not obtained, but there was no indication that the snails in these bodies of water differed significantly from those living in habitats that dry annually.

Since there is a marked seasonal rainfall cycle in the area where these studies were made and many of the habitats of *T. centimetralis* are dry from 5 to 7 months of the year, transmission of infections with *Schistosoma mansoni* by snails living in habitats that dry annually can only occur during a period lasting not more than 5 to 7 months of the year. Actually, transmission may occur over a shorter interval than this Barbosa and Coelho (1953) and Olivier, Barbosa, and Coelho (1954) have shown that specimens of *A. glabratus* harboring mature infections with *S. mansoni* either die or lose their infections when they are removed from the water. If this is also true for infections of *S. mansoni* in *T. centimetralis*, then there may be no infections in the snails that survive the dry season out of water. Even if the surviving snails were exposed to miracidia of *S. mansoni* as soon as the water returned, it would be about one month before infections could develop in them. A much longer period would pass before snails of the new generation could be implicated in the transmission of schistosomiasis. Therefore, the transmission period in temporary bodies of water might not exceed 3 to 5 months of the year.

The available molluscicides are not efficient against snails living out of water during the dry season since large quantities of chemical must be used and even then not all the snails are affected (Barlow and Azim, 1947; Dobrovolny and Barbosa, 1953). Therefore, snail destruction with molluscicides must be attempted during the wet season when the snails are in the water. Since, in temporary pools, the snails are least numerous when the pools first become flooded, this is probably an excellent time to use molluscicides against them. This could reduce the population to a very low level and should severely affect the size of the new generation usually produced by the small numbers of snails which survive the dry season. As a result, the wet season population might be kept so small that the possibilities of transmission of *S. mansoni* infection could be greatly reduced. If two or more treatments could be given near the start of the wet season, the benefits would be even greater and eradication of snails from some of the habitats might result.

Since the snails may pass the dry season in the protection of vegetation and debris, clearing and burning the snail harborages might be highly effective in reducing the dry season snail population.

Olivier and Barbosa (1955) have dealt with the observations others have made concerning the survival out of water of fresh-water pulmonates and so the subject will not be reviewed here.

SUMMARY

An extensive field study of *Tropicorbis centimetralis* was made in Northeastern Brazil. These snails, which are vectors of *Schistosoma mansoni* there, live in both permanent and temporary bodies of water. Their seasonal cycle was studied in both types of habitats, and information was gained concerning their growth rate, reproductive rate, and life span. It was found that under certain conditions the snails may survive the long dry season of 5 to 7 months out of water. The significance of these observations is discussed.

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SUMÁRIO

Extensos estudos de campo sôbre *Tropicorbis centimetralis* foram feitos no Nordeste do Brasil. Êstes caramujos, vetores do *Schistosoma mansoni* nesta

região, vivem tanto em coleções d'água permanentes como temporárias. Êste ciclo estacional foi estudado em ambas as condições e dados sôbre crescimento, reprodução e duração de vida foram consignados. Observou-se que, em determinadas condições, os caramujos podem sobreviver, fora d'água, na estação sêca o período de 5 a 7 meses. A significação destas observações é discutida.

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