Original Communications.

REPORT ON THE RESULTS OF THE BILHARZIA MISSION IN EGYPT, 1915.

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(Continued from p. 55.)

PART II: PREVENTION AND ERADICATION.

WATER IN RELATION TO THE SPREAD OF BILHARZIA
Methods of Irrigation
Subsoil Water
Rainfall

BASIS OF PROTECTIVE MEASURES

PREVENTION OF BILHARZIOSIS IN TOWNS
Origin of Bilharzia Infection in Cairo
Effect of Varying Velocities of the Nile
Velocities of the Canals in the Delta

INFECTION IN THE MARITIME CANAL ZONE

PREVENTION OF BILHARZIOSIS IN AGRICULTURAL DISTRICTS
Government Control of Water

SUGGESTIONS FOR ERADICATION
Drying
Closed Drains
Chemical Measures
Canal Clearances
A Summer Campaign
Utilizing Lean Years
Effect of the Campaign on Cotton Worm

PAGE
148
149
152
154
154
155
156
158
162
164
165
165
167
167
168
168
172
172
Water in Relation to the Spread of Bilharzia.

With the knowledge that the infective agent of Bilharziosis is the cercaria, and that this can only develop in certain molluscan intermediaries, we have to consider whether anything can be done to control the spread of the disease. Professor Madden, who possesses, perhaps, the most intimate acquaintance of bilharziosis in all its clinical manifestations, wrote in 1910 that "among the Egyptian people generally there exists a widespread endemic disease, responsible for much suffering and a very considerable mortality among the agricultural population particularly, which we, as the controlling powers of the public health of the country, have done nothing to try and prevent." "Only those who are conversant with the habits and ways of the people are capable of judging of the apparent hopelessness of the task; but it is surely time that a beginning should be made with it, though along what lines it is not easy to indicate."

It was hoped by the authorities in Egypt that the preventive measures now being applied to ankylostomiasis would also prove efficacious in dealing with bilharziosis. These comprise free treatment, the introduction of conservancy, and the dissemination of knowledge of the disease amongst the natives. Such measures would appear, however, to be of little value in the control of bilharziosis, for the following reasons:

1. In ankylostomiasis treatment not only rapidly cures the individual patient, but by killing the adult parasites also assists in limiting the spread of the disease. In bilharziosis there is no recognized treatment other than merely palliative.

2. In ankylostomiasis the disease is spread by the faeces only. In bilharziosis both urine and faeces would require control. The introduction of conservancy would not necessarily ensure the immunity of canals and the smaller streams of water from contamination with urine in agricultural districts.
(3) The co-operation of the natives in Egypt could only follow upon years of instruction resulting in a radical change in the habits of the people.

The remedy is to be sought elsewhere. Fortunately, there are certain physical conditions almost peculiar to Egypt which are inimical to the cercaria and its carrier, and which, if properly exploited, might bring about almost complete eradication of the disease in the course of a few years.

Water is absolutely essential for the life of the Bilharzia outside the body. In Egypt all water is derived from the Nile, directly by irrigation canals or indirectly by seepage into wells, and from rain.

**Fig. 23.**—Showing annual rise in the Nile during the autumn.

**The Nile: Irrigation.** Almost the whole of the water required for the cultivation of the land and for the use of the population is derived from the Nile. Until 1820 the cultivated land was irrigated by the Nile only during its annual rise. The land at the river's edge is ordinarily about nine metres above the river-bed. Every autumn the river rises from seven and a half to ten metres above its bed, as shown in the accompanying diagram (fig. 23). In the early days of Egyptian
history the Nile at these times inundated the whole of the valley. As the population increased, huge dykes were built parallel to the banks of the Nile, and from these other dykes were made stretching from the river to the hills to form large compartments or basins. During the flood the turbid waters of the river were led into these basins by artificial canals, and allowed to saturate the soil thoroughly and to deposit their rich mud on the surface. When each basin was properly irrigated, the water was allowed to pass on into other basins at a lower level, and eventually to return into the Nile when the flood had sufficiently receded to allow this.

According to Willcocks and Craig, this system of "basin" irrigation was in operation over the whole country through the times of the Pharaohs, Ptolemies, and Romans, down to the Arab Conquest in the seventh century. Between 700 A.D. and 1800 A.D. the dykes were uncared for and irrigation was abandoned over the greater part of the delta. The population gradually dwindled from 12,000,000 to 2,000,000. In 1821 Mohamed Ali changed the whole system by excavating a number of deep canals capable of drawing off the waters of the Nile at low level during the summer. This allowed of the cultivation of a summer crop and thus brought about the introduction of cotton upon a large scale. An area of over 3,100,000 acres is now perennially irrigated in Lower Egypt. In 1874, a quarter of a million acres in Upper Egypt and the whole of the Fayum were similarly converted from basin to perennial irrigation. The completion of the Assiut and Assouan barrages have been steps in the conversion of further large areas. At the present day the whole of Lower Egypt under cultivation is irrigated from canals which run throughout the whole year, while in Upper Egypt 964,000 acres are now also perennially irrigated, while 1,287,000 acres still receive their waters in basins through canals running only in flood. During a low flood the amount of water available is not sufficient to keep the whole area under cultivation. Those lands thus thrown out of cultivation are termed "Charaki" and are exempted from taxation (p. 151). With the extension of perennial irrigation the amount of "Charaki" is being continually diminished.

The extension of perennial irrigation has resulted in a marked increase in the prosperity of the people. The population has again risen to over 12 millions. At the same time, perennial irrigation appears to have encouraged the spread of bilharziosis. The disease is much more common at the present day in the Delta and in the Fayum than in those parts of Upper Egypt still supplied only with
RÉPARTITION PAR MOUDIRCHEHS DES TERRES "CHARAKI," 1899-1912.

<table>
<thead>
<tr>
<th>Années</th>
<th>Totaux</th>
<th>Assiout</th>
<th>Assouan</th>
<th>Beni Souef</th>
<th>Gizeh</th>
<th>Kena</th>
<th>Minia</th>
<th>Kharga</th>
<th>Dakahlieh</th>
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<td>1,618</td>
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<td>726</td>
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<td>3,617</td>
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<td>..</td>
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<td>..</td>
<td>17</td>
<td>5</td>
<td>235</td>
<td>..</td>
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<tr>
<td>1912</td>
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<td>2,873</td>
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<td>744</td>
<td>2,378</td>
<td>6,968</td>
<td>9</td>
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</table>

Ce sont les terres soumises au régime des bassins lesquelles, pendant les années de bas étage, restent incultes faute d'eau et sont par conséquent exemptes de l'impôt foncier. La superficie de ces terres tend naturellement à diminuer avec l'extension du système de l'irrigation permanente. (From Annuaire Statistique de l'Egypte, 1914.)
basin irrigation. This has been remarked upon by Milton. In the Records of the Egyptian Government School of Medicine for 1904 he states:—

"Cairo is on the dividing line between Upper Egypt and the Delta, and patients come to Kasr-el-Ainy for treatment from all parts of the country; still the disproportion between the number of cases of bilharzia drawn from the two natural divisions of the country is so very marked that there must be some very well defined cause constantly acting, and this, I believe, is to be found in the way in which water is supplied to the different provinces for the purposes of irrigation. The provinces of Lower Egypt are supplied with water for irrigation all the year round, or practically so, whereas the Upper Provinces are supplied with water for irrigation only during and after the time of High Nile. Thus the peasant from Lower Egypt has a much longer period of time during which he is exposed to the chance of infection, and infection is more frequently repeated than is the case with his brother of the Upper Provinces.

"The province of Ghizeh is a case very much in point, for here, although it borders immediately on Cairo, and although Cairo is its hospital town, the proportion of its population per 100,000 coming for treatment for bilharzia is but 9·75 as compared to Sharkieh 19·85, Qalioubieh 18·06, and Menoufieh 13·47, the three other provinces adjoining the capital, but then Ghizeh is basin irrigated, whereas the other provinces named are perennially irrigated."

The relative frequency of bilharziosis in perennially irrigated areas may be due in part to continued liability of the workers to infection as suggested by Milton, but the favourable environment created for the propagation of the intermediate host is probably a much more important factor.

Subsoil water is generally derived from local rainfall, but in Lower Egypt it is practically all the result of seepage from the Nile and its canals. The average thickness of the Nile alluvium is said to be about seven metres, below this is a layer of sand and gravel into which the river-bed dips. Through this layer, when the river is in flood, a natural flow of water takes place and the static head of the river in flood is thus transmitted to great distances, causing a rise in the level of the subsoil water. This rise is sometimes actually visible, for low-lying land near the river may become covered with water. The subsoil water of the deep sand and gravel strata is utilized for the water supply of towns and for purposes
of irrigation in Upper and Middle Egypt and in the southern half of the Delta. In the fields it is not an uncommon sight to see the water being lifted from deep wells by means of Persian wheels or "sakias" as they are termed in Egypt, driven by one or two blindfolded animals: usually buffaloes, but sometimes camels and bullocks (fig. 24). The "sakia" consists of a vertical wheel carrying an endless rope, slung with earthen pots or buckets which dip into the water. On its axle is a rough wooden-cogged wheel actuated by another cog-wheel placed horizontally. This wheel is moved by a pole fixed at one end to the axle and at the other to the neck of the animal being used to turn it.

According to Mr. Crawley there are five thousand two hundred and fifty-five "sakias," and two thousand two hundred and ninety wells with engines and pumps, drawing subsoil water in fields in the Lower Egypt Irrigation Inspectorate.

The rainfall in Egypt is at no time enough of itself to moisten the soil sufficiently for agricultural use, and is confined to the winter months from October to April. As will be seen from the accompanying table, no rain was recorded from any part of Egypt during the months of June, July, August, and September. Mr. Hurst, of the Physical Science Department of Egypt, has examined the official records for the last twenty years, and has found that an absence of rain during these months has been constant.

**MONTHLY RAINFALL IN MILLIMETRES DURING 1912.**

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<td>8</td>
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The average rainfall per annum at Cairo during the last nineteen years is only 3.28 centimetres. Willcocks and Craig estimate that the amount of the Nile water used on the Delta to irrigate the crops corresponds approximately to a rainfall of 1.30 metres, i.e., fifty-one inches per annum.

PROTECTIVE MEASURES.

The life of the bilharzia outside the body may be divided into three periods: (1) That between the passage of the egg into water and the entrance of the hatched parasite into the mollusc; (2) the stage of metamorphosis within the mollusc; (3) that prior to the entrance of the free-swimming cercaria into the human body after it has left the mollusc. It is universally recognized that in Egypt under present circumstances it is practically impossible to prevent the contamination of water with infected urine and faeces. In order to break the life-cycle of the bilharzia worm one must find some simple means of destroying it during the free-swimming infective stage, or of depriving it of its essential intermediate host.
The former is the line of attack suited to the conditions under which bilharziosis is acquired in large towns; the latter is applicable to country villages and districts.

Prevention of Bilharziosis in Towns.

It has been shown earlier in the report that bilharziosis is frequently contracted by young children in the city of Cairo. The infection could have been derived only from the public water supply, and it was suggested that the unfiltered water supplied throughout Cairo by pipes for garden and stable purposes was the most likely source. This water is pumped from the Nile where infections are known to have been contracted. It has been our experience that very few gastropod molluscs could be found on the banks of the Nile in the neighbourhood of Cairo. It is obvious, therefore, that preventive measures applicable to Cairo and similarly situated large towns should be directed to the destruction of the cercaria in the water taken from the Nile. The ideal, of course, would be to do away with the unfiltered supply entirely. It is said, however, that such a course would deprive Cairo of its gardens and would meet with tremendous opposition. As this unfiltered water must be a continual source of grave risk to the public health from other and more virulent diseases than bilharziosis, it is evident that such opposition must have been both strenuous and triumphant when this system of dual supply is still tolerated by the authorities. Numerous experiments were made to determine if infected water could be rapidly sterilized. The results of this inquiry will be detailed later in connection with the supply of safe water to small bodies of men. They were entirely inapplicable to the requirements of Cairo. There is, however, one feature about the bilharzia cercaria which may be used possibly to conserve the unfiltered water supply; that is the brief duration of life of the free-swimming cercaria. It has been found impossible to keep the cercaria alive for more than thirty-six hours. If it were practicable to store Cairo's daily requirement of unfiltered water for two days or a day and a half, there is no doubt that it would become practically free from danger as far as bilharziosis is concerned. It may be noted, however, that it would at the same time lose that heavy sediment which has a distinct manurial value. Against this loss may be set the fact that, under the present system, one-third of the thirty thousand children born annually in Cairo become infected with bilharzia.
ORIGIN OF BILHARZIA INFECTION IN CAIRO.

The source of infection of the Nile water at Cairo is somewhat difficult to locate. Under the miracidium infection theory it was attributed to contamination of the water by infected urine from the crews on the boats which daily congregate near the Kasr Nil bridge. On the alternative hypothesis of a molluscan intermediary one must look farther afield. The molluscs known to harbour bilharzia cercaria congregate mostly in the smaller canals and ditches where there is a good deal of vegetable substance for food. They are air-breathers and require to seek the surface from time to time. In the Delta, water does not return to the Nile when once it has been used for irrigation purposes. The whole of the agricultural drainage water is discharged either into the salt lakes near the Mediterranean shore or directly into the sea. That of the valley or "Wadi Tumilat" which runs from Zagazig to Ismailia discharges into Lake Timsah on the Suez Canal. In Upper Egypt, however, the canals have escapes at various points on their courses which allow surplus water to return into the Nile. The agricultural drains also discharge into the Nile at certain places. These escapes are indicated on the accompanying map (fig. 25). It will be seen that from Minia to Fashn the drainage is turned sometimes into the Nile, and at other times into the Bahr Yusef, whence it makes its way through the Fayum into Lake Kurun or continues to discharge at El Ayat by the Giza Canal escape. Between Fashn and El Ayat all drains escape into the Nile, while below El Ayat the drains discharge into the large Moheet drain which enters the Rayah el Behera below the Barrage north of Cairo. A few miles south of Cairo it will be noticed that the Giza Canal has two escapes into the Nile.

EFFECT OF VARYING VELOCITY

The velocity of the Nile varies from month to month. Whereas the movement of water down the Nile from the Assiut Barrage to the Delta Barrage occupies seven days in a mean year during March to August, in September the water travels the same distance in three days, in October and November it takes four days, while from December to February five days are necessary. Taking one and a half days as the approximate duration of life of the free-swimming cercaria, it is evident that at all times of the year water freshly contaminated with cercaria at Assiut would become safe long before it reached Cairo. During high flood in September the Nile has a velocity of about one hundred and fifty kilometres per diem, that is water containing freshly discharged cercaria entering the Nile within about one hundred and fifty miles up-stream of Cairo would
still be infective when passing the city. Minia is a little more than this distance from Cairo, so that all the drainage water which, as we have seen, discharges into the Nile between Minia and El Ayat would still be infective at Cairo during the time of high Nile. During the summer months when the Nile is at low stage the maximum velocity at Wasta (see fig. 25) varies between thirty and thirty-three kilometres per diem, according to Craig. Farther down stream this will be less as the Delta Barrage is reached, owing to decrease of slope. About thirty kilometres per day would be a fair average over this reach. According to this, active cercaria would only travel thirty miles in a day and a half, so that infected water entering the Nile more than thirty miles up-stream, i.e., above El Ayat, should have become innocuous by the time it reached Cairo except in so far as occasional infected molluscs may be carried down by the current.

If the facts upon which these conclusions are based are approximately correct, the Nile at Cairo, and therefore the unfiltered water supply, should be infective chiefly during the autumn; the source of infection during the rest of the year being apparently limited to the escapes between El Ayat and Cairo.

**Velocities of Down stream from Cairo, water only re-enters the Canals in the Nile and the main canals by seepage. From the Delta.**

September to December water takes 1'6 to 1'9 days to travel from the Delta Barrage to the sea. From January to April the period gradually lessens from 2'1 to 2'6 days; in May, June and July 2'8 days are occupied. From this we conclude that even during Nile flood the branches of the Nile and the main canals in the northern half of the Delta are less liable than the Nile above Cairo to be infective. The bulk of infections in the Delta must therefore originate directly from the small tertiary canals, the agricultural drains and the large drains which carry the discharge from these to the sea.

**Infection in the Maritime Canal Zone.**

This brings us to a consideration of the Ismailia or sweet water canal carrying fresh water from the Nile north of Cairo to Ismailia, Suez and Port Said.

**The Sweet Water Canal.**

The Ismailia Canal from Cairo to Ismailia is 128 kilometres, i.e., 80 miles. From Ismailia to Suez 90 kilometres, i.e., 56 miles, from Ismailia to Qantara it is approximately 34 kilometres, and thence to Port Said about 43 kilometres. The maximum velocity on the Ismailia Canal is near
the head, about 42 kilometres per day, which probably falls somewhat lower down. On the Suez portion of the fresh-water canal at 40 kilometres from Ismailia, the velocity, according to Mr. Hall, is 0.27 metre per second—i.e., less than 24 kilometres, or 15 miles, per twenty-four hours.

Mr. Craig, of the Statistical Department, writes, that the time of flow from the Barrage to Ismailia may be taken as two days, and that this rate does not vary much from low stage to high stage of the river. From this one may conclude: 

(a) that any infection entering the canal at its head, even during high flood, would have died out before it reached Ismailia;

(b) any bilharzia infections acquired in the Canal zone from the Port Said and Suez branches of the canal must originate from local infection of molluscs in the Ismailia Canal. In the stretch from Cairo to Ismailia the canal is very free from vegetation, and molluscs are relatively very rare. From Ismailia to Qantara, and from Ismailia to Suez, the amount of weed is so great that it is difficult to traverse these sections
by motor launch. Among the weed, specimens of Bulinus are common. We did not succeed in finding infected forms. These two canal branches are the sole sources of supply of fresh water to Port Said and Suez. They are open to contamination with bilharzia: (1) from villages upon the banks; (2) from the pathways running the whole course of the canal; and (3) from shipping. The water appears to be infective only to a relatively small degree, because the children in the schools of Suez and Port Said show a low percentage of cases. At Suez, one child out of nineteen in a school on the outskirts of the town was infected. At Port Said, according to Dr. Orme, bilharzia eggs were found in the urine of five out of forty healthy pupils in the Government school. At Ismailia, unfiltered water taken from the canal on the outskirts of the town is supplied to the European houses and is actually laid on as the cold water supply in the bathrooms. Had the canal water been commonly infected a considerable number of cases of bilharziosis should have been recorded among the European inhabitants.

Fig. 27.—The sweet water canal outside Ismailia.
The Port Said section of the fresh-water canal is not being used by boats and is only open to infection at the present time from those using the footpath along its bank. If this path were diverted the risk of infection should become negligible after some months. On the southern section from Ismailia to Suez a number of villages have arisen on both banks. Paths follow both banks. The canal is used regularly by small boats making forty to one hundred journeys per month in each direction. From this canal water is led at intervals by small channels to the posts on the maritime canal. It appears impossible to insure under present circumstances that the water reaching these posts should be free from infection.

Local practitioners state that there is a fair amount of bilharzia amongst the native population of Ismailia. This is most probably acquired in the low-lying fields and marshes to the south-west of the town, and from the Taftish el Wady drain, which carries off the whole of the drainage of the Wady Tumilat, between Tel el Kebir and Ismailia, and ultimately debouches into Lake Timsah. Specimens
Planorbis boissyi were common in the marshes and ditches there and were found harbouring developmental stages of bilharzia type. Marshes, which usually occupy low-lying areas and derive their water in part from seepage, can only be dealt with adequately by filling. The value of the land reclaimed should compensate for this necessary outlay. Moreover, these marshes are the main breeding-places of malaria-bearing mosquitoes, and on this account alone their abolition is called for even at some cost to the State, as shown in the accompanying photograph (fig. 29). The marshes near Ismailia which were found to be a possible source of danger on account of bilharziosis are being rapidly filled in as an anti-malaria measure in completion of Sir Ronald Ross' recommendations for the protection of Ismailia.

Prevention of Bilharziosis in Agricultural Districts.

Whereas the essential condition to the prevention of bilharziosis in towns was found to be the destruction of the free-swimming
Fig. 30.—The wooden trough, “badala” or “waboer,” for lifting water from twenty-five to fifty centimetres, in use.

Fig. 31.—The “nattala,” a closely plaited straw basket with four cords, for lifting water about one metre.
cercaria, in country districts water in small canals, shallow ditches and irrigated fields is so general and there are certain agricultural appliances (such as those illustrated in fig. 30 and fig. 31) which necessitate continual exposure to infected water in such common use that other preventive measures must be found.

**Fig. 32.**—Iron pipe in the course of the Marg Canal regulating amount of flow.

**GOVERNMENT CONTROL OF NILE WATER.**

In those areas enjoying the privileges of perennial irrigation the water is not allowed to run indiscriminately. The supply is carefully husbanded and is entirely under the control and constant supervision of the Irrigation Department. The irrigation outlets from the public canals are furnished with iron pipes of a definite diameter so that the amount of water passing shall bear a calculated relation to the area served (fig. 32).

During the summer months the water in the canals is controlled by the periodical closure of the head regulators for definite periods. These times are officially announced by the Government.
of the announcement for the earlier part of the summer of 1915 is reproduced on the page opposite. It will be seen that after running for a period of six days the water was shut off for fifteen days. This system of "rotation" was enforced at the beginning of April and was maintained until the Nile flood (as shown in fig. 23) reached the Delta early in August.

Under the Canal Act of 1894 severe penalties are imposed upon those attempting to interfere in any way with the working of the irrigation system. Imprisonment for periods up to two months and fines not exceeding £20 may be imposed in cases of infraction or disregard of the law.

With the increase in the amount of water available which has followed upon the building of the various dams and reservoirs, new lands more remote from the Nile have annually been brought under cultivation.

SUGGESTIONS FOR ERADICATION.

If some simple means could be found of stamping out the molluscs in those situations in which the molluscs harbouring bilharzia congregate and multiply not only would the incidence of the disease be greatly reduced in the country, but the liability to infection would also be greatly diminished in the large towns, e.g., Bilbeis, on the main drains into which the small drainage ditches discharge. The following proposals are based upon a study of the problem in the district of which Marg is the centre. The method, which seems applicable to other parts of Lower Egypt, save, perhaps, those in which rice is the chief crop during the summer months, utilizes the present "rotations" in the supply of water enforced by the Government from April until August. During periodical stoppages of fifteen days the El Marg Canal became dry except for occasional puddles (figs. 11, 12, 33, 34, 35). The molluscs were either stranded upon the drying mud or collected in these puddles. It was found that several days before the return of the water the Planorbis and Bullinus taken from the dry bottom did not revive when placed in water. Those in the small puddles of water had been able to survive, the Planorbis being apparently more hardy than the Bullinus. Had any attention been given to the alignment of the Marg Canal so that small collections of residual water could not provide a "carry-over" for the molluscs, these would have been killed automatically by the "rotation" alone, just at the commencement of their annual reproductive activity. The same...
MINISTRY OF PUBLIC WORKS.

IRRIGATION DEPARTMENT—FIRST CIRCLE.

PROGRAMME OF SUMMER ROTATIONS, 1915, IN QALIUBIA, SHARQA, AND DAKHLA PROVINCES.

Canals on Cotton Rotations.

The following are the sections into which the various canals are divided for rotation purposes:

<table>
<thead>
<tr>
<th>Names of Canals</th>
<th>Section A</th>
<th>Section B</th>
<th>Section C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From</td>
<td>To</td>
<td>From</td>
</tr>
<tr>
<td>Ismailia branches</td>
<td>Head</td>
<td>Qaliubia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>boundary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharqawia</td>
<td>Head</td>
<td>Khalili</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Head</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sissa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marsaawia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qenneba and branches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khalili and branches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zefita and branches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shebini and branches</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SUMMER ROTATIONS (1915) IN LOWER EGYPT.

Summer Rotations, in accordance with the lists already published for each Circle of Irrigation, will be imposed throughout Lower Egypt as per the time-tables given below:

Canals on Cotton Rotations.

<table>
<thead>
<tr>
<th>Period</th>
<th>From</th>
<th>To</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>April 8...</td>
<td>April 13</td>
<td>Stopping</td>
<td>Working</td>
<td>Stopping</td>
</tr>
<tr>
<td>21 days</td>
<td>14</td>
<td>19</td>
<td>Stopping</td>
<td>Working</td>
<td>Stopping</td>
</tr>
<tr>
<td></td>
<td>April 21...</td>
<td>April 25</td>
<td>Working</td>
<td>General stopping</td>
<td>Stopping</td>
</tr>
<tr>
<td></td>
<td>April 22...</td>
<td>April 27</td>
<td>Stopping</td>
<td>Working</td>
<td>Stopping</td>
</tr>
<tr>
<td></td>
<td>April 23...</td>
<td>May 3</td>
<td>Working</td>
<td>General stopping</td>
<td>Stopping</td>
</tr>
<tr>
<td></td>
<td>April 24...</td>
<td>May 10</td>
<td>Stopping</td>
<td>Working</td>
<td>Stopping</td>
</tr>
<tr>
<td></td>
<td>April 25...</td>
<td>May 12</td>
<td>Working</td>
<td>General stopping</td>
<td>Stopping</td>
</tr>
<tr>
<td></td>
<td>April 26...</td>
<td>May 17</td>
<td>Stopping</td>
<td>General stopping</td>
<td>Stopping</td>
</tr>
<tr>
<td></td>
<td>May 18</td>
<td>May 24</td>
<td>Stopping</td>
<td>General stopping</td>
<td>Stopping</td>
</tr>
<tr>
<td></td>
<td>May 19</td>
<td>May 25</td>
<td>Stopping</td>
<td>General stopping</td>
<td>Working</td>
</tr>
<tr>
<td></td>
<td>May 26</td>
<td>May 31</td>
<td>Stopping</td>
<td>General stopping</td>
<td>Working</td>
</tr>
</tbody>
</table>

REMARKS.

(1) Suff channels not specifically named in this list will be on the same rotation as the parent channel from which they derive their supply.

(2) The working turn, or period over which irrigation is allowed, begins at sunrise of the first day of the period and ends at sunrise of the day following the last day of the period.

(3) During the working turn of any section, water will be supplied, to the extent that the available supply of water may permit, to all public and private canals and outlets lying within the limits of that section, as described in the programme.

(4) The heads of all private canals and all outlets must be punctually closed and all lifting machines must cease to work at the expiration of the working turn.

(5) By Article 32 (30) of the Canal Act, 1894, it is enacted:

"Whoever takes water from a canal, whether by opening the head of the canal, or of the watercourse, or by cutting banks, or by lifting the water artificially during the days that the Inspector of Irrigation or any other authority duly authorized shall have made known that water from the canal must not be used for irrigation, will be punished by imprisonment for a period of from fifteen days to two months, and a fine not exceeding £.E.20.

(6) The provisions of Article 32 (30) of the Canal Act must be strictly enforced, and the Irrigation Service will take such further administrative measures in case of infraction or disregard of the Law as the nature of the case may require.

(7) The breakdown of a lifting machine gives no right to compensation-supply out of turn.
object might be attained by the provision of an alternative route for the "rotation" water from the secondary canal to the fields.

**Chemical Agents.**

The small collections of residual water might be treated chemically so as to destroy the surviving molluscs. As the water so treated would be carried on to the land at the commencement of the following "rotation" it would be essential that the chemical used should not be injurious to the crops. Certain chemicals are used nowadays on a large scale as manures. It was found experimentally that some of these, especially ammonium sulphate, in weak solution killed the molluscs within a few hours. This chemical manure can therefore be used with safety, and *without ultimate loss*, to kill off those molluscs which had escaped destruction by drying.

**Closed Drains.**

The small drains, such as that figured on page 39, are less cared for, as a rule, than the small supply canals. They consequently become over-grown...
with weeds, which frequently afford sufficient protection to the molluscs to enable them to survive for a considerable period. In Egypt, drainage is always effected by means of open drains. The periodical clearing of these drains must, therefore, be regarded as an essential part of any scheme for the eradication of bilharziosis until the open drain can be abolished.

The English system of field drainage by underground pipes has scarcely received proper trial in Egypt. Quite recently the State Domains Administration made some experiments on the washing of salted land by filtration into drain pipes and this method was found to be better than that of filtration into open drains. The cost, however, proved out of proportion to the extra benefit from the agriculturists' point of view.

Although the initial cost may seem considerable, it should not be overlooked that there would be a distinct saving in other directions. The annual charges for clearing the open drains would be abolished, there would be no heavy losses or damage through the falling of live stock into the drains, and the land recovered would represent a considerable increment of capital.

Lang-Anderson has estimated that if pipes could be obtained in Egypt at about the same cost as prevails in England, the conversion of an open drain 300 metres in length into a covered drain would involve an outlay of a little over £3. About 1,200 square metres of land previously occupied by the open drain would then be available for agricultural purposes. Valued at £42 per feddan, this recovered land would be worth £12.

The mole drain plough is said to be an efficient and very cheap method of drainage. Lang-Anderson believes that the soil of Egypt would give a satisfactory bore to this machine. If this proved to be the case earthenware pipes could be dispensed with.

The canals are closed annually for a period of a month, usually from December 25 to January 25, to allow of the removal of silt. If it were practicable to carry out these canal clearances at the commencement of the summer in conjunction with the rotations of water, the work should greatly assist in the elimination of the fresh-water molluscs.

As the anti-bilharziosis measures proposed depend for their success upon the summer rotations, the campaign would be confined to the months from April to August. We now proceed to acquaint ourselves with the agricultural activities in perennially irrigated land during these months, to see to what extent these would assist or
Fig. 34.—Marg Canal as it enters the village, a few days after the water has been cut off in the "rotations."

Fig. 35.—Marg Canal passing the railway station, same view as in fig. 5, but during the "rotations."
interfere with the steps proposed. The main crops in Egypt are cotton, wheat, clover, and maize. Wheat and clover are winter and spring crops, and are harvested by May. Cotton occupies the land from April until October. Maize is a "catch" crop, sown late in July and harvested in October. Apparently the chief crop under cultivation during June and July is cotton. Cotton is not grown annually. On the best land it can be grown every alternate summer, but it is usually planted once in three years on the same land.

### Dates of Sowing and Harvesting in Lower Egypt

<table>
<thead>
<tr>
<th>Sowing</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>March to April</td>
<td>March to April</td>
</tr>
<tr>
<td>Cotton</td>
<td>Cotton</td>
</tr>
<tr>
<td>L. etc.</td>
<td>L. etc.</td>
</tr>
<tr>
<td>May to June</td>
<td>April</td>
</tr>
<tr>
<td>Winter rice</td>
<td>Summer melons</td>
</tr>
<tr>
<td>June to July</td>
<td>April</td>
</tr>
<tr>
<td>Sesame</td>
<td>Summer melons</td>
</tr>
<tr>
<td>July to August</td>
<td>May</td>
</tr>
<tr>
<td>Flood rice</td>
<td>Wheat</td>
</tr>
<tr>
<td>Sept. to Nov.</td>
<td>July</td>
</tr>
<tr>
<td>Berseem (clover)</td>
<td>July to August</td>
</tr>
<tr>
<td>Lupins, Flax</td>
<td>Henna</td>
</tr>
<tr>
<td>Wheat, Barley,</td>
<td>Maize, Sesame</td>
</tr>
<tr>
<td>Beans</td>
<td>Millet, Melons</td>
</tr>
<tr>
<td>Nov. to March</td>
<td>Nov. to Dec.</td>
</tr>
<tr>
<td>Sugar-cane</td>
<td>Maize, Millet</td>
</tr>
<tr>
<td>Nov. to May</td>
<td>Nov. to March</td>
</tr>
<tr>
<td>Green berseem</td>
<td>Dates — cotton</td>
</tr>
</tbody>
</table>

On the simple three years' rotation usual in Egypt the land is divided into three parts, and placed under wheat, clover, and cotton. Wheat and clover being winter crops are harvested before June, and the land is left in bare fallow until the following February, unless a catch crop of maize is interposed at the beginning of August. We see from this that at the present time two-thirds of the land is annually in bare fallow during June and July, while the remaining third is under cotton.

Turning now to fig. 36, it will be observed that May, June and July are the months in which humidity reaches its lowest point, and the temperature attains its maximum, consequently evaporation is most rapid at this time. The climatic and agricultural conditions in Egypt are therefore most favourable for a campaign against the
<table>
<thead>
<tr>
<th>Average</th>
<th>FIRST YEAR</th>
<th>SECOND YEAR</th>
<th>THIRD YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Winter</td>
<td>Summer</td>
<td>Winter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bare fallow</td>
</tr>
<tr>
<td>One-third</td>
<td>Wheat</td>
<td>Bare fallow</td>
<td>Clover (&quot;Catch&quot; crop)</td>
</tr>
<tr>
<td>One-third</td>
<td>Clover</td>
<td>Wheat</td>
<td>Bare fallow</td>
</tr>
<tr>
<td>One-third</td>
<td>Clover (&quot;Catch&quot; crop)</td>
<td>Cotton</td>
<td>Clover (&quot;Catch&quot; crop)</td>
</tr>
</tbody>
</table>

**Fig. 38.** Monthly average temperature, humidity, and evaporation.
molluscan carriers of Bilharzia during June and July. Taking tertiary canals as supply units, it should be possible by adjusting the rotation of crops so to group the land under cotton that, in a given area, a third only of the tertiary canals need be used during these months. The tertiary canals and drains supplying the other two-thirds of the land would become thoroughly desiccated, and their molluscan fauna completely destroyed.

If the additional precaution of screening the tertiary canal head were taken, the diminished supply involved by the mesh should be compensated for by the insertion of a second screened pipe rather than by the replacement of the original pipe by one of larger bore. The screens would require periodical cleaning and supervision throughout the year.

The table of charaki lands given on p. 151 shows in feddans that a large area, varying from year to year, is thrown out of cultivation when there is a shortage of Nile water during the summer. Further, the Government, under circumstances like those operating during the present War, takes steps to restrict the area placed under cotton. Whenever the land is brought into bare fallow from such causes, efforts should be made as far as possible so to group the incidence of fallow and cotton fields in a given area that the transient financial loss directly contributes to a diminution in the amount of Bilharziosis in the district penalized.

The proposal to render cultivated land as dry and hot as possible during the whole of June and July as a means of attacking the bilharzia-carrying molluses would be very beneficial for the cotton fields themselves. The prominence of Egyptian cotton in the world's market is based upon its quality alone, and it has been shown that considerable deterioration follows a too copious supply of water. Moreover, when green and well-irrigated fields of clover are interspersed between the cotton fields during June, the cotton worms are provided with plenty of food and shade until the young cotton plants have produced sufficient foliage to receive them. If, on the other hand, the cotton fields can be kept dry, and the plants consequently hard and fibrous, millions of the cotton worms would perish.

The contamination of the water with infected urine and faeces must continue so long as the river and main canals are the chief vehicle for transport in Egypt. There are still few main roads, and these generally
occupy the banks of canals and main drains which are entirely open to pollution. At the present day, as in the time of Herodotus, "The Egyptians perform publicly those natural functions which it is the custom for members of other races to carry out in private." In the new areas now being reclaimed, it should be possible to provide more adequate protection for the main watercourses.

The replacement of the small agricultural drains by piping or by "mole" drains, together with the proper utilization of canal clearances and the periodical drying of the small canals during the summer "rotations," should prove successful in controlling bilharzia, even although the molluscan intermediaries were not entirely destroyed. The molluscs are slow in growth and propagation as compared with other animal carriers of human diseases. Restocking with half-grown or adult forms might be prevented if it proved practicable to screen the iron pipe regulating the flow of a tertiary canal at its head.

CONCERNING RECLAMATION.

At the beginning of the nineteenth century, owing to neglect, the cultivated area of the Delta had shrunk to that portion lying between Cairo and an irregular line (shown on fig. 26) passing through Delingat, Damanhur, Itai el Barua, Shubrakhit, Desuq, Qallin, Simella, Mansura, Faqs, Burdein, and Bilbeis. The introduction of perennial irrigation brought about a rapid increase in the population of Egypt, which was met by an extension of the area brought under irrigation. This increase still continues and is greatest where irrigation projects are most active. During the ten years ending 1907 the population, according to Willcocks, had increased sixteen per cent, while the cultivated area increased only thirteen per cent. It is clear, therefore, that new land must be brought continually under cultivation to meet the increasing needs. The total acreage of Lower Egypt is 5,190,000 acres. Of this, 3,100,000 acres are now cultivated land, 1,190,000 acres are waste land ("Berea"), or ordinarily too salted to produce crops without reclamation; 600,000 acres are covered by lakes. The whole of the Berea or waste land was cultivated in the Ptolemaic and Roman era. According to local tradition some of these waste tracts now bordering the lakes were once covered with vineyards or divided into enormous basins planted with wheat. The numberless mounds strewn with bricks and pottery which nowadays arise from these extensive barren plains are evidence that they once supported a dense population.
As we have seen (p. 150) the extension of perennial irrigation in the past has been accompanied by a similar extension of bilharzia infection. The bilharzia-carrying fresh-water molluscs cannot live in saltish water. Every effort should be made, therefore, in the future reclamation of the salted lands in the north of the Delta to ensure, as far as possible, that favourable conditions are not created at the same time for their colonization by the bilharzia-spreading molluscs.

Fig. 37.—The relations of villages to the canals. A, village on either bank of a main or secondary canal; B, village on a tertiary canal; C, village between two tertiary canals.

(1) If the banks of main canals or drains are used as roads the water should be adequately protected from contamination. If possible, however, the roads should run between the terminations of two systems of tertiary drains.

(2) Villages should not be made on the main drains or on the primary or secondary canals. They should be located as far as
possible between two tertiary canals. A glance at fig. 37, A shows at once that where a village is on the bank of a main or secondary canal the bilharzia eggs and embryos carried on in the main stream passing through the village are liable to infect all the tertiary canals supplied from the canal in the section down stream of the village. This arrangement one sees frequently on the Suez section of the sweet water canal. Where the village is on a tertiary canal (fig. 37, B) as happens at El Marg, the water passing through the village is dissipated on the surrounding fields so that the area of infectivity of the village is limited practically by its own communal boundaries. Where a village lies between two tertiary canals, as in fig. 37, C, the liability to contamination of the water channels is practically restricted to those paths leading from the village and such branches as are used for washing and other domestic purposes.

(3) The village water supply should be derived from "sakias" or deeper wells. Each irrigation unit should possess paired supply canals and drains, so that these may be alternately dried without interfering with the irrigation. At Marg, when the canals became practically dry during the rotations, a certain amount of water was drawn from a sakia in the middle of the village. On one occasion when the shortage was becoming serious, a neighbouring land proprietor diverted a generous supply of clear artesian water into the Marg Canal. This, however, revived enormous numbers of molluscs which otherwise would, undoubtedly, have been killed by drying before the completion of the rotation cycle!

(4) Surface-water drains should be reduced, as far as possible, by the utilization of infiltration drains.

The Mosseri system of field drainage, which is said to be simple, economical, and extraordinarily effective, seems, of the various systems of land reclamation at present in use, to be the one most likely to produce those conditions that are unfavourable to the spread of bilharziosis.

Its dual system of "collecting" drains affords more complete control. From the section shown in fig. 39, it will be apparent that the bulk of the surface water, after irrigating the land, rapidly drains by a separate surface drain into the main drain, while the water which has soaked into the soil is drawn off by a deep infiltration drain to be pumped later into the main drain. The surface water drain can therefore be readily sterilized during the summer by drying, while if need be, the deep infiltration drain can be treated with chemical agents, or periodically cleared.
If a campaign against bilharziosis were commenced on the lines here proposed it is evident that the whole scheme should be under the charge of a medical zoologist, who should be attached, not solely to the Public Health Service as in an ankylostomiasis campaign, but also to the Department of Irrigation. In this way only could the full and continuous effect of the present administrative control of the Nile
water be brought to bear upon the bilharzia-carrying molluscs so as to ensure their permanent eradication from lands now heavily infected and their exclusion from new areas about to be reclaimed.

PROTECTION OF TROOPS AND PERSONAL PROPHYLAXIS.

Having dealt with the mode of transmission and suggested the lines upon which eradication might be effected in the course of a few years if undertaken by the State, we come now to consider the preventive measures that should be adopted by the individual, or collections of individuals, working in districts where the disease is still rife. It is obvious from what has been said on p. 47 (Part I), that in large towns where filtered water is supplied both for drinking and bathing there is practically no risk to the European. A study of the bionomics of the cercaria gives the data wherewith unfiltered water can be rendered safe where filtered water is unavailable or insufficient for all personal purposes.

BIONOMICS OF BILHARZIA CERCARIAE.

ACTIVITY. The bilharzia cercariae move by loping and by swimming. They crawl rapidly over any surface by alternate use of the oral and ventral suckers, the tail being dragged behind passively. When swimming the tail and the whole body gyrates and the cercaria progresses with the pronged tail foremost. Swimming is not continuous. Brief periods of activity are regularly alternated with periods of rest. During these latter the cercaria very slowly sinks. When seen with a hand lens their attitudes recall slightly minute mosquito larve. As a rule they frequent the surface, but when a small mammal like a mouse is placed in the water they at once attack the skin. As successful infection resulted in a young mouse after only ten minutes' immersion on a single occasion they appear to be able to pierce the skin very rapidly.

DURATION OF LIFE. In ordinary tap-water freshly discharged cercariae usually live about twenty-four hours. A considerable number survive thirty-six hours, but none has ever been found alive after forty-eight hours. They are apparently unable to obtain nourishment from water. An infected mollusc will apparently continue to discharge active cercariae for a long period. On two occasions infected Planorbis boissyi were kept in tap-water, which was renewed daily for three weeks. Large numbers of cercariae were discharged into the water every day.
The cercariae can survive on a damp surface from which the visible water has disappeared. They are immediately killed if the drying process is allowed to proceed to the extent of abstracting fluid from their bodies. They cannot withstand the slightest desiccation.

Although the bilharzia cercariae, with one exception, are not provided with eye-spots, the bulk are found near the surface of the water. They accumulate there irrespective of exposure to light. If a thin layer of oil or refined paraffin is poured on to the surface of the water the length of life of the cercariae is reduced to a few hours. This may also be observed when a drop of water containing cercariae is periodically examined under a sealed cover-glass. If a bubble of air has been left in the preparation it will be noticed that the cercariae course round and round its circumference like moths around a flame.

The obvious purpose is to obtain oxygen from those portions of the water nearest the air.

The free-swimming bilharzia cercariae can survive a temperature of 45° C. They are killed, however, when the temperature is momentarily raised to 50° C. This corresponds very closely to the clinical finds of Conor [116] in Tunis. He noted that bilharziosis is acquired from the waters of the thermal springs at Gafsa, Tozeur and Gabès, which have a temperature of from 28° C. to 45° C., while the disease was quite absent in the neighbourhood of other springs in Tunis where the temperature ranges from 50° C. to 70° C.

Very weak alkalies were found to have a stimulant action and weak acids an inhibitory effect on the movements of the bilharzia cercariae. One in five hundred hydrochloric acid kills immediately. The following acids, acid salts, essential oils and antiseptics were found in dilute solutions of varying strengths to have a lethal effect on the cercariae:

- Salicylic acid... 1 in 1,000... Kills at once.
- Benzoic acid... 1 in 2,000... Slight movement after 60 minutes.
- Sodium bi-sulphate... 1 in 1,000... Kills at once.
- Oil of cloves... 1 in 1,000... Kills almost immediately.
- Creosote... 1 in 1,000... Kills in 10 minutes.
- Felix mas... 1 in 5,000... Immediate paralysis; slight movement of tail.
- Chiniosol... 1 in 1,000... Kills in 15 minutes.
- All dead in 4 hours.
<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Concentration/Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisopurin</td>
<td>1 in 1,000: All dead in 50 minutes.</td>
</tr>
<tr>
<td>Microcidine</td>
<td>1 in 10,000: All dead in 20 minutes.</td>
</tr>
<tr>
<td></td>
<td>1 in 20,000: Dead in 60 minutes.</td>
</tr>
<tr>
<td></td>
<td>1 in 40,000: Dead in 2 hours 50 minutes.</td>
</tr>
<tr>
<td>Beta-naphthol</td>
<td>1 in 1,000: Kills immediately.</td>
</tr>
<tr>
<td></td>
<td>1 in 10,000: Stopped swimming immediately.</td>
</tr>
<tr>
<td></td>
<td>1 in 100,000: Fibrillar twitching and wriggling in 1/4 hour; motionless in 2 hours.</td>
</tr>
<tr>
<td></td>
<td>1 in 200,000: Swimming stopped in 1 hour; quite motionless in 2 hours.</td>
</tr>
<tr>
<td>Emetin</td>
<td>1 in 2,000: Dead in 90 minutes.</td>
</tr>
<tr>
<td></td>
<td>1 in 10,000: Slight contraction at 50 minutes; dead in 83 hours.</td>
</tr>
<tr>
<td>Thymol</td>
<td>1 in 1,000: Kills immediately.</td>
</tr>
<tr>
<td></td>
<td>1 in 10,000: All movement stopped in 1/2 hour; dead in 3 hours.</td>
</tr>
<tr>
<td></td>
<td>1 in 20,000: Swimming stopped in 2 minutes; some creeping.</td>
</tr>
<tr>
<td>Fresh chlorinated lime</td>
<td>1 in 30,000: Kills at once.</td>
</tr>
<tr>
<td></td>
<td>1 in 50,000: Dead in 8 minutes.</td>
</tr>
<tr>
<td></td>
<td>1 in 100,000: Actively swimming after 1/4 hours.</td>
</tr>
<tr>
<td></td>
<td>1 in 500,000: Active after 3 hours.</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>1 in 1,000: Immediate immobilization.</td>
</tr>
<tr>
<td></td>
<td>1 in 5,000: Actively swimming after 2 hours.</td>
</tr>
<tr>
<td>Chloroform water</td>
<td>1 in 1,000: Paralyzes swimming; ineffective creeping movements. On addition of water swimming regained in 5 minutes.</td>
</tr>
</tbody>
</table>

**Effect of Temperature on Metamorphosis.**

Many trematodes undergo their larval metamorphosis in molluscs during certain months of the year. Looss [290] remarked that in Egypt when the temperature falls in winter to about 5° to 6° C. the growth and multiplication of larval trematodes is sometimes wholly suspended, while in Central Europe it is only retarded at this temperature. Autumn seemed to be the most favourable period for fresh infections of intermediate hosts. During winter young parasites develop little by little but only reach the stage of cercarial production in the warm season. The appended table shows the monthly variations in the temperature of water near Cairo.

During February we found sporocysts containing secondary sporocysts and bifid-tailed cercariae in *Planorbis mareoticus*. In March eyed bilharzia cercariae were found also in this species. Non-eyed bilharzia cercariae were first detected in *P. boissyi* on April 17 and in *Bullinus* on June 8. Once located, the cercariae were obtainable when desired up to the time of our departure in July. It would appear, therefore, that infection is by no means
confined to the autumn as has been generally supposed, but may be contracted during the greater part of the year.

**Penetration.** Free swimming cercariae could not be recovered from infected waters, as they pass through the finest silk mesh. They readily pass through stocking material, and, given time, will succeed in traversing several inches of sand if there is a continuous flow of water through it. Unlike the ankylostome larvae, they are unable to traverse ordinary filter-paper.

**Temperature of Nile Water at Hawamdia, near Cairo.**

<table>
<thead>
<tr>
<th>Month</th>
<th>6 a.m. (deg. C.)</th>
<th>4 p.m. (deg. C.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>14.2</td>
<td>14.8</td>
</tr>
<tr>
<td>February</td>
<td>10.8</td>
<td>12.9</td>
</tr>
<tr>
<td>March</td>
<td>16.1</td>
<td>18.1—18.6</td>
</tr>
<tr>
<td>April</td>
<td>20</td>
<td>21.9</td>
</tr>
<tr>
<td>May</td>
<td>22.4</td>
<td>24.4</td>
</tr>
<tr>
<td>June</td>
<td>25.7</td>
<td>27.4</td>
</tr>
<tr>
<td>July</td>
<td>26.7</td>
<td>28.1</td>
</tr>
<tr>
<td>August</td>
<td>26.8</td>
<td>27.8</td>
</tr>
<tr>
<td>September</td>
<td>25.5</td>
<td>26.5</td>
</tr>
<tr>
<td>October</td>
<td>25</td>
<td>25.5</td>
</tr>
<tr>
<td>November</td>
<td>21.9</td>
<td>21.9</td>
</tr>
<tr>
<td>December</td>
<td>16.8</td>
<td>17</td>
</tr>
</tbody>
</table>

(From "The Physiography of the Nile," by G. H. Lyons.)

**Practical Conclusions.**

From the above it may be concluded that unfiltered water taken from canals, ditches, or birkets would be rendered safe:

1. If kept beyond the survival period of the cercaria, i.e., for forty-eight hours.
2. If heated to 50°C, a temperature at which the cercaria is immediately killed.
3. If previously treated with those chemicals that are lethal to the cercaria.

The chemical sterilization of water is chiefly effected by the use of 
(a) sodium bisulphate, and (b) chlorine. These two substances react upon cercaria very differently in the strength at which they are more commonly used for the destruction of bacteria in water.

**Chemical Sterilization.** (A) Sodium bisulphate is used in "tabloid" form to sterilize water for drinking purposes. Two "tabloids" are dissolved in a quart water-bottle as a rule. Each "tabloid" contains 16 gr. (1 grm.). This gives a dilution of 1 in 567. In a previous paragraph it was shown...
that a dilution of 1 in 1,000 was quickly lethal to the bilharzia cercaria. These "tabloids" may therefore be used with safety in bilharzia-infected countries.

(B) The germicidal value of chlorine for *Bacillus coli* according to Captain Nesfield is 1 in 760,000 acting for ten minutes. 1 in 1,000,000 acting for half-an-hour is in common use. There is one part of available chlorine in three parts of fresh chlorinated lime. One part of chlorinated lime in 300,000 with half-an-hour's contact is therefore an efficient bactericide. From the tabulated effects of chemical reagents on the cercaria it will be seen that this dilution would not have the slightest effect upon the activity of the bilharzia cercaria. It would be necessary to use twenty parts of bleaching powder per 1,000,000, and afterwards to dechlorinate in order to render water taken from the canals and ditches in Egypt free from bilharzia infection.

Attention should be given to the following points:

1. Personal contact of any kind with unfiltered water is risky. The surface of the water is the most likely to be infective as the cercariae congregate there. An intake pipe should always be led therefore to the centre of the stream and should draw the water from near the bottom and at a place where there is little or no vegetation.

2. It is essential in drawing water for storage, in order to destroy the bilharzia cercaria, that no infective mollusc be admitted. This can be ensured by screening the intake pipe with gauze having about sixteen meshes to the linear inch. The common mosquito gauze or phosphor-bronze wire gauze is very serviceable.

3. The water in the wells and "sakias" may be regarded as much safer than that from other sources. Hitherto molluscs have not been found in these wells.

4. Shallow barrel sand-filters are open to suspicion. It has been found experimentally that after fifteen minutes cercariae succeed in passing in large and increasing numbers through four inches of desert sand.

5. Although the reproductive activity of bilharzia in the molluscs is probably most intense during the summer months the occurrence of mature cercariae in infected molluscs in February shows that there is a certain liability to the infection throughout the year.

(To be continued.)
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(To be continued.)
THE CAUSATION AND PREVENTION OF ENTERIC FEVER IN MILITARY SERVICE, WITH SPECIAL REFERENCE TO THE IMPORTANCE OF THE CARRIER.

BEING AN ACCOUNT OF WORK DONE AT NAINI TAL ENTERIC DEPOT, 1908-11.

BY MAJOR D. HARVEY.¹
Royal Army Medical Corps.

(Continued from p. 120).

NOTES ON CARRIERS AT THE DEPOT IN 1908.

(1) On April 27, Private H., Bedford Regiment, was found to be passing typhoid bacilli in his faeces. This man had had a severe attack of enteric fever in Jhansi in March, 1907, and had been at Kasauli from June, 1907, to March, 1908. He arrived at Naini Tal in April, 1908. While at Kasauli his excreta were for a time examined daily, and he passed typhoid bacilli frequently, at first both in his faeces and urine, latterly only in his faeces and at longer intervals. The bacillus was again isolated from the stools at Naini Tal on several occasions, and as there was no doubt that this man was a chronic carrier, his name was submitted to headquarters, and he was invalided home in November, 1908. This man looked pale, but stated that he felt perfectly fit. He had no symptoms of cholecystitis, and as his serum only gave a low index for typhoid, there was really no indication of his condition. A vaccine was prepared from the strain isolated from the faeces, but owing to pressure of other work I was unable to proceed with this line of treatment.

On November 25, 1908, the day before he left the depot for England, the Bacillus typhosus was again isolated from the faeces.

\[
\begin{array}{ccc}
\text{Agglutination} & 20 & 40 & 100 \\
\text{Stock strain} & \pm & - & - \\
\text{Own strain} & - & - & - \\
\end{array}
\]

Phagocytic index, average five per cell.
Opsonic index, average less than one per cell.

The examinations of this man were continued in England, He was invalided out of the Service in 1910, and is still a carrier (1911).

¹ Now Lieutenant-Colonel.