SECTION D

Helminthology
It is the purpose of this paper to put on record observations made in 1935 and 1936 in the area around El Marg, Egypt, on the seasonal incidence of infestation of Bulinus truncatus and Planorbis boissyi with the cercariae (larval forms) of Schistosoma haematobium and Schistosoma mansoni, respectively. There is a well recognized seasonal variation in human infection by these two schistosomes, but little work has been done to show whether a seasonal variation also exists in the infestation of each of the two significant snails, B. truncatus and P. boissyi, with cercariae of these trematodes.

Earlier observations of seasonal variation in cercarial infestation in molluscs were made by Manson-Bahr and Fairley (1920), Soparkar (1921), McCoy (1928), and Fairley and Jasudasan (1930).

Manson-Bahr and Fairley, working in El Marg, Egypt, during the 12-month period from May, 1917, to April, 1918, examined 1,102 bulinus and 5,789 planorbis snails, and found throughout the winter months marked growth and multiplication of larval trematodes (S. haematobium, S. mansoni, and others), with maximum infestation for both snails occurring in December, although they claimed that there was definite evidence to show that endemically the areas were potentially infectious throughout the year. During the months stated by Fairley and Jasudasan (1930) to be the period of maximum infectivity (November to January) the canals were full of irrigation water as a result of the annual rise of the Nile. This would appear to have been one factor in the high rate. In this region there is a seasonal variation in temperature from as low as freezing to 46° C.

Soparkar’s work in Bombay, India, 1917 (reported in 1921), dealt with the cercariae of S. spindale, a trematode which affects animals but not human beings. His experimentation indicated that the incidence of snail infection with this parasite is highest during the autumn months and lowest during late winter and early spring.

Manson-Bahr and Fairley and Soparkar conducted their researches for the purpose of finding the best season for obtaining material for the manufacture of schistosome antigen. In a study in pure science, McCoy (1928) recorded the seasonal infestation with larval trematodes of over 6,500 specimens of P. trivolvis from a small lake near St. Louis, Missouri, over a 2-year period. Although the data did not show any clear-cut seasonal fluctuations, the degree of infestation varied widely from time to time.

In 1930 Fairley and Jasudasan reported on their examination of a total of 236,354 snails of the species P. exustus taken from water tanks on Salsette Island near Bombay between 1922 and 1925. They found a definite seasonal incidence of “infection” with cercariae of S. spindale, with the lowest “infective” rates during the monsoon months.
from June to September, and the highest in the cool period from November to March. Their data and those recorded earlier by Manson-Bahr and Fairley in El Marg were graphically presented for purposes of comparison with the results in that part of India and in Egypt. The Egyptian equivalent of the Indian monsoon is the annual rise of the Nile, most marked during the autumn months of August, September, and October, which season corresponds with the low cercarial infection period in *P. boissyi*. From these two studies it would appear that "the optimum time for collecting infected molluscs for antigen manufacture in both Western India and Egypt is during the cool weather, and in making snail surveys the seasonal factor should always receive consideration."

In these studies the seasonal variations of infectivity and the infestation rate in the significant snails were of special interest from the viewpoint of schistosome control and the determination of likely sources of human infection. A statement made by McCoy that the coolness of the water probably retards the development of the ova seemed so sound biologically that it stimulated the writer to make the present investigations. It is more than probable that the seasonality observed by the various investigators depends upon both the effect of water temperature upon schistosome eggs discharged by man into the water, and the effect of temperature upon the larval schistosomes within the bodies of the significant snails. Also, the winter closure of water dries up a great many snails, thus preventing the entrance of miracidia. Snail infection by schistosome miracidia, which follows the return of water in the spring, does not produce the discharge of cercariae from infested snails until about a month later.

The writer chose the same region (El Marg, Egypt) as the area for his research because it was there that Manson-Bahr and Fairley had made their studies in 1917-1918. He felt, from a careful study of the results of their work, that certain features of the earlier investigations appeared illogical and were probably due to some differences in methods of collecting material or developing the study. These differences he hoped to discover and to be able to explain. He also wished to check his preliminary findings against theirs.

**Material and Methods**

Collecting nets having handles 2 meters long were used. These nets were hand-pushed "D"-shaped dredges with frames of tool steel, 12 millimeters in diameter, onto which galvanized iron wire netting was soldered. Tin cans with a capacity of 750 cc were used as containers of collected material. They were numbered serially on both cans and covers. A belt, with a cloth pocket to hold the can, left the collector's two hands free for operating the net. Surgeon's rubber gloves, covered with thin cotton gloves, aided in picking up the slippery snails. Long forceps also proved useful in sorting debris and picking up snails. Hip boots were used for wading in the canals. This equipment, though hot, ensured safety from infection.

The method of study was to make collections monthly over the whole El Marg area. The area was divided among the five experienced workers, each man keeping to his own locality. Collections were made at nearly the same time of day as possible and the water temperatures were taken with a self-registering thermometer at the time of collection. At the end of the year data for all the localities were combined and the seasonal variations for the area shown in monthly percentages.
Examinations of the snails, especially where the number from any locality was considered small, had to be made as rapidly as possible as the snails do not live long after removal to the laboratory. The snails from each can were crushed, examined, and the results recorded. The author made all the examinations personally, the laboratory assistants crushing the snails, preparing slides, and handing them to him for identification. In order to make certain that only human schistosomes were included, only cercariae so nearly mature that they could be positively identified were counted.

Description of irrigation system

El Marg is a restricted area lying about 14 kilometers north of Cairo, just at the beginning of the delta region of Egypt. The map of the area (map 1) shows that irrigation water is brought, by gravity flow, from the south by a small canal (canal I) branching from the Tawfikia Canal. Just at the entrance to the town of El Marg canal I branches. One branch, marked canal III, which gives off canal IIIa, runs under the Cairo-Marg road to the west. The other branch, marked canal II, runs under the railway line south of the station of El Marg and thence along the western side of the village, to branch into two. One of these branches, canal IV, continues along the edge of the village, through a date palm grove and well out into the country, where it gives off a branch marked canal IVa. Canal IVa gives off a small branch marked canal VI which begins with a pothole for lifting water to the surrounding fields. Canal IV is interesting in that the water is so dirty from running through the town that no snails are found alive in it until it gets well away from the village. The other branch, canal V, runs westward back under the railway line north of the station, past some houses, through a palm grove, and thence to the open fields beyond. All the land lies at about the same level and the surplus water is drained off to the north, into the Bilbeis drain. The canals are small and enter extensively into the intimate life of the town. The water is used for the village laundering, for bathing, for cooking, and even for drinking, raw. It is always polluted with the urine and stools of schistosomiasis patients.

Analysis of significant collections

The curves of the combined collections from all localities are shown in graph 1. There was very little infestation during the cool months of January, February, and March. This season, beginning with December 25th, includes the dry period of the winter closure. The general trend of the curves for _B. truncatus_ and _P. boissyi_ is much alike, which is to be expected with two snails related so closely generically as well as by habits and environment.

Canal VI, pothole no. 1, in the 1935-1936 collections, showed much the same percentages of infestation in _P. boissyi_ as did the collections for all localities, except that there was a sharp drop in September, 1935, clear down to no infestation, which condition continued until April, 1936. _B. truncatus_ showed a sharp rise in February, 1935, a drop to no infestations in March, April, and May, 1935, and then another rise in June, with a drop to no infestations in July through to December, 1935, a slight rise in January, 1936, and a fall to no infestations again in February to April, 1936.

These differences from the collections of all localities (graph 1) result from the local conditions in this small pothole, which is one used for setting the Archimedes' screw for lifting the water onto the surrounding fields and therefore
never fully dries up during the rotations or the winter closure of water. The infestation percentages for *B. truncatus* are greatly modified by the small number of these snails living in the pothole. The sharp drop in *P. boissyi* infestations in September, 1935, and the subsequent absence of infestations until May, 1936, were due to the fact that during these months there was little use of the pothole.
and little flow of water to bring in new snails, and the few in the pothole had all been collected.

Mahmoud's Pond, for the 1935–1936 collections, showed *Planorbis* as having infestation percentages not differing very widely from those from all localities, but *Bulimus* was quite at variance, there being only 2 months during which infestations occurred, June, 1935, and February, 1936. The June rise was high because only four snails were collected and one of them was infested, while eleven snails were collected in February and one was infested. This pond is not favorable to *B. truncatus* while it does favor growth of *P. boissyi*.

Canal II, for the 1935–1936 collections, shows marked departures from the percentages of all localities, with planorbis as well as bulinus snails. From January, 1935, to May, 1935, inclusive, the infestation rate is very low, being affected by the winter closure. Then, with the advent of water, the rate rises to a peak in August, falls in September, and then rises very sharply in October to a height which is greatly in excess of that for October in all localities. January, February, and March of 1936 show no infestations, but a small number of snails collected, with a relatively large number of them infested, brings the April percentage well above that of the April,

![Graph](https://academic.oup.com/aje/article-abstract/30-SectionD/3/73/123530)
1936, collections for all localities. Canal II runs through the lower end of El Marg village, and parts of it are wet to moist through the winter and some parts of it are highly polluted. This would also account for the variation of the bulinus population, which follows no definite course.

Canal III gives off canal IIIa at about the middle of its course through the date grove. It is a mere ditch but fairly deep and well supplied with *Pannicum obtusifolium*, a water grass upon which planorbis snails like to feed, but which is not so acceptable to bulinus snails. The first part of canal III is sandy but runs through a much polluted area back of some houses and into the date grove. All the rest of its course is muddy and there are plenty of *Potamogeton crispus* plants to serve as food for bulinus as well as grass for planorbis snails. While *P. boissyi* showed an amount of infestation which closely followed the percentage seen in all localities, *B. truncatus* showed some of the vagaries of single locality collections.

In canal IIIa, whereas the variations in infestations in planorbis snails were slight, the general trend was an increase in the percentage infested over those seen in graph 1. For so small a canal, planorbis snails throve very well indeed, and the number found was more nearly...
Canal II

Graph 3. The percentage of infested snails is shown on the upright. The base line is marked off into monthly intervals of snail collections. P = *P. bovisyi*, represented by solid lines; B = *B. truncatus*, represented by broken lines. The figures following P and B show all the snails collected each month during 1935–1936 in the locality.
representative than was the case with bulinus. Only 25 bulinus snails were collected between January, 1935, and April, 1936, inclusive. The percentage infestation among such small numbers, while accurate for that locality, is entirely misleading for the whole area.

Canals I and V showed the same vagaries of infestation as appear in other single localities and for the same reasons; therefore, data on them have not been given here.

**DISCUSSION AND CONCLUSIONS**

That the snails of the El Marg area carry infestation throughout the year is certain but that they spread human schistosomiasis throughout the year is open to doubt. During and following the Nile flood there is always a heavy increase of silt in the water, with the result that the plants on which these snails feed die down. It is likely that the silt also affects the snails and the reinfection of young snails. Whatever the cause, there is a steady decline of infestations from October to January.

The testimony of the farmer working in the water is that he is not "stung" during the winter but only in the summer when the water is warm. This seems logical, although it may be possible that rare cases of infection of human beings might take place during the winter in highly infected areas, such as El Marg, if snails were accidentally crushed in water warm enough for the cercariae to become active. For 5 years the writer and his men have worked barehanded in the El Marg area during January, February, and March without becoming infected. Constant crushing and dissecting of snails have presented a picture of such inactivity of whatever cercariae exist that an assumption of security seems warranted.

Temperature is a marked factor in the activity of the larval human schistosomes of Egypt and it has been shown by experiment that during cold weather little if any escape of cercariae from the snails is to be expected.

Desiccation due to the 40-day winter closure of water also acts unfavorably upon a winter infestation, there being few holdovers. Practically none of the April infestations were carried through the winter closure, as evidenced by the empty or degenerating sporocysts found in thousands of snails in widely separated areas. If snails which survive the winter closure carry over but few of their infestations, then the infestations of the latter part of April and early May must be the result of a definite spring infection by miracidia. Probably the infestation which does survive the winter closure is of little infectivity importance to either snails or mankind.

April was also a month of low incidence of infection (graph 1) but this is due to the fact that the diagnosis was based on adult cercariae rather than on early larval stages; the first marked rise came in May after the cercariae had had time to mature. The peak was attained in July, August, and September, and ran into October in the case of *B. truncatus*.

In cases in which only a few sections of a locality, or only a few localities of an area are considered, the incidence of infestation, and possibly of infectivity as well, may not present a true picture of the locality and this may distort the findings for the area, especially when the locality lies in a much-polluted area and when but few snails are collected.

For efficient planning of schistosomiasis control it is important to know whether there are seasonal variations and upon what factors these variations depend. If the people can work freely in the water during the winter and fairly
safely until April they can plan their work for this period, thus reducing the likelihood of infection.

If areas in various parts of the country differ in infestation rates it would be advantageous to make surveys similar to this one, to arrive at definite knowledge of such variations. It is desirable to know the snail infection periods in order to make more efficacious the control attack upon the snails. A prerequisite to determining the most satisfactory method for such a survey is a careful, patient collection of snails and their examination for infestation, over a period of a year or two at most.

**SUMMARY**

1. An examination of 11,730 *Planorbis boissyi* and 6,132 *Bulinus truncatus* in 1935 and 1936, at El Marg, Egypt, showed that there was a seasonal fluctuation in the infestation rate of these snails, with diminished infection during the winter. This is due to three factors: the Nile flood, a cold season from December to March, and the winter closure of water by the Irrigation Department.

2. Infestation percentages were demonstrated to reach their peak from July to October, inclusive, all these months being hot.

3. The temperature curve for the months which were studied approximates closely the curves of infestation rates for both *P. boissyi* and *B. truncatus*.

4. Schistosome control measures may be improved by gaining a knowledge of the seasons when snails are most easily infected (by miracidia) and when men may most safely work in water in an attack upon the snail hosts.

**REFERENCES**

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