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# Forest litter and stream fauna on a tropical island, St. Vincent, West Indies

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With 1 figure and 3 tables in the text

HYNES (1963) discusses the trophic conditions in mountain streams and points out that they usually carry very low concentrations of plant nutrients so that the debris from terrestrial plants is a major base of the food chain. The aim of this paper is to show that allochthonous forest debris is not only significant as the prime substrate of the food nexus but is also important in zonation. In the island of St. Vincent forest litter is the major factor in both the distribution and density of stream bottom animals, creating a zonation which superficially might be attributed solely to altitude and temperature.

## Description of the island

St. Vincent lies at the southern end of the Lesser Antilles chain, 13° 15′ N, 61° 15′ W, and, like most of the other islands of the group, is volcanic in origin. Although it is a small island, 28 km long and 18 km wide, at least two thirds of it lies over 305 m above sea level. There are six mountain peaks which tower above 900 m, the highest being the active volcano, La Soufriere, at 1,225 m. There are two main watersheds, the conical La Soufriere massif at the northern end of the island, and the elongated central spine containing the Morne Garu Mountains, Peak Seventeen and, in the south, the Grand Bonhomme Mountains which form the highly eroded rim of a very ancient crater.

From the central elongated watershed there arise innumerable lateral knife-edge ridges, some of which plunge directly into the sea without any flattening out. Each of these therefore has its own watershed reaching down into the valleys below. These laterals are usually narrow and steep, but there are several broader expanses, notably the Mariaqua Valley on the windward (eastern) coast and the Buccament Valley on the leeward (western) coast.

The main water courses start among the peaks as mountain torrents, often with waterfalls, but are reinforced lower down by innumerable sidestreams originating from springs and small marshes.

Most of St. Vincent has a climate suitable for the development of forest cover. The mountains and higher foothills and valleys are clothed with rain forest and the lower altitudes with drier coastal forest. Historical accounts indicate that the island was almost completely forested until colonized by Europeans in the eighteenth century. The only exception was the conical mass of La Soufriere which has been kept fairly clear of forest by periodic eruptions. Now over most of the island the forest has been cleared to about the 400 or 500 m level, leaving a cap of rain forest with interspersed patches of elfin woodland and palm brake. There are also a few small areas of dry coastal forest. However, forests do persist to lower levels at the northern end of the Morne Garu Range.

Cleared areas are used for agriculture, mostly bananas, coconuts, arrow root and other root crops. Nevertheless, fruit trees abound, especially near settlements, and these include breadfruit, mangoes, nutmeg, citrus and many other types. Indigenous trees are often to be found along the banks of rivers and streams and in some parts riparian strips of original forest persist.

## Methods of study

Temperature and pH readings were taken in the field and water samples were taken in polyethylene bottles and brought back to the laboratory for analysis. Water for nitrite, nitrate and phosphate analyses was examined the same day or stored in a refrigerator and analysed as soon as possible. Reactive phosphate estimations were made using a special method for low concentrations outlined by Strickland & Parsons (1968). Nitrate was reduced to nitrite in a cadmium-copper column, modified from Strickland & Parsons (1968), the nitrite being determined using Shinn's azo-spectrophotometric method (Strickland & Parsons 1968). Other anions were determined by standard methods and cations by means of an atomic absorption spectrometer.

Faunal samples were taken by means of a triangular-shaped hand net with a 27 cm base and a bag of 21 mesh/cm (0.3 mm openings) nylon netting (Nitex). Comparative, quantitative samples were obtained by marking out a 27 cm square area immediately upstream from the net and digging out stones and gravel by hand to a depth of about 15 cm and washing them vigourously into the net. From three to six samples were taken on each occasion. Samples were washed in the laboratory through a net of the same mesh and large debris such as stones and gravel picked out. Organisms were identified and counted under a dissecting microscope.

This sampling method seldom captured more active organisms such as Atyidae, Palaemonidae and the river crab *Guinotea dentata* but there were few of these in the stony runs studied.

## Sampling stations

Eleven sampling stations were chosen for the purpose of this study. All were torrential mountain streams or fast-flowing rivers in the lower valleys as shown in Tab. 3. All samples were taken from small stony runs or stickles. The Majorca station was on a mountain stream in rain forest and the Dalaway was near the point where the stream emerged from dense riparian trees continuous higher up with the forest. Other stations were in cultivated valleys except for the Rabacca River, which forms a special case; in its lower reaches the bed has been greatly widened during past explosive volcanic eruptions of La Soufriere when water from the crater lake was forced out very rapidly to scour out this section of the valley leaving an expanse of rocks and stones. Later flash floods from the denuded mountain catchment have prevented colonisation by shrubs and trees. The river at the sampling site flows through this denuded region and there is no bank vegetation for at least 1.5 km upstream.

## Results

### Water temperatures (Tab. 1)

Day temperatures taken at the same time as the faunal samples and supplemented by regular observations taken all around the island for a period of nearly two years showed no marked seasonal variations. Nevertheless, during periods of heavy rain, daytime temperatures tended to fall. This was particularly noticeable in the lower river zones, where they fell to 25 °C, a drop of 3 to 5 °C from those shown in Tab. 1. During dry periods there were marked diurnal changes in lower reaches of as much as 4 or 5 °C; during this time there could be a 10 °C difference between daytime temperatures at 600 m and those at stations near sea level. During wet periods this overall difference was reduced to 4 or 5 °C.

Tab. 1. St. Vincent rivers: chemical analysis of waters.

| | Yambou River system | | | Buccament River system | | | Colonarie River | Owia River | Fancy River | Rabacca River |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1. Mountain torrent- in forest cap | 2. Mountain torrent- open | 3. Lower valley | a. Mountain torrent- open | b. Middle valley | c. Lower valley | Middle valley | Near mouth | Near mouth | Near mouth |
| Altitude in metres | 442 | 410 | 114 | 260 | 183 | 61 | 213 | 30 | 23 | 8 |
| Temperature °C | 21.5 | 21.0 | 26.0 | 25.5 | 25.5 | 28.0 | 22.0 | 24.7 | 25.9 | 29.5 |
| Conductivity $\mu$mhos | 73.5 | — | — | 95.8 | 105 | 112 | — | 76.1 | 86.7 | 76.2 |
| pH | 7.76 | 7.01 | 8.2 | 8.0 | 8.07 | 8.02 | 8.3 | 8.25 | 8.19 | 8.2 |
| Bicarbonates, mg/l $HCO_3^-$ | 39.0 | 33.5 | 91.5 | 46.8 | 60.5 | 68.8 | 45.8 | 48.3 | 78.5 | 53.8 |
| Calcium, mg/l $Ca^{2+}$ | 8.5 | 7.0 | 11.0 | 12.8 | 14.0 | 15.5 | 6.5 | 10.0 | 12.2 | 9.6 |
| Magnesium, mg/l $Mg^{2+}$ | 2.8 | 4.4 | 5.0 | 4.3 | 4.2 | 4.8 | 3.3 | 3.8 | 5.6 | 4.1 |
| Sodium, mg/l $Na^+$ | 8.8 | 9.8 | 14.12 | 8.7 | 9.0 | 10.0 | 6.8 | 8.8 | 11.9 | 8.7 |
| Potassium, mg/l $K^+$ | 0.6 | 0.5 | 1.4 | 0.6 | 0.6 | 0.8 | 0.7 | 1.6 | 1.6 | 1.4 |
| Chloride, mg/l $Cl^-$ | 24.3 | 15.8 | 23.1 | 31.6 | 25.5 | 25.5 | 11.3 | 32.8 | 19.8 | 19.3 |
| Sulphate, mg/l $SO_4^{2-}$ | 0.8 | 1.0 | 3.5 | 1.0 | 2.5 | 4.0 | 2.0 | 1.0 | 1.5 | 3.1 |
| Reactive silicate, mg/l Si | 12.45 | 12.88 | 18.03 | 22.24 | 13.74 | 13.82 | 13.00 | 21.18 | 22.37 | 18.34 |
| Reactive phosphate, mg/l P | 0.0025 | 0.0051 | 0.0100 | 0.0070 | 0.0050 | 0.0050 | 0.0050 | 0.0210 | 0.0090 | 0.0350 |
| Nitrite, mg/l N | 0.0000 | 0.0010 | 0.0010 | 0.0045 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0002 | 0.0006 |
| Nitrate, mg/l N | 0.1347 | 0.1270 | 0.5170 | 0.0250 | 0.0850 | 0.1220 | 0.0690 | 0.0550 | 0.0000 | 0.0122 |

Tab. 2. Detrital and algal conditions in stony runs of the Yambou River.

| Station | Zone | Conditions |
|---|---|---|
| 1. | Majorca: mountain torrent, in forest cap. | Large amounts of vegetable detritus, including whole leaves (a few green, but mostly brown), leaf fragments, parts of flowers and fruiting bodies.<br>Algae: little, mostly *Fragilaria* sp.<br>No mud. |
| 2. | Golden Grove: mountain torrent, just below forest cap. | Abundant leaf detritus; whole leaves rare.<br>Algae: some *Fragilaria* sp.<br>No mud. |
| 3. | Mesopotamia: lower valley. | Some very fine vegetable detritus; larger pieces mainly midribs, petioles, and twigs. Occasional whole leaves.<br>Algae: some *Fragilaria* sp. and tufts of filamentous algae, mainly *Phormidium.*<br>Some mud under stones. |
| 4. | Escape: near mouth. | Very little fine vegetable detritus.<br>Algae: stones thickly convered with *Phormidium.*<br>Mud mixed with the *Phormidium* and under stones. |

### Water chemistry (Tab. 1)

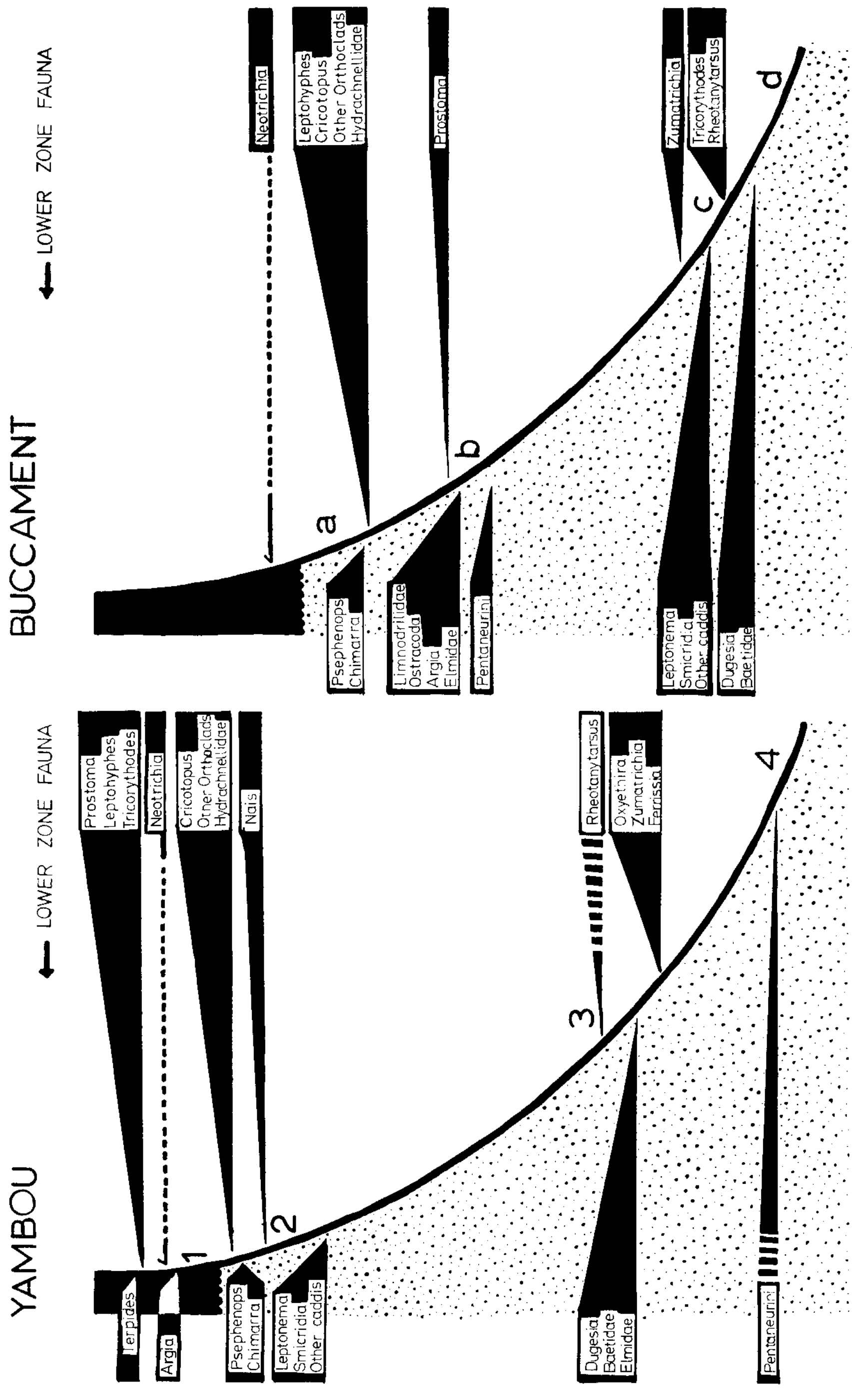
Stream and river water was moderately soft but definitely alkaline. Calcium values ranged from 6.5 to 15 mg/l as $Ca^{2+}$ and bicarbonate values from 39 to 91.5 mg/l as $HCO_3^-$. Values for reactive phosphate and nitrates were very low.

### Detritus picture (Tab. 2)

Selected stations on the Yambou River are shown in Tab. 2. The stony runs in the headwater forest stream (Station 1, Majorca) were full of leaves in various stages of decay, flowers, fruiting bodies, leaf scales and so forth. In the lower reaches most of the vegetable detritus was particulate leaf remains with a few larger pieces; there were always a few entire leaves from trees on the bank but no dense accumulations were seen except in backwaters. In the upper streams there was little or no mud under the stones and very little algae, but in the lower zones of rivers in agricultural regions a small amount of mud was always freed when stones were moved, and growths of filamentous algae were common.

### Fauna (Fig. 1 and Tab. 3)

Fig. 1 shows that there is a very obvious upper zone community which is characteristic of the forest cap and extends below it to different levels in different rivers.


YAMBOU
BUCCAMENT
← LOWER ZONE FAUNA
UPPER ZONE FAUNA →
Prostoma
Leptohyphes
Tricorythodes
Neotrichia
Cricotopus
Other Orthoclads
Hydrachnellidae
Nais
Rheotanytarsus
Oxyethira
Zumatrichia
Ferrissia
Lerpides
Argia
Psephenops
Chimarra
Leptonema
Smicridia
Other caddis
Dugesia
Baetidae
Elmidae
Pentaneurini
1
2
3
4
Limnodrilidae
Ostracoda
Elmidae
a
b
c
d

Tab. 3 shows that the density of forms such as the leptophlebid *Terpides jessiae,* the Baetidae, the caddis *Leptonema* sp. and *Smicridia* sp., the psephenid beetle *Psephenops smithi* and the Elmidae tends to be reduced downstream and they may be entirely absent in the lower zones.

A few organisms are only found in the lower zones; such are the hydroptilid caddis *Oxyethira* sp. and *Zumatrichia* sp., and the gastropod *Ferrissia radiata.* Most other forms were found in all zones.

A gut content analysis was carried out on *Leptonema* sp. and *Smicridia* sp.; *Smicridia* was packed with leaf and other vegetational debris but no animal remains were found, whereas *Leptonema* sp. also contained much vegetational debris but in addition had animal remains, mainly *Smicridia* sp. and *Leptohyphes* sp.

## Discussion

A careful examination of the results presented together with qualitative data from many other streams and rivers on the island has led to the conclusion that the apparent zonation of the fauna according to altitude is largely illusory.

The only common species which always appeared to be limited to upper zones were *Psephenops smithi* and *Microcylloepus* sp. Their distribution could be due to their need of lower maximum temperatures and very clean, mountain stream conditions.

Fig. 1 and Tab. 3 show that whereas *Leptonema* sp. and *Smicridia* sp. had disappeared by 114 m in the Yambou River, they were found in small numbers down to 61 m in the Buccament River. This is associated with the fact that rain forest trees extend to a lower altitude in the Buccament Valley and that there are more streamside trees on the banks of the lower river and its tributaries. Rivers in the less developed north eastern part of the island showed this more clearly. The Richmond River valley has not been developed for intensive agriculture and patches of forest are to be found down to 130 m, especially on steep valley sides; the river is heavily shaded by riparian trees and leaves are abundant in the runs. In samples taken at this altitude *Smicridia* sp. formed about 30 % of the fauna. The valley of the nearby Wallibou River is undeveloped, the upper zones are well forested and in the lower zone coastal scrub forest extends almost to the sea; *Leptonema* sp. and *Smicridia* sp. are to be found in stony runs at 8 m just before the torrential river runs down the sea beach.

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Fig. 1. Distribution of bottom fauna in two river systems. Faunal elements characteristic of upper zones are shown on the left of each diagram, those characteristic of lower zones are on the right. Dark pointers touch river profiles at approximate altitude where extreme downstream or upstream records were obtained; broken pointer lines indicate a gap in distribution between higher and lower levels. Dark sections at top of profiles indicate extent of forest cap.

| | |
|---|---|
| 1 = 442 m, 21.5 °C | a = 602 m, 25.5 °C |
| 2 = 381 m, 21.0 °C | b = 182 m, 25.5 °C |
| 3 = 114 m, 26.0 °C | c = 61 m, 28.0 °C |
| 4 = 7.6 m, 27.0 °C | d = 7.6 m, 30.0 °C |

Tab. 3. St. Vincent Rivers: Stony-run fauna. Number of organisms per square metre (mean of 3 to 6 samples).

| | Yambou River system | | | | Buccament River system | | | Colonarie River | Owia River | Fancy River | Rabacca River |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1. Majorca | 2. Golden Grove | 3. Meso-potamia | 4. Escape | a. Dalaway | b. Vermont | c. Hope Flats | | | | |
| | Mountain torrent-forest cap | Mountain torrent-open | Lower Valley | Near Mouth | Mountain torrent-open | Middle Valley | Lower Valley | Middle Valley | Near Mouth | Near Mouth | Near Mouth |
| Altitude in m | 442 | 410 | 114 | 8 | 260 | 183 | 61 | 213 | 30 | 23 | 8 |
| Turbellaria: | | | | | | | | | | | |
| *Dugesia arimana* Hyman | 191 | 105 | 69 | — | 102 | 176 | 40 | — | — | — | — |
| Nemertea: | | | | | | | | | | | |
| *Prostoma* sp. | 32 | 82 | 525 | 370 | 82 | 18 | 4 | 4 | — | 34 | — |
| Naididae: | | | | | | | | | | | |
| *Nais* sp. — mostly | — | 96 | 1,060 | 51,882 | 96 | — | — | — | — | 500 | — |
| Tricorythidae: | | | | | | | | | | | |
| *Leptohyphes* sp. | 963 | 146 | 5,745 | 1,466 | 486 | 1,048 | 1,134 | 268 | 352 | 214 | 44 |
| *Tricorythodes* sp. | 4 | 83 | 2,051 | 233 | 20 | 14 | 7 | — | — | — | — |
| Leptophlebidae: | | | | | | | | | | | |
| *Terpides jessiae* Peters & Harrison | 54 | — | — | — | — | — | — | — | 4 | — | — |
| Baetidae: | 466 | 1,649 | 4 | — | 76 | 64 | 2 | 4 | 108 | — | 10 |
| Zygoptera: | | | | | | | | | | | |
| *Argia* sp. | 4 | — | — | — | 12 | 4 | — | — | 4 | — | — |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Trichoptera: | | | | | | | | | | | |
| *Smicridia* sp. | 1,863 | 744 | — | — | 238 | 52 | 2 | 10 | 6 | — | 2 |
| *Leptonema* sp. | 27 | 297 | — | — | 30 | 362 | 58 | 30 | — | — | — |
| *Chimarra* sp. | 18 | 73 | — | — | 4 | — | — | 2 | — | — | — |
| *Neotrichia* sp. | 27 | 14 | — | 370 | 16 | 4 | — | — | 10 | 2 | — |
| *Oxyethira* sp. | — | — | 87 | 41 | — | — | — | — | — | — | — |
| *Zumatrichia* sp.[1] | — | — | 197 | 41 | — | — | ++ | — | — | — | — |
| Other caddis | 63 | 27 | 32 | — | 16 | 2 | 4 | — | — | — | — |
| Coleoptera: | | | | | | | | | | | |
| Elmidae[2] | 187 | 77 | 32 | — | 73 | 20 | — | 10 | 20 | 2 | — |
| *Psephenops smithi* GROUV. | 311 | 18 | — | — | 18 | — | — | — | 2 | — | — |
| Chironomidae: | | | | | | | | | | | |
| Pentaneurini[3] | — | 320 | 14 | 41 | 4 | 6 | — | — | 4 | 18 | — |
| *Cricotopus* sp. | 46 | 105 | 716 | 1,411 | 8 | 130 | 14 | 28 | 26 | 25 | — |
| Other orthoclads | 270 | 566 | 421 | 507 | 22 | 172 | 109 | 6 | 194 | 225 | 16 |
| *Rheotanytarsus* sp. | — | — | 800 | — | — | — | 2 | 22 | — | — | — |
| Hydrachnellidae: | 28 | 187 | 858 | 41 | 24 | 23 | 10 | 6 | 4 | 4 | — |
| Ancylidae: | | | | | | | | | | | |
| *Ferrissia radiata* GUILD. | — | — | 73 | 137 | — | — | — | — | — | — | — |
| Other organisms: | 116 | 140 | 32 | 767 | 12 | 36 | 10 | 26 | 18 | 10 | 4 |
| Total: | 4,666 | 4,729 | 12,684 | 57,307 | 1,226 | 2,137 | 1,396 | 416 | 744 | 1,054 | 80 |

— None found
++ Present, uncounted
[1] Mainly *Zumatrichia anomaloptera* FLINT
[2] *Hexanchorus caraibus* (COQ.) with *Microcylloepus* sp. in upper zones
[3] mainly *Labrundinia* sp.

The very low nitrate and phosphate content normal to the river water on St. Vincent makes it clear that algal primary production alone could not support a dense fauna. In the stony run fauna dense communities of benthic forms are found only where large amounts of tree litter fall constantly into the water or where agricultural and domestic pollution or enrichment occurs. This latter effect was particularly noticeable in the lower Yambou River which flows through the highly populated and intensively cultivated Marriaqua Valley.

In rivers where this secondary food supply is not available the faunal density may fall to very low levels. An extreme case is the lower Rabacca River flowing through its denuded valley; here no leaves fall in nor is there enrichment of any kind and the faunal density is reduced to 80 animals per square metre.

HYNES (1971) studied the small Arima River in Trinidad just over 300 km away from St. Vincent. This river starts at much the same altitude as those discussed here and he found a faunal zonation which seemed to depend on mainly physical factors; he has recorded no dense communities of *Leptonema* sp. or *Smicridia* sp. or any other organisms in the rain forest zone which appeared to be exploiting the forest litter in a similar manner to those on St. Vincent. This could have been because the Arima stream appears to have been largely lined with bamboo, which has very tough leaves. BISHOP (1971) made a very detailed study of the Sungai Gombak in Malaya and found a distinct faunal zonation but did not report any similar dense communities of Hydropsychidae in the upper forested zone.

Thus the zonations on St. Vincent suggest the situation which is natural to tropical volcanic islands where virgin forest is undisturbed. Further studies on islands such as Dominica, which has a lush forest cap extending well down to lower altitudes, would be extremely rewarding. The taxonomic papers on Dominica arising from the Bredin-Archbold-Smithsonian Biological Survey, such as FLINT (1968) and CHACE & HOBBS (1969) were not concerned with this problem, but close examination of their fauna lists and biological notes indicate to us that Dominica would confirm the St. Vincent findings.

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