CONTRIBUTION TO THE KNOWLEDGE OF THE FRESHWATER-FAUNA OF THE ISLE OF ANJOUAN (COMORES)

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RÉSUMÉ

1. Une mission hydrobiologique du Premier Institut Zoologique de l'Université de Vienne (Autriche) a étudié, pendant un voyage aux différentes îles de l'Océan Indien, 27 stations dans des ruisseaux et rivières d'Anjouan, deuxième île (424 km²) de l'Archipel des Comores.

2. La température de l'eau varie entre 20 °C, dans les sources et ruisselets de montagne, et 26 °C dans les embouchures de la zone côtière.

3. Les montagnes centrales sont élevées (N'Tingui, 1595 m) et les pentes des rivières sont donc très fortes, entre 150 et 200 °/₀₀ dans les cours supérieurs, entre 60 et 100 °/₀₀ dans les cours moyens et de 30 à 50 °/₀₀ dans les cours inférieurs.

4. La conductivité de l'eau est très faible dans le lac Dzialandze (900 m) : 35 µSiemens, pour une dureté totale de 0,5° dH. La conductivité monte à 94-142 µSiemens, dans les cours supérieurs (dureté totale de 1,9 à 3,15° dH) et est la plus élevée dans les cours inférieurs de 120 à 255 µSiemens pour une dureté totale située entre 1,0 et 4,24 dH. Le pH reste toujours dans le domaine alcalin, entre 7,8 et 8,4.

5. Dans les torrents, on trouve des zones de cascades et des zones calmes. Dans les zones de cascades dominent, dans les cours supérieurs et moyens, des larves de Baëtides, Hydropsychides, Orthocladiines et, en particulier, des Simuliides. Sous les pierres, on trouve des larves d'Anisoptères comme Trithemis kirbyi ardens, Zygonyx torrida *et* Orthetrum julia falsum. *Les zones calmes sont caractérisées par* Dugesia milloti, Caridina typus *et* brachydactyla *; des larves de Zygoptera, Nepidae, Ranatridae et Naucoridae,* Lymnaea (Radix) natalensis *et* Ceratophallus sp. *En surface, on trouve toujours des Veliidae, Gerridae et les gyrins* Orectogyrus speculum *et* Dineutus sinuosipennis comorensis. *Les cours inférieurs sont caractérisés par les Neritides, comme* Neritina gagates, N. pulligera knorri, Septaria borbonica, Clithon comorensis *et* Neritilia consimilis. *Aux œufs des Neritides est associé l'hydracarinide* Hygrobates soari *et aux pierres s'attache* Sicyopterus (? Sicydium) lagocephalus *à ventouse ventrale.*

1. INTRODUCTION

In continuation of hydrobiological and faunistic studies on the fauna and flora of running waters on tropical, geologically longtime-isolated continental and oceanic islands in the Indopacific a study was carried out, under consideration of ecological factors, such as water-temperature, velocity of the current between the borders and cascade-zones, sort of bottom and chemistry of the stream-water, in selected rivers of the island of Anjouan in the Comores Archipelago.

Studies on the fauna of running waters of tropical islands in the Indian Ocean were carried out in Sri Lanka (Ceylon) by STARMÜHLNER & COSTA, 1972 and WENINGER, 1972. The freshwater-fauna of

Madagascar was partly studied by PAULIAN, 1953, at the isle of Nossi-Bé between the Comores Archipelago and NW-Madagascar by PAULIAN, 1949. The river-fauna of Madagascar was studied especially by STARMÜHLNER, 1962, 1969 and RAMANANKASINA, 1969. A general survey on the fauna of running waters on a tropical island of the SW-Pacific is given by STARMÜHLNER, 1968, 1970 and WENINGER, 1968 with investigations on the fauna of streams and rivers of New Caledonia.

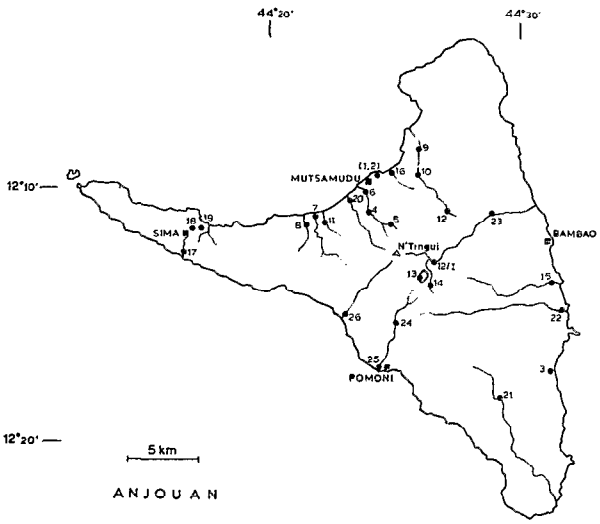


Fig. 1. — Map of the island of Anjouan (Comores-Archipelago) with numbers of the collection-stations on the rivers.

Very few contributions are to find about the ecology of the fauna of the running waters of the Comores-Archipelago. There are mostly systematically contributions like the papers of MORELET, 1877, 1879, 1881, 1882, 1883; HAAS, 1929, PELLEGRIN, 1933 and some others. The mission to the island of Anjouan was carried out in March, 1974 and the members of the mission collected from 27 stations on brooks and streams of Anjouan, including the Lac Sacré, the origin of some river-systems of the island (fig. 1). At nearly every station was collected in different habitats, such as banks and pools between cascades, on and under stones in the stronger current and on rocks and boulders in the rapids and cascades. If developed, it was also collected on the vegetation, such us algae or higher waterplants.

2. METHODS

The animals were collected both qualitatively and quantitatively. The plants, mostly algae, were collected only qualitatively, scratched off from the stones and rocks. The freely simming or crawling species of running water, animals such as fishes, tadpoles, crabs, water beetles, water bugs, shrimps, etc. were collected by net or larger sieves.

The qualitative collections of the mesofauna were made by means of different wiremesh sieves (mesh-width: 0'1-0'5 mm) with mud, sand and finer gravel soil, whereas on larger pebbles and boulders the collections were made by removing the animals from the stones with tweezers and placing them into a plastic dish or container. Collections from rocks (mostly in rapids, torrents, water-falls) were made exclusively with forceps only.

Regarding the quantitative collections, as a rule stones from a ground of 1/16 m² (squares of 25 cm length) were taken and the collections where then poured into plastic dishes; the remaining sediments were sieved. Apart from that the density of population of the most frequent species of the mesofauna was determined per 1 dm² or 1/16 m² (only for larger species such as biger gastropods, crabs etc. per 1/4 m² or 1 m²). Most freshwater animals were conserved in 75 % alcohol, but fishes, frogs, tadpoles, oligochaets, algae and water-plants were preserved in 4 % formol. Turbellaria (Tricladida), rarely oligochaetes and gastropods, were fixed in BOUIN's liquid for subsequent histological examination. The separation of the animals (and plants), collected from different habitats of a station, took place in the laboratories of the first Zoological Institute of the University of Vienna, Section of Malacology.

3. GEOLOGY AND CLIMAT

The Comores Archipelago comprises from E toW four principal islands: Grand Comore (without any running water!) Anjouan, Mohéli and Mayotte between 43° and 45° E longitudes and 11° and 13° S latitude. Anjouan, the second largest island covers

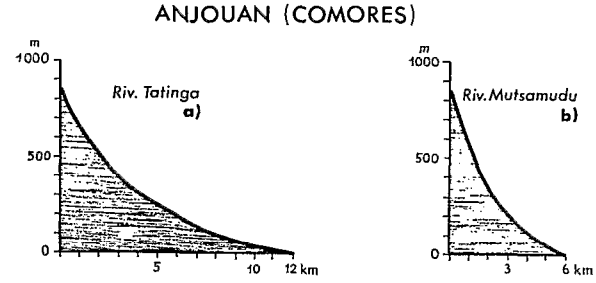


Fig. 2. — Gradient of some Rives of Anjouan (altitude 20 × higher).

an area of 424 km² and has the form of a triangle (W to E: 45 km, N to S: 40 km, Fig. 1).

The islands are almost entirely volcanic and show a simple age progression along the length of the archipelago with youngest from E-SE to oldest W-NW. The older islands of Mohéli, Anjouan and Mayotte all show clear evidence for small-scale late-stage or rejuvenescent activity. From de SAINT OURS (1960) comparative studies on the geomorphologie of the Comores volcanoes and those of northern Madagascar we are led to conclude that basaltic activity commenced on Mayotte, the oldest island in the East, in Miocene or possibly even Cretaceous times. Grand Comore shows in its regular coastline and undissected shield volcanoes, its relative youthfulness. Two main volcanic centres, the Massif de la Grille (1087 m) and the Karthala (2361 m) form its northern and southern halves. Both have been the site of historic volcanism and are coalescing shield volcanoes built up by a combination of flows from central and fissure eruptions (ESSON *et al.*, 1970). It has nearly no river erosion on the flanks of the mountains. The waters of the heavy rainfalls during the NW-monsoon seep away in the lava-slacks. The population of Grand Comore has constructed large cisterns to collect rainwater during the rainy season. No running waters occurs on Grand Comore. The mission 1974 has collected and studied the fauna of the streams of Anjouan, the second largest island of the Comores Archipelago. This triangulary-shaped island contains rugged, forest-clad topographies, with deep river gorges and amphitheatre-headed valleys. The highest peak N'Tingui (1595 m) is centrally situated (Photogr. 7, pl. II). The coasts are strongly embayed and the original constructional surfaces have been almost entirely obliterated.

The precipitous mountains of N'Tingui, Djadjana, Habakiri and Trindrini appear to be composed of a relatively monotonous succession of basalts and ankamarites similar to those of Grand Comore. Whereas these older rocks are compositionally analogues to those of Grand Comore, the younger lavas are predominately, highly alcalic and feldspathoidal, and include basanites, hornblende-trachybasalts and phonolithes (ESSON *et al.*, 1970).

The curved northern coastline with the broad bay of Mutsamudu has been defined by fracturing associated with subsidence towards the deep gulf that lies between Anjouan and Grand Comore. SAINT OURS (1960) has shown the topography to be dictated by deep river erosion of older basaltic sequences, modified by the constructional slopes of younger lava flows and well-preserved cinder cones. Fringing reefs are relatively mature compared to those of Grand Comore and barrier reefs are in the early stage of development around the western part of Anjouan.

The Comores-Archipelago is, like the Seychelles, in the tropical trade-wind belt. There are two seasonal periods : the West-monsoon and the South East-trade-wind. The first wind, coming from the equator, blows between November and April and brings very heavy rainfalls to the western sides of the islands, specially in the mountains.

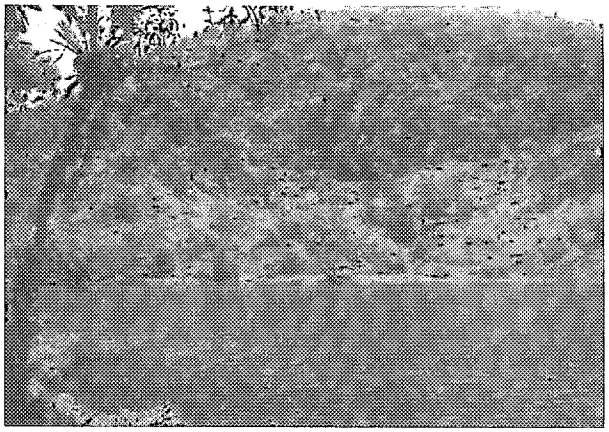
The long-year annual mean air-temperature is at Mremani (800 m altitude) : 22'2 °C, at Mutsamudu (20 m altitude): 26'6 °C. The long-year annual rainfall reaches at Mremani (800 m altitude): 2450 mm (highest annual mean: 2987 mm), at Mutsamudu (20 m altitude): 2262 mm (highest annual mean: 3590 mm). In March, 1974 the month of the visit by the mission has had a monthly mean air-temperature of 23 °C at Mremani (800 m) with a mean rain-fall amount of 758 mm. At Mutsamudu (20 m) was the monthly mean air-temperature 26'7 °C and the mean rain-fall amount 457 mm.

The volcanic Comoro-islands were originally covered by dense tropical primeval forest containing many endemic species, originating from species immigrated from East-Africa and Madagascar. Up to 600 m altitude these indigenous forests are disrupted by plantations. Dominating are cultivations of parfume-plants, like Ylang, Patchouli and Citronell, but also bananas, sugar-cane, coffee, sisal, vanille, and, near the coasts coconut-plantations.

4. PHYSICAL CONDITIONS OF THE RIVERS

At the island of Anjouan is, like on all high-elevated islands of the Indian Ocean, the distance of the rivers between the source and headwaters in the central mountains of N'Tingui at about 1000 m altitude and the mouth on the coast only 6 to 12 km. In consequence show the rivers of Anjouan a very steep gradient in the upper and partly also in the middle courses (fig. 2) : The River Tatinga (photogr. 2, pl. I) about 12 km long, has an average gradient of 75 °/₀₀ to 90 °/₀₀. The upper course and affluents with torrents have a gradient of 200 °/₀₀, the middle course in the volcanic "Cirque of Dindi" with a gradient of 60 °/₀₀ and the lower course of 30 °/₀₀. The River Mutsamudu (photogr. 4 pl. I and photogr. 5 pl. II) from the steep slopes of the N'Tingui flows for 6 km over an average gradient of 150 °/₀₀. The upper course with tributaries are torrents but also the middle course with 100 °/₀₀ is characterized by waterfalls and cascades, interrupted by pools. The lower course of these river has also a

PLATE I



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1. Lac Sacré or Lac Dzialandze (900 m altitude).

2. Transition region between upper course to the middle course of the River Tatinga.

3. Upper course of the River Ouani.

4. Middle course of the River Mutsamudu.

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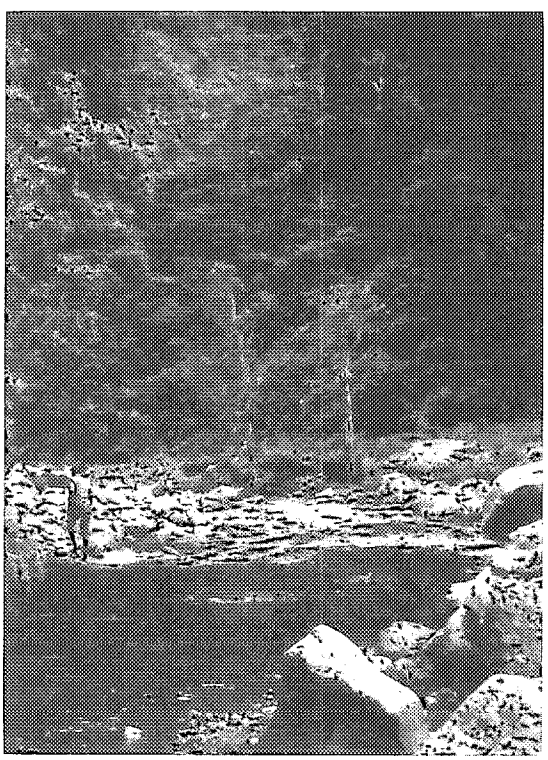

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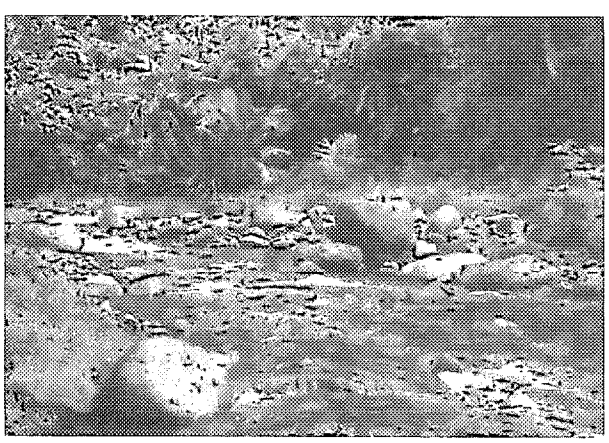

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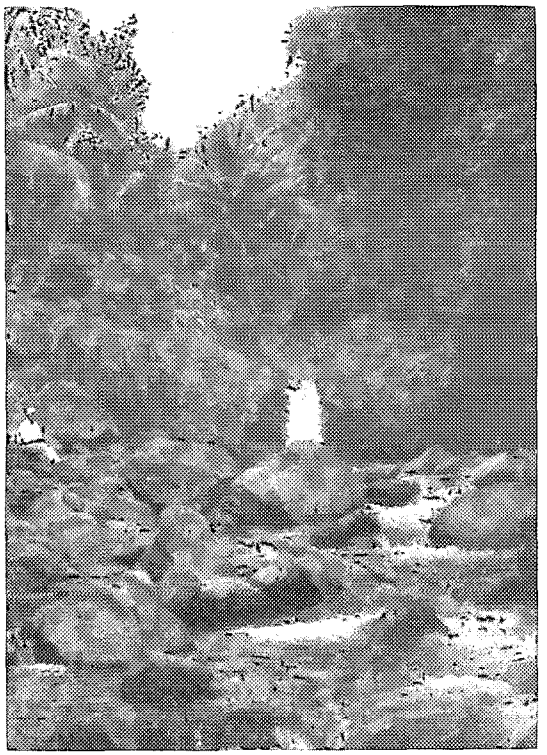

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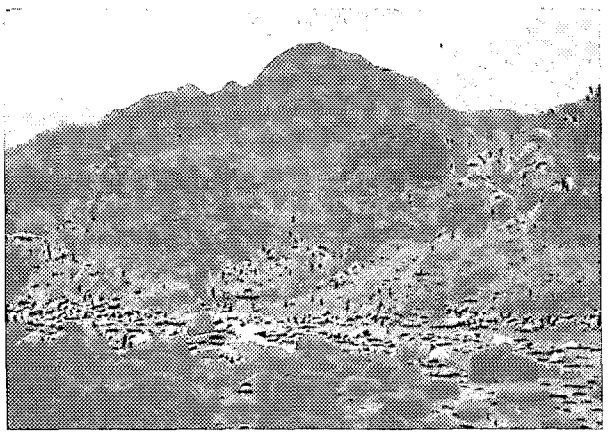

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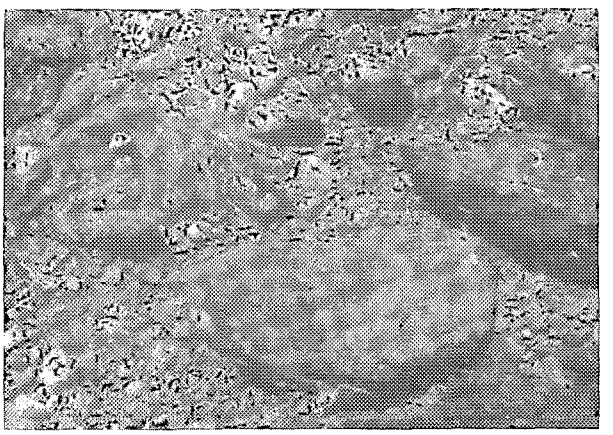

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5. Lower course of the River Mutsamudu after a waterfall and a deep pool.

6. Bottom of the lower course of the River Pouzine with basaltic boulders and gravel, on the stones right below are *Sicyopterus (? Sicydium) lagocephalus*, with a ventral sucker attached.

7. Lower course of the River Pomoni, view upstream to the central mountains of N'Tingui.

8. Lower course of the River Pomoni, view downstream to the mouth.

relatively steep gradient of 50 °/₀₀! In consequence of these steep gradients the average velocity of the current reaches more than 1 m/sec, and only near the banks and in the pools between the cascade-zones is the current, with values between 0-30 cm/sec, very slow and with characters of stillwater-habitats. The bottom of these torrents is composed of basaltic rocks (current more than 1 m/sec), boulders and gravel (current between 50 cm/sec-1 m/sec) and near the banks and in the pools of sand, partly covered with mud and vegetable debris (current: 0-30/50 cm/sec).

Sometimes a rich growth of floating filamentous clusters of green-and blue-algae and films of diatoms are developed on rocks and boulders. The water-temperatures of the rivers of Anjouan increases after our measurements in March, 1974

from the headwaters in 800 m altitude (forest)	from about 20 °C
to	
the mouth on the coast	to about 26 °C

with an average increase of 6 °C. The difference between highest and lowest day-time temperatures is in the headwaters 2° to 3 °C, near the mouth about 1'5 °C.

The average water-temperatures of the rivers of Anjouan (11° S to 13° S latitude) are nearly the same as in the upper and middle courses of the mountain streams of the Seychelles (4° S to 5° S latitude) and the mountain streams of SW-Ceylon (7° N latitude). Only in the lower courses near the coast the water-temperature is in the rivers of Anjouan 3° to 5° lower than in the rivers of the Seychelles-Archipelago or Ceylon (STARMÜHLNER & COSTA, 1972). But the values correspond exactly with the water-temperatures of the streams near the E- and NW-coast of Madagascar and on the island of Nossi-Bé counted by STARMÜHLNER (1962).

5. CHEMICAL CONDITIONS

As noted above are the islands of the Comores-Archipelago volcanic and the mountains of Anjouan are composed of basalts and ankamarites. The younger lavas are highly alcaline. In comparison with the rivers of granitic islands of the Indian Ocean, like the Seychelles or Ceylon (STARMÜHLNER & COSTA, 1972; WENINGER, 1972), partly also Madagascar (STARMÜHLNER, 1962) is the content on dissolved mineral salts in these volcanic basalt-streams higher and in consequence also the conductivity, total hardness and pH. The lowest values were found at Anjouan in the Lac Sacré (photogr. 1, pl. I), a crater lake on the slopes of the central massive of N'Tingui at an altitude of 900 m above sea-level. This lake is filled with rainwater and from the lake flows subterraneously, after a statement of the Service des Eaux et Forêts of Mutsamudu, water to the headwaters of the mountain-brooks.

	pH	Conductivity	Total Hardness
Lac Sacré or Dzialandze (900 m).....	8'6	35 µSiemens	0'6° dH
Headwaters (900-700 m).....	7'8-8	94-125 µSiemens	1'9°-2'6° dH
Upper courses (700-400 m).....	7'8-8	142 µSiemens	3'15° dH
Middle courses (400-150 m).....	8'4	180 µSiemens	3'5° dH
Lower courses (150 m-mouth region)...	8'4	120-255 µSiemens	1°-4'25° dH

The values, after measurments in March, 1974 show a distinct increase from the upper courses to the lower courses, sometimes under influence of sewage of villages or fertilizers swashed out from the plantations.

6. THE ANIMAL COMMUNITIES IN THE DIFFERENT ZONES

6.1. **Headwaters and Upper courses between 900 m and 400 m** (photogr. 3, pl. I)

6.1.1. BANKS AND POOLS (0-30 CM/SEC)

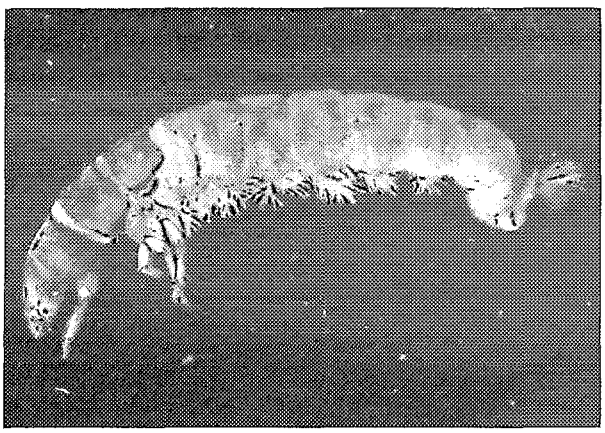
Dugesia milloti; Lumbricidae gen. spec.; *Caridina lypus*, *Atya pilipes*; Leptophlebiidae gen. spec.; *Pseudagrion pontogenes*, Anisoptera-larvae gen. spec.; Sericostomatidae gen. spec.; Lepidostomatidae gen. spec.; Ranatridae gen. spec., Nepidae gen. spec., Naucoridae gen. spec.; *Hyphydrus separandus*, *Laccophilus tigrinus*; larvae of *Potamodytes africanus*; *Lymnaea (Radix) natalensis*; Surface: Veliidae gen. spec., Gerridae gen. spec.; *Orectogyrus speculum*, *Dineutus sinuosipennis comorensis* (photogr. 10).

6.1.2. MEDIUM CURRENT (30-75 CM/SEC)

Dugesia milloti; Leptophlebiidae gen. spec., Baetidae gen. spec.; *Trithemis kirbyi ardens*, *Zygonyx torrida*, *Orthetrum julia falsum*; Hydropsychidae gen. spec. (photogr. 9); Orthocladiinae gen. spp., Simuliidae gen. spp.

6.1.3. STRONG CURRENT (75 CM/SEC->1 M/SEC)

Baetidae gen. spec.; larvae of Anisoptera gen. spp.; Hydropsychidae gen. spp. (photogr. 9); Orthocladiinae gen. spp., Simuliidae gen. spp.



Photogr. 9. — Larva of a Hydropsychidae gen. spec. (River Tatinga).

6.1.4. HYGROPETRIC AREAS ON ROCKS

Limonia cf. *tipulipes* (larvae, pupae); *Potamodytes africanus* (imago).

6.1.5. ON THE BORDERS

Paratettix cinereum; Gryllidae gen. spec.

6.2. **Upper to Middle courses between 400 m and 150 m** (photogr. 4 pl I)

6.2.1. BANKS AND POOLS (0-30 CM/SEC)

Dugesia milloti; Caridina typus, *Atya pilipes;* Leptophlebiidae gen. spec.; larvae of Zygoptera gen. spp.; Lepidostomatidae gen. spec.; Naucoridae gen. spec.; larvae of *Potamodyles africanus; Lymnaea (Radix) natalensis*, *Gyraulus* sp.; Surface : Veliidae gen. spec., Gerridae gen. spec.; *Orectogyrus speculum*, *Dineutus sinuosipennis comorensis* (photogr. 10).

6.2.2. MEDIUM CURRENT (30-75 CM/SEC)

Dugesia milloti; Macrobrachium lar; Leptophlebiidae gen. spec., Baetidae gen. spec.; *Orthetrum julia falsum*; Hydropsychidae gen. spp. (photogr. 9); Orthocladiinae gen. spp., *Rheotanytarsus* sp.

6.2.3. STRONG CURRENT (75 CM/SEC-> 1 M/SEC)

Baetidae gen. spec.; Hydropsychidae gen. spp. (photogr. 9); Orthocladiinae gen. spp., *Rheotanytarsus* sp., Simuliidae gen. spp.

6.3. **Middle to Lower courses between 150 m and 10 m** (photogr. 5, pl. II)

6.3.1. BANKS AND POOLS (0-30 CM/SEC)

Dugesia milloti; Caridina typus, *C. brachydactyla*, *Atya pilipes; Hygrobates soari;* Leptophlebiidae gen. spec.; larvae of Zygoptera gen. spp. and Anisoptera gen. spp.; *Anopheles mascarensis*, *Culex pipiens cinque-fasciatus*, *Rheotanytarsus* sp. (30 cm/sec!); Ranatridae gen. spec., Naucoridae gen. spec.; *Sternolophus solieri*, larvae of *Potamodytes africanus; Ceratophallus* sp.; Surface : Veliidae gen. spec., Gerridae gen. spec.

6.3.2. MEDIUM CURRENT (30-75 CM/SEC)

Macrobrachium australe, *M. lar; Hygrobates soari;* Leptophlebiidae gen. spec., Baetidae gen. spec., *Prosopistoma* sp.; Hydropsychidae gen. spp., Sericostomatidae gen. spec.; Chironomini-, Pelopiinae (Pentaneurini)-, Orthocladiinae gen. spp., *Rheotanytarsus* sp.; *Neritina gagates* (from about 120 m altitude), *Neritina pulligera knorri* (from about 120 m altitude), *Septaria borbonica* (from about 120 m altitude), *Neritilia consimilis* (from about 120 m altitude, near the water-level); *Sicyopterus (?Sicydium) lagocephalus* (with ventral sucker, attached to stones; photogr. 6, pl. II and photogr. 11).

6.3.3. STRONG CURRENT (75 CM-> 1 M/SEC)

Hygrobates soari; Baetidae gen. spec., *Prosopistoma* sp.; Hydropsychidae gen. spp.; Orthocladiinae gen. spp., *Rheotanytarsus* sp., Simuliidae gen. spp.; *Neritina gagates* (from about 120 m altitude; under stones), *Neritina pulligera knorri* (from about 120 m altitude; under stones), *Septaria borbonica* (from about 120 m altitude, upside of stones), *Neritilia consimilis* (from about 120 m altitude; near the water-level); *Sicyopterus (? Sicydium) lagocephalus* (with ventral sucker, attached to stones; photogr. 6 pl. II and photogr. 11).

6.4. **Lower courses to the Mouth between 10 m and 0 m altitude** (photogr. 8, pl. II)

6.4.1. BANKS AND POOLS (0-30 CM/SEC)

Caridina typus, C. brachydactyla, Atya pilipes; Leptophlebiidae gen. spec.; *Trithemis arteriosa;* larvae of *Potamodytes africanus; Neritilia consimilis* (near the water-level); if the recurrent of brackish water during high tide ascend in the mouth-region: brackish-water and marine fishes, like *Kuklia rupestris, Microphis brachyurus and Eleotris fusca*; Surface: Veliidae gen. spec., Gerridae gen. spec.

6.4.2. MEDIUM CURRENT (30-75 CM/SEC)

Macrobrachium lar; Hygrobates soari; Leptophlebiidae gen. spec., Bactidae gen. spec.; larvae of Anisoptera gen. spp.; Chironomini-, Orthocladiinae gen. spp., *Rheotanytarsus* sp.; *Neritina gagates, N. pulligera knorri, Septaria borbonica, Clithon comorensis* (from about 3 m altitude, always in the sector of the recurrent flow during high tide), *Neritilia consimilis* (near the water-level); *Sicyopterus (? Sicydium) lagocephalus* (with ventral sucker, attached to stones; photogr. 6, pl. II and photogr. 11), during high tide with recurrent flow: different brackish-water and marine fishes.

6.4.3. STRONG CURRENT (75 CM-> 1 M/SEC)

Hygrobates soari; Baetidae gen. spec., larvae of Anisoptera gen. spec. (under stones); Orthocladiinae gen. spp., *Rheotanytarsus* sp., Simuliidae gen. spp.; *Neritina gagates* (under stones), *N. pulligera knorri* (under stones), *Septaria borbonica* (upside of stones), *Clithon comorensis* (from about 3 m altitude, always in the sector of the recurrent flow during high tide, under stones), *Neritilia consimilis* (near the water-level); *Sicyopterus (? Sicydium) lagocephalus* (with ventral sucker, attached to stones; photogr. 6, pl. II and photogr. 11).

6.4.4. HYGROPETRIC AREA ON ROCKS

Potamodytes africanus; [sometimes in the spray-water of waterfalls of the bluffs of the coast : *Neritina gagates, N. pulligera knorri*]

7. THE DISTRIBUTION AND DENSITY OF THE FOUND ANIMALS BETWEEN THE HEADWATERS AND THE MOUTH

(*Abbreviations* : H. = Headwater; U.C. = Upper Course; M.C. = Middle Course; L.C. = Lower Course; M. = Mouth; 0-30 = 0-30 cm/sec; 30-75 = 30-75 cm/sec; 75-1 = 75 cm/sec-1 m/sec; Hyg. = Hygro = petric area; + = sporadic; ++ = medium; +++ = very frequent; (+) = not recolted by the collections of the mission, but the occurence is probably; the numbers indicate the average numbers of individues on 1/16 m² (after quantitative collections);

The headwaters of the rivers and streams of Anjouan lie in the central volcanic mountains of the N'Tingui massive between 600 m and 1000 m altitude. Information obtained from the Service des Eaux et Forêts in Mutsamudu, indicated subterranean water from the crater lake Dzialandze or Lac Sacré (photogr. 1, pl. I), on the slopes of the N'Tingui at an altitude of 900 above sea-level. This lake collect rain water from the highest very humid area (annual mean of rainfall-amount up to 3000 mm!) of the island. The conductivity of these water is only 35 µSiemens with a total hardness of 0'6° dH, but the pH was with 8'6 distinctly alkaline. On the banks of these lake are to find larvae of a *Cloën* sp., larvae of different Odonata, such as *Enallagma kauderni, Trithemis arteriosa, Rhyothemis* sp., *Zygomma* sp. and *Orthetrum julia falsum.* On the sandy-muddy bottom are larvae of Chironomini, *Chironomus thummi* (?) — group and Pentaneurini (Pelopiinae), also larvae of Tabanidae frequent. In the free water swimm swarms of *Gambusia affinis holbrooki*, an introduced species. On the borders is living the ripicol grashopper *Paratettix cinereum.*

In contrast to the "collected rain water" of the Lac Sacré is the conductivity in the running waters between the headwaters with 94 µSiemens and the lower courses with maximal 225 µSiemens much higher. Also the total hardness increase between the headwaters from 1'9° dH to maximal 4'25° dH in the lower parts of the rivers. The pH values were between 7'4 and 8'4 always alkaline.

The upper courses (photogr. 3, pl. I) possess a rich flora of floating and cushion-like green-and blue-algae, and also, in darker parts of the primeval forests, a thick cover of diatoms.

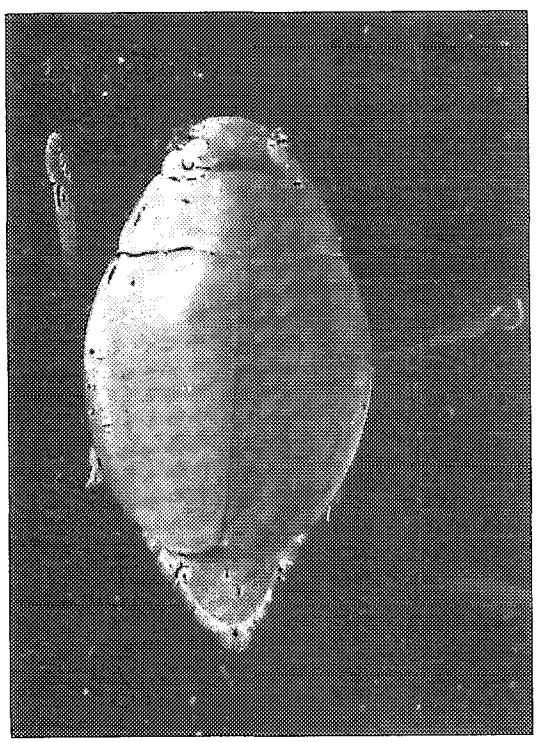
In consequence of the steep gradient with strong currents and rocky bottom, with basaltic boulders and gravel, are the dominant forms "petricole" species, living on, under or between stones such as Baëtidae, *Prosopisloma* sp., some larvae of Anisoptera, like species of *Trithemis, Zygonyx* and *Orthetrum.* Further are to find always larvae and pupae of Hydropsychidae (photogr. 9), Orthocladiinae, in muddy cases-*Rheotanytarsus* sp. and-in cascades and waterfalls-especially the larvae and pupae of Simuliidae. They occur on basaltic rocks in very strong current (more than 1 m/sec) in very dense populations up to 2500 individues /1/16 m²!

A rich fauna-of more stillwater forms-is also developped near the banks, in small creeks, and in pools situated between the cascade-zones. Some of these species are also adapted to settle in regions with medium current under stones or in filamentous, floating algae. The triclad *Dugesia milloti*, a species known from Madagascar, often aboundant is found

ANJOUAN	H.-U.C. 900-400 m				U.C.-M.C. 400-150 m				M.C.-L.C. 150-10 m			L.C.-M. 10-0 m			
	0-30	30-75	75-> 1	Hyg	0-30	30-75	75-> 1	Hyg	0-30	30-75	75-> 1	0- t 30	30-75	75-> 1	Hyg
Dugesia milloti	45	30	—	—	70	20	—	—	+	—	—	—	—	—	—
Lumbricidae gen. spec.	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Caridina typus	+++	—	—	—	+++	—	—	—	+++	—	—	++	—	—	—
Caridina brachydactyla	—	—	—	—	—	—	—	—	++	—	—	++	—	—	—
Atya pilipes	+++	—	—	—	++	—	—	—	++	—	—	++	—	—	—
Macrobrachium lar	—	—	—	—	—	+	—	—	—	+	—	—	+	—	—
Hygrobates soari	—	—	—	—	—	—	—	—	+	5	5	—	1-2	1-2	—
Leptophlebiidae gen. sp.	+	25	—	—	20	15	—	—	20	(+)	—	+	+	—	—
Baetidae gen. spp.	—	100	100	—	—	150	+++	—	—	20	9	—	2	2	—
Prosopistoma sp.	—	—	—	—	—	(+)	(+)	—	—	+	+	—	—	—	—
Zygoptera gen. spp.	(+)	—	—	—	+	—	—	—	+	—	—	—	—	—	—
Pseudagrion pontogenes	+	—	—	—	(+)	—	—	—	(+)	—	—	—	—	—	—
Anisoptera gen. spp.	+	6	6	—	(+)	+	—	—	+	+	—	+	+	—	—
Trithemis arteriosa	—	—	—	—	—	—	—	—	—	—	—	+	(+)	—	—
Trithemis kirbyi ardens	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—
Zygonyx torrida	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—
Orthetrum julia falsum	—	1	—	—	—	6	—	—	—	—	—	—	—	—	—
*Paratellix cinereum**	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gryllidae gen. spec.*	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hydropsychidae gen. spp. (photogr. 9)	—	15	75	—	—	25	45	—	—	20	30	—	(+)	(+)	—
Sericostomatidae gen. spp.	100	(+)	—	—	(+)	(+)	—	—	(+)	+	—	—	—	—	—
Lepidostomatidae gen. spp.	+	—	—	—	+	—	—	—	—	—	—	—	—	—	—
Chironomini gen. spp.	—	—	—	—	—	—	—	—	—	++	—	—	++	—	—
Pelopiinae (Pentaneurini) gen. spp.	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—
Orthocladiinae gen. spp.	—	25	25	—	—	++	++	—	—	++	++	—	+	+	—
Rheotanytarsus sp.	—	—	—	—	—	250	++	—	+	++	+	—	++	+	—
Simuliidae gen. spp.	—	300	2 500	—	—	++	2 500	—	—	(+)	++	—	(+)	+	—
Anopheles mascarensis	—	—	—	—	—	—	—	—	+	—	—	(+)	—	—	—
Culex pipiens 5-fasc.	—	—	—	—	—	—	—	—	+	—	—	(+)	—	—	—
Limonia cf. *tipulipes*	—	—	—	45	—	—	—	++	—	—	—	—	—	—	?
Veliidae gen. spec.	++	—	—	—	++	—	—	—	++	—	—	++	—	—	—
Gerridae gen. spec.	+	—	—	—	+	—	—	—	+	—	—	(+)	—	—	—
Ranatridae gen. spec.	+	—	—	—	(+)	—	—	—	+	—	—	—	—	—	—
Nepidae gen. spec.	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Naucoridae gen. spec.	+++	—	—	—	+++	—	—	—	++	—	—	—	—	—	—
Orectogyrus speculum	++	—	—	—	+	—	—	—	—	—	—	—	—	—	—
Dineutus sinuosipennis comorensis (photogr. 10)	++	—	—	—	+	—	—	—	—	—	—	—	—	—	—
Hyphydrus separandus, Laccophilus tigrinus	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sternolophus solieri	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—
Potamodytus africanus larvae	30	—	—	—	++	—	—	—	+	—	—	(+)	—	—	—
Potamodytus africanus imago	—	—	—	++	—	—	—	++	—	—	—	—	—	—	+
Neritina gagates	—	—	—	—	—	—	—	—	—	+	+	—	3	5	4
Neritina pulligera knorri	—	—	—	—	—	—	—	—	—	+	+	—	3	5	4
Septaria borbonica	—	—	—	—	—	—	—	—	—	13	45	—	7	35	—
Clithon comorensis	—	—	—	—	—	—	—	—	—	—	—	—	6	6	—
Neritilia consimilis	—	—	—	—	—	—	—	—	(+)	12	12	+	30	++	—
Lymnaea (Radix) natalensis	+	—	—	—	++	—	—	—	—	—	—	—	—	—	—
Ceratophallus sp.	—	—	—	—	+	—	—	—	+	—	—	—	—	—	—
Sicyopterus (? Sicudium) lagocephalus (photogr. 11)	—	—	—	—	—	—	—	—	—	++	+	—	++	+	—

* = these species are outside of the water near the border, but also able to swin for short time (to escape)

on muddy stones and under vegetable debris, Between floating roots and plants from the border. under stones of the banks and between vegetable debris *Caridina* species, such as *C. typus* and *C. brachydactyla* (in the transition of middle to lower courses) and *Atya pilipes* are dominant, also larvae of Leptophlebiidae and Zygoptera, such as *Pseudagrion ponlogenes*. Sometimes occur larvae of Sericostomatidae with tube-like cases from sand and Lepidostomatidae (?) with cases from leaves. Sporadic are Nepidae and Ranatridae in the upper courses. Very frequent are Naucoridae, mostly to find under flat stones or free swimming near the bottom, like the species of *Hyphydrus separandus*, *Laccophilus tigrinus* and the larvae of the dryopid beetle *Potamodytes africanus* (mostly on wood). Of the molluses in the banks of the upper and middle courses, only *Lymnaea (Radix) natalensis* (a South-African-Madagassian species) and *Ceratophallus* sp. are represented.



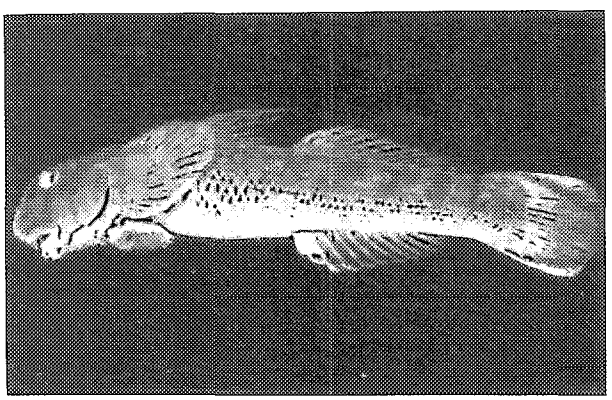
Photogr. 10. — *Dineutus sinuosipennis* ssp. *comorensis* (River near Bazmini).

On the surface of the water are near the borders and in pools Veliidae and Gerridae always frequent; also the gyrinid beetles *Orectogyrus speculum* and the big *Dineutus sinuosipennis* ssp. *comorensis* (originally described from Anjouan, photogr. 10).

On the borders of the upper courses were found (like on the borders of the Lac Sacré) the ripicol grashopper *Paratettix cinereum* and a species of Gryllidae (only larvae, not determinable, were found) feeding on algae near the water-level of the banks. It is to note, that on the border of the mountain streams of Ceylon were found also a typical ripicol Tettrigidae, *Euscelimena gavialis* and a Gryllidae, *Paranemobius pictus*, feeding on ripicol algae (KALTENBACH, 1973).

Near the waterfalls and cascades are typically hygropetric areas sprayed with water from the falls. These habitats are characterized by the larvae and pupae of *Limonia* cf. *tipulipes* (also found on hygropetric areas in South-Africa, Seychelles, La Réunion, Ceylon) and the imagos of the dryopid *Potamodytus africanus*.

The lower parts of the rivers, with medium to strong currents of more than 1 m/sec in the middle section, are characterized by different species of Neritidae, such as *Neritina gagates*, *N. pulligera knorri*, *Septaria borbonica* and *Neritilia consimilis* (ocurring from about 100 m altitude). Just before the mouth, in the zone of brackish water during the recurrent flow of the high tide, *Clithon comorensis*, sometimes with short spines, is also found. These occurence of the different species of Neritidae correspond with the observations made in Madagascar, New Caledonia and some othe Pacific islands by STARMÜHLNER (1969, 1970, 1976).



Photogr. 11. — Lateral view of *Sicyopterus (? Sicydirum) lagocephalus* with a ventral sucker (River Hanghoué).

The number of species and the density of typically running water forms of freshwater insects decreases in the lower parts with higher temperatures (i. e. Baetidae, Hydropsychidae, Orthocladiinae and Simuliidae). Only a *Rheotanytarsus* sp.-in muddy tubes on the surface of the stones-is sometimes

very frequent on boulders. On stones with eggs of Neritidae occur the hydracarinid *Hygrobates soari* and, in stillwater creeks of the banks, the larvae of *Anopheles mascarensis* and *Culex pipiens cinque-fasciatus*.

In the lower parts *Sicyopterus (?Sicydium) lagocephalus* with a ventral sucker is always present, attached on basaltic rocks and boulders (photogr. 6, pl. II and photogr. 11). In the mountain streams of Ceylon lives in a similar habitat the gobiid *Gobius (= Awaous) grammepomus*, indicated by RADDA (1973). In the mouth region are some species of typically marine and brackish-water fishes present (i. e. *Kuhlia rupestris*, *Microphis Trachyurus* and *Eleotris fusca)*.

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