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Benthic rotifera inhabiting the bed sediments of a mountain gravel stream

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Keywords: Rotifera, Monogononta, Bdelloidea, micro-meiofauna, gravel stream.

Summary: 69 Rotifera species (42 Monogononta and 26 Bdelloidea species) were recorded in the bed sediments of the mountain gravel stream Oberer Seebach, between October 1991 and October 1992. 30% of the total number of species were present in a debris dam area between April and October 1992. Moreover, 19% of all species occurred at the sediment surface (0-10cm), while 12% were exclusive inhabitants of the hyporheic interstitial (0-40cm).
General remarks on their spatial and temporal distribution in this gravel stream are given. This information is complemented with figures of the species collected, as further contribution in their general ecology.

Introduction:

The importance of rotifers as members of the benthic meiofaunal assemblages has been well documented and more recently there has been an increase awareness of the potential link that rotifers may form in the substrate of flowing freshwaters (PALMER, 1991; PALMER et al.,1992; SCHMID-ARAYA, 1992a,b). Nevertheless, compiled Rotifera species lists in lotic systems referred often to Rotifera assemblages inhabiting: a) the sediment surface of small streams (DONNER, 1975; ZULLINI & RICCI, 1980; EVANS, 1984; SCHWANK, 1988), b) moss dwelling rotifers (BURGER, 1948; MADALINSKY, 1961; DONNER, 1970, 1972) or c) submersed macrophytes (DONNER, 1964).

On the other hand, there is an increasing recognition of the existence of a distinct hyporheic fauna confirmed by the raising number of publications (see BOULTON et al. 1992, and references therein). Nevertheless, among several of these works the group Rotifera has been often either considered as: a) a poor representative group in streams (e.g. SCHWOERBEL, 1965; BOULTON et.al. 1992), and rivers (DANIELOPOL, 1976), or b) evidenced as a dominant taxa in sandy bottom streams (PALMER 1991), and rivers (FERRARESE & SAMBURGAR, 1976). In both views, a lack of species lists persists in the literature, with the exception of records of hyporheic rotifers in the River Adige (BRAIONI & GOTTARDI, 1979) and River Brenta in Italy (BRAIONI et al. 1980).

The present contribution, as part of a larger research project, gives preliminary results on the benthic Rotifera taxonomy inhabiting the sediment surface (0-10cm) and the hyporheic interstitial (0-40cm) of a mountain stream, between October 1991 and October

1992. Additional information is given respect of the rotifer species occurring at a debris dam in the backwater area of the stream, between April and October 1992.

Material and Methods

The study compiles data obtained from a sampling routine carried out in the experimental area Ritrodat of the Oberer Seebach between October 1991 and October 1992, described in SCHMID-ARAYA (1992a,b). Quantitative samples at the sediment surface were collected using a modified Hess sampler (area: 2.83 dm^{-2}, mesh net: 60 µm) in five different locations at roughly weekly intervals. Samples from the hyporheic interstitial were obtained from four different replicated depth layers (0-10, 10-20, 20-30 and 30-40cm) using stand-pipe traps installed permanently within the experimental reach at every fortnight intervals. One litre of interstitial sediment and water was collected after maintaining the pipes opened for twenty-four hours (SCHMID-ARAYA, 1992b).

Samples were cooled and transported to the laboratory within 1-2 hours. These were stirred, homogenized and sieved through 250, 100 and 30µm mesh nets and stored in a temperature-controlled chamber at 4°C.

In addition qualitative samples were taken from a debris dam situated in a backwater area of the Oberer Seebach, between the end of April through October 1992.

Identification and enumeration took place in each fraction on live material, as already recommended for freshwater interstitial rotifers by RUTTNER-KOLISKO (1971). Trophy analysis were executed in a number of rotifers belonging to the Superorder Monogononta with the use of 5% KOH. For individuals belonging to the Superorder Bdelloidea, identification was done on live specimens. Because the procedure can take some days, these individuals were kept in culture dishes in temperature controlled chambers. The following systematic works were used for diagnostic: a) Bdelloidea: BARTOS (1951), DONNER (1965); b) Monogononta: HARRING & MYERS (1924), VOIGT (1957 in German), BARTOS (1959, in Czeckoslovakian), RUDESCU (1960, in Rumanian), KUTIKOVA (1970, in Russian), RUTTNER-KOLISKO (1974) and KOSTE (1978 in German).

Results

A total of 69 taxa of rotifers from which 42 species belong to the Superorder Monogononta and 27 species to the Superorder Bdelloidea (Digononta) were recorded in the Oberer Seebach between October 1991 and October 1992 (Table 1). All 42 Monogononta species are first time records in this mountain gravel stream, while the comparison to the Bdelloidea species list of BRYCE (1926), reveal 20 first time records of this group in this area. 30% of the total species number was found in the backwater debris dam, between May and October 1992, from which 4% were exclusive inhabitants of this

area (Table 1). At the same time, 19% of all species occurred only at the sediment surface (0–10cm), while 12% appeared only in samples from the hyporheic interstitial (0–40cm, Table 1).

Super Order MONOGONONTA			
Order Ploimida			
Fam.Brachionidae			
1. *Notholca foliacea* (Ehrb.)	x	o	#
2. *N. cf. labis* Gosse	x	-	-
3. *N. squamula* (O.F.M)	x	o	-
Fam.Euchlanidae			
4. *Euchlanis deflexa* (Gosse)	x	o	-
Fam.Mytilidae			
5. *Lophocharis salpina* (Ehrb.)	x	-	-
Fam.Colurellidae			
6. *Colurella colurus* (Ehrb.)	x	o	-
7. *Colurella sp.*	x	o	#
8. *Lepadella acuminata* (Ehrb.)	-	o	-
9. *L. ovalis* (O.F.M.)	x	o	#
10. *L. triptera* Ehrb.	-	o	-
Fam.Proalidae			
11. *Proales theodora* (Gosse)	x	o	-
12. *P. globulifera* (Hauer)	x	-	-
13. *P. fallaciosa* Wulf.	x	-	-
14. *P. similis* De Beauchamp	x	o	-
15. *Proales sp.*	x	o	-
Fam.Notommatidae			
16. *Drilophaga bucephalus* Vejdovsky	x	-	-
17. *Monommata sp.*	-	o	-
18. *Resticula nyssa* H.& M.	-	-	#
19. *Resticula sp.*	x	-	#
20. *Pleurotrocha petromycon* Ehrb.	x	o	-
21. *Notommata sp.*	-	o	-
22. *Cephalodella forficula* (Ehrb.)	x	o	-
23. *C. gibba* (Ehrb.)	x	o	#
24. *C. cf. gobio* Wulf.	x	o	-
25. *C. cf. gracilis* Donner	x	o	-
26. *C. cf. incila* Wulf.	x	o	-
27. *C. cf. rigida* Donner	-	o	-
28. *Cephalodella sp.*	-	o	-
Fam.Trichocercidae			
29. *Trichocerca (Diurella) porcellus* (Gosse)	x	-	-
30. *T. (Diurella) taurocephala* (Hauer)	x	o	-
Fam.Synchaetidae			
31. *Synchaeta sp.*	(&)		
Fam.Dicranophoridae			
32. *Dicranophorus forcipatus* (O.F.M.)	x	-	#
33. *D. liepolti* Donner	x	o	-
34. *D. lütkeni-sigmoides* (Bergendal)	x	o	-
35. *D. uncinatus* Milne	x	o	#
36. *Wierzejskiella sabulosa* (Wiszniewski)	-	o	-
37. *Encentrum cf. gulo* Wulf.	-	o	-
38. *E. cf. incisum* Wulf.	x	o	#
39. *E. cf. lupus* Wulf.	x	o	-
40. *E. mustela* (Milne)	x	o	-
41. *E. mucronatum* Wulf.	-	o	#
42. *Encentrum sp.*	x	o	-
43. *Paraencentrum longipes* (Wulf.)	x	o	-
Order Gnesiotrocha			
Suborder Collothecacea			
Fam.Collothecidae			
44. *Collotheca sp.*	(&)		

Super Order DIGONONTA			
Order Bdelloidea			
Fam. Habrotrochidae			
45. *Habrotrocha collaris* (Ehrb.)	x	o	-
46. *Habrotrocha proxima* Donner	x	-	#
47. *Habrotrocha cf.pusilla* (Bryce)	-	-	#
Fam.Philodinidae			
48. *Philodina acuticornis* Milne	x	o	-
49. *P. flaviceps* Bryce	x	o	#
50. *P. nemoralis* Bryce	x	o	-
51. *P. plena* (Bryce)	x	-	-
52. *P. vorax* (Janson)	x	-	-
53. *Embata laticeps* Murray	x	o	-
54. *E. hamata* (Murray)	x	o	-
55. *Dissotrocha aculeata* (Ehrb.)	-	o	-
56. *D. macrostyla* (Ehrb.)	x	o	-
57. *Rotaria rotaria* (Pallas)	-	o	#
58. *R. sordida* (Western)	x	o	-
59. *R. socialis* Kellicott	x	-	-
60. *Rotaria sp. A*	x	-	-
61. *Rotaria sp. B.*	x	-	-
62. *Macrotrachela cf.habita* (Bryce)	-	o	#
63. *Macrotrachela papillosa* (Thompson)	-	-	#
64. *M. plicata* (Bryce)	-	o	#
65. *M. timida* Milne	x	-	#
66. *Macrotrachela sp.*	-	o	-
67. *Mniobia scarlatina* (Ehrb.)	x	o	-
68. *Mniobia sp.*	x	-	#
Fam. Adinetidae			
69. *Adineta vaga* (Davis)	x	o	#
70. *Adineta sp.*	x	o	#
Fam Philodinavidae			
71. *Philodinavus paradoxus* (Murray)	-	o	-

Table 1: Rotifera species composition and presence at the sediment surface (x), insterstitial sediment (o) and debris dam (#), in the gravel stream Oberer Seebach during 1991 and 1992. (&) indicates dead animals, probably washed out from the upper lakes in the area.

Despite the high Rotifera species richness in the experimental reach during a year-cycle, the maximum species number achieved at the sediment surface fluctuated from a mean of 1.60 to 9.60 species dm^{-2}, and these changes differed significantly in time (ANOVA, F= 2.029, df= 34,140, P= 0.002; Fig.1a). There were also significant differences among sampling sites at the sediment surface (ANOVA, F= 8.433, df= 4,170, P< 0.001). Thus, a higher mean number of rotifer species was found at places with low water velocity, shear stress and high water levels, characterized as pool areas (Fig. 1a).

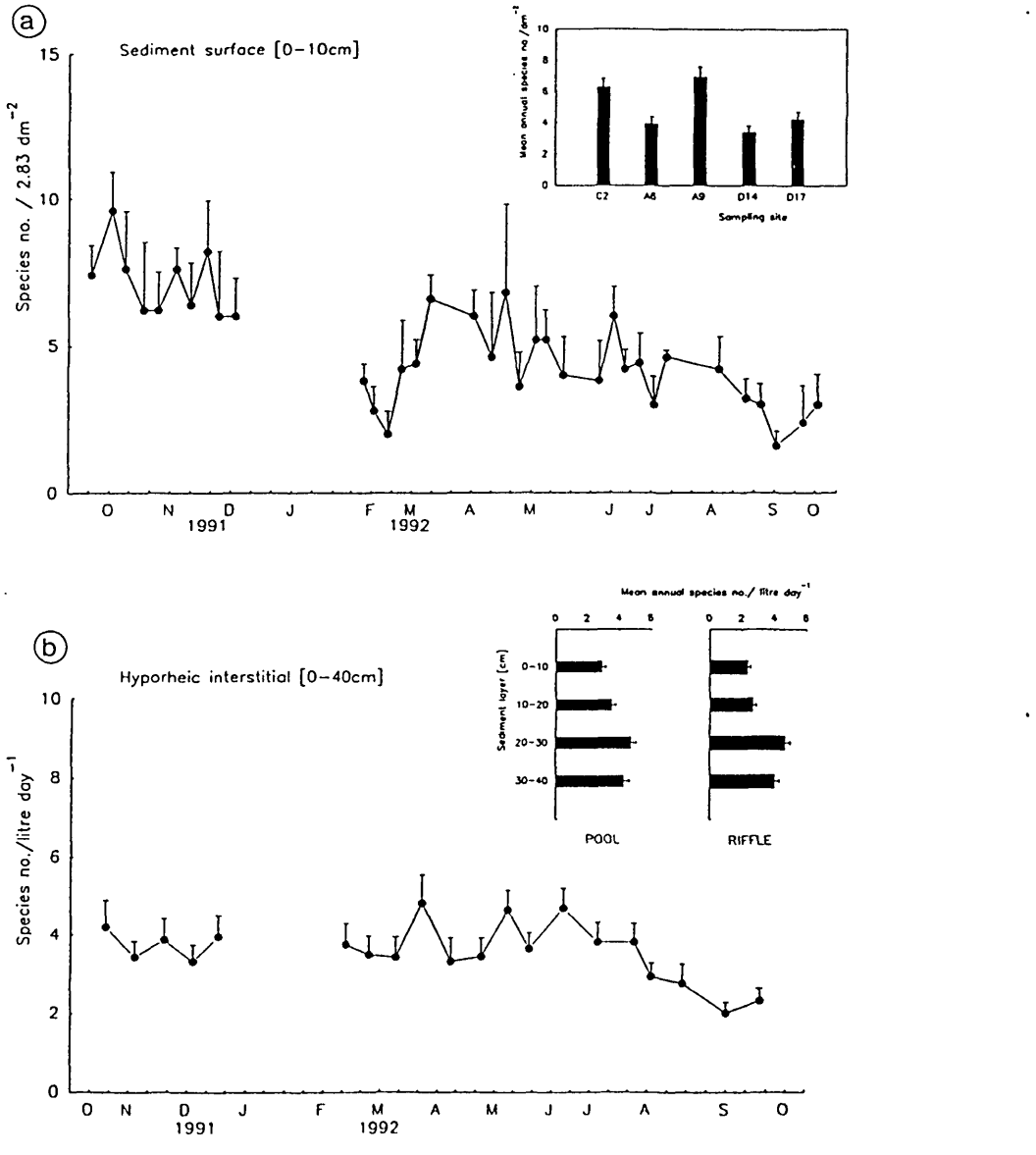

Figure 1: The mean Rotifera species number found at the sediment surface, and within the bed sediments in the experimental reach of the Oberer Seebach, between October 1991 and October 1992. Insert at the upper panel shows the annual mean of species number occurrin at different sampling sites at the sediment surface (as in SCHMID-ARAYA, 1992a,b). Insert at the lower panel, illustrates the annual mean of species number at different depth layers within the bed sediments in pool and riffle sites.

At the hyporheic interstitial (0–40cm), the mean rotifer species number ranged significantly throughout time between 2.0 to 4.8 species litre^{-1} day^{-1} (ANOVA, F= 2.438, df= 20,314, P<0.001; Fig.1b). Similarly, significant differences were found among sampling sites (ANOVA, F= 4.516, df= 1,331, P<0.034; and sediment depth layers (ANOVA, F= 23.171, df= 3,331, P<0.001; Fig.1b).

Remarks on collected species

Notholca (Fig.2a,b,c)

Three species occurred in the Oberer Seebach during 1991 and 1992, from which most common were *Notholca foliacea* (Ehrenberg) and *Notholca squamula* (O.F.M.) (Fig.2a,c). *Notholca cf. labis* (Gosse) (Fig. 2b),was found twice in single occurrence in 1991 and 1992 at the sediment surface. *N. squamula* and *N. foliacea* were present simultaneously at the sediment surface (0–10cm) in autumn 1991 and spring–summer 1992. In the hyporheic interstitial, only *N.squamula* inhabited down to depth layers of 30–40cm in pool and riffle areas, whereas *N. foliacea* reached down to 20–30cm in six sampling occasions in the pool area, and in two sampling dates down to 30–40cm in the riffle and pool sites. These two species have been reported in littoral and plankton of lakes and ponds (RUTTNER-KOLISKO, 1974; KOSTE, 1978 and references therein). Nevertheless, BRAIONI & GOTTARDI (1979) found *N. squamula* in the hyporheic interstitial (30cm sediment depth), while *N. foliacea* has been found at the sediment surface in river ecosystems (PAWLOWSKI, 1958; DONNER, 1964).

N. foliacea length: 170-190μm; width: 65-68μm; median occipital spines: 18-20μm; caudal projection: 24-30μm.

N. labis length: 180-190μm; width: 90-100μm; median occipital spines: 17-20μm; caudal projection: 18-20.5μm.

N. squamula length: 220-230μm; width: 150-160μm; median occipital spines: 36-38μm.

Euchlanis deflexa (Gosse) (Fig. 3)

This species inhabited the bed sediments down to depths of 20–30cm in autumn 1991. The species has been reported as widespread in freshwaters, usually between the submerged macrophytes (MYERS, 1930; DONNER, 1964). In this mountain gravel stream, the species appeared in an unpredictable manner in time and among sampling sites. Dorsal plate length: 190-350μm; width: 140-250μm; ventral plate length: up to 322μm; toes length: 55-100μm (after KOSTE, 1978)

Lophocharis salpina (Ehrenberg) (Fig.4)

This species was found in June and October 1992 in pool sites at the sediment surface. This species is defined as benthic, commonly occurring in freshwater habitats (DONNER,

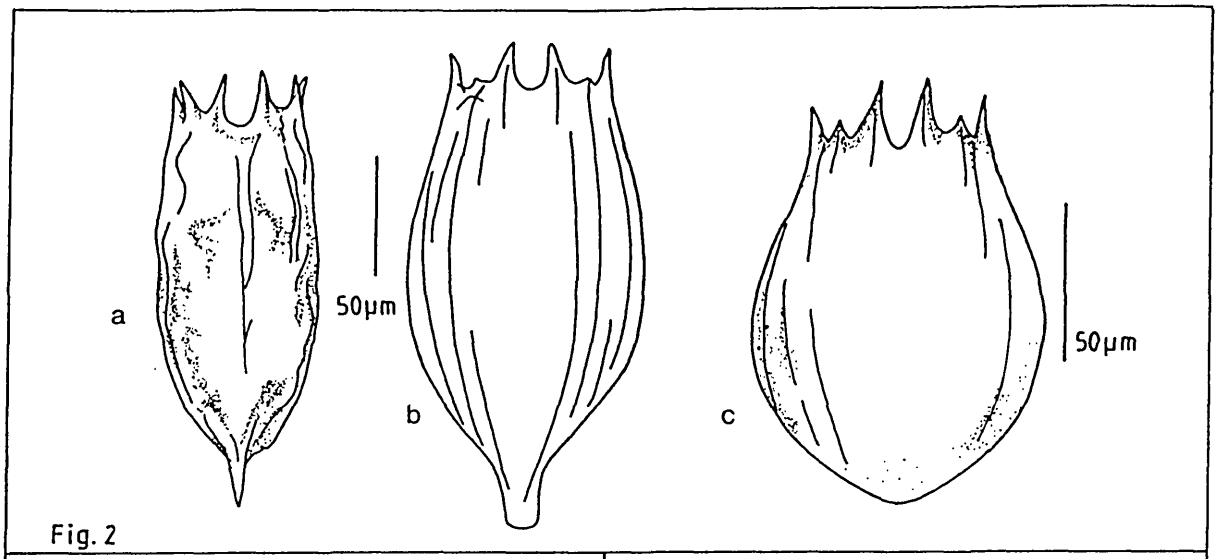

Fig. 2

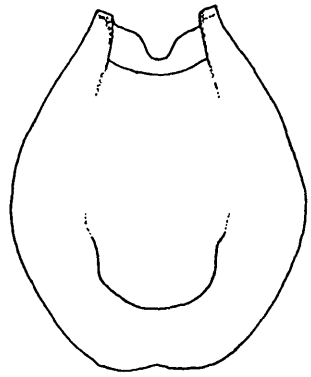

Fig.3

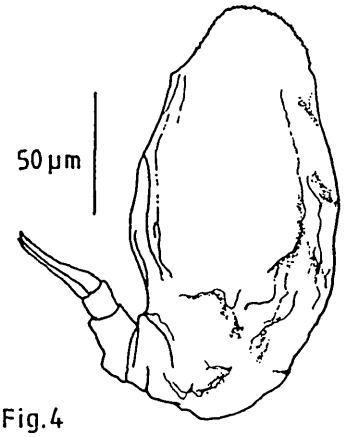

Fig.4

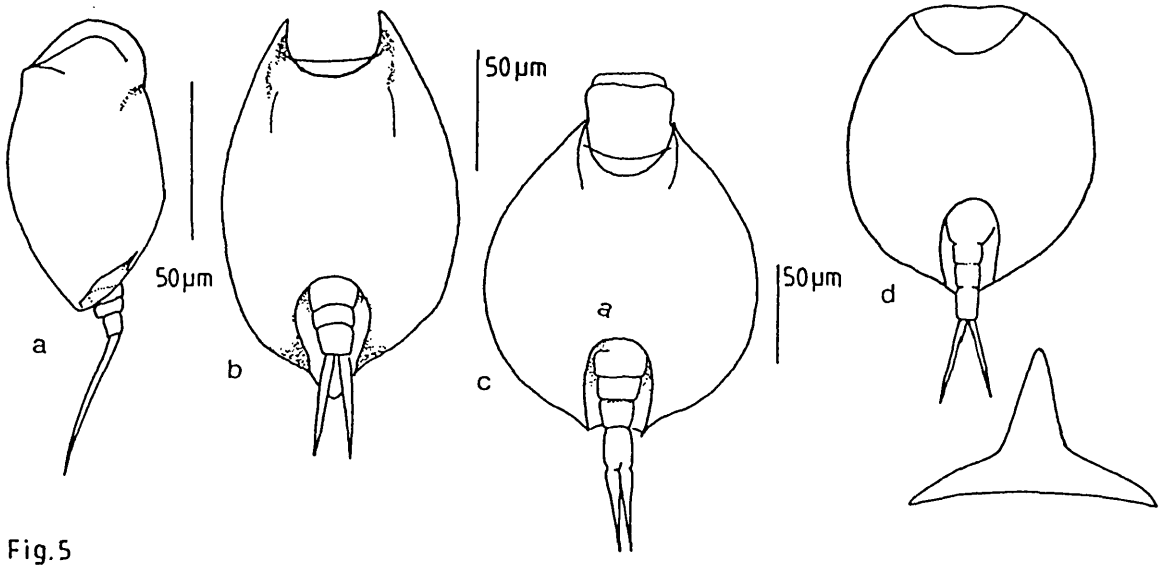

Fig.5

Figure 2: a. *Notholca foliacea* (Ehrb.). b. *Notholca cf. labis* (Gosse). c. *Notholca squamula* (O.F.M.). **Figure 3.** *Euchlanis deflexa* (Gosse)(after KOSTE, 1978). **Figure 4.** *Lophocharis salpina* (Ehrb.). **Figure 5.** a. Colurella colurus (Ehrb.). b. *Lepadella acuminata* (Ehrb.). c. *Lepadella ovalis* (O.F.M.). d. *Lepadella triptera* Ehrb. (after KOSTE, 1978).

1978) and brackish waters (ALTHAUS, 1957). Length: 160-180µm; width: 80-88µm; toes length: 25-28µm.

Colurella colurus (Ehrenberg) (Fig. 5a)

This species has a widespread distribution in freshwaters, namely stagnant and lotic systems (DONNER, 1964). During this study, it occurred at the sediment surface (0-10cm) mainly from October through December 1991, but persisted in pool places during the summer of 1992. In the hyporheic interstitial, the species could be found down to sediment depths of 30–40cm. Moreover, KOSTE (1978) gave information about the species feeding habits comprising detritus, bacteria and faecal pellets of *Gammarus*. This probably might explain the success and presence of the species in this type of habitat. Lenght: 70-90µm; width: 25-38µm; toes length: up to 40µm.

Lepadella (Fig. 5b,c and d)

Three species were found in the Oberer Seebach, one of which also inhabited the debris dam. The cosmopolitan benthic species *Lepadella ovalis* (O.F.M.) (Fig.5c), was present in autumn 1991 at the surface and within the bed sediments. *Lepadella triptera* Ehrenberg (Fig.5 d), occurred occasionally in summer 1992 within the hyporheic interstitial only at the riffle area (down to 30–40cm). This particular benthic species is mentioned as widespread between fresh and brackish waters (RIDDER, 1981). Similarly, *Lepadella acuminata* (Ehrenberg) (Fig. 5b) was found at 30–40cm in the bed sediment in winter 1992. This finding contributes further to the distribution given by DONNER (1964).

L. acuminata length: 90-100µm; width: 62-72µm; toes length: 30-34µm.

L. ovalis length: 100-151µm; width: 80-130µm; toes length: 35-36µm.

L. triptera length: 58-65µm; width: 50-57µm; toes length: 13-22µm (after KOSTE, 1978)

Proales (Fig.6 to 11)

Four species were found and identified on basis of trophy analyses in this gravel stream.

Proales theodora (Gosse) (Fig.6a,b)

It occurred in both the sediment surface and the hyporheic interstitial. At the surface, it was found from December 1991 until May 1992, and within the bed sediments the species goes down to 20cm and 30cm in pool and riffle areas.

Only in one occasion (April 1992), specimens penetrated 35cm deep in the pool site, coinciding with a high water peak. This particular species has a wide range of distribution in rivers and streams mainly at the sediment surface between *Fontinalis* mosses (PAWLOWSKI, 1958; MADALINSKI, 1960; DONNER, 1964, 1970; BRAIONI & GOTTARDI, 1979). Total length: 300-380µm; toes length: 30-33µm; trophy length: 23-28µm.

Proales globulifera (Hauer) (Fig.7a,b)

The species was present at the sediment surface in autumn 1991, and within the bed sediments it was found down to 20-30cm in February 1992. The species is widespread but

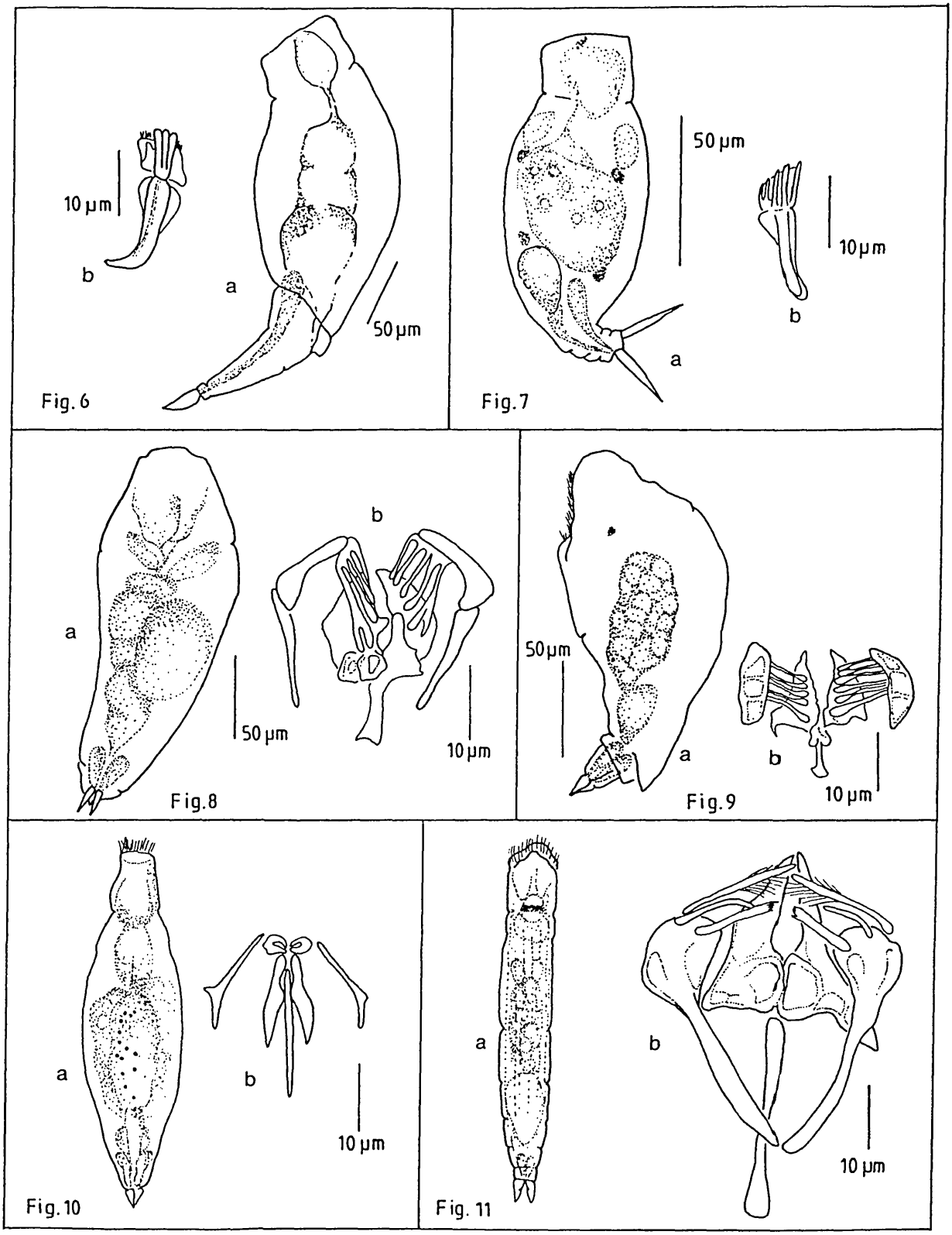

Figure 6: a. *Proales theodora* (Gosse). b. Trophy. **Figure 7**. a. *Proales globulifera* (Hauer). b. Trophy. **Figure 8**. a. *Proales fallaciosa* Wulf.. b. Trophy. **Figure 9**. a. *Proales similis* De Beauchamp. b. Trophy. **Figure 10**. a. *Drilophaga bucephalus* Vejdovsky (after PAWLOWSKI, 1934). b. Trophy. **Figure 11**. a. *Resticula nyssa* H.& M. (after HARRING & MYERS, 1924). b. Trophy.

Proales fallaciosa Wulfert (Fig. 8a,b)

In contrast to other species, this occurred only at the sediment surface between October and November 1991. It is a widespread inhabitant in diverse freshwater habitats (WULFERT, 1939; RADESCU, 1960; DONNER, 1964 among others), and also in brackish waters (ALTHAUS, 1957). KOSTE (1978), mentioned the species as a scavanger feeding on the debris of dead insect larvae. Total length: 230-250μm; toes length: 15-18μm; trophy length: 31μm.

Proales similis De Beauchamp (Fig.9a,b)

The species was found in autumn 1991 at the sediment surface, having an occasional occurrence within the hyporheic habitat (10-20cm deep) in this gravel stream. Total length: 200μm; width: 88μm; toes length: 14μm; trophy length: 22μm.

Drilophaga bucephalus Vejdovsky (Fig.10a,b)

Individuals of this species were found in one occasion at the sediment surface in a pool site in November 1991. The species has a characteristic transparent appearance, and the unci at the trophi has an anchor shape (Fig.10b). These specimens were found as free-living, but PAWLOWSKI (1934) and later KOSTE (1978), mentioned that it is a parasite of oligochaetes, such as *Lumbriculus variegatus*, *Rhynchelmis sp.*, *Stylodrilus sp.* and *Nais elinguis*. These Oligochaeta species are present within the experimental reach (SCHMID-ARAYA & SCHMID, 1991), so it is feasible that the individuals were caught while searching for the hosts. Total length: 260μm; trophy length: 19μm.

Resticula nyssa Harring & Myers (Fig.11a,b)

This characteristic large species was found only in samples from the debris dam in April 1992. Coincidently (DONNER, 1975), also found the species in the same month, and described that the species is able to build up tubes from detritus particles, and lives inside. It has a wide range of distribution in freshwater habitats (HARRING & MYERS, 1924; WULFERT, 1940; KOCH-ALTHAUS, 1962; DONNER, *op cit.*). Total length: 300-630μm; toes length: 14-21μm (after KOSTE, 1978); trophy length: 56μm.

Pleurotrocha petromycon Ehrenberg (Fig.12a,b)

The species was present at the sediment surface, and reached down to 30cm in the bed sediments during the autumn and winter months. This finding coincides with BRAIONI & GOTTARDI (1979), who reported the species at 30cm depth in the River Adige. It is a cosmopolitan species, found in running waters, as well as brackish and eutrophic waters (HARRING & MYERS, 1924; WULFERT, 1935; KUTIKOVA, 1970). Total length: 500μm; trophy length: 26μm.

Cephalodella

This genus comprises 10-12% of the total number of species present in the Oberer Seebach. Due to the fast body contraction, besides the high variability found in small-sized

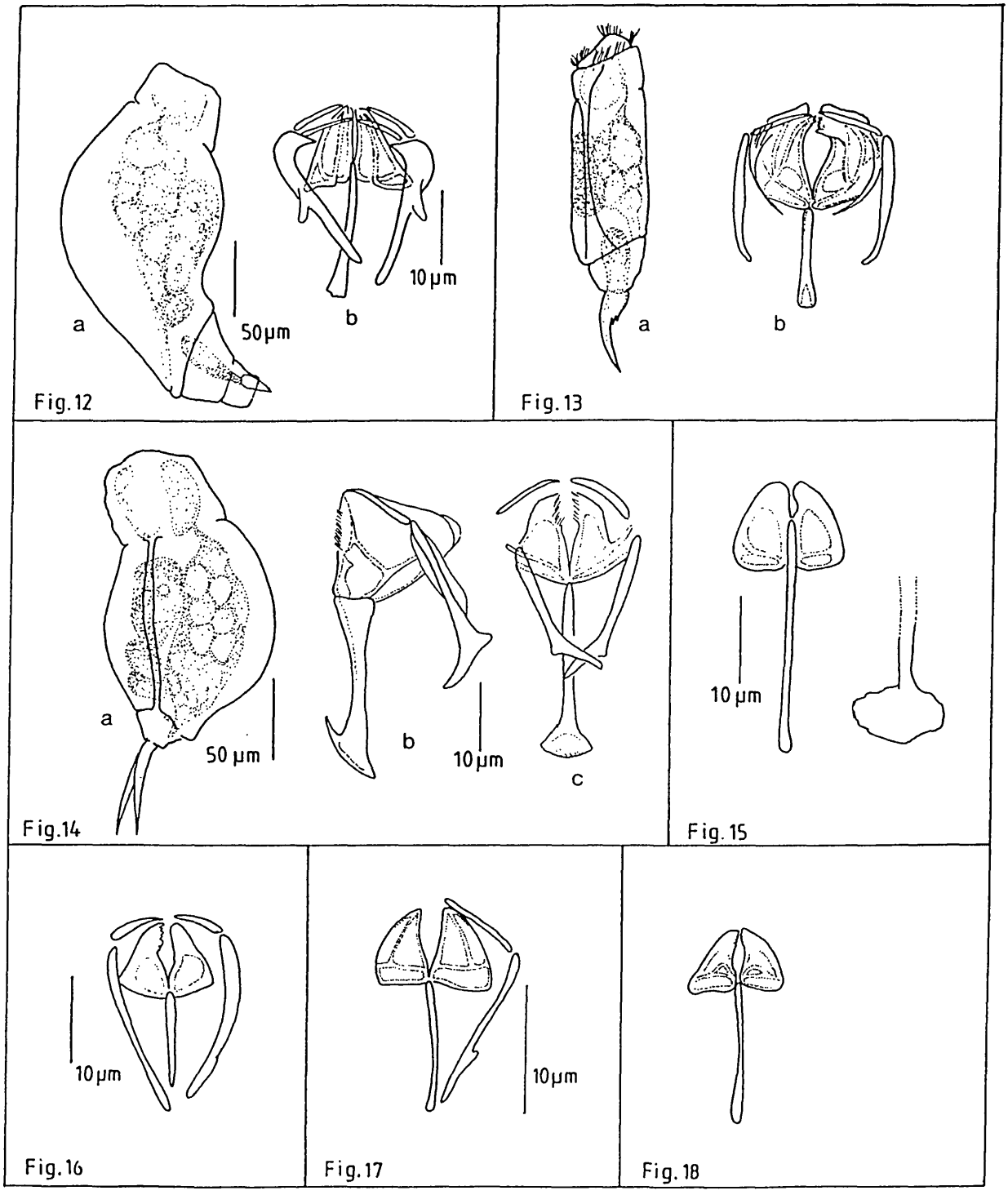

Figure 12: a. *Pleurotrocha petromycon* Ehrb.. b. Trophy. **Figure 13.** a. *Cephalodella forficula* (Ehrb.). b. Trophy (after WULFERT 1938). **Figure 14.** a. *Cephalodella gibba* Ehrb.. b. Trophy lateral view. c. Trophy dorsal view. **Figure 15.** *Cephalodella gobio* Wulf. trophy. **Figure 16.** *Cephalodella cf. gracilis* Donner trophy. **Figure 17.** *Cephalodella incila* Wulf. trophy. **Figure 18.** *Cephalodella rigida* Donner trophy.

species, all specimens were identified on basis of trophy analyses. This genus has been often mentioned as a littoral occurring amongst macrophytes, but it also inhabits the bed sediment of a gravel stream.

Cephalodella forficula (Ehrenberg) (Fig.13a,b)

At the sediment surface (0-10cm), it occurred in December 1991, and within the bed sediments down to 20cm depth in summer 1992. The same species was recorded at 30cm in the hyporheic interstitial in the River Adige by BRAIONI & GOTTARDI (1979). On the other hand, WULFERT (1938) cited the species as benthic during the winter months. In addition, KOSTE (1978) states that *C. forficula* builds up tubes from detritus particles and feeds on diatoms. Total length: 300-375µm; toes length: 80-90µm; trophy length: 45µm (after WULFERT, *op.cit.*)

Cephalodella gibba Ehrenberg (Fig.14 a,b & c)

This species is common and very abundant in the Oberer Seebach, inhabiting throughout the year at the sediment surface with maximum densities in autumn 1991, early winter 1991/92, and also in summer 1992. In the bed sediments, it reaches down to 30-40cm in winter and summer months. This is a typical cosmopolitan species found in diverse habitats (HARRING & MYERS, 1924; WULFERT, 1937; DONNER, 1964), it feeds on algae, flagellates and ciliates (KOSTE, 1978). Total length: 220-300µm; toes length: 62-80µm; trophy length: 41-81µm.

Cephalodella gobio Wulfert (Fig.15a,b)

It was present occasionally in autumn 1991 and during the spring of 1992 in the bed sediments (0-10 and from 10-40cm depth). It has been reported from mud and 'aufwuchs' in running waters (WULFERT, 1937; DONNER, 1964, 1972). Total length: 140-160µm; trophy length: 20-30µm (after WULFERT, *op.cit.*).

Cephalodella cf. gracilis Donner (Fig.16)

Specimens were found at the sediment surface, and within the bed sediments down to 30-40cm depth in October 1991. DONNER (1964) mentioned that the species has highly variable characters in the trophy structure. It has been cited in fresh and brackish waters (WULFERT, 1936; KOSTE, 1978). Total length: 110µm; toes length: 20µm (after DONNER, 1970); trophy length: 22µm.

Cephalodella incila Wulfert (Fig.17)

The species was identified following the work of DONNER (1964) and WULFERT (1937). In the Oberer Seebach it was found at the hyporheic interstitial during autumn 1991 and spring of 1992. It can be found also in flood-plain meadows (DONNER, *op.cit.*). Total length: 128-180µm; toes length: 26-40µm (DONNER, *op.cit.*); trophy length: 18µm.

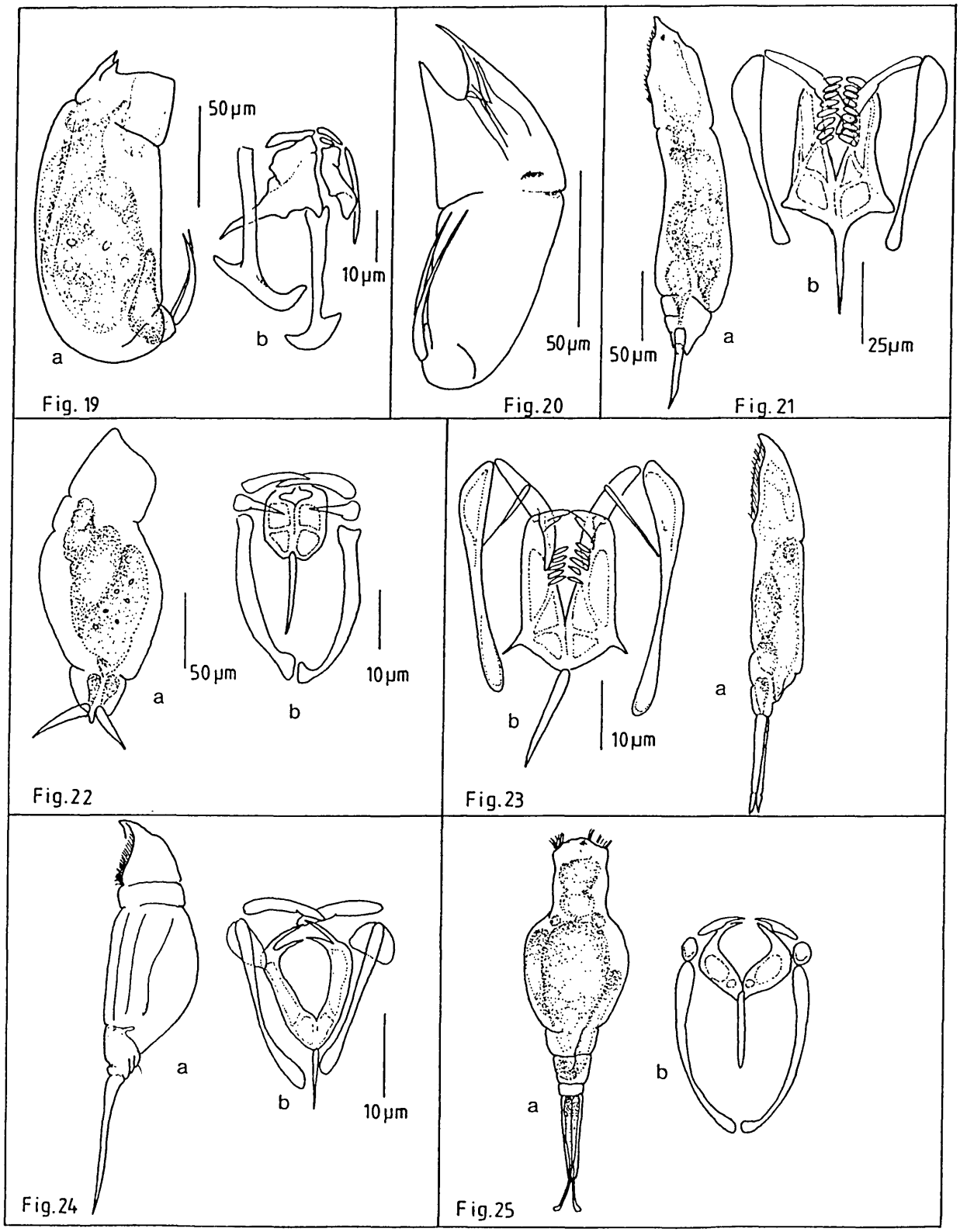

Figure 19: a. *Trichocerca porcellus* (Gosse). b. Trophy. **Figure 20.** *Trichocerca taurocephala* (Hauer). **Figure 21.** a. *Dicranophorus forcipatus* (O.F.M.). b. Trophy. **Figure 22.** a. *Dicranophorus liepolti* Donner. b. Trophy. **Figure 23.** a. *Dicranophorus lütkeni-sigmoides* (Bergendal) (after KOSTE, 1978). b. Trophy. **Figure 24.** a. *Dicranophorus uncinatus* Milne (after KOSTE, 1978). b. Trophy. **Figure 25.** *Wierzejskiella sabulosa* (Wiszniewski). b. Trophy (after KOSTE, 1978).

Cephalodella rigida Donner (Fig.18)

It has been found occasionally within the hyporheic interstitial (0–40cm) in October 1991. But it has been reported in ponds, pools and submerged mosses in running waters (DONNER, 1964, 1970). Total length: 132–175μm; toes length: 33–43μm (DONNER, *op.cit.*).

Trichocerca (*Diurella*)

Two species were found in this gravel stream between 1991 and 1992. These were *Trichocerca porcellus porcellus* (Gosse) (Fig.19a,b) which occurred only at the sediment surface in pool sites from October 1991 through December 1991. It is a typical cosmopolitan species, usually amongst macrophytes (DONNER, 1950; WULFERT, 1960b; RIDDER 1981). The second species, *Trichocerca taurocephala* (Hauer)(Fig.20) was present at the surface and within the bed sediments (10–20cm) in September and October 1992. It is a common species in rivers and streams, including sandy bottoms (VOIGT, 1957; PAWLOWSKI, 1958; RUDESCO, 1960; DONNER, 1964; KOSTE 1978).

T. porcellus body length: 166μm; left toe: 42μm; right toe: 35μm; trophy length: 50μm.

T. taurocephala body length: 110μm; left toe: 49μm; right toe: 19μm; trophy length: 34μm.

Dicranophorus

Four species appeared during 1991 and 1992. *Dicranophorus forcipatus* (O.F.M.) (Fig.21a,b) was only at the debris dam and in one pool site at the sediment surface within the experimental reach in May 1992. Its range of distribution includes a wide variety of habitats between macrophytes, and it has been reported in water treatment plants (BARTOS, 1959; DONNER, 1964). The same author indicates that this species feeds on ciliates, other rotifer species and nematodes which feed on algae. The second species, *Dicranophorus liepolti* Donner (Fig.22a,b), was a common inhabitant at the sediment surface (0–10cm) and within the bed sediments (down to 30–40cm) throughout the year. DONNER (1964) stressed the intermittent occurrence in running waters during the winter and spring months.

The third species was *Dicranophorus lutkeni-sigmoides* (Bergendal) (Fig.23a,b), which appeared at the sediment surface between April through May 1992, and sometimes from July through August 1992. This species was also in the hyporheic interstitial down to 30cm depth from May to August 1992. Often it is found in the littoral of large rivers, and of stagnant waters in the Arctic, Palearctic and Nearctic (WULFERT 1960a, KUTIKOVA, 1970; RIDDER, 1972).

Another species was *Dicranophorus uncinatus* Milne (Fig.24a,b), which had a wide temporal presence at the sediment surface including winter and summer months. It can reach down to depth of 40cm. Often it has been reported in stagnant water bodies and running waters (PAWLOWSKI, 1958; BARTOS, 1959; RUDESCO, 1960). DONNER

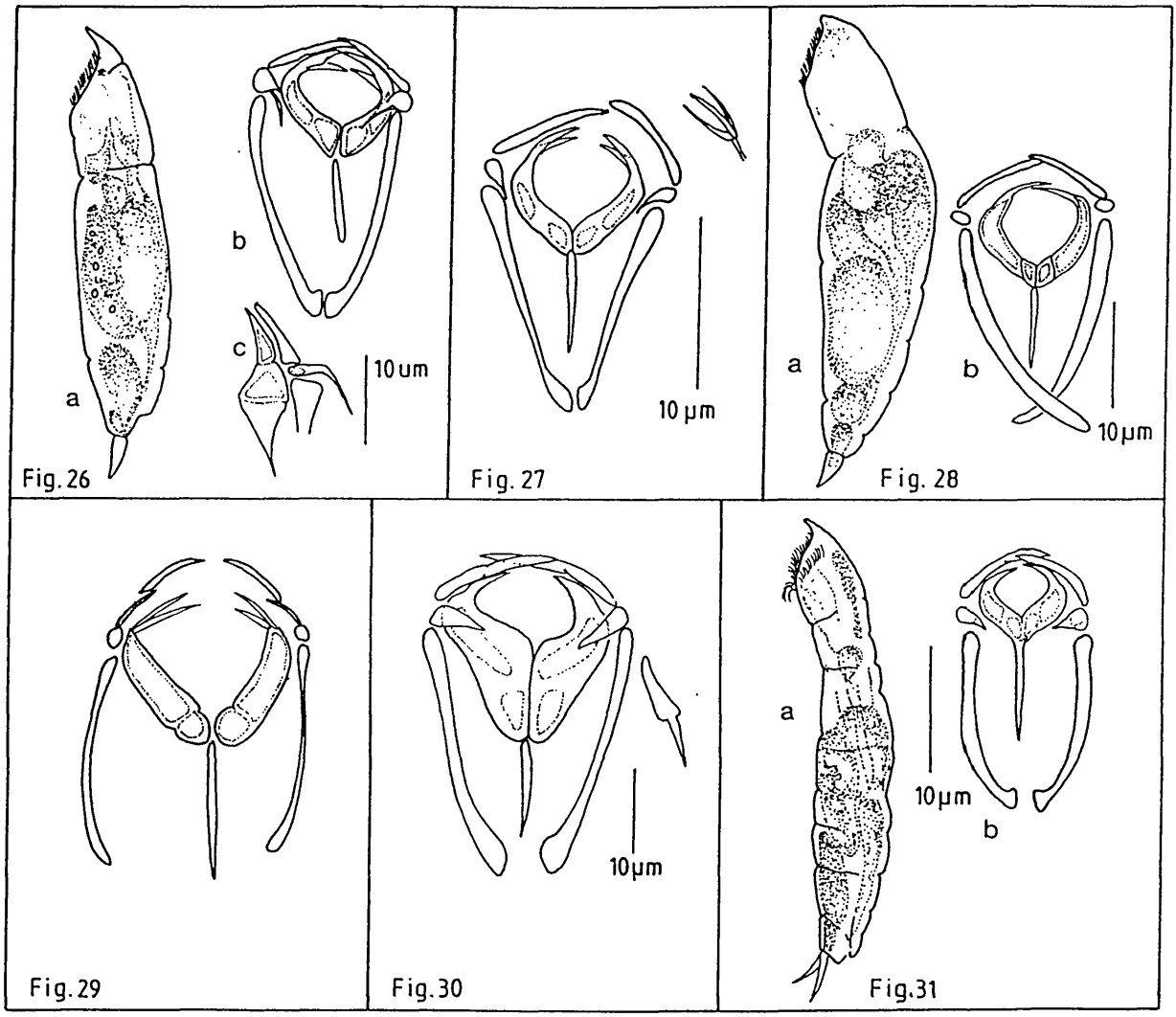

Figure 26: a. *Encentrum gulo* Wulf.. b. Trophy (after WULFERT, 1936). c. Trophy lateral view. **Figure 27**. *Encentrum incisum* Wulf. trophy. **Figure 28**. a. *Encentrum lupus* Wulf. (after WULFERT, 1936). b. Trophy. **Figure 29**. *Encentrum mustela* (Milne) trophy. **Figure 20**. *Encentrum mucronatum* Wulf. trophy. **Figure 31**. a. *Paraencentrum longipes* (Wulf.) (after KOSTE, 1978). b. Trophy.

(1964) gave information of its food items which include diatoms and testaceans (i.e. type *Difflugia*).

D. forcipatus total length: 300μm; toes length: 68μm; trophy length: 81μm. *D. liepolti* total length: 125μm; toes length: 28μm; trophy length: 36μm. *D. lütkeni* total length: 240μm; toes length: 63μm; trophy length: 48μm. *D. uncinatus* total length: 200μm; toes length: 50μm; trophy length: 26μm.

Wierzejskiella sabulosa Milne (Fig.25a,b)

It occurred occasionally in the bed sediments (20–30 and 30–40cm) in August 1992. It has been found in the interstitial groundwaters of the lake of Plön (BARTOS, 1959; KOSTE, 1978). Total length: 140–220μm; toes length: 10–18μm; trophy length: 17–22μm (after KOSTE, *op.cit.*)

Encentrum

This genus comprised 10% of the total number of species, five of these species were successfully identified, including one species of *Paraencentrum* (*sensu* KOSTE 1978). Most species of this genus are difficult to identify, except when trophy analyses can be carried out.

Encentrum cf.gulo Wulfert (Fig.26a,b & c)

Specimens were found at the hyporheic interstitial (down to 30–40cm) in summer 1992. The identification was carried out following WULFERT (1936). This species occurs mainly in muddy habitats, as well as saline inland waters (ALTHAUS, 1957). Moreover, KOSTE (1978) reports that this species feeds on nematodes and protozoans. Total length: 180μm; toes length: 14μm (WULFERT, *op.cit.*); trophy length: 22–24μm.

Encentrum cf.incisum Wulfert (Fig.27)

The species occurred in the bed sediments down to 40cm, and also occasionally in the debris dam from spring to late summer 1992. It is a common species found in wet soil close to running waters (WULFERT, 1936; DONNER, 1970). Total length: 200μm; toes length: 14μm (after WULFERT, *op.cit.*); trophy length: 20μm.

Encentrum cf. lupus Wulfert (Fig.28a,b)

Specimens were found within the bed sediments between March and April 1992 (down to 30–40cm sediment depth), and also in August 1992 at 20–30cm. It has been mentioned in moss patches in streams (WULFERT,1936); moreover, the same author described having observed *E.lupus* feeding on large ciliates. Total length: 150–200μm; toes length: 9–10μm (after WULFERT, *op.cit.*); trophy: 24μm.

Encentrum cf. mustela (Milne) (Fig.29)

The species occurred at the sediment surface (0–10cm), and within the hyporheic interstitial down to 40cm, mostly in winter but it also appeared in low abundances during the summer. WULFERT (1936) described a similar seasonal occurrence; this species

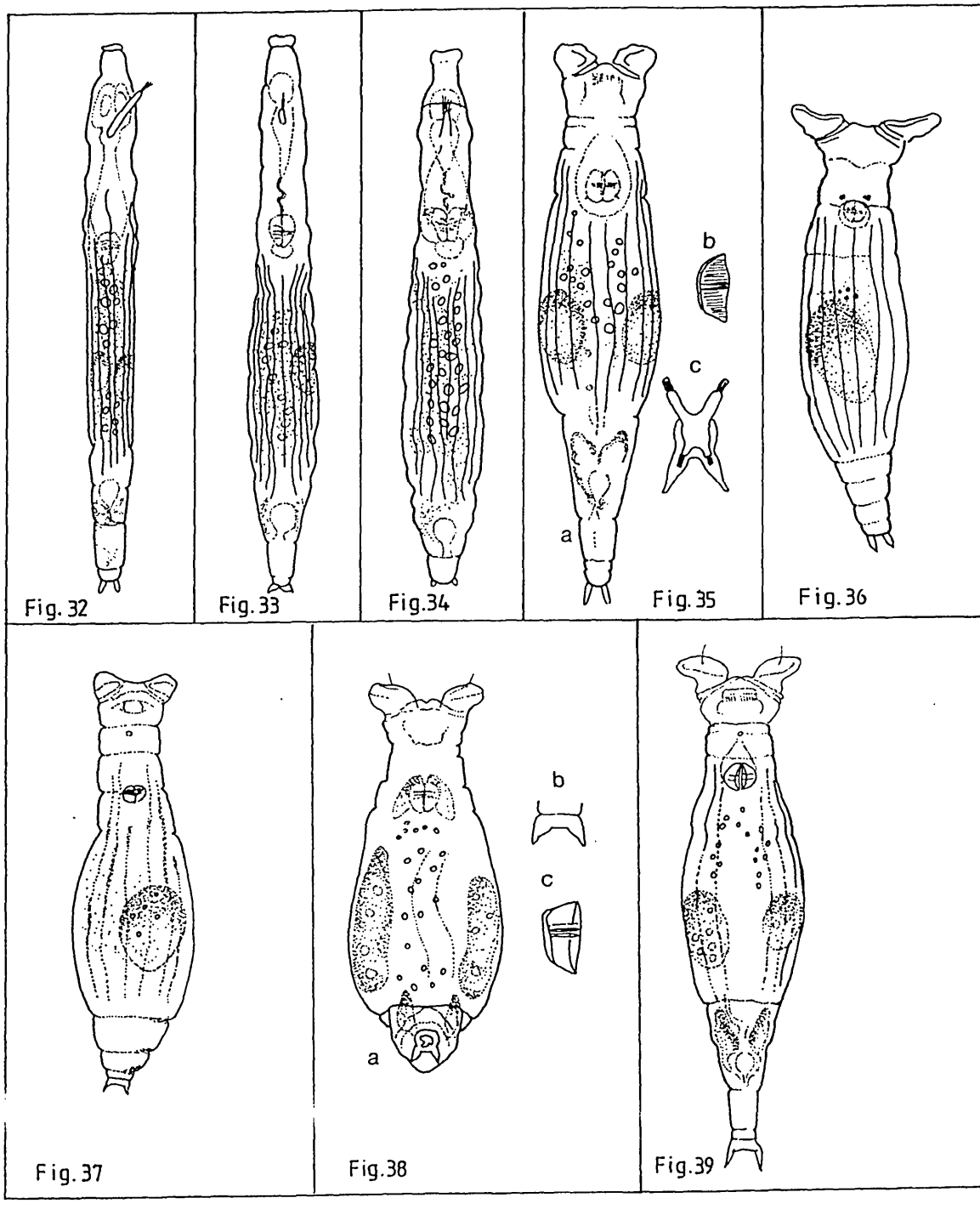

Figure 32: *Habrotrocha collaris* (Ehrb.) (after DONNER, 1965). **Figure 33.** *Habrotrocha proxima* Donner (after DONNER, 1965). **Figure 34.** *Habrotrocha pusilla* (Bryce) (after DONNER, 1965). **Figure 35.** a. *Philodina acuticornis odiosa* Milne. b. Trophy. c. Toes and spurs (after DONNER, 1965). **Figure 36.** *Philodina flaviceps* Bryce. **Figure 37.** *Philodina nemoralis* Bryce. **Figure 38.** a. *Philodina plena* (Bryce). b. Spurs. c. Trophy (after DONNER, 1965). **Figure 39.** *Philodina vorax* (Janson) (after DONNER, 1965).

inhabits muddy areas in pool, ponds, and drainage channels. It feeds on ciliates and small-sized algae (KOSTE, 1978). Total length: 142-330µm; toes length: 8.5-22µm; trophy: 18-35µm (after KOSTE, *op.cit.*).

Encentrum mucronatum Wulfert (Fig.30)

In the Oberer Seebach, it occurred within the bed sediments and also in the debris dam from April to October 1992. WULFERT (1936), stated that the species lives in spring pools or moss patches, feeding on other rotifer species and small algal cells. Total length: 300-420µm; toes length: 20µm (after WULFERT, *op.cit.*); trophy length: 38µm.

Paracencentrum longipes (Wulfert) (Fig.31a,b)

This is a common species in this gravel stream, occurring at the sediment surface and within the bed sediments down to 40cm sediment depth from May to August 1992. It appears in low water depth drainage pools,and amongst submerged mosses in running waters (WULFERT, 1936; DONNER, 1964). Total length: 170-180µm; toes length: 15-18µm (after KOSTE, 1978); trophy length: 20-21µm.

BDELLOIDEA

This particular rotifer group can colonize a wide variety of freshwater and terrestrial habitats (RICCI, 1983). BARTOS (1951), divided Bdelloidea into two ecologically different groups: the aquatic species which cannot support dessication, and the xerophile group with species able to withstand drying periods. Diagnosis of the species group can be time-consuming due to the fact that it can only be carried out on living specimens.

Habrotrocha

Three species were found in the Oberer Seebach throughout the year cycle, these were *Habrotrocha collaris* (Ehrenberg), *Habrotrocha proxima* Donner and *Habrotrocha cf. pusilla* (Bryce).

H.collaris (Fig.32), was present intermittently through time at the sediment surface, and also within the hyporheic interstitial reaching down to 40cm depth in riffle areas, and 30cm in pool areas. The species is cosmopolitan (BARTOS, 1951; VOIGT, 1957; DONNER, 1965; KOSTE & SHIEL, 1986). Total length: 193-337µm, trophy length: 15-17µm (after DONNER, *op.cit.*).

The second species *H. proxima* (Fig.33), was examined following DONNER (1965) diagnosis, and it was found at the sediment surface, and the debris dam in May 1992. The systematic status remains unclear because of synonymies given and discussed by many authors (BARTOS, 1951; RUDESCO, 1960; DONNER 1965). Its presence is mentioned in wet soil, and wet moss patches. Total length: 215-290µm; trophy length: 16.5µm (after DONNER, *op.cit.*).

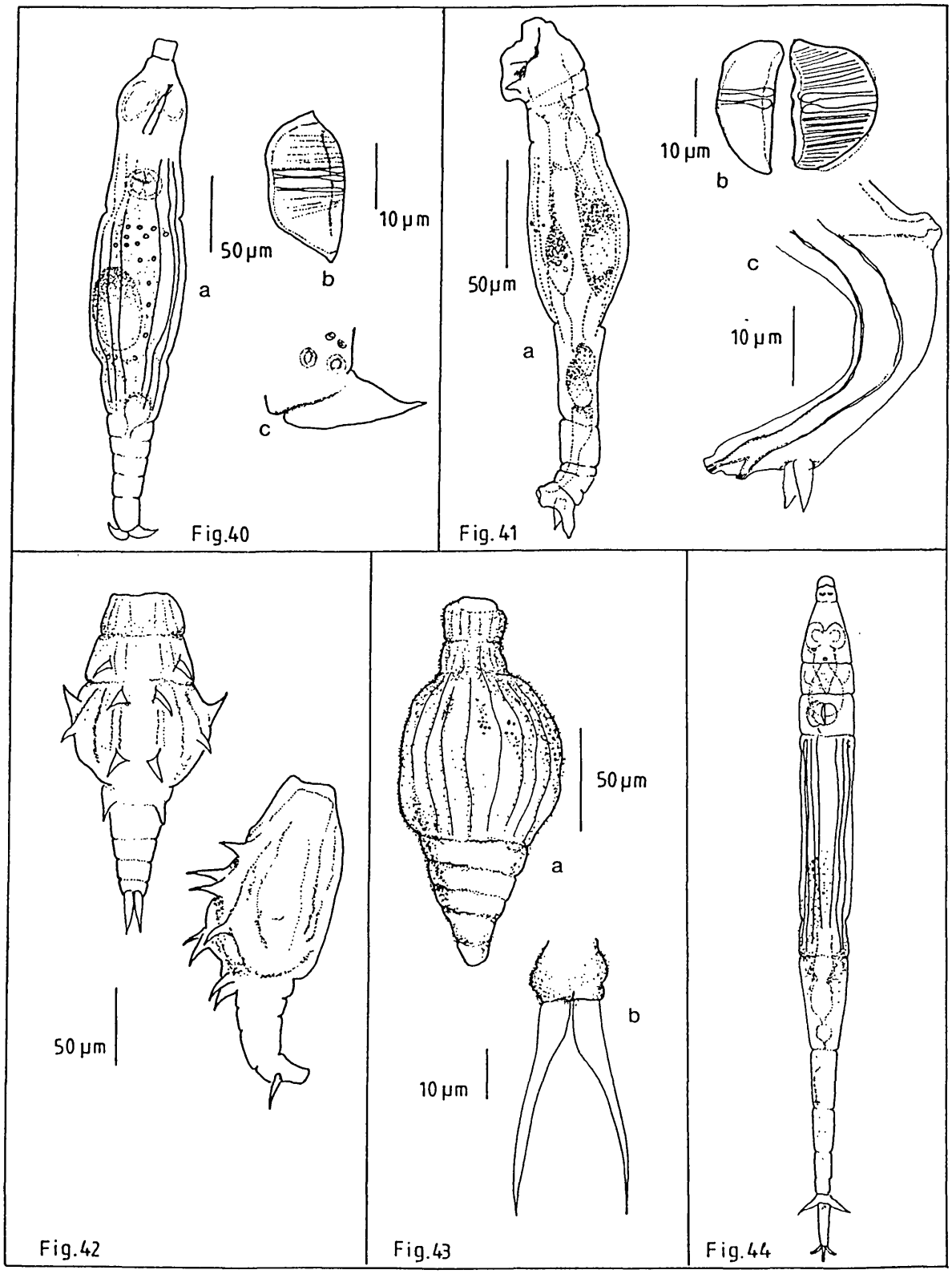

Figure 40: a. *Embata hamata* (Murray). b. Trophy. c. Spurs and toes. **Figure 41.** a. *Embata laticeps* Murray. b. Trophy. c. Foot. **Figure 42.** *Dissotrocha aculeata* (Ehrb.) dorsal and ventral view. **Figure 43.** a. *Dissotrocha macrostyla* (Ehrb.). b. Spurs. **Figure 44.** *Rotaria rotaria* (Pallas) (after DONNER, 1965).

The third species, *H.pusilla* (Fig.34) was found only at the debris dam in July 1992. According to the literature (BARTOS, 1951; DONNER, 1965), the species lives inside a shell made of debris, but the individuals caught in the Oberer Seebach backwaters were without shells. Total length: 195-240µm (after DONNER, *op.cit.*).

Philodina

This genus comprised five species in the Oberer Seebach during 1991 and 1992. Four of these species were mentioned by BRYCE (1926) in the same area. This is a typical aquatic genus.

Philodina acuticornis Milne (Fig.35a,b & c)

It was found occasionally at the sediment surface during November 1991 and also in summer of 1992. However, occurrence took place down to 40cm sediment depth in a riffle site within the experimental reach. Most characteristic is the end of the foot which resembles lateral toes permanently extended sidewards, so that it looks as if it would have two pairs of spurs (BARTOS, 1951; DONNER, 1965). It is a typical cosmopolitan species. Total length: 233-500µm (after DONNER, *op.cit.*).

Philodina flaviceps Bryce (Fig.36)

It is a common species in the sediment surface, within the hyporheic interstitial (down to 20-30cm sediment depth) and in the debris dam. A typical characteristic of this species is the spurs shape, blunt, conical and short, these run parallel to each other. The collected specimens in the Oberer Seebach had a light orange coloured trunk. This bdelloid is often found in running waters as well as in lakes amongst macrophytes (DONNER, 1965). Total length: 306-354µm (after DONNER, *op.cit.*).

Philodina nemoralis Bryce (Fig.37)

It also occurs intermittently at the sediment surface and within the hyporheic interstitial (20-30cm) throughout the year 1991 and 1992. The habitats vary from drying mosses, *Sphagnum*, and macrophytes in running waters (DONNER, 1965). Total length: 170-285µm (after DONNER, *op.cit.*).

Philodina plena (Bryce) (Fig.38)

It was found occassionally at the sediment surface (0-10cm), and can be recognized by the characteristic spurs shape (Fig.38b). It is a cosmopolitan species (DONNER, 1965). Total length: 260.386µm (after DONNER, *op.cit.*).

Philodina vorax (Janson) (Fig.39)

Specimens were found only in one sampling occasion in March 1992 at the sediment surface (0-10cm) within the experimental study area. DONNER (1970), mentioned that it feeds on diatoms and green algae, and lives in mosses and humic soils. Total length: 350-490µm (after DONNER, *op.cit.*).

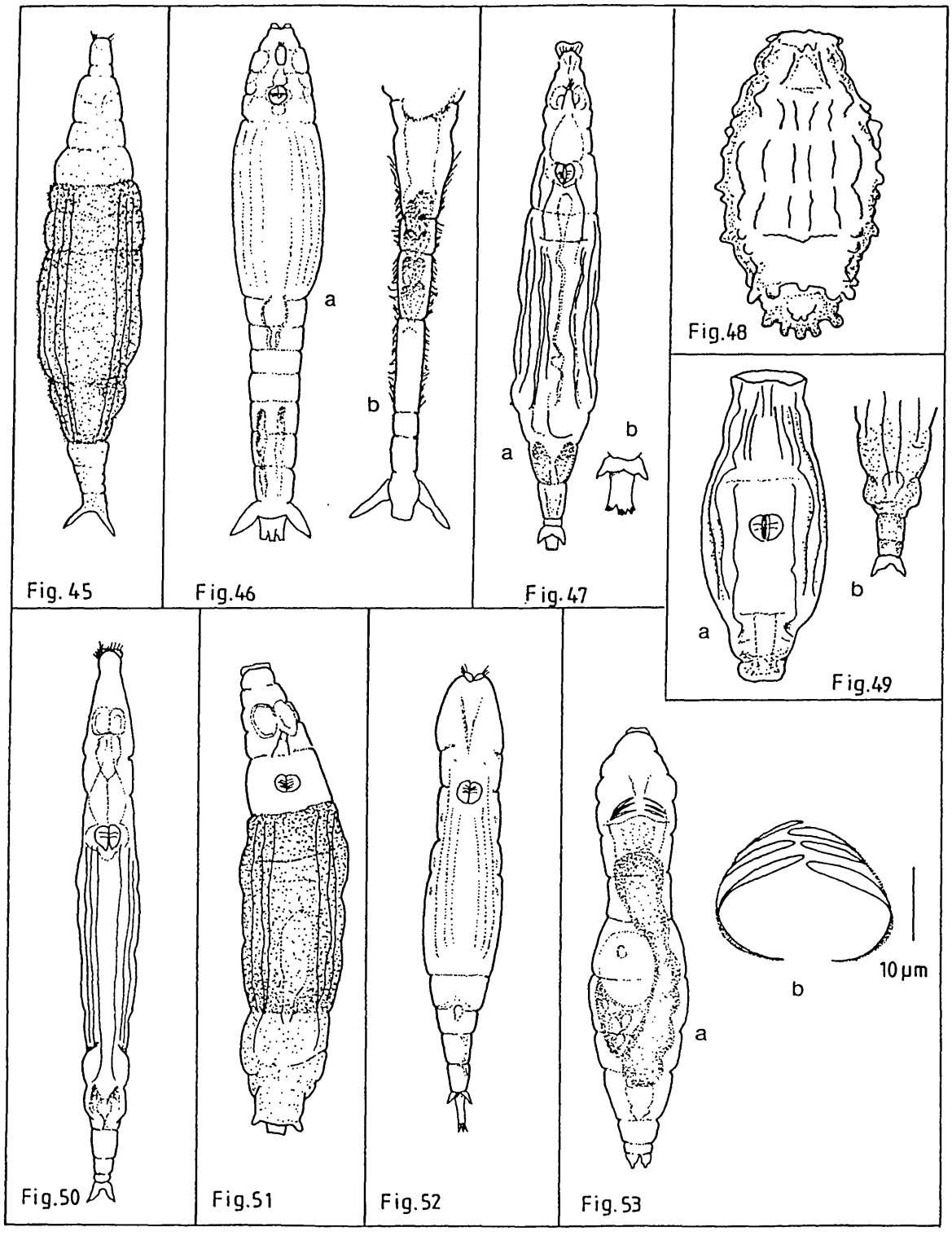

Figure 45: *Rotaria sordida* (Western). **Figure 46.** a. *Rotaria socialis* Kellicott. b. Foot (after DONNER, 1965). **Figure 47.** a. *Macrotrachela cf. habita* (Bryce). b. Spurs (after DONNER, 1965). **Figure 48.** *Macrotrachela papillosa* (Thompson) (after DONNER, 1965). **Figure 49.** a. *Macrotrachela plicata* (Bryce). b. Foot and spurs (after DONNER, 1965). **Figure 50.** *Macrotrachela timida* Milne (after DONNER, 1965). **Figure 51.** *Mniobia scarlatina* (Ehrb.) **Figure 52.** *Adineta vaga* (Davis). **Figure 53.** a. *Philodinavus paradoxus* (Murray) (after DONNER, 1965). b. Trophy.

Embata hamata (Murray) (Fig.40a,b & c)

It occurred commonly at the sediment surface in spring 1992, and it was also found down to 40cm depth in April-May 1992 within the experimental area. The characteristic spurs are directed laterally and hook-shaped (Fig.40c); the animal has also a clumpsy creeping (SHIEL & KOSTE, 1986). The species is distributed in all types of water bodies (DONNER, 1965). Total length: up to 340µm (after DONNER, *op.cit.*).

Embata laticeps Murray (Fig.41a,b & c)

This species is often found as epizoic on *Asellus aquaticus*, and Ephemeroptera larvae (BARTOS, 1951). However, DONNER (1965) stated that it is also possible to find it free-living. In this study, *E.laticeps* individuals were mostly free, and occasionally commensalism on Plecoptera (Perlidae) and Trichoptera (Limnephilidae) larvae was observed. It is a characteristic large species, with a very broad wheel-organ, and long leaf-shaped spurs (Fig.41c). In the study reach of the Oberer Seebach, it occurred at high abundances at the bed sediments reaching down 40cm depths throughout the year cycle. Total length: 375-700µm (after DONNER, *op.cit.*).

Dissotrocha aculeata (Ehrenberg)(Fig.42a,b)

The species has a characteristic variable number of cuticular spines (2-12) with a stiff integument, and it is viviparous. In the Oberer Seebach, it was present occasionally at 10-20cm in the bed sediments in autumn 1991. However, personal observations on freeze-core samples, reveal that the species was present during the year 1990 at similar sediment depths. It constitutes a benthic species according to DONNER (1965); the same author described a number of different subspecies. Total length: 350-500µm (after DONNER, *op.cit.*).

Dissotrocha macrostyla (Ehrenberg) (Fig.43a,b)

It was found at the sediment surface and within the hyporheic interstitial in autumn and winter 1991/92. Usually the trunk is covered with secretion deposits, and the spurs are long and pointed with a knobby thickening at the base (BARTOS, 1951; KOSTE & SHIEL, 1986). The species is cosmopolitan and found amongst water plants and mosses (DONNER, 1965). Total length: 306-500µm (after DONNER, *op.cit.*).

Rotaria

Five species were found in the Oberer Seebach between 1991 and 1992, from which three could be successfully identified. All species occurred intermittently in time.

Rotaria rotaria (Pallas) (Fig.44)

Specimens were found in March 1992, and also it appeared at sediment depths of 20-30cm in a riffle area in August 1992. It has two conspicuous red eye-spots in the short rostrum, a slender body with a long foot. This is a cosmopolitan species even found in plankton

samples (DONNER, 1965; KOSTE & SHIEL, 1986). Total length: 230-1090µm (after DONNER, *op.cit.*).

Rotaria sordida (Western) (Fig.45)

It often occurred in April, May and June 1992, reaching down to 40cm sediment depth in a pool site in August 1992. The species has the whole trunk surface covered with debris particles, due to a thick mucous layer (BARTOS, 1951; DONNER, 1965; KOSTE & SHIEL, 1986). It is also a cosmopolitan species. Total length: 340-635µm (after DONNER, *op.cit.*).

Rotaria socialis Kellicott (Fig.46a,b)

Free-living individuals were present once in April 1992, despite the fact that the species is believed to be an epizoic on crustaceans. This species can be easy confused with *Embata laticeps* (DONNER, 1965). Total length: 350-650µm (after DONNER, *op.cit.*).

Macrotrachela cf. habita (Bryce)(Fig.47a,b)

The species was present in the bed sediments (down to 40cm sediment depth) in autumn 1991/92, but it was also present in the debris dam during spring 1992. The species has several cuticular ridges, namely at the side, and very short spurs, wide at the base, usually diverging from each other. At the posterior border of the first foot segment, there is usually a knob which projects well beyond (BARTOS, 1951). It is a characteristic cosmopolitan species (DONNER, 1965). Total length: 370-570µm (after DONNER, *op.cit.*).

Macrotrachela papillosa (Thompson) (Fig.48)

At the debris dam it occurred in October 1992. The species has strongly developed appendages at the posterior borders of the trunk segment. It is cosmopolitan and inhabits drying mosses, *Sphagnum*, and humic soils (BARTOS, 1951; DONNER, 1965). Total length: 127-306µm (after DONNER, *op.cit.*).

Macrotrachela plicata (Bryce) (Fig.49)

It was present in the debris dam and at 10-20cm sediment depth in April 1992. The integument has longitudinal folds, and the body has a broad posterior end. The foot is short. This species has been found in the area of the Oberer Seebach by BRYCE (1926). Total length: 210-370µm (after DONNER, *op.cit.*).

Macrotrachela timida timida Milne (Fig.50)

The species appeared at the sediment surface of the experimental reach, and in the debris dam at the backwater area of the Oberer Seebach during summer 1992. The posterior border of the foot protudes. It is a typical species on wet soil (DONNER, 1965). Total length: up to 423µm (after DONNER, *op.cit.*).

Mniobia scarlatina (Ehrenberg) (Fig.51)

It occurred at the bed sediments reaching down to 40cm sediment depths in summer 1992. The trunk cuticle is covered with coarse granules in black colour, which contrasts to the

reddish coloured digestive tube. It has a short and pointed foot, besides a long suction plate on the end of the foot. Its main habitat are drying mosses (BARTOS, 1951; DONNER, 1965). Total length: 435-1090µm (after DONNER, *op.cit.*).

Adineta vaga (Davis) (Fig.52)

This species occurred intermittently at the bed sediments (down to 40cm sediment depth) throughout the year. The species is colourless or light reddish pink, and has a ciliated rostrum and a wide head. Several varietes and forms have been described in Europe (BARTOS, 1951; DONNER, 1965). Total length: 200-270µm (after DONNER, *op.cit.*).

Philodinavus paradoxus (Murray) (Fig.53a,b)

It was found at the hyporheic interstitial down to 40cm and also at the sediment surface in March 1993. The species has a characteristic trophy not rigidly united (Fig.53b). The body is enlarged at the height of mastax and the posterior end of the trunk. It is a species very often found in running waters or littoral of lakes (BARTOS, 1951; DONNER, 1965). Total length: 254-317µm (after DONNER, *op.cit.*).

Conclusions:

Low order streams such as the Oberer Seebach can be extremely fluctuating and unpredictable as habitats, and presumably the normal condition of a stream community may be a state of recovery from the last high water or drought (RIECE, 1985).

At this preliminar taxonomical survey, the rotifer assemblage found in this gravel stream during a year cycle is very diverse, and their occurrence in time and space seems to respond to the heterogeneity of the stream bed. In addition, the temporally rich rotifer fauna, reflects the adequacy of the gravel bed sediments as an habitat, characterized in the Oberer Seebach by large interstitial spaces, and a 100% oxygen saturation down to sediment depths of 60cm. Thus, many Rotifera species can inhabit the hyporheic interstitial down to 40cm sediment depth. This result contributes further to the general characterization of habitats colonized by the rotifer fauna, which was stressed for some rotifer species in a larger River in Italy by BRAIONI & GOTTARDI (1979). Moreover, the debris dam in a backwater area of the study reach exposed to substantial drying conditions from late summer onwards, contained a clear predominance of Bdelloidea species. Those species belonged to the bdelloid group able to withstand dessication.

In addition, this rotifer assemblage comprised a wide variety of feeding specialization, including macrophagous and predatory species (i.e. Dicranophoridae, POURRIOT, 1977), to microphagous and filter feeders such as bdelloids (POURRIOT, 1979).

It may be plausible that such a meiofaunal group has been completely underestimated because of mesh nets too large to retain it, and also due to the fixation methods. The preservation of material is inadequate for delicate rotifers lacking a stong lorica, and

examination on living specimens seems to be the alternative when species identification is required.

Thus, few works are expected to be devoted to particularly population dynamics and community structure of the rotifer fauna in this kind of habitats, and whether rotifers are quantitatively important in the benthic community is still unknown. Nevertheless, ecological research orientated on the multispecies dynamics (after PIMM, 1991), is strongly needed in such a fluctuating enviroment; particularly when taking into account concepts such as: resilience, variability and persistence. At a species level, embedded in a community, further examination is also necessary in the context of population variability, recovery, invasion and their consequences, in such an unpredictable habitat.

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