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Laboratory Studies on the Relation Between Aquatic Vegetation and the Presence of Two Bilharzia-Bearing Snail Species

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ABSTRACT

Investigations into the irrigation system of the Mansuriya District (Egypt) have pointed out that the occurrence of the two Bilharzia-bearing snails, *Biomphalaria alexandrina alexandrina* (Ehrenberg) and *Bulinus truncatus* (Audoruim), depends to a large extent on the aquatic vegetation. Laboratory experiments indicate that the absence of aquatic vegetation could have an important impact on the regeneration of the snails. The reproduction of snails is reduced significantly when there are fewer aquatic plants. Also, indirect effects (e.g. increased predation by omnivorous fish) could play an important role.

Key words: Biomphalaria alexandrina, Bulinus truncatus, Bilharzia, Schistosomiasis, Aquatic vegetation, Weed control, Omnivorous (molluscivorous) fish, *Tilapia zillii,* Irrigation management, Egypt.

INTRODUCTION

Bilharzia (Schistosomiasis), caused by a trematode (*Schistosoma sp.*), is a serious problem in Egypt, affecting a large proportion of the population. Bilharzia is transmitted by a watersnail of the species *Biomphalaria alexandrina alexandrina* (Ehrenberg) and *Bulinus truncatus* (Audoruim), which commonly occur in the vast irrigation systems of this country. It is generally assumed that the aquatic vegetation in the irrigation and drainage canals offers a favourable habitat to the snails (el Gindy, 1962; Dazoo *et al.*, 1966; Mitchell, 1977).

Field observations in the irrigation system of the Mansuriya District, near Cairo, have revealed that the presence of these snails is almost completely restricted to places with aquatic vegetation. During March-June 1982 ten waterways have been sampled 620 times with a dip-net on the occurrence of snails. The correlation between the presence of aquatic vegetation and the two species of snails was highly significant ($P < 0.005$) (van Schayck, unpublished data).

This correlation could be attributable to several factors. In this study, laboratory experiments were carried out in Egypt to investigate three factors that may affect the presence of snails: 1. the soft parts of aquatic plants, as well as unicellular algae attached to the plants, are important sources of food for the snail; 2. the leaves of aquatic plants offer a good substratum for egg deposition, and 3. the leaves of aquatic plants act as a shelter from predators. The effect of each factor on the presence of the snails was determined in three separate experiments.

MATERIALS AND METHODS

General set-up of the experiments. The experiments were carried out in aquariums filled with filtered water from the River Nile. The macrophytes used pondweed (*Potamogeton nodosus* Poir), waterhyacinth (*Eichhornia crassipes* (Mart.) Solms) and hornwort (*Ceratophyllum demersum* L.)) are common aquatic plants in Egypt. Pondweed and hornwort were planted in a layer of 5 cm washed sand. Sexually mature snails, that is snails with a diameter of more than 5 mm (el Gindy, 1960), were evenly distributed in the aquariums.

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Technical details. All aquariums were exposed to a regime of 12 hours of light and 12 hours of darkness. An air pump kept the oxygen concentration in aquariums with fish (experiment 3) at 8 ppm. In the other aquariums the oxygen concentration varied between 1 and 4.7 ppm. The temperature was 22 to 26 C and the calcium concentration in the water was 38 to 44 ppm.

Experiment 1: Dependence on macrophytes for food. For 47 days, 15 snails of one species per aquarium (20x20x20 cm) were fed on 50 to 100 cm^2 pondweed leaves or on 40 g detritus from the bottom of a drainage canal. In the latter case algae were injected. Each experimental group (i.e. one snail species on one type of food) consisted of 3 aquariums, so that in all there were 12 aquariums. Pondweed was selected for this experiment because it proved best able to survive the experiments under the prevailing conditions.

Once a week, living and dead snails were counted, their diameter measured, and the number of newly deposited egg masses and newly-emerged snails recorded. At the same time the water was refreshed, the leaves were replaced and an algae injection added. The detritus was replaced only once. The rate of oviposition (i.e. the total number of egg masses divided by the total number of mature snails per day) was calculated. In this calculation the dead snails were counted for half a week. The egg masses deposited on the walls of the aquariums were marked on the outside of the aquariums and those deposited elsewhere were removed in order to avoid confusion in following counts. The hatching ratio was expressed as the mean number of snails emerging per egg mass. The emerged snails were also removed.

Experiment 2: Dependence on macrophytes for oviposition. This experiment was carried out separately with pondweed and waterhyacinth for 14 and 16 days resp. For each snail species, 10 aquariums (50x45x30 cm) were used. The leaf plus stem surface area of the plants increased progressively by 75 cm^2 per aquarium, from 0 to 675 cm^2. The floating surface area of waterhyacinth was determined volumetrically. The surface area of non-plant material was about 6800 cm^2 in all aquariums. Together with pondweed, 23 *B. alexandrina* snails or 25 *B. truncatus* were introduced into each aquarium, and with waterhyacinth, 21 *B. alexandrina* or 20 *B. truncatus.*

Growth of the macrophytes was negligible. The rate of oviposition was calculated at the end of each period in the same way as in experiment 1.

Experiment 3: Dependence on macrophytes because of predation by omnivorous fish. The experiment was carried out in 10 aquariums (100x45x30 cm) with *Tilapia zillii* (Gerv.) for 15 days. This fish species, the main predator of snails in the irrigation system of the Mansuriya District, was fed on the two snail species. The fish were caught in the River Nile and used after some weeks of acclimatisation.

In 5 of the 10 aquariums 400 g of hornwort was planted. Hornwort was selected for this experiment because it provides shelter for snails against predation by *T. zillii.* In addition, it has been observed that *T. zillii* will feed on this species of plant. Thirty-four snails of the species *B. alexandrina* and 12 *B. truncatus* were introduced into each aquarium with two *T. zillii:* these were either of equal length (15 to 16 cm) or of dissimilar length (15 to 16 cm and 16 to 17 cm). One fish died during the experiment and was replaced by one of the same size. The aquariums were covered with nets to prevent *T. zillii* from jumping out, and they were surrounded with black plastic foil to prevent disturbance.

The number of snails that survived was determined at the end of the period.

RESULTS AND DISCUSSION

Whereas the presence of the Bilharzia-bearing snails, *B. alexandrina* and *B. truncatus,* seems to be restricted to places with aquatic vegetation, the question is raised whether the snails are directly or indirectly dependent on aquatic plants. Abdel Malek (1958) and Watson (1958) both concluded that snails can live and reproduce without aquatic vegetation. This study confirmed that, at least during a period of 47 days, the snails are not directly dependent on macrophytes: it was found that there was no clear difference in growth and mortality between *B. alexandrina* and *B. truncatus* fed on pondweed or on detritus. Although the soft parts of macorphytes and the periphyton growing on them are the favourite food sources (Abdel Malek, 1958 and el Gindy, 1960), the snails are not strictly herbivorous (Baker, 1945). In this respect the snails are not directly dependent on aquatic plants, but they may prefer a habitat with aquatic vegetation.

A more obvious reason for the fact that the presence of the snails correlates with aquatic vegetation, might be that both snail species have a strong preference for depositing their egg masses on plant material. The number of egg masses deposited on pondweed was 5 to 6 times higher than on the same surface area of non-plant material. On waterhyacinth it was even 90 to 100 times higher (table 1). The snails had at least equal possibility for depositing their egg masses on non-plant material, for at daytime they were more often found on non-plant material than on the macrophytes. The mean oviposition and hatching ratio were considerably higher when the snails were fed on a macrophyte (figure 1 and 2). Moreover, there was a significant increase in the egg production for both snail species, with an increase in the leaf surface area of pondweed ($P < 0.005$) (figure 3). However, an increase in the leaf surface area of waterhyacinth only caused a significant increase in egg production of *B. alexandrina,* whereas the egg production of *B. truncatus* decreased significantly ($P < 0.01$ and $P < 0.1$ respectively) (figure 4).

El Gindy (1960) and Heckmat (unpublished data) also concluded that Bilharzia-bearing snails tend to deposit their egg masses on hard, broad leaves. According to Pelwagora-Szumbewiez (1958) oviposition is stimulated by the oxygen produced by the plant. This last suggestion was

TABLE 1. RELATIVE PREFERENCE OF *B. alexandrina* AND *B. truncatus* FOR DEPOSITING EGG MASSES ON PONDWEED AND WATERHYACINTH IN COMPARISON WITH NON-PLANT MATERIAL.

	pondweed	waterhyacinth
B. alexandrina	5	91
B. truncatus	6	98

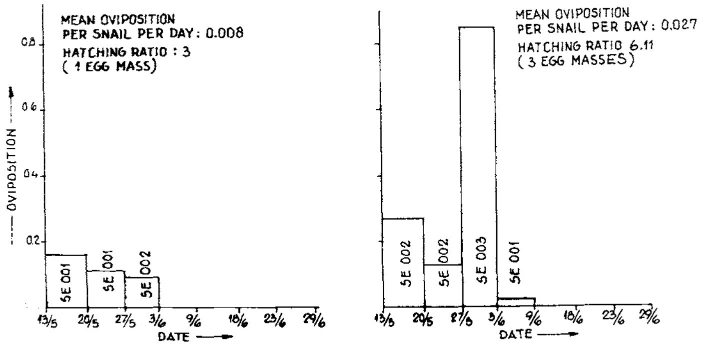
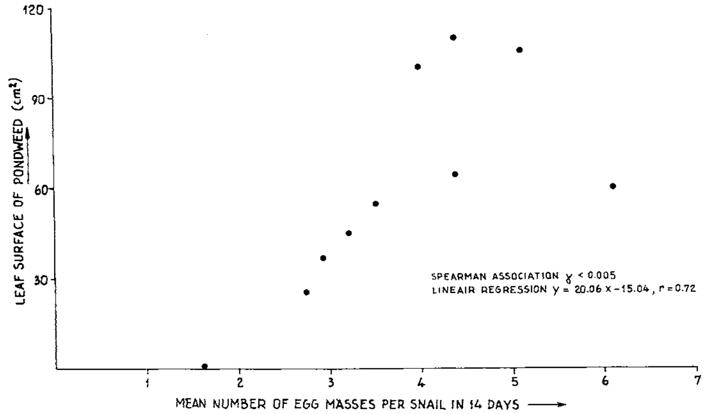


Figure 1. Mean and standard error (SE) of ovipostition (per snail) of *B. alexandrina* fed on detritus (left) and fed on pondweed (right).



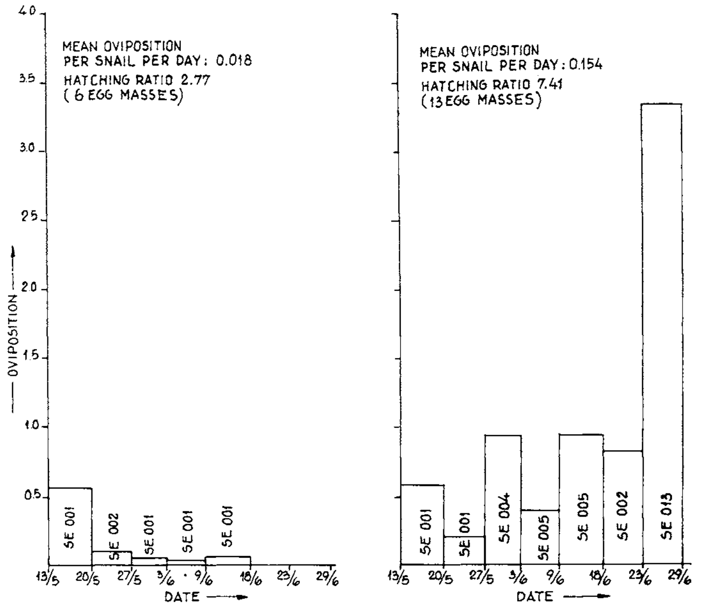


Figure 2. Mean and standard error (SE) of ovipostition (per snail) of *B. truncatus* fed on detritus (left) and fed on pondweed (right).

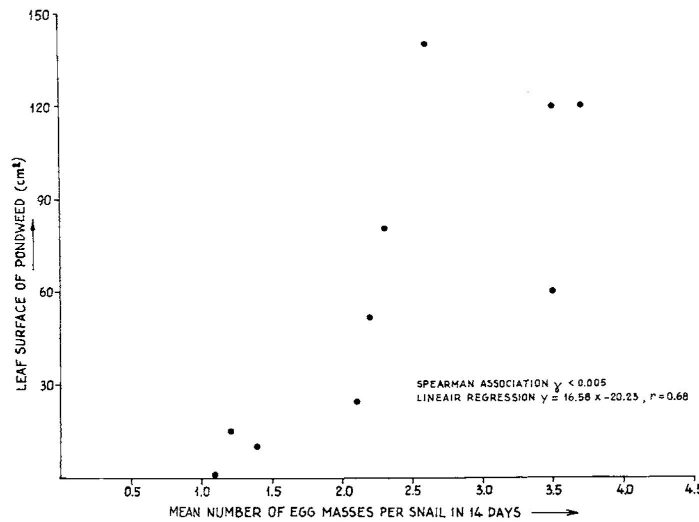


Figure 3a. (top) Relationship between the egg production of *B. truncatus* and the leaf surface area of pondweed and 3b. (bottom) Relationship between the egg production of *B. alexandrina* and the leaf surface area of pondweed.

not confirmed, since both species of snails strongly preferred to deposit their egg masses on waterhyacinth in comparison with non-plant material. The underwater parts of the floating waterhyacinth are white and do not produce oxygen. A better explanation for the preference for oviposition on plant material might be the presence of periphyton growing on the macrophytes, which is, according to Abdel Malek (1958), a very suitable food source for young snails.

A likely explanation for the decline in egg production of *B. truncatus* is to be found in the decreasing oxygen concentration caused by the increase in the leaf surface area of waterhyacinth (figure 4a). When the oxygen concentration is low, the egg production of *B. truncatus* will be reduced, according to Watson (1958).

Under optimum conditions in the aquariums both snail species produced 10 to 20 new-born snails per day. Reduction in the egg production could have an important effect on the regeneration of the snails.

In the irrigation system of the Mansuriya District, snails are liable to be eaten by three omnivorous fish species: *Tilapia zillii*, catfish (*Clarias lazera* Cuv. & Val.) and *Haplochromis spec.* Stomach analyses indicated that *T. zillii* consumed the highest proportion of Bilharzia-bearing snails (van Schayck, unpublished data). The predation on *B. alexandrina* and *B. truncatus* by *T. zillii* can be dependent on the presence of macrophytes in two ways: on the one hand, the vegetation may provide shelter for snails against the fish, while on the other hand, omnivorous fish may prey more readily upon snails if there is less plant food available (Coates and Redding-Coates, 1981). Our study showed that in laboratory conditions *T. zillii* consumed significantly more snails of both species when macrophytes were absent (*B. truncatus:* $P < 0.05$ and *B. alexandrina:* $P < 0.025$) (figure 5). Both snail species were consumed by *T. zillii* even when some parts of the hornwort plants remained. It is very likely that this phenomenon will also take place in nature. Investigations in Ghana have shown that omnivor-

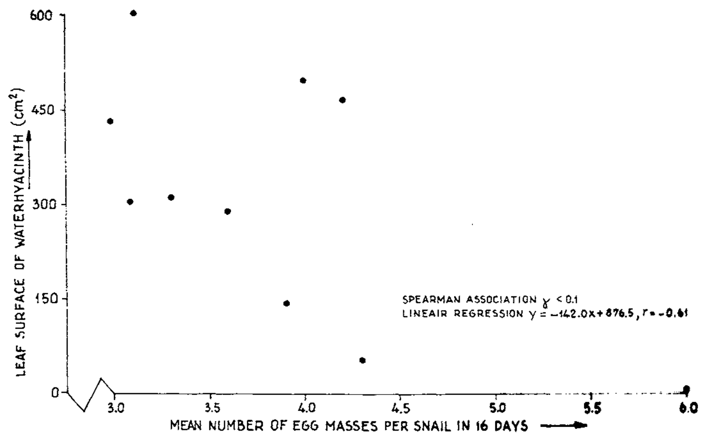


Figure 4a. Relationship between the egg production of *B. truncatus* and the leaf surface area of waterhyacinth.

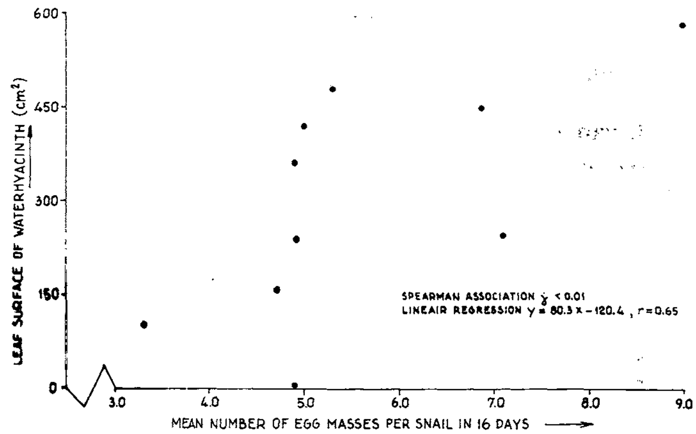


Figure 4b. Relationship between the egg production of *B. alexandrina* and the leaf surface area of waterhyacinth.

ous fish consumed considerably more snails when the aquatic vegetation had been removed (Paperna, 1969).

In the literature there are three other factors that may contribute to the dependence of Bilharzia-bearing snails on aquatic vegetation:

- Leaves of floating plants protect snails from bright sunlight and high temperature (el Gindy, 1960; Heineman, 1973; Odei, 1973); at low water-levels, plants also protect them from drying out (Beadle, 1974).
- Aquatic vegetation may have a positive effect on the habitat of snails by supplying oxygen and absorbing toxic substances (Abdel Malek, 1958; Heineman, 1973). It is even assumed that macrophytes produce snail-attracting chemicals (Sterry et al., 1983).
- Water plants reduce the velocity of the current in the habitat of the snail. When the current is fast, snails are no longer able to hold on to the substratun (W.H.O., 1965). Slower currents may still be injurious to the snails as the silt scours the vulnerable parts of the animal and restricts its action radius (Abdel Malek, 1958).

These factors can only be investigated in outdoor experiments and are therefore difficult to establish. Like herbivorousness, these factors may play an additional role in the very obvious preference of the snails for habitats with aquatic vegetation. Presumably the oviposition of the snails plays the major role in this observed phenomenon.

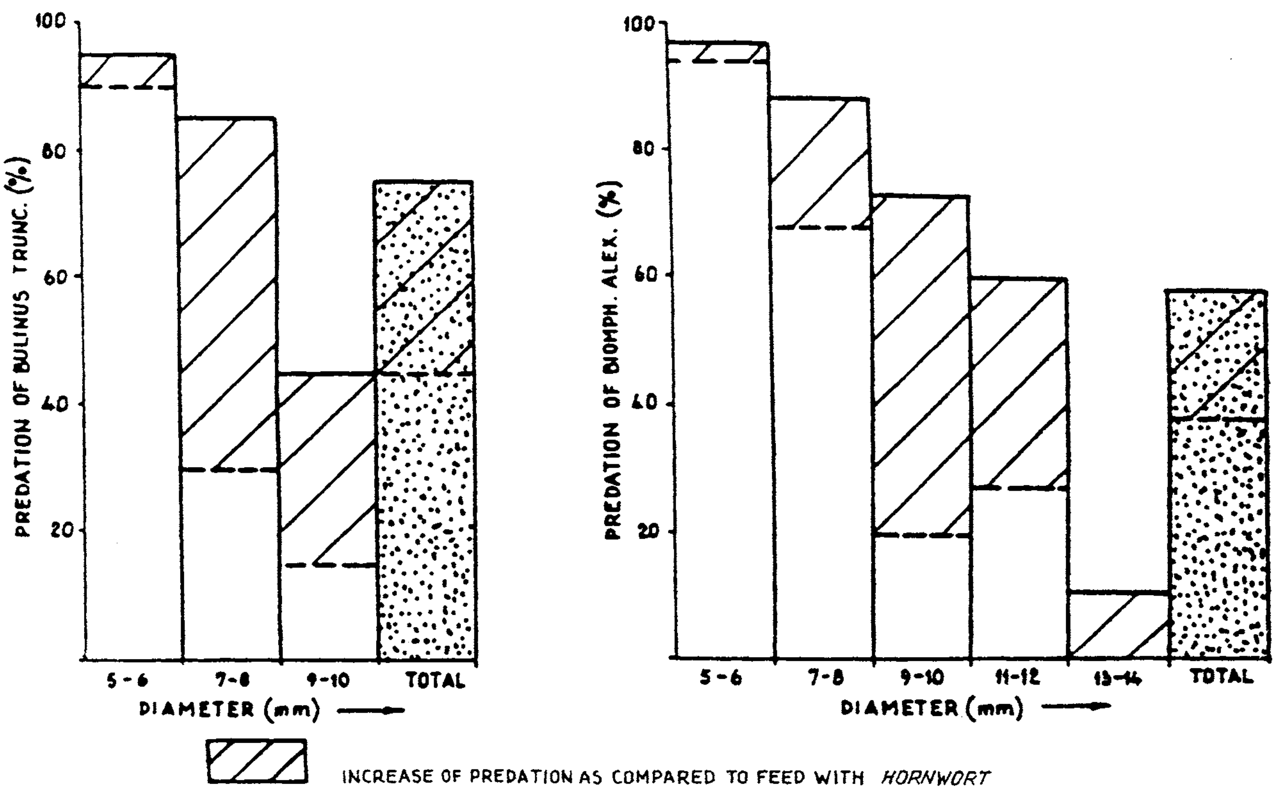


Figure 5. Proportion of total predation on *B. truncatus* (left) and *B. alexandrina* (right) by *T. zillii* (in % per range of diameter of the snails) with and without hornwort as extra feed.

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LITERATURE CITED

Abdel Malek, E. 1958. Factors conditioning the Habitat of Bilharziasis intermediate Hosts of the family Planorbidae. Bull. W.H.O. 18:785-818.

Baker, F. C. 1945. The Molluscan Family Planorbidae. Univ. Illinois Press. Urbana, 1945.

Beadle, L. C. 1974. The inland waters of tropical Africa (an Introduction to tropical Limnology). Longman, London.

Coates, D. and T. A. Redding-Coates. 1981. Ecological Problems associated with Irrigation Canals in the Sudan, with particular References to the Spread of Bilharziasis, Malaria and aquatic Weeds and the ameliorative Rate of Fishes. Int. Journ. Envir. Stud. 16:207-12.

Dazoo, B. C., N. G. Hairston, and J. K. Dawood. 1966. The Ecology of *Bulinus truncatus* and *Biomphalaria alexandrina* and its Implications for the Control of Bilharziasis in Egypt 49 Project Area. Bull. W.H.O. 35:339-56.

Gindy, H. I. el, 1960. On the Ecology of Snail intermediate Hosts of *Schistosoma* and *Fasciola*. Ph. D. Thesis, Faculty of Science. Cairo University, 1960.

Gindy, H. I. el, 1962. Ecology of Snail Vectors of Bilharziasis. Proc. 1th Int. Symp. on Bilharziasis pp. 305-18. Cairo Govt. Print, 1962.

Heineman, D. W. 1973. Epidemiologie en bestrijding van Schistosomiasis in Suriname. Ph. D. Thesis, University of Leiden, 1973.

Mitchell, D. S. 1977. Water Weed Problems in Irrigation Systems. Arid Land Irrigation in Developing countries: Environmental Problems and Effects. Oxford, U.K., Pergamon Press, 1977:317-28.

Odei, M. A. 1973. Observations on some Weeds of malacological Importance in the Volta Lake. Bull. de l'Institut Fondamental d'Afrique Noire, 35, 1:57-66.

Paperna, 1969. Studies of the Transmission of Schistosomiasis in Ghana III. Notes on the Ecology and Distribution of *Bulinus truncatus* and *Biomphalaria pfeifferi* in the Lower Volta Basin. Ghana Med., 7:139-45.

Pelwagora-Szumbewiez, A. 1958. Studies on the Biology of *Australorbis glabratus,* Schistosome-bearing Brazilian Snail. Hev. Bras. Mal., Rio de Jan., 10:459-69.

Sterry, P. R., J. D. Thomas, and R. L. Patience. 1983. Behavorial Responses of *Biomphalaria glabrata* (Say) to chemical Factors from aquatic Macrophytes including decaying *Lemna paucicostata* (Hegelm. ex Engelm.). Freshw. Biol., 13(5):465-76.

Watson, J. M. 1958. Ecology and Distribution of *Bulinus truncatus* in the Middle East. Bull. W.H.O., 18:833-94.

W.H.O. 1965. Snail Control in the Prevention of Bilharziasis. Geneva, 1965.