Annals of Tropical Medicine and Parasitology, Vol. 85, No. 4, 443–446 (1991)

Shade as a means of ecological control of *Biomphalaria pfeifferi*

By M. LOREAU

Department of Animal Biology, C.P. 160, Université Libre de Bruxelles, 50 avenue F.D. Roosevelt, B-1050 Brussels, Belgium

AND B. BALUKU

Centre de Recherches en Sciences Naturelles, Lwiro, DS Bukavu, Zaire

Received 7 May 1990, Revised 11 November 1990, Accepted 7 January 1991

Species of *Biomphalaria* are attracted to light and negatively affected by darkness. Artificial shading of a breeding-site eliminated a population of *B. pfeifferi* within six weeks. The site was recolonized by eight weeks after the shade was removed. The time taken for recolonization suggests that shade acts not only by affecting snail behaviour but also indirectly by removing the diatoms which are food for the snails. The use of natural shade for ecological control of some snail vectors of schistosomiasis deserves, at least, careful consideration.

Attempts at controlling snail intermediate hosts of schistosomes have to a large extent rested on the use of molluscicides. This solution has several drawbacks, among which are its cost, the need for repeated use, and the need for qualified staff. Many other methods of ecological and biological control have been proposed (Jordan *et al.*, 1980; McCullough, 1981; Thomas and Tait, 1984; WHO, 1987*b*), but they remain little used at the present time, indeed they are of uncertain value. Therefore chemotherapy and research into the prospects of immunological intervention are now being given precedence over control of vector snails (WHO, 1985, 1987*a*). Our studies on the ecology of the snail *Biomphalaria pfeifferi* in Zaire suggested an extremely simple method for its ecological control: providing shade by reforestation of stream sides (Baluku *et al.*, 1989). Here we provide field experimental evidence for the potential effectiveness of this method.

Shade has generally been considered to be favourable to freshwater molluscs, which avoid strong sunlight (Thomas and Tait, 1984). However, recent laboratory experiments showed that *Biomphalaria* species are attracted to light (Schall *et al.*, 1985, 1986*a,b*) and negatively affected by darkness (El-Emam and Madsen, 1982). The field distribution of *B. pfeifferi* is also limited by tree cover (Baluku *et al.*, 1989). There are probably two components to the negative effect of strong shade on *B. pfeifferi*: a direct, behavioural component (El-Eman and Madsen, 1982; Schall *et al.*, 1985, 1986*a,b*), and an indirect, ecological component, shade reducing the abundance of diatom algae on which this species feeds (Baluku *et al.*, 1987).

Our field experiment was intended as a first test of the effect of shade on the population density of *B. pfeifferi.* It was carried out from October 1988 to April 1989 in the Gaho stream in Lwiro (Zaire, longitude 28°48′E, latitude 2°15′S, altitude 1740 m). This stream has been converted to a concreted canal over a length of 7·5 m. This canal was divided into three zones each 2·5 m long. During the first part of the experiment (the first 15 weeks) the first zone (A) was shaded artificially with a dense cover of banana leaves on a wooden matrix, which blocked almost all the direct incident light. The

0003–4983/91/040443+04 $03.00/0

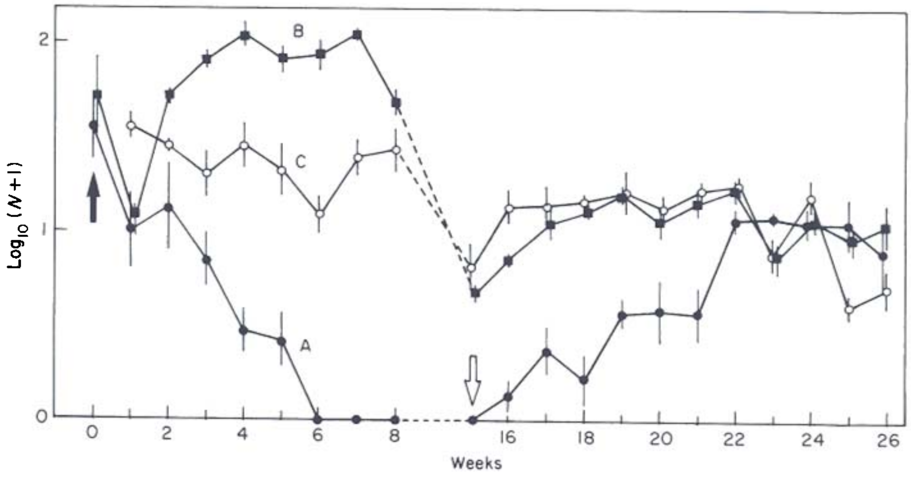

Fig. Changes in the population density (mean ± 1 S.E.) of *Biomphalaria pfeifferi* in the three zones from the commencement of the experiment. A, experimentally shaded zone; B, control zone without aquatic vegetation; C, control zone with aquatic vegetation. The density (*N*), expressed as the number of individuals in a 25 × 25 cm quadrat, is log-transformed. The black arrow indicates the laying of cover in zone A, and the white arrow indicated the removal of the cover. Sampling was interrupted from weeks nine to 14.

other two zones served as controls: zone B was devoid of aquatic vegetation, as was zone A; zone C contained abundant natural aquatic vegetation. During the second part of the experiment the artificial cover was removed from zone A. Snails on the canal walls were counted each week using six 25 × 25 cm quadrats in each zone (three on each side of the canal, placed in the middle 75 cm of the zone to avoid side effects). Sampling was unavoidably interrupted for six weeks because one of us had health problems.

During the first part of the experiment a marked reduction in the *B. pfeifferi* population density in zone A, a temporary increase in the density in zone B due to migration from zone A, and a roughly stable density in zone C (where the population present in the aquatic vegetation should act as a buffer against density fluctuations on the canal walls), were expected. During the second part of the experiment, recolonization of zone A was expected. Although the experimental design did not allow proper discrimination between the behavioural and ecological components of the effect of shade, the time-scale of recolonization was taken as an indication of the importance of the ecological component. Relying on estimates of movements of *B. pfeifferi* in the field (Balaku, 1987), this recolonization was expected to take place within a few days if only a behavioural response was involved, but over a longer period in the order of several weeks if recolonization by diatoms was a limiting factor.

The results fully accorded with expectations (Fig.). *Biomphalaria pfeifferi* was completely eliminated from the shaded zone within six weeks, and recovered to the same density as in the other zones within eight weeks after removal of the artificial cover. The lower overall density during the second part of the experiment is explained by normal seasonal population fluctuations (Loreau and Baluku, 1987). The long duration of recolonization supports the hypothesis that shade acts indirectly through its effects on food resources, but this obviously requires further investigation.

Our experiment clearly demonstrates that shade is potentially an effective means of controlling the schistosomiasis vector snail *B. pfeifferi*. Although light could diffuse laterally along the canal, the thick experimental cover we used provided an artificially dense shade. However, even the natural shade of banana trees might be sufficient to reduce populations of *B. pfeifferi* considerably, as suggested by the 50-fold drop in density which was observed fortuitously by Baluku *et al.* (1989) following the planting of banana trees along another stream.

A quarter of a century ago Jackson (1965) pleaded eloquently for reforestation along natural waters to fight against the spread of schistosomiasis. Our findings show that this potential means of ecological control deserves, at the least, careful consideration, especially since it is natural, easy to carry out, and free. With the prospect of increasing deforestation and shortage of wood in Africa, tree galleries along streams could become assets managed by local communities. It must be borne in mind, however, that shade might possibly favour other schistosomiasis vector snails such as *Bulinus* species, which seem more tolerant of shade. In regions where *Bulinus* also are likely to transmit schistosomiasis, the planting of banana trees might be a good choice because these produce relatively few dead leaves on which *Bulinus* might feed. Banana trees could also be used in agricultural plots along drains that need periodic cleaning with a machine, for their rapid growth allows restoration of shade cover within a few months after cutting. In any event, further work on the effects of natural shade on snail vectors of schistosomaisis is urgently required.

ACKNOWLEDGEMENTS. We thank G. Josens for his comments on the manuscript, and N. Van Mol for preparing the Figure.

REFERENCES

BALUKU, B. (1987). *Contribution à l'étude des hôtes intermédiaires des bilharzioses: écologie des mollusques dulcicoles dans deux cours d'eau du Zaïre oriental.* Doctoral dissertation, Université Libre de Bruxelles.

BALUKU, B., JOSENS, G. & LOREAU, M. (1987). Le régime alimentaire de *Biomphalaria pfeifferi (Gastropoda: Planorbidae) au Zaïre oriental. Revue de Zoologie africaine,* **101**, 279–282.

BALUKU, B., JOSENS., G. & LOREAU, M. (1989). Etude préliminaire de la densité et de la répartition des mollusques dans deux cours d'eau du Zaïre oriental. *Revue de Zoologie africaine,* **103**, 291–302.

EL-EMAM, M. A. & MADSEN, H. (1982). The effect of temperature, darkness, starvation and various food types on growth, survival and reproduction of *Helisoma duryi, Biomphalaria alexandrina* and *Bulinus truncatus* (Gastropoda: Planorbidae). *Hydrobiologia,* **88**, 265–275.

JACKSON, J. H. (1965). Bilharziasis: an approach to the control of an endemic disease with particular reference to Natal and Zululand. *South African Journal of Medicine,* **39**, 152–158.

JORDAN, P., CHRISTIE, J. D. & UNRAU, G. O. (1980). Schistosomiasis transmission with particular reference to possible ecological and biological methods of control. *Acta tropica,* **37**, 95–135.

LOREAU, M. & BALUKU, B. (1987). Population dynamics of the freshwater snail *Biomphalaria pfeifferi* in Eastern Zaire. *Journal of Molluscan Studies,* **53**, 249–265.

MCCULLOUGH, F. S. (1981). Biological control of the snail intermediate hosts of human *Schistosoma* spp.: a review of its present status and future prospects. *Acta tropica,* **38**, 5–13.

SCHALL, V. T., JURBERG, P. & ROZEMBERG, B. (1986*a*). Orientation of the snail *Biomphalaria straminea* (Dunker, 1848) in response to light in a situation of selection. *Memorias do Instituto Oswaldo Cruz, Rio de Janeiro,* **81**, 255–263.

SCHALL, V. T., JURBERG, P. & VASCONCELLOS, M. C. (1986*b*). Behavioral responses to light by the snail *Biomphalaria tenagophila. Revista Brasileira de Biologia,* **46**, 127–138.

SCHALL, V. T., JURBERG, P. & VASCONCELLOS, M. C. (1985). Orientation to light of juvenile and adult forms of melanic and albino populations of *Biomphalaria glabrata* (Say, 1818). *Memorias do Instituto Oswaldo Cruz, Rio de Janeiro,* **80**, 101–111.

THOMAS, J. D. & TAIT, A. I. (1984). Control of the snail hosts of schistosomiasis by environmental manipulation: a field and laboratory appraisal in the Ibadan area, Nigeria. *Philosophical Transactions of the Royal Society of London, B,* **305**, 201–253.

WORLD HEALTH ORGANIZATION (1985). *Research on Tropical Disease.* 7th TDR report, Geneva: World Health Organization.

WORLD HEALTH ORGANIZATION (1987*a*). Prospects for immunological intervention in human schistosomiasis. *Acta tropica*, **44** (Suppl.), 12.
WORLD HEALTH ORGANIZATION (1987*b*). *Report of an Informal Consultation on the Detection, Isolation, Identification and Ecology of Biocontrol Agents of Disease Vectors*. Geneva: World Health Organization.