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ECOLOGY OF BIOMPHALARIA GLABRATA, 4

aes AND MARISA CORNUARIETIS IN

LAKES OF PUERTO RICO

june 1979 5

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

[UNIVERSITY OF PUERTO RICO ~ US. DEPARTMENT OF ENERGY 5

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; Ecology of Sionphalaria glabrata and

isa cornuarietis in Lakes of Puerto Rico.

By

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INTRODUCTION

The ampullarid snail Marisa cornvarietis has displaced Biomphataria glabrata, the intermediate snail host of bilharzia, from many of the 28 man-made lakes of Puerto Rico. These lakes were reservoirs created for irrigation, hydroelectric power

and domestic water supply (Figure 1). The biological process of displacement was gradual and occurred over a 20 year period. It was the purpose of this study to examine the ecology of these Lakes and determine what factors were most important in the competition between the two snails. In addition the information should assist in evaluating the potential for using

comnuartetis in other countries, and in designing or evaluating proposed Irrigation and hydroelectric reservoirs in the tropics. This {nformation 1s especially imporcant in Africa where new reservoirs have invariably resulted in Increased bilharzia transmission or caused other health

problems (Table 1).

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Lake Carraizo in Trujillo Alto, Puerto Rico was constructed as part of the San Juan water supply and also generates electric power. Unfortunately it also receives poorly treated sewage from upstream connunities and thus contains heavy

aquatic plant populations and other undesirable

conditions

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TABLE 1 3

YDROELECTRIC RESERVOIRS WITH POTENTIAL,

REACT ON HIMAN HEALTH 1 AFRICA

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WATERIALS AND ETHODS

The ecological studies began in 1975 with preliminary reconnaissance surveys of all 28 reservoirs, followed by 3 years of intensive studies on the 6 most important hydro-electric reservoirs, and occasional observations on another 6 reservoirs which represent the wide range in sizes ond conditions of man-made lakes in Puerto Rico (Table 2)-

The reservoirs were surveyed for snail populations, coliform bacteria, general water quality, algae populations and productivity, dissolved oxygen distribution, temperature, and clarity of the lake waters, Records were obtained on fluctuations in the water level and on incident solar radiation. The sempling methods and analyses used were standard for such ecological surveys and a detailed record of all data is

available (1).

The six hydroelectric reservoirs studied in detail were Lakes Caoniilas, Carratzo (Loiza), Dos Bocas, Carzas, Cuayo

and Prieto (Figure 2). These studies began in January 1976

?and ended in September 1978 with a total of 49 separate Lake surveys, averaging 2.7 surveys per year, per lake.

The additional six reservoirs, given occasional surveys between December 1975 and October 1978 were Lakes Carite, Cidra, Guajataca, Matrulles, Pattllas, and Toro. They were surveyed a total of 16 times in the 3 years, about once a year. The remaining 16 reservoirs not included in these studies were surveyed only once, in 1975 or 1976, collecting information

fon snail populations and cheateal water quality (2).

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Table 2. MAJOR LAKES OF PUERTO RICO

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The basic equipment for the surveys included a mobile

laboratory with appropriate vehicles and boats for continuous monitoring of the lakes, usually in remote mountain regions. The mobile laboratory used in these surveys included Living accomodations for a crew of four as well as laboratory faci- Lttes for chemical titration and bacterial analyses (Figure 3).

Two boats were used on the lakes, a 12 foot aluminum Jon boat for shore sampling and an 18 foot fiberglass boat with @ small crane and winch for deep-water work (Figure 4). The availability of this equipment and the mobile Laboratory nade It possible to gather much more information on each lake than had been previously feasible. In the past only one-day expeditions with easily transported row-boats were possible due to the long trips involved from San Juan. With the new equipment the surveys lasted a week and up to 4 men could work full-time on each Lake.

Sampling stations were established with marker buoys in each lake, usually at each major tributary, in the main body of the lake near the dam, and in any major branches in the Lake.

Each lake survey lasted four days, alloning for three 24 hour photosynthesis rounds using two light and two dark bottles at each station to determine changes in dissolved oxygen due to photosynthesis and respiration. The four hotties were suspended in a wire rack about 0.5 meters from the surfae

and the bottles were changed approximately the

same time each day. An initial oxygen determination was made

at each station every day as well. Also the water temperature

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0.1 m below the surface, the depth of visibility of a Secchi

disk and the water depth at the station were recorded each

aay.

One liter samples were taken once during the week at each

station for measurenent of algae and chemical quality. The

parameters measured later in the central laboratory were color, turbidity, hardness, chlorides, nitrogen, phosphates and iron.

Alo:

samples wore filtered through millipore paper, fixed and examined microscopically. Coliform samples were filtered and cultivated in the field by the standard Millipore technique and counted visually after 2 hours of incubation in a portable Incubator at 34°C.

Snail surveys were conducted from boats and on foot, making @ complete shore-line inspection and scooping at 10 or 20 meter intervals with wire mech dippers. When the bilharzia snails were found they were held in a strong light 3-4 hours to detect cercarial shedding and later crushed and examined microscopically if found negative on the first examination, Water levels in the lakes during the surveys were obtained from records of the Water Resources Authority and the Aqueduct and Sewer Authority. Wind records and cloud cover were obtained from unpublished reports of the federal

Weather Bureau. *

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Small launct on Lake Dos Bocas in Utuado, Puerto Rico. This boat and an aluminum Jon boat made it possible to survey the larger lakes fairly

quickly.

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RESULTS

The initial reconnaisance surveys of 1975 and 1976 were conducted primarily to ascertain the presence or absence of

Bionphalaria glabrata and to select 6 reservoirs for intensive study in the subsequent 3 years. In this first survey of the

28 reservoirs it was determined that B. glabrata was present

only in Lakes Carite, Carralzo, Dos Bocas and Garzas. However Lakes Caonillas, Prieto, and Guayo were added to the first since they were interconnected with them by tunnels and overflow spillways. Also Lake Carite was not a hydroelectric reservoir anynore, thus it was placed in the second set of 6 lakes which were selected for occasional study because they typified the many types and purposes of reservoirs throughout the island, giving a general representation of all 28 reservoirs.

Woter quality in an additional 1% lakes was estimated from a single set of samples taken from the tributaries and near the dam, usually taken at all points on a given reservoir during the same week. The remaining 2 reservoirs were not sampled for chemical quality as Lake Coamo has been abandoned because it was full of sediment, and Rio Blanco reservoir was only @ small dam on the Blanco River with virtually no storage volume. Two brackish lagoons, Cartagena and Tortugero were also omitted from the sampling because they were coastal lagoons,

rot man-made reservoir.

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Five Major Reservoirs

The data from the intensive studies on the major reservoirs was analyzed in detail in terms of the Dos Bocas Hydroelectric systen (Lakes Caonillac, Dos Bocas and Garzas) and the Lajas Valley System (Lakes Cuayo and Prieto). For the sixth reservoir, Lake Carratzo which is part of the San Juan Water Supply System

the data will be presented separately.

Lake Caonillas

Conditions in the main body of Lake Caonillas were repre-sented by Stations Ay 8, and E which generally had no significant differences between them, thus the data was combined (Figures 5 and 6). However the turbidity decreased approaching Station A near the dam, probably due to sedimentation. Thus turbidity at Station A was always lower than at B and £E. The number of blue-green algae was comparatively high at Station ? in October 1976 while the oreen algae were few in number. Also in June 1977 high concentrations of iron coming in from the Jayuya River raised the Iron concentration at Station E significantly.

Station D represented the inflow from the Jayuya River and C represented the Vivi River, with some minor differences between them. The Jayuya River Station had more algae and diatons, higher algal productivity, and a higher tron concen-tration. However the phosphate and nitrate concentrations in the ayuya River Station were slightly lower than at the

Vivi River Station.

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Figure 5. Lake Caonillas is the largest lake In Puerto Rico,

in volume, and discharges Into Lake Dos Bocas as

part of a hydroelectric generating system.

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Figure 6

Location of Sampling Stations on Lake Caonillas

CAONILLAS

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Grouping tht main Stations A, B and £ showed the trends with time and lake level (Table 3). The lake dropped to about M.S.L. in the summer of 1977, then rose abruptly from Septenber through Novenber, declining again during the winter of 1978 in a fairly simple pattern (Figure 7). The water quality showed no unusual variations except for a high pH in September 1977 at the low lake level with a low respiration rate. The inflow from September to November diluted the concentration of chlorides, hardness. tron and color, 33 expected, However nutrients and phyto-plankton did not change very much.

coliform bacteria counts averaged 4000 per 100 ml for the 4 periods samples, fairly heavy contamination. In January 1978 the water was quite clean however, with a mean of 730 coliform per 100 ml. During the other 3 sampling periods the

counts ranged from 3000-5000 per 100 mi.

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Lake Dos Bocas

Lake Dos Bocas is the principal hydroelectric station in Puerto Rico (Figure 8). Although the geographical variation In water quality was not extreme, Station ¢ is the only representative station for the entire lake due to the differences in Station 8 affected by the Arecibo River and Station D affected by the combined flows from the Limon River and the discharge from the Caonillas turbines (Figure 9).

Seasonal variations in water quality at Station C near the dam were minor, probably affected mainly by large rain storms. The lake was maintained between 87.8 meters and 90.2 meters above sea level during the two year of observation, a fluctuation range of less then 2.5 meters (Figure 10). This reservoir generates fairly continuously at maxinun head, utilizing the upstream reservoirs for storage. At Station C the water was clearest and cleanest with the lowest coliform bacteria counts on the Lake and the highest phytoplankton. Apparently the phytoplankton were limited by the very low nutrients (Table 6), The Secchi disk could be read at a mean depth of 1.34 meters, the water being more turbid and colored during the rainy season.

There was a sharp oxygen stratification at 5 meters depth with virtually no oxygen at deeper Levels and 6 to 7 mg/l above that depth. However the stratification was not caused by a thermocline, but more likely due to good vertical mixing in the upper layer and a high benthic

oxygen demand (Figure 11).

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VERTICAL DISTRIBUTION OF TEMPERATURE AND DISSOLVED OXYGEN

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FIGURE 11

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Lake Garzas

The main body of water was represented by Station A on Lake Garzas near the earth dem (Figure 12 end 13). However the only significant difference between this station and the other 4 was a slightly higher phytoplankton population, nore eoliforn bacteria and slightly higher turbidity at Station A.

Lake Garzas was a fairly clean lake with low nutrients and moderate nunbers of phytoplankton. Only in November 1976

41d the turbidity go above 6 standard units but color was

fatrly constant at about 10 standard units (Table 5)

The lake dropped to its lowest Level of 723.4 M in July

1976 and rose to its maximum level by Novenber 1976 of 736-1 ¥

a range of about 13.M. In general the lake was usually full

during 1977 and 1978 (Figure 14).

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Figure 12

Location of Sampling Station on Lake Garzas.

LAKE GARZAS

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Figure 13.

Overflow spillway on Lake Garzas in AdJuntas,

Puerto Rico.

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Lake Guayo

Lake Cuayo, one of the most attractive lakes in Puerto Rico 1s located near Castafier. Stations C and D represent

the main portion of the lake while Station A was the entrance fof the Guayo River and Station 8 the entrance of the Cidra River. (Figure 15).

Nutrients were generally low except in May 1978 when the Total Phosphates rose to 0.08 mg/l, accompanied by a drop to zero nitrogen. This followed a period of extremely clean water during the Winter of 1978 (Table 6). The lake was quite full with a stable level at about 945 M from Septenber 1977 through June 1978. The previous year however the lake had fluctuated

severely dropping to 1410 f

t of 430 M in August 1976 and Fising to 1460 feet or 445 M in December 1976, a range of 15 M (Figure 16). The level dropped again in uly of 1977, but only to about 1430 feet or 436 4.

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Figure 15

Location of Sampling Stations on Lake Guayo.

LAKE GUAYO

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Lake Prieto

This lake 1s one of the smallest studied, and was relatively polluted. Station A near the dam was the most representative station (Figure 17), Mutrients were relatively high with a mean total phosphate concentration of 0.02 mg/l, nitrogen of 0.33 mg/l and iron of about 1 mg/l (Table 7). Color and turbidity were also high and the Secch! Disk depth was only 0.5 m, The lake Level was quite steady at the Level of the overflow to the diversion tunnel, as the overflow has a very large capacity in comparison to the mean

flow of the Prieto River, thus lake level was not recorded.

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Snail Populations

Snail populations in the 5 major hydroelectric reservoirs

showed the strong interaction of Marisa cornuarietis with

Biomphalaria glabrata, with the eventual disappearance of the

latter from all reservoirs except Lake Prieto (Table 8). By

the third and fourth quarters of 1978 only Lake Prieto contained

8

glabrata, while all 6 contained

The B. glabrata in Lake Prieto were usually infected with cornuarietis (Figure 18).

Schistosoma mansoni

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Figure 18.

This muddy shore on the northern bank of the Linn River was the last habitat of Biomphala glabrata in Lake Dos Bocas. Large numbers of Marisa cornuartetis were also present here and glabrata was not found again, after late 1976.

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Water temperatures

Each day during the photosynthesis surveys the water temperatures were taken at each station 10 centimeters below the surface. These surveys usually occurred during mid-morning, a time when water temperatures approximate the mean daily temperature in Puerto Rican Lakes. The 11 All temperature has been found to closely approximate the mean daily temperature (Jobin and Ferguson, 1976, PRNC Report #201). Hourly Graphs of temperature for each survey make it possible to estimate the mean monthly temperatures for the 5 lakes, using the 11 AM value (Figure 19). As expected the highest mean temperatures occurred in Lake Dos Bocas which is closest to sea level, and the lonest temperatures occurred in Lakes Garzas and Prieto, the highest lakes of the group (Table 9).

The water temperatures in the lakes reached minimuns between December and March, the cool dry season, but maximum temperatures occurred any time between June and Novenber (Figure 20).

By using the seasonal curves for water tenperature for each lake it was possible to estimate the temperature range for breeding of M. cornuartetis (Table 10). Many caus of the ampullarid snail were found at temperatures from 23.0°C to

25.0°C, but no eggs were seen at lower tenperatures of 18.0%

oF 19.7% nor were they seen at higher temperatures of 25.2%,

or 26.0%, indicating the optinum range for i. co

may be somewhat lower and narrower than the range for 8. glabrata

which is 20° to 30° with a maximum at 25°.

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Table 10

Hontns during wh

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observed in lakes of Puerto Rico, 1975-1975.

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(estimated)

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Garzas gun 77 25.0 Hany

carzas bec 77 23.0 Many

cuayo gun 77 (25.2) Not seen

Prieto dun 78 23.0 Many

Prieto Nar 75 18.0 Hot seen

Prieto aul 77 25.0 Not seen

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Secchi Disk Measurements

The depth at which a seechi disk Is no Longer visible gives an Indication of the depth of the photic sane, the depth which Light penetrates significantly to cause algo!

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fieant geographical vartations

Although there were sign

In secehi depths between stations, only the averaye was calculated for cach lake survey. The clearest Lake was Lake Guayo with visibility up to 3.6% meters (Table 11). However 3 of the lakes had visibilities less than 1 meter, Lakes Caonillas, Des Bocas and Prieto. The lowest visibility was in Lake Prieto (0-10 =).

Significant variations occurred in the depth of visibility

during the various seasons of the year. Minimum visibilities occurred during the Second Quarter (April, May, June) in Lakes Caonillas and Garzas, but during the Fourth Quarter (Uetober, November, December) in Lakes Dos Bocas and Pricto. Maxtaun visibilities occurred during the Fourth Quarter for Lakes Caonillas and Garzas with no particular pattern In the others.

The periods of low visibility correspond to the two rainy seasons but it was not clear why Caonillas and Garzas should

have their best visibility during these same rainy periods

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Table 1

SLASONAL VARIATIONS 11 HEAIL OL SECCHT DEPTH, BY LAKE, 1976-1975.

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os Bocas 033 1B 1.22 0.68 0.83

Carzas 2.30 1691.99 2.36 2.08

Guayo 3.68 3.35 3.50)

Prieto 0.30 0.10 0.80 0.40

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Shore Stope

Flatter shores provide mire suitable habitats for aquatic

snails since there 1s usuilly more vegetation and better

protection against wave action. The mean shore slope r.

From 5:1 for the horizontal: verti

1 slope of Lake Guayo to

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1 for Lake Garzas (Table 12).

One can caleulate the maximum potential

bitat by using

the shore slope Information aud the depth of the photic zones

This will give the average width of submerged shore which

receives light. Multiplied by the shore length this equals

the maximum area of potential habitat. Thus Lake Guayo, with

@ shore slope of 5.1:1 and a photic zone of 3.5 meters had an

average illuminated shore width of 17.85 meters. As the shore

Jength was approximately & kilometers the total illuminated area was 0.143 square kilometers.

In contrast the larger Lake Caonillas, which had mater quality similar to that of Lake Guayo, had a mean shore slope of 2.321 and a mean photic zone 0.2 M deep, the width of the illuminated shore was 2M. As the shore length was about 7.5

Kilometers, the total potential habitat was only 0.015 square

kilometers, about 10% of the potential habitat in Lake Guayo.

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Table 12

Mean Shore Slope at High Water Level of 5 Major Hydroelectric

Reservoirs in Puerto Rico.

(Taken from maps at scale of 1:20,000 with 10 meter contour Intervals. Slope given is ratio of horizontal:vertical distance).

Lake Mean Shore Approximate Kilometers of

Slope Shoreline by class of slope

From:

Caont lias 23k 1.0

bos Bocas aac 3.5

carzas Lets 0.0 3.5 0.0 0.0

cuayo Sets 0.0 6.5 0.5 0.5

Prieto 3.021 0.0 1.0 0.0 0.0

"Straight Line distances, ignoring indentations and small

projections in shorelines.

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Seven Representative Lakes.

Results from the annual surveys made on the 6 reservoirs of Lakes Carite, Cidra, Guajataca, Matrullas, Patillas and Toro were combined with data from Lake Carratzo to indicate

the general range and va

tion of conditions in these representative reservoirs (Table 13). In general the water quality conditions are nut remarkably different, with Lake Carratzo representing the polluted extreme for Puerto Rico and Lake Matrullas, although highly colored, representing

the least contaminated condition.

AlL of the reservoirs except Lake Matrullas and Lake Toro supported Large numbers of snails and usually 3 or 4 species at the same tine (Tables § and 14). The most ubiquitous snat! was the ampullarid Marisa cornuarietis which was found in all lakes except Toro. The thiarid snail Iarebia granifera was also very common and usually found in such large numbers U

a

they defied counting (Figure 21). Biomphalaria glabrata, the

planorbid snail which transmits Schistosoma mansoni was found

in five of the hydroclectric reservoirs, and in Lake Prieto

the snails were shedding the cercarial forms of the parasite

(able 8), Another parasite, Fasciola hepatica which infects

cattle in Puerto Rico, was found in lymnaed snails in Lake

Chora (Table 14).

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All Biomphalaria glabrata recovered in the surveys were examined for schistosome infections, but observations on

trematode infections in other snails were made

nly 06%

nally. In every instance the numbers of B. glabrata recovered were very small and the snails were confined to a single habitat. These habitats were shallow with usually Jess than O.1 meters of water, insuffictent depth for N. cornuarietis. Except for Lake Carite, the habitats were always near the entrance of a tributary stream from a watershed knonn to contain population of B. glabrata, suggesting they were recent arrivals washed in from upstream. In the exception on Lake

Carite, the B. glabrata were found in a broad swampy overflow

which often had only a trickle of water passing over it, Insufficient for establishment of a strong population of gornuarietis. Thus these small habitats served as refuges

tor the last reanants of the ®. glabrata populations. The

total number of B. glabrata found in these places never approached 100 snails and usually fewer than 10 snails were found after intensive searching.

The transitory nature of these remnant populations is

further documented by the occasional absence of 8. glabrata

from these lakes during one or more of the surveys before 1978, despite extra searching when they were not encountered. In Lake Garzas the planorbid snails were found only twice in 5 surveys, and in Lake Prieto 2 out of 4 times. This supports the hypothesis that they were snails washed in from upstream and unable to establish strony populations due to pressure

from

cornuarietis.

---Page Break---

Kenang yaanog SS Kaaing pays © K@aang puoses =? Kaaans asa

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Figure 21,

Tarebia granifera was found in almost every lake, sometimes in uncountable numbers, It usually

imnabited highly oxygenated water such as exposed

shorelines, whereas

arisa o sand

ected

Blonphalaria glabrata were found tn quiet, pri

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The final surveys in 1974 indicated that the long tera trend of elimination of Giomphalaria glabrata by Maris cornuarietis was continuing. The only lake containing Bs glabrata at the end of 1978 was Lake Prieto. The plunorbids has disappeared from the overflow of Lake Carite, from the bank of the Linbn iver in Lake Dos Bocas, from the shallow pooL at the entrance to Lake Garzas and from the swampy fringes of Lake Carratzo (Figure 22). In each of these sites

large growing populations of ¥

isa cornuarietis were found.

However in Lake Prieto the Marisa cornuarietis were clearly

being limited by shallow water, as the B. glabrata occurred in a swamp at the entrance of the river into Lake Prieto,

where vegetation was thick, and water level was shallow.

---Page Break---

FIGURE 22. BIOLOGICAL CONTROL OF BILHARZIA SNAILS IN RESERVOIRS

OF PUERTO RICO, 1956-1978

Loo

MARISA CoMMUARIETIS BIOL

CONTROL AGENT

ee

080

Host OF BILMARZIA

040

020

PROPORTION OF RESERVOIRS INHABITED BY SNAILS

1958 ee ??=es CT! ~~SC« 7H 7B

YEAR OF SURVEY

54

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%

Remaining 14 Lakes

The remaining 14 lakes showed normal ranges of water quality although the water had Less color than the 12 reservoirs studied in detail (Table 15). tone of the remaining 18 lakes contained populations of 8. glabrata

although M. cornuarietis, I. yranifera and many others

mere found (Table 16).

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Table 1

Water quality of 14 reservoirs in Puerto Rico

Guring reconnaissance survey of 1975 and 1976 (3).

Tn Standard Units Tn eg/iiter

Lake Mo. of Color Turbidity Chlorides Total Iron Nitrate Hardness os

Samples Phosphates and "ag Soy

oP nitrite

Adjuntas 3 7 Dou 0.2 0.2 0.2 168

comerio WM & a 206 03 01 05266

conerio #2 8 5 01 0.3 0.6 10

Guyabal 6a 5 8 O1 ona

cuineo ? 5 203 00 0.0 z

ordin aaa) 2 0.0 0.1 0.0 157

laPlata 5 5 16 0.0 6.2 0.2 © ate

lascurias 5 5 ep ihe 00° ol 02%

Loco ein tas ss 0.0 0.0 own

Luckett! 23 5 > 8 0.0 02 0.3187

Pellelas 2G 6 10 00 05 00 1s

Toa vce 2 O1 0.6 0.0 30

. Vivi Seas 2 1 0.0 oa ae

© Yahuecas?& 0 5 0.0 a

EAS z vaca O1 0.2 0.2 14

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?

Table 16

Snall Species in 14 minor reservoirs of Puerto Rico,

1976 to 1978.

Lake Snail Species Present

By Me Ty) Pa Pho Ly Te

Adjuntas = eee

Comerio = + ee

Comerio #2 = 6 4 = ee

Guayabal == ee ee

Gutneo ee a ee

Jordan Pe es

(acPawese * Sa te 44 es

lasCurias - + 4 - - = |

Loco = ey

Miche Sieg eG

Palieiiy ecw = ew Se

Toro pee ee

Vivi ee

Yahuecas - 8 -

Bg = Biomphalaria glabrata

No = Marisa cornuarietis

Ty = Tarebla granifera

Pa = Pomacea australis

Ph = Physa cubensis

Ly = Lyanea columella

Tr = Troplcorbis riseii.

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Discussiv

Ihe major portion of the data collected deals with the Lakes of the Dos Bocas Hydroclectric System (Table 17) and

the Lajas Valley Irrigation and Hydroelectric System (Figure 23) During the past 15 or 20 years there were general indications that the original focus of bilharzia transmission around the

Dos Bocas Reservoir System had decreased significantly while

the prevalence by skin test in the population near the reservoirs

of the Lajas Valley System had held steady or increased (Table 1s).

---Page Break---

TABLE 17

---Page Break---

HYDROELECTRIC RESERVOIRS IN TH: Dos WOCAS SYST

Reservoir Year of Construction Montes pality

ee

Lake Dos Bocas 1942 ?Arecibo and Utuado

Lake Caoni lla: 1948 evade

Lake Jordan 1950 vewado

Lake Pellejas 1950 Adjontas

Lake Vivi 1950 veuado

Lake Adjuntas 1950 Adjuntas

–

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Figure 23.

vaLLey

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The Dos Bocas and Lajas Reservoir System in Puerto R

ATLANTIC OCEAN

CARI

BBEAN

sow

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4

ADWUSTLD POSITIVITY FOR SCHISTOSOMIASIS OBTAINED FROM SKIN TEST

OF FIFTH GRADERS IH PUERTO RICO, 1963, 1969, and 1976 FoR THE

AREAS. SURKOUNDING THK DUS BOCAS AND THE LAIAS RLSLRVOIR SYSTLNS.

Watershed 1963"

os Bocas System

Utuado, Jayuya, Adjuntas 2 95d

Lajas System

Yauco, Cuayaniila, Pefuelas Ey 16 93

Upper Yauco, Castafier 25 6

"Adjusted for change in methodology fron Kagan et al, 1966 (2).

Corrected, Rulz et al, 1973 (3).

?s++From Negron and Nazario, 1975 (4).

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The Dos Bocas Hydroclectric Complex

During the Second World War construction began on a

of 6 interconnected reservoirs near Utvade, a classical foc

of schistosomiasis. Lake Dos Bocas 1s the largest of the six

and receives the Clow from turbines at Caonillas w

Win uae

receives the flow from Lakes Jordan, Pellejas, Vivi and Adjuntas (Figure 23). The population around Utuado was about 10,000 in 1960.

Because of the relatively large contributing watershed and because It 1s now used primarily for short-term supplemental Power generation, Lake Dos Bocas is maintained at a fairly

constant level. Th

other lakes however are subject to large Fluctuations, as was Dos Bocas before 1950. The combined system generates about 63 million kilowatt hours per year. There Is very little direct utilization of the water for Lerigation.

Although a survey in 1955 did not encounter 8. gla in Lake Dos Bocas or in Lake Caonillas (Harry and Cumbie, 1956)

a more detailled survey a few years later discovered a small

Population in Lake Dos Bocas at the mouth of the Limdn River,

the eastern tributary, as well as a few small colonies in

swamps adjacent to the western tributary, the Arecibo River

(Figureis). The lake was full of floating water hyacinth and

the thiarid snail Tareb

granifera (Ritchie et al, 1962). A

regular inspection system was instituted on Lake Dos Bocas,

Lake Caonillas and Lake Adjuntas in 1956, demonstrating the

presence of B. glabrata in Lake Dos Bocas from 1956 to 1976,

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os

Primarily in the same small colony on the Limbn River (Jobin et al, 1977). The planorbid snail was also found in Lake Caonillas as late as 1966, but Lt was not found after Intensive searching in 1976, The two times Lake Adjuntas was surveyed It did not contain B. glabrata, Lakes Jordin, Vivi and Pellejas were not surveyed until 1976 because of their small size and inaccesibility. They did not contain Bs glabrata In 1976 (Jobin et al, 1977). Lake Dos Bocas and

Lake Caonillas contained enormous numbers of Tari

2 grant tera

in 1976, primarily on exposed redelay shores (Jobin et al, 1976). In the watersheds contributing to these lakes the snails have been found in many places both upstream and downstream

Of the lakes, especially on the flood plains of the Vivi and Arecibo River near Utuado, in the Jayuya streans which

contribute to Lake Caonilias, in the Limén River

eh contri-

bute to the eastern branch of lake Dos Bocas, and in the lower

Flood plain of the Arecibo River, below the entire system.

Despite the presence of U. glabrata throughout the watershed,

At was somewhat surprising that none of the lakes contained Significant population of the snails.

The molluscan hervibores in Puerto Rican Lakes are not generally subjected to significant predation by larger forms, thus their population dynamics are regulated by intra-species and inter-species competition for food and habitat space, by suitability of oviposition sites, by water temperatures and

in the case of 8. glabrata, by predation on eggs and young

from M. cornuarietis. Other minor mechanisms of population

regulation may be predation by fish, and other loryer animals.

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Snail death rates are funetions of aging, diseases including parasitism, mechanical stress due to wave action, and perhaps chemical deficiencies, primarily oxygen. However most lakes in Puerto Rico seem quite suitable chemically for snail populations.

One snail which Is found infrequently is apparently

restricted by lack of suitable oviposition sites. Pomacea

australis 1s found In Large numbers only along the rocky shores of Lake Patillas, near the entrance of Rlo Patillas and Wio Marin. It 1s found in small numbers in a few other lakes such as Carratzo, Carite, Cldra, and Guayo. This large snail lays Its eggs on vertical faces above the water surface by erawling out at night, thus it needs rocks or other solid vertical surfaces which emerge above the water in lakes with

fairly st

ly levels during the oviposition sites, since Bs glabrata and Marisa usually lay their eggs on vegetation or

miscellaneous debris.

bia granifera Is ovoviviparous

and coincidentally the most ubiquitous and numerous aquatic snail on the Island, found in large numbers in all watersheds. The factors determining distribution and numbers of Lymnaea and Physa in the lakes are not understood. Their numbers are always few with no discernible patterns to their distribution. Perhaps the amphibious Lyanaea is affected by terrestrial conditions, and perhaps Physa requires high

concentration of organic matter. Helisoma is absent from

all lakes, apprently being very sensitive to contaminants and a very weak competitor ayainst other snails under Puerto

Rican conditions.

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The most important determinants to be considered in

general analysis of snail populations are thu

Water tomporature

food (peri-phyton)

habitat volume

number of same species

number of other snails.

If one compares the reservoirs in the Dos Bocas System,

where bilharzia prevalence has been declining steadily since

the reservoirs were constructed, with the reservoirs in the

Lajas System where bilharzia prevalence has been increasing

since the construction of the reservoirs, it is possible to

find some ecological differences which may be responsible.

In the Lajas system Bionphalaria populations remained stable in Lake Prieto and they were usually infected with 5. gansoni while the planorbids gradully disappeared from the Dos Bocas system and they were never found infected.

The Lakes of the Lajas System had significantly higher concentrations of hardness, phosphates, nitrates and nitrites than had the lakes of the Dos Bocas System (Tables 19 and 20). Also the net productivity and the ratio of net productivity to respiration were lower in the Lajas Systen, However the other parameters including coliform bacteria and phytoplankton

populations showed no siyaif

nt differences.

A second interesting comparison can be made regarding the

suitability of lakes for Mari

wenuarietis, based on a

comparison between Lake Guayo which is undoubtedly the take which supports the largest most, productive population of

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Marisa cornuarietis in Puerto Rico, and Lake Caonillas which

is very similar in many respects to Lake Guayo but which

contains only a few M. cornuarietis, and sonetines none.

While Lake Guayo had more nutrients than Lake Caonillas

and a deeper photic zone, the net oxygen productivity at the

surface of Lake Caonillas was twice the productivity of Lake

Guayo, with similar ratios of oxygen productivity/respiration

(Table 21). The higher oxygen productivity was confirmed by

the high algae counts in Lake Caonillas.

This suggests that algae is not as important for

comnuartetis as 1s Littoral vegetation. With the flatter 4

shoreline of Lake Guayo, deeper photic zone and higher

nutetents, the amount of rooted shoreline vegetation was

enormous, while in Lake Caonillas the steep shorelines and

low nutrients produced virtually no 1ittoral vegetation, with

erosion of most of the shore.

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Table 21

Comparisons of lakes as habitats for Marisa comwarietis.

Paraneter Ideal Habitat for Very poor Habitat for

Marisa cornvarietis ?isa comnvarietis

Lake Guayo Lake Caoniitas

Chorides-ng/1 n ?

Marcnessong/1 09 M950, we no

pH 7.8 7S

Total Phosphates as P 0.03 0.01

Nitrates and Nittettes as Neng/t 0.10 0.06

Tron 0.06 0.13

Seccht Disk ne Ma

Turbtatty 5.0. 10 22

colors. a 1%

Net Productivity mg/l 0,/day 07 Ls

Respiration-ng/} 0,/day os 1

Coltform bacteria per 100 ml aus 3975

Bive green algae per 100 al 4836 180

Green algae per 100 a suo 1160

Diatons per 100 a ae 6m

Flagellates per 100 al 178 170

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