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Formation of the turbellarian fauna in a submontane stream in Italy

[With 28 text-figs.]

Kształtowanie się fauny wirków w podgórskim strumieniu we Włoszech

Abstract. Turbellarian fauna of a small submontane stream, Monti d'Oltreserchio, Apennine Peninsula, has been studied through 1973 and 1974 from taxonomical and ecological points of view. Amongst 61 identified turbellarian species 12 turned out new. The stream fauna is rich in comparison with other water bodies. A dominating taxonomical group are the *Catenulida* with the genus *Stenostomum* as the most important unit. A considerable habitat differentiation is thought to be the main factor responsible for the faunal richness of *Turbellaria*. From the genetical point of view the investigated fauna of *Turbellaria* is heterogeneous: terrestrial and marine-originated forms have a remarkable share in comparison with the dominating rest of genuine freshwater species. Some large European turbellarian genera: *Gieysztoria*, *Mesostoma*, *Phaenocora*, *Castrada*, *Olisthanella* are poorly represented in the studied watercourse. General features of the species distribution in the stream biozones and principal habitats have been analyzed and discussed within the ecological succession theory. A considerable role of upper clean stream sections in preserving more stenotopic and old forms has been revealed.

CONTENTS

Introduction	298
Abbreviations in the figures	299
Description of the stream Fosso Contesora	299
Material and methods	304
Taxonomical and ecological characteristics of species	307
Systematical list of species	307
Comments on particular species	309
Biological observations	327
Biocoenological characteristics of the stream <i>Turbellaria</i>	328
Distribution of species within different habitats	329
Ecological ordination of species — synecological species groups	336
Syngenetical groups of species	340
Downstream succession of turbellarian communities	343
Conclusions	346
Acknowledgments	347
References	347

INTRODUCTION

While ecology and systematics of marine *Microturbellaria* are intensively studied, the freshwater ones have been seriously neglected in recent times. Several papers which have been sporadically appearing in the two last decades cannot close the gap and retardation in this field.

The most extensive investigations dealing with *Microturbellaria* have been carried out in Germany (BAUCHHENS 1971; KAISER 1967, 1969, 1974; RIXEN 1961, 1965, 1968), in England (YOUNG 1970, 1973 and other articles), in Roumania (MACK-FIRĂ 1970 and other articles) and in Poland (KOLASA 1973, 1974, 1977c and others). *Turbellaria* of the north and central Italy were investigated by several authors but we are still far from a satisfactory faunistic picture of this region probably because it is extremely heterogeneous as regards environmental and historical situations. Data on the Italian *Microturbellaria* are reviewed by PAPI (1952). Newer records may be found in PAPI (1959a), PAPI and TAVANI (1959), LUTHER (1960, 1963) and KOLASA (1976).

Small running waters in Europe have been subject of many limnological, faunistic and ecological papers (see, for instance HYNES 1972). This type of water courses may be considered, however, as neglected in comparison with standing waters or rivers. Among the most important studies on the small running waters the following can be cited: ANGELIER (1953), BEYER (1932), CUMMINS et al. (1966), EGGLESHAW (1969), GIEYSZTOR (1958), HYNES (1961), ILLIES (1961), PENNAK (1971), PERCIVAL and WHITEHEAD (1929), THORUP (1966), SOWA (1965), ULFSTRAND et al. (1971).

A considerable group of papers (HUSMANN 1956, 1967, 1970; MOTAS 1962; ORGHIDAN 1959; PICARD 1962; RIEMAN 1965; SCHWOERBEL 1967; TILZER 1968, and others) were concerned with the hyporheic interstitial fauna, thus following the precursory study by CHAPPUIS (1946).

Knowledge of turbellarians inhabiting running waters is very fragmentary. Except triclads turbellarians of those waters have been devoted few papers limited to selected habitats only: AN DER LAN (1967), KAISER (1969), KOLASA (1974). Certain amount of data are available in papers by LUTHER (1955, 1960, 1963), MACK-FIRĂ (1968a, 1970), RIXEN (1961) and in papers by some older authors. So far we have no complete study on turbellarian fauna of a whole watercourse.

Hence, an investigation aimed at comprehensive characterization of turbellarians inhabiting a variety of habitats in a watercourse seems fully justified. In order to be useful in determination of migrations and succession directions of fauna in the running waters such a study should consist of ecological and genetical analyses. Moreover, any study of freshwater turbellarians in the field has to deal at large with taxonomical problems which arise quite frequently. In the present study a particular attention is also paid to ecological characteristics of species for it is believed that ecological nature of a species may prove to be an important source of indirect information which can be transformed suitably into more general ecological and historical conclusions.

Abbreviations in the figures

- a* — atrium
- b* — brain
- bc* — bursa copulatrix
- cg* — cement glands
- cpde* — cuticular parts of ductus ejaculatorius
- e* — eye
- g* — gland (-s)
- go* — genital organs
- gp* — gonopore
- gpb* — gonopore bulb
- gr* — granulations
- i* — intestine
- lrm* — light refracting masses
- n* — protonephridium
- o* — ovary
- ph* — pharynx
- rh* — rhabdoids
- s* — stylet
- sh* — sensory hair
- sph* — sphincter
- t* — testicle
- vd* — vas deferens
- vs* — vesicula seminalis
- vst* — Verschlussapparat

DESCRIPTION OF THE STREAM FOSSO CONTESORA

The stream Fosso Contesora which was chosen for pursuing of taxonomical and ecological research flows down on the slopes of Monti d'Oltreserchio (province of Lucca, Italy). The Monti d'Oltreserchio emerged from the sea not later than in the Pliocene, i. e. 5—4 million years ago. The sea water level was then 30 m higher than now and the mountains constituted a part of the sea shores. The stream Fosso Contesora was chosen because it is one of the biggest streams in the area. It is also accessible at all attitudes. The maximum altitude its confluences start at is about 400 m above sea level. From the beginning it heads east and then turns slowly south to become, after a total of some 10 km, a tributary of Serchio River. The stream runs on rocks of differentiated origin. The section I (Fig. 1) flows on Oligocene sandstones. The spring and the section II drain waters of upper Cretaceous argillaceous slates. The sections III A and partly II flow on lithographic limestone. The section III B separates lower Cretaceous limestones to north and Oligocene sandstones of various composition to south of the stream valley. In the section IV recent or today's alluvial sediments are present. The above information has been obtained from the Carta Geologica d'Italia 1 : 25 000, Pisa, F° 104 and from kind explanations made by Dr. F. BONADONNA (Institute of Geology, University of Pisa).

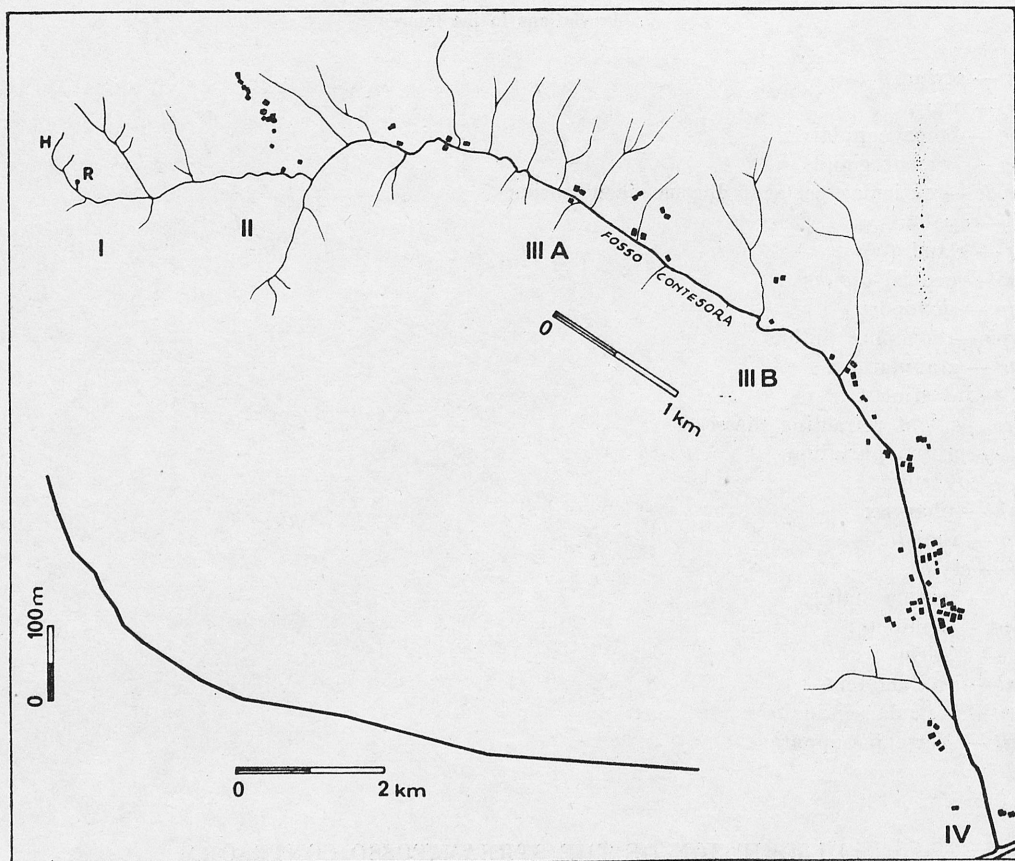


Fig. 1. Map of the stream Fosso Contesora. Indicated: sampling sections (I—IV), helocene (H) and reocene (R) springs

Morphology

Like many other streams the Fosso Contesora descends rather steeply (Fig. 1) in its upper 2 kilometers by a series of rocky chutes and waterfalls alternating with gravely riffles and deeper pools. After that the bottom changes in favour of gravel or rounded stones with some boulders at intermediate stations. Deposits of silt and sand are scanty and rare. The width of the stream (from less than 1 m up to 4 m) depends on season and activity of small tributaries some of which are temporary. From June to September the section IV becomes dry. The section III B may dry up a few times during summer reflecting the intensity of rainfall. Mean turbidity was estimated as follows: the section I and II — exceptionally clear, III A and III B clear or slightly turbid. Other information concerned with characteristics of the stream will be given along with the description of biotopes at particular stations.

Physical and chemical conditions

a. Temperature: measurements were made at monthly intervals throughout a year except in April. Often a few of them were used to calculate an average value as isolated temperature records appear of little reliability in streams (MACAN 1958a). In the Fig. 2 one can observe a characteristic and biologically important divergency of amplitudes in particular sections during various seasons. The temperature of spring reaches its maximum in winter. It might be explained by a delayed descent of cold winter water through rocks. The

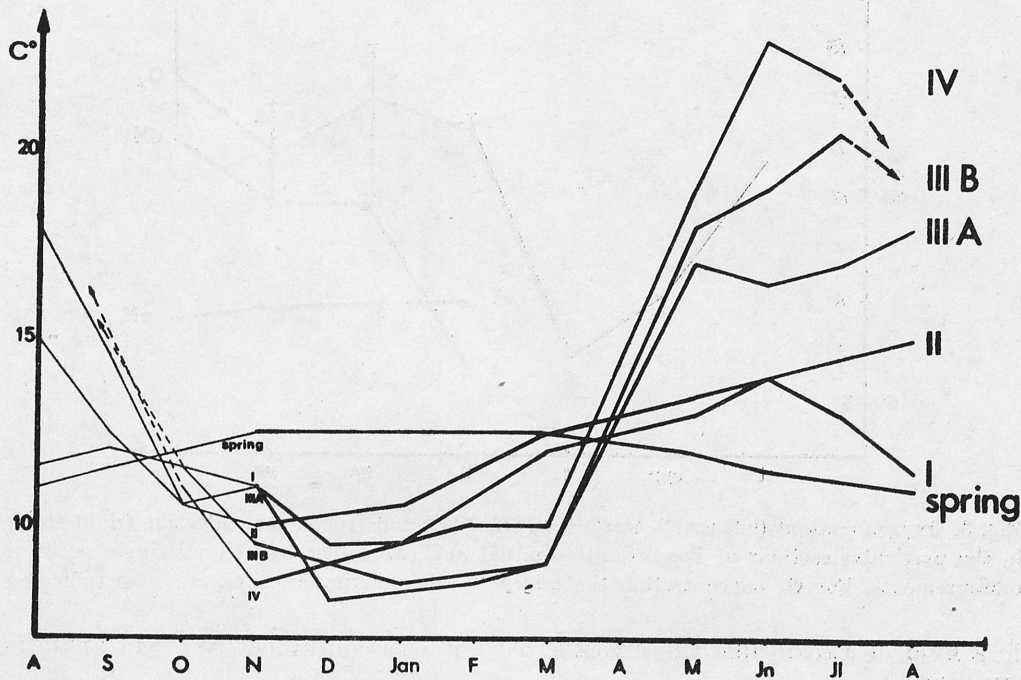


Fig. 2. Mean temperature values (°C) recorded monthly in the sampled sections

abrupt decrease of temperature could be caused by shade due to dense vegetation over the riffle and to a lower position of the sun. The maximum record of 27°C occurred in the section IV and the minimum was only 8°C (the former has been reduced by other records at the same site to an average of 23°C which is represented in the figure). Temperature in the sections I, II and the spring are relatively stable.

b. pH values varied from 6.5—7.5 degrees depending on the sort of bottom sampled. Samples from pools with considerable amount of sedimented organic matter were revealed as more acid. The others were normally around 7. Perhaps the indicators used were not sensitive enough to detect more subtle differences. A single series of exact measurements revealed a slight decline of values from 8.1 in upper sections to 7.8 in downstream ones (Fig. 3).

c. Oxygen availability: measurements revealed oversaturation in the sections II—IV. Lower oxygen concentration occurred in the spring (83%), permanent part of section I (70%) and interstitial water in the section II (43%). A single sample in the temporary part of the section I showed good oxygen level (109% of saturation). Low oxygen level ascertained in interstitia water of the section II was probably due to abundant deposits of fine organic silt mixed with sand grains. Generally speaking, good oxygenation expected

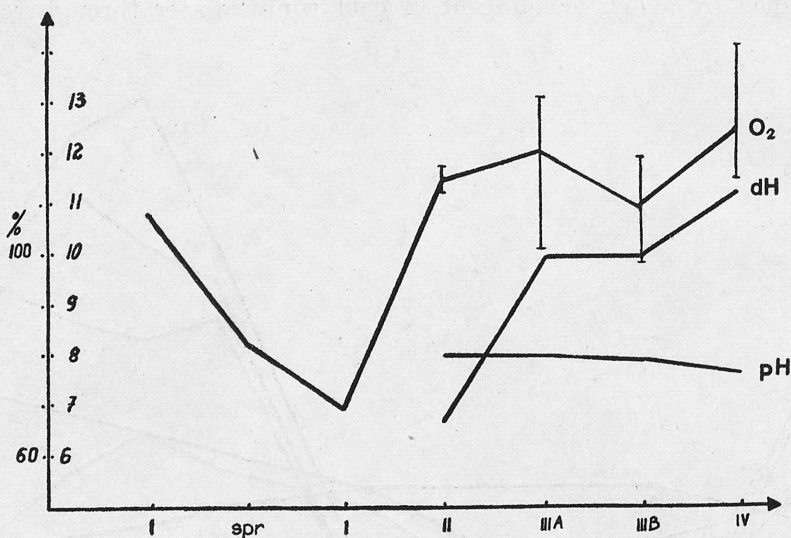


Fig. 3. Oxygen content (left scale), water hardness (dH) and H^+ ion concentration (right scale) in the particular sections of Fosso Contesora. dH and pH values based on a single series of measurements. For O_2 concentration the minimum and maximum values are also indicated

in a kind of stream like the investigated one was confirmed by direct analysis (Fig. 3).

d. Water hardness measured in German degrees increased along the water-course from average 6.8 in the section II to 11.3 in the section IV (Fig. 3).

Description of biotopes sampled

The stream had operationally beendivided in to four sections adequate to observed morphological and expected biological differentiation of its course. In all the segments various habitats were individualized for sampling as it is listed below.

Section I. The stream is wide about 0.5 m. It is situated in woodland with prevailing chestnut tree in the valley bottom and pines on slopes. Higher up a mediterranean macchia is developed. Beginning with the reocrene spring the water course is uninterrupted downstream (Fig. 1).

1. Highest segment of the stream bed. Temporary flow of water (limited to the winter time). Sandy bottom with decaying leaves on it.

2. Helocrene spring 50 m downstream. Mosses on always wet banks. First permanent water flow.

3. Same site; sandy bottom with detritus.

4. Next temporary section (probably because of deep sand layers and slight inclination of the bottom the water flows underground). Deposits of sand.

5. Rock step 2 m high, covered with mosses which are soaked with permanently trickling water. During months with abundant rainfalls it becomes a waterfall. Mosses.

6. Small reocrene spring situated 1 m aside of the main stream bed, constant water flow of approximately 1/2 l per sec. Mosses.

7. Very angular gravel in the spring riffle.

8. Gravel in the main bed at the level of the spring.

9. Same site, interstitial waters in gravel and small stones about 20 cm off the water edge.

10. Temporarily appearing green algae in the spring.

Section II. Permanent and almost stable water flow. The stream width approximately 1 m. Woodland with chestnut and fir trees; rich brushwood.

11. Mosses moistened by cascades, on rocky banks of the stream.

12. Gravelly and stony bottom in moderate current; grains angular.

13. Sandy bottom. Very fine sands with admixture of organic sediments the amount of which variable; depending on the seasonal rate of litter decomposition and current velocity.

14. Organic sediments. These were considerably heterogeneous; they included rough detritus and silt in most cases.

15. Interstitial waters in sand or, when it was possible, also in fine angular gravel up to 3 mm in diameter. 10—30 cm from the water edge.

16. Dense mosses on the rocks in the strong current.

Section III A. Permanent water flow with distinct seasonal variations; the stream is 0.5—1.5 m wide. Woodland composed of olive and cedar trees chiefly. The stream flows under dense shade producing bushes.

17. Sandy bottom. Medium to coarse sands with angular grains.

18. Gravelly and stony bottom. Small stones (up to 5 cm along longer diameter) mixed with gravel. Both the substratum components subangular or subrounded.

19. Organic sediments; same nature as in the section II. Often not accumulated.

20. Deposits of litter in the immediate vicinity of water edge.

21. Mosses on boulders in strong current.

22. Interstitial waters 20—40 cm from the water edge in gravel or very coarse sand.

23. Interstitial waters more than 60 cm away from the water edge in medium or fine sand.

Section III B. Temporary flow and great variability of conditions. The width of the stream varies from 0.5 to 2 m. This section runs mostly through a grassland with bushes growing on its banks. A few farms release their sewage into the stream. Except the valley — woodland as described for the preceding section.

24. Stony bottom; subrounded and rounded small and medium stones.

25. Interstitial waters sampled in sand or stones embedded in gravel depending on state of alluvial deposits.

26. Organic sediments; normally detritus composed of twigs, leaves and other plant originating particles. High waters wash the sediments away.

27. Mosses and algae in moderate current on stones; developed well in winter and spring only.

28. Mosses near the mouth of a small tributary; water is much cooler and cleaner here.

Section IV. Temporary section up to 4 m wide during culminating waters. The stream flows in the large Serchio River valley.

29. Stony bottom in moderate or swift stream. Stones rounded and well rounded; sometimes partly overgrown by algae.

30. Sandy bottom; fine or medium grains.

31. Algae and organic detritus.

32. Interstitial waters in large and deep sand deposits.

33. Interstitial waters in gravel and small stones; grains at least subrounded.

34. Bottom (sandy with detritus or other organic sediments) in marginal pools in the sections III A and IV. The water of these eyelets was normally exchanging with that of the stream.

MATERIAL AND METHODS

Material consisted of 7646 specimens of *Turbellaria* found in 220 samples. The specimens belong to 38 genera and 61 species of which 5 have been identified to the generic or family level only.

Sampling. Three kinds of samples were taken during a period of 18 months of partly interrupted field work. Two of them were quantitative and one qualitative. The quantitative sampler of bottom, which was used, belongs to MACAN's (1958b) category of "boxes and cylinders". It was a square tin box covering a surface of 400 cm². When the box was pushed against the bottom all the material (sand, silt, detritus, gravel, stones) was dug out with a shovel approximately down to 3 cm and put into a bucket. The use of the box was possible because most of stony areas of the investigated bottom were covered

by small stones and thereby not imposing insuperable difficulties in operating the box; the larger stones lied on softer substrata. Animals swimming in the box were swept out with a plankton net and the water from the box was used for further washing of the substratum in the bucket. After that, the box content was washed by repeated violent stirring and sieved through two nets in the field; the first one being the brass wire net with meshes 1.2×1.2 mm. It was set onto a frame of the second dense mill gauze net. The brass sieve served to separate larger animals which could have damaged fragile species of *Turbellaria*. This sort of animals was preserved in 40% etanol. The second net was provided also with a plexiglass container of 125 cc volume.

Another quantitative sampling was applied for interstitial fauna. In the main it follows the processing developed by CHAPPUIS (1946) and applied by many investigators (SCHWOERBEL 1967). Water removed from a hole dug out in the stream bank in proximity of water edge (0.1—1 m) is poured through the same net system as described above. The only difference between surface and interstitial sampling concerns the quantitative unit which is one litre of filtered water in the latter. Water was taken from the excavations by means of a scoop in order to pick up animals creeping on the bottom.

Finally, the third kind of samples was constituted of various portions of such habitats as mosses, decaying leaves on banks, acumulations of detritus or algae. From these samples solely *Turbellaria* were extracted; their volumes were 50, 100, 250 cc. These samples were not washed.

Laboratory treatment of samples. Each sample was sieved again in the lab through another brass net having meshes 0.7×0.7 mm within an hour as it was transported to the laboratory. The remainder of a washed quantitative sample was filled up with tap water in 600 cc jar and let to stagnate one to three days depending on the oxygen depletion which is produced by organic matter mineralization processes. During this period each sample was checked twice or more a day for *Turbellaria* which were pipetted out for microscope examination. Often, samples taken from clean mineral substrata did not reveal any worms or only few of them during that time. Those samples and also all the others in which results were uncertain were subject to additional procedures. A sample was heated on the hot plate until the first animals were observed to swim in the water. Then the plate was swiched off till their escapement ceased. The operation was repeated twice or more and the removing of animals took place at intervals. It is important to avoid overheating of lower layers of sediment because hot gas bubbles would disturb clarity of the water and rise lethally the water temperature. The results of that heating are shown in Table I.

In many cases as many as 100% of animals were obtained only after the sample heating. For example, a sample of 100 cc of gravel yielded all of its 86 turbellarians in such a way in spite of three day's stagnation which gave no results. Also, this method proves a very efficient and the only satisfactory way of extraction of interstitial freshwater *Turbellaria*. Many of other taxa

of meiofauna were escaping from the upper layer of substratum during the heating. The noted ones were *Aelosomatide*, *Hydracarina*, small *Oligochaeta*, *Ostracoda*, *Copepoda*, *Protozoa*, minute larvae of *Insecta*, *Nematoda*.

Methods applied in the taxonomical study. Normally turbellarians were checked in a binocular microscope and selected for either squash mounts in a microscope of higher resolution or for fixation. Most of specimens obtained during this study were identified on squash preparations. Some of them have

Table I

Percentage of the total number of animals obtained by means of the heating method from different habitats

	spring	winter	summer	fall
mosses and algae	0	0	0	43
silt	0	0	24	66
detritus	0	0	0	1
stones and gravel	19	66	64	21
sand	47	47	82	29
interstitial waters	54	46	74	87

been preserved with "Turttox" as permanent in toto mounts. Similar mounts have also been prepared with use of acetocarmine for staining. For some *Typhloplanidae*, however, the reconstructions based on sectioned individuals proved to be a necessary supplement procedure in order to enable a correct identification. In this case STIEVE's fixative was used to kill animals and one of two staining techniques, or both of them when a larger number of animals was available, were followed: MALLORY's fuchsine and ERLICH's haematoxylin/eosin. The kind of the technique used for a particular species is specified in the text.

Thickness of paraffin-wax sections was chosen from 2—6 μ m, according to the size of animal and goal of preparation.

Statistical methods. To compare distribution of a large number of species and their ecological groups a statistical ordering of data was thought to be reasonable.

CHODOROWSKI (1960) adapted an application of phytosociological methods for description of turbellarian taxocenes with use of classical terms of abundance, constancy of occurrence (frequency) and coverage. Probably a more legible system of data analysis is that of ROMANISZYN (1970) which is applied in the present study. Inclusion of "coverage" as a coefficient corresponding to size of an animal seems to have little ecological sense in the animal kingdom and therefore it was rejected. As a matter of fact we know that rate of metabolism changes rather inversely with respect to the body size.

JACCARD'S formula $r = \frac{a+b-2w}{a+b-w}$ is used to calculate separately the statistical distance between the species and between the biotopes. The species are compared on the basis of a number of common biotopes in which their appear, and similarly, the biotopes are characterized by a number of species and their individual number which they share in common. The comparison can only follow by steps with two variables under consideration at a time. The "a" and "b" stand for the number of individuals of two species (biotopes) respectively, whereas "w" is the number of elements of the same kind that occur in "a" and "b" simultaneously. Hence "r" is understood as a distance measure. When the distances are calculated the species (biotopes) are arranged in a linear way according to the criterion that the smaller the "r" the closer the two species (biotopes) which are being compared. In such a way a two-dimensional construction may be arrived at. One of the axes is built of species and the other of biotopes. Instead of commonly used numerical values squares are drawn; their surface being equal to the number of specimens of a species in one of the biotopes. For each of 4 seasons (winter, spring, summer and fall) an independent diagram has been constructed. This permitted to avoid the mixing of phenologically different species.

TAXONOMICAL AND ECOLOGICAL CHARACTERISTICS OF SPECIES

Systematical list of species

Catenulida

1. *Catenula lemnae* ANT. DUGES, 1832
2. — *macrura* MARCUS, 1945
3. — *sekerai* BEAUCHAMP, 1919
4. *Dasyhormus pygmaeus* (REISINGER, 1924)
5. *Suomina turgida* (ZACHARIAS, 1902)
6. *Rhynchoscolex evelinae* MARCUS, 1945
7. — *simplex* LEIDY, 1851
8. *Stenostomum anatirostrum* MARCUS, 1945
9. — *anops* NUTTYCOMBE et WATERS, 1938
10. — *beauchampi* PAPI, 1967
11. — *leucops* (ANT. DUGES, 1828)
12. — *occultum* KOLASA, 1971
13. — *pegephilum* NUTTYCOMBE et WATERS, 1938
14. — *predatorium* KEPNER et CARTER, 1931
15. — *romanae* KOLASA, 1980
16. — *temporaneum* KOLASA, 1980
17. — *unicolor constrictum* LUTHER, 1960
18. — *ventronephrium* NUTTYCOMBE, 1932

Macrostomida

19. *Microstomum lineare* (MÜLLER, 1774)
20. *Macrostomum gilberti* FERGUSON, 1939
21. — *karlingi* PAPI, 1953
22. — *retortum* PAPI, 1951
23. — *sensitivum* (SILLIMAN, 1884)

Lecithoepitheliata

24. *Prorhynchus stagnalis* M. SCHULTZE, 1851
25. *Geocentrochora sphyrocephala* DE MAN, 1876

Neorhabdocoela

26. *Pilgramilla sphagnorum* SEKERA, 1812
27. *Bresslauilla relictia* REISINGER, 1929
28. *Graffillidae* sp.
29. *Gieysztorina pisana* KOLASA, 1980
30. *Microdalyellia armigera* (O. SCHMIDT, 1861)
31. — *dastychi* KOLASA, 1980
32. — *microphthalma* (VEJDOVSKY, 1895)
33. — *schmidtii* (GRAFF, 1882)
34. *Castrella truncata* (ABILDGAARD, 1789)
35. *Acrochordonoposthia conica* REISINGER, 1924
36. *Chorizogynopora italica* KOLASA, 1980
37. *Krumbachia paludicola* SCHWANK, 1979
38. *Limnoruanis romanae* KOLASA, 1977
39. *Pseudobockia limicola* KOLASA, 1980
40. *Ascophora paradoxa* FINDENEGG, 1924
41. *Dochmiotrema limicola* HOFSTEN, 1907
42. *Adenocerca minima* KOLASA, 1980
43. *Adenoplea paraproxenetes* REISINGER, 1924
44. — *meridionalis* KOLASA, 1980
45. *Castrada brevispina* PAPI, 1959
46. *Lutheria minuta interstitialis* subsp. nov.
47. *Olisthanella luteophila* KOLASA, 1980
48. *Opisthomum fuscum* WEISE, 1942
49. *Ethmorhynchus youngi* KOLASA, 1977
50. *Gytrix hermaphroditus* EHRENBURG, 1831
51. *Opisthocystis goettei* (BRESSLAU, 1906)
52. *Sekerana stolci* (SEKERA, 1911)
53. *Uncinorhynchus karlingi* KOLASA, 1977
54. *Phaenocora* sp.

- 55. *Typhloplanidae* sp. I
- 56. *Typhloplanidae* sp. II
- 57. *Typhloplanidae* sp. III

Tricladida

- 58. *Dugesia gonocephala* (DUGES, 1830)
- 59. — *polychroa* (O. SCHMIDT, 1861)
- 60. *Microplana terrestris* (MÜLLER, 1774)
- 61. *Atrioplanaria* sp.

Comments on particular species

Catenula lemnae ANT. DUGES, 1832

Only several specimens were encountered on sites without any water current. The species seems to be characteristic of various standing water bodies and humid soil which can be inferred from up-to-date ecological data in PAPI (1952, 1967), BAUCHHENS (1971), KRAUS (1965), LUTHER (1960,) YOUNG (1973).

Catenula macrura MARCUS, 1945

A few specimens of this species were found in F. Contesora. For morphological details see Fig. 4—5.

The ecology of *C. macrura* is poorly known. It seems to be similar to that of *Dasyhormus pygmaeus*. The species is recorded from France, Finland, Poland, Italy (present paper) and Brazil.

Catenula sekerai BEAUCHAMP, 1919

A few specimens were obtained from an interstitial sample. Scarcity of data makes difficult any conclusion as to the species ecological requirements. The species was discovered in France and successively reported of a few stands in Europe and North America.

Dasyhormus pygmaeus (REISINGER, 1924)

Catenula pygmaea, REISINGER 1924; *Dasyhormus lithophorus*, MARCUS 1945, *Catenula pygmaea*, AN DER LAN 1954; *Dasyhormus pygmaeus*, KOLASA 1973.

Morphological observations correspond well to the earlier descriptions. Two specimens were found only. The species is known from various terrestrial substrata of considerable humidity as well as from mosses, particularly *Sphagnum* (KOLASA 1974). In more arid climate it is probably restricted to humid zones along water-courses and standing water bodies.

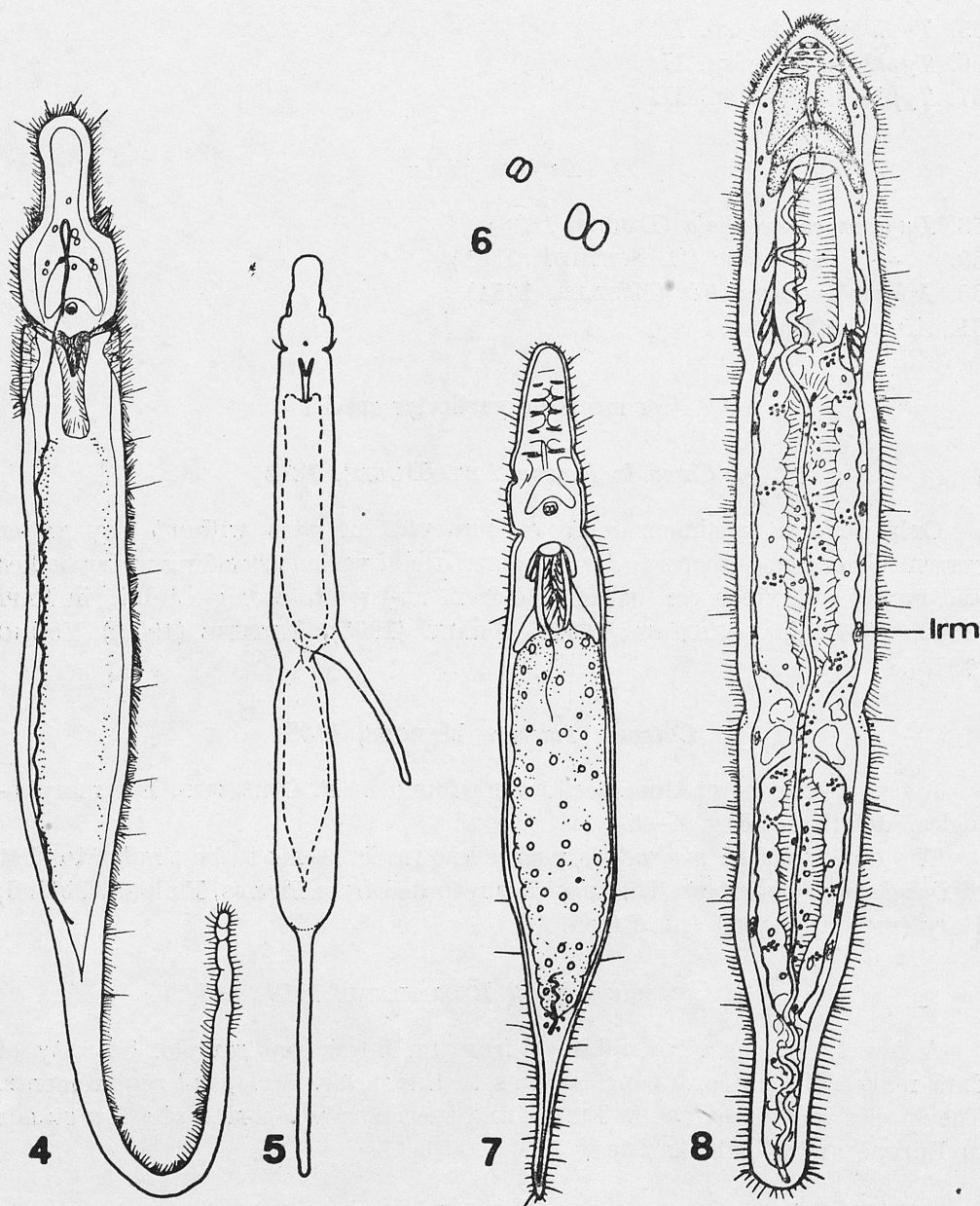


Fig. 4—8. *Catenula macrura*: typical specimen — 4, specimen in an advanced stage of division — 5; *Rhynchoscolex evelinae*: statoliths — 6, the specimen found — 7; *Stenostomum pegephilum*: general body shape and anatomy — 8

Suomina turgida (ZACHARIAS, 1902)

Only single specimens were found in interstitial water of F. Contesora in winter time. Data available suggest that it is a summer occurring species. The present finding apparently does not give support to such a notion though

it should be remembered that the Tuscany is a warm region of Europe. This rare species is known from Finland, Poland, Soviet Union (Lwów), Austria and Brazil.

***Rhynchoscolex evelinae* MARCUS, 1945**

Only a few specimens were found in F. Contesora (Fig. 6—7). The animals of a single zooid have a narrow smooth tail. The prostomium is irregularly conical. The statocyst with two statoliths bound together is situated in the center of the proximal prostomium part. Diameter of that composed structure is about 6.6 μ m. The coat of longer sensory and shorter locomotory cilia is visible all over the body. The heavily ciliated pharynx is long-barrel like with the oval mouth. Larger pharyngeal glands are conspicuous at its basis, while the smaller ones at the mouth level. The number of transversal septa, which are observed in front of brain, was 7—8. Details of brain structure were hardly visible. The protonephridium opens little behind the intestine end. It has not been noticed whether this opening is dorsal or ventral. General body, shape small dimensions, two connected statoliths leave few doubts as to identity of the species found. The hitherto distribution of *Rhynchoscolex evelinae* was Brazil (MARCUS 1945).

***Rhynchoscolex simplex* LEIDY, 1851**

A few specimens found in F. Contesora occurred in interstitial waters mainly. The species is frequent in threshold biotopes like ground waters, springs marshes as well as in water bodies like lakes, ponds (PAPI 1967; KOLASA 1974). Its distribution is Europe, Americas, Japan islands.

***Stenostomum anatirostrum* MARCUS, 1945**

Fifteen specimens of this species were found in both interstitial waters and wet mosses on banks of the stream F. Contesora.

The body shape as described in KOLASA and YOUNG (1974). Length of animals of two zooids about 750 μ m; width 70 μ m. Pharyngeal glands are of diffuse type though in the basic pharynx part they are somewhat compact. In the anterior pharynx part the glands are smaller. Granulation of the protonephridium is present. Rhabdoids are also present. The nephridiopore is terminal. Excretophores are distributed in two rows above the enteron. A tail was not observed. Specimens examined in Italy fit best MARCUS' description (1945) of Brazilian population, they are however considerably smaller and more transparent.

The species is known from Europe, Africa and South America (KOLASA and YOUNG 1974).

Stenostomum anops NUTTYCOMBE et WATERS, 1938

External characters of this species can be confused with many species of the *Stenostomum anatirostrum* species group but it never lacks rosette-shape epidermal glands. Specimens found in F. Contesora accorded well with previous descriptions. In this stream it occurs most frequently, though in low numbers, in interstitial waters. *Stenostomum anops* has been known in North America and Poland so far (KOLASA and YOUNG, 1974).

Stenostomum beauchampi PAPI, 1967

A few specimens were found in lower sections of F. Contesora. We have records of this species from France (*Stenostomum unicolor*, BEAUCHAMP 1948), Italy and Poland (KOLASA 1977c). It is probably a moderate thermophile.

Stenostomum leucops (ANT. DUGES, 1828)

Present morphological observations do not reveal new details. More recent physiological and ecological data (BORKOTT 1970; BAUCHHENS 1971; YOUNG 1970; YOUNG and KOLASA 1974; KOLASA 1974; LUTHER; KRAUS 1965; YOUNG 1973; CHODOROWSKI 1959) indicate that *Stenostomum leucops* has a great ability of adaptation to many environmental conditions. It seems to explain many aspects of its distribution. Beside that, the BORKOTT's work brings to one's mind a possibility of existence of several strains of *Stenostomum leucops* which differ in ecological properties and, possibly, are even expressed morphologically. This aspect of the so-called ubiquitous species was recently pointed out by STERRER (1973). The concept of adaptation through assumed ecologically different strains could perhaps explain this case of biological phenomenon called eurytopy.

In F. Contesora this species has a distribution pattern which essentially confirms the previous observations. It predominates all year long in the sections IIIA—IV. It is also present in habitats of the upper sections though its share, in comparison with other species, is low there.

Stenostomum occultum KOLASA, 1971

No new morphological features were perceived in the Italian material. This species was found in F. Contesora and in a small stream near Asciano (prov. Pisa); in dark organic mud, interstitial water and stony bed of the former

stream. Numerous specimens were present in samples throughout the year. This species has been known from a few stations in Poland so far (KOLASA 1974).

Stenostomum pegephilum 1938

A remarkable number of specimens of this species was found in F. Contesora. Individuals composed of two zooids measured 600—820 μ m in length and 40 up to a maximum of 60 μ m in width (Fig. 8). Length of an animal of one zooid about 450 μ m. Noteworthy peculiarities of the body shape are: the anterior prostomium portion which changes from almost triangular into cylindrical and the posterior end of body which is tapered to resemble a tail of variable length. This part of body is sometimes bent aside, its cilia are motionless and can attach to sand grains functioning as an adhesive organ. The animals do have a considerable ability of getting attached to various objects, even to the removing glass pipette. A few animals were lost in this way. The prostomium is more or less separated by a constriction. Animals are flattened ventro-dorsally. The body is covered with cilia of the length equal to the epidermis thickness. Thin sensory hairs are rarely distributed and have the length twice as much as the locomotory ones. Tiny rhabdoids were observed in distal parts of epidermal cells at the level of ciliated pits. The latero-ventral ciliated pits are medium in size and lie anterior to the largest section of the prostomium. The body colour is white in reflected light and transparent in transmitted light. Fine, sometimes distinct excretophores are present. No light refracting bodies. The mouth situated just beyond a constriction delimiting frontal part of the prostomium is transversely elipsoidal in shape. The pharynx has weakly muscular walls and ciliated lumen. No transverse musculature is visible. Its walls run parallel and in the proximal portion of it small elongate glands are attached. The brain is situated typically. Its two frontal lobes are relatively long. Hind lobes connected by a large transverse commissure are observed not in all specimens. There are 4—6 transverse muscular septa in front of the brain. In most specimens in the pseudocoel there are numerous highly refractive masses composed of granules. This feature is considered to be characteristic of the species (NUTTYCOMBE and WATERS 1938). Lumen of the intestine is narrow because of thick epidermis and because of epithelium which is thick twice as much. The posterior limits of the intestinal lumen could not be established with certainty for there are free or weakly fixed cells which are penetrated, it seems so, by some particules of the intestine content. Quite frequently the protonephridium is irregularly twisted in this region. The anterior loop of the protonephridium passes ventrally under the brain and then the main canal assumes a dorsal position. The nephridiopore is terminal.

Discussion. Undeniably *Stenostomum* species described above and *Stenostomum pegephilum* from America are the same species. However, there is a number of differences of less taxonomical importance which are listed below:

specimens from America
 enteron does not extent (does rarely) to the caudal end of the pseudocoel
 the species secretes much mucus what sometimes makes it difficult to dislodge animals from the sediments
 lumen of the interstine large glands distributed all over the pharynx

specimens from Italy
 observations not certain
 animals show clinging ability but mucus not observed
 lumen of the intestine narrow glands observed in the proximal half of the pharynx only

Regarding these differences it can be admitted that it is likely that these forms constitute geographical subspecies.

Stenostomum pegephilum inhabits mainly inorganic sediments of upper sections. It seems to be a cold-stenothermic and reophile species.

Stenostomum predatorium KEPNER et CARTER, 1931

A single specimen was obtained from F. Contesora and four from decaying leaves in a small stream near Asciano. Length of specimens composed of 3 zooids up to 1200 μm ; of 2 zooids about 700 μm . The specimens found appeared weak and undernourished. General body shape and internal structure show no essential differences in comparison with the previous descriptions of KEPNER and CARTER (1931) and NUTTYCOMBE and WATERS (1938) except of the pharynx. Though it is a big organ, the ratio of its length to width is 2 only. Besides, tiny rhabdoids were observed in epidermis. These had not been reported by the precedent authors. Despite these differences some characters are strikingly similar, for example: the mouth, the musculature of pharynx, appearance of the enteron. Therefore there should not be any doubt as to this identification. It may be added that every population examined till now differs in certain characters from the others.

This species is recorded in U.S.A. — Virginia, North Carolina, Georgia (NUTTYCOMBE and WATERS 1938), Poland — a greenhouse in Poznań and in heated lakes near Konin (KOLASA 1973, 1977c) as well as in Italy (present paper).

Stenostomum romanae KOLASA, 1980

This species occurred in interstitial waters of Fosso Contesora, particularly in its lower sections as well as in a cove in Monti Pisani. Hence this form is considered a stygophile (KOLASA 1980a).

Stenostomum temporaneum KOLASA, 1980

Stenostomum temporaneum occurred quite frequently in mineral substrata like sand, gravel, stones in the upper stream segments (KOLASA 1980a). Its hitherto distribution is F. Contesora only.

Stenostomum unicolor constrictum LUTHER, 1960

This species deserves attention for the same reason as *Stenostomum leucops* does; it is much variable morphologically and ecologically. Since LUTHER's description of two new subspecies, namely *Stenostomum unicolor sphagnetorum* and *S. u. constrictum* a display of different views on the taxonomical status of this species has taken place (VAN DER LAND 1965; PAPI 1967; YOUNG and KOLASA 1974). As we cannot yield more taxonomically significant characters and the known ones are not sufficient (BAUCHHENS 1971) it is proposed to retain the old name, i. e. *Stenostomum unicolor* with the two subspecies.

Stenostomum unicolor is known so far from Europe, Africa, Asia, Sumatra and Formosa. Probably the American species *Stenostomum virginianum* NUTTYCOMBE, 1931, known from U.S.A., Canada, Brazil, is a synonym of *Stenostomum unicolor* (MARCUS 1945). In such a case the distribution of this species would be cosmopolitan and resembling greatly that of *Stenostomum leucops*. Ecological data presented further on show that *Stenostomum leucops* and *S. unicolor* are supplementing each other to a certain degree.

Stenostomum ventronephrium NUTTYCOMBE, 1932

In the present case this species was found in the temporarily drying up parts of F. Contesora. It can readily live in humid soil as well as in various water bodies. Its occurrence in Italy was ascertained by PAPI (1959a). Until then the exclusive records referred to the U.S.A. (NUTTYCOMBE 1932; NUTTYCOMBE and WATERS 1938) and Brazil (MARCUS 1945).

Microstomum lineare MÜLLER, 1774

In F. Contesora it occurred in lower sections only and in low quantities as well. Usually *Microstomum lineare* is one of the most abundant species in standing or slowly running waters (see for instance YOUNG 1973).

Macrostomum gilberti FERGUSON, 1939

As regards details of female reproductive system the description of this species is rather meagre because of the poor development of female parts. All the other characters are described in more detail since the FERGUSON's note was found limited and insufficient by modern standards. In F. Contesora three mature individuals were collected only.

Length of body of the fully matured specimens varied from 450 to 750 μm . The body (Fig. 13) is tapering from the end of intestine and from the pharynx level toward its extremities. The ratio of the length by width is 6—7. The body has slight yellow colouration but in reflected light it appears rather transparent.

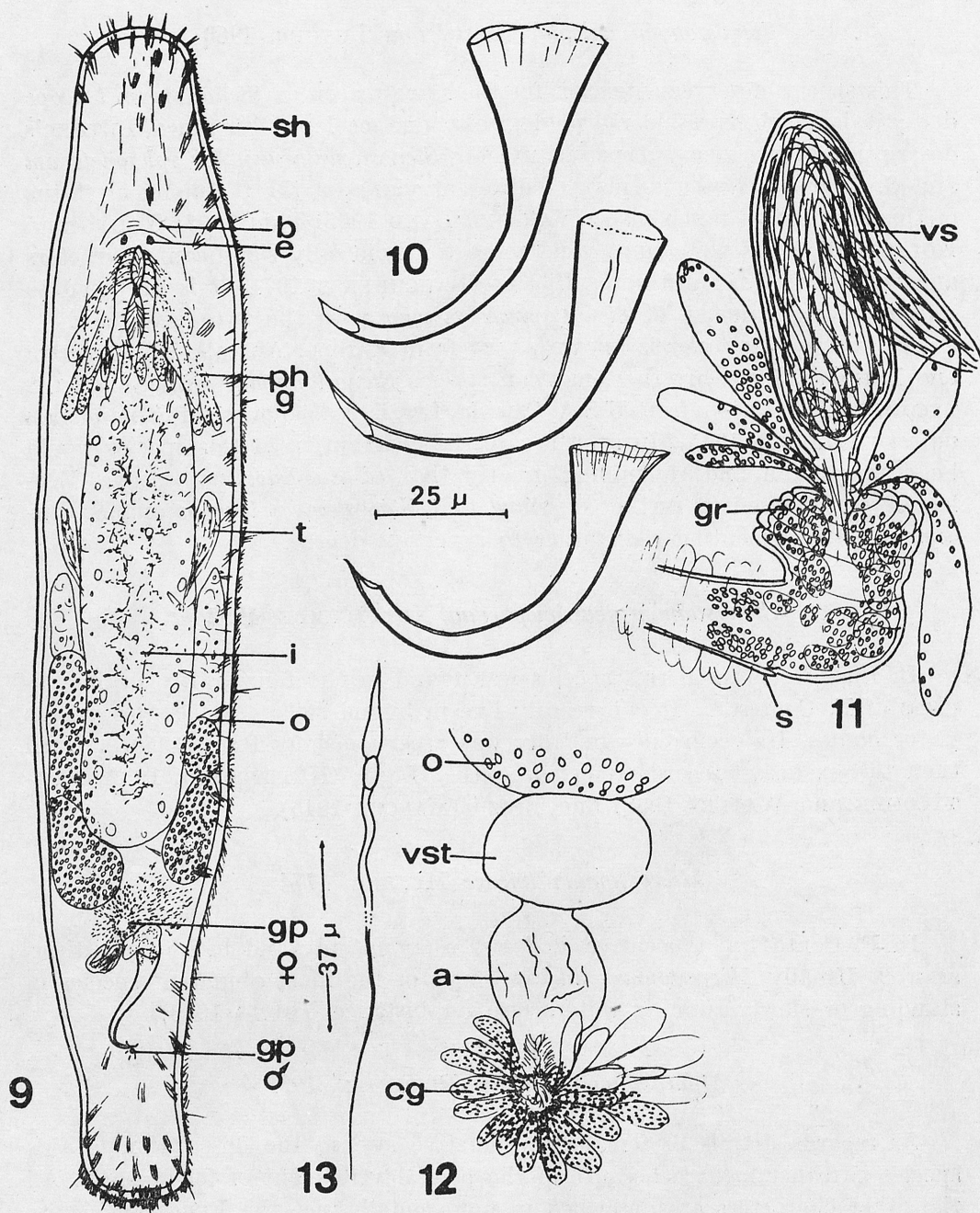


Fig. 9—13. *Macrostomum gilberti*: general body shape and anatomy — 9, stylets — 10, soft parts of the copulatory organ — 11, female sexual organs — 12, sperm cell — 13

The epidermal height is about $7\text{ }\mu\text{m}$. Locomotory cilia are up to $8.5\text{ }\mu\text{m}$ in length. Semi-rigid sensory hairs occur at the anterior margin of the body and reach $11\text{ }\mu\text{m}$. They are often surrounded by thinner normal sensory hairs that

are scarcely scattered over the rest of body and that reach up to 20 μm . Since those hairs are very thin in *Macrostomum gilberti*, it was unfeasible to count properly their number in a single tuft. Rhabdoids are plentiful and occur usually in groups of 5–6. Their number per group vary from 2 to 12. They attain about 14 μm in length in the anterior body half and up to 17 μm in the posterior one. Thinner rhabdoids were observed in tracks in front and aside of the pharynx. Tail epidermal outgrowths are well developed though short (about 4 μm). It was noticed that the outgrowths, sticking close to each other,

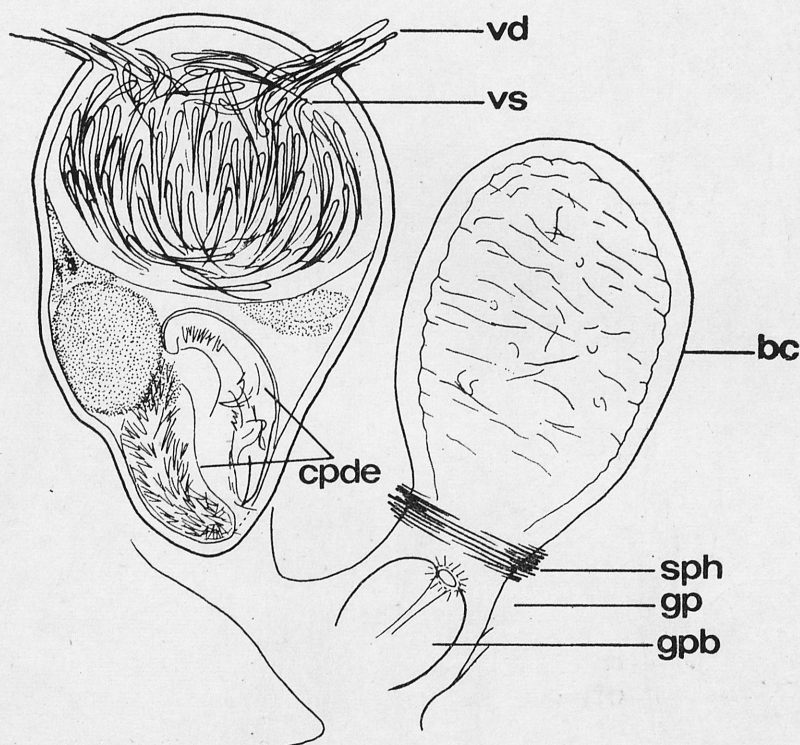


Fig. 14. *Adenoplea paraproxenetes*: some reproductive organs on a squash preparation

form a kind of a sucker which help animals to cling to objects. Eyes situated just in front of the pharynx are less distant from each other than each from its nearest body margin. Their colouration is black with some red and brown seen at a great magnification. The typically built pharynx simplex is surrounded by numerous glands. Its inner epithelium is ciliated. The mouth is a rather short slit. Outer walls of the intestine are deeply undulated in some or fairly smooth in other specimens. Ovaries extend more than half-way along the intestine. The short vagina is ciliated. No cilia were observed in the genital atrium (Fig. 16). A big and oval "Verschlussapparat" is quite translucent and therefore its structure was not decipherable on squash preparations. Fairly abundant cement glands, full of oval granulations, appear around the female

gonopore. Position of small testicles is variable; they abut on the anterior margin of the ovaries. The elongate vesicula seminalis joins, via a rather short ductus intervesicularis, with an oval and muscous vesicula granulorum

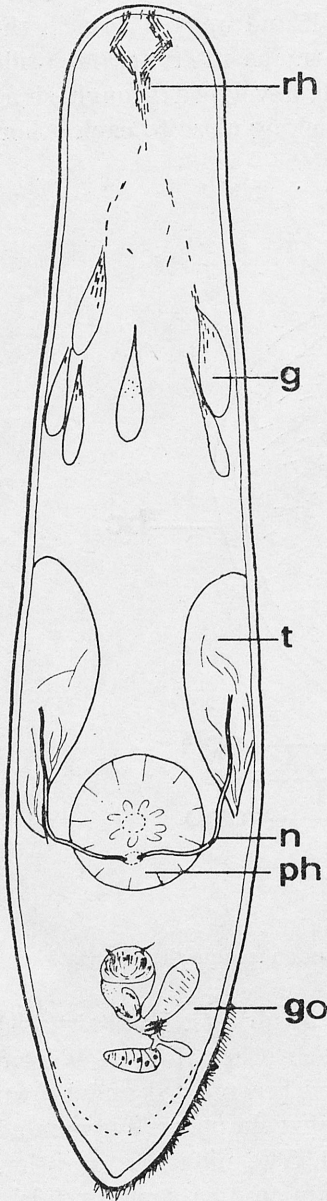


Fig. 15. *Adenoplea paraproxenetes*: general view of body and gross anatomy

(Fig. 15). Granulations of the latter enter the stylet lumen to a certain extent. Muscles of the vesicula granulorum may apparently divide its walls and lumen into a few chambers (the FERGUSON's ciliated chambers?). The spiral stylet is pointed at its distal end and provided with a distinct tip which projects

beyond the margin of the opening (Fig. 14). The distal opening is terminal and about 4 μm long. In the proximity of this opening the stylet is 3 μm wide. The proximal portion of the stylet is funnel-like, while the distal part is a narrow tube. Measurements taken: proximal openings before squeezing 11, 13 and 17 μm ; on squash mounts 15, 16 and 20 μm , respectively; the distances between the farthest extremities 60, 64 and 68 μm . On squash mounts the stylets assume the shape of a deep bow, though the most accentuated curve in the middle of its length does not reach the right angle. Sperm cells are about 40 μm long (Fig. 17).

Discussion. *Macrostomum pithecusae* PAPI, 1959, which lives on Ischia Isle, is probably the most closely related to *M. gilberti*. Its stylet is, however, bent less and the ratio of the stylet length to the proximal opening diameter is 5—6 against 4 in *Macrostomum gilberti* (PAPI 1959b). These differences are fully confirmed by the present material. The ratio concerned is 4, 4 and 3.4 in the specimens studied. Hence, a hypothesis that the two species may turn out two zoogeographical subspecies (PAPI 1959a) must be rejected; new observations discriminate even deeper the taxa and do not disclose any intermediate values in measurable characters in the stylet structure.

Macrostomum gilberti has been discovered in North America — Tennessee, in springs and streams (FERGUSON 1939), that is, in biotopes similar to European ones.

***Macrostomum karlingi* PAPI, 1953**

It is undoubtedly a stenothermic species with a wide distribution in Europe. In examined streams (F. Contesora as well as a small stream near Asciano) it occurred in considerable numbers in their upper sections. *Macrostomum karlingi* is known so far from cold springs (PAPI 1953, 1967; KOLASA 1974) and from interstitial waters (AN DER LAN 1967).

***Macrostomum retortum* PAPI, 1951**

The present investigation showed this species to be very common in F. Contesora and a small stream near Asciano (unpublished data). In F. Contesora its distribution area overlaps that of *M. karlingi* to a certain degree but it does not extend upstream as high as *M. karlingi* does.

This species has been discovered by PAPI (1951) in a temporary pond with decaying leaves in winter time (February). Occurrence of *Macrostomum retortum* in various types of waters points at its ecological valency; however the species seems to be cold-stenothermic. Individuals submitted experimentally to room temperature died out after 24—48 hours.

Macrostomum sensitivum SILLIMAN, 1882

This species occurs in lakes, temporary ponds or puddles or even in a damp soil (PAPI 1967) and presently it was found between stones and gravel in the stream lowest section. In Europe we have scarce records on its distribution: Roumania (MACK-FIRĂ 1968b), Italy (PAPI 1951) and Poland (KOLASA 1973).

Prorhynchus stagnalis M. SCHULTZE, 1851

Without ecological specialization, often terrestrial, cosmopolitan (PAPI 1967). Moreover, a new form, *Prorhynchus stagnalis intersitalis*, was discovered in interstitial waters (AN DER LAN 1967). From works of BAUCHHENSS (1971), CHODOROWSKI (1959), KOLASA (1977c), RIXEN (1961) and YOUNG (1973) a conclusion may be drawn that *P. stagnalis* is common in most types of water bodies though it occurs almost always in low numbers.

Geocentrophora spyrocephala DE MAN, 1876

This species is usually recorded in rather cold streams, lakes, helocrene springs, forest pools, wet soil, turbaries, litter and mosses. Its occurrence has then amphibiotic character. See, for instance, BAUCHHENSS (1971), LUTHER (1960), AN DER LAN (1963). In F. Contesora a limited number of specimens were found in mosses mostly.

Pilgramilla sphagnum SEKERA, 1912

Several, mostly young specimens were found in the section IIIA of F. Contesora. This is why the precise observation of characters that are supposed to differ this species from *Haplovortex bryophilus* REISINGER, 1925 could not be carried out. Doubts have arisen as to whether to retain an independent status of the two taxa because much similarities do exist. The question, however, has not been solved yet (MACK-FIRĂ 1970). The examined specimens externally showed characters of either *Pilgramilla sphagnum* or *Haplovortex bryophilum*, or they were intermediate in this regard. This would argue that we have only one genus to deal with. However, the specific synonymy cannot be ascertained without a detailed comparison of adult individuals collected in loci typici.

Ecology of *Pilgramilla sphagnum* is not known well; it was sporadically found in much different habitats (cf. SEKERA 1912; MACK-FIRĂ 1970). According to MACK-FIRĂ (1970) some data suggest that this species is cold-stenothermic. The distribution of *Pilgramilla sphagnum* is Roumania (MACK-FIRĂ 1970), probably Austria (REISINGER 1924b), Italy and Poland (unpublished data), Czechoslovakia and Russia (NASONOV 1926).

*Bresslauilla relict*a REISINGER, 1929

The only specimen found in F. Contesora (the southernmost station of the species) confirms a notion that the hypothesis considering *Bresslauilla relict*a a relict species (REISINGER 1929) and discussed by RIXEN (1961), AX (1959), MACK-FIRĂ (1967) and others has still less support. Regardless taxcnomical relationships this species should be considered an old European form with explanation of its distribution pattern hardly searched for in glacial events.

*Bresslauilla relict*a occurs mainly in standing waters or in slowly flowing streams, canals etc. It is widely distributed in Europe.

Graffillidae sp.

Only one juvenile specimen of *Graffillidae* was found in damp mosses of the section I. Because of its immaturity identification was impossible; probably it was *Archivortex silvestris* REISINGER, 1924. The habitat it occurred in and a general outlook of the animal permit this supposition.

*Gieysztor*ia *pisana* KOLASA, 1980

*Gieysztor*ia *pisana* was encountered in various samples of mosses in clean cold and well oxygenated parts of the stream F. Contesora. Undoubtedly it is a cold preferring species (KOLASA 1980b).

Microdalyellia amigera O. SCHMIDT, 1861

In the communities of F. Contesora it is an occasional element. It occurred most frequently in the sections II and III. Ecological valence of this species is broad as it is evidenced by records of BAUCHHENS (1971), KRAUS (1965), KOLASA (1974), RIXEN (1961), YOUNG (1970) and others. Essential for this paper is the fact that *Microdalyellia armigera* is an eurythermic and rheo-tolerant species. In Europe it inhabits most of the geographical regions.

Microdalyellia dastychi KOLASA, 1980

This species is known from F. Contesora so far. It inhabits its lower sections. Major part of individuals were obtained from interstitial waters in gravel and stones (KOLASA 1980b).

Microdalyellia microphthalma (VEJDOVSKY, 1895)

Though *M. microphthalma* is a well described form, there are still some difficulties in identifying not fully developed specimens. Morphological variability of the stylet has been explicitly presented in BAUCHHENS' work (1971) but

it may be impossible to distinguish even a single adult individual if found together with juveniles of *Microdalyellia armigera*; usually a number of specimens is necessary to identify it correctly. In this paper juveniles of *M. microphthalma* and *M. armigera* were distributed proportionally to the matured individuals. Causes of mistakes lie in weak development of handles and also in poor discernibility of the characteristic cuticular outgrowth.

Generally, this species may be defined as cold-stenothermic (BAUCHHENSS 1971). It is quite common over large areas in Europe.

Microdalyellia schmidtii (GRAFF, 1882)

According to BAUCHHENSS (1971) *M. kupelwieseri* is a synonym of *M. schmidtii*. Until further data are revealed which could confirm the BAUCHHENSS' statement, it is useful to characterize concisely the form found.

This population has never the spines pattern 1 : 1, though the combination 1 : (2—3) may already occur. Counts were not carried out for other than occasional specimens.

The ecological form called until recently *Microdalyellia kupelwieseri* is a typical inhabitant of sources, brooks and various cool small water bodies. The present observations maintain its previously known characteristics. It occurs in limited numbers in F. Contesora, though in the upper temporary parts of the stream it becomes a dominant for other turbellarians occur in low numbers only.

Castrella truncata (ABILDGAARD, 1789)

This species is evidently without any ecological specialization in Europe. In F. Contesora a single specimen was found only. *Castrella truncata* is spread in Eurasia (PAPI 1967).

Acrochordonoposthia conica REISINGER, 1924

This is the commonest member of the typically terrestrial genus. It occurs mainly in wet mosses and also in humus. In the investigated stream it is limited to its moss-grown banks; only several specimens were found. *Acrochordonoposthia conica* is known from dispersed stations in Europe; from Greenland to Italy (PAPI 1967).

Chorizogynopora italica KOLASA, 1980

This rare species (five specimens) was found only in heavily moistened mosses in an upper (II) section of the stream. It belongs to a typical terrestrial genus *Chorizogynopora* REISINGER, 1924 (KOLASA 1980d).

Krumbachia paludicola SCHWANK, 1979

A few specimens were found in interstitial waters of gravel banks in the section II of F. Contesora. The species occurs also in sandy bottom and in interstitial waters in sand as well as in fine mud of clean highland streams in Germany (SCHWANK 1979).

Limnoruanis romanae KOLASA, 1977

This species inhabits cold running waters. In F. Contesora it is indicative of the section II. Its hitherto distribution is Poland and Italy (KOLASA 1977b).

Pseudobockia limicola KOLASA, 1980

Pseudobockia limicola occurred in moderate numbers in interstitial waters in the upstream portions of F. Contesora. Taxonomically it was placed in the mostly terrestrial subfamily: *Protoplanellinae* and therefore the terrestrial origin of this species was discussed by KOLASA (1980c).

Ascophora paradoxa FINDENEGG, 1924

The species is known from marshes, humid soil and streams in Austrian Alps, Alsace (FINDENEGG 1930) and in Eastern Carpathians (GIEYSZTOR and SZYNAL 1939; MACK-FIRÁ 1970). It is the first finding at a site distant from great mountains. Three specimens were found and preserved in the section IIIA of F. Contesora.

Dochmiotrema limicola HOFSTEN, 1907

Until now it was usually found in psammal and sometimes in silt sediments in various water bodies. A few specimens were found in silty habitats of the lowest section of F. Contesora and in interstitial waters in the sections II and IIIA. This species is known at a few stations in Europe: Switzerland, Finland, Russia, Poland, Germany, Roumania (HOFSTEN 1907; LUTHER 1963; GIEYSZTOR 1938; RIXEN 1961; BAUCHHENS 1971; MACK-FIRÁ 1970).

Adenocerca minima KOLASA, 1980

So far *Adenocerca minima* has been found in mosses on damp banks of the section I of F. Contesora (KOLASA 1980d). Most probably it is a terrestrial species.

Adenoplea paraproxenetes REISINGER, 1924

A single specimen of this terrestrial species was found in interstitial water of the sandy stream bed and another in mosses near the helocrene spring in the section I of F. Contesora. As the morphological description by REISINGER lacks figures, these are enclosed (Fig. 14—15) in order to facilitate future identifications.

Adenoplea paraproxenetes has been known from Austria so far (REISINGER 1924a).

Adenoplea meridionalis KOLASA, 1980

Adenoplea meridionalis is essentially a terrestrial species which lives in mosses in the proximity of the helocrene spring of F. Contesora. The spring maintains the habitat humidity at a fairly constant level (KOLASA 1980e).

Castrada brevispina PAPI, 1959

The ecology of this species is poorly known. Poland — a helocrene spring with sand and mosses (KOLASA 1974,) Italy — a winter seasonal pond in forest (PAPI 1959a) and a helocrene spring in the range of Alpi Apuane, about 100 m high in mosses (unpublished records). Beside that, F. Contesora and its cold tributaries, in mosses. All the collections, except for Poland were performed during winter; the species seems to be cold-stenothermic.

Lutheria minuta interstitialis subsp. nov.

Two individuals were extracted from interstitial and fine sediment samples. Both had the reproductive systems developed characteristically of *Lutheria minuta minuta* HOFSTEN, 1907. Their body length however was only 600 μ m. The anterior extremity truncate. Distribution of yolk glands, testicles and pharynx are similar to those described for the type species. Differences in regard to other populations known from Switzerland (HOFSTEN 1907), Roumania (MACK-FIRĂ 1970) and Poland (KOLASA 1974) refer to a lack of eyes in the Italian material and to the presence of a pair of light refracting spots composed of small granulations in the basal pharynx region in this subspecies. Thus the erection of a new subspecies is on purely morphological grounds since the ecological and zoogeographical data on *Lutheria minuta* are very scarce.

***Olisthanella luteophila* KOLASA, 1980**

In F. Contesora it lives in the section II in organic sediment mixed with fine sands. The species was also discovered in Poland in a helocrene spring and a small creek in Poznań vicinity (KOLASA 1980e).

***Opisthomum fuscum* WEISE, 1942**

Two specimens were found in F. Contesora in cold water originating from a small tributary. Anatomical remarks referring to some characters discussed in the literature: a cuticular ring on the distal part of the cirrus present, brown granulations above the intestine are visible and apparently these are not particles of food, length of animals estimated as 1 mm. Testicles situated just in front of the pharynx in one of the specimens but in the other one testicle was more anterior, while the second one was shifted backwards in the region close to the pharynx (according to LUTHER 1963 and WEISE 1942 testicles should have a more anterior position). Hence we may consider their localization as a variable character. An egg observed in the uterus in one specimen had already developed stalk.

There are few data on the species ecology. Nearly all records refer to lakes (PAPI 1967). The species is known from Finland, Germany (LUTHER 1963; RIXEN 1961) and Poland (unpublished data). In F. Contesora it occurred in sand of the sections II and III.

***Ethmorhynchus youngi* KOLASA, 1977**

Three individuals of this species were found in the section II of F. Contesora (KOLASA 1977a). The species has not been found in other water courses as yet. Some of its ecological characters, i. e. the occurrence in fine organic silt in winter time, low abundance, sensitivity to laboratory conditions (temperature, oxygen?), suggest that *E. youngi* has narrow ecological valence and may be indicative of a well determined set of environmental parameters.

***Gyratrix hermaphroditus* EHRENBURG, 1831**

Occasionally encountered in the stream F. Contesora. By most authors considered as an eurytopic and cosmopolitan species.

***Opisthocystis goettei* (BRESSLAU, 1906)**

Like the above described species it occurred only occasionally in samples from lower sections of F. Contesora. This species has probably no ecological

specialization. Some authors (RIXEN 1961; BAUCHHENS 1971) suppose some cold water preferences of *O. goettei*; the species was also found in heated lakes in Poland (KOLASA 1977c).

Sekerana stolci (SEKERA 1911)

A few individuals were met with in lower sections of F. Contesora. Muddy bottom is the most frequently mentioned habitat of this species (STEINBÖCK 1948) as it is also in the present case. This rare species was revealed in several distant localities in Europe. It occurs in Iceland, the central Europe, Alps (STEINBÖCK 1948) and Russia in surroundings of Leningrad (NASONOV 1926). Italy constitutes a real extension of the known area settled by *S. stolci*. Recently this species was also reported from heated lakes in Poland (KOLASA 1977c).

Uncinorhynchus karlingi KOLASA 1977

This species is interesting for two reasons. It is an element of marine origin and shows similar ecological requirements as *Ethmorhynchus youngi*. It is known from sand of the section II of F. Contesora (KOLASA 1977a) and from Breitenbach in Germany (P. SCHWANK, in litteris).

Phaenocora sp.

Only two juvenile unidentifiable specimens were found in the lowest, most polluted, section of F. Contesora.

The other three Microturbellarian species were determined to the family level only. All were found to belong to *Typhloplanidae*.

Dugesia gonocephala (DUGES 1830)

This identification has a general character only because *Dugesia gonocephala* is considered now as a "superspecies" (BENAZZI 1955; DAHM 1958). From the central and south Italy a number of "microspecies" have been described but no *D. gonocephala* sensu stricto, i. e. identical with the north European populations. *D. gonocephala* is a world-wide distributed species which occurs mainly in swift well oxygenated and unpolluted streams. This species is numerous in the section II of F. Contesora. Its zoogeography and ecology are reviewed by DAHM (1958).

Dugesia polychroa (O. SCHMIDT, 1861)

A single specimen of *D. polychroa* appeared in the lowest section of F. Contesora. This species forms a species complex (sibling species) together with *D. lugubris* (O. SCHMIDT, 1860) and, despite the excellent works of REYNOLD-

SON (1958) and BENAZZI et al. (1970), their taxonomical status is not quite clear. The found specimen was sexually immature and, consequently, its identification was based on morphological characters only.

The both mentioned species are common inhabitants of lakes, rivers, streams and even springs, yet, they are neither cold-stenothermic nor reophilic; they are confined to more productive lakes in England (REYNOLDSON 1958). The two species are common in all Europe.

Microplana terrestris (MÜLLER, 1774)

Specimens of *Microplana terrestris* occur on the damp banks of F. Contesora underneath mosses overgrowing loose humus soil in the section I. This is a typical but not common terrestrial triclad broadly distributed in Europe. The only stations in Italy known so far are in Prealpi Venete, i. e. much more to the North (MINELLI 1974).

Atrioplanaria sp.

In the upper part of F. Contesora a species belonging to white *Planariidae* was collected a few times. All obtained specimens were sexually immature. Reared they showed propagation by means of fission. That is why the exact identification of the species could not be carried out. The general body habit with distinct tendency to show short but already well pronounced tentacles allows to relate this form to the group of species called *Atrioplanaria*. According to DAHM (1958) the genus *Atrioplanaria* BEAUCHAMP is a purely morphologically expressed group of species and its older generic name, i. e. *Phagocata* LEIDY should be retained until good taxonomical criteria for *Planariidae* are worked out. DAHM (1964) provides us in such criteria based on caryological examinations and splits definitely the white *Planariidae* into two genera: *Atrioplanaria* DE BEAUCHAMP, 1932 and *Phagocata* LEIDY, 1847 (? = *Fonticola* KOMAREK, 1926), but, in this case a caryological examination was not carried out. Since the living material has been put at Prof. M. BENAZZI's disposal, a successful identification may be expected in the future. Taking into account this fact and the DAHM's cited opinion the name attributed to the found species has to be treated provisionally.

The species was most abundant in the temporary portions of F. Contesora.

Biological observations

To understand trophic relations between turbellarians and other water organisms it is useful to collect data on intestine contents. Observations recorded during the present investigations are listed below (Table II). These records are too few however in order to ascertain diet preferences of individual species

with one or two exceptions only. Moreover, some attempts of cannibalism among turbellarians were observed. Unsuccessful attempts on record: *Stenostomum leucops* upon *S. leucops* and *S. unicolor*; *S. unicolor* upon *S. unicolor*. Successful attempts: *S. beauchampi* and *Dochmiotrema limicola* fed on *S. unicolor*.

Table II

Records on the diet of some species of *Turbellaria*. D — *Diatomae*, A — other *Algae*, C — *Ciliata*, R — *Rotatoria*, N — *Nematoda*, T — *Tardigrada*, O — *Oligochaeta*, Te — *Tendipedidae*

Species	D	A	C	R	N	T	O	Te
<i>Dasyhormus pygmaeus</i>	+							
<i>Stenostomum pegephilum</i>	+					+		
<i>Stenostomum ventronephrium</i>				+				
<i>Macrostomum karlingi</i>	+							
<i>Gieysztoria pisana</i>	+	+	+	+				
<i>Microdalyellia microphthalmia</i>	+			+			+	
<i>Acrochordonoposthia conica</i>				+				
<i>Chorizogynopora italica</i>								+
<i>Limnoruanis romanae</i>	+				+			
<i>Castrada brevispina</i>		+		+				
<i>Lutheria minuta</i>				+	+			
<i>Adenoplea meridionalis</i>					+			

Encysting abilities: observed in *Adenoplea meridionalis* and *Macrostomum sensitivum*.

Parasites: an individual of *Macrostomum retortum* infected by 80 unidentified *Ciliata* was once observed. It behaved normally.

BIOCOENOLOGICAL CHARACTERISTICS OF THE STREAM *TURBELLARIA*

Discussion of species distribution in the studied stream F. Contesora is based on three different approaches which complement each other and expose various interesting properties of this fauna. It was done by means of:

- a description of fauna of particular biotopes together with indication of characteristic species,
- a formation of species groups according to similar ecological properties (synecological groups),
- and groups of species with common ecological origin (syngenetical groups).

The above characteristics were elaborated in order to take a broad view of the turbellarian succession in the studied stream.

Distribution of particular turbellarian species in habitats of Fosso Contesora. S — spring, H — hypocrenon, D — domination index

habitats	Section I			S				H	S	Section II							Section IIIA						Section IIIB						Section IV						Sum	D(%)
species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34		
<i>Catenula lemnae</i>																	1								1	2	1					1		7	0.09	
<i>Catenula macrura</i>	1	1																															2	0.02		
<i>Catenula sekera</i>															5																		5	0.06		
<i>Dasyhormus pygmaeus</i>	4	2																															6	0.08		
<i>Suomina turgida</i>									13																								16	0.21		
<i>Rhynchoscolex evelinae</i>							1					3			1																		5	0.06		
<i>Rhynchoscolex simplex</i>																	1																13	0.17		
<i>Stenostomum</i>	4	35	12		18				5	2		1	3	2	14		32	2			3	1	1			8						4	1	4	142	1.89
<i>Stenostomum anops</i>																									2									8	0.10	
<i>Stenostomum beauchampi</i>																	1																	5	0.06	
<i>Stenostomum leucops</i>			20		1	1	2		12		2	48	15	15	12	5	262	707	46	17	402	467	16	195	114	47	119	10	360	244	99	5	80	228	3551	47.51
<i>Stenostomum occultum</i>												9	10	29	8		32	115			4	119	11	55	5	1			4		1		4	409	5.47	
<i>Stenostomum pegephilum</i>							3		27		2	55	24	87	54		29	26		1				8									4	354	4.73	
<i>Stenostomum predatorium</i>							1																											1	0.01	
<i>Stenostomum romanae</i>												1											1										28	31	0.41	
<i>Stenostomum temporaneum</i>												39	37	6	37		3					6		2									1	132	1.76	
<i>Stenostomum unicolor</i>			6	1	1	5	3		3	24	22	27	8	51	33	26	6	60	4	64	120	63	49	46	41	65	28	10	80	112	34	2	13	90	1094	14.63
<i>Stenostomum ventronephrium</i>	1		4																															7	0.09	
<i>Microstomum lineare</i>																									3				2	4	49		3	61	0.81	
<i>Macrostomum gilberti</i>																																1		1	0.01	
<i>Macrostomum karlingi</i>			2		7	12			4		31		2		10		2	1					2		2			1						76	1.01	
<i>Macrostomum retortum</i>					1						162	125	66	41	1	165																		561	7.50	
<i>Macrostomum sensitivum</i>																																		3	0.04	
<i>Prorhynchus stagnalis</i>			5			1		1	1			1	7	7	3		1	1						5	1		1							35	0.46	
<i>Geocentrophora sphyrocephala</i>		3	1	8	2							1										1	1	1										18	0.24	
<i>Pilgramilla sphagnorum</i>														1			12						1											14	0.18	
<i>Bresslauilla relicta</i>																																1		1	0.01	
<i>Graffillidae</i> sp.		1																																1	0.01	
<i>Gieysztoria pisana</i>					21						2	1																11						35	0.46	
<i>Microdalyellia armigera</i>													8	5	1		26	28				1		7	4							1		81	1.08	
<i>Microdalyellia dasytychi</i>									2								13	23			1	4		54	9							2		108	1.44	
<i>Microdalyellia microphtalma</i>											5	36	56	39	5	2	5	51			9	6		38		20			6			1	26	3	308	4.12
<i>Microdalyellia schmidtii</i>			12	1					3	1									7	1				1		1						1		28	0.37	
<i>Oastrella truncata</i>																													1						1	0.01
<i>Acrochordonoposthia conica</i>				1																	1													2	0.02	
<i>Chorizogynopora italica</i>					5																													5	0.06	
<i>Krumbachia paludicola</i>									3						1																			4	0.05	
<i>Limnoruanis romanae</i>									1			1	22	13			1							1	1									40	0.53	
<i>Pseudobockia limicola</i>									1			1	2	12																				16	0.21	
<i>Ascophora paradoxa</i>																	3																	3	0.04	
<i>Dochmiotrema limicola</i>													1	2	1		3													1		1		9	0.12	
<i>Adenocerca minima</i>		1																																1	0.01	
<i>Adenoplea paraproxenetes</i>				1	1																													2	0.02	
<i>Adenoplea meridionalis</i>		5																																5	0.06	
<i>Castrada brevispina</i>																		1		3							1	10								

Distribution of species within different habitats

The distribution of species within habitats is shown in summative terms in Table III. Habitats which occur in several segments of the stream are mosses, stones and gravel, sand deposits, organic sediments, interstitial waters and temporary waters. Of the listed habitats the most relevant for discussing the stream succesional development seem those in strong current, i. e. stones and gravel, in slow water current (sands) and those in slack water near banks or

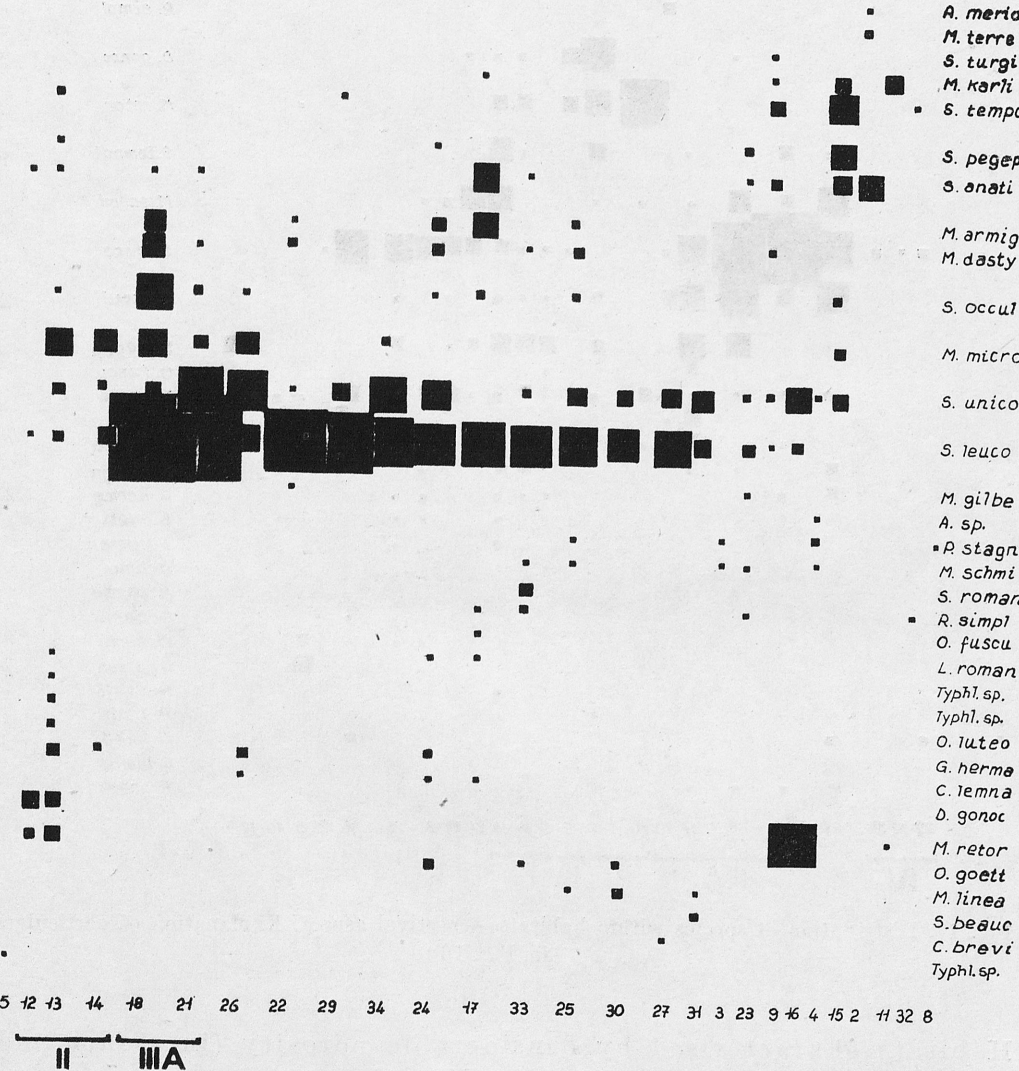


Fig. 16. Distribution of species within habitats (horizontal row of numbers) — vernal aspect. Arrangement of species and habitats explained in the text. Habitats of the same section, if neighbouring, indicated by brackets. Surface of the squares directly proportional to the number of individuals. The smallest square means one individual

in stream bed depressions (organic sediments). These habitats differ from place to place retaining, however, their essential nature. This may be read in Fig. 16—19 where the purely statistical similarities between habitats and species are shown. These figures demonstrate also to what extent fauna is specific to a given stream section and what similarities exist between the particular sections.

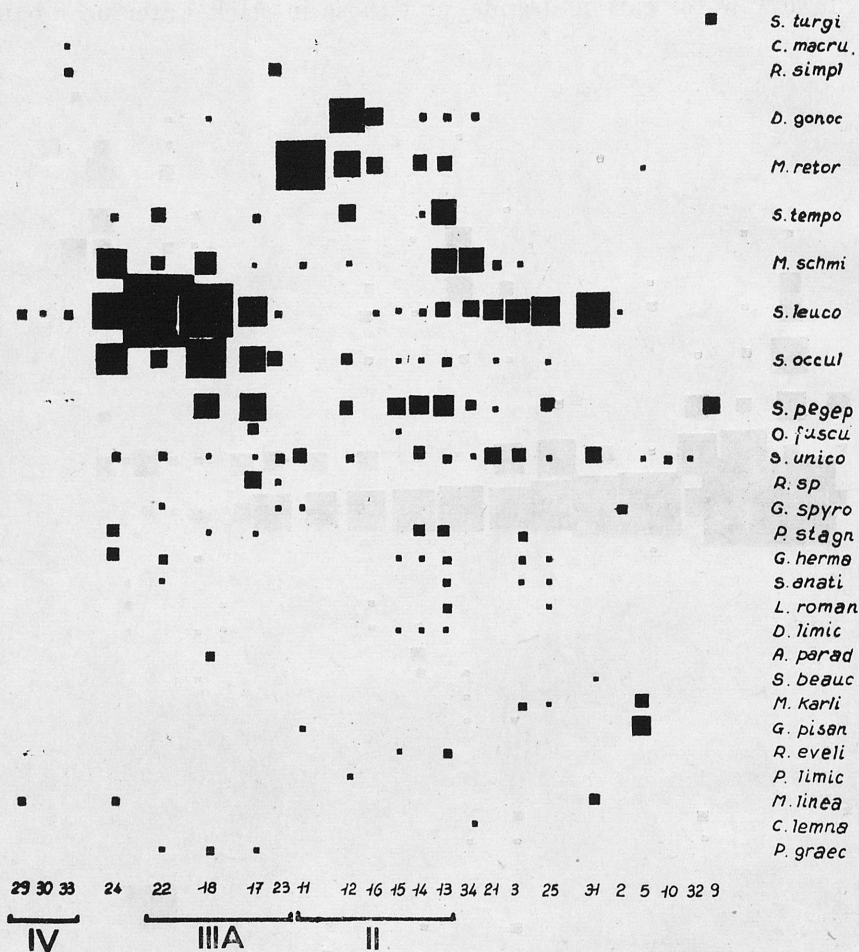


Fig. 17. Distribution of species within habitats — aestival aspect. Explanation of particulars in Fig. 16

Habitats characterised by considerable porosity (in stones and gravel)

Most of the typical limnic genera have their representatives here. Rich in species are the upper sections, while the lower ones are impoverished. *Dugesia gonocephala* is one of indices of this habitat in the upper sections. Also

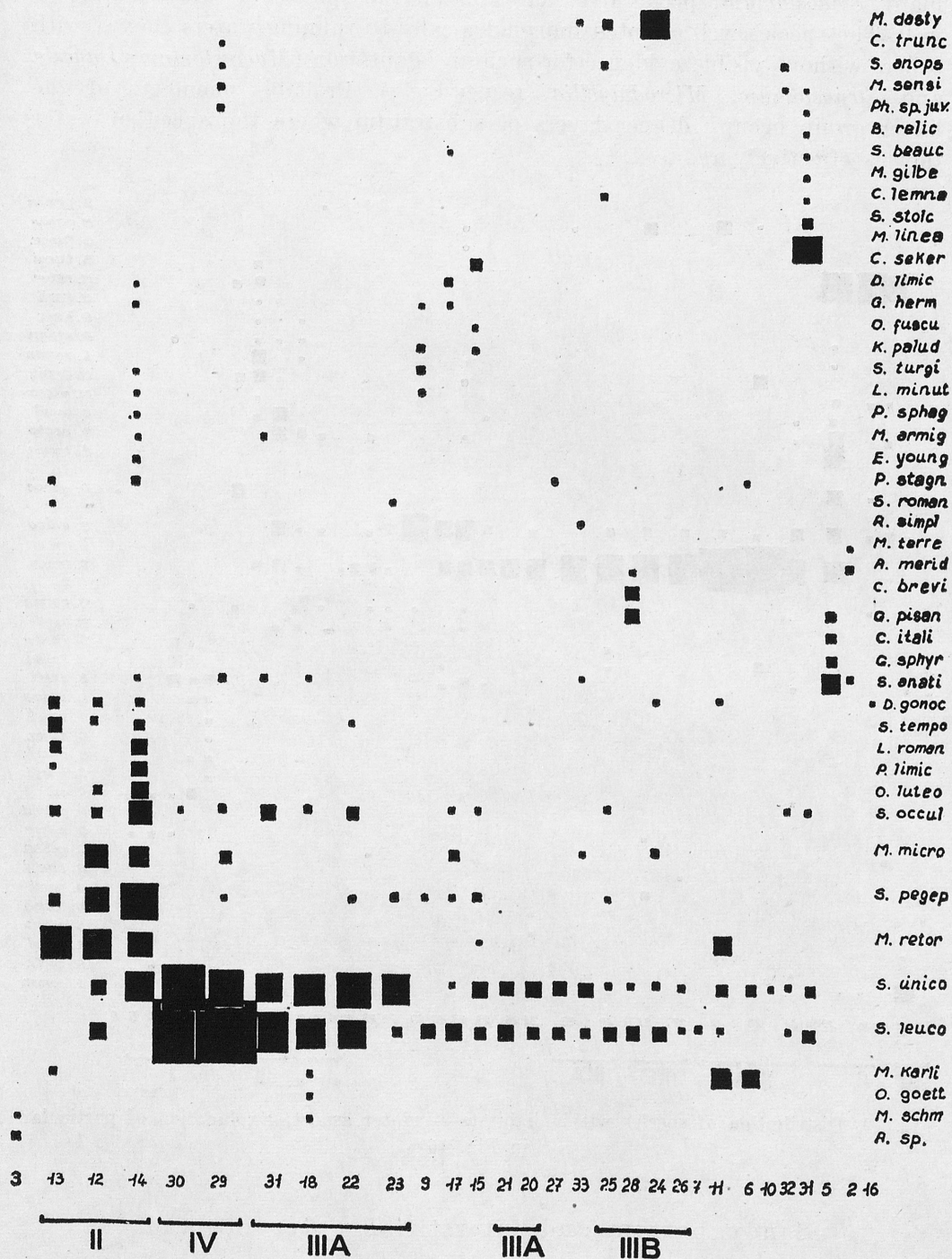


Fig. 18. Distribution of species within habitats — autumnal aspect. Explanation of particular in Fig. 16

many *Stenostomum* species live here and all the species of *Macrostomum* as well. The species well adapted morphologically to running waters coexist with others without visible evidence for such an adaptation (*Macrostomum*, *Dugesia* and *Stenostomum*, *Microdalyellia*, respectively). Probably members of the latter group occupy deeper layers of substratum where the speed of water flow is effectively reduced.

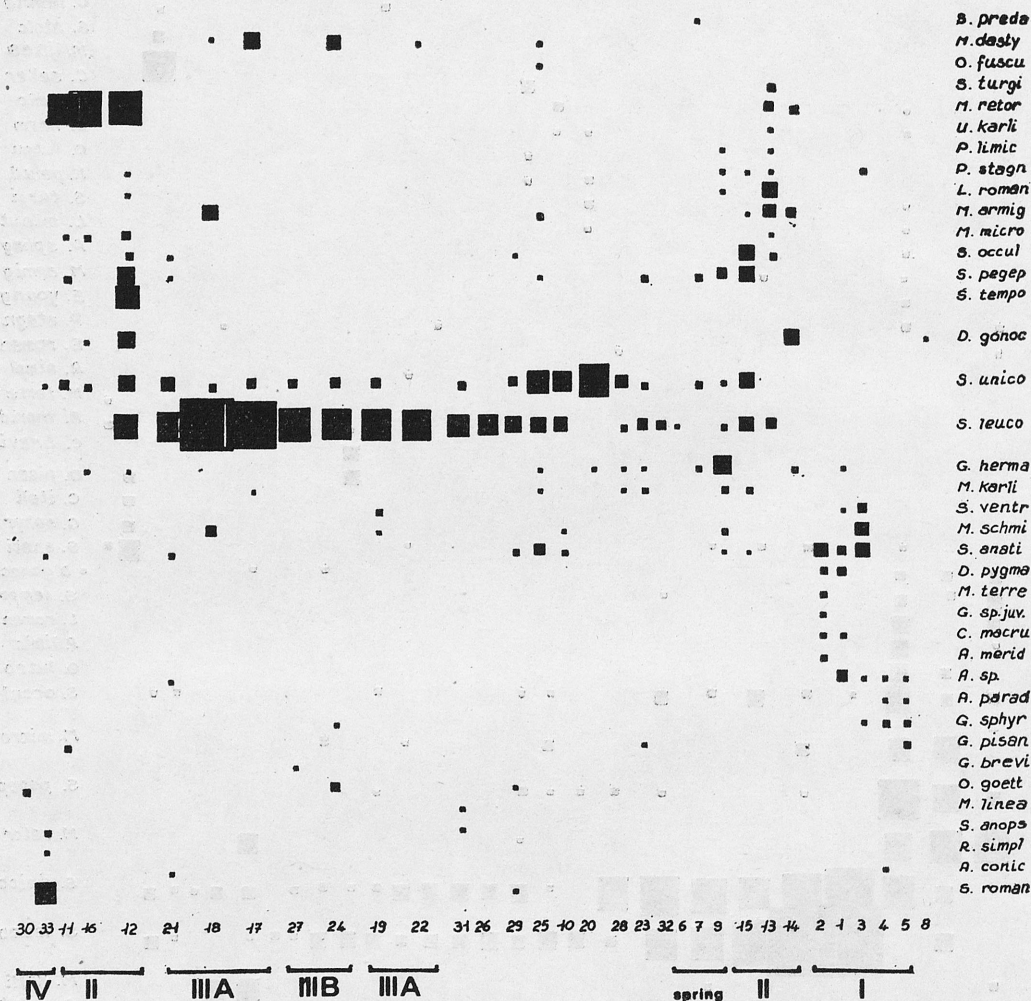


Fig. 19. Distribution of species within habitats — winter aspect. Explanation of particular in Fig. 16

Sandy bottom and interstitial water in sand

At any station but the lowest one this habitat houses a rich array of forms, especially of the genus *Stenostomum*. Many rare species occur here: *Limnoruanis romanae*, *Uncinorhynchus karlingi*, *Opisthomum fuscum*, *Microdalyellia*

microphthalma, *Pilgramilla sphagnorum* and others. Nevertheless, even the species with a high exclusiveness value do not show profound morphological adaptations like elongation of body and adhesive organs as it might be expected and is frequently met in marine psammonic forms. As it was pointed out by BUSH (1968), particularly deep adjustments to interstices appear when movements of water between sand grains are violent. This is not the case with the fine sands of F. Contesora. On the other hand it must be reckoned with that the investigated fauna is relatively young in comparison with the marine turbellarians studied by BUSH. Though some of the species found have the body proportionally longer than average freshwater turbellarians (*Limnoreanis*, *Uncinorhynchus* and a very slim *Typhloplanidae* sp.) or have adhesive abilities (*Stenostomum pegephilum*), these are characteristic of taxonomical higher units rather than of a way of life.

Organic sediments

Despite successful findings in marine sand bottoms (FENCHEL and RIEDEL 1970) no animals were found under anaerobic conditions in F. Contesora. Sediments with sufficient quantity of dissolved oxygen show a species composition differentiated in relation to the stream section or the sort of sediment, but, essentially give shelter to the same species as do nearby habitats. To the species sporadically found though obviously characteristic of this habitat category belong *Sekerana stolci*, *Olisthanella luteophila*, *Ethmorhynchus youngi* and, perhaps, *Phaenocora* sp. In general, the fauna of organic sediments is not very abundant.

Interstitial water between stones and gravel

Like interstices in sand this habitat offers niches for many taxonomically interesting species which seem to be almost exclusive in it but occur in low quantities: *Pseudobockia limicola*, *Suomina turgida*, *Stenostomum romanae*, *Rhynchoscolex evelinae* and *R. simplex* as well as *Microdalyellia dastychi*. However, most of the species found in interstitial waters in stones and gravel were also discovered in adjacent habitats (Table III, Fig. 16—19), the general specificity of the habitat thus being rather low. The fauna of interstitial waters will be discussed in more detail in a separate paper (KOLASA, in preparation).

Mosses

Mosses moistened by waters flowing out of high banks or by a rise of capillar stream water are populated by terrestrial and by amphibious species of the genera *Catenula*, *Dasyhormus*, *Stenostomum*, *Adenocerca*, *Adenoplea*, *Acrochordonoposthia* and *Microplana*.

Mosses which are in direct contact with the stream water sometimes build up a quantitatively rich and different at particular sections fauna. Intermediate and upper sections harbour many *Stenostomum* species, *Macrostomum retortum* and, to a less extent, *Macrostomum karlingi*, *Gieysztorina pisana*;

sometimes *Dugesia gonocephala* and *Castrada brevispina*. The lower sections which are more rich in organic matter, allow thriving *Stenostomum leucops* and *S. unicolor*.

Resuming, the fauna of submerged mosses is composed of accidental limnic elements. Species living in mosses above the water level are prevailingly of terrestrial genera or are typical terrestrial members of limnic genera, yet their occurrence is apparently determined by the stream. It was verified that the true terrestrial fauna of mosses in this area is unlike that associated with the stream. No specific new morphological adaptations have been observed in this habitat.

Temporary sections

Adenoplea paraproxenetes, *Atrioplanaria* sp., *Catenula macrura*, *Geocentrophora sphyrocephala* and some other species occur in the temporary part of the section I. This is a typical amphibious fauna that could be expected here.

In order to compare the distribution of species taking simultaneously into consideration their numbers in particular sections of the stream the diversity index was calculated. It was computed for all the sections in their autumnal aspect according to the modified SIMPSON's formula (cf. COLLIER et al. 1973):

$$di = \frac{\sum_{n=1}^s n_i \left(\sum_{n=1}^s n_i - 1 \right)}{\sum_{n=1}^s n_i (n_i - 1)}$$

where, n_i — number of individuals of i^{th} species; s — number of all species.

The diversity values obtained for the sections are shown in Fig. 20. If the number of presumable relict species is plotted against the diversity values, a positive correlation may be found. The nature of this correlation (Fig. 21) is, however, difficult to interpret. Probably small changes of environment favour an increase in the number of species as well as the survival of old forms (the following species are considered as old elements in the stream: *Uncinorhynchus karlingi*, *Ethmorhynchus youngi*, *Limnoruanis romanae*, *Pseudobockia limicola*, *Lutheria minuta*).

The description of turbellarian distribution through biotopes would be incomplete if seasonal changes in species composition and numbers were neglected. Since most of the species occurred in small numbers, the phenological categories are not very precise, though they may illustrate with some approximation the seasonal variations of fauna. Many species could not be ascribed to any category at all which is due to scarce records.

1. Summer and summer-fall species: *Stenostomum beauchampi*, *Pilgramilla sphagnorum*, *Dochmiotrema limicola*.

2. Fall-spring species: *Adenoplea meridionalis*, *Macrostomum gilberti*, *Microplana terrestris*, *Olisthanella luteophila*.

3. Fall-winter-spring species: *Microdalyellia armigera*, *M. dastychi*, *M. microptalma*, *Castrada brevispina*, *Stenostomum romanae*, *Atrioplanaria* sp.

4. Fall-winter species: *Dasyhormus pygmaeus*, *Macrostomum sensitivum*, *Krumbachia paludicola*, *Acrochordonoposthia conica*, *Adenoplea paraproxenetes*, *Uncinorhynchus karlingi*, *Ethmorhynchus youngi*, *Lutheria minuta*, *Pseudobockia limicola*.

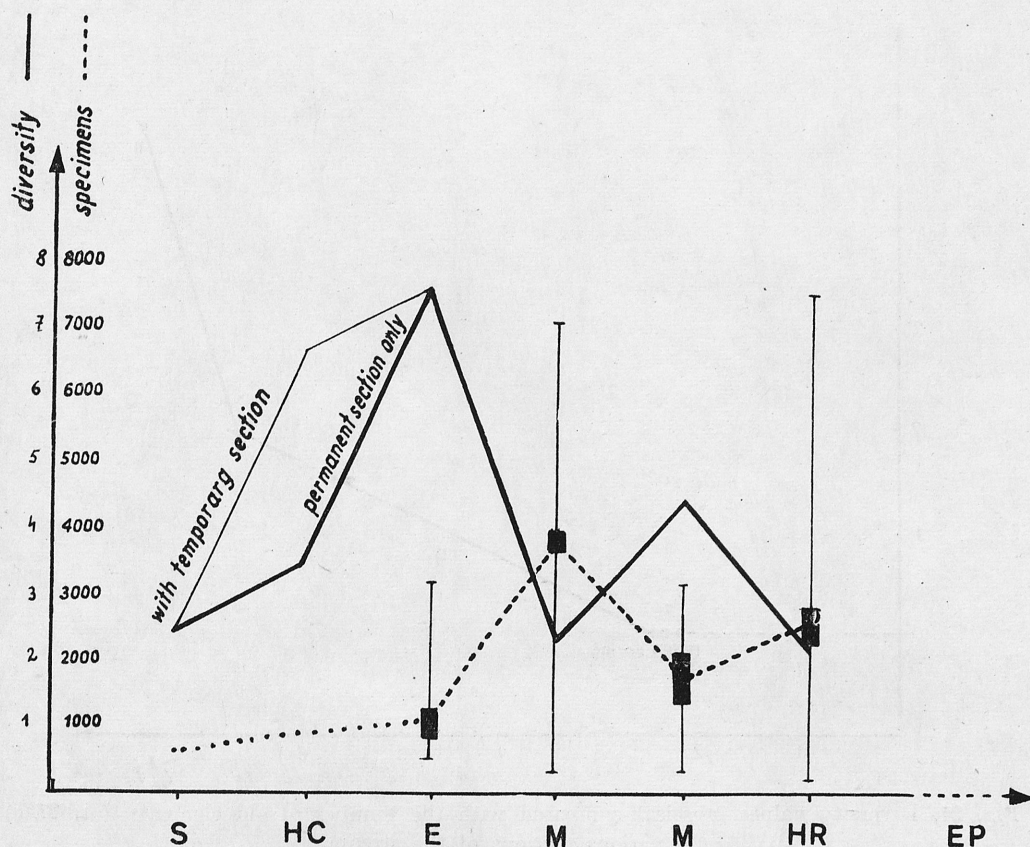


Fig. 20. Diversity values and numbers of specimens per m^2 in various parts of the stream (indicated: arithmetical mean, standard deviation — black rectangles). S — spring, HC — hypocrenon, E — epirhithron, M — metarhithron, HP — hyporhithron, EP — epipotamon

5. Perennial species: *Rhynchoscolex simplex*, *Suomina turgida*, *Stenostomum temporaneum*, *S. unicolor*, *S. leucops*, *S. pegophilum*, *S. anatirostrum*, *S. occultum*, *Microstomum lineare*, *Macrostomum karlingi*, *M. retortum*, *Microdalyellia schmidtii*, *Prorhynchus stagnalis*, *Opistomum fuscum*, *Limnoruanis romanae*, *Gyratrix hermaphroditus*, *Dugesia gonocephala*, *Gieysztorina pisana*.

The general character of phenological changes is due to two main features of the stream: a) its zonation and related to it longitudinal differentiation of

abiotic factors in particular sections and b) seasonal water flow in the sections I and IV (responsible for a lower number of species in summer).

Faunal differences brought about by these main factors may be revealed while analyzing similarities in composition of species in particular sections and habitats (Fig. 16—19). It is found that the linear ordination of biotopes is the best in the sections retaining the most torrential nature (II—IIIB) and during spring, autumn and winter, i. e. when the water flows in all the sections.

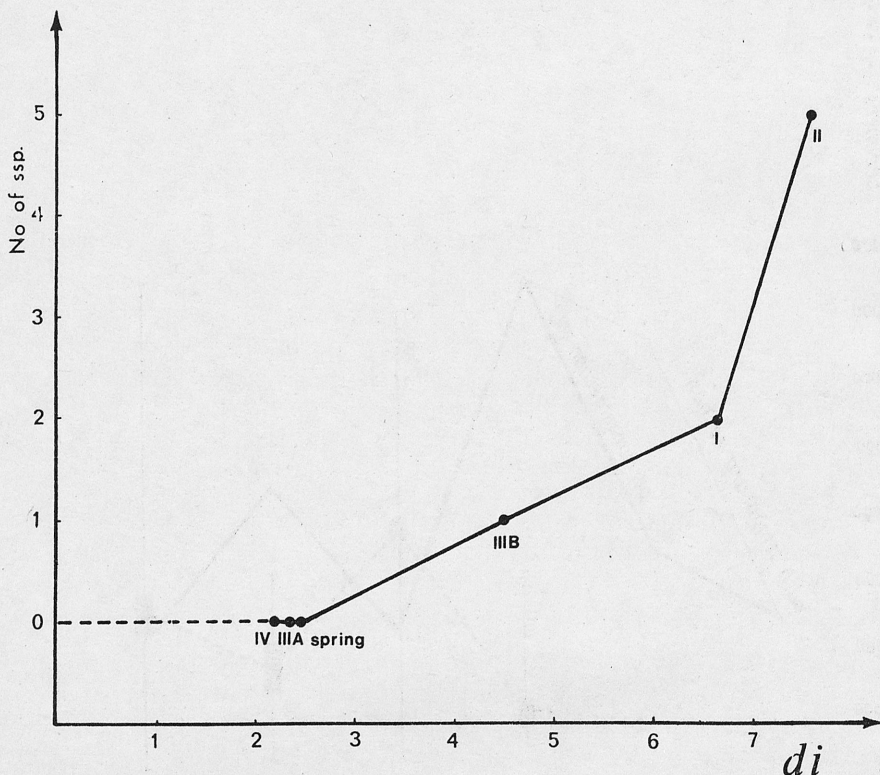


Fig. 21. Diversity values (abscissa) compared with the number of old elements (ordinate) in various sections of the stream

For *Stenostomum leucops*, an eurytopic species present in most sections during the whole year, a seasonal shift of the abundance peak was observed within the sections IIIA—IV.

Ecological ordination of species — synecological species groups

The species occurring in Fosso Contesora have been arranged in groups according to ecological similarities between them. A criterion for recognizing the similarities was the distribution of species within various biozones and biotopes of the stream as well as the literature data. Unfortunately, it was not possible to take into consideration some other ecological characteristics such as, for instance, biology of reproduction, feeding habits etc. because of

the lack of comparable data. The partitioning of the analyzed fauna is not equally precise for different species and synecological groups. If a species occurred in a number of biotopes, the biotope it was observed in the highest number and with a considerable constancy has been decisive of the group to which the species must be included. The nature of other biotopes settled by the species was also regarded. In this context then it is obvious that a certain discrepancy observed between the ecological classification of a species and data obtained for Fosso Contesora results from taking into account also the literature and the author's own unpublished records. The results of the ecological analysis of species are presented in Table IV.

The richest in species is the group of amphibious species (11 species). This situation corresponds to a considerable differentiation of temporary habitats in the upper stream portion. *Turbellaria* of springs are poorly represented and this group comprises species which do not occur in the spring of F. Contesora or, if do so, are more numerous in other biotopes.

Turbellarians of the sandy bottom form also a large group (6 species). Its precise constitution has been obstructed to some extent because of occurrence of sandy bottom species in interstitial waters on one hand and in springs on the other (e. g. *Microdalyellia microphtalma* and *Limnoruanis romanae* are not uncommon in lowland and submontane springs).

Some interstitial species show also connections with the stony bottom which weakens the division line drawn between this group and the group of stone bottom dwellers. This is understandable for interstitial waters fill spaces between sand grains as well as between stones and gravel. Moreover, the strong differentiation in shape and size of both sand and gravel grain in various stream segments contributes significantly to the observable reduction of differences in species composition in stony bottom and other mineral bottoms.

Turbellarians of the organic bottom are, in comparison with the three previous groups, a small though well separated unit.

Finally, a group of limnophilous species may be distinguished. This category is very general but the application of more detailed divisions does not seem purposeful to analyze stream dwelling fauna.

A considerable part of the whole fauna falls to the group of eurytopic species. The species belonging here differ substantially in their degree of eurytopy; further detailed investigations will presumably allow to determine more exactly their habitat requirements. Some of them are, to some extent, amphibious (e. g. *Prorhynchus stagnalis*) or cold preferring species (*Microdalyellia armigera*, *M. schmidtii*, *Opisthocystis goettei*, *Bresslawilla relicta*).

In order to analyze changes of fauna along the stream course in more depth it is important to pay attention not only to synecological groups, but also to consider transformations of their internal structure. A study of the synecological group internal structure has been limited to their genetical composition; the species were arranged in groups reflecting their ecological and zoogeographical origin.

Syngenetical groups of species

An extensive presentation of underlying principles which were employed in grouping the species of common ecological and zoogeographical origin will be published by BIESIADKA (in preparation). In this paper only the basic criterion, which seems to determine the species origin, is explained. For the habitat (or area) of origin of a species is considered either that habitat (area) in which most of the related species occur, or the habitat the species is mainly associated with. In the case of more detailed divisions, e. g. that of freshwater species, a degree of association with the habitat remains the main criterion for determination of the ecological origin. Such a solution is due to the fact that the ecological differentiation of the genuinely freshwater fauna does not correspond, as a rule, to the similar taxonomical differentiation (compare taxonomical composition of the synecological groups — Table IV).

The following syngenetical species groups have been distinguished:

1. Group of terrestrially originated species
2. Group of marine originated species
3. Group of species of freshwater origin
 - a) species of underground waters
 - b) species of clean running waters
 - c) species of stagnating waters
 - d) eurytopic species

The species which could not be classified into any of the groups because of their poor knowledge have been denominated as "others".

Group of terrestrially originated species

Species belonging to typically terrestrial genera or families and often occurring in terrestrial biota are included here: *Acrochordonoposthia conica*, *Adenoplea meridionalis*, *Adenocerca minima*, *Microplana terrestris*, *Chorizogynopora italica*, *Adenoplea paraproxenetes*, *Pseudobockia limicola*.

Group of marine originated species

Species belonging to sea dwelling genera or families and or species related most closely to marine fauna. The following are included here: *Limmoruanis romanae*, *Uncinorhynchus karlingi*, *Ethmorhynchus youngi*, *Opisthocystis goettei*, *Pilgramilla sphagnum*, *Sekerana stolci*. *Gyatriax hermaphroditus* has been excluded from the group despite its undoubtedly marine origin since it belongs to the eurytopic species group. Similarly, *Bresslauilla* seems to be associated mainly with stagnant waters (lakes). In these two cases the marine origin is much more remote in comparison to freshwater one.

Groups of species of freshwater origin

Species included in this group belong to higher taxa which have undergone the differentiation in freshwaters.

a) species of underground waters

The knowledge of underground water turbellarians is very scanty. Among species which are probably typical dwellers in this habitat the following are listed: *Stenostomum romanae* and *Krumbachia paludicola*.

b) species of clean running waters

This group comprises: *Dugesia gonocephala*, *Ascophora paradoxa*, *Macrostomum karlingi*, *M. gilberti*, *Stenostomum pegephilum*, *Gieysztoria pisana*, *Microdalyellia microptalma*, *M. dastychi*.

c) species of stagnating waters

The following group of species includes forms considerably different from the ecological point of view: *Catenula lemnae*, *Stenostomum beauchampi*, *S. anops*, *S. predatorium*, *Microstomum lineare*, *Macrostomum sensitivum*, *Bresslauilla relicta*, *Opisthomum fuscum*, *Dugesia polychroa*.

d) eurytopic species

Stenostomum unicolor, *S. leucops*, *Prorhynchus stagnalis*, *Castrella truncata*, *Gyratrix hermaphroditus*.

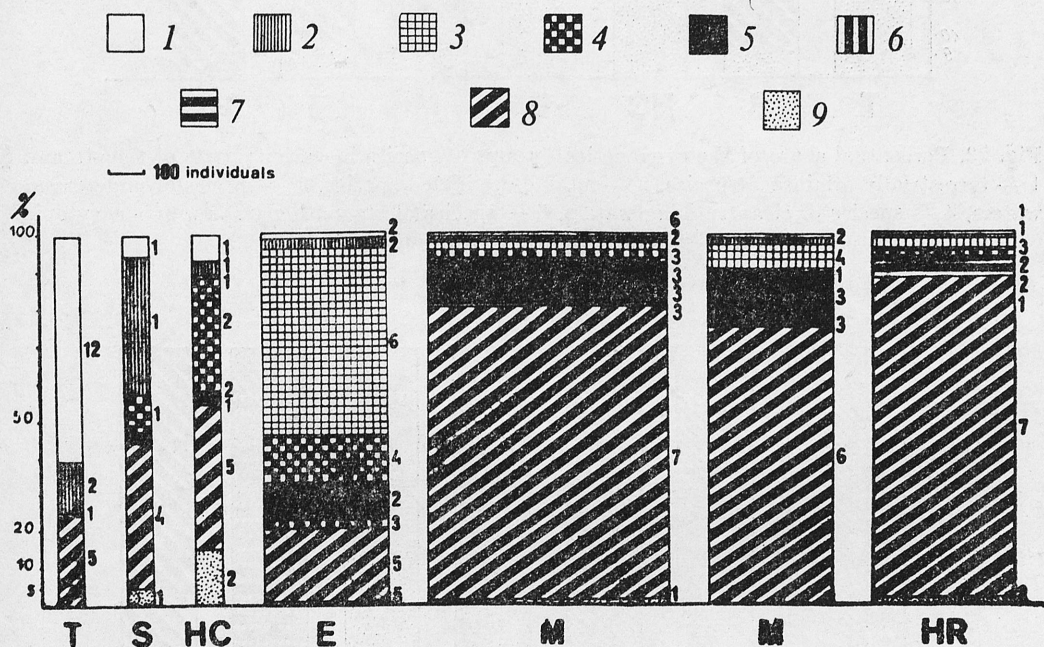


Fig. 22. Percentual share of the synecological groups of species in diverse parts of the stream. 1 — amphibious species, 2 — species of springs (crenophiles), 3 — sandy bottom species, 4 — interstitial species, 5 — stony bottom species, 6 — species of the organogenic bottom, 7 — limnophilous species, 8 — species of wide ecological valence, 9 — others. T — temporary section, S — spring, HC — hypocrenon, E — epirhithron, M — metarhithron, HR — hyporhithron. Ciphers on the right side of columns mean the number of species in each group

The distribution and share of the synecological groups in particular stretches of the stream are presented in Fig. 22, while those of the syngenetical groups in Fig. 23. The genetical structure of the synecological groups is illustrated in Fig. 24. An analysis of these figures (Fig. 22—24) leads to the formulation

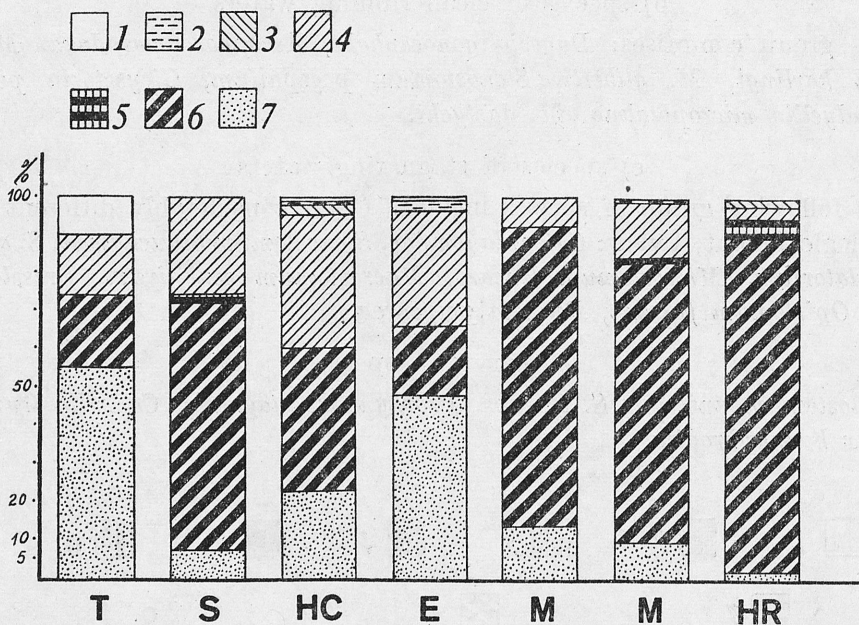


Fig. 23. Percentual share of the syngenetical groups of species in various parts of the stream. 1 — terrestrially originated species, 2 — marine originated species, 3 — species of underground waters, 4 — species of clean running waters, 5 — species of stagnating waters, 6 — eurytopic species, 7 — others. Other abbreviations as in Fig. 22

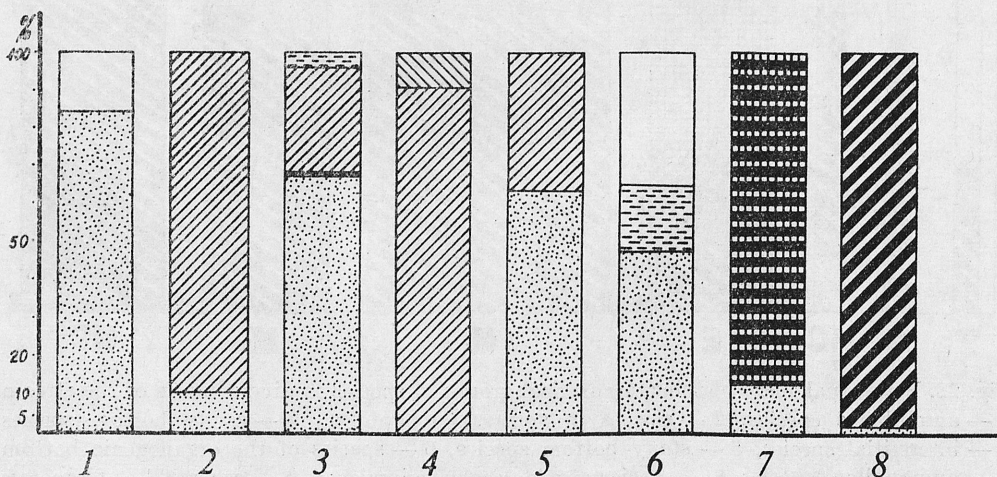


Fig. 24. Genetical composition of the synecological groups (numbered 1—8 as in Fig. 22). Shading pattern of the syngenetical groups as in Fig. 23

of some general properties of the distribution of fauna along the stream. These are as follows:

- a relatively complex synecological structure of fauna in the temporary section, spring, hypocrenon and epirhithron,
- a relatively high specificity of turbellarian communities in the foresaid stream zones: in the temporary section — a group of amphibious species, in the spring — a group of crenophilous species, in the hypocrenon — an interstitial species group, in the epirhithron — a group of sand living species,
- a downstream increase in the share of species which have wider ecological valency with a simultaneous decrease of specificity in composition of species settling particular habitats,
- a decline in the number of species associated with running waters correlated positively with the direction of water flow,
- an occurrence of land originating species almost exclusively in the section with temporary flow of water.

Downstream succession of turbellarian communities

A concept of ecological succession introduces some ordination into interpretation of mosaic and zonal differentiation of fauna and therefore it improves the description of this fauna. If in stagnant water bodies time or extensive comparative studies are required to study succession, in running waters the successional processes may be investigated in different stretches (MIKULSKI 1958; BIESIADKA 1978).

The most suitable way to discuss the turbellarian succession is to base its description on recognized ecological zones. SCHWOERBEL (1965) and BIESIADKA (1978) have determined more exactly the biological zones in montane and submontane watercourses originally distinguished by ILLIES and BOTOȘANEANU (1963). The biozones found in F. Contesora are as follows: eucrenon, hypocrenon, epirhithron and metarhithron. The biozone formation is related to a geomorphological development of the stream valley and bed; the conditions occurring in F. Contesora are shown in Fig. 25. The distinguished biozones differ also as regards their faunal diversity and number of individuals found in each (Fig. 20). Differences of this type seem characteristic of submontane running waters in general.

An analysis of the sequence and paths of settlement of particular habitats can serve as a basis to study the formation of species communities. In fresh waters the patterns of turbellarian succession, with exception of triclads, have not been paid attention so far.

Fauna of the helocrene spring, which feeds the section I temporary part, does not penetrate into any of the adjacent habitats, thus it does not constitute an initial succession stage for those habitats (Fig. 26 and 27). The helocrene species are elements with wider ecological valency and diverse origin. This and a traceable similarity to the fauna of metarhithron (e. g. the presence of

Microdalyellia schmidtii) suggest it to be a remainder of a faunistic complex with rather complicated history. A community of the temporary section finds itself on species of terrestrial origin, which are probably immigrating repeatedly into this section, and on species well adapted to the temporary waters (*Geocentrophora sphyrocephala*, *Adenoplea paraproxenetes*, *Catenula macrura*, *Stenostomum ventronephrium* and others). This community shows, like the previous one, no further succession but it is neither its variation. The main sequence of sera begins from the reocren spring. Crenon elements, or perhaps even underground water elements (*Macrostomum karlingi*, *Krumbachia paludicola*) have certain share in the hypocrenon interstitial group of species.

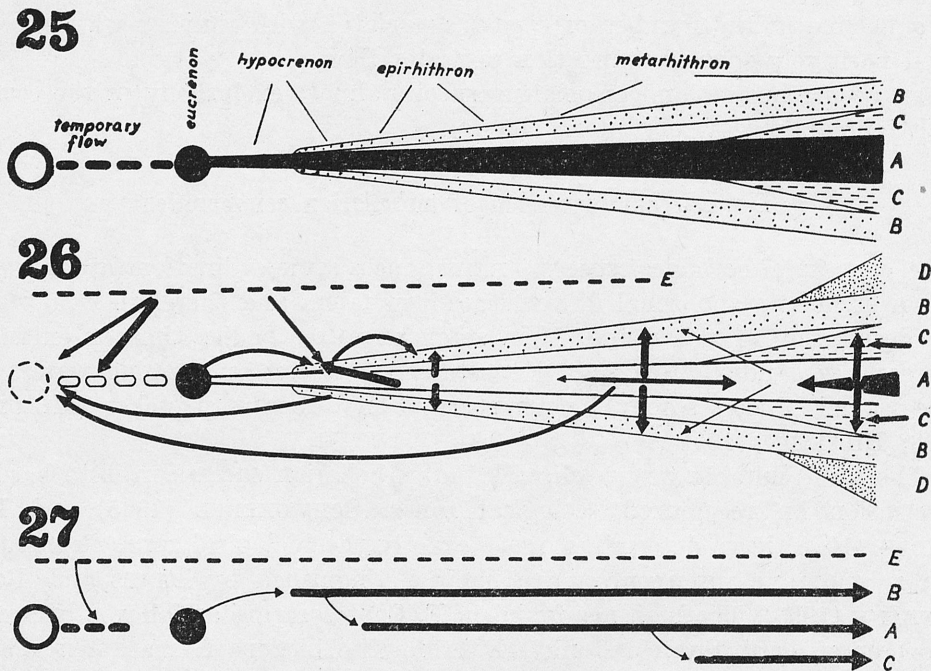


Fig. 25—27. Fosso Contesora: schematical division into biological zones and main habitats — 25; approximative estimation of main directions along which individuals of particular species are thought to migrate; the arrow basis indicates the habitat where a concerned group of species is abundant most — 26; schematical representation of succession of turbellarian fauna in Fosso Contesora — 27. A — main current, B — interstitial habitats, C — slack waters (marginal pools), D — deep interstitial waters, E — terrestrial habitats

Beside that, the hypocrenon community is enriched with terrestrial and epirhithron elements (*Stenostomum anatirostrum*, *S. pegophilum*, *Limnoruanis romanae*, *Pseudobockia limicola*; Fig. 26). The community of benthic fauna of epirhithron may be considered the next successional stage of the line which begins in the reocrene spring. In this community both the qualitative and quantitative share of terrestrial originated forms decreases; they are replaced by typical reophile forms (*Dugesia gonocephala*, *Macrostomum retortum*?, *Microdalyellia*

microphthalma). An initial stage of another line of succession may be seen in the community inhabiting epirhithron interstitials. The line of interstitial water fauna develops, to some extent, independently of the surface water communities. In this line changes in the composition of fauna are characterized mainly by an increase in the share of typical benthic forms with wider ecological valency (*Stenostomum leucops*, *S. unicolor*, *Microstomum lineare* and others). The status of interstitial communities is evidenced in Fig. 16—19 which represents faunal similarities between particular habitats. In the four diagrams the interstitial habitats appear as 26 elements. Ten of them show similarities to the neighbouring benthic habitats. In three cases they are similar to habitats occurring in other sections and lastly, thirteen disclose statistical affinity to other interstitial biotopes, i. e. there are seven cases of distinct similarity. The closest are the biotopes 9 and 15 in the permanent part of the section I and in the section II, respectively. Their similarity lasts through three seasons

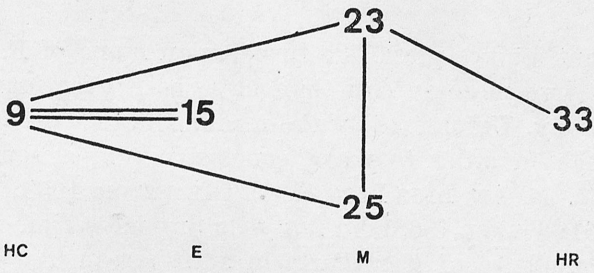


Fig. 28. Similarities between interstitial habitats of Fosso Contesora. The habitats numbered according to the list of habitats sampled (page 302—304). HC — hypocrenon, E — epirhithron, M — metarhithron, HR — hyporhithron

but summer. In the winter and fall this is the only detected case of similarity. The other statistical connections visualized by the diagrams are as follows: 9 and 25 (in the section IIIB); 9 and 23 (the distant interstitial site in the section IIIA); 23 and 33 (in the section IV between stones and gravel) and ultimately, 23 and 25. This situation, presented graphically in Fig. 28, reflects with certain approximation the linear development of the stream.

The interpretation of this picture cannot be unequivocal. On one hand the common features of the interstitial biotopes are undeniable and on the other the strong and frequently occurring coenological similarities to the benthic communities point at a functional unity between the two domains rather than a pure penetration.

In the epirhithron some species sporadically found in hypocrenon become more numerous (*Pseudobockia limicola*, *Suomina turgida*, *Stenostomum pegophilum*). From this zone on the immigration of species from adjacent habitats is less visible in the benthic fauna. In the course of its succession replacements of species inhabiting typically in-current habitats (triclads and species of the genera *Macrostomum* and *Microdalyellia*) as well as replacements in the organic

and mixed sediments are observed to take place (members of the *Kalyptorhynchia* exemplify this phenomenon). The partly isolated marginal pools, which appear in the metarhithron zone, are populated mainly with benthic forms which are usually more numerous in slack waters (*Stenostomum leucops*, *Catenula lemnae*, *Microstomum lineare*). In short, the fauna of the marginal pools tends to resemble that of small stagnant waters. Probably some stagnant water species immigrate into this type of habitat from pools and puddles not uncommon in the Serchio River flood terrace.

In Fig. 26 the deeper layers of interstitial waters, which occur in the section IV, are shown. Their rather individual though simple faunal structure may apparently be related to successional line of the interstitial waters of Serchio River into which the studied stream disembcgues.

CONCLUSIONS

The carried out studies prove the turbellarian fauna of F. Contesora to be very rich. There live more species than have been ever found in any single standing water body. Unfortunately the running waters were not investigated thoroughly enough in order to make conclusive comparisons. However, the available data (e. g. AN DER LAN 1967; GIEYSZTOR 1958; HUSMANN 1966; SCHWOERBEL 1961; TILZER 1968) did not yield any indication of the high faunal diversity and abundance of *Turbellaria* in swift streams.

It seems that the faunal richness is a result of the two following factors: the first one is a considerable habitat differentiation in the studied type of watercourse (on the one hand the differentiation is due to great changes in the physico-chemical and biological regimes occurring along the watercourse, on the other hand it is due to the mosaic distribution of various substrata which is caused by both the diversified shape of the stream bed and the water velocity — GIEYSZTOR 1958. Local geological conditions have also certain impact on the final diversity of environment).

It may be supposed that there is second prerequisite necessary for formation of a rich fauna in F. Contesora. It is the general richness of turbellarian fauna in running waters; this conclusion needs, however; a field confirmation over larger areas in Europe.

The investigated fauna of *Turbellaria* was found to be genetically very heterogeneous. Unfortunately, the very important group of those species, which are genetically bound to running waters, is poorly known as far as their distribution and autecology are concerned. As a proof of it the finding of 12 new species in F. Contesora may be adduced. Eight of them are expected to occur in running waters only. Other three reveal genetical connections with terrestrial fauna which is also insufficiently known.

Noteworthy is the high share of both terrestrial forms and forms of marine origin in the fauna of F. Contesora. It seems to be a main character differing small

running waters from the other types of water bodies (e. g. rivers, estuaries, oligotrophic lakes are also inhabited by a relatively high number of marine originating species (KOLASA 1977d) but do not show relations with the terrestrial fauna).

Another interesting feature of the studied stream, which is hardly explainable at the moment, is the great quantitative and qualitative importance of *Catenulida* and of the genus *Stenostomum* in particular (76.6 per cent of the total domination, Table III). There are at least four genera either outnumbering or equalling the genus *Stenostomum* as far as the species richness is concerned but in the stream investigated only the genera *Macrostomum* (8.6 per cent of the total domination) and *Microdalyellia* (7.0 per cent of the total domination) have certain significance in the formation of fauna. The other large European genera: *Gieysztoria*, *Mesostoma*, *Phaenocora*, *Castrada*, *Olisthanella* are represented very poorly (below 0.5 per cent of the total domination) or not at all. At the present stage of turbellarian knowledge it is difficult to recognize whether the obtained faunistical pattern is commonly developed in the small running waters.

As a result of this study the number of species known in Appenine Peninsula increased by 27.

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Znajomość wirków wód bieżących jest bardzo słaba i praktycznie ograniczona jedynie do obszaru Europy. W celu uzyskania danych umożliwiających wstępne scharakteryzowanie fauny wirków w tym rodzaju wód oraz danych pogłębiających ogólną znajomość wirków europejskich podjęto badania nad wybranym strumieniem podgórskim w środkowej części Półwyspu Apenińskiego (Fosso Contesora w Monti d'Oltreserchio). Badany strumień wykazuje znaczne zróżnicowanie środowiskowe charakterystyczne dla tego typu wód.

Badania prowadzono przez ponad jeden rok pobierając regularnie próby w odstępach miesięcznych w 34 środowiskach wyróżnionych w poszczególnych odcinkach strumienia. Z ogólnej liczby 220 prób uzyskano 7600 osobników należących do 61 gatunków. W niektórych, typowych środowiskach potokowych, pobierano próby ilościowe ramką: na dnie kamienistym, żwirowatym, piaszczystym oraz w interstycjalu. W pozostałych środowiskach pobierano nieco mniejsze próby jakościowe. Wprowadzono nową i bardziej wydajną metodę uzyskiwania zwierząt z tych prób, w których osadzie nie wykształca się wyraźny deficyt tlenowy.

Omówiono znalezione gatunki ze szczególnym podkreśleniem charakteru środowisk, które są zwykle przez nie zasiedlane. W wielu przypadkach omówienie zawiera częściowe lub pełne opisy morfologiczne. Redeskrypeji dokonano w stosunku do *Stenostomum pegephilum* i *Macrostomum gilberti*. W wyniku przeprowadzonych badań stwierdzono i opisano w odrębnych notatkach 12 nowych dla nauki gatunków wirków należących do różnych rodzin i rodzajów: *Stenostomum romanae*, *S. temporaneum*, *Gieysztoria pisana*, *Microdalyellia dastychi*, *Chorizogynopora italica*, *Pseudobockia limicola*, *Adenocerca minima*, *Adenoplea meridionalis*, *Lutheria minuta interstitialis*, *Olisthanella luteophila*, *Uncinorhynchus karlingi*, *Ethmorhynchus youngi* i *Limnoruanis romanae*.

Wśród ostatnio opisanych gatunków na szczególną uwagę zasługują formy nie wykazujące bliższych powiązań genetycznych ze słodkowodną fauną wirków: *Ethmorhynchus youngi*, *Limnoruanis romanae*, *Uncinorhynchus karlingi*, *Pseudobockia limicola*. W faunistycznym obrazie badanego strumienia podkreślić należy duży udział gatunków pochodzenia lądowego, amfibiotycznych oraz gatunków pochodzenia morskiego.

Uzyskane dane dotyczące liczebności i rozmieszczenia gatunków w poszczególnych środowiskach zostały wykorzystane do utworzenia synekologicznych i syngenetycznych grup gatunków w celu stworzenia podstaw dla omówienia i ogólnego scharakteryzowania badanego strumienia przez wirki. Zauważono pewne ogólne cechy rozmieszczenia wirków:

- struktura synekologiczna fauny w odcinku okresowym, źródle, hypocrenonie i epirhithronie jest bardziej złożona, niż w dolnych odcinkach,
- specyfika składu gatunkowego w powyższych odcinkach jest stosunkowo duża: w odcinku okresowym charakterystyczna jest grupa gatunków amfibiotycznych, w źródle — grupa gatunków krenofilnych, w hypocreno-

- nie — grupa gatunków interstycjalnych, w epirhithronie — grupa gatunków dna piaszczystego,
- w dół strumienia wzrasta udział gatunków o większym stopniu eurytopowości i spada jednocześnie specyfika zasiedlenia środowisk,
 - liczba gatunków związanych ściśle z wodami bieżącymi spada w dolnych odcinkach strumienia,
 - gatunki pochodzenia lądowego występują głównie w odcinku okresowym.

Podjęto próbę odtworzenia dróg sukcesji wirków Fosso Centesora ze zwróceniem uwagi na kolejno wyodrębniające się, w miarę przebudowy warunków geomorfologicznych i biotycznych cieku, kierunki kształtowania fauny. Wyraźniej zaznacza się kierunek związany z głównym nurtem potoku oraz kierunek związany z trwalszymi zastoiskami. Zasadniczy ciąg stadiów sukcesyjnych środowiska prądowego zawiązuje się dopiero w epirhithronie.

Zauważono, że fauna badanego strumienia jest bogata w porównaniu z innymi rodzajami wód (brak niestety poważniejszych danych porównawczych z innymi drobnymi, naturalnymi i czystymi wód bieżącymi). Przypuszczalnie oznacza to, że fauna wirków czystych wód bieżących jest bardzo zróżnicowana.

Stwierdzono, że w faunie badanego strumienia szczególnie dużą rolę odgrywają wirki z filogenetycznie prymitywniejszej grupy rzędów *Archophera*; szczególnie *Catenulida* z rodzaju *Stenostomum*.

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