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DISPLACEMENT OF *BIOMPHALARIA GLABRATA* BY *THIARA GRANIFERA* UNDER NATURAL CONDITIONS IN THE DOMINICAN REPUBLIC

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After a study of the population dynamics of Biomphalaria glabrata *snails in several breeding places in the Dominican Republic, the snail* Thiara granifera *was introduced in some* B. glabrata *habitats.* T. granifera *became established in one point in one habitat in the town of Quisqueya, in the east of the country. Around this point of establishment 6 points were selected in order to observe the population dynamics of both species of snails and the chemical and biological characteristics at each point. Four of these points already harbored* B. glabrata. *One control point was selected also harboring* B. glabrata. *After 14 months of observations, the results showed that* T. granifera *was competing with and displacing* B. glabrata. *This competition does not seem to be competition for food or vital space. Rather,* B. glabrata *avoids the presence of T. granifera and moves away to new areas, and this is possibly due to a chemical substance(s) secreted by* T. granifera *or by physical contact with the large number of individuals of* T. granifera.

Key words: ***Biomphalaria glabrata*** · ***Thiara granifera*** · displacement - biological control - schistosomiasis mansoni - Dominican Republic

In various countries studies have been undertaken on biological control of snails using the phenomenon of competition by non-medically important snails. Chernin et al. (1956), and later others demonstrated the competitive action of the snail ***Marisa cornuarietis*** against ***Australorbis glabratus*** (= ***Biomphalaria glabrata***) in the laboratory. The competitive effect of ***M. cornuarietis*** has also been demonstrated under field conditions in Puerto Rico (Oliver-Gonzalez et al., 1956; Radke et al., 1961; Ruiz-Tiben et al., 1969; Jobin et al., 1977). The competition is through food and accidental predation on eggs and young snails. Another laboratory competitor has been the snail ***Helisoma duryi***, whose effect has been demonstrated against various species of ***Biomphalaria*** (Abdalla & Nasr, 1973; Malek & Malek, 1978; Frandsen & Madsen, 1979; Madsen, 1979). The effect of this planorbid has also been demonstrated in the field in Tanzania and in semi-natural conditions in Santa Lucia. Another competitor snail that has been studied in the laboratory is the ampullarid ***Pomacea*** sp. against ***B. glabrata*** (Paulinyi & Paulini, 1972).

The Oriental melaniid snail ***Thiara granifera*** has been introduced in various countries with ornamental plants and fish and among these countries are the United States including Hawaii, Brazil, and several Caribbean islands. Casual observations in Puerto Rico and the Dominican Republic indicate that ***T. granifera*** is a competitor of ***B. glabrata*** (Ferguson, 1978; Vargas et al., 1982: Schneider et al., 1985). It was demonstrated also that ***T. granifera*** intercepts miracidia of ***Schistosoma mansoni*** (Laracuente et al., 1979). In the laboratory we demonstrated the competitive action of ***T. granifera*** against ***B. glabrata*** (Gomez et al., 1990). Under field conditions on the island of St. Lucia Prentice (1983) demonstrated the effectiveness of ***T. granifera*** in eliminating ***B. glabrata*** in certain streams and swamps. Pointier &

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McCullough (1989) reviewed the subject of biological control of the snail hosts of *S. mansoni* in the Caribbean area using *Thiara* spp.

The present study encompasses the results of 14 months of observations of the competitive effect of *T. granifera* against *B. glabrata* in the Dominican Republic.

DESCRIPTION OF THE STUDY AREA

These studies started after one year of observations on the population dynamics of *B. glabrata* in various natural habitats in the country. *Thiara granifera* snails were brought from certain natural habitats and introduced in proportions of 5 to 10,000 in *B. glabrata* habitats. Monthly counts were made and recorded of both species.

Of all the habitats where *T. granifera* was introduced this snail became established only in Quisqueya, an urban community in the east of the country that is characterized by small drainage canals which collect superficial waters and residual waters from houses. From the point of fixation of the snail *T. granifera* (A), six points were selected for observation, B, C, D, E, F and G.

Figure 1 shows the area of study, which is limited in the north by Street N, in the south by street B, in the west by the drainage canal of the sugar refinery, and in the east by a number of houses isolated from the community. Point B is at 20 meters north of Point A, Point C is at 15 meters east, Point D at 20 meters towards the southeast.

Points B, C, D and E are against the water current, while point F is in the direction of the water current but opens in a canal which is a barrier for mollusks because of the high temperature produced by the water and products which come from the sugar refinery or because of unsuitable content of organic materials. Water at Point G does not connect with the latter.

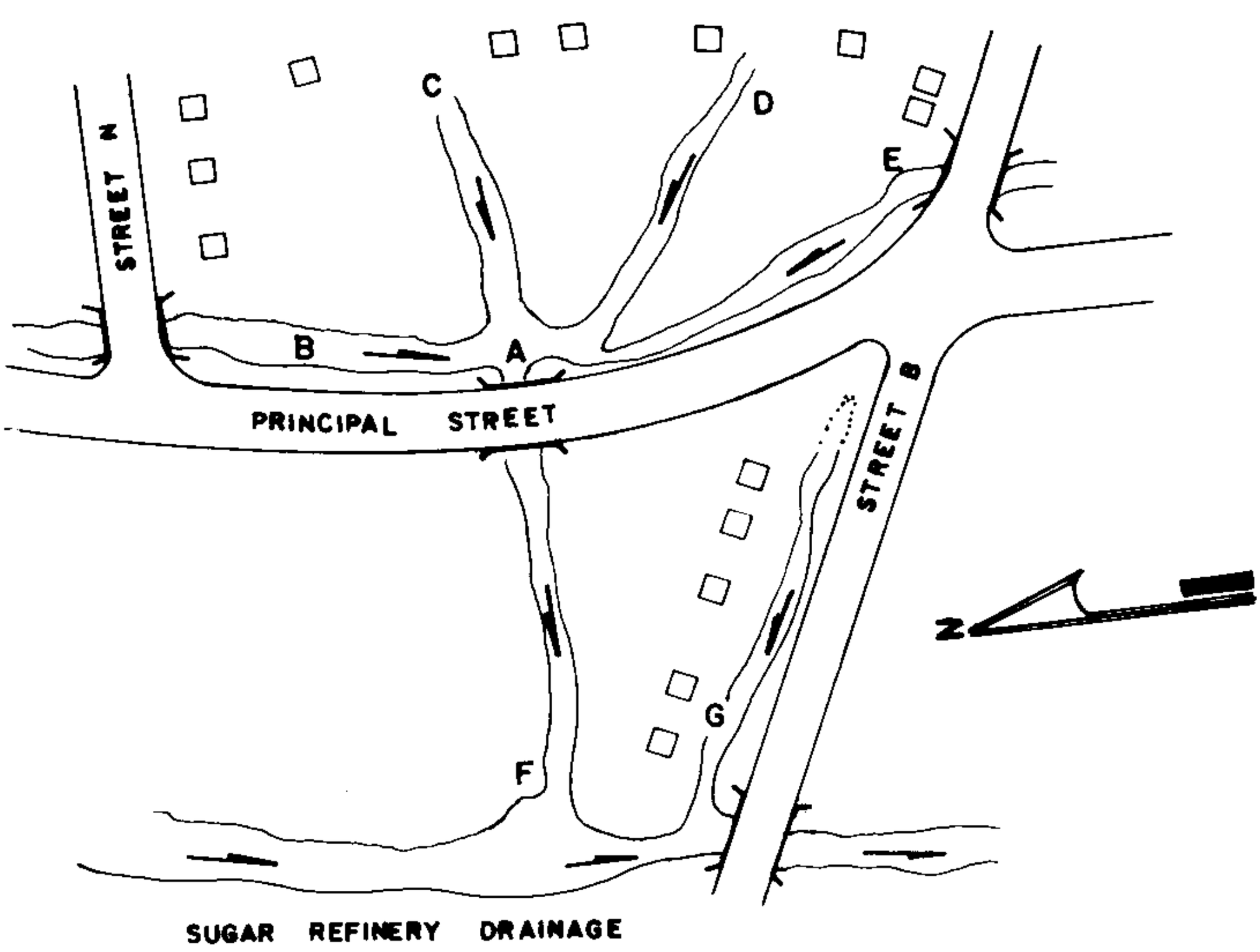

Fig. 1: diagram showing the central part of Quisqueya, with the different observation sites (A, B, C, D, E, F, G), the direction of the water current, and the distribution of the houses.

TABLE I

Average values in 42 months of chemical analyses of water in the habitats investigated in Quisqueya

Environmental factor	Habitat						
	A	B	C	D	E	F	G
pH	6.4	7.4	6.8	6.2	7.3	7.6	7.0
Salinity	0.61	0.50	0.49	0.61	0.60	0.68	0.45
Conductivity	0.46	0.37	0.48	0.41	0.38	0.43	0.47
Temperature (°C)	25.0	25.4	25.9	24.2	24.9	26.7	24.7

Biomphalaria glabrata occurs naturally in B, C, F and G, but is absent in D and E.

METHODS

During 14 months starting in March of 1987 observations were made in the study area, especially on the speed by which *T. granifera* invaded the selected points with respect to the presence or absence of *B. glabrata* as well as in the direction of or against the water current.

In the first two months the observations were made weekly; in the following 8 months they were made biweekly, and in the rest of the period they were made monthly. In addition to studying the population dynamics of the two snail species at all selected points, the temperature, the pH, the salinity and conductivity of the water, other mollusks and associate vegetation were recorded. The counting of the snails was done by the number of snails collected per man/hour, and after counting and measurements the snails were returned to their respective habitats.

For statistical analyses X^2 was used to determine the relation between the number of each snail species and its preference for a certain habitat. The equation $Y = a + bt$ was also used, where Y = number of *B. glabrata* in time (t) in months. The coefficients a and b are the intercept and the value of the regression, respectively. Another equation was also used, that is, $Y = ab^t$. Both equations are for qualifying the variations which affected *B. glabrata* during the observation period.

RESULTS

The seven sites studied presented similar chemical and biological characteristics (Table I).

It was demonstrated that *T. granifera* adapts easily to *B. glabrata* habitat except that it reproduces more rapidly than the latter.

It should be noted that the two species differ in their diets. *B. glabrata* feeds on the scummy layer on aquatic vegetation and other floating articles, whereas *T. granifera* in the majority of cases is seen on the bottom of the habitat scraping on the mud and leaving marks on the mud where it has been moving.

The initial snail populations in site A for the month of March 1987 were 108 for *B. glabrata* and 253 for *T. granifera*. However, in the month of July the populations were zero for *B. glabrata* and 8,000 for *T. granifera* and this was maintained until the end of the counting in March 1988, when *T. granifera* numbered 10,000, replacing totally *B. glabrata*. Site B, at 20 meters from A and against the current, presented for the first two months only *B. glabrata* (Table II) but in the third month *T. granifera* started appearing in the proportion of 225 snails for 653 *B. glabrata*. The displacement of *B. glabrata* by *T. granifera* was comparable to two pyramidal habitats with their spires overlapping and the main portion of the population at their bases. The two snail species coexist in the zone of overlap demonstrating clearly that the population of *T. granifera* is invading and is displacing *B. glabrata* (Fig. 2). In later months there was a further reduction of the *B. glabrata* population and an increase in the population of *T. granifera*. Table II shows the changes in the population of *B. glabrata* at sites C, F, and G. Site G is the control and in it *B. glabrata* maintained its population strength with slight fluctuation.

DISCUSSION

During the period May 1987 — April 1988 the populations of both mollusks, *B. glabrata* and

TABLE II

Number of *Biomphalaria glabrata* (B.g.)/Month/Habitat

Months	Places of observation								
	A[a]	B		C		F[b]		G	
	No.B.g.	No.B.g.	Log.B.g.	No.B.g.	Log.B.g	No.B.g.	Log.B.g.	No.B.g.	Log.B.g.
March	108	54	1.7324	96	1.9823	700	2.8451	220	2.3424
April	114	144	2.1584	700	2.8451	7000	3.8451	140	2.1461
May	219	653	2.8149	420	2.6232	6500	3.8129	300	2.4771
June	2	1275	3.1055	500	2.6990	4100	3.6128	410	2.6138
July		516	2.7136	48	1.6812	2600	3.4150	500	2.6990
August		276	2.4409	6	0.7782	1325	3.1222	450	6.6532
September		126	2.1004	76	1.8808	67	1.8261	500	2.6990
October		84	1.9243	44	1.6415	24	1.3802	201	2.3032
November		79	1.8976	120	2.0792	31	1.4914	219	2.3404
December		65	1.8129	304	2.4829	7	0.8451	206	2.3139
January		60	1.7782	648	2.8116			144	2.1584
February		97	1.9868	535	2.7284			201	2.3032
March		114	2.0569	671	2.8267			242	2.3838
April		133	2.1239	700	2.8451			276	2.4409
Mean	34	263		348		2047		286	
Stand. Dev.	70.375	343.063		276.820		2868.062		126.27	
Correl. (r)		−0.4208	−0.4157	0.3718	0.3009	−0.6989	−0.8512	−0.245	−0.2039
Level of Dependence		17.70%	17.23%	13.85					
				%	9.05%	48.85%	72.46%	6.00%	4.16%
a		521.363							
			2.5034	163.20	1.9424	4731.7	4.36	341.82	2.4872
b		−34.506	−0.0419	24.6	0.0449	−418.0	−0.3169	−7.395	−0.009

a: the linear model was not considered.

b: each indicator was determined on the basis of 10 months.

T. granifera living together, were studied under field conditions. It was shown that the complete displacement of *B. glabrata* by *T. granifera* did take place in some of the selected sites. In spite of the inconvenience of the habitats having been affected periodically by the cleaning of the canals by the factory, the two snail species continued to reproduce after the cleaning and maintained a certain population strength.

It is to be noted that when the two snail species are placed together in the laboratory *T. granifera* is indifferent to the presence of *B. glabrata* (Gomez et al., 1990). The same is also true in the field, resulting in the two species existing together in the same space. In the field *B. glabrata* is observed to avoid *T. granifera*, abandoning its space and migrating to other areas of the habitat as happened in site B. It is suggested that *T. granifera* produces a certain chemical substance(s) which causes the emigration of *B. glabrata* away from its habitat.

The correlation of the number of *T. granifera* for 100 *B. glabrata* in site B is 0.90, which is considered high and is increasing, and the same correlation is 0.82 in site F. These coefficients of correlation indicate that there is a constant increase in the number of *T. granifera* for each 100 *B. glabrata*, and that this increase with time in both points of observation is exponential of the equa-

TABLE III

Number of ***Biomphalaria glabrata*** (Bg) and ***Thiara granifera*** (Tg) in each Habitat in Quisqueya
Number of *T. granifera* per 100 *B. glabrata* (Tg/100 Bg)

Month	Places of Observation											
	A			B			C			F		
	Tg	Bg	Tg/100 Bg	Tg	Bg	Tg/100 Bg	Tg	Bg	Tg/100 Bg	Tg	Bg	Tg/100 Bg
March	123	108	113	—	54	All Bg	—	96	All Bg	—	700	All Bg
April	5200	114	4561	—	144	All Bg	—	700	All Bg	3600	7000	51
May	3758	219	1716	225	653	35	—	420	All Bg	3700	6500	57
June	7560	2	378000	3750	1275	294	—	500	All Bg	4200	4100	102
July	8000	—	All Tg	176	516	34	2	48	4	500	2600	192
August	8500	—	All Tg	900	276	326	2	6	33	500	1325	377
September	8601	—	All Tg	1156	126	913	2	76	3	200	67	300
October	8620	—	All Tg	280	86	333	—	44	All Bg	48	24	200
November	8000	—	All Tg	366	79	463	—	120	All Bg	51	31	165
December	9000	—	All Tg	504	65	775	—	304	All Bg	63	7	900
January	1000	—	All Tg	960	60	1600	480	648	74	60	—	All Tg
February	9312	—	All Tg	2100	97	2100	506	535	95	409	—	All Tg
March	10100	—	All Tg	4108	114	3604	233	671	35	808	—	All Tg
April	10500	—	All Tg	7100	133	5338	60	700	9	1800	—	All Tg
Monthly Mean	7743	34	22,774	1616	263	651	93	348	27	1781	2047	87

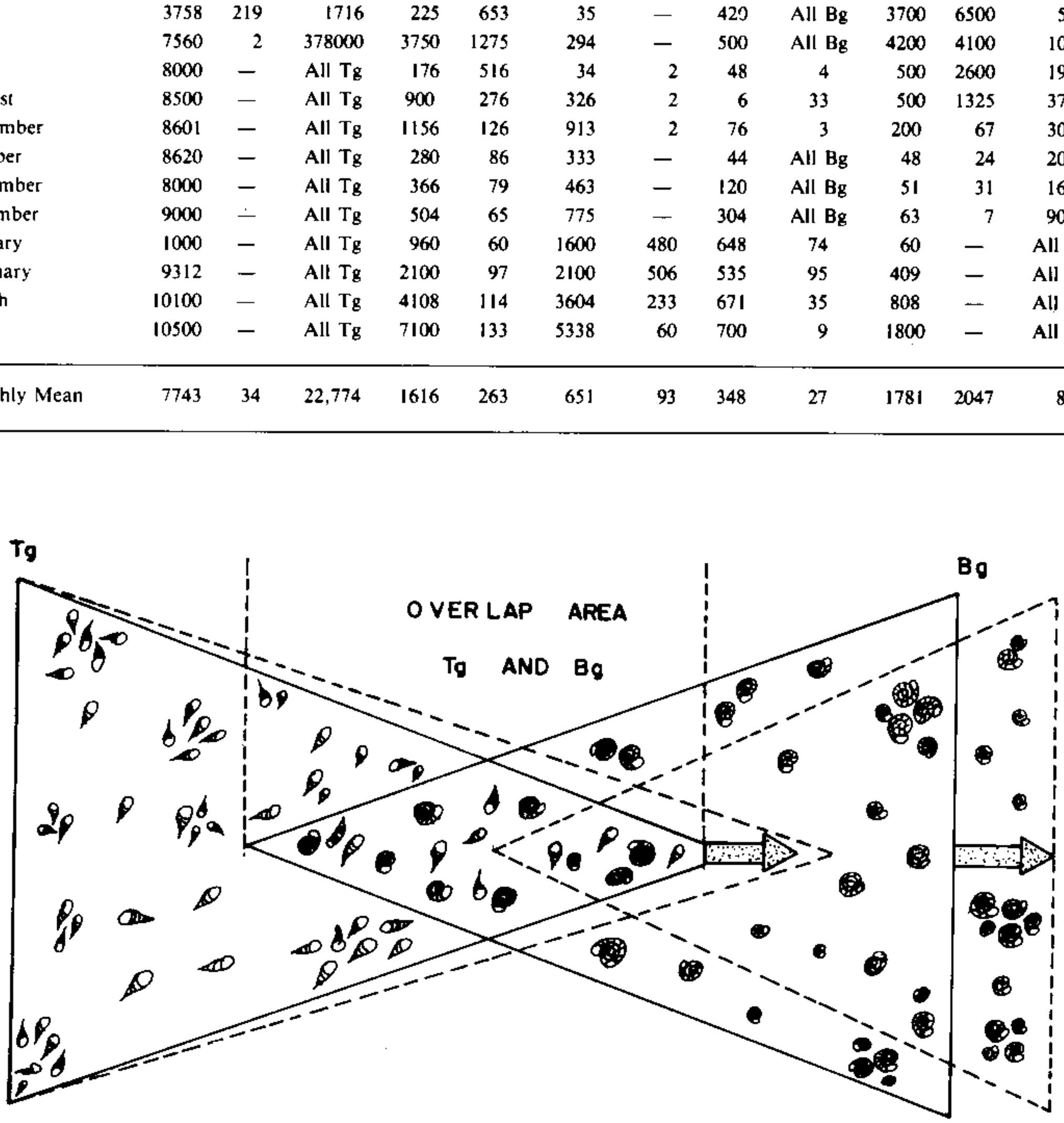

Fig. 2: diagram showing the process by which ***Thiara granifera*** displaces ***Biomphalaria glabrata***. Tg = ***Thiara granifera***; Bg = ***Biomphalaria glabrata***.

tion mentioned before ($Y - Ae^{Bt}$) (see Fig. 3). The extent of dependence of the number of *T. granifera* for each 100 *B. glabrata* in time is determined as 81.1% and 67.88% for sites B and F,

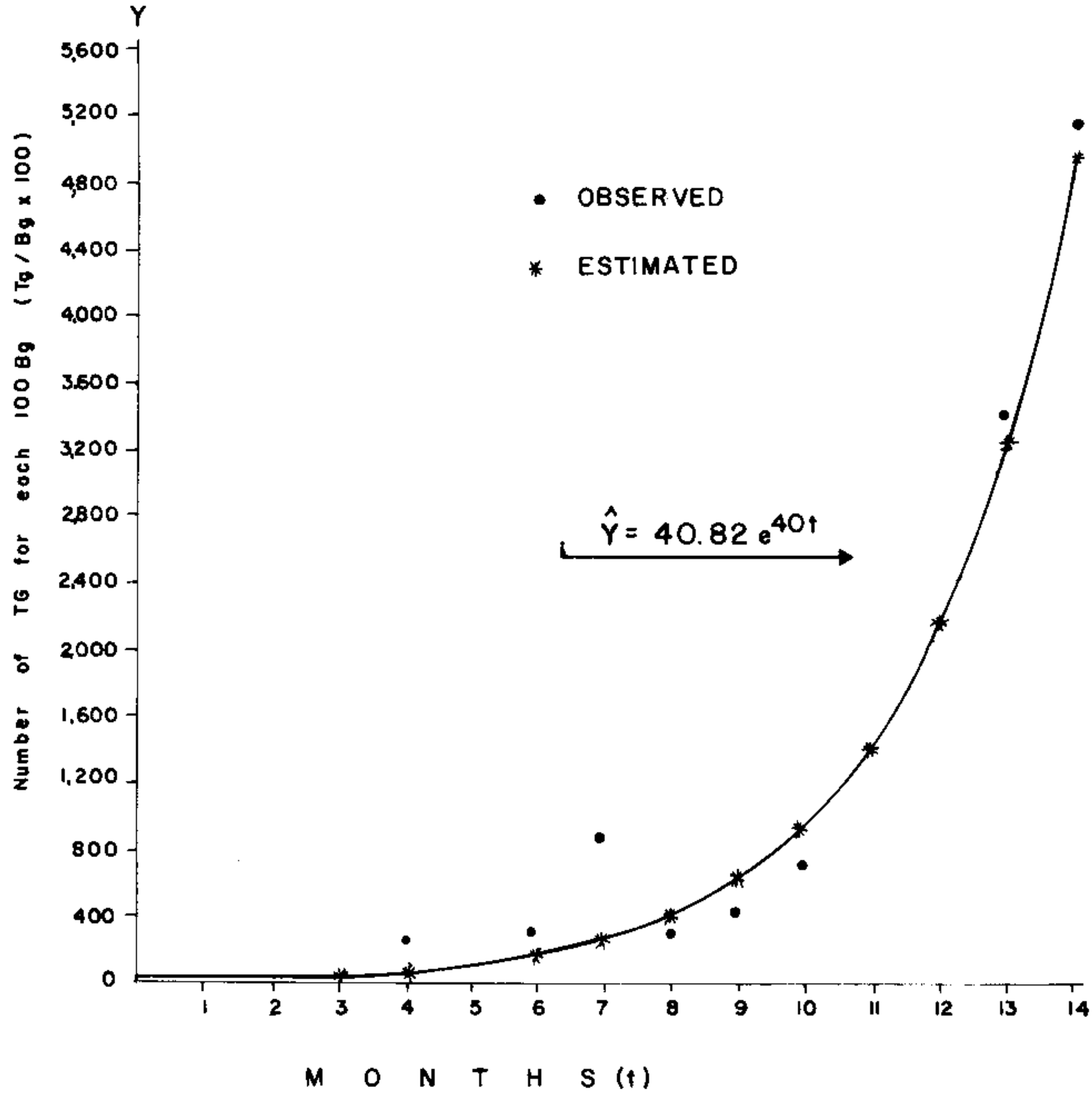

Fig. 3: relation of the number of ***Thiara granifera*** for each 100 ***Biomphalaria glabrata*** in site B. Estimation of the equation of regression with time in months.

respectively, which indicates that the factor of time positively influenced the establishment of *T. granifera* in the sites indicated.

Through the analysis of variance of the regression it is shown that at site B the regression of *T. granifera* for each 100 *B. glabrata* is significant ($P < 0.01$) seen as dependent on time. At site F the regression is also significant, but at a level higher than at site B.

It can be concluded that *T. granifera* can live in the habitat of *B. glabrata* and it can exhibit pronounced competence against the latter species. This competition is not due to food, nor due to space available. It can be explained on the basis

of several reasons, for example the production by *T. granifera* of a chemical substance(s) which causes *B. glabrata* to emigrate away from its habitat and/or physical contact with the large population of *T. granifera* or due to other factors.

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