WATER FAUNA OF A MADEIRAN STREAM WITH NOTES ON THE ZOOGEOGRAPHY OF THE MACARONESIAN ISLANDS

By ANGELIKA STAUDER *

SUMMARY: The stream of Madeira here examined, the Ribeira das Cales, springs from below the Pico do Areeiro and reaches the sea at Funchal. Due to its geological origin it shows a poor ion and nutrient content. Likewise, its biocoenosis is very poor as is to be expected in an island. Some groups, e.g., Plecoptera and Gammeridae are completely missing and others are only represented in small quantities. Only one new species was found. 9 species and 4 genera are reported for the first time from Madeira. Of the species occurring in the Ribeira das Cales 17 are endemic and 33 are also found on other islands or the mainland. The investigation further reveals that some species which occur in Madeira were not found in the Ribeira das Cales. This could be due to climatic differences between the southern and northern parts of Madeira, but also to the higher anthropogenic influence in the southern regions where intensive forestry and construction are carried out.

At present, the entire freshwater fauna of Madeira is composed of 60 endemic, 18 macaronesian and 60 other species which are more widely distributed. The non-endemic species show a predominantly European and Mediterranean influence.

RESUMO: FAUNA AQUÁTICA DE UM CURSO DE ÁGUA DA MADEIRA, COM NOTAS SOBRE A ZOOGEOGRAFIA DAS ILHAS MACARONÉSICAS. O curso de água aqui estudado, Ribeira das Cales nasce abaixo do Pico do Areeiro atingindo o mar no Funchal. Dada a sua origem geológica este curso de água apresenta uma composição pobre em nutrientes e iões. Alguns grupos (*Plecoptera* e *Grammeridae*) não foram encontrados enquanto outros estão fracamente representados. Apenas é assinalada uma nova espécie. Nove espécies e quatro géneros são assinalados pela primeira vez para a Madeira. Das epécies que ocorrem na Ribeira das Cales, 17 são endémicas e 33 encontram-se também em outras ilhas ou no continente. Este estudo revela ainda que algumas espécies assinaladas para a Madeira não foram encontradas na Ribeira das Cales. Tal facto pode dever-se a diferenças climáticas entre o sul e o norte da ilha, ou ainda à grande influência humana nas regiuões do sul onde se verificou intensa actividade florestal e de construção.

Actualmente a fauna de água doce da Madeira é composta por 60 espécies endémicas, 18 espécies macaronésicas e 60 espécies de grande dispersão. As espécies não endémicas são predominantemente europeias e mediterrânicas.

* Institut für Biologie 1 der Albert-Ludwigs-Universität, Albertstasse 21a, D-7800 Freiburg, Germany.

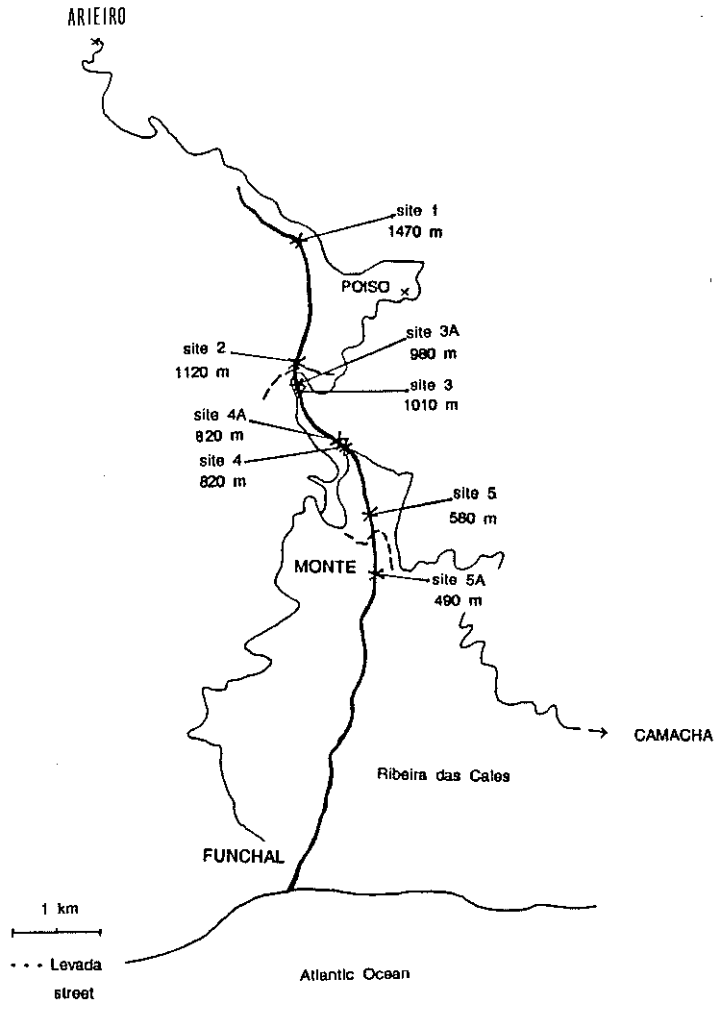

Fig. 1 - Locations of sampling sites at the stream Ribeira das Cales.

INTRODUCTION

In the summer of 1988 and spring 1989 extensive collecting of the macrozoobenthic fauna was carried out in the Ribeira das Cales, a stream situated in the southern part of the island of Madeira. Collections were taken regularly at 5 different sites along the stream from its origin down to 490 m. a.s.l. Three other sites were also visited. Chemical analyses of the water samples were made. A survey of the limnological literature concerning Madeira is also presented. Distribution patterns of the fauna and conclusions on the colonization of the macrozoobenthic fauna are drawn, based on the collected material and existing literature.

DESCRIPTION OF THE SAMPLING SITES

The examined stream, Ribeira das Cales, is situated in the southern part of the island just above its capital, the town of Funchal. The origin of the stream lies just below the mountain Pico do Areeiro at appr. 1500 m. a.s.l. (fig. 1). With a total length of 9 km., the Ribeira das Cales has a very steep slope. Such steep slopes are common to the streams of Madeira. From its origin down to about 1400 m. a.s.l., the stream crosses a 1 km. wide high plateau with only a slight declination. Thereafter the rate of decline of the slope increases. The streambed contains rocks which are up to 2 m. in circumference. Small step-like waterfalls are common. An irrigation channel, the so-called levada, crosses the stream at 1100 m. a.s.l.. In dry summers the water flow can thus be stopped for 300 m. until the second source joins the stream at 980 m. a.s.l. Below the second source the size of the waterfalls increases and between them there are calm basins of water with aquatic vegetation. At 500 m. a.s.l. a second levada crosses the stream, so that in dry summers, the water dries up along the final 4 km. stretch. Apart from the levadas, the stream shows a natural morphological structure without man-made constructions. The velocity of the stream varys greatly from site to site due to the many different choriotops for which reason no average velocity is given.

Site 1:

This site lies appr. 500 m. below the permanent source (see Fig. 1).
Altitude: 1470 m. a.s.l.
Length examined: 14 m.
Width: 1.5 - 3 m., average 1.5 m.
Depth: 5 - 30 cm., average 10 - 15 cm.
Substrate: Stones 5 - 15 cm. diameter lie loose on sandy bottom; between them partial gravel. Only some moss and considerable growth of *Nasturtium of-*

Fig 2. - Sampling site 1.

ficinalis.

Shade: Almost throughout the entire day the stream is shaded by the riparian vegetation.

Plants: *Erica arborea*, *Vaccinium padifolium*, *Mentha palegium*, *Pteridium aquilinum*, *Blechnum spicant* and diverse Juncaceae.

Site 2:

The second site lies some metres above the first levada which crosses the stream. The streambed is divided by a small island, with a maximal width of 3 m..

Altitude: 1120 m. a.s.l.

Length examined: 24 m.

Width: 13 m. with island; max. 4.5 m.; min. 0.8 m.; average 2 m..

Depth: 5 - 40 cm., averaging about 10 - 15 cm..

Substrate: This section of the stream is heterogeneous. Large rocks are located in the streambed and along the edges. The east side is characterized by larger stones changing to smooth rocks. A calm area with a slow current shows a rich growth of *Nasturtium officinalis* and other plants. In the lower part gravel occurs. The west side is at first without a slope and shows a sandy and muddy bottom with isolated stones. Along the edge there is a rich vegetation of aquatic plants. Further downstream the water flow shows a step-like pattern which is caused by larger stones.

Shade: The site is shaded over until 11.00 a.m. and after 7.00 p.m.

Plants: *Erica arborea*, *Eucalyptus globulus*, *Pinus* spp., *Acacia* spp., *Nasturtium officinalis*, *Juncaceae*.

Site 3:

This site is situated after the second source joins the stream.

Altitude: 980 m. a.s.l.

Length examined: 16 m..

Width: 1.5 - 4.5 m., average 2 m..

Depth: 5 - 15 cm., average 7 cm..

Substrate: Stones from 5 - 15 cm. diameter, which are over-grown with moss and algae. Large assemblages of leaves occur intermittently between the stones. Rocks are spread about the margins of the stream. In the lower part there are two pools of about 3 m. length, separated by a small waterfall.

Shade: Until about 11.30 a.m. the site is shaded. Then sunlight enters the valley and there are no trees to provide shade.

Plants: *Genista scoparia*, *Pteridium aquilinum*, *Mentha palegium*, *Rubus fruc-*

ticosus, Pinus spp., *Erica scoparia, Plantago lanceolata, Epilobium apiflorum, Athyrium filix-femina, Apium nodiflorum, Nasturtium officinalis, Pellia epiphylly, Jubula hutchinsiae* and a lot of *Juncaceae.*

Site 3A:

This site lies 250 m. distant from site 2 and dried out in the summer of 1988.
Altitude: 1010 m. a.s.l.
Length examined: 17.5 m.
Width: 2 - 8 m., average 4 m.
Depth: 5 - 45 cm., average 15 cm.
Substrate: Large rocks and stones are situated in the streambed and outside it. Also smaller stones of 5 - 25 cm. diameter are present and some moss and other plants.
Shade: The site is shaded by trees growing on the bank until 2.00 p.m.
Plants: *Genista scoparia, Erica scoparia, Mentha palegium, Pteridium aquilinum, Rubus fruticosus, Jubula hutchinsiae* and various Juncaceae.

Site 4:

This site lies beside a quarry. The quarry was closed for a long time, but started working again in the beginning of 1990.
Altitude: 820 m. a.s.l.
Length examined: 15 m.
Width: 12 m. with an island in the middle; max. 5 m.; min. 0.8 m.; average 1.5 m.
Depth: 5 - 40 cm., average 12 cm.
Substrate: The flow is divided into two parts by the island. On the west side, the stones are 5 - 15 cm. in diameter. In the east much growth mainly consisting of *Nasturtium officinalis* and in the lower part a pool with a sandy-muddy bottom and a few stones.
Shade: There is no shade until 4.30 p.m., after which time direct sunlight no longer reaches the valley.
Plants: *Eucalyptus globulus, Pinus* spp., *Nasturtium officinalis* and a diversity of herbs and grasses.

Site 4A:

Directly at site 4 there is a waterfall 25 m. long. This is site 4A .
Altitude: 820 m. a.s.l.

Length examined: 2.5 m..
Width: 1 m..
Depth: Hygropetric area.
Substrate: Rocks with weakly falling water and splash-water zones.

Site 5:

Site 5 is situated about 80 m. above the second levada, which diverts the water from the stream. Thus the streambed can sometimes be dry.
Altitude: 580 m. a.s.l.
Length examined: 9 m.
Width: 5 m., average 3 m.
Depth: 4 - 45 cm., average 10 cm.
Substrate: Numerous, scattered smooth rocks making up the bottom. Some loose stones (diameter 5 - 20 cm.) are found in places where leaves and branches have accumulated.
Shade: This site is shaded all day by overhanging tree branches.
Plants: *Eucalyptus globulus, Acacia* spp., *Pinus pinaster, Laurus* spp., *Pteridium aquilinum, Ageratina adenophora, Ageratina riparia, Dryopteris maderensis* and various grasses.

Site 5A:

This site lies 500 m. below site 5 and dried up in the summer of 1988.
Altitude: 490 m. a.s.l.
Length examined: 12 m..
Width: 5 m., average 2.5 m..
Depth: 5 - 50 cm., average 15 cm..
Substrate: Large rocks and also substrate of less extention (5 - 20 cm.) and gravel.
Shade: The site is shaded by trees almost the entire day.
Plants: *Eucalyptus globulus, Acacia* spp., *Laurus* spp., *Pinus* spp., *Pteridium aquilinum* and various other herbs and grasses.

CHEMICAL AND PHYSICAL ANALYSIS

Water samples were taken on 19.7.1988, 28.7.1988, 22.8.1988, 6.9.1988, 20.3.1989 and 19.4.1989. Oxygen- and BOD_5 - determination was carried out in the Laboratório das Pescas. Dr. FILOMENA SEABRA of the laboratory of the Health Service measured calcium, magnesium, hardness, phosphate, ammoniac, nitrite, nitrate,

alkalinity, clorine, sulfate and Iron. Apart from this the pH, conductivity and temperature were measured.

The results show a low ion and nutrient content due to the geological formation. Conductivity values ranged from 0 - 70 µS/cm and pH from 6.7 - 8.2. The proof limits of 100 µg/l for phosphate, ammoniac, and nitrite were methodically too low to determine the exact geological basic value. Normally the value for phosphate lies at 40 µg/l, for ammoniac at 30 µg/l and for nitrite at 10 µg/l. Since the proof limits were too low, it was not possible to decide if there was a slight anthropogenic influence or if the geochemical basic values were very high. Probably there is no strong human influence. The high percentage of chlorid-ions 11 - 12 mg/l is probably due to aerosols which have accumulated in the rain and ground water. Water temperatures ranged in the summer of 1988 from 10 °C to 25 °C and in the spring of 1989 from 8°C to 12°C.

INVESTIGATION OF THE BENTHIC ORGANISMS

1. Methods

Samples were taken during July, August and September of 1988, and March and April of 1989.

Due to the structure of the stream-bed, it was not possible to take samples with a surber-sampler. Hence a half-circled net with a radius of 15 cm. was used. The length of the rod was 70 cm. and mesh size 350 µm.

Samples were taken in the upwards stream direction at different substrate types (e.g., plants, stones, rocks, mud and sand) for a determined length of time. In the summer of 1988 the material was sorted directly at the sites. Thus it was possible to search for rare specimens. Apart from that it was possible to observe the animals "*in vivo*". Unfortunately, very small organisms may have gone unnoticed.

The Hydrocarinae were preserved in Koenicke, the Cyclopidae in 4% formaldehyde and all other species in 70% ethanol.

During the winter the author contacted various specialists to determine the species. Results were available for the major groups by spring so that I could specifically investigate the different kinds of substrate in the spring of 1989. To accomplish this I took 8-10 samples from diverse substrates at each sampling-site which I brought to the museum, where they were kept in aquariums and the living specimens were sorted. The numbers of animals at the different habitats were registered for investigation according to their substrate preference. In this manner the smaller organisms were not neglected.

Ephemeroptera

From Madeira, only 3 species of the family Baetidae are known. Papers on the Ephemeropterous fauna of the island have been presented by EATON (1883-1889) and BRINCK & SCHERER (1957).

Baetidae

Baetis rhodani PICT.

Besides the larvae of Simuliidae, the most abundant organism at all sites of the Ribeira das Cales were in the summer of 1988 as well as in the spring of 1989 the nymphs of *B. rhodani*. Normally, 200-500 of these nymphs were taken in each catch. *B. rhodani* was just as well represented in other streams of the island. There is hardly any running-water which isn't inhabited by this species (BRINCK & SCHERER, 1957).

The determination of the nymphs produced difficulties. The structure of the labial palpus was not in accordance with the description in the keys by SCHOENEMUND (in DAHL, 1930), ELLIOT & HUMPESCH (1983) and MÜLLER-LIEBENAU (1969). The nymphs, however, were determined as *B. rhodani* since the subimagines, which were reared from the nymphs, showed the typical design of the metatergit. DANIEL HEFTI of the Zoological Institute in Fribourg (Switzerland) confirmed this determination.

The nymphs did not show any substrate preference. They were present at all sites in varying habitats. In Europe *B. rhodani* often appears in streams and rivers and also in lakes. It is one of the most frequent and widely distributed species (MACAN, 1979). During the time of investigation *B. rhodani* was present in all stages of development. Adults were captured in the riparian vegetation or were reared from the nymphs in rearing cages. *B. rhodani* possibly produces 3 generations in Madeira. The high temperatures, especially in the lower parts, favours this. Normally *B. rhodani* only produces 2 generations a year.

Baetis pseudorhodani M.-L.

This species had hitherto only been known from the Canaries (MÜLLER-LIEBENAU, 1971) and is now for the first time recorded from Madeira. The nymphs are dark brown to black. The body is flattened and its appearance is more like that of a Heptageniidae nymph than a Baetidae. In addition, the feature of the widely spread legs is not typical for a Baetidae. The occurrence of *B. pseudorhodani* was very rare in comparison with the frequent and dominant *B. rhodani*. We found a total of 19 nymphs at sites 4 and 5 in the summer of 1988 and in the

spring of 1989. No nymphs were found at sites 1 and 3, which are sources, and at 3A and 5A, which were dry in summer. *B. pseudorhodani* was present in different stages of development. The nymphs ranged from 4 mm. to mature size (17 mm.). It was not possible to raise imagines, in spite of intensive efforts. They always died, even when placed in rearing cages kept in the streambed. The nymphs always remained above small waterfalls, under stones in the riffle zone or mostly, on large smooth rocks, surrounded by fast running water. At first I supposed that *B. pseudorhodani* preferred or required a habitat with very fast running water. Supplementary investigations were conducted at Fajã da Nogueira, in the Northern part of Madeira, where at one place particullarly *B. rhodani* and *B. pseudorhodani* occurred more or less frequently. Samples near stones in the riffle-zone and on smooth rocks were taken and it was found that at each substrate there was no significant difference between the number of each species. At this site a relatively high conductivity of water (101,8 uS/cm) was observed. The sites 4 and 5, where *B. pseudorhodani* was found most frequently, exhibited conductivities of roughly 60 uS/cm and 70 uS/cm, respectively. These values represent low conductivities, but they are significantly higher than that at site 1, which measures only 35 uS/cm. Perhaps this explains the occurrence or lack of occurrence of *B. pseudorhodani*. To verify this, further ecological investigations would be necessary.

Cloeon dipterum L.

Not until the beginning of September did I catch nymphs of *Cloeon dipterum*. They were in a pool at site 2, which was separated from the streambed by plants and had a very slow current. 22 nymphs were found, 5 of which were preserved in ethanol and the rest was taken to the laboratory. The subimagines emerged the next day and two days later the imagines. One imago was impossible to determine using the literature (SCHOENEMUND in DAHL, 1930; BELFIORE, 1983; ELLIOT & HUMPESCH, 1983). At site 4 another 26 nymphs were gathered in an abundant growth of *Nasturtium officinalis*. In the small pools next to the stream at site 5 nymphs of *C. dipterum* were also found. Apart from these, 4 adults were caught in the riparian vegetation. In March and April, 1989, no nymphs at all were found. But at the end of April, I caught 4 adults and 1 subadult in my room in Funchal. They probably came out of a pool from the adjacent gardens.

C. dipterum prefers small pools having a high summer temperature. It is possible to find them in slow-flowing parts of streams with closed vegetation. According to SCHERER & BRINCK (1957) *C. dipterum* occurs in the Azores only in man-made habitats. They assumed that it occurs in the same kind of habitat in Madeira. EATON (1883-1889) found *C. dipterum* in slow-flowing streams just above Funchal, which I could confirm. *C.dipterum* was not found on the northern

part of the island, which is not strongly influenced by people, however some characteristic habitats existed there.

Apart from this, CLASSEY (1966 b) reported finding a female subimago of *Centroptilum* sp. from site Bica da Cana in August.

Trichoptera

MOSELY (1938) and NYBOM (1948, 1963, 1965) have researched the Trichopterous fauna. They worked only on adults, not on nymphs. At present, the determination to the species level of the Trichopterian nymphs of Madeira is not possible. However, it is possible to determine the family or genus. Thus, for those families and genera in which only one species is known to occur in Madeira, I was able to give the specimens a species designation. I am grateful to H. MALICKY from the Institute for Limnology in Lunz (Austria) for his assistance and advice in this matter. He determined the greater part of the collected material. The determination is only valid as long as there are no other species present from these groups. Apart from this, it was possible to draw conclusions based on the combined presence of adults and nymphs at individual sites. Information on distribution of Madeiran Trichoptera was kindly made available to me by MALICKY (pers. com., 1989).

Hydropsychidae

Hydropsyche maderensis HAG.

The only member of this family found in Madeira is *H. maderensis*. This species is the most common Trichoptera and occurred at all sites during the entire investigation. No substrate preferences were detected. During the sampling-period I always caught nymphs, pupae and adults. *H. maderensis* is also common in many other streams in Madeira. NYBOM (1965) reported it from localities all over the island.

Hydroptilidae

Hydroptila spp.

Three species of Hydroptilidae are known from Madeira: *H. vectis* CURTIS, *H. juba* ENDERL. and *H. fortunata* MORTON.

The adult males of these species are easy to determine. The females are difficult and it is not possible to determine the nymphs. In the summer of 1988

the samples from the riparian vegetation at sites 3, 4 and 5 contained females and males of adult *H. juba*. Hydroptilidae nymphs were found at sites 1 to 4, but never at site 5. They were found at very different choriotopes. At site 1, I found them mostly among the water moss, while at site 3 they occurred more often on the stony substrate. It is remarkable that the nymphs were sometimes very frequent and at other times absent.

Oxyethira spinosella McL.

This species has hitherto only been recorded twice from Madeira. In June, 1880, EATON found one in the Ribeiro Frio and another in Santana (NYBOM, 1965).

I found one adult male at site 2 in July of 1988. As no other species of this genus are known to occur in Madeira, I determined the nymphs as *O. spinosella*. A total of one nymph each was taken at site 2 in the summer of 1988 and spring of 1989 and at site 4 2 nymphs were caught in March and one in April of 1989. All nymphs were taken on gravel.

Stactobia spp.

As yet the only known *Stactobia* from Madeira are *S. atra* HAGEN and *S. nybomi* SCHMID . As is the case with the genus *Hydroptila*, the males of *Stactobia* are easy to determine, the females are difficult and nymphs impossible. I myself did not catch any adult *Stactobia*. It is not possible to catch them using conventional methods such as hand nets or light-traps. Normally they run over wet rocks and at first glance they appear to be small ants. (MALICKY, pers. com., 1989). The nymphs were only present on the rocks of a waterfall receiving small amounts of running water. Great numbers of these nymphs occurred in association with *Ancylus fluviatilis*, larvae of *Chironomidae* and *Thaumaleidae*. They were most frequent in areas with overhanging rocks.

Limnephilidae

Limnephilus nybomi MAL.

L. nybomi used always to be given in the literature as *L. affinis* (MOSELY, 1938; NYBOM, 1948, 1963, 1965). However, the Madeiran species shows significant differences to the frequent and widely distributed *L. affinis*. The differences are not great but the consistancy of the different features suggest a separation which is also justified by the geographic isolation of Madeira (MALICKY, 1980). In the

summer of 1988, I found one nymph in heavy growth of *Nasturtium officinalis* and one adult female at site 2. In spite of intensive search during the spring of 1989 no further specimens were found. The habitat of a rich vegetation of *Nasturtium officinalis* was poorly represented and the plant seemed to have been cut down. Which is not so surprising since *Nasturtium officinalis* is commonly used as a green salad in Madeira.

Polycentropidae

Polycentropus flavostictus HAG.

Of this family only *P. flavostictus* is known from Madeira. Nymphs were found which I attributed to this species. I also found adults. *P. flavostictus* occurred at all sites as did *Hydropsyche maderensis,* but not as frequently. The nymphs preferred sites with low water velocity.

Psychomyidae

Tinodes spp.

Of this family 3 species are recorded from Madeira: *T. cinerea* HAG., *T. grisea* HAG. and *T. merula* MCL.

Although they are recognized as 3 species, MALICKY still regards this an open question. In addition, *T. canariensis* McL. known from the Canaries and Sardinia, can hardly be distinguished from the above mentioned species (MALICKY, pers. com., 1989). Hence I felt compelled to lump all collected adults and nymphs together as *Tinodes* spp.

The nymphs were present at all sites. It was remarkable that at site 3 in March I found 75 nymphs in moss, however, in the following month only one nymph. It is supposed that during this intervening period they developed into the pupal stage.

Apart from this, 2 endemic species have been reported from Madeira: *Synagapetus punctatus* HAG. and *Mesophylax oblitus* HAG. Although I did not find any nymphs of this species in the Ribeira das Cales, I was able to collect them in running waters in the northern part of the island in regions not influenced by humans. In the material collected by LUNDBLAD both species were present. They were all collected at Rabaçal (NYBOM, 1965), a region in the northwest of the island with a very humid climate and a pristine laural vegetation.

Odonata

Libellulidae

Sympetrum nigrifemur (SELYS)

This species belongs to the *striolatum*-group. Originally described as a race of *Diplax vulgata*, and later considered a subspecies of *S. striolatum*, it is presently recognized as its own species (GARDNER, 1955). I captured nymphs of this species at sites 2, 3 and 4 in small pools or slow-flowing sections with masses of *Nasturtium officinalis*. The first 2 nymphs I caught in the middle of August in a pool at site 2, where previously I had searched intensively and found *C. dipterum*. In the beginning of September I found more nymphs. Some of them I brought to the laboratory, where I raised them with Simuliidae and Baetidae until adults emerged. In March and April of 1989, I found no nymphs despite intensive search efforts. No adults were caught during the investigation. All were reared from 11th - 12th instar nymphs, which I had collected. The nymphs exhibited the same pattern of emergence as related in the investigations carried out by GARDNER (GARDNER & CLASSEY, 1963). According to the length and width of the head given by GARDNER for the instars, I should have caught nymphs from the eighth instar since I used a net with 350 um mesh size. Why this was not so, is not clear. It is possible that the younger instars remained at other choriotope and only later entered the *Nasturtium officinalis* habitat.

Sympetrum fonscolombei (SELYS)

I found no nymphs of this species, but did capture 2 adult males in the beginning of September 1988 at site 3. Considering the sex and mature stage of the specimens I caught, it is probable that the species does not develop there.

This species flies from June to November in Central Europe, whereas in southern France they begin to fly in March and produce 2 generations per year (ASKEW, 1988). I assume that at least 2 generations develop in Madeira.

Aeschnidae

Anax imperator LEACH

Neither nymphs nor adults of *A. imperator* were caught, however, I did observe an adult flying up and down at site 4 in July, 1988. According to ASKEW

(1988), *A. imperator* flies from June to August. In the south of Europe they appear as early as May and in Madeira a mature adult was captured in April (GARDNER, 1968).

Additionally, *Ischnura pumilio* (CHARP.) and *I. senegalensis* (RAMB.) are recorded from Madeira (GARDNER & CLASSEY, 1963).

DIPTERA

Chironomidae

The larvae of Chironomidae in Madeira have never been studied. Studies on the adults have been made available by STORA (in FREY, 1948) and FREEMAN (1959). In this paper the larvae were determined down to the subfamily or tribus and sometimes to the genus.

Chironominae

Chironomini

Two species from the tribe Chironomini have been recorded from Madeira in previous studies: *Chironomus dorsalis* (MEIGEN) and *Polypedilum convictum* (WALKER) (FREEMAN, 1959; FREY, 1948).

Only a few Chironomini larvae were found in the summer of 1988 and spring of 1989. Remarkable was the occurrence of 6 larvae of the *Chironomus-thummi*-group at site 3 in August. This group is typically found in sewage contaminated waters. Upstream from this site are 2 houses which may affect this section of the stream.

Tanytarsini

From this tribe *Micropsectra funci* (MEIGEN) and *M. freyi* STORA are recorded from Madeira. Apart from them larvae of *Rheotanytarsus* were found. As yet no adults of this genus have been recorded.

Rheotanytarsus sp.

In the summer of 1988 I frequently collected *Rheotanytarsus* sp. at all sites. In September large amounts occurred at sites 3, 4 and 5, where the water velocity was low, however, not all of the fly cases were inhabited.

Apart from *Rheotanytarsus*, other larvae from the tribe Tanytarsini were found but could not be determined.

Diamesinae

From this subfamily *Diamesa alata* STORA and *Boreoheptagyia legeri* (GOETGHEBUER) are known to occur on Madeira (FREEMAN, 1959; FREY, 1948).

I found no larvae of Diamesinae during the summer of 1988, but they were very frequent at site 1 in the spring of 1989. At sites 2, 3 and 4 a few Diamesinae larvae were found, but at site 5 there were none. Three different species were represented in the material collected, however, it was not possible to determine them.

Orthocladiinae

The following species of this subfamily are known from Madeira (FREEMAN, 1959; FREY, 1948): *Metriocnemus fuscipes* (MEIGEN), *M. ochraceus* (WULP), *Parametriocnemus stylatus* KIEFFER, *Paraphenometriocnemus impensus* WALK, *Cricotopus bicinctus* (MEIGEN), *Cardiocladius freyi* STORA, *Orthocladius devonicus* (EDWARDS), *Chaetoclacius melaleucus* MEIGEN, *Synorthcladius semivirens* (KIEFFER), *Limnophyes mininus* (MEIGEN), *L. prolongata* (KIEFFER), *Thienemanniella clavicornis* (KIEFFER), *Smittia stercoraria* DEGEER, and *S. aterrima* (MEIGEN).

The larvae of this subfamily occurred at all sites during the summer of 1988 and spring of 1989. In springtime, the Orthocladiinae were the most frequently represented group of the Chironomidae. In determining the material only *Cardiocladius* could be separated out. In addition, the following genera were present: *Rheocricotopus*, *Synorthocladius*, *Eukiefferiella*, *Thienemaniella*, *Metrocnemus* and *Cricotopus*. The species, *Eukiefferiella E. atlantica* (STORA), has been recorded from Madeira and the Azores. Supposedly the larvae live marine since the adults were always taken from rocks along the coast (FREEMAN, 1959).

Tanypodinae

Macropelopini

Previously no species of this tribe were known to occur in Madeira. However, on rare occasions I found the larvae of *Macropelopia* sp. but never at site 1.

Pentaneurini

From this group only *Zavrelimyis nubila* (MEIGEN) is known to occur in Madeira. It is also recorded from the Azores (FREEMAN, 1959). In the summer of 1988, larvae of this genus were found at all sites except at site 1. In March and April it occurred quite rarely, but still frequently at site 2 .

Culicidae

Culex hortensis maderensis MATT.

C. hortensis commonly occurs in the Mediterranean region and southern Germany. The subspecies *C. hortensis maderensis* was found twice by myself in slow flowing stretches of site 3. CHRISTOPHERS (1929) collected this species in pools with submersed vegetation. In the material which he collected it was the most common and widely distributed species in Madeira. 50 years later CAPELA (1981) studied the Culicid fauna of Madeira. He found only one specimen of *C. hortensis maderensis,* which was in the Ribeira da Fajã at 800 m. elevation. From this find it can be concluded that *Culiseta longiareolata* is presently the most widely distributed Culicid in Madeira. *C. longiareolata* is an element of Ethiopian coastal regions and rarely occurs along the Atlantic coast. Other culicid species reported from Madeira are the following: *Aedes eatoni* EDWARDS, *Culex pipiens* L., *C. molestus* FORSKAL and *C. theileri* THEOBALD (CAPELA, 1981).

Dixidae

Dixa tetrica, which occurs in the Canaries, has been repeatedly mentioned for Madeira (STORA, 1941; FREY, 1948; MALMQVIST, 1988). The collected material was determined by R. WAGNER of the Max-Planck-Institut for Limnology in Schlitz (Germany), who has already worked on *D. tetrica* of the Canary Islands (WAGNER & BAEZ, 1987). He maintains that *D. tetrica* does not occur on Madeira, and that the material collected by me represents a new species (pers. com., 1989). The description of the new species is not yet completed. For present purposes it has been labelled *Dixa* nov. sp.

Dixa nov. sp.

The larvae occurred throughout the summer at all sites with varying frequency. Dixidae are metapneustic, that is they live in a boundary zone between the surface of water and the air. The number of occurring specimens is depend-

ent on the presence of proper habitats such as tree trunks, branches and leaves which penetrate the water. Furthermore, I found them on stones in the splash-water zones. In the spring of 1989, larvae of Dixidae were found almost exclusively at site 4 among growth of *Nasturtium officinalis*. At site 3 I caught 3 adult males.

Empedidae

At present, Empedidae larvae can be determined to the genus level but not the species level. All larvae which were found belong to the genus *Chelifera*, which until now has not been recorded from Madeira.

Chelifera sp.

No larvae of this genus were found in the summer of 1988. In the spring of 1989 I found 3 larvae in a gravel area of site 1, a further 3 in slower flowing stretches and among vegetation at site 4, and 2 further larvae in gravel at site 5. In the summer of 1988 I collected freshly emerged adults from the water samples and with the net in the riparian vegetation. The results of the determination are the following:

Clinocera haemorrhoidalis (BECKER)

This species occurred at sites 3, 4 and 5. In the collected material 3 more species were represented which have not yet been recorded in the literature. They will be described in a separate publication (WAGNER & STAUDER, in press) and have been provisionally labelled sp. I, sp. II and sp. III. Sp. I was found in August at site 3, sp. II in July and August at site 5 and sp. III was also caught at site 5 in September.

Other Empedidae which are recorded from Madeira are *C. rabacali* FREY and *Roederioides longirostris* FREY. Both are endemics (FREY, 1948).

Limoniidae

At one time the subfamilies Limoniinae and Tipulinae were united in the family Tipulidae, but presently they are recognized as separate families. The earlier literature on the Macaronesian islands used the old nomenclature (FREY, 1948; THEOWALD, 1977). At present it is only possible to determine the larvae to the generic level. The collected material was determined by P. OOSTERBROEK of the Zoological Museum in Amsterdam.

Cheilotrichia nemorensis (SAN.)

This species had hitherto only been known from the Canaries and is now recorded for the first time from Madeira. The 5 male specimens were captured at night at site 4.

Dicranomyia maderensis (WOLL.)

I caught adults of this species in August and September of 1988 at sites 1, 2, 3 and 5. In the spring of 1989 3 adult males were collected along with *C. nemorensis*. FREY, and STORA made collections in May, 1938 and LUNDBLAD in May, 1935. All these authors recorded *D. maderensis* from throughout the island.

Dicranomyia michaeli THEOW.

Of this species one male and 2 female adults were discovered in September of 1988 at site 3. *D. michaeli* was recorded from Caldeirão Verde and Queimadas (April 1970) and from Ribeiro Frio and Rabaçal (May, 1938) (NIELSON, 1961b; THEOWALD, 1977).

Dicranomyia vicina MACQ.

I caught adults of this species at site 1 in September and August of 1988, and at site 3 in September. A night collection in April of 1989 at site 4 resulted in one female specimen. *D. vicina* was collected by STORA in May 1938 in Funchal, Monte, Ribeiro Frio, and by LUNDBLAD in July and August 1935 in Rabaçal and Caramujo.

All larvae of Limoniidae which were obtained, belong to the genus *Dicranomyia*. All sites yielded specimens of this genus. Often they were rolled up between the thalli of Hepaticae or on the stalks of *Nasturtium officinalis*. Further species of Limoniidae that have been reported from Madeira (THEOWALD, 1977) are: *Geranomyia atlantica* WOLL., *G. bivittata* BECK., *G. canariensis* BERGR., *G. unicolor* HAL., *Phylidorea contraria* (WOLL.), *Trimicra pilipes* (FABR.), *Molophilus appendicatus* STAEGI, *Nephrotoma antithrix* MHS., *N. brevipennis* WOLL.

Muscidae

Limnophora **sp.**

Muscidae of the genus *Limnophora* have not yet been recorded from Ma-

deira. Nonetheless larvae of this genus were found in the spring of 1989, however, they could not be specifically determined. They occurred under large-sized stones in a sandy-muddy substrate at all sites.

Simuliidae

Papers on Simuliids have been published by STORA (in FREY, 1948), CARLSSON (1963), SANTOS GRÁCIO (1984/85) and CROSSKEY (1987a). All of them dealt with larvae, pupae and adults with the exception of STORA. According to the most recent publication (CROSSKEY, 1987a), only *Simulium intermedium* ROUBAUD and *S. petricolum* (RIVOSECCHI) exist in Madeira. All other alledged species are either synonymous with these or they are incorrectly determined. Thus *S. intermedium* ROUBAUD = *S. ornatum nitidifrons* EDWARDS = *Odagmia maderensis* (CARLSSON); *S. (Eusimulium) petricolum* (RIVOS.) = *Eusimulium azorense* (CARLSSON); *S. ruficorne* MACQUART = *S. beckeri* ROUBAUD = *S. annulipes* BECKER = *S. divergens* POMEROY = *S. diversipes* EDWARDS.

The collected larvae and pupae were determined using the keys of CARLSSON (1963) and CROSSKEY (1987a). CROSSKEY (1987 a) suggests that the adult *S. ruficorne* MACQUART which STORA collected had drifted to Madeira carried by winds, since neither he nor the Lund-expedition found aquatic stages of this species.

However, two additional species did not run throuhg the keys. P. SCHROEDER (CONSTANCE) confirmed this assumption. I therefore reared larvae during March and April in order to obtain adults for the necessary determination. All the larvae and pupae collected in the summer of 1988 and the spring of 1989, as well as the reared adults were given to SANTOS GRÁCIO in Lisbon. Unfortunately the determinations are as yet incomplete. Hence it is not possible to give detailed results in this paper.

Larvae and pupae occurred often at all sites. In the summer of 1988 they were often found together with *Baetis rhodani*. The larvae and pupae preferred locations with a higher water velocity. At site 4 they were very numerous among the large amounts of *Nasturtium officinalis*.

Thaumaleidae

Thaumalea subafricana has been recorded from Madeira (STORA, 1941). According to WAGNER (pers. com., 1989) this is erroneous . He identified the specimen as *T. brincki*, and supposed that *T. subafricana* occurs only on the Canaries.

Thaumalea brincki VAILL.

T. brincki was found in the summer of 1988 at all sites. It appeared most frequently on rocks at the waterfall of site 4 A. In the spring of 1989 I found *T. brincki* only at site 1. The Thaumaleidae live as do the Dixidae in the hygropetric area.

Tipuliidae

The Tipuliidae were formerly united with the Limoniidae into one family. Adult Tipuliidae can be determined to species level, as yet the larvae only to the generic level. Both adult Tipuliidae and Limoniidae were determined by P. OOSTERBROEK of the Zoological Museum in Amsterdam. The following adult species were caught using a net:

Tipula atlantica MANNH.

Adults of this species were only obtained at site 1 in August and September of 1988. *T. atlantica* is also recorded from Curral das Freiras, Queimadas, Ribeira do Lapa and Pico do Serrado (MANNHEIMS, 1962).

Tipula lundbladi MANNH.

T. lundbladi was collected in the summer of 1988 at sites 1 and 3. LUNDBLAD collected one male of this species in August 1935 (MANNHEIMS, 1962b).

I myself found larvae of the genus *Tipula* in August and September 1988 only at site 3. In the spring of 1989, I collected one larva at site 2 and another at 5A. They occurred on stones with a sandy-muddy underground. The specimens at site 3 were found among the humid riparian vegetation along the Ribeira das Cales.

Apart from this *T. paludosa* MG. and *T. rufina maderensis* LACKSCHW. are recorded from Madeira (THEOWALD, 1977).

During the summer of 1988 adult specimens of the families Syrphidae, Dolichopodidae and Ephydridae were captured on the riparian vegetation. Since larvae of these groups were not found, they will not be further mentioned.

Coleoptera

Dryopidae

Dryops luridus ERICK.

From Madeira only *D. luridus* is recorded. In the summer of 1988 I found 2 adults at site 2 and in the spring of 1989 one adult at site 4.

Hydraenidae

Ochthebius spp.

Recorded from Madeira are the following (LUNDBLAD, 1958): *O. quadrifoveolatus* WOLL., *O. quadricollis heeri* WOLL., *O. rugulosus* WOLL., *O. subpictus* WOLL. and *O. algicola* WOLL. Of this genus I found 3 adults at site 2, in addition 3 adults and 2 larvae at site 3.

Hydracarina

In the summer of 1935 LUNDBLAD investigated the fauna of the Hydracarina in Madeira. He discovered 25 species all of which except *Sperchon brevirostris* were described for the first time. 5 of these spieces were represented in the Ribeira das Cales excluding the Torrenticolidae. An extensive preparation is necessary to determine Torrenticolidae and the results are not very certain. LUNDBLAD described 10 species of this family. This is the family represented best in his collection with the largest number of specimens. The comparatively small number of species in my investigations is probably due to the fact that LUNDBLAD collected in different habitats such as among mosses and on moist rocks. He made collections at Rabaçal, Paul da Serra and Caramujo, which are located on the north eastern part of Madeira. Altogether he collected at 22 different locations, with elevations from about 900 m. to 1500 m. a.s.l. The determinations were made by SCHWOERBEL from the Institute of Limnology at Freiburg and Constance (Germany).

Aturidae

Aturus atlantis KRAM.

Only 2 females of this species were found in April at site 1. Both were collected between small stones. The water velocity that was middle to high. LUNDBLAD

found *A. atlantis* in 2 small streams on the high plateau of Paul da Serra. He believed that they were also present in the lower regions (LUNDBLAD, 1942, p.113), however, I could not confirm this.

Hygrobatidae

Atractides macaronensis (LDBL.)

The number of individuals of this species decreased with increasing elevation. At sites 4 and 5 the majority of the population was represented in August and September. They preferred choriotopes with small stones and middle to high water velocity. In the summer of 1988 as well as in the spring of 1989, there were almost exclusively adults. Only 3 nymphs were taken. LUNDBLAD rarely found *A. macaronensis*. At 3 different locations, which were all approximately at 900 m. a.s.l., he collected 18 specimens, which represent 0.5% of his Hydracarina material. 2 further specimens were found in a stream near Bica da Cana. This site lies at 1500 m. a.s.l., but it showed a significantly higher temperature (17.2° C) than the other sites, where the temperature ranged from 11 - 15°C. My results, as well as those of LUNDBLAD, reveal that *A. macaronensis* prefers lower elevations.

Atractides rutae (LDBL.)

In the summer of 1988 this species occurred only at site 1, which is at the origin of the stream. In the spring of 1989, I also found *A. rutae* at sites 2 and 3 and a single specimen in April at site 5A. Apart from 3 nymphs I collected only adults. In the material collected by LUNDBLAD, *A. rutae* was the second most frequent and most widely distributed species after *Torrenticola pharyngealis*. *A. rutae* appeared at 18 of 22 of his sites, which, as already mentioned, are all located on an elevation between 900 m. and 1500 m. a.s.l. The species showed no preference for a particular substrate. It occurred in sections with a slow water velocity, as well as on stones which were partially situated in middle to high water currents. The spieces seems to prefer the low temperatures, which were consistently measured at sites 1 and 3. Also, the sites at which Lundblad collected indicate that *A. rutae* is a cold-stenotherm species.

Lebertiidae

Lebertia madericola LDBL.

L. madericola was rare at all sites and never occurred at site 2. The samples taken in the spring of 1989 showed that *L. madericola* prefers weak water veloci-

ties. It never occurred in samples taken from strong currents, but always on shallow and muddy and sometimes gravelly areas with low water velocities. LUNDBLAD found *L. madericola* at 9 localities most of which had a moss vegetation.

Sperchonidae

Sperchon brevirostris KOEN.

This was the most frequently found species in the collected material. In the summer of 1988 it was clearly the dominant Hydrocarina-species at sites 1 and 3. However in the spring of 1989 *A. rutae* occurred almost as numerously. No substrate preference was discernable. Nymphs were infrequently found during the summer of 1988, but in the spring of 1989 they were almost always more numerous than the adults. The material obtained by LUNDBLAD did not show a clear dominance of *S. brevirostris*, although he collected in spring and summer. Only at one location, a small channel at Paul da Serra, was *S. brevirostris* dominant.

Torrenticolidae

The Torrenticolidae material could not be determined and was thus treated as *Torrenticola* spp. LUNDBLAD (1942) who described the following 10 species: *T. mandibularis, T. insulicola, T. rotundos, T. nesiotis, T. crassirostris, T. elliptiformis, T. crassus, T. maderensis, T. pharyngealis, T. affinis.*

Apart from these the following species are also reported from Madeira: *Thyas incerta* LDBL., *Thyopsis maderensis* LDBL., *Trichothyas rutae* (LDBL.), *Lebertia maderigena* LDBL., *Limnesi atlantica* LDBL., *Atractides maderensis* (LDB.), *A. insulanus* (LDBL.), *Maderomegapus hystricipes* LDBL., *Neumania atlantida* LDBL., *Arrenurus autochthonus* LDBL. All species are endemic, except *T. rutae* and *N. atlantida* which also occur on the Canaries (LUNDBLAD, 1962).

Copepoda

Eucyclops serrulatus (FISCH.)

This is the first record of *E. serrulatus* from Madeira. In the summer of 1988 I found it at sites 2 and 3. At site 2 it occurred together with *Cloeon dipterum* and *Strandesia obliqua* in large amounts in the pool near by the streambed . In the spring of 1989 I found it only occasionally. It occurred at all sites in samples taken from slow flowing waters with a muddy bottom or between *Nasturtium officinalis*. *E. serrulatus* is one of the most adaptable and widely distributed species

of Cyclopidae. Normally it lives in stagnant waters. But it also occurs in river sources, streams, pools, inland salt-water and brackish water along the coast (DAHL, 1928).

Ostracoda

So far no Ostracoda had been recorded from Madeira. All collected Ostracoda were determined by MEISCH (Luxembourg). He informed me about their ecology and distribution as well (pers. com., 1989).

Cyprididae

Cypricercinae

Strandesia obliqua SARS

In the summer of 1988 this species was found at all sites except site 1. The collected specimens were nearly all adult females and some were juvenile females. In the spring of 1989 I collected two additional females at sites 3 and 4, a juvenile and a subadult. They preferred areas with considerable vegetation and slow flowing water. In September they occurred in great quantities in the pools separated from the streambed. *S. obliqua* is a moderately good swimmer. The species occurs in the riparian areas around lakes, but also among water plants in small waters. Only females occurred in the summer of 1988 and the spring of 1989. This indicates a parthenogenetic form of reproduction and explains its immense presence in the late summer.

Cypridopsinae

Cypridopsis brincki PETK.

This species was first described from the Azores (PETKOVSKI, 1963). I found it only in the spring of 1989 at sites 3 and 4 in slow flowing sections and among *Nasturtium officinalis*. They were all adult females, whereas the collected *Strandesia obliqua* were juvenile or subadult females. Hardly anything is known concerning their ecology.

Potamocypris pallida ALM.

I found *P. pallida* only in April at site 1. All 6 specimens occurred in a sample taken from stones, located in an area with moderately flowing water. All speci-

mens were, as *C. brincki*, adult females. *P. pallida* prefers cold-stenotherm waters, such as sources or streams. According to LOFFLER (1961 a,b) it prefers waters which are poorly electrolytic. Site 1 shows the lowest conductivity of all sampled sites with 35 µS/cm. Further information on the distribution, ecology and determination is given in a separate publication (MEISCH & STAUDER, in press).

Oligochaeta

R. O. BRINKHURST (1969) investigated the material from Madeira and the Azores collected by the 1957 Lund-expedition. In the Madeiran material he found *Nais communis* and/or *N. variabilis* (the determination is uncertain) as well as *Allonais paraguayensis*. The determination of the material which I collected was carried out by R. SCHMELZ of Freiburg (Germany). Regarding the ecology of these species nothing is known, although they show a cosmopolitan distribution.

Lumbricidae

Eiseniella tetraedra (SAV.)

I found one specimen of this species in the summer of 1988 at site 3 and another in the spring of 1989 at site 2. They occurred in samples taken from stones on a gravelly-muddy bottom.

Lumbriculidae

Lumbriculus variegatus (MÜLL.)

I found 3 specimens under stones on sandy-muddy bottom at site 2 in the spring of 1989.

Naididae

Nais communis P./ N. variabilis P. ?

Which one of these two species was actually present, could not be ascertained. I found specimens at sites 1, 4 and 5 in samples taken from stones on a sandy-muddy bottom.

N. eliguis MÜLL.

Two specimens of this species were discovered at site 4 in the gravel substrate.

Slavina appendiculata (Od).

Two specimens were collected at site 2 in a sandy-gravelly substrate in the spring of 1989.

Hirudinea

Erpobdellidae

Dina lineata (O.F. Müll.)

The only leech known from Madeira is *D. lineata* (Sciacchitano, 1961). Consequently, I have assumed that the specimens which I collected belong to this species. Sciacchitano (1961) examined the material collected by Brinck and Dahl in 1957, who collected several individuals of this species, some of which from Ribeira das Cales. *D. lineata* occurred both in the summer of 1988 and in the spring of 1989 under stones on muddy underground. It inhabits Middle European pools and temporary waters (Illies, 1978).

Mollusca

Ancylidae

Ancylus fluviatilis O.F. Müll.

In the summer of 1988 I found several *A. fluviatilis* at sites 1 through 4 on stones among swift currents. It occurred more frequently at site 4A, the waterfall, together with larvae of Thaumaleidae, Chironomidae and Stactobiae in the hycropetric area. At site 5, I found it frequently on accumulated leaves of eucalyptus. Also, in the spring of 1989, I collected *A. fluviatilis* more often at the sites of lower elevation. It never occurred at the sites which went dry during the summer. In spite of the poor calcareous content of the water they were astonishingly large-sized, up to 0.8 cm. in length. In the warmer waters of southern Europe, *A.fluviatilis* reaches a greater size than in central Europe. It does not seem to be influenced by the low calcareous content of the water (Meier-Brook, pers. com., 1989).

Lymnaeidae

Galba truncatula (Say)

I found this species only once. It was on a rock in the splash-zone at site 5 in August. However, in the lower sections of the Ribeira das Cales, which run

dry in the summer, I found 15 specimens located among the moss on wet rocks. In the northwestern part of Madeira near Porto Moniz, I also found *G. truncatula* on moist rocks adjacent to waterfalls. The species occurs in central Europe in ponds and drains (MEIER-BROOK, pers. com., 1989).

Gyraulus parvus (O.F. MÜLL.)

In the summer of 1988 I found a single *G. parvus* at site 1, and 4 specimens at site 4. At site 5 in the beginning of August, 1988 I collected two specimens, at the end of August 35 specimens and in September 159 individuals. They were located mostly on accumulated leaves of eucalyptus. How and why they developed in such large quantities is yet not explained, however the phenomenon is also known from central Europe (MEIER-BROOK, pers. com. 1989). In the spring of 1989 I found several individuals at sites 4 and 5. *G. parvus* is an element of the North American fauna and was brought to the Mediterranean region about 1940 and since 1970 it occurs in central Europe. Normally the species inhabits small, quiet and artificial waters, not streams as it does in Madeira (MEIER-BROOK, pers. com. 1989).

Pseudamnicola similis DRAP. and *Physa acuta* DRAP. are also known from Madeira. On excursions to the northern parts of Madeira I collected specimens from the families Pupilidae and Hydrobiidae, which are as yet undetermined.

Turbellaria

Turbellaria spp.

The collected planarias couldn't be determined to species level as I was not able to preserve the individuals in the proper manner. BRINCK and DAHL during their excursion in 1957, collected Turbellaria which were determined by E. & E. MARKUS (1959). In this material only one aquatic species occurred. It belongs to the family Planariidae but could not be determined because the individuals lacked copulatory organs. The authors wrote that the specimens showed the typical appearance of the genus *Phagocata*: a rounded head with 2 eyes. This is the case as well in the specimens which I collected and labelled *Turbellaria* sp. In the summer of 1988 I found only a single specimen, which was at site 5. They were more numerous in the spring in 1989, but didn't occur at sites 1, 3 and 5. Unusual is that at sites 3A and 5A, which ran dry in the summer, they were present in especially high numbers. The individuals showed a dark-gray to dirty-white coloration, some were brownish-orange. They all changed to a white colour after several days

in the aquarium.

Apart from that I found *Turbellaria* which resembled *Dugesia gonocephala* in the northern part of Madeira at Ribeira de S. Vicente, about 70 m. before the mouth of the stream.

Amphibia

Reported from Madeira are *Hyla meridionalis* BOETT. (family Hylidae), *Rana perezi* SEOAN. and *R. temporaria* L. (family Ranidae). These species are not native to Madeira, but were introduced (KAMMER, 1982).

Rana perezi

I found tadpoles of this species at site 4 in the summer of 1988 and small frogs in the spring of 1989.

Pisces

In the beginning of this century *Salmo gaidneri* (RICH.) and *Salmo trutta fario* (L.) were introduced in Madeira. The fish are bred and raised in hatcheries in Ribeiro Frio and Chão da Ribeira. They have also been released in several streams, including the Ribeira das Cales. The trout were introduced from America and Europe in the beginning of the 1880's. I observed them at all sites, but never caught them.

Table 1

	Azores	Madeira	Canaries	Distribution
Ephemeroptera				
Baetidae				
Baetis rhodani Pict.		x		Palaearctic
B. pseudorhodani M.-L.*		x	x	Macaronesic
Cloeon dipterum L.	x	x	x	Holarctic
Trichoptera				
Glossomatidae				
Synagapetus punctatus Hag.		x		endemic
Hydropsychidae				
Hydropsyche maderensis Hag.		x	x	Macaronesic
Hydroptilidae				
Hydroptila juba End.		x	x	Iber. Peninsula, Tunisia
H. fortunata Morton	x	x		Macaronesic
H. vectis Curtis	x	x		Europe, N-africa
Oxyethira spinosella McL.		x	x	Macaronesic
Stactobia atra Hag.		x		endemic
S. nybomi Schmid		x		endemic
Limnephilidae				
Limnephilus nybomi Mal.		x		endemic
Mesophylax oblitus Hag.		x		endemic
Polycentropidae				
Polycentropus flavostictus Hag.		x		endemic
Psymyidae				
Tinodes cinerea Hag.		x		endemic
T. grisea Hag.		x		endemic
T. merula McL.		x		endemic
Odonata				
Coenagrionidae				
Ischnura pumilio (Charp.)	x	x		N-Africa, Middle East
I. senegalensis (Ramb.)	x	x	x	N-Africa
Libellulidae				
Sympetrum fonscolombei (Selys)	x	x	x	Medit., Middle East
S.nigrifemur (Selys)	x	x	x	Macaronesic
Aeschnidae				
Anax imperator Leach	x	x	x	Europe, Mid.-East, S-Afr.

	Azores	Madeira	Canaries	Distribution
Diptera				
Chironomidae				
Chironominae				
Chironomini				
Chironomus-thummi-Gruppe				
Chironomuus dorsalis (Meig.)	x	x	x	Europe,Iceland,N-America
Polypedilum convictum (Walk.)		x		Europe
*Tanytarsini**				
Micropsectra junci (Meig.)	x	x		England, Belgium
M. freyi StorÁ	x	x		
Rheotanytarsus sp.				
Diamesinae				
Diamesa alata StorÁ	x	x		Macaronesic
D. sp.				
Boreoheptagyia legeri (Goethg.)		x		French Alps
Orthocladiinae				
Metriocnemus fuscipes (Meig.)	x	x		Europe
M. ochraceus (Wulp)		x		Netherlands
Parametriocnemus stylatus Kieff.	x	x		Engl., Germany
Paraphenometrioc. impensus Walk.		x		Europe, N-Africa
Cricotopus bicinctus (Meig.)	x	x		Europe
Cardiocladius freyi StorÁ	x	x	x	Macaronesic
Orthocladius devonicus (Edw.)		x	x	Engl., Belgium
Chaetocladius melaleucus Meig.	x	x		Engl., B., G, Iceland
Synorthocladius semivirens (Kieff.)		x		Europe
Limnophyes mininus (Meig.)	x	x	x	Europe, N-Africa
L. prolongatus (Kieff.)		x		endemic
Thienemanniella clavicornis(Kieff.)		x		Germany, Engl.
Smittia stercoraria Deeg.	x	x	x	Europe, Iceland
S. aterrima (Meig.)	x	x	x	Europe, Iceland
Tanypodinae				
*Macropelopini**				
Pentaneurini				
Zavrelimyia nubila (Meig.)	x	x		Europe
Culicidae				
Aedes eatoni Edw.		x	x	Macaronesic
Culiseta longiareolata (Maq.)		x	?	Ethiopic
Culex hortensis maderensis Matt.		x		endemic
C. molestus Forsk.	?	x	?	Palaearctic
C. pipiens L.	?	x	?	Palaearctic
C. theileri Theob.	x	x	?	Ethiopic, Med., East
Dixidae				
Dixa nov.sp.				
Empedidae				
Clinocera haemorrhoidalis (Beck.)		x		endemic

	Azores	Madeira	Canaries	Distribution
C. rabacali Frey		x		endemic
Roederioides longirostris Frey		x		endemic
Chelifera sp.*				
Limoniidae				
Cheilotrichia nemorensis (San.)*		x	x	Macaronesic
Dicranomyia maderensis Woll.		x		endemic
Dicranomyia michaeli Theow.		x	x	Macaronesic
Dicranomyia vicina Macq.	x	x	x	Macaronesic
Geranomyia atlantica Woll.	x	x	x	Macaronesic
G. bivittata Beck.		x		endemic
G. canariensis Bergr.		x	x	Macaronesic
G. unicolor Hal.	x	x	x	Atlantic
Phylidoria contraria (Woll.)		x		endemic
Trimicra pilipes (Fabr.)	x	x	x	cosmopolitan
Molophilus appendicatus Staegi		x	x	Europe
Nephrotoma antithrix Mhs.		x		endemic
N. brevipennis Woll.		x		endemic
Muscidae				
Limnophora sp.*				
Simuliidae				
Simulium petricolum (Rivos.)		x		SW-Palaearctic
Simulium intermedium Roub.		x	x	W- Palaearctic
Thaumaleidae				
Thaumalea brincki Vaill.		x		endemic
Tipuliidae				
Tipula atlantica Mannh.		x		endemic
Tipula lundbladi Mannh.		x		endemic
T. paludosa Mg.		x	x	Europe
T. rufina madarensis Lackschw.		x		endemic
Coleoptera				
Dryopidae				
Dryops luridus Erick.	x	x	x	Europe
Dytiscidae				
Coelambus confluens (F.)	x	x	x	Europe
Hydrotarsus lundbladi Falk.		x		endemic
H. obsoletus Aubé		x		endemic
Potamonectes dubius (Aubé)		x		endemic
Agabus maderensis Woll.		x		endemic
A. wollastoni Sharp.		x		endemic
A. dissimilis Falk.		x		endemic
A. nebulosus Forst.		x	x	Europe
Meladema lanio (F.)		x		endemic
Eretes sticticus (L.)		x	x	Europe

	Azores	Madeira	Canaries	Distribution
Hydrophilidae				
Ochthebius quadrifoveolatus Woll.		x	x	Mediterranean
O. quadricollis heeri Woll.		x		endemic
O. rugulosus Woll.		x	x	Macaronesic
O. subpictus Woll.		x		endemic
O. algicola Woll.		x		endemic
Limnebius grandicollis Woll.		x		endemic
Dactylosternum insulare Lap.		x	x	Europe
Anacaena marchantiae Woll.		x		endemic
A. conglobata Woll.		x		endemic
Laccobius atricolor Orch.		x		
Enochrus politus Küst.		x	x	endemic
				Europe
Hydracarina				
Arrenuridae				
Arrenurus autochthonus Ldbl.		x		endemic
Aturidae				
Aturus atlantis Kram.		x	x	Macaronesic
Hydrophantidae				
Thyas incerta Ldbl.		x		endemic
Thyopsis maderensis Ldbl.		x		endemic
Trichothyas rutae (Ldbl.)		x	x	Macaronesic
Hygrobatidae				
Atractides macaronensis (Ldbl.)		x		endemic
A. rutae (Ldbl.)		x		endemic
A. maderensis (Ldbl.)		x		endemic
A. insulanus (Ldbl.)		x		endemic
Maderomegapus hystricipes Ldbl.		x		endemic
Lebertiidae				
Lebertia madericola Ldbl.		x		endemic
L. maderigena Ldbl.		x		endemic
Limnesiidae				
Limnesia atlantica Ldbl.		x		endemic
Sperchonidae				
Sperchon brevirostris Koen.	x	x		Palaearctic
Torrenticolidae				
Torrenticola mandibularis (Ldbl.)		x		endemic
T. insulicola (Ldbl.)		x		endemic
T. rotundos (Ldbl.)		x		endemic
T. nesiotis (Ldbl.)		x		endemic
T. crassirostris (Ldbl.)		x		endemic
T. elliptiformis (Ldbl.)		x		endemic
T. crassus (Ldbl.		x		endemic
T. maderensis (Ldbl.)		x		endemic
T. pharyngealis (Ldbl.)		x		endemic

	Azores	Madeira	Canaries	Distribution
T. affinis (Ldbl.)		x		endemic
Unionicolidae				endemic
Neumania atlantida Ldbl.		x	x	Macaronesic
Isopoda				
Assellidae				
P. coxalis perarmatus (Remy)		x	?	endemic
Janiridae				
Jaera nordica insulae Veuille*	x	x	?	Macaronesic
Copepoda				
Eucyclops serrulatus (Fisch.)*	x	x	?	Holarctic
Ostracoda				
Cyprididae				
Cypricercinae				
Strandesia obliqua Sars*	x	x	?	Europe, Asia, N-Africa
Cypridopsinae				
Cypridopsis brincki Petk.*	x	x	?	Spain, Port., Mazedonia
Potamocypris pallida Alm.*		x	?	Europe
Oligochaeta				
Lumbricidae				
Eiseniella tetraedra (Sav.)	x	x	x	cosmopolitan
Lumbriculidae				
Lumbriculus variegatus (Müll.)*	x	x	?	cosmopolitan
Naididae				
Nais communis P./*N. variabilis* P.?	x	x	?	cosmopolitan
N. elinguis Müll.*	x	x	?	cosmopolitan
Slavina appendiculata (Od.)*		x	?	Europe
Hirudinea				
Erpobdellidae				
Dina lineata (O.F.Müll.)	x	x	?	Europe, Middle-E, N-Afr.
Mollusca				
Ancylidae				
Ancylus fluviatilis O.F.Müll.	x	x	x	Europe, Mediterranean
Hydrobiidae				
Pseudamnicola similis Drap. sp.?*		?		
Lymnaeidae				
Galba truncatula (Say)	x	x	x	Europe, Mediterranean

	Azores	Madeira	Canaries	Distribution
Planorbidae				
Gyraulus parvus (O.F.Müll.)*	?	x	?	Europe, N-America
Physidae				
Physa acuta Drap.	?	x	?	Europe
Turbellaria				
spec				
Amphibia				
Hylidae				
Hyla meridionalis Boett.		x	x	Europe, N-Africa
Ranidae				
Rana perezi Seoan.	x	x	x	Mediterranean
R. temporaria L.		x		Europe
Pisces				
Salmonidae				
Salmo gaidneri (Rich.)	?	x	?	cosmopolitan
S. trutta fario (L.)	?	x	?	cosmopolitan

Macaronesic: found on the Azores, Madeira and/or the Canaries
*: species new to Madeira
?: Occurrence doubtful or insufficiently investigated for Madeira

ZOOGEOGRAPHIC ASPECTS OF THE LIMNIC FAUNA

Table 1 lists all fresh water species for Madeira which have so far been recorded, together with their distribution. Species, which occur in the Canary Islands or Azores, but not in Madeira, are not listed. However investigations of some groups, e.g. Oligochaeta, Cyclopidae, Culicidae are totally lacking in the Canaries and the Azores. Groups for which there is no information have received a question mark in the table. Information on the distribution of the species was taken from ASKEW (1988), CAPELA (1979), CROSSKEY (1987b), FREY (1948), ILLIES (1978), LUNDBLAD (1942,1958), SVENSSON (1977), as well as written communications from MALICKY, MEIER-BROOK, MEISCH and OOSTERBROEK (1989). Information on the Chironomidae is certainly old, but more recent literature does not exist. Apart from this it is not known if all Limoniidae and Tipulidae which are listed have aquatic stages. The Macaronesian islands, like other oceanic islands, are relatively poor in species numbers. The Ephemeroptera are only represented by 3 species within one family: *Baetis pseudorhodani*, which is restricted to Macaronesia, another, *B. rhodani*, which is palaearctic, and *Cloeon dipterum* which is holarctic. Trichoptera are represented by 6 families, and many of their continental families are missing. The high percentage of endemic species is striking. 9 of 14 species are endemic to Madeira, 3 to Macaronesia and 2 are widely distributed. Among the Odonata 3 families are represented by 5 species. Only one of these species is limited to the Macaronesian islands. This is not astonishing since dragonflies have a wide radius of distribution. Some aquatic Dipterous families, such as Syrphidae and Dolichopodidae, do not appear in the list, although they were collected because they exist only as adults.

The Chironomidae will not be further considered. A revision of these groups is urgently needed. They are only mentioned for the sake of completeness. It is remarkable that of the 6 species of Culicidae, two are Ethiopian elements. All Empedidae species are endemic. Of the 13 Limoniidae, 5 are endemic, 5 Macaronesian, 2 European and one is cosmopolitan. Of the 2 Simuliidae one has a West Palaearctic distribution, the other a southwestern one. Only imagines were found of a third species, *Simulium ruficorne*, which is distributed over Africa and the Middle East. The only Thaumaleidae is endemic to Madeira. The one new species of Dixidae is also endemic, its description is forthcoming. 3 of the 4 Tipuliidae are endemic to Madeira. The Coleoptera, one of the best investigated groups on Madeira, shows a surprisingly high percentage of endemism, 3 families with altogether 22 species are represented of which 14 are endemic, 1 Macaronesian and 7 distributed in Europe. Also here several aquatic families are missing, such as the Gyrinidae. The Hydracarina are represented on Madeira by 25 species, of which 21 are endemic, 3 Macaronesian and one, *Sperchon brevirostris*, is Pa-

laearctic in distribution. Several Hydracarina genera, which are found on the continent, do not exist in Madeira. The 2 Isopods are subspecies of European species. All occurring species of Copepoda, Ostracoda, Oligochaeta, Hirudinea and Mollusca show European or even cosmopolitan distribution patterns. Not all genera of families of these groups are represented on Madeira and the number of their species is low. According to the present state of knowledge neither Amphipoda nor Plecoptera occur. In addition, some families of Diptera, e.g., Ceratopogonidae, Blephariceridae and Athericidae are not represented.

Considering the entire fresh water fauna of Madeira as it is known, 60 species are endemic, 18 Macaronesian and 60 have a wider distribution. Those species which are neither endemic nor Macaronesian, largely show a European or Mediterranean distribution. Some families, such as the Culicidae, represent Ethiopian elements. They are species distributed from the Middle East to Asia. Some of the Oligochaeta exhibit a cosmopolitan distribution.

COMPARISON OF THE AZORES, MADEIRA AND THE CANARIES ON SELECTED TAXA

The Azores are situated approximately 1000 km. northwest of Madeira and 1500 km. of the Iberian Peninsula. The Canaries lie 400 km. to the south of Madeira. Fuerteventura and Lanzarote are 200 km. from the African coast and Las Palmas 500 km. Madeira is situated 920 km. southwest of Lisbon and 620 km. east of the African continent.

In table 2 the number of species is given for each of the best investigated groups on the 3 islands.

	Azores	Madeira	Canaries
Ephemeroptera	1	3	5
Trichoptera	3	14	14
Odonata	5	5	10
Limoniidae	9	13	23
Tipulidae	1	4	6
Hydracarina	2	25	15

Tab.2 - Numbers of species of selected taxa from the Azores, Madeira and Canaries.

Considering the humid climate and the amplitude of water in the Azores, one would expect an abundant freshwater fauna. Since some of the Canary islands are rather dry, one would expect a poor macrozoobenthic fauna. In both cases

the opposite is true. Table 2 shows that the Azores have fewer species while the drier Canaries are richer in numbers of species. Madeira assumes an intermediate position, except for the Trichoptera and Hydracarina fauna. Due to their great distance from the continent, the Azores are more difficult to colonize, at least as regards freshwater organisms.

The different climatic conditions on Madeira, the north from the south, may play an important role in the distributional pattern of the freshwater species. It is possible that in the humid northern part of the island more elements of the fauna of the Azores would be found, while in the southern part of the island, where rainfall is low, more elements of the Canarian fauna should occur. To verify this assumption further investigations are necessary, which would consider the entire fauna and flora.

DISCUSSION

Since Madeira lies at a great distance from the mainland one must examine the possible means of colonization to explain the composition of the Madeiran fauna. It is important to distinguish between early modes of invasion and settlement in former geological periods and recent forms of introduction by humans. Madeira emerged from the sea floor during the early Tertiary. Since then Madeira has been available for colonization. The geographical situation of the islands was probably not the same as it is today. During the Tertiary geological processes took place which affected many parts of the world including the Mediterranean region. It can be assumed that the distances between the 3 islands were smaller and that the distance to the continents was shorter. Mountains which are nowadays below sea level could have been used as stepping stones (KAMMER, 1982).

Table 3 shows the percentage of endemic, Macaronesian and more widely distributed species of selected groups. It can be seen that the number of indigenous species of Coleoptera and Hydracarina is noticeably high, although these are animals which are not necessarily restricted to a narrow distribution range. This indicates an early invasion, which probably occurred under geological and climatic conditions which were more favorable than they are at present. Due to a long isolation period and the resulting lack of genetic exchange, the endemic species developed. The ecological niche which these species nowadays possess represents a competitive advantage over newly arriving species, affording them little opportunity to settle. Other largely endemic species belong to the Trichoptera, Empedidae, Thaumaleidae, Limoniidae and Tipulidae. These insects are conservative in as much as their home-range is small. They may, however, by chance be drifted by winds. The probability of mainland representatives reaching once again the island is very low, hence genetic exchange with the continental

population has been basically stopped. This situation leads to endemism. Most adult Odonata and Simuliidae are able to cover broad distances and genetic exchange between the island and mainland individuals is very probable. The Madeiran species of these groups manifest a wide distribution pattern. For example, those of the Simuliidae are spread throughout the west Palaearctic. The northeast trade-wind repeatedly enables these "active" insects to reach Madeira. The dragonfly species of Madeira show a North African distribution. Since dragonflies are able to fly actively for a long time and cover long distances, the 650 km. between the continent and the island do not represent a great hindrance. Furthermore, the dry winds coming from the Sahara, the so-called "leste" can support the flight.

	Total number of species	Endemic species		Macaronesian species		Widely distributed species	
		#	%	#	%	#	%
Ephemeroptera	3	-	-	1	33.3	2	66.6
Trichoptera	14	9	64.3	3	21.4	2	14.3
Odonata	5	-	-	1	20	4	80
Culicidae	6	1	16.6	1	16.6	4	66.6
Empedidae	3	3	100	-	-	-	23
Limoniidae	13	5	38.5	5	38.5	3	100
Simuliidae	2	-	-	-	-	2	25
Thaumaleidae	1	1	100	-	-	-	31.8
Tipulidae	4	3	75	-	-	1	4
Coleoptera	22	14	63.6	1	4.6	7	100
Hydacarina	25	21	84	3	12	1	100
Isopoda	2	-	50	1	50	-	100
Copopoda	1	-	-	-	-	1	100
Ostracoda	3	-	-	-	-	3	100
Oligocheta	5	-	-	-	-	5	100
Hirundinae	1	-	-	-	-	1	100
Mollusca	3	-		-	-	3	100

Tab.3 - Distribution patterns of different groups in absolute quantities and percentages.

The Ephemeroptera, represented in Madeira by one family and 3 species, show a perplexing distribution pattern since none of them are endemic. One is Macaronesian and the other 2 are widely distributed species. The Ephemeroptera, like the Trichoptera, are very conservative insects, so that one would expect a high percentage of indigenous species. Thus recent introduction by humans

cannot be excluded. We may draw from the example of *Cloeon dipterum*, which is Palaearctic and among the best investigated Ephemeroptera on the Azores. Early researchers in the 19th century did not record it from the Azores. However, BRINCK & SCHERER (1957), who investigated Madeira and the Azores in this century, very often found *C. dipterum*. They wrote: "There will of course be no opportunity for us to fix the arrival of the species to the islands. But it is of some interest that two skilled investigators of Azorean aquatic habitats in the 19th century (de GUERNE and BARROIS) do not mention Ephemeroptera among their material. BARROIS (1896) examined most of the water bodies of Santa Maria, São Miguel and Faial [Azores] and should have met with *C. dipterum* if it were as common as today, even though he specialised in Crustacea and lower invertebrates." This strongly indicates a recent colonization of *C. dipterum*. Since it lives in small pools and streams with ample water vegetation, it could have been introduced together with the waterplants which were introduced from England, Germany and Poland in the 19th century. Furthermore, numerous eggs of various freshwater fish were also introduced this century, so that there were several opportunities for nymphs to be brought to the islands. On Madeira and the Azores BRINCK & SCHERER (1957) found *C. dipterum* only in habitats which were created by or heavily influenced by human action. *C. dipterum* never occurred in the uninfluenced habitats of the northern parts of Madeira, but in artificial ponds and near the capital Funchal.

Several other groups could likewise have been introduced by humans. Other than the water plants, which were introduced in the 19th century, two species of North American and European trout were intentionally released in the streams: *Salmo gaidneri* (RICH) and *Salmo trutta fario* (L.). The mollusc, *Gyraulus parvus,* most certainly can be considered as recently introduced, since it is now reported for the first time on Madeira. This species was brought from North America to the Mediterranean region around 1940 and about 1970 it appeared in Middle Europe.

None of the following groups on Madeira developed endemic species: Copepoda, Ostracoda, Oligochaeta, Hirudinea and Mollusca. This is perhaps because they have good possibilities for dispersal through passive transport and therefore maintain genetic exchange with continental groups. However, it is also possible that at least some members of these groups were recently introduced by people.

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