The Central African Journal of Medicine

Editor:
MICHAEL GELFAND, C.B.E., M.D., F.R.C.P.

Assistant Editor:
JOSEPH RITCHKEN, M.D.

Volume Eighteen

JANUARY - DECEMBER

1972

SALISBURY : RHODESIA

The effect of Natural Alkaline Waters upon the Ova and Miracidia of *Schistosoma haematobium*

BY

PETER R. MORGAN,
Chancellor College, University of Malawi.

INTRODUCTION

Although schistosomiasis is widespread in the plain surrounding Lake Chilwa, Malawi, repeated attempts to locate infected carrier snails in the lake itself have so far failed. There is a high degree of contact between the marginal human population and the lake and *Bulinus globosus,* one of the schistosome-carrying snails, is abundant. Areas of heavy human infection are often associated with freshwater swamps and streams which run into the lake, and the most extensive of these occurs around the Domasi stream (Fig. 1.) where 100 per cent. of school children are infected either with *S. haematobium* or *S. mansoni.* The dispensary at Chamba (Fig. 1.) also reports a high incidence of schistosomiasis, the source being an unhealthy swamp, and the Makwapala dispensary near the Likangala River reports the occurrence of *S. haematobium* contracted from water holes in the area. The Likangala River, one of the largest flowing into the lake has a fairly low incidence of *S. haematobium,* and the nearby Chinese rice farm reports a negligible number of cases. Further north, where the population is scattered, there are numerous cases of schistosomiasis, and it is thought that sufferers initially contracted their disease in the Domasi stream area (McCleery, pers. comm.).

One might have expected a relatively high incidence of snail infection in waters which drain from areas where schistosomiasis is common but the snail collections of earlier workers were without infection (McLachlan, pers. comm.), and a more recent collection of 1 300 snails taken in February, 1971, along the southern shores of Kachulu Bay were also uninfected. Of these snails 7 per cent. released harmless unforked cercaria, and 0,08 per cent. released forked cercaria, but the latter belonged to the family Clinostomatidae. The remainder had no patent infection. These results were indicative of a very low rate of transmission of the disease in the month and site tested.

The apparent low level of infection at this site may have been caused by the quality of the lake water which is both turbid and alkaline, unlike the freshwater streams and lagoons which seem to act as potential sources of human infection. The present paper describes the effects of Lake Chilwa water upon the ova and miracidia of *S. haematobium.*

MATERIALS AND METHODS

The percentage patent infection of *Bulinus* was determined by first washing the snails thoroughly in tap water, and then placing individuals into 3 x 1 inch glass tubes containing one inch of distilled water. These were placed under a strong light and after a few hours infected snails released cercaria which could be readily observed.

The effects of lake water on the ova and miracidia were studied in a constant temperature room (23°C±1°C) under constant illumination. Measurements were made on the percentage hatching rate of ova, the mean hatching time of ova and the life span of miracidia in a series of water samples with increasing concentration. Natural lake water was either diluted with deionised water or concentrated by slow evaporation to make up a series of concentrations equivalent to 100, 2 000, 4 000, 6 000 and 8 000 μmho/cm. conductivity. Before use the lake water was alowed to settle and lose it turbidity.

The percentage hatching rate of ova was determined by diluting $\frac{1}{4}$ ml. infected urine sediment with 15 ml. lake water, allowing three hours for hatching and observing the resulting centrifugal sediment on a glass slide with a microscope. Individual counts were made of the unhatched ova and the ova cases (representing hatched ova) for samples diluted in the range of lake waters indicated above. Records of hatching time were made by diluting ova as above and placing 15 eggs selected at random under the field of a high power binocular microscope. The period of time elapsed between dilution and hatching was recorded for each ovum in samples diluted with the range of lake waters.

The mean life span of miracidia was determined by pippetting small numbers (3 to 6) of recently hatched individuals into a series of small glass observation vessels containing 2 ml. lake water. Two experiments were run, 20 vessels being used in each with four for each concentration of lake water. To reduce the concentrative effects of evaporation each vessel was placed within a petri dish partly filled with water. Each vessel was observed at regular intervals through a microscope, a note being made of the number of living miracidia on each occasion until all had perished.

RESULTS

The results, illustrated graphically in Fig. 2 and tabulated in Table 1. indicate that alkaline waters

Table 1

EFFECTS OF L.-CHILWA WATER ON OVA AND MIRACIDIA OF *S. haematobium*.

Conductivity μmho/cm.	Alkalinity meq/1.	pH	Mean life span of Miracidia	Ova % hatching	Ova, mean hatching time
100	1,0	8,0	638,9 mins (36)	87,2% (447)	18,2 mins (15)
2 000	13,0	8,4	579,9 mins (38)	85,9% (264)	19,5 mins (15)
4 000	23,0	9,0	415,3 mins (42)	69,1% (777)	24,7 mins (15)
6 000	34,0	9,2	169,9 mins (40)	30,7% (862)	40,6 mins (15)
8 000	46,0	9,4	55,6 mins (31)	18,0% (874)	67,6 mins (15)

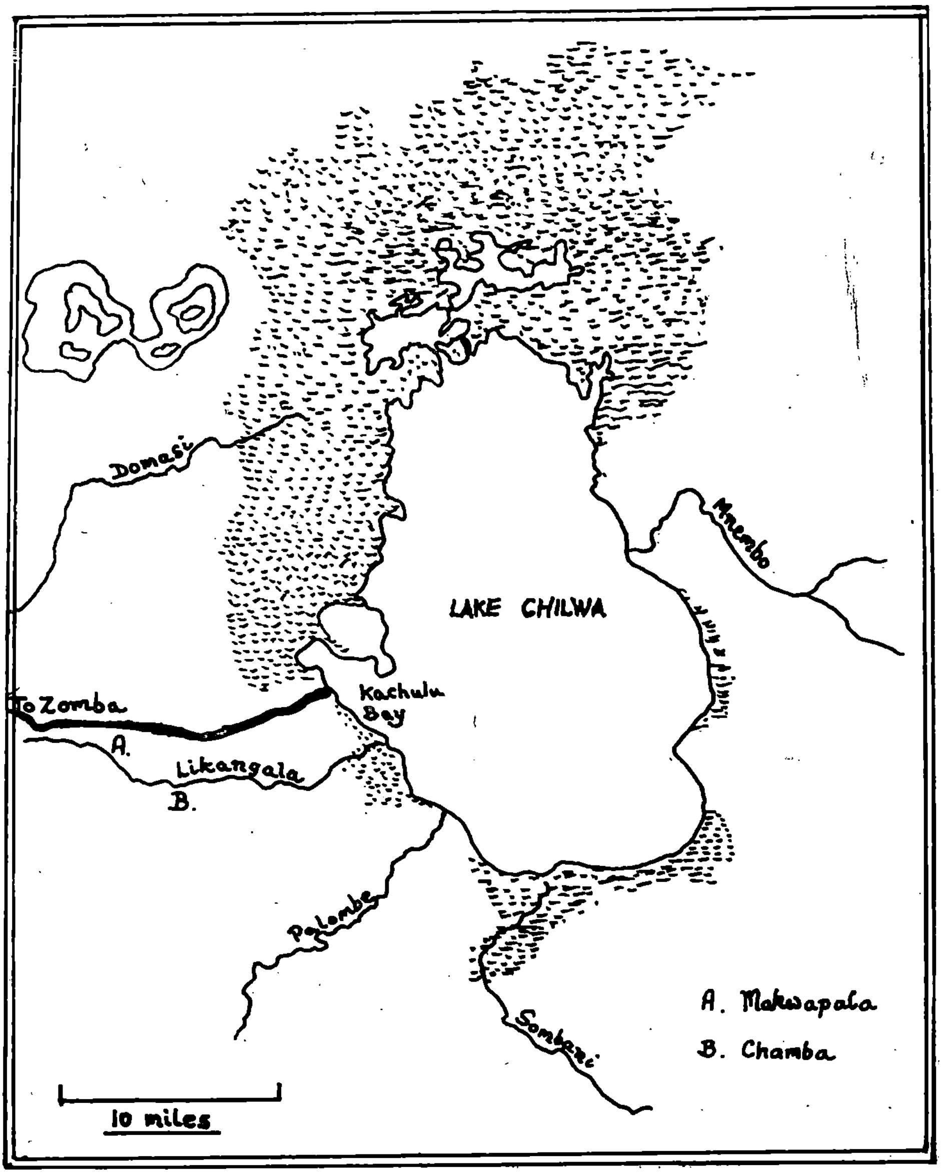

Fig. 1. — Map of Lake Chilwa area showing main rivers. Shaded areas are swamp.

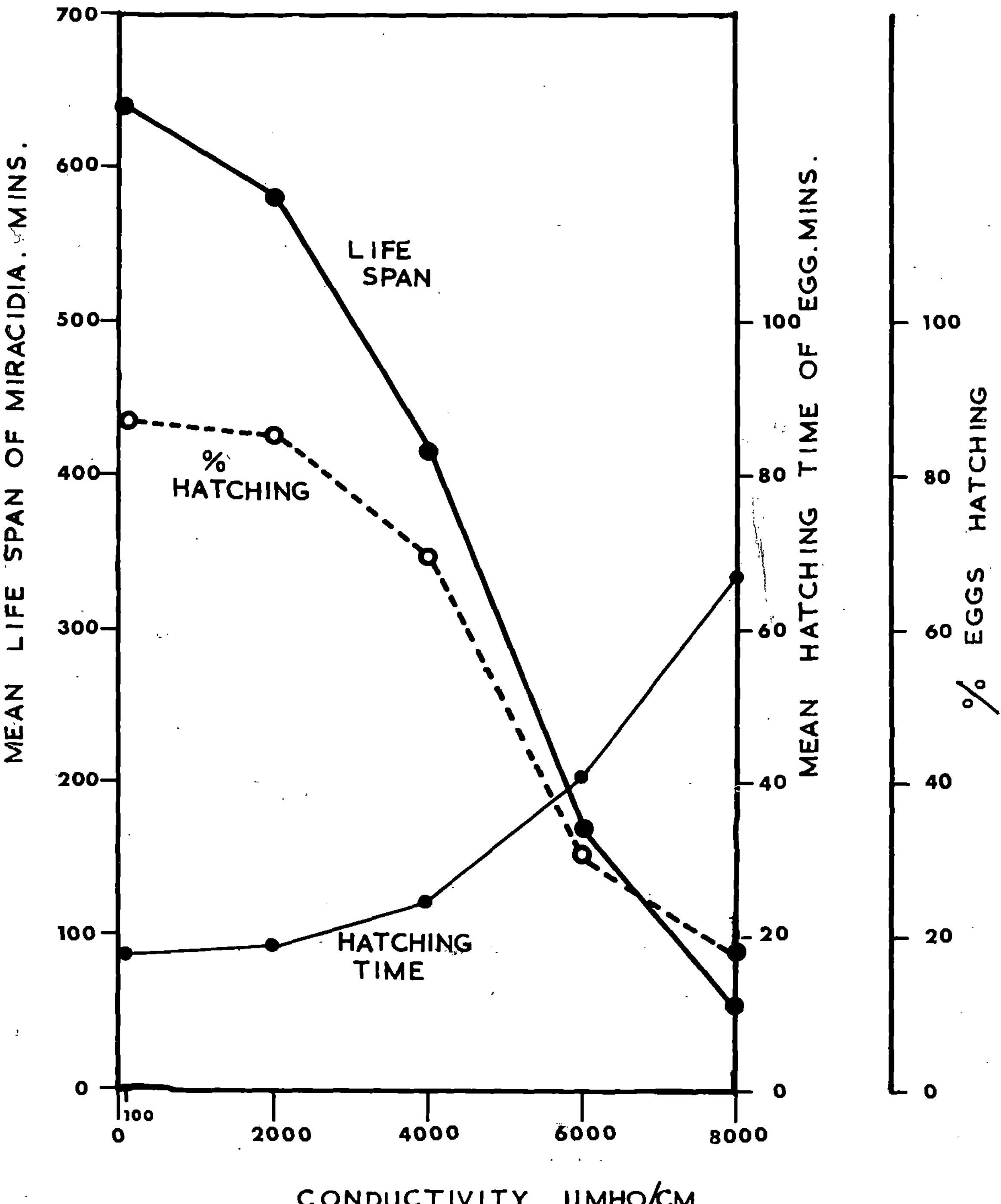

Fig. 2—Effects of L. Chilwa water on Ova and Miracidia of *S. haematobium*.

can have a pronounced effect on the ova and miracidia of *S. haematobium* if the concentration of the water is high. In experimental conditions the maximum longevity for individual miracidia was 15 hours at 23°C, the mean value for the lowest water concentration being 10,6 hours. This value was reduced to 6,9 hours at 4 000 μmho/cm. and slightly less than one hour at 8 000 μmho/cm. At high concentrations miracidia became dumbell shaped as a result of dehydration. Ova became less viable at higher alkalinities and also took longer to hatch. Over the range of concentrations tested, the mean hatching time was increased from 18,2 minutes to 67,6 minutes at 23°C, and the percentage hatching of ova decreased from 87,2 per cent. to 18,0 per cent., the latter value being at the highest concentration. The minimum individual hatching time was 13 minutes.

DISCUSSION

Waters of high salinity are known to inhibit the hatching of both *S. mansoni* and *S. haematobium* ova (CHERNIN and BOWER, 1971; HIRA, 1967), and hatching, for *S. haematobium,* is said to take place ideally in the narrow pH range of 7 to 8 (HIRA, 1967). Consequently the alkaline waters of L. Chilwa, which have a pH range of 8,0-10,8 (MORGAN and KALK, 1970), might be expected to inhibit hatching. During hatching which is partly controlled by an osmotic mechanism the initial rate of water uptake by the ovum would depend on the osmotic tension of the surrounding water, and would be reduced where this was more concentrated. Despite this, miracidia of *S. mansoni* are known to successfully emerge in 12,5 per cent sea water (CHERNIN and BOWER, 1971), although *S. haematobium* appears to be considerably less tolerant (HIRA, 1967). Once hatched, the longevity of the miracidium depends on many factors, and where the rate of metabolism is increased as a result of increased temperature, for instance, the larval life may be considerably reduced (FARLEY, 1962; HIRA, 1968). Similarly, larval life may be reduced where the osmoregulatory rate is increased in waters of high salt content, possibly because the rate of uptake of limited metabolic reserves is increased. Inhibition of the hatching of ova and limitation of the longevity of miracidia would considerably lessen the chances of snail infection.

In common with many other shallow alkaline lakes the waters of L. Chilwa become concentrated during the dry season and rapidly diluted during the rains. L. Chilwa dried up in 1968, but was reflooded in 1969, and since that time the conductivity has not exceeded 3 000 μmho/cm. Experimental results suggest that where the conductivity of L. Chilwa rises above 4,000 μmho/cm. the life cycle of *S. haematobium* may be seriously affected, but at lower values the influence is much less intense. When the lake is high the seasonal variation in conductivity lies between 500 and 3 000 μmho/cm., and under such conditions the salt content of the water may have little effect on the transmission of schistosomiasis. However during severe recessions which occur periodically, water concentrations rise considerably and the conductivity peak for 1966 was 12 000 μmho/cm., being over 30 000 μmho/cm. for 1967 and 1968. During these years the salt content of L. Chilwa may have inhibited the transmission of the disease in the lake. The conductivity of the collecting site of February, 1971 was only 1 000 μmho/cm. however, and the concentration of the water alone did not offer an explanation for the apparent low level of transmission.

Another factor which is known to influence the hatching of ova is the intensity of light (STANDEN, 1951; SUGIURA, *et al.,* 1954; HIRA, 1967). One of the most noteable features of L. Chilwa is its marked turbidity, due largely to the presence of fine grained inorganic particles maintained in suspension by wave action. Spectrographic analysis of unfiltered water samples taken in late 1970 indicated that the depth at which light was reduced to 1 per cent. of its surface intensity was always less than 50 cms. (McLachlan *et al.* in preparation). The intensity of light at the mud bottom where ova would tend to settle would be neglible and this feature alone might seriously inhibit the hatching of ova and the release of miracidia. According to HIRA (1967), the speed of hatching is dependent on the intensity of light. In a laboratory experiment 89 per cent. of *S. haematobium* ova hatched within three hours in daylight, but only 12 per cent. hatched in a similar period in total darkness. No difference was noticed however where the incubation period was increased to 24 hours. In this respect it is relevant to discuss the possible situation in L. Chilwa. If eggs were released into the turbid waters of the lake they would sink into reduced light conditions which might suppress the speed of hatching. On coming into contact with the mud at the bottom any unhatched ova might suffer oxygen depletion as the mud has a very high oxygen demand (MORGAN, 1971; 1972) and tends to deoxygenate the water immediately above it. It is therefore possible that contact with the mud bottom would further suppress the hatching ability of ova, although experimental evidence would be necessary to establish this.

Single sources of snail infection are known to induce considerable areas of human infection (VAN EEDEN, 1966; HIRA, 1969) and the prevalence of schistosomiasis in the Chilwa plain may result from a series of focal points such as the Domasi stream and Chamba swamp. It is possible that in this respect the situation is similar to that described by WEBBE and JORDAN (1966) for Lake Victoria, where most of the transmission is confined to the streams of the coastal plain rather than the body of the lake itself.

Although there appeared to be no lack of *Bulinus globosus* during the surveys of 1970 and 1971 in L. Chilwa, it is possible that the successive periods of flood and desiccation, especially at the margins of the lake, may restrict the excessive multiplication of snails. The work of SHIFF (1964) has shown, however, that *B. globosus* is a remarkably successful species in fluctuating or temporary habitats, especially if the temperature is high and consequently the mean generation time is short.

In Lake Chilwa elevated levels of alkalinity and high pH together with considerable turbidity and relatively high temperatures of the water may, when their effects are combined, lead to a reduction of the transmission of schistosomiasis in the lake itself. A great deal of further work is necessary, however, for the snails so far collected and examined have been taken from a limited area and not throughout the year. The full effects of L. Chilwa water on the life cycle of *Schistosoma*, the distribution and percentage infection of *Bulinus*, and the distribution patterns of the disease itself all deserve further investigation. Such studies may be of epidemiological importance since any factor which influences the rate of infection of snails also affects the transmission of the disease itself.

ACKNOWLEDGEMENTS

I am indebted to the staff of the Queen Elizabeth Central Hospital, Blantyre, for their generous co-operation in the supply of urine samples. Sincere thanks are also due to Dr. C. J. Shiff, for his advice and identification of cercaria, and for his examination of the manuscript.

REFERENCES

CHERNIN, E. & BOWER, C. (1971). Experimental transmission of *Schistosoma mansoni* in brackish waters. *Parasitology*, 63, 31-36.

FARLEY, J. (1962). The effect of temperature and pH on the longevity of *Schistosoma douthitti* miracidia. *Can. J. Zool.*, 40, 615-620.

HIRA, P. R. (1967). Studies on the hatching of *Schistosoma haematobium* Ova and some factors influencing the process. *J. West Afric. Sci. Assoc.* 12, 2, 95-102.

HIRA, P. R. (1968). Studies on the Miracidia and Cercaria of *Schistosoma haematobium* Bilharz. *J. West. Afric. Sci. Assoc.* 13, 2, 165-172.

HIRA, P. R. (1969). Transmission of Schistosomiasis in Lake Kariba, Zambia. *Nature*, 224, 670-672.

MORGAN, A. & KALK, M. (1970). Seasonal changes in the waters of Lake Chilwa (Malawi) in a drying phase, 1966-68. *Hydrobiologia*, 36, 1, 81-103.

MORGAN, P. R. (1971). The Lake Chilwa *Tilapia* and its fishery. *Afric. J. Trop. Hydrobiol. Fisheries* (1. 51-58).

MORGAN, F. R. (1972). Studies of Mortality in the endemic *Tilapia* of Lake Chilwa (Malawi). *Hydrobiologia* (in press).

SHIFF, C. J. (1964). Studies on *Bulinus (Physopsis) globosus* in Rhodesia. III. Bionomics of a natural population existing in a temporary habitat. *Ann. Trop. Med. Parasit.* 58, 240-255.

STANDEN, O. D. (1951). The effects of temperature, light and salinity upon the hatching of the ova of *Schistosoma mansoni*. *Trans. Roy. Soc. Trop. Med. Hyg.*, 45, 225-241.

SUGIURA, S., SASKI, T., HOSKA, Y., & ONO, R. (1954). A study of several factors influencing the hatching of *Schistosoma japonicum* eggs. *J. Parasit.*, 40, 381-386.

VAN EEDEN, J. A. (1966). The intermediate hosts—their ecology and distribution. Symposium on Bilharzia. *South African Institute for Medical Research.*

WEBBE, G., & JORDAN, P. (1966). Recent advances in knowledge of Schistosomiasis in East Africa. *Trans. Roy. Socd. Trop. Med. Hyg.*, 60, 279-306.