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Occurrence, Longitudinal Distribution and Geographical Range of the Fresh- and Brackish water Molluscs of the Lesser Antillean Islands (Guadeloupe, Dominica and Martinique) - A Kisantillák (Guadeloupe, Dominica és Martinique) édes- és brakkvízi puhatestűinek elterjedése

ABSTRACT: The longitudinal distribution of fresh- and brackishwater molluscs between the headwaters and the mouths of the running waters of the Lesser Antillean Islands /Guadeloupe, Dominica and Martinique/ are discussed.

During a hydrobiological mission to the Lesser Antillean Islands of Guadeloupe, Dominica and Martinique between March and May 1979 the longitudinal distribution of the fresh- and brackishwater molluscs between the headwaters and mouths of the mountain streams was studied. The collections were made qualitatively and quantitatively (1/16 m<sup>2</sup> to 1 m<sup>2</sup>) at selected stations of the running waters. In connection with the collections also ecological parameters of the habitat were measured, such as velocity of the surface current, temperature, bottom material (rocks, boulders, gravel, sand or mud), aquatic vegetation and chemistry (electrolytic conductivity, total hardness, pH, content on Ca<sup>2+</sup>, K, Mg<sup>2+</sup>, Na, Cl, SO<sub>4</sub>, NO<sub>3</sub>, NO<sub>2</sub>, PO<sub>4</sub> and SiO<sub>2</sub>) (STARMÜHLNER & THEREZIEN, 1982a, b; 1983a, b).

#### GENERAL COMMENTS ON THE RUNNING WATERS OF THE ISLANDS

The Archipelago of the Lesser Antillean, tropical islands, is situated between 12°N and 18°N latitude and 59°W and 63°W longitude /Fig.1/. The Archipelago stretches as a chain of islands in a lenght of 750 km. In contrast to the Greater Antillean Islands, with old cretaceous rocks, are the Lesser Antillean Islands from younger geological date.

The eastern group of the Lesser Antillean Islands /with Guadeloupe, Dominica and Martinique/ are composed as an arc of islands between the island of Anguilla in the North and the island of Grenade in the South. The rocks are calco-alcaline in a association of basalte-andesite-dacite-rhyolite, where the andesite is dominant. The Archipelago is divided in two groups:

1/ Limestone Caribees, such as Grenade Terre /of Guadeloupe/, Marie Galante, La Désirade, Antigua, St. Barthélemy, St. Martin, Anguilla, Dog and the Sombrero-islands.

2/ Volcanic Caribees, such as Grenada, Grenadines, St. Vincent, St. Lucie, Martinique, Dominica, Iles des Saintes, Basse Terre /of Guadeloupe/, Montserrat, Nevis, St. Kitts, St. Eustache and Saba.

The Limestone Caribees are at first volcanic origine /Eocene to Oligocene/ but in the following epochs the volcanic rocks were eroded /Oligocene to Miocene/ and covered by a cap of limestones of marine origine. In the later Miocene these limestone-deposits were lifted up over the sea level. Only few running waters, drying out for longer time, occur on these flat islands.

The Volcanic Caribees are mountainous and composed by rocks, as result of eruptions between the younger Miocene and the later Pliocene up to epochs of the recent times. On the island of Basse Terre the volcanisme is still active with the volcano La Soufrière and at Martinique with the volcano Mt. Pelée. In the South of Dominica there are hot springs and fumarols in the Valley of Desolation nearby the famous Boiling Lake.

In consequence of the relatively small volcanic islands the distances of the mountain streams /between headwaters and mouths/ are very short to short /Basse Terre: 3/5 km /West-coast/ to maximal 30km /East-

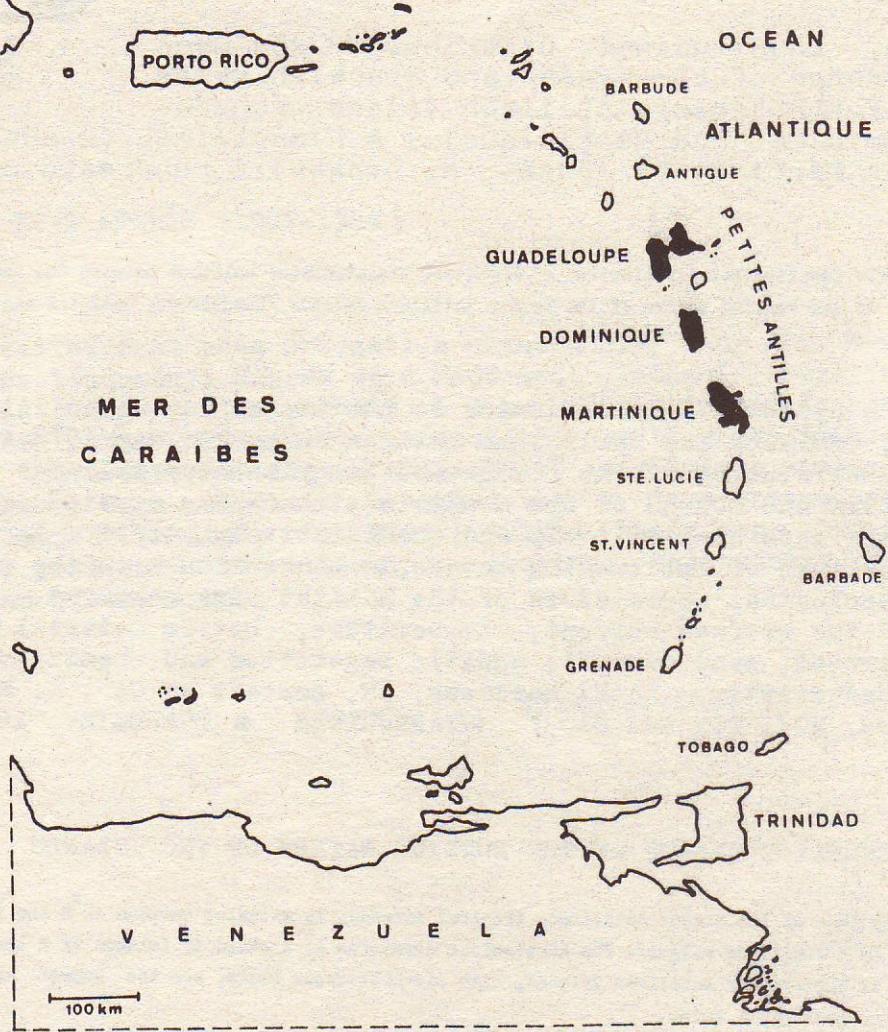


Figure 1.: Map of the Lesser Antillean Islands.  
The investigated islands of Guadeloupe,  
Dominica and Martinique are black indicated.

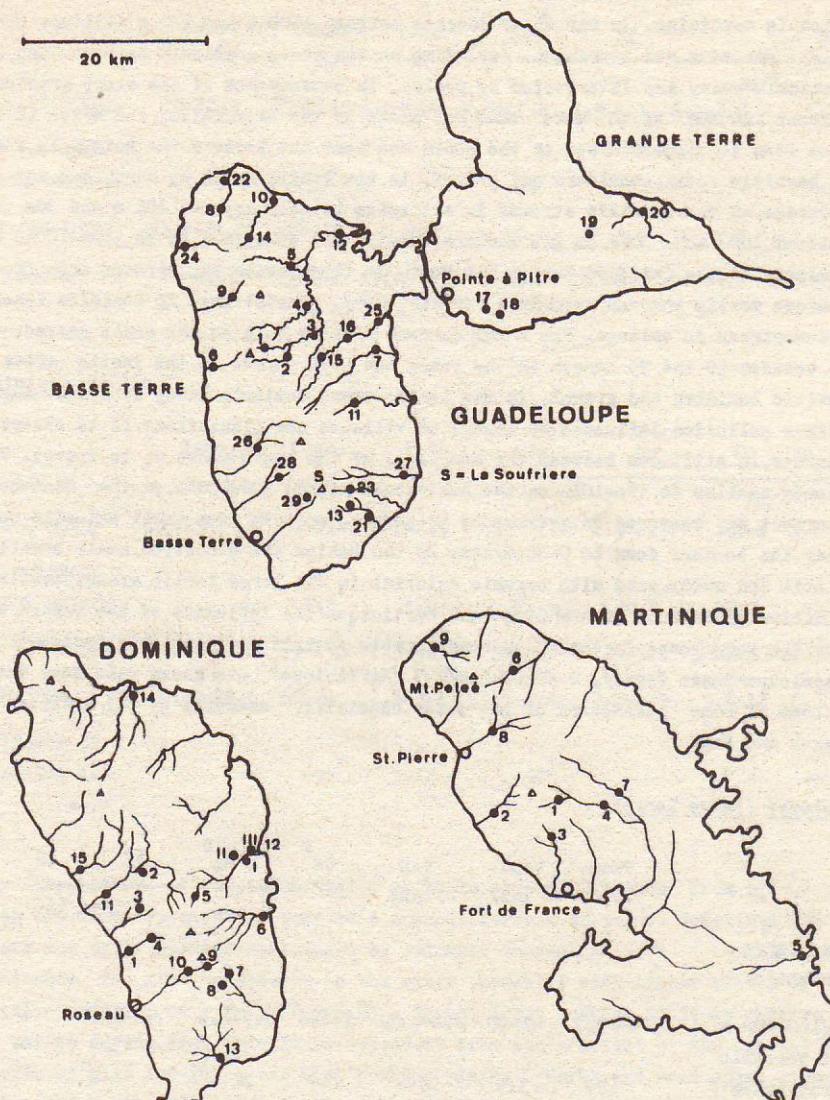


Figure 2.: Map of Guadeloupe /Basse Terre and Grande Terre/, Dominica /Dominique/ and Martinique with the main rivers. The stations of records are indicated with a black point and the number of collection. The triangles indicate the highest points of the islands.

coast; Dominica: 5 to 14 km; Martinique: 2 to 20 km lenght; Fig. 2/.  
The headwaters of the mountain streams have it sources mostly in the primary and secondary rain forests, covering the volcanic mountains. In the upper courses between 1000 m and 100 m altitude there are spectacular waterfalls, cascades and torrents, depending on the steep gradients between 75‰ and up to 150‰! The stair-like cascade-zones are interrupted by pools. In consequence of the steep gradients the velocity of the water current reaches up to more than 2-3 m/sec in the waterfalls, 1-2 m/sec in the cascades and torrents and slow down to 75cm-30cm/sec in the pools and near the borders. The bottom is composed in the lotic areas by basaltic rocks, boulders and gravel, in the lentic areas by sand, mud and organic deposits. In the middle courses of the mountain streams in altitudes between approx. 100 m and 30m the steep gradients changes between 10‰ and 30‰ on the Eastern coast, but sometimes up to 50‰-100‰ on the steeper slopes of the islands to the Caribbean Sea in the West. In these zones the streams are flowing at Basse Terre and Martinique mostly through secondary forests, resp. plantations. At Dominica reaches the primary forests partly downstream to valleys. The water current reaches only in the small cascade-zones up to 1m/sec, in average between 50 and 75 cm/sec in the lotic and 0-30 cm/sec in the lentic areas. The bottom consists of basaltic boulders and gravel, in the lentic areas dominate muddy sand and layers of organic deposits. Sometimes pollution influence by sewage of villages and plantations is to observe.  
In the lower courses, in altitudes between the sea level of the mouth-zones up to approx. 20-30 m altitude the steep gradients decline to 1‰-10‰ on the East-coast and to 10‰-30‰ on the West-coast. The velocity of the current was measured in average by 50 cm/sec, only in some small cascades up to 1 m/sec, but in pools and near the borders down to 0-30cm/sec. On the bottom are deposited small basaltic boulders and gravel in the lotic and muddy sand with organic material in the large lentic areas. Sometimes - at the dense populated and cultivated islands of Guadeloupe and Martinique - the influence of the sewage of the villages and pollution by the sugar-cane factories is considerable /putrid and anaerobic mud!/.  
In Table 1 /Guadeloupe-Basse Terre/, 2 /Dominica/, 3 /Martinique/ are shown the mean water temperatures and the mean values of some parameters of the water chemistry, measured by the Austrian-French Mission 1979 between March and May:

Table 1: Guadeloupe /Basse Terre/:

Temp.	Cond.	T.H.	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Cl	SO <sub>4</sub> <sup>2-</sup>	NO <sub>3</sub> <sup>-</sup>	SiO <sub>2</sub>
/°C/	/µS/	/°dH/	/mg/l/	/mg/l/	/mg/l/	/mg/l/	/mg/l/	/mg/l/

Guadeloupe-Basse Terre  
/East-coast, Atlantic/

Upper courses /100-600 m/ +/influence of volcanic mineral water!/	19.4-23.7 179 <sup>+</sup>	41-90 3.9 <sup>+</sup>	0.4-1.5 18.4 <sup>+</sup>	1.6-6 2.7 <sup>+</sup>	0.7-1.6 21.6 <sup>+</sup>	7.2-10.5 8 <sup>+</sup>	2-4 2.2 <sup>+</sup>	0.5-1.7 2.8 <sup>+</sup>	8-22 28 <sup>+</sup>
Middle courses /30-100m/	22.1-26	75-103	1.2-1.8	5.2-8	1.7-3.2	6.8-12	1-2	0.5-2.5	17-24
Lower courses to mouth /0-30m/ +/brackish influence of the repulsion flow/	23.4-28	600-	10.9-	18-	36.5-	574-	36-	1-2,4	13-22
		5961 <sup>+</sup>	38.9 <sup>+</sup>	52 <sup>+</sup>	137 <sup>+</sup>	2028 <sup>+</sup>	233 <sup>+</sup>		

/West-coast, Caribic/

Upper courses /100-600m/	19.7-22.8	48-155	0.7-2.9	3.6-14	1-4.1	7-20.4	2-3	0.5-1.2	11-28
Middle courses /30-100m/	23.6	140-152	2.2	10	3.6	16	17	0.8	30
Lower courses /5-30m/	24.2-25.4	102-146	1.5-2.5	5.2-12	1.7-3.4	12.6-17.2	2	0.5-1.2	24-32

Table 2: Dominica

	Temp. °C	Cond. μS	T.H. °dH	Ca <sup>2</sup>	Mg <sup>2</sup>	Cl	SO <sub>4</sub>	NO <sub>3</sub>	SiO <sub>2</sub>
mg/l									
Upper courses /100-900m/ + /influence of volcanic mineral water/	20-22.9	75-117	1.5-2.6	7.2-11.2	1.9-4.4	6.4-7.6	3-21	0.5-1	14-36
Middle courses /30-100m/	24.2-24.8	103-117	2.1	10.8	2.4	8.8	3	0.5	34
Lower courses /3-30m/	24-26.1	85-162	1.6-3.4	8-16.8	1.9-4.4	8-9.2	0.7-0.9	3-24	14-34

Table 3: Martinique

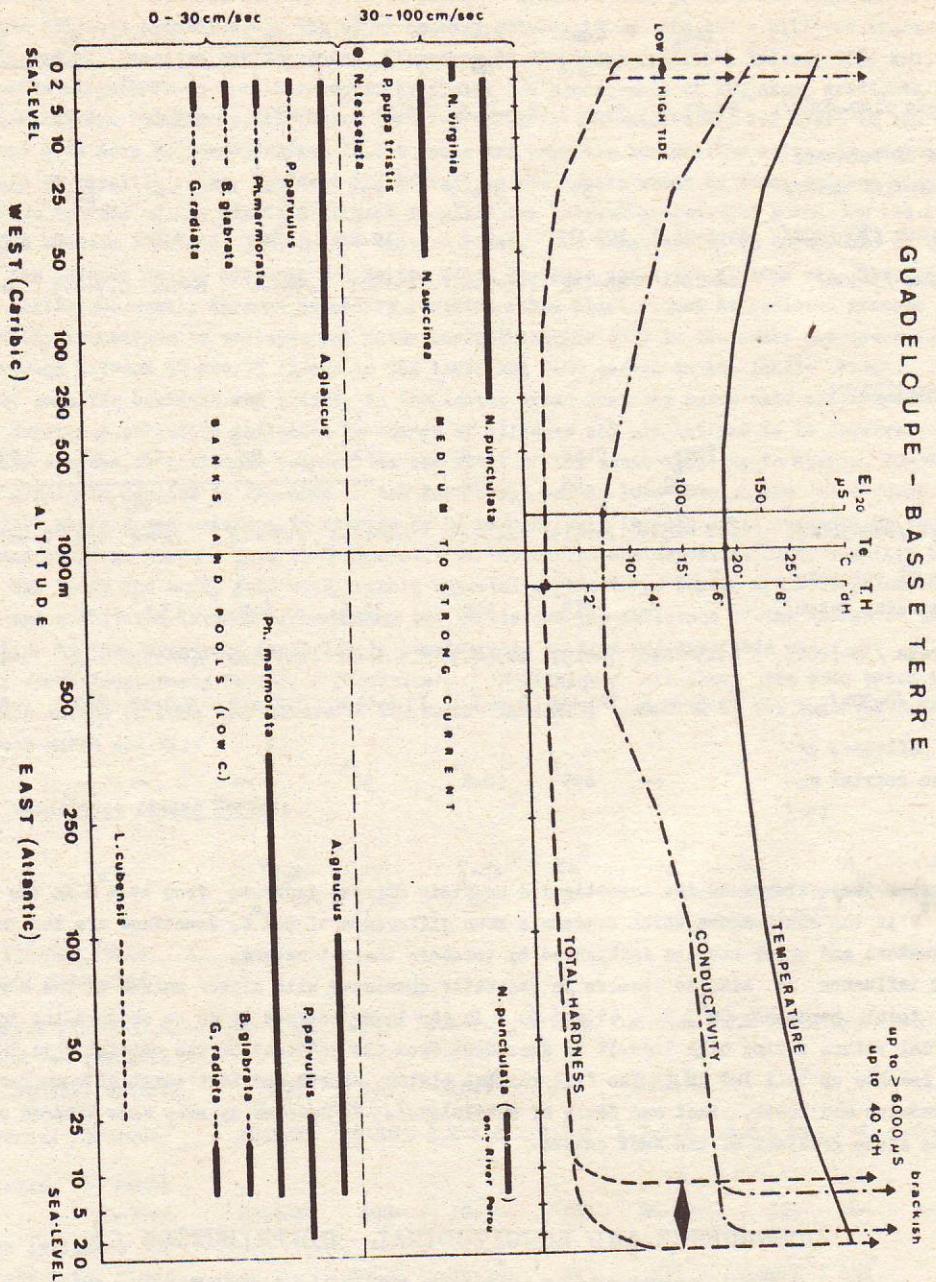
	Temp. °C	Cond. μS	T.H. °dH	Ca <sup>2</sup>	Mg <sup>2</sup>	Cl	SO <sub>4</sub>	NO <sub>3</sub>	SiO <sub>2</sub>
mg/l									
Upper course /100-500m/ + /influence of volcanic mineral water/	21.7-25.6	74-114	1.2-2.4	5.6-12.4	1.9-2.9	7.4-8	1-2	0.9-1.5	22-34
Middle courses /30-100m/	24.5-28.6	74-197	1.3-4.3	5.6-20	2.4-5.6	9.6-15.6	1-3	1-1.2	12-44
Lower course /0-30m/ + /brackish influence of subterranean coastal wa- ter/	24.8-28.6	128-149	2.6-3.1	13.6-14.4	3.2-4.9	9.2-12	2-3	0.8-1	26-32
				—	695 <sup>+</sup>	10.2 <sup>+</sup>	52 <sup>+</sup>	—	—

The water temperatures of the investigated mountain streams increase from 19.4°C in the headwaters up to 28.6°C in the mouth-zones, which express a mean difference of 9.2°C. Sometimes are the temperatures of the headwaters and upper courses influenced by volcanic thermal waters.

These influence is also to observe in the water chemistry with higher values of the electric conductivity, total hardness, Ca<sup>2</sup>, Mg<sup>2</sup>, Cl and SO<sub>4</sub>. In the lower courses it is to observe the influence of brackish tidal waters during high tide. It is dependent from the gradient of the coastal area. The brackish influence reaches up till 1-2 km in the flat coastal plains /North and East coast of Basse Terre, some areas of Dominica and North, East and South of Martinique/. He reaches up only some hundred meters /and less/ on the steep gradient of the West coasts.

#### OCCURRENCE AND LONGITUDINAL DISTRIBUTION OF THE GASTROPODS IN THE MOUNTAIN STREAMS

Conchological collections and malacological researches on freshwater molluscs of the Lesser Antillean Islands are reported for Guadeloupe and Martinique by SCHRAMM (1869), MAZÉ (1874, 1883 and 1890). Researches on Planorbidae were executed by DREYFUSS (1953) and for Lymnaea cubensis by GRETILLAT (1967). Comprehensive studies on the freshwater molluscs of Guadeloupe are pointed out by POINTIER (1974, 1976). Specially studies on the ecology and distribution of the planorbid snail Biomphalaria glabrata as intermediate host of Schistosoma mansoni are published by LEVEQUE & POINTIER (1976), POINTIER & DELPLANQUE (1976), POINTIER & COMBES (1976) and by POINTIER, SALVAT, DELPLANQUE & GOLVAN (1977). The freshwater molluscs of the Lesser Antillean Islands of St. Vincent and St. Lucie, two islands to be adjacent in the South



**Figure 3.:** Longitudinal Distribution of Fresh and Brackishwater Gastropods of Guadeloupe-Basse Terre in the Mountain streams /between Headwaters/approx.1000m and the Mouth-zones at Sea-Level/0m/ at the West /Caribic/ and the East /Atlantic/ coast. In comparison with 3 Ecological Parameters such as Water-Temperature, /in °Celsius/, Electrolytic Conductivity / $E_{1,20}$  in  $\mu$  Siemens/ and Total Hardness /in  $^{\circ}dH$ /.

of Martinique are studied carefully by HARRISON & RANKIN (1975, 1976, 1978), RANKIN & HARRISON (1979), MCKILLOP & HARRISON (1980), MCKILLOP, HARRISON & RANKIN (1981) and by HARRISON (1982).

#### Guadeloupe (Basse Terre): East coast (Atlantic) (Fig. 2)

A) Upper courses (100 m to 600 m altitude): Headwaters - mostly waterfalls and torrents - originate in primary or secondary mountain rain forests. The lower parts (100-300 m altitude) are flowing partly through open landscapes with shrubs, bushes and plantations. Temperatures and chemistry: Table 1.

Species found: No molluscs in the headwaters! Upper courses: Low current /banks and pools: 0-30 cm/sec/: Only Physa marmorata up to 400 m altitude.  
Medium to strong current /30 cm - 1 m/sec/: No molluscs!

B) Middle courses (30 m to 100 m altitude): Flowing partly through secondary forests, partly through open landscapes and plantations. Temperatures and chemistry: Table 1.

Species found: Low current /banks and pools: 0-30 cm/sec/: Ampullarius glaucus; Lymnaea cubensis /very sporadic!/: Physa marmorata.  
Medium to strong current /30 cm->1 m/sec/: No molluscs!

C) Lower courses to the mouth-zones (0-30 m altitude): Flowing through open landscapes, sugar-cane plantations, lower parts in the mangrove area. In these areas influence of brackish water during high tide. Temperatures and chemistry: Table 1.

Species found: Low current /banks and pools: 0-30 cm/sec/: Ampullarius glaucus; Pyrgophorus parvulus; Lymnaea cubensis/very sporadic!/: Physa marmorata; Biomphalaria glabrata; Gundlachia marmorata.  
Medium to strong current /30/50 cm->1 m/sec/: Neritina punctulata /only in the lower course of the Riv. Perou upstream of the influence of brackish water/.

#### West- and Northwest coast (Caribic) (Fig. 3)

A) Upper courses (100 m to 600 m altitude): The torrential mountain streams of the steep West coast originate partly in primary, partly in secondary forests. The lower parts flowing mostly through open landscapes surrounded by shrubs. Temperatures and chemistry: Table 1.

Species found: Low current /banks and pools: 0-30 cm/sec/: No species recorded/probably Physa marmorata.  
Medium to strong current /30/50 cm->1 m/sec/: Neritina punctulata.

B) Middle courses (30 m to 100 m altitude): In consequence of the shortness of the mountain streams of the West coast short cascade-zones alternate with pools. Surrounded by aride woods with xerophytes, partly plantations. Temperatures and chemistry: Table 1.

Species found: Low current /Banks and pools: 0-30 cm/sec/: Ampullarius glaucus;/probably Physa marmorata.  
Medium to strong current /30/50 cm->1 m/sec/: Neritina punctulata; Neritilia succinea /up to 50 m altitude/.

C) Lower courses to the mouth-zones (0 m to 30 m altitude): Very short, the influence of brackish water during high tide only some hundred meters, only on the flater North-east coast larger. Surrounded by aridic shrubs and bushes, sometimes plantations; partly influence of sewage of nearby villages. Temperature and chemistry: Table 1.

Species found: Low current /banks and pools: 0-30 cm/sec/: Ampullarius glaucus; Pyrgophorus parvulus; Physa marmorata; Biomphalaria glabrata; Gundlachia radiata.  
Medium to strong current /30/50 cm->1 m/sec/:  
Freshwater /Cond.: 102-146  $\mu$ S/: Neritina punctulata; Neritilia succinea; Fresh- to brackish water /Cond.: up to 500-600  $\mu$ S and more/: Neritina virginea; Brackish water /Cond.: up to 6000  $\mu$ S and more/: Puperita pupa tristis; Sea water /rocky shores/: Nerita tessellata /and other marine species/

#### Dominica: East coast (Atlantic) (Fig. 2)

A) Upper courses (100 m to 900 m altitude): Torrents originating in primary rain forests, in the South influenced by volcanic thermal and mineral waters (Valley of Desolation). Temperatures and chemistry: Table 2.

Species found: No species recorded.

B) Middle courses (30 m to 100 m altitude): Small rivers in the valleys, surrounded by secondary forests and plantations. Temperatures and chemistry: Table 2.

Species found: No species recorded.

C) Lower courses to the mouth-zones (0 m to 30 m altitude): Rivers and brooks flowing through the coastal plains, surrounded by plantations. Temperatures and chemistry: Table 2.

Species found: Low current /banks and pools: 0-30 cm/sec/: Ampullarius glaucus; Melanoides tuberculata.

Medium to strong current /30/50 cm->1 m/sec/:

Freshwater /Cond.: 77-162  $\mu$ S/: Neritina punctulata; Neritilia succinea;

Fresh- to brackish water /Cond.: up to 500-600  $\mu$ S and more/: Neritina virginea;

Sea water /rocky shores/: Nerita tessellata /and other marine species/.

#### West coast (Caribic) (Fig. 2)

A) Upper courses (100 m to 900 m altitude): Like East coast. Temperatures and chemistry: Table 2.

Species found: Low current /banks and pools: 0-30 cm/sec/: No species recorded.

Medium to strong current /30/50 cm->1 m/sec/: Neritina punctulata

B) Middle courses (30 m to 100 m altitude): Like East coast. Temperatures and chemistry: Table 2.

Species found: Low current /banks and pools: 0-30 cm/sec/: Melanoides tuberculata

Medium to strong current /30/50 cm->1 m/sec/: Neritina punctulata

C) Lower courses to the mouth-zones (0 m to 30 m altitude): Like East coast. Temperatures and chemistry: Table 2.

Species found: Low current /banks and pools: 0-30 cm/sec/: Melanoides tuberculata

Medium to strong current /30/50 cm->1 m/sec/:

Freshwater /Cond.: 77-162  $\mu$ S/: Neritina punctulata; Neritilia succinea;

Fresh- to brackish water /Cond.: up to 500-600  $\mu$ S and more/: Neritina virginea;

Brackish water /Cond.: up to 6000  $\mu$ S and more/: Puperita pupa tristis;

Sea water /rocky shores/: Nerita tessellata /and other marine species/.

#### Martinique: West coast (Caribic) (Fig. 3)

A) Upper courses (100 m to 500 m altitude): Torrents in the primary and secondary rain forests. Temperatures and chemistry: Table 3.

Species found: Low current /banks and pools: 0-30 cm/sec/: Drepanotrema aeruginosum /only in flooded pools near the banks, no current!/.

Medium to strong current /30/50 cm->1 m/sec/: No species recorded, but Neritina punctulata to expect!

B) Middle courses (30/20 m to 100 m altitude): Small rivers in the valleys and the central plains; surrounded by plantations and shrubs; partly polluted by sewage of nearby villages and little towns. Temperatures and chemistry: Table 3.

Species found: Low current /banks and pools: 0-30 cm/sec/: Drepanotrema aeruginosum /only in flooded pools near the banks, no current!/: Physa marmorata; Gundlachia radiata;

Medium to strong current /30/50 cm->1 m/sec/: Neritina punctulata;

C) Lower courses to the mouth-zones (0 m to 20/30 m altitude): Rivers with a breadth from 273 m to 10 m and more; surrounded by plantations, mostly of sugar cane, but also shrubs; partly polluted by nearby villages and small towns. Temperatures and chemistry: Table 3.

Species found: Low current /banks and pools: 0-30 cm/sec/: Pyrgophorus parvulus; Drepanotrema aeruginosum; Physa marmorata; Gundlachia radiata;

Medium to strong current /30/50 cm->1 m/sec/:

Freshwater /Cond.: 128-149  $\mu$ S/: Neritina punctulata; Neritilia succinea;

Fresh- to brackish water /Cond.: up to 695  $\mu$ S and more/: Neritina virginea;

Brackish water /Cond.: up to 6000  $\mu$ S and more/: Puperita pupa tristis;

Sea water /rocky shores/: Nerita tessellata /and other marine species/.

Comparing the results of the longitudinal distribution of the found fresh- and brackish water gastropods in the mountain streams of the volcanic islands of Guadeloupe-Basse Terre, Dominica and Martinique it is to state that Neritina punctulata is the only watersnail occurring in the lotic areas of the running waters from the upper to the lower courses. But it is suspicious that these species occur mainly in the streams of the West (or Caribic) coasts of these islands. Only one record belongs to a river from the South-east coast of Basse Terre (Riv. Perou) and an other record to the East coast of Dominica (Riv. Rosalie).

These surprising restricted and discontinuous geographical distribution of Neritina punctulata (and Neritilia succinea) was also found by HARRISON & RANKIN (1978) on the island of St. Vincent. The authors write on page 171: "(it) appears to be related to an ancient distribution pattern... in addition to the effect of the varying extent of forest cap and riparian strips" (reported by HARRISON & RANKIN, 1975).

In the lower courses the longitudinal distribution of the Neritidae is influenced by the ascendend and descendend repulsion flow of brackish water from the mouth-zones between the high and low tides (Fig. 1, 2, 3). In purely freshwater (conductivity (El<sub>20</sub>): between 77 and 162  $\mu$ S), upstream of the influence of brackish water dominate Neritina punctulata and Neritilia succinea. In the transition zones between fresh- (low tide) and brackish water (high tide; conductivity (El<sub>20</sub>): up to 500-600  $\mu$ S and more) Neritina virginea occurs. The shells of these species are varying extremely in the colour pattern. In the mouth-zones with brackish resp. saline water Neritina virginea disappears and is replaced by Puperita pupa tristis (conductivity (El<sub>20</sub>): up to 6000  $\mu$ S and more). In the transition of the mouth-zone to the rocky shore on the litoral coast the marine species Nerita tessellata (accompagned by other litoral species such as Patellidae, Trochidae, etc.) is typically.

In the lower current (0-30 cm/sec) near the banks and in pools between cascades occurs only Physa marmorata up to the upper courses (at Basse Terre). From the middle to the lower courses was recorded Ampullarius glaucus and sporadically Lymnaea cubensis (at Basse Terre). Drepanotrema aeruginosum, a planorbid watersnail, was only at Martinique found, recorded from the middle to lower courses, but exclusively in flooded pools near the banks (stagnant water!). The hydrobiid snail Pyrgophorus parvulus, very frequently in stagnant waters, was partly recorded in the lentic areas of the lower courses (Basse Terre, Martinique) with dense aquatic vegetation. In regions, influenced by brackish water the varying shell shows knobs or spines. In habitats with pure freshwater the surface of the shell is more and less smooth, but in some populations occur all transitions from smooth to spiny shells (also reported by POINTIER, 1974: 907; HARRISON & RANKIN, 1978: 187). The thiariid snail Melanoides tuberculata (introduced unintentional by man /?/) was only found at Dominica and these record is probably the first finding of the Lesser Antillean Islands.\*

The planorbid snail Biomphalaria glabrata, well known as intermediate host of Schistosoma mansoni and widely spreaded in the stagnant waters of the Caribbean islands (POINTIER, 1974 and others) and the ancylid snail Gundlachia radiata were recorded only sporadically in the lentic areas of the lower courses with dense growth of aquatic plants.

#### COMPARISON OF THE LONGITUDINAL DISTRIBUTION OF THE FRESH- AND BRACKISH WATER GASTROPODS OF TROPICAL INDOPACIFIC ISLANDS AND LESSER ANTILLEAN MOUNTAIN STREAMS

In Table 4 is given a comparative survey of the longitudinal distribution of different species of fresh- and brackish water gastropods in the lotic areas (30/50 cm/sec 1 m/sec) of mountain streams of tropical Indopacific Islands and Lesser Antillean Islands.

In Table 4 is to observe that in the lotic areas of the different zones (upper, middle, lower courses to mouth-zones) of the mountain streams of islands in the different geographical areas (Indian Ocean /Madagascar, Sri Lanka and Andamans/, South-Pacific /New Caledonia and different islands such as New Hebrides, Solomons, Fiji and Tahiti/ and Caribbean /and Atlantic/ Sea) the occurring families of geologically old groups of prosobranch gastropods such as Neritacea-Neritidae, Cerithiacea-Thiaridae and Potamidiidae and sometimes Rissoacea-Hydrobiidae are represented by vicarying genera resp. species. It seems that the splitting of populations or biotas in connection with the wandering continents and continental islands is an essential factor of the recent faunal relationships among tropical islands. But it is also to consider that some species of tropical freshwater gastropods are introduced unintentional on islands by man with waterplants, riceplants etc. or by water birds (spawn).

All the superfamilies, resp. families in the Tables 4 and 5 have a marine origine with the main-evolution in the Mesozoikum and an immigration in the streams seems to be started with the end of Cretaceous and the beginning of the Tertiary. An immigration is possible upstream over the brackish zones between the mouth and the lower courses in connection with the recurrent flow of high tide (Table 5).

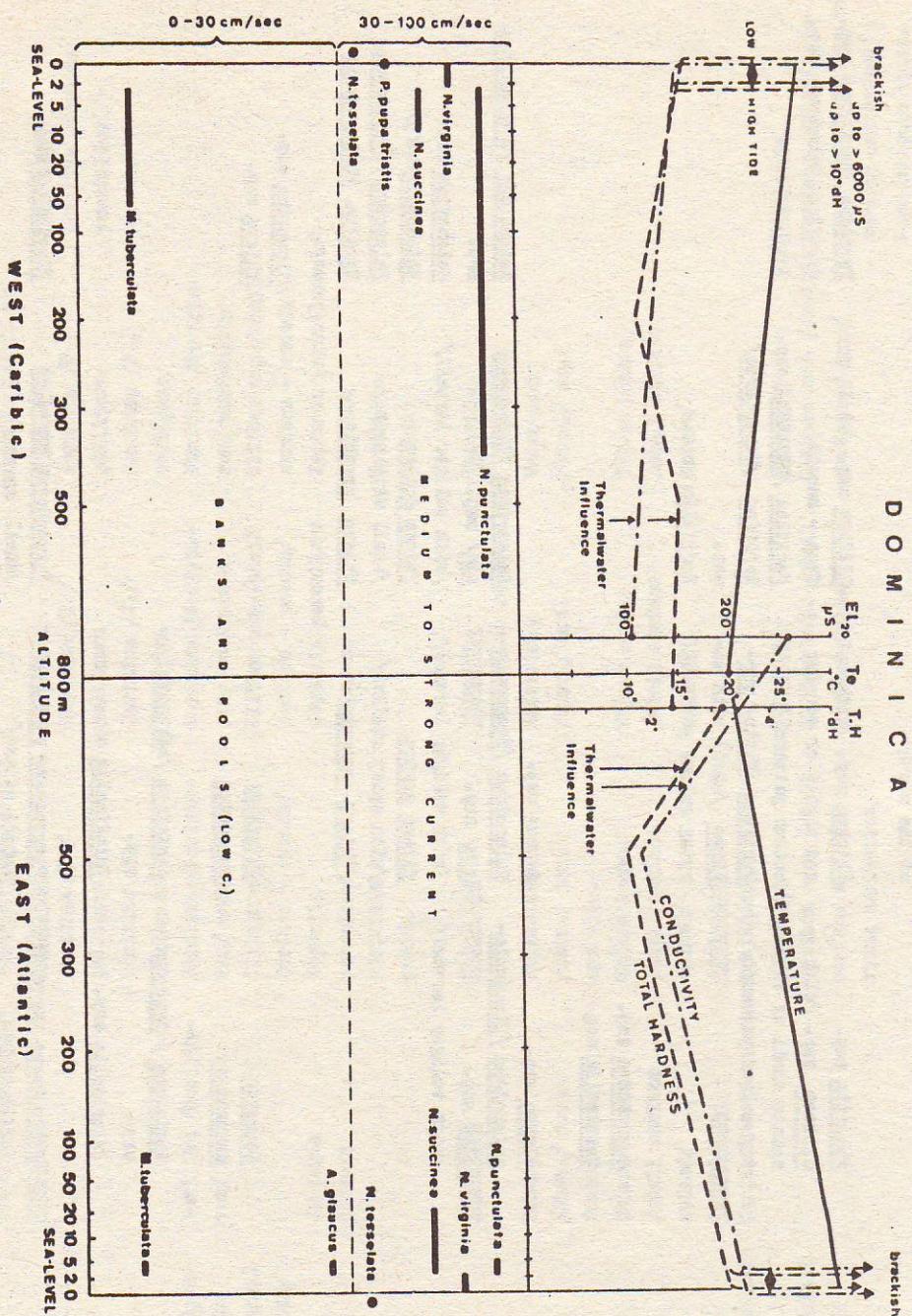
\* After an oral information from Dr. J. P. POINTIER /Mus. Nat. Hist. Nat., Paris, Lab. de Malacologie/ he has found Melanoides tuberculata - as first record 1983 - also in Guadeloupe and Martinique!

Table 4.

MADAGASCAR	SRI LANKA	ARDAMAN	INN CALEDONIA	S-PACIFIC ISLANDS	LESSER ANTILLES ISL.
<u>Heritidae</u>	<u>Tarebia granifera</u>	<u>Tarebia granifera</u>	?	<u>Tarebia granifera</u>	
<u>Heritina /n./</u>	<u>Heritidae</u>	<u>Heritidae</u>	<u>Heritidae</u>	<u>Heritidae</u>	
<u>pulligera</u>	<u>Heritina /n./</u>	<u>pulligera</u>	<u>Heritina /n./</u>	<u>Heritina /n./</u>	
<u>Heritina /n./</u>	<u>pulligera</u>	<u>pulligera</u>	<u>pulligera</u>	<u>pulligera</u>	
<u>gagates</u>	<u>variegata</u>	<u>variegata</u>	<u>variegata</u>	<u>variegata</u>	
<u>Heritina /scripte-</u>	<u>Heritina /scripte-</u>	<u>Heritina /scripte-</u>	<u>Heritina /scripte-</u>	<u>Heritina /scripte-</u>	
<u>ron/ auriculata</u>	<u>ron/ auriculata</u>	<u>ron/ auriculata</u>	<u>ron/ auriculata</u>	<u>ron/ auriculata</u>	
<u>Clithon spp./shell</u>	<u>Clithon spp./shell</u>	<u>Clithon spp./shell</u>	<u>Clithon spp./shell</u>	<u>Clithon spp./shell</u>	
<u>surface + smooth/</u>	<u>surface + smooth/</u>	<u>surface + smooth/</u>	<u>surface + smooth/</u>	<u>surface + smooth/</u>	
<u>Septaria</u>	<u>Septaria</u>	<u>Septaria</u>	<u>Septaria</u>	<u>Septaria</u>	
<u>boreonica</u>	<u>lineata</u>	<u>lineata</u>	<u>porcellana</u>	<u>porcellana</u>	
<u>Heritilia</u>		<u>Heritilia</u>	<u>depressa</u>	<u>depressa</u>	
<u>consimilis</u>		<u>rubida</u>	<u>depressa</u>	<u>depressa</u>	
<u>Heritilia</u>			<u>Heritilia</u>	<u>Heritilia</u>	
			<u>rubida</u>	<u>suecinae</u>	
<u>Thiaridae</u>			<u>Thiaridae</u>		
<u>Melanoides</u>			<u>Melanoides</u>		
<u>/Stem./ tor.</u>			<u>/Stem./ art.</u>		
<u>Famus atar</u>			<u>and plic.</u>		
<u>Thiara scabra</u>			<u>Thiara scabra</u>		
<u>/shell surface</u>			<u>/shell surface</u>		
<u>spined/</u>			<u>spined/</u>		
<u>Potamididae</u>			<u>Potamididae</u>		
<u>Cerithidea decollata</u>	<u>Cerithidea cingulata</u>		<u>Cerithidea cingulata</u>		
<u>Heritidae</u>			<u>Heritidae</u>		
<u>Clithon spp./shell</u>			<u>Clithon spp./shell</u>		
<u>surface spined/</u>			<u>surface spined/</u>		
			<u>varying coloration/</u>		
			<u>Puperita papa trist.</u>		
Littoral near the					
North-zone marine!					
Herita spp.			Herita spp.		
Herita tesselata			Herita tesselata		

Table 5.

<u>Superfamily</u> <u>Heritacea -</u> <u>Heritiidae</u>	Marine-littoral, near the South-zones <u>/mouth/</u>	Change of brackish and freshwater between high and low tide /upstream of the south/	Freshwater-zones upstream of the brackish influence <u>/middle and upper course</u>
<u>Heritacea -</u> <u>Cerithiidae</u>	<u>Herita</u> ssp.	<u>Puperita</u> ssp. <u>Clithon</u> ssp. /with spined shell or vary- ing colour pattern/ <u>Heritina</u> /Vitta/ ginea /shell with re- rying colour pattern/ <u>Heritilla</u> ssp.	<u>Clithon</u> ssp. /with spi- ned shells or varying colour pattern/ <u>Heritina</u> /Vittina/ ssp. <u>Heritina</u> /Heripteron/ ssp. <u>Heritilla</u> ssp.
<u>Cerithiidae -</u> <u>Potamididae</u>		<u>Cerithidea</u> ssp. <u>Erebrialia</u> ssp.	<u>Heritina</u> /Meritina/ ssp. <u>Heritina</u> /Nerdina/ ssp. <u>Septaria</u> ssp.
<u>Thiaridae</u>	<u>Faujas</u> ssp.	<u>Faujas</u> ssp. <u>Melanoides</u> / <u>Stenocela-</u> <u>nla</u> / ssp.	<u>Melanoides</u> / <u>Stenocela-</u> <u>nia</u> / ssp. /with veliger larvae/ <u>Thiara</u> <u>scabra</u> /with spiny shells/ <u>Thiara</u> <u>aserrula</u>
<u>Rissoacea -</u> <u>Sternothyridae</u>			<u>Melanoides</u> / <u>Meritina</u> / /shell smooth/ <u>Thiara</u> ssp.
<u>Assimineidae</u> / = <u>Synceridae</u>		<u>Assimines</u> /- <u>Syncea</u> / ssp. <u>Paludinella</u> ssp.	<u>Meritina</u> / <u>Meritina</u> / /shell smooth/ <u>Thiara</u> ssp.
<u>Atrypidae</u>		<u>Euphorborus</u> <u>parvulus</u> /shell spined/	<u>Euphorborus</u> <u>parvulus</u> /shell smooth/ <u>Thiara</u> ssp.



**Figure 4.: Longitudinal Distribution of the Fresh and Brackishwater Gastropods of Dominica in the Mountain streams/between Headwaters /approx. 800/900m/ and the Mouth-zones at Sea-Level /0m/ at the West/Caribic/ and East/Atlantic/ coast.In comparison with 3 Ecological Parameters such as Water-Temperature/in °Celsius/, Electrolytic Conductivity / $\text{El}_{20}$  in  $\mu$ Siemens/, and Total Hardness /in °dH/.**

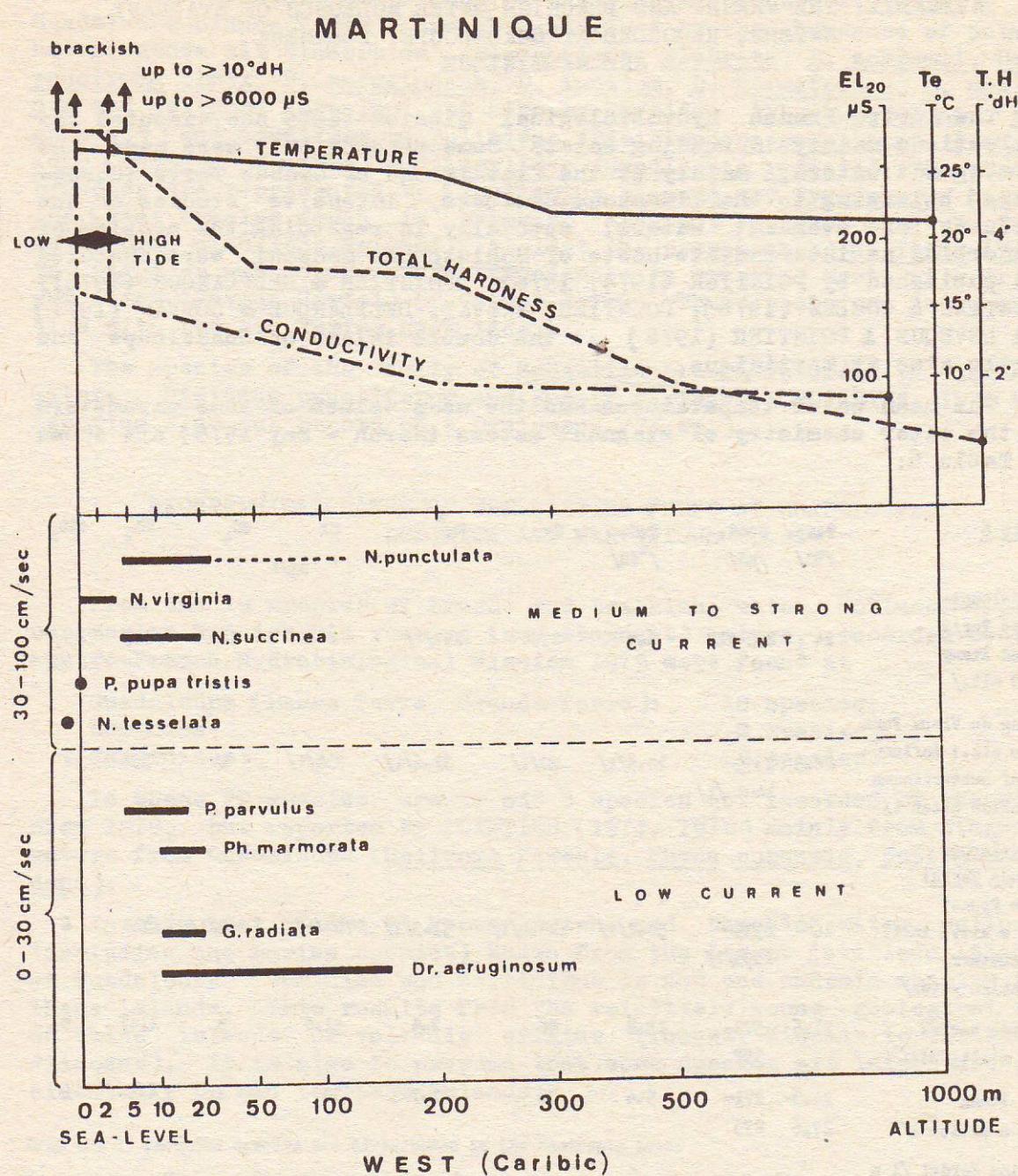


Figure 5.: Longitudinal Distribution of the Fresh and Brackishwater Gastropods of Martinique in the Mountain streams/between Headwaters /approx. 800m/ and the Mouth-zones at Sea-Level /0m/ at the West / Caribbean/ coast. In comparison with 3 Ecological Parameters such as Temperature of the Water/in  ${}^{\circ}\text{Celsius}$ /, Electrolytic Conductivity / $\text{El}_{20}$  in  $\mu\text{Siemens}$ / and Total Hardness /in  ${}^{\circ}\text{dH}$ /.

APPENDIX: THE FRESH- AND BRACKISH WATER MOLLUSCS OF STAGNANT  
WATERS, RECORDED AT GUADELOUPE, DOMINICA  
AND MARTINIQUE

The Austro-French Hydrobiological Mission 1979 has executed the collections mainly in running waters. Some records only were made also in stagnant waters, mainly at the flat island of Grande Terre (Guadeloupe) belonging to the limestone Caribees. Intensive studies of the molluscs of stagnant waters, specially in regarding the problem of planorbids as intermediate hosts of Schistosoma mansoni were executed and published by POINTIER (1974, 1976); POINTIER & DELPLANQUE (1976); POINTIER & COMBES (1976); POINTIER, SALVAT, DELPLANQUE & GOLVAN (1977) and LEVEQUE & POINTIER (1976) at the double island of Guadeloupe and partly also at Martinique.

The mean water temperatures and the mean values of some parameters of the water chemistry of stagnant waters (March - May 1979) are shown in Table 6:

<u>Table 6</u>	Temp. /°C/	Cond. / $\mu$ s/	T.H. /°dH/	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Cl mg/l	SO <sub>4</sub>	NO <sub>3</sub>	SiO <sub>2</sub>
<u>Guadeloupe-</u>									
Basse Terre	24	203-217	5.9	23.2	117/1/	26.4	11	1.7	25
Grand Étang /400 alt./									
Étang du Vieux Fort /1 m alt.; influe- nce of subterranean brackish water 1/	28.5	1399- 1402 /1/	18.5/1/	80/1/	31.6/1/	338/1/	1	3.4	12
<u>Guadeloupe-</u>									
Grande Terre:									
Mare Poucet /20 m alt.; infl. of subterr. brackish water/	26	2535- 2595/1/	30.2/1/	128.4/1/	53.3/1/	700/1/	69/1/	11.1	6
Grande Ravine /30 m altitude/	21.6	578- 597	15.2	96	7.8	51.6	3	11.7	9
Bel Étang /10 m altitude/	24.3- 27.6	271- 275	5.4	36	1.7	38	1	4.9	6
Ravine Gardel /1 m alt. infl. of brackish water	28	33.218/1/	294/1/	96/1/	1007/1/	14830/1/	1329/1/	7.4	2.5
Dominica: Pool /100 m alt./	28.5	-	1	-	-	-	-	-	-
Martinique: Pool in a dried out river bed near the East cost /1 m alt.//infl. >30 of brackish water/	28.6-	695	10.2	52	-	-	-	-	-

The freshwater gastropods in the stagnant waters - specially at Guadeloupe-Grande Terre - are characterized by the abundance of pulmonates, above all planorbids (Biomphalaria glabrata, B. schrammi, Drepanotrema cimex, D. aeruginosum, D. lucidum, D. kermatoides, D. anatinum and Helisoma foveale), but also by Physidae (Physa marmorata, Ph. cubensis) and sometimes by Bulinidae (Pleisiophysa granulata), Lymnaeidae (Lymnaea cubensis) and Aculyidae (Gundlachia radiata). The prosobranchs are represented by Ampullarius glaucus and Pyrgophorus parvulus (last species found in brackish stagnant waters, shell surface sculptured with long spines!). At last the prosobranche Neritina (Vitta) virginea was found in high abundance in brackish pools of a dried out river (Ravine Gardel) of Grande Terre. These pools are in connection with the sea during high tide.

The species of the family of Sphaeriidae were recorded in stagnant waters: Pisidium punctiferum and Eupera viridans (POINTIER, 1971 has reported also one record of a Dreissena /?/ sp.).

GEOGRAPHICAL RANGE OF THE SPECIES FOUND AT GUADELOUPE,  
DOMINICA AND MARTINIQUE

From the 19 species of fresh- and brackish water molluscs (plus one marine species) in running (and stagnant) waters, recorded by the Austro-French Hydrobiological Mission 1979 were found at

Guadeloupe (Basse Terre, Grande Terre): 18 species;  
 Dominica: 8 species;  
 Martinique: 9 species.

To these 20 species are to add 3 species not recorded by the Mission 1979, but reported by POINTIER (1974, 1976) mainly from stagnant waters from Guadeloupe (*Helisoma foveale*, *Physa cubensis*, *Eupera viridans*).

In this list of the 23 known fresh- and brackish water molluscs (including one marine species) known from the Lesser Antillean Islands of Guadeloupe, Dominica and Martinique is not one endemic species for these islands. This results from the relatively young geological age of these islands of volcanic origine (Younger Miocene to the Later Pliocene). It is also to presume that some species are introduced accidentally by man to these islands.

From the 23 recorded species are distributed in the Neotropic Area:

- 1/ Between  $35^{\circ}$  N and  $35^{\circ}$  S Latitude:

1A/ From  $35^{\circ}$  N /Southern N-America /S-Carolina//  
to  $35^{\circ}$  S /Southern S-America /S-Chile; S-Argentina//  
Drepanotrema kermatoides, Dr. cimex = 2 species = 8.6 %

1B/ From  $35^{\circ}$  N /Southern N-America /S-Carolina//  
to  $25^{\circ}$  S /Brazil, N-Argentina/:  
Neritina Vitta /virginea = 1 species = 4.3 %

1C/ From  $30^{\circ}$  N /Southern N-America /Florida//  
to  $10^{\circ}$  N /Greater and Lesser Antillean Isle.:  
Nerita tessellata /marine !/ = 1 species = 4.3 %

1D/ From  $30^{\circ}$  N- $10^{\circ}$  N /Central-America, Greater and Lesser Antillean Islands/

to $20^{\circ}$ S- $30^{\circ}$ S /Middle and Southern S-America/:	
<u>Biomphalaria glabrata</u> , <u>Drepanotrema lucidum</u> , <u>Dr. anatinum</u> ,	= 6 species = 26.2 %
<u>Dr. aeruginosum</u> , <u>Physa marmorata</u> , <u>Pisidium punctiferum</u>	
1E/ From $20^{\circ}$ N /Central-America /Guatemala/, Lesser Antillean Islands/	
to $0^{\circ}$ /Ecuador, Northern S-America/:	
<u>Neritina /hereina/ punctulata</u> , <u>Ampullarius glaucus</u> ,	= 3 species = 13.1 %
<u>Pleisiophysa granulata</u>	
1F/ From $10^{\circ}$ N /Southern Central-America /Guatemala/, Lesser Antillean Islands/	
to $0^{\circ}$ /Northern S-America/:	
<u>Biomphalaria schrammi</u>	= 1 species = 4.3 %
1G/ From $15^{\circ}$ N	
to $10^{\circ}$ N /Lesser Antillean Islands/	
<u>Melanoides tuberculata</u> /introduced!/	= 1 species = 4.3 %
	15 species = 65.1 %

15 /or about 65 % of all known species/ occur from the Southern Part of N-America, resp. Central America /including the Greater and Lesser Antillean Islands/ to the region of the Equator and in South to the Northern Part /partly also to the Southern Part/ of S-America. Melanoides tuberculata, an indopacific species, is introduced!

2/ Between  $35^{\circ}$  N and  $5^{\circ}$  N Latitude:

2A/ From $35^{\circ}$ N- $20^{\circ}$ N /Southern N-America /S. Carolina/ and Central-America/	
to $10^{\circ}$ N /Greater and Lesser Antillean Islands and partly N-Eastern Part of S-America/:	
<u>Pyrgophorus parvulus</u> , <u>Helisoma foveale</u> , <u>Lymnaea cubensis</u>	
<u>Gundlachia radiata</u> , <u>Physa cubensis</u> , <u>Eupera viridans</u>	= 6 species = 26.2 %
2B/ From $20^{\circ}$ N /Greater Antillean Islands/	
to $10^{\circ}$ N /Lesser Antillean Islands/:	
<u>Puperita pupa tristis</u>	= 1 species = 4.3 %
2C/ From $15^{\circ}$ N	
to $10^{\circ}$ N /Lesser Antillean Islands/:	
<u>Neritina succinea</u>	= 1 species = 4.3 %
	8 species = 34.8 %
Total	= 23 species = 99.9 %

8 species, resp. approx. 35% of all found species occur from the Southern Part of N-America to Central America, resp. the Greater and Lesser Antillean Islands. Only one species - Neritilia succinea occurs exclusively on the Lesser Antillean Islands Guadeloupe Basse Terre, Dominica, Martinique and St. Vincent. This is probably a vicarying species of the splitted genus Neritilia. He occurs - in similar habitats - with one species /N. consimilis/ at the islands of the Southern Indian Ocean, with one species /N. rubida/ at some South Pacific Islands and with one species /N. manœu/ at some islands on the coast of Western Africa.

Summarizing it is to state that the present fresh- and brackish water molluscs of the Lesser Antillean Islands show the type of distribution to be expected from the breakup of an Ancestral biota. This problem is discussed generally by CROIZAT, NELSON & ROSEN (1974), NELSON & PLATNICK (1981) and NELSON & ROSEN (1981) in view of the freshwater fauna of the Lesser Antillean Island of St. Vincent by HARRISON & RANKIN (1976). The fragmentation of a Primary Ancestral biota (the suggested "Gondwanaland of Southern Continent") by fracture and separation of large continental masses has led to the isolation of Northern, Central Southern and Southern Secondary Ancestral biota.

The present Circum-Caribbean Fresh- and Brackish Water biotas seem to be the consequence of the isolation of the Lesser Antillean Islands from the Northerly Part of the Southern and from the Central Southern Secondary Ancestral biotas. The recent fresh- and brackish water molluscs of the Lesser Antillean Islands present with the Circum-Caribbean species a clear connection with the Central and South-American fauna. The planorbid genus Biomphalaria is represented not only in Central and Northern South America, but also in Africa and Madagascar, where is also found the family of Bulinidae.

At last it is to presume that some of the freshwater mollusc species are probably introduced by man unintentionally.

#### ACKNOWLEDGMENTS

I thank the Austrian "Fonds zur Förderung der Wissenschaft" /Projekt N. 3672/ and the "Kulturamt der Stadt Wien" for grants. It is also to thank the members of the "Laboratoire d'Hydrobiologie" /Chef du Laboratoire: Ing. Y. THEREZIEN/ of the "Institut National de la Recherche Agronomique /I.N.R.A./ in Petit-Bourg at Guadeloupe. Further is to thank the "Division of Forestry" /Chief Forestry Officer: M.C.C. MAXIME/ at Dominica and Mons. M. NEPLAZ of the "Rectorat" of Martinique. Lastly I thank Mrs. Prof. M. MIZZARO for the figures.

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