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Study of the growth of *Biomphalaria glabrata* (Say) and other Planorbidae in Guadeloupe (West Indies)

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It is essential to understand the biology of organisms before one can assess their ability to colonise potentially favourable environments. This knowledge is vital before control programmes are planned against disease vectors. On Guadeloupe the biology of the snail vectors of schistosomiasis mansoni was studied as part of a control programme for the Action concertée de la Délégation Générale à la Recherche Scientifique et Technique—Convention 7 270 165.

It is preferable to investigate the growth and development of organisms in their natural habitats; this is fairly easily done with groups of individuals born during a known limited period, when a growth curve can be made by taking successive samples at fixed intervals. The method is generally applicable to organisms which have short periods of reproduction, but when reproduction is continuous or prolonged, as is commonly the case with invertebrates in the tropics, the natural population at any one time may include individuals of all ages, and their growth cannot be studied directly from samples. One has then to resort to marking techniques or *in situ* rearing (Lévêque, 1971) and the latter technique has been employed in the present study.

TABLE 1

Values of the parameters k *and* L∞ *from the growth equation of von Bertalanffy, from* in situ *cultures of four species of Planorbidae on Guadeloupe. Interval between two successive measurements* (L_t *and* L_{t+1}) *is 15 days*

Species and habitat	*k*	*L∞*	*Validity, mm*
Biomphalaria glabrata			
Damencourt	0·254	24·9	3·5–20·6
Devarieux	0·268	19·9	4·5–21·4
Grand Camp Ravine	0·101	20·9	4·1–14·1
Biomphalaria schrammi			
Canal des Galbas	0·560	6·2	3·7–6·2
Drepanotrema kermatoides			
Devarieux	0·866	7·5	3·4–7·2
Drepanotrema lucidum			
Ravine des coudes	1·06	6·1	2·6–5·8

By *in situ* observations it is in effect possible to follow the growth of individual snails throughout their lives. If the life span is long and the study period short, it is desirable to have a quicker method for evaluating the results obtained from the cultures, and this may be done by, for example, employing the von Bertalanffy (1938) growth equation, often used by ichthyologists and recently applied successfully to molluscs (Hughes, 1970; Lévêque, 1971).

In the von Bertalanffy equation, $Lt = L\infty(1-e^{-kT})$, Lt is the size of the animal at time t after birth, $L\infty$ is the value of Lt for a zero growth rate, k is a constant characteristic of growth, and T is the age of the animal. The parameters k and $L\infty$ are calculated by Walford's (1946) method, where Lt at time t along the abscissa is plotted against $Lt+1$ at time $t+1$ along the ordinate, using as unit time the interval between two successive observations: measurements are therefore taken at regular intervals. The slope of the regression line then gives e^{-k} and the value of the coordinates where the regression line crosses the line $y = x$ is $L\infty$ (Fig. 1).

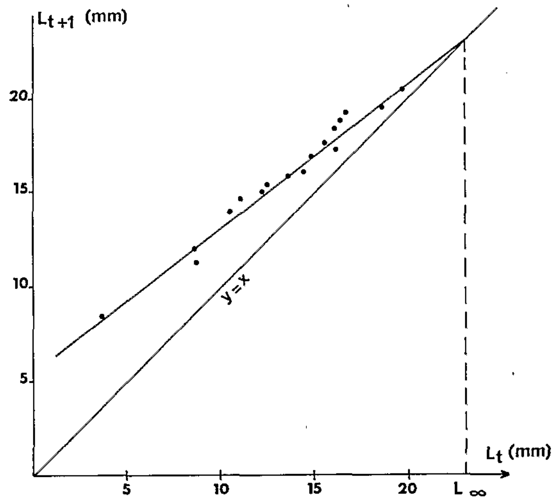

Fig. 1. Walford method for the calculation of k and $L\infty$ in the von Bertalanffy equation. L_t: diameter of the shell at time t; L_{t+1}: diameter at time $t+1$ (the time unit is 15 days).

The slope of the regression line, and thus k, depend upon the interval between successive measurements, and this is allowed for in the von Bertalanffy equation where T is expressed in time units corresponding to this interval. The calculated growth curve is completely valid only for the range of sizes observed and can be extrapolated only with caution. It is therefore desirable to obtain data for as large a range of sizes as possible. In Planorbidae the size is usually taken as the greatest diameter of the shell.

MATERIALS AND METHODS

The growth of *Biomphalaria glabrata* was studied in three biotopes. Damencourt and Devarieux are shallow ponds in Grande Terre which contain abundant aquatic vegetation and which at the time of the study had a water temperature of 25 °–27 °C. The Grand

Camp Ravine (Beaugendre valley), in Basse Terre, is at a high altitude; it is cut into the rock and has poorly mineralized water. Its temperature is about 22 °C. In this habitat there is no aquatic vegetation although it contains many decomposing banana leaves.

Cages made of mosquito netting and measuring 50×50×50 cm were used to isolate and rear *in situ* batches of 30 snails of known size. As far as possible each cage contained samples of as large a size range as was available. Aquatic vegetation from natural snail habitats was placed in the cages to provide food and support. The plants were mainly *Polygonum*, *Nymphaea* and *Characeae*. The snails were measured at intervals of 15 days, when the vegetation was also renewed.

In addition to *B. glabrata*, three other species of Planorbidae were studied: *Drepanotrema kermatoides* in a pond and *D. lucidum* and *B. schrammi* in slow running waters invaded by vegetation.

Our experiments concluded with laboratory cultures (Table 2). Snails were collected from their natural habitats and placed in aquaria, each of approximately 20 l capacity, and filled with water from the original habitat of the sample. The aquaria temperature was 25 °–26 °C.

TABLE 2

Values of the parameters k *and* L∞ *from the growth equation of von Bertalanffy, from laboratory cultures of four species of Planorbidae on Guadeloupe. Interval between two successive measurements* (L_t *and* L_{t+1}) *is 15 days*

Species and habitat	*k*	*L*∞	*Validity, mm*
Biomphalaria glabrata			
Devarieux	0·254	21·5	3·2–18·7
Grand Camp Ravine	0·151	22·3	3·1–13·3
Drepanotrema kermatoides			
Devarieux	0·446	9·7	4·7– 9·1

RESULTS

The values for *k* and *L*∞ were calculated for the four species (Table 1) and growth curves drawn (Figs. 2 and 3).

The growth of *B. glabrata* under natural conditions was much slower at Grand Camp Ravine than in the other two stations. This was probably due to its lower temperature and poorer food supply, as Sturrock and Sturrock (1972), who studied the effect of temperature on the growth of *B. glabrata* in the laboratory, showed that growth is similar at 25 °C and 30 °C but much slower at 20 °C. The fastest growth of *B. glabrata* observed on Guadeloupe was in Damencourt pond and it is significant that the largest recorded specimens of this species (31·5 mm) were recovered from this site, indicating a very favourable environment. The coefficient *k*, which indicates the rate at which the size tends to *L*∞, is very high for *D. lucidum* and *D. kermatoides*, both of which have a very fast growth rate and become almost fully grown in one month. The growth rate of *B. schrammi* is rather slower.

Snails from the Grand Camp Ravine reared in the laboratory on banana leaves grew faster than their contemporaries in the wild. This difference was probably due to the higher temperature in the laboratory cultures.

Snails from Devarieux, fed on lettuce, grew slightly faster in the laboratory than in the wild; their rate of growth was also faster than in laboratory cultures of snails from the

Grand Camp Ravine. Data from laboratory cultures of Etges and Ritchie (1971) enabled us to calculate a growth curve ($k = 0{\cdot}629$, $L\infty = 19{\cdot}3$), similar to that from Devarieux, but much shallower than the one obtained by these authors under natural conditions (Fig. 2, curve 8).

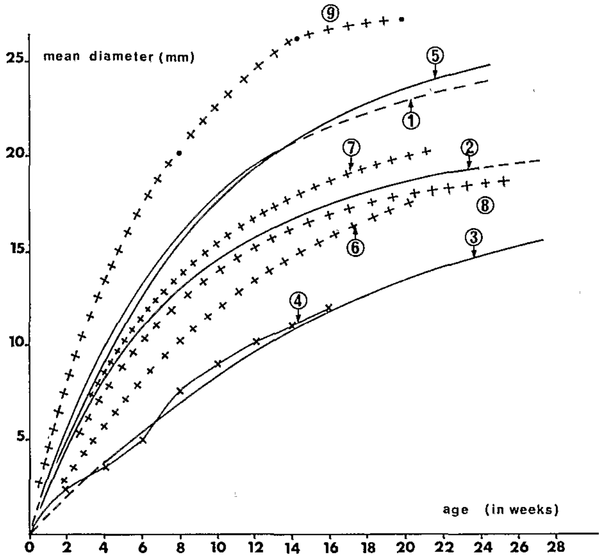

Fig. 2. Growth curves for *B. glabrata* in this and previous studies. *In situ* cultures in Guadeloupe: (1) Damencourt pond, (2) Devarieux pond, (3) Grand Camp Ravine. Natural habitats: (4) St Lucia (Sturrock, 1973), (5) Puerto Rico (Etges and Ritchie, 1971). Laboratory cultures: (6) Grand Camp Ravine, Guadeloupe, (7) Devarieux, Guadeloupe, (8) Puerto Rico (Etges and Ritchie, 1971), (9) Puerto Rico (Ritchie *et al.*, 1963).

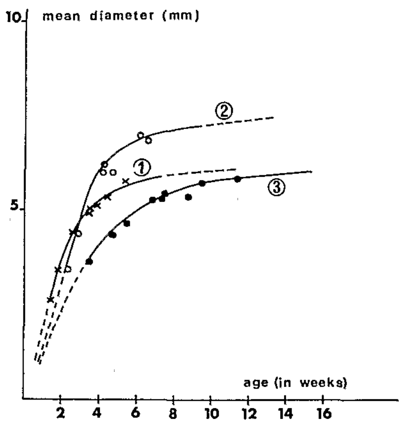

Fig. 3. Calculated growth curve, using the von Bertalanffy equation, for three planorbids from Guadeloupe: (1) *Drepanotrema lucidum*, (2) *D. kermatoides*, (3) *Biomphalaria glabrata.*

DISCUSSION

The growth curve for *B. glabrata* as observed under natural conditions on St. Lucia by Sturrock (1973) is very similar to the one we calculated for the high altitude station at Grand Camp Ravine (Fig. 2, curve 4).

The growth of *B. glabrata* has been studied by Etges and Ritchie (1971), who evaluated the increase in size of the snails after a pool on Puerto Rico had dried out and reflooded, because the shells bore a recognizable mark corresponding to the cessation of growth at that time The growth rate was studied over a period of 37 days, and from their results we calculated the von Bertalanffy equation: $k = 0{\cdot}539$, $L\infty = 26{\cdot}8$; the curve thus obtained (Fig. 2, curve 5) is thus identical with that calculated for Damencourt.

Under natural conditions in Brazil, Olivier and Barbosa (1955) demonstrated an increase in the mean size of a population of *B. glabrata* from 10·0 to 14·5 mm in three weeks. Their results, which were also obtained from a pond habitat, were very similar to those from Damencourt and Puerto Rico. Ritchie *et al.* (1963) obtained a faster rate of growth than had been observed in Puerto Rico or Damencourt, their snails attaining a mean size of 20 mm after two months and 27 mm after five months. It was suggested that this approached the maximum potential growth rate for this species. Pimentel (1957) presented a growth curve for cultured *B. glabrata,* but his culture attained only 10 mm after five months.

The calculated growth is a mean value for the individuals of the population studied and takes no account of individual variation. This should be borne in mind in the use of theoretical growth curves and in the interpretation of field data. Similarly, growth will vary according to the population and the characteristics of the population, so that a growth curve obtained in one biotope should be used with caution when considering another biotope.

SUMMARY

The growth of *Biomphalaria glabrata, B. schrammi, Drepanotrema lucidum* and *D. kermatoides* was studied in three habitats on Guadeloupe.

Theoretical growth curves were calculated for each species by applying the Walford method and the von Bertalanffy equation.

On Guadeloupe, the growth of *B. glabrata* was faster in the ponds of Grand Terre than in the small high altitude streams of Basse Terre. There is good correlation between the observations made in Guadeloupe and previous data obtained on Puerto Rico and St Lucia.

REFERENCES

Bertalanffy, von L. (1938). 'A quantitative theory of organic growth.' *Human Biology*, **10**, 181–213.

Etges, J. & Ritchie, L. S. (1971). 'Comparative observations on growth rate and reproduction of *Australorbis glabrata* in field and laboratory conditions.' *Bulletin of the World Health Organization*, **34**, 963–966.

Hughes, R. N. (1970). 'Population dynamics of the bivalve *Scrobicularia plana* (Da Costa) on an intertidal mud flat in North Wales.' *Journal of Animal Ecology*, **39**, 333–356.

Lévêque, C. (1971). 'Equation de Bertalanffy et croissance des mollusques benthiques du lac Tchad.' *Cahiers ORSTOM, série Hydrobiologie*, **5**, 263–283.

Olivier, L. & Barbosa, F. S. (1955). 'Seasonal studies on *Australorbis glabratus* Say from two localities in Eastern Pernambuco, Brazil.' *Publicaçoes Avulsas do Instituto Aggeu Magalhaes*, **4**, 70–103.

Pimentel, D. (1957). 'Life history of *Australorbis glabrata*, the intermediate snail host of *Schistosoma mansoni* in Puerto Rico.' *Ecology*, **38**, 576–580.

Ritchie, L. S., Berrios–Duran, L. A. & Deweese, R. (1963). 'Biological potentials of *Australorbis glabratus*: life span and reproduction.' *American Journal of Tropical Medicine and Hygiene*, **15**, 614–617.

Sturrock, R. F. (1973). 'Field studies on the population dynamics of *Biomphalaria glabrata*, intermediate host of *Schistosoma mansoni* on the West Indian island of St Lucia.' *International Journal for Parasitology*, **67**, 165–174.

Sturrock, R. F. & Sturrock, B. M. (1972). 'The influence of temperature on the biology of *Biomphalaria glabrata* (Say), intermediate host of *Schistosoma mansoni* on St Lucia, West Indies.' *Annals of Tropical Medicine and Parasitology*, **66**, 385–390.

Walford, L. A. (1946). 'A new graphic method of describing the growth of animals.' *Biological Bulletin*, **90**, 141–147.