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A conspectus of the Cladocera of the subterranean waters of the world

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Abstract

A synthesis of current knowledge of the Cladocera living in non-surface waters is provided. For all 94 species and subspecies recorded (Dec. 1994) we give information on their ranges, ecological characteristics, and a review of literature data. We also give a historic survey of the development of concepts, identify categories among groundwater-dwelling species, and discuss their adaptations and the evolutionary lines present. Of the estimated total of c. 450 non-marine Cladocera of the world, c. 20% *may* occur in underground aquatic habitats, but true groundwater forms (stygobionts or stygobites) are relatively few, possibly not more than 10 species (c. 2.5% of the total). This number may increase, as attention is given to subterranean habitats outside Europe.

Introduction

The Cladocera (term here used in the traditional, non-taxonomical sense; for a discussion see Fryer, 1987) form an assemblage of planktonic, phytophilic and benthic microcrustaceans of stagnant or running freshwater. Some species can tolerate considerable salinities (up to 105‰, see Negrea, 1983), and may be marine, or occur in hypersaline waters.

At present, of the c. 450 spp. known (rounded upwardly from Dumont, 1994), in 12 families and c. 70 genera, about 20% have been found in underground environments. Of these, however, true underground forms (stygobitic species) represent only a tiny fraction, not more than c. 2.5% of the total.

The present paper is intended to give a full review of all data relating to Cladocera in non-surface waters across the world.

Above published data, we include personal unpublished observations, in order to achieve an exhaustive synthesis, completing earlier ones (Dumont, 1987, 1995, Negrea, 1994).

We begin by a brief historical sketch of research on groundwater Cladocera, followed by an annotated catalogue of species up to end 1994, and conclude by a discussion of the ecological categories of underground Cladocera, their origin and geographical distribution.

Historical overview of research on underground cladocerans

Since the beginning of studies, and until recently, the presence of cladocerans in underground aquatic systems had been qualified as fortuitous by a majority of workers.

In the apparent absence of true troglobitic species, finds were interpreted as resulting from accidental, passive transport to cave and interstitial waters.

Kurz (1874) was probably the first to mention cladocerans in groundwater. He records the regular stygoxenic *Daphnia obtusa* in the Aggtelek cave, Hungary. Only a decade later, in two papers on the arthropod fauna of a series of caves in the Slovenian ('Kraina') karstic region, Joseph (1881, 1882), described the first, and unfortunately mythical underground species, *Leptodora pellucida*.

Moniez (1889), in a study of the fauna of phreatic water in the area of Lille, Northern France, mentioned several Cladocera there. These include the probably stygophilic *Ceriodaphnia reticulata*, three regu-

lar stygoxenics (*Daphnia magna, D. pulex, Camptocercus rectirostris)*, and three stygoxenics (*Pleuroxus trigonellus, P. truncatus, Alona costata*). Six years later, Garbini (1895) found *Daphnia pulex* in the drinking water system of Verona, Italy.

In the following two decades, little was added to our knowledge of subterranean Cladocera although Lilljeborg (1900) described *Chydorus pigroides* (now *Pleuroxus pigroides*: see Frey, 1976) from a small, groundwater-fed marsh at Malma, near Uppsala. This species, which has never been found back since, was probably the first stygobitic species to be discovered. The pond at Malma (now part of Uppsala) no longer exists, and attempts by B. Pejler to find back the species in the area around it, using a Beladjal trap, have so far failed.

Chappuis (1922), in a reservoir at Basel, and in wells near the same city, found two stygophiles, viz. *Alona rectangula* and *Leydigia leydigii.*

Spandl (1926) provided the first monograph on subterranean aquatic life. Unfortunately, his records of Cladocera in cisterns in Dalmatia, Bosnia and Herzegovina, although abundant, produced only the commonest of cladocerans, typical of surface waters. He correctly attracts attention to the fact that species living in shallow wells are not living in complete darkness, suggesting that most of them may have been introduced by man.

A single specimen of *Chydorus sphaericus*, which he himself collected in the cave of Stirfel in Moravia, he considered as a case of passive dispersal to the cave, with the water of an inflowing brooklet. This reflects the dominant opinion of that time, which persisted until quite recently. Thus, Chappuis (1927, 1942, 1946) does never again mention cladocerans in the numerous subterranean environments which be studied.

Typical is also Karaman (1935), who states to have seen some Cladocera in samples from wells in the surrounding of Skopje and Privorica, but did not even bother to identify them because 'such animals do not live in true underground waters'.

Stammer (1932), Rammner (1935) and Wolf (1938) cite 13 stygophilic, probably stygophilic, and stygoxenic species collected from groundwater in the cave system of Postojna - Planina, i.e. the Postojnska jama (Adelsberger cave, Grotta tricolore), the Cerna jama (Schwarzen Grotte = Grotta nera = Black cave), the Magdalenen Grotte, and the Unteren Grotte (= Lower cave), viz. *Daphnia longispina, Simocephalus vetulus, Ceriodaphnia reticulata, C. affinis, Macrothrix laticornis, Bosmina longirostris, Eurycercus lamellatus, Pleuroxus laevis, P. piger, Disparalona rostrata, Alona quadrangularis, A. rectangula, and Leydigia leydigii.*

Motaș & Orghidan (1948) embarked in 1946 on a study of the 'phreatic fauna' in alluvial fillings of river valleys in Romania. Their samples revealed several species of Cladocera, especially in the valley of the River Bistritza at Brosteni, eastern Carpathians, and in the valley of the River Bogata near Racos, Transsylvania. At Bistritza, they found one female of the stygophile *Alona quadrangularis* (described by them as *Alona macrops* n.sp.). In the gravels of the Bogata stream, they recorded three stygophiles (*Ilyocryptus sordidus, Chydorus sphaericus, Leydigia leydigi*), as well as a probable stygobitic species, *Macrothrix bialatus* n.sp. The authors add that 'these are burrowing forms, living in the bottom, and more or less regularly found in epigean, stagnant water; they are not phreatobitic, but since most had embryos in their brood pouch, we may classify them as phreatophilic'.

In the period 1950–1969, few papers appeared which dealt with subterranean Cladocera (Pacaud, 1952; Pljakic & Zivkovic, 1957; Ponyi, 1960; Ponyi & Ponyi, 1961, and Motas et al., 1962).

More progress was made in 1970–1979, with the groundwater fauna of Sweden being studied by Husmann & Teschner (1970) and Frey (1976), that of Germany by Flössner (1972), that of France by Gibert et al. (1977), that of Central Asia by Manuilova (1972), and that of Cuba by Orghidan & Negrea (1970, 1973).

Yet, a real breakthrough only occurred when Petkovski & Flössner (1973) described *Alona smirnovi*, the first confirmed stygobitic cladoceran, thrown up to the surface by springs along Lake Ohrid, Macedonia. It has lost its eye, but not its ocellus, and is a member of the *A. protzi*-group.

Another decade later, Dumont (1983) discovered the second true stygobitic species, *Alona phreatica*, in hyporheic water of a brook in Auvergne, France. Here, an eye and ocellus are present, but they are reduced with respect to those of the neonata. *A. phreatica* is another member of the *A. protzi*-group and crawls, but cannot swim. It co-occurred with *A. bessei*, a *guttata*-group member with normal ocellus and eye, and *Pleuroxus piger* (see Dumont, 1983).

Around that time, a thorough study of the hyporheic fauna of the alluvial zone of the upper Rhone in France was underway, with papers by Gibert et al. (1981), Seyd-Reihani (1980), Dole (1983), Marmonier (1988), Creuzé des Châtelliers & Marmonier (1990), and later, Creuzé des Châtelliers (1995) and Schmidt (1994). Both *A. protzi* and the related *A. phreatica* were

rediscovered here, while in the basin of the River Ter, Catalonia, Sabater (1987) was able to follow a year-long population cycle of the latter, of which he also described the male. Also more or less contemporaneous are studies on groundwater-dwelling Cladocera in Ireland (Duigan, 1990), Italy (Margaritora, 1985, Stoch, 1993), 'Yugoslavia' (Brancelj & Sket, 1990; see also Sket, 1993, 1994a,b, Sket & Brancelj, 1992, Sket et al., 1994 and Bole et al. 1993), Romania (Negrea, 1983, Orghidan et al., 1993), and Iran (Pesce et al. 1982). Other studies deal with the area of New York (Strayer, 1988), the 'wet campo' area near Brasilia (Reid, 1984), and wet forests (Frey, 1980).

But the true sensation of the early 1990ies was the discovery of two blind chydorids, *Alona herzegovinae* and *A. sketi* (Brancelj 1990, 1992), because these were the first two cavernicolous Cladocera, completely devoid of eyes *and* ocelli. Both live in karstic caves in the former Yugoslavia, and they evidently raise questions about the possibility of the presence of similar species in caves elsewhere in the world. Quite recently, Dumont & Brancelj (1994) added a novel intriguing feature to this list, with the discovery, in river gravels in Yemen, of *Alona alsafadii*, an *A. karua*-like chydorid that parallels *A. smirnovi* in having lost its eye. In addition, this species has conserved a number of interesting primitive characters, based upon which Dumont (1995) gave a first discussion of the evolution of groundwater Cladocera.

The widespread application of specific techniques of collection seems to be what advanced the field most, starting with the classical Chappuis method (Chappuis 1942, Motas 1962), over the pump method (Bou, 1967; Bou & Rouch, 1967), to modern standpipe methods (Bretschko & Klemens, 1986) and trapping methods (Beladjal et al., 1993).

To conclude, we mention some general works or reviews which contain topical information: Karaman (1935), Wolf (1938), Angelier (1953), Margalef (1953), Orghidan (1959), Schwoerbel (1961), Motas (1962), Vandel (1964), Williams & Hynes (1974), Ginet & Decu (1977), Hrbacek et al. (1978), Williams (1984), Botosaneanu (1986), Rouch & Danielopol (1987), Dumont (1987, 1995), Negrea (1994, 1995), Dole-Ollivier et al. (1994) and Gibert et al. (1994).

Materials, methods, and abbreviations used.

Methods in use for inventorying cladocerans from subterranean origin are qualitative and quantitative:

- filtration of stagnant water in caves, of drinking water piping systems, sand filters, cisterns, closed reservoirs, and springs, with the help of various types of plankton nets.
- filtration of wells by a Cvetkov-type plankton net (Cvetkov, 1968).
- sampling by the Chappuis-Karaman technique of digging a hole into groundwater layers, or pumping up interstitial water by the Bou-Rouch method, or one of its modifications for river underflows, or in dead arms of rivers, or canals, or lakes.
- trapping specimens in funnel-shaped traps, buried into the groundwater of rivers, baited or not (Beladjal et al., 1993).

An important step (at which, we believe, cladocerans have been frequently ignored in the past), is the picking out of individuals from preserved samples.

The material upon which we base the next section of this article was collected from the literature. In addition, we used data from unpublished sources: Austria, 1978–1993 (leg. D. Danielopol and associates, det. S. Negrea), Algeria (1981, leg. R. Leys, det. S. Negrea), Romania (1956–1980, leg. C. Plesa, det. S. Negrea; 1924–1993, leg. S. Negrea et al., det. S. Negrea), as well as from the Mauritanian (1975, 1976) and Algerian (1977, 1980) Sahara (leg. and det. H. Dumont), and from a cave in South China (1989) (leg. and det. H. Dumont).

For each of the 94 species and subspecies listed hereafter, we briefly indicate geographic range, habitat preference (whether typical of running or stagnant water, and substrate preference, groundwater included), material seen by ourselves, and bibliographic references. Species are arranged in systematical order.

Abbreviations used in the text after 'legit' are: BL = Botosaneanu L., CA = Chappuis A., CI = Capuse I., DD = Danielopol D., DH = Dumont H., LR = Leys R., MC = Motas C., MJ = Mertens J., NS = Negrea S., OT = Orghidan T., PC = Pleşa C., RI = Rogoz I.

Abbreviations referring to the bibliography: BL = Beladjal et al. (1993), BR 1 = Brancelj A. (1990), BR 2 = Brancelj A. (1992), BR 3 = Brancelj A. & Sket B. (1990), CR 1 = Creuzé des Châtelliers M. (1995), CR 2 = Creuzé des Châtelliers M. & Marmonier P. (1990), DG = Duigan C.A. (1990), DM 1 = Dumont H.J. (1983), DM 2 = Dumont H.J. (1986), DM 3 = Dumont H.J. (1987), DM 4 = Dumont H.J. & Brancelj A. (1994), FL = Flössner D. (1972), FR = Frey D.G. (1976), GB 1 = Gibert J. et al. (1977), GB 2 = Gibert J.

et al. (1981), GR = Gurney R. (1921), HR = Hrbacek J. et al. (1978), HS = Husman S. & Teschner D. (1970), JS = Joseph G. (1882), KR = Kurz W. (1974), MN = Manuilova E.F. (1972), MT 1 = Motaş C. et al. (1962), MT 2 = Motaş C. & Orghidan T. (1948), MZ = Moniez R. (1889), NG = Negrea S. (1983), OR 1 = Orghidan T. (1959), OR 2 = Orghidan T. et al. (1993), OR 3 = Orghidan T. & Negrea S. (1970), OR 4 = Orghidan T. & Negrea S. (1973), PC = Pacaud A. (1952), PL = Pljakic M.A. & Zivkovik A. (1957), PN 1 = Ponyi J. (1960), PN 2 = Ponyi J. & Ponyi L. (1961), PR = Parenzan P. (1932), PS = Pesce G.L. et al. (1982), PT = Petkovski T. & Flössner D. (1972), RD = Reid J.W. (1984), RM = Rammner W. (1933), SB = Sabater F. (1987), SC = Schmidt C.M. (1994), SO = Stoch F. (1993), SP = Spandl H. (1926), SR = Strayer D. (1988), ST = Stammer H.J. (1932), WL = Wolf B. (1938).

Other abbreviations: SB = stygobiont, SF = stygophile, SXR = regular stygoxene, SX = stygoxene, BR = pumping-filtration by Bou-Rouch technique, CK = Chappuis-Karaman collecting method, ad. = adult female without (parthenogenetic) eggs, alt. = altitude, eph. = ephippial female, ex. or spec. = specimen, juv.= juvenile, ov. = ovigerous parthenogenetic female, prov. = province, temp. = temperature.

Checklist of cladoceran species reported from non-surface waters (up to Dec. 1994).

Leptodoridae Lilljeborg 1861.

1. *Leptodora pellucida* Joseph 1882 Only reported from the karst of Slovenia. Cave waters. Planktonic. SB?

Literature records.

Slovenia. - Kraina, two caves: Kumpoljska jama (Cumpole cave) and Skocjanske jama (cave of San Canziano) (JS, PR, WL and BR 3).

Note. Joseph (1881, 1882) gave only a superficial description, without figures, stating that the species was blind 'Die Augen fehlen vollständig; an ihrer Stelle finden sich jederseits des schnabelförmigen Kopfes ein Tasthaar' (!). This animal has never been found again in either of the caves, and Sket (1994) bluntly relegates it to the realm of science fiction. Perhaps, it may have been (a) specimen(s) of *L. kindtii* (Focke), accidentally washed into the cave and which, with time and obscurity (Kapterew, 1912; Tschugunoff, 1913) lost most of its eye pigment (see also Vandel, 1964 and Negrea, 1983, 1994).

Sididae (Baird, 1850).

2. *Sida crystallina crystallina* (O.F. Müller 1776). Palaearctic (Korovchinsky, 1992)

Small and large stagnant waters, rich in vegetation (macrophytophilic). Occasional in hyporheic and phreatic waters. SX?

Material examined.

Austria. - Danube valley at Lobau (Vienna), floodplain: standpipe sample D15, 10 m depth, 5 liters of water, 16.I.1992, 1 ♀ ad. (DD).

Literature records.

Alluvial floodplain of the French upper Rhône: in river gravel (CR1); idem, 25 km downstreams of Lyon (pump sample BR in gravels 0.2–1.0 deep, 26.IX.1990, 21 ex. (SC).

3. *Diaphanosoma brachyurum* (Liévin 1848), emend. Negrea 1983 (s. str.).

Palaearctic (Korovchinsky, 1992).
Typical of large-sized eutrophic waters; accidental in interstitial water. Planktonic. SX?

Material examined.

Austria. - Danube valley at Lobau (Vienna), floodplain: standpipe LC 40, 0.4–0.5m depth, 3 liters of water 23.VIII.1978, 3 ♀♀ ad. (DD). Note. First record from groundwater.

4. *Diaphanosoma excisa* (Sars, 1885)

Circumtropical.
Typical of freshwater lakes and ponds. Planktonic. SX?

Literature record.

Chatterji et al. (1995) record a seasonally fluctuating population (with a maximum of 46 ind. $10cm^{-2}$ of surface area in September and at 0.1–0.15 cm depth) in an intertidal sandy beach at Balrangar, India. This is the first report of Cladocera in a marine beach, where they were most abundant at the lowest salinities (highest freshwater flow of the river).

Daphniidae Schoedler, 1858.

5. *Daphnia magna* Straus 1820.
Holarctic, afrotropical, and oriental.

Typical of small-sized, eutrophic waters, occasionally in wells and springs. Planktonic. SXR?

Material examined.

Romania. - Floodplain of Danube at Potelu, limnocrene, 7.XI.1970, 545 ♀ juv., ov. (RI); valley of Desnatui at Radovanu, limnocrene, 27.VIII.1971, 1420 ♀ juv., ad. (RI).
Algeria. - Saida Province, few km. for El Biod: well driven by windmill, 8 m deep, of which 3 m water, 7.IV.1981, 325 ♀ juv., ov. eph. and ♂; idem, well near Krebazza, windmill-driven wells in rock bottom, 5.5 m deep, of which 1.5 m water, 7.IV.1981, 11 ♀ juv., ad. and ♂ (LR).

Literature records.

Danube valley at Potelu: spring (NG); valley of Desnatui, spring (NG); Lille (well) (MZ: *Daphnia schaefferi*).

6. *Daphnia similis* Claus, 1876. Oriental, afrotropical, often in ephemeral waters, in arid and semi-arid climates. SX.

Material examined.

Mauretania. - Well at Ouadane, (20°58'N, 11°40'W), 04.II.1976, numerous parthenogenetic females (DH). First record from underground waters.

7. *Daphnia obtusa* Kurz 1874, emend. Scourfield, 1942.

Palearctic, afrotropical and oriental.
Typical of small stagnant waters, rich in organic matter; sometimes in caves, wells, cisterns, springs. Planktonic. SXR?

Material examined.

Romania. - Valley of the Iza at Poienile Izei, well, 4.X.1967, 9 ♀ juv., ov., eph., ♂ (BL); same valley, at Strimtura, well, 3.X.1967, 1♀ (BL); valley of the Belareca at Mehadia, well, 11-14°C, 21.VII.1955, 24 ♀ juv., ov., eph. and ♂; 7.VIII.1956, 462 ♀ juv., ov., eph. and ♂; 29.IX.1957, 38 ♀ juv., ov., eph. (CI); valley of the Neajlov at Comana, in forest; spring in bed of Alisteu brooklet, temp. 10.5°C, pH 6.7, 12.X.1959, 452 ♀ juv., ov., eph. and ♂ (NS).

Literature records.

Valley of the Alisteu: spring (MT 1 and NG); valley of the Iza: well (NG); valley of the Belareca: well (NG); Aggtelek cave (KR and WL: *Daphnia pulex* var. *obtusa*); Slovenia, Timavo, villae Caresana: cistern (ST).

8. *Daphnia pulex* Leydig 1860, emend. Scourfield 1942.

Holarctic, afrotropical, oriental.
Ponds and temporary pools, sometimes lakes. Not rare in different types of subterranean waters (wells, hyporheic water piping systems, cisterns, springs). Planktonic. SXR?

Literature records.

Karstic zone of Bosnia-Herzegovina and Istria in wells and cisterns, up to 14 spec. per sample (PL); Verona: drinking water system (Garbini, 1895); Germany, limnocrenes (FL); alluvial floodplain of upper Rhône in France, BR pump samples from river gravels (CR1); Lille: wells (MZ: *Daphnia pennata*).

9. *Daphnia curvirostris* Eylmann 1887, emend. Johnson 1952.

Palaearctic and afrotropical.
Small stagnant waters, rivers and streams with slow current, rich in organic matter. Occasional in hyporheic water, wells, springs. Planktonic. SX?

Material examined.

Romania. - Valley of the Danube at Bechet, well, 7 m deep, 14°C, 23.IX.1970, 22 ♀ juv, ad. (RI).

Literature records.

Central Asia, S. Kazakhstan, underground water pit and collections of spring water near Poustynoi Stantzy, and wells Sultan-Bibi and Djingilkoudouk, 30 ♀ parth., and ♂ (MN); Danube valley at Bechet, well (NG).

10. *Daphnia longispina* O.F. Müller 1785.

Palaearctic.
Typical of small and large, shallow eutrophic ponds and lakes. Sometimes in subterranean water (caves, wells, cisterns, hyporheic waters). Planktonic. SXR?

Literature records.

Cave system of Postojna-Planina: 'Magdalena cave' (WL: *Daphnia longispina* var. *longispina f. friedeli*); same, puddles in bed of subterranean river Pivka in 'Black cave' (ST: *D. longispina* var. *longispina f. friedeli*); Slovenia, Timavo province,

Caresana village: cistern (ST: *D. longispina* var. *litoralis* and var. *rosea*); karst of Bosnia-Herzegovina and Istria: wells and cisterns, 1 ex (PL); alluvial floodplain of upper Rhône (France), river gravels, including in dead arms: BR pump samples at 0.6 m in gravel, 1975–1978 (GB2, CR1).

11. *Daphnia hyalina* Leydig 1860.

North-palaearctic.
Characteristic of large oligotrophic lakes; occasional in hyporheic waters. Planktonic. SX.

Literature records.

Alluvial floodplain of upper Rhône (France): BR pump samples from river gravel (CR1); idem, 25 km downstreams of Lyon: BR pump samples in gravel at 0.2–1.0 m deep, 26.IX.1990, few specimens (SC).

12. *Daphnia galeata galeata* Sars 1864, emend. Brooks 1957.

Palaearctic.
Characteristic of large, eutrophic lakes, but also found in ponds and even in slow-running rivers; occasional in hyporheic water. Planktonic. SX.

Literature records.

Alluvial floodplain of upper Rhône (France): BR pump samples in gravels (CR1); idem, 25 km downstreams of Lyon: BR pump samples in gravels at 0.2–1.0 m deep, 26.IX.1990, few specimens (SC).

13. *Daphnia cucullata* Sars 1862.

North-palaearctic.
Characteristic of large eutrophic lakes, but also in ponds and slow-running rivers. Sometimes in hyporheic and interstitial waters of lakes. Planktonic. SX?

Literature records.

Sandy beaches of Lake Balaton at Tihany and Abrahámhegy (Hungary): CK sampling at 0.3–0.4 m depth, 17.VI.1956, 6.IX.1957 and 1.VII.1959, few juveniles ♀ (PN1); alluvial floodplain of upper Rhône (France), BR pump samples in gravels (CR1), idem, 25 km downstreams of Lyon, BR pump samples in gravels at 0.2–1.0 m deep, 26.X.1990, few specimens (SC); Sweden: Orlova-Bienkowskaja in gravels and sandy beaches of rivers (HS: *D. cucullata kahlbergensis).*

14. *Daphnia ambigua* Scourfield 1947.

Nearctic, introduced in Europe.
Stagnant water of lakes and ponds; accidental in caves. Planktonic. SX.

Material examined.

Cuba. - Oriente prov., in cave 'Cueva del Fustete' in darkness: small fresh water basin with guano, sandy bottom, 0.5 m deep, 22.8°C, 10.IV.1969, 180 juv., ad, 99 ♂ (NS).

Literature record.

Cave on Cuba: lake (OR 3, OR 4)

15. *Daphnia* sp.

Literature record.

Iran, Cialestore near Teheran: well with sandy bottom and detritus, 12.5 m deep, of which 3 m water, 18°C, pH 7.5–8, 28.V.1978 - *Daphnia* sp. here together with *Nitocra lacustris, Microcharon raffaellae* etc. (PS). SX?

16. *Simocephalus vetulus* (O.F. Müller 1776).

Geographic range imperfectly known: Europe, parts of Asia and perhaps of Africa, North and South America (Orlova-Bienkowskaja, 1993).
Stagnant waters and slow-running waters, large and small, rich in vegetation. Often in subterranean waters (caves, wells, springs, phreatic and hyporheic waters). Macrophytophilic. SF.

Material examined.

Romania. - Valley of Motru at Glogova: limnocrene, 27.III.1974, 42 ♀ juv., ov. (*spinosulus*) (RI); valley of the Danube at Bechet: well, 7 m deep, 14°C, 23.IX.1970, 66 ♀ juv., ov. (*spinosulus*) (RI); valley of Cotmeana at Vlascauta, alt. 170 m: helocrene Balta Popii, 20°C, pH 6.6, 21.V.1960, 1 ♀ juv (NS); valley of Teleorman at Izvoru de Sus, in forest, alt., 145 m: small limnocrene Zlotea, 13°C, 12.VI.1959, 26 ♀ juv., ov. (*spinosulus*) (NS); valley of Calnistea at Naipu, in Arman forest: limnocrene, 0.2 m deep, 21°C, pH 7.8–8.0, 27.VII.1959, 2 ♀ ad (*spinosulus*) (NS); valley of Colentina at Pantelimon: spring in forest, 29.X.1945, 1 ♀ juv. (OT). Austria. - Valley of Danube at Lobau (Vienna), floodable zone: standpipe R1, 1.7 m depth, 5 liters of water, 11.IX.1992, 1 ♀ ad. (DD).

Literature records.

Valleys of Cotmeana, Teleorman and Calnistea: springs (MT 1, NG); valley of Colentina: spring (NG); valley of Motru: limnocrene (NG); Danube valley at Bechet: wells (NG); idem, at Bratislava: CK sampling, 4 ♀ juv, ad, 2 ♂ (PN2); Sava river at Tomacevo-Ljubijana: BR pump samples in gravel up to 0.8 m deep, numerous ♀ (BR3); Karst of Bosnia-Herzegovina and Istria: wells and cisterns, 1 ♀ (PL); Slovenia, Timavo prov., Monticello village: helocrenes (ST); cave system Postojna-Planina: 'Adelsberger cave' and 'Magdalena cave' (WL); idem, lakelets in 'Black cave', 19–27.VIII.1930, 3 ♀ juv (RM); idem, puddles in drying bed of cave river Pivka in 'Black cave' and 'Lower cave' (ST); idem, in course of cave river Pivka (over 9 km): numerous specimens during floods and few in remaining puddles, the latter specimens always well fed (BR3); Germany: wells (FL); alluvial floodplain of the upper Rhône, France: BR pump samples in gravels (CR 1); idem, side channel with gravel, pebbles and sand, BR pumping at 0.5 m, up to 339 specimens per sample (only 1 spec. found in benthos of the same channel !) (CR2); idem, 25 km downstreams of Lyon: BR pump samples in gravels at 0.2–0.5m deep, 26.IX.1990, 15 specimens (SC).

17. *Simocephalus exspinosus* (De Geer 1778) s.lat.

Geographic range incompletely known: Europe, Asia, Africa (?), North America (?), South America (?) (Orlova-Bienkowskaja, 1993).

Smallish stagnant waters and sluggish rivers, rich in vegetation; sometimes in the hyporheic. Macrohytophilic. SXR?

Literature records.

Alluvial floodplain zone of upper Rhône (France): BR pump samples, including dead arms, at 0.6 m deep in gravels, 1975–1978 (GB 2, CR 1); idem, side channel with gravel, pebbles and sand: BR pumping at 0.5 m, 43 ex. at station 12 (none in the benthos of the channel !) (CR2); idem, 25 km downstreams of Lyon: BR pump samples in gravel at 0.2–0.5m, 26.IX.1990, 15 ex. (SC).

18. *Simocephalus congener* (Koch 1841) s.str.

Europe (Orlova-Bienkowskaja, 1993).
Characteristic of small stagnant waters, with luxurious aquatic vegetation; occasionally in wells and springs. Macrophytophilic. SXR?

Material examined.

Romania. - Valley of the Belareca at Mehadia: wells, 11–14°C, 7.VIII.1956, 8 ♀ ov., and 29.IX.1957, 12 ♀ ad. (CI); valley of the Saraceaua at Bailesti: well, 16.VII.1970, 321 ♀ juv, ov. (RI); Danube valley at Bechet, well, 7 m deep, 14°C, 29.IX.1970, 12 ♀ juv, ov. (RI); idem, at Gura Padinii, well, 12 m deep, 8°C, 23..1970, 5 ♀ ad. (RI); valley of Calnistea at Naipu, in Arman forest: limnocrene, 0.2 deep, 21°C, pH 7.8–8.0, 27.VII.1959, 12♀ juv, ov. (NS); idem, limnocrene in village Naipu, 16.5°C, pH 7.8, 26.VII.1959, 1 ♀ juv. (NS).

Literature records.

Valleys of the Danube, Saraceaua and Belareca: wells (NG); valley of the Calnistea, springs (MT1, NG).

19. *Simocephalus serrulatus* (Koch 1841).

Europe, Asia, Africa, North and South America (Orlova-Bienkowskaja, 1993).

Shallow stagnant waters with much vegetation; accidental in the hyporheic. Macrophytophilic. SX?

Literature records.

Alluvial floodplain of upper Rhône (France), in gravels: BR pump samples (CR 1).

20. *Ceriodaphnia reticulata* (Jurine 1820).

Holarctic, afrotropical, neotropical.

Smallish stagnant waters, permanent or ephemeral, rich in vegetation, but also large lakes and slow running waters. Often in subterranean waters (caves, wells, hyporheic waters, springs, citerns). Planktonic and macrophytophilic. SF?

Material examined.

Romania. - Valley of Belareca at Mehadia: wells, 11–14°C, 7.VIII.1956, 14 ♀ ov., eph., ♂; 29.IX.1957, 17 ♀ juv., ov., eph. ♂ (CI); valley of the Colentina, in Andronache forest: well, 3.V.1945, 12 ♀ juv., ad (TO); valley of Teleorman at Izvoru de Sus, in forest, alt. 145 m: small limnocrene Zlotea, 13°C, 12.VI.1959, 244 ♀ juv, ov. (NS).

Algeria. - Saïda prov., 12 km from Aïn Sefra towards Mecheria: windmill-driven well, 8.IV.1981, 88 ♀ juv, ov.; idem, 13 km from Aïn Sefra towards Mecheria: wells (with windmill), 20 m deep of which

11 m water, 8.IV.1981, 4♀; idem, c. 38km from Mecheria (towards Aïn Sefra), windmill-driven well, 42 m deep of which 38 m water, 8.IV.1981, 1 ♀ ad. (LR).

Literature records.

Valley of Teleorman: spring (MT1, NG); valley of Belareca: well (NG); valley of Colentina: well (NG); karst of Bosnia-Herzegovina and Istria: wells and cisterns, 2 ♀ (PL); cave system of Postojna-Planina: 'Magdalena cave' (WL); idem, puddles in drying bed of subterranean river Pivka in 'Black cave' (ST); cave Vilina Pecina: underground water course with origin at Gatacko Polje (BR3); Slovenia, Timavo prov., villages Sasseto and Monticello: helocrenes (ST); alluvial floodplain of upper Rhône (France), river banks and dead channels: BR pumping at 0.6 m in gravels, 1975–1978 (GB2, CR1); idem, 25 km downstreams of Lyon: BR pumpings in gravels at 0.2–1.0 m, 14.VII.1990, 5 ex (SC); Lille: wells (MZ).

21. *Ceriodaphnia megops* Sars 1862.

Holarctic.

In similar environments as *C. reticulata*; occasional in hyporheic. Planktonic, macrophytophilic, SX.

Literature records.

Alluvial floodplain of upper Rhône (France), river banks and dead arms: BR pumpings at 0.6 m in gravels, 1975–1978 (GB2, CR1); idem, 25 km downstreams of Lyon: BR pumpings in gravels, 0.2–1.0 m deep, 14.VII.1990, 1 ex (SC).

22. *Ceriodaphnia laticaudata* P.E. Müller 1867 s.lat.

Holarctic, afrotropical.

Small stagnant waters with muddy bottom and much vegetation; sometimes in caves and shallow wells. Planktonic, macrophytophilic. SXR?

Material examined.

Romania. - Valley of Belareca at Mehadia: wells, 11–14°C, 29.IX.1957, 1 ♀ eph. (CI); Danube valley at Gura Plaiului: well, 12 m deep, 8°C, 23.IX.1970, 6 ♀ ad. (RI); idem, at Bechet: well, 7 m deep, 14°C, 23.IX.1970, 15 ♀ juv, ov, eph, ♂ (RI); well on beach of lake Sutghiol at Ovidiu, 8.XI.1968, 31 ♀ ov, eph, ♂ (DD).

China. - Reedflute cave in karstic area near Guilin, S. China, 20.VII.1989, numerous ♀ (DH).

Literature records.

Valleys of the Danube and Belareca: wells (NG); Ovidiu: well (NG); karstic zone of Istria, 'holes of St. Canzian' (ST).

22a. *Ceriodaphnia laticaudata deserticola* Manuilova 1972.

Restricted to Central Asia?

Found in wells only. A stygobitic subspecies of an epigean species? SB?

Literature reference.

Central Asia, South Kazakhstan: well Djingilk-oudouk, > 30 ♀ part., eph. (MN).

23. *Ceriodaphnia pulchella* Sars 1862.

Holarctic.

Smallish and large eutrophic waters rich in vegetation, and slow running rivers; occasional in interstitial waters. Planktonic, macrophytophilic. SX?

Material examined.

Austria. - Danube valley at Lobau (Vienna), floodplain; standpipe LC 40, 0.4–0.5 m depth, 3 liters of water, 23.VIII.1978, 3 ♀ ad. (DD). This is the first record of this species from the subterranean domain.

24. *Ceriodaphnia affinis* Lilljeborg 1900.

Range unsatisfactorily known, probably palaearctic. Some authors consider this species as synonymous with *C. dubia* Richard, but Dr. D. Berner, Philadelphia (pers. comm.), having re-examined the type series of *C. affinis*, is of the opinion that both are valid.

Stagnant water or water with slow current, rich in vegetation; accidentally in caves. Planktonic and macrophytophilic. SX.

Material examined.

Algeria. - Sahara, Hoggar mountains, guelta (rock-pool) of Imeleoulaouene, sample in coarse sand at water edge, numerous ♀ juv., ov., May 1980 (DH).

Literature records.

Cave system of Postojna-Planina: 'Magdalena Cave' (WL); idem, large lakes of 'Black cave', 19–27.VIII.1930, 3 ♀ juv. (RM).

25. *Ceriodaphnia cornuta* (s.lat., 'hairy form') (*fide* D. Berner, Philadelphia).

Populations of 'hairy' appearance from Cuba and Florida are different from *C. cornuta* Sars 1885 (s.str.) from Australia (with frontal horn) and from *C. rigaudi* Richard 1884 from Vietnam (without frontal horn) (Dr. D. Berner's, pers. comm.). This species, still undescribed, has also been found in Mexico (H. Dumont, unpublished observations).

In Cuba, this species was found in a dead river arm with stagnant water of pluvial origin, rich in waterplants (30.5°C, pH 6.7), and in cave water (Orghidan & Negrea, 1970). Planktonic, macrophytophilic, SF.

Material examined.

Cuba. - Oriente prov., cave 'Cueva del Fustete': small freshwater basin in total darkness with sandy bottom and guano, 0.5 m deep, 22.8°C, 10.IV.1969, 1 ♀ ad, without frontal horn (NS); Caguanes island, inside Cueva Grande de Caguanes: freshwater lake with thick mud layer at the bottom, in total darkness, 23°C, 24.IV.1969, 524 ♀, juv., ov., without frontal horn (BL); Pinar del Rio prov., cave 'Cueva del Agua de Ganahacabibes', in darkness: phreatic freshwater lake, 3.VI.1969, 58 ♀♀ juv, ov, with frontal horn (NS); Pinos island, cave 'Cueva del Agua', in darkness: freshwater lakes microgours, and accumulations of percolation water, 11.VI.1969, 318 ♀, juv., ov., without frontal horns (NS); Matanzas prov., Cueva la Pluma, in darkness: phreatic freshwater lake with guano on the bottom, 25°C, 15.XI.1970, 135 ♀ juv., ov., without frontal horns (OT).

Literature records.

Caves of Cuba: phreatic freshwater lakes, microgours and accumulations of percolation water (OR 3, OR 4: *C. cornuta rigaudi*, for forms without frontal horn, and *C. cornuta cornuta* for horned forms).

26. *Scapholeberis mucronata* (O.F. Müller 1776).

Palaearctic and north nearctic.

Large and small stagnant waters rich in vegetation, and rivers with slow current. Sometimes in interstitial (phreatic, hyporheic) water and in springs. Hyponeustic, macrophytophilic. SXR?

Material examined.

Austria. - Danube valley at Lobau (Vienna), floodplain: standpipe samples D3 at 2 m depth, 5 liters of water, 28.V.1991, 2 ♀ juv, ad. (*cornuta*), D10 at 1.5 and at 5 m depth, 10 liters of water, 28.V.1991, 2 ♀ ad. (*cornuta*) (DD). Note. The females collected at 1.5 and at 2 m depth had depigmented eyes and ocelli; those at 5 m had pigment in decomposition.

Literature records.

Germany: 'Springs' (FL); alluvial floodplain of the upper Rhône (France), shores and dead arms: BR pumpings at 0.6–0.9 m depth in gravels, abundant at one station, 1975–1978 (GB1, GB2, DM3, CR1); idem, 25 km downstreams from Lyon: BR pumpings in gravels at 0.2 m depth, 14.VII.1990, 1 ex (SC).

27. *Scapholeberis rammneri* Dumont & Pensaert 1983.

Range incompletely known: palearctic and perhaps north-nearctic.

Small and large, shallow, warm eutrophic water, rich in vegetation; also in slow running rivers. Occasionally in interstitial water of lakes and springs. Hyponeustic, macrophytophilic. SX.

Material examined.

Romania. - Valley of the Teleorman at Izvoru de Sus, in forest, alt. 145 m, small limnocrene Zlotea, 13°C, 12.VI.1959, 4 ♀ juv., ov. (NS); idem, captured spring in hollowed-out tree trunk, 0.85 m deep, of which 0.80 m of water, 11.6° C, pH 7.5, 12.VI.1959, 21 ♀ juv., ov. (NS).

Literature records.

Valley of the Teleorman: springs (NG: *Scapholeberis kingi*); sandy beaches of Lake Balaton at Zamardi: CK pumpings at 0.3–0.4 m deep, 1.VI.1959 (PN 1: *S. kingi*); Sunda-Expedition, hot mineral spring, 35.5°C, pH 2.68 (Brehm, 1933: *S. kingi*).

28. *Scapholeberis kingi* (Sars 1903).

Australian, oriental, afrotropical.

In same types of environments as previous two species; sometimes in caves. Hyponeustic, macrophytophilic. SX?

Material examined.

China. - Reedflute cave, shallow lake, VII.1989, numerous juv. and adult females, still fully pigmented (cave frequently lighted during tourist visits) (D.H.). Note. First record from a cave, but perhaps an artefact because of the artificial light conditions.

Moinidae Goulden 1968

29. *Moina brachiata* (Jurine 1820), emend. Goulden 1968.

Palaearctic and afrotropical.

Small, stagnant, warm eutrophic waters with muddy bottom, rich in organic matter. Occasional in subterranean waters (wells, sand filters, cisterns). Planktonic. SX.

Material examined.

Romania. - Valley of the Dambovita in Bucarest: sand filters of the Arcuda, 4.VI.1957, 7 ♀ ad. (NS).

Libya. - Well at Benghasi (31°46'N, 20°02'E), 24.VI.1978, numerous ♀ (D.H.).

Literature records.

Valley of the Dambovita: sand filters (NG); karst of Bosnia-Herzegovina and Istria: wells and cisterns, up to 2 ex. per sample (PL).

30. *Moina micrura* Kurz 1874, emend. Goulden, 1968.

Almost cosmopolitan.

Larger stagnant waters, dead arms of rivers, rice fields, slow flowing rivers, accidental in wells. Planktonic. SX.

Literature record.

Central Asia, South Kazakhstan: water barrel from Shourouk well; water of a well near Poustynoi Stantzy, 10–30 ♀, ♂ (MN: *Moina weberi* Richard).

31. *Moina macrocopa macrocopa* (Straus 1820).

Palaearctic, oriental.

Temporary waters, as well as warmwater ponds, rich in organic material; slow rivers; often in subterranean waters (wells, hyporheic waters, springs, cisterns). Planktonic. SF?

Material examined.

Romania. - Saraceaua valley at Balasan: abandoned well, 6.5 m deep (of which 2.5 m water), 15°C, 5.X.1970 (RI); Calnistea valley at Naipu, in forest Puntea Pasii: limnocrene with muddy bottom, 0.1 m deep, 23°C, pH 7.7–7.9, 26.VII.1959, 8 ♀ juv., ov. (NS); idem, Arman forest: limnocrene with muddy bottom, 0.2 m deep, 21°C, pH 7.8–8.0, 27.VI.1959, 640 ♀ juv, ov and ♂ (NS). Algeria. - Well at Tesnou (-2m), Sahara (24°43'N, 04°39'E), 18.III.1977, and well of Meniet (25°00'N, 04°21'E), 18.III.1977, numerous parthenogenetic females (DH).

Literature records.

Oltenia plain at Balasan: well (NG); Calnistea valley, springs (MT1, NG); karst of Bosnia-Herzegovina and Istria: wells and cisterns, 1 ex. per sample (PL); Eastern Pyrenees, Las Routes near St. Cyprien Plage: groundwater filtered before irrigating a rice field, ♀ juv., ov., eph. and ♂ (PC, DM3).

32. *Moina salina* Daday 1888, emend. Negrea 1983.

South-Palaearctic, australian.

Restricted to saline waters (3.5–104.7 <?WP 4, 75> salinity); sometimes in wells. Planktonic. SX?

Material examined.

Algeria - Oum El Bouaghi prov., between Batna and Constantine: freshwater well, 8 m deep (of which 1.5 m of saline water), 18.IV.1981, 204 ♀ juv., ov., eph. and ♂ (LR).

Note. This is the first record of this species from a subterranean environment.

33. *Moina* sp. 1

Literature record.

Central Asia, South Kazakhstan. - Wells Sarykiariz, Urouzkoudouk, and Ayak-Goujoumdy, 2–7 ♀ (MN). SX?

34. *Moina* sp. 2

Literature records.

4pt]

Iran, Kargash (Abbas-Abad), near Caspian Sea: freshwater wells with sandy-muddy bottom and detritus, 6.5 m deep (5 m of water), 17°C, pH 8, 30.VIII.1977 - *Moina sp.* here together with *Asellus aquaticus* etc. (PS); idem, Karaj near Teheran, 2 cisterns with sandy loamy bottom, 2–2.5 m deep (1.5–2.0 of water), 18°.5-19°.C, , pH 7–7.5 - *Moina sp* here together with cyclopoids, ostracods, etc. (PS).

Note. These waters were so shallow that this *Moina* sp. may not have been a stygobiont. SX?

Ilyocryptidae Smirnov 1992.

35. *Ilyocryptus sordidus sordidus* (Liévin 1848).

Palaearctic.

Floodable zones, vegetation-rich gulfs of lakes, ponds, slow flowing rivers; often in the hyporheic, springs, occasionally in caves. Pelophilic, sometimes macrophytophilic. Capable of swimming but also of filtering submerged in mud. SF.

Material examined.

Romania. - Motru valley at Gura Motrului: CK sample, 5 ♀ ov. 14.IX.1962 (NS).

Literature records.

Bogata valley at Racos: CK sample, 7.5°C, 24.XI.1946, ♀ ad. (MT2); Motru valley: hyporheic waters (NG); Lake Techirghiol: spring on shore (NG); Danube valley at Bratislava, CK samples, 4 ♀ juv ad. (PN2); cave system of Postojna-Planina, in underground course of river Pivka (9 km): numerous ♀ ov. at all stations in summer after floods and few ♀, but well fed during winter (thus, a permanent subterranean population present !) (BR3); Slovenia at Zuzemberk: karstic spring Tomincev Studenec, few ♀ but present throughout the year, together with stygobitic and crenobitic species (BR3); alluvial floodplain of the upper Rhône (France), shores and dead arms: BR pumpings at 0.6 m deep in gravels, 1975–1978 (GB2, CR1); idem, at Brégnier, Miribel and Donzère: BR pump samples in gravels at 0.5 m, VIII-IX.1988, max. 14 ex. at Donzère (1793 ex. in benthos), and I-II.1989 max. 9 ex. at Brégnier (none in benthos) (CR1); idem, channel with gravel, pebbles and sand: BR pumpings at 0.5 m deep, max. 16 ex. per sample (CR2); idem, 25 km downstreams of Lyon: BR pumpings in gravel at 0.2–1.0 m deep, 26.IX.1990, 71 ex. (SC).

36. *Ilyocryptus agilis* Kurz 1878.

Palaearctic, but also cited from central Africa and Taiwan.

Stagnant water (lakes, ponds), river with sluggish flow; sometimes in phreatic and hyporheic water. Pelophilic, macrophytophilic. SF?

Material examined.

Austria. - Danube valley at Lobau (Vienna), floodable zone: standpipe LB(1), 0.4–0.5 m depth, 1 liter of water, 17.X.1980, 1 ♀ ov. (DD).

Literature records.

Alluvial floodplain of upper Rhône (France), shores of the river: BR pumpings in gravel (CR1); idem, at Miribel and Donzère: BR gravel pumping, VIII-IX.1988, max. 15 ex. at Donzère (1305 ex. in benthos) and none on I-II.1989 (CR1); idem, 25 km downstreams of Lyon: BR pumpings in gravel at 0.2–1.0 m, 29.IX.1990, 71 ex. (SC).

37. *Ilyocryptus acutifrons* Sars 1862.

Holarctic, afrotropical.

Stagnant water (lakes, ponds) and slow rivers; accidentally in hyporheic water. Pelophilic. SX?

Literature record.

Alluvial floodplain of upper Rhône (France), along shores: BR pumpings in gravel (CR1).

Macrothricidae Norman & Brady 1867.

38. *Lathonura rectirostris* (O.F. Müller 1785).

Holarctic (Smirnov, 1992).

Lakes, ponds, canals, rich in vegetation, and slow running rivers. Pelophilic and macrophytophilic. SX?

Literature records.

One general citation in 'Limnofauna Europaea', where the species is classified under species likely to occur in groundwater (HR).

39. *Macrothrix laticornis* (Fischer 1851).

Holarctic (Smirnov, 1992).

Small and large eutrophic lakes with clear water, muddy or sandy bottom, submerged vegetation. Also in sluggish rivers. Common in hyporheic waters, caves, sometimes in springs. Pelophilic, macrophytophilic. SF.

Material examined.

Romania. - Desnatui valley at Radovanu: rheocrene near river, 6.III.1970, 8 ♀ ad. (NS).

Literature records.

Desnatui valley: spring (NG); sandy beaches of Lake Balaton in Tihany and Abrahamhegy, CK samples at 0.3–0.4 depth, 17.VI.1956, 1.VII.1959 (PN1); cave system Postojna-Planina: 'Adelsberger cave' and 'Magdalena cave' (WL); idem, in subterranean river

Pivka over 9 km, numerous ♀ ov. at all stations after floods (BR 3); idem, puddles in drying river Pivka in 'Black cave' and 'Lower cave' (ST); alluvial floodplain of upper Rhône (France) in banks of river and dead arms: BR pumpings in gravel (CR1); idem, at Miribel and Donzère: BR pumpings in gravels at 0.5 m depth, VIII-IX.1988, max. 8 ex. at Donzère (367 ex. in benthos), and I-II.1989, max 9 ex. at Donzère (none in benthos) (CR1); idem, channels with gravel, pebbles and sands: BR pumpings at 0.5 m depth, up to 6 ex per sample (in the benthos: 15 ex. per sample) (CR2); idem, 25 km downstreams of Lyon: BR pumpings in gravels at 0.2–0.5 m deep, 26.IX.1990, 3 ex. per sample (SC); several stations SE of New York: filtrations of subterranean water, 0.2 ex. per 3 liters of water (SR).

40. *Macrothrix bialatus* Motas & Orghidan 1948.

Restricted to Transylvania?
Hyporheic. Pelophilic. SB?

Literature record.

Bogata rivulet (a tributary of the Olt River, Transylvania), at Racos, alt. 445 m: a CK sample, 7.5°C, 24.X.1946, numerous ♀ (MT2, OT1, NG). Note. Unfortunately, this animal, with 'normal' eyes, was not sufficiently well described, and the type series was lost. It will be necessary to rediscover it in its type locality to ascertain whether it is specifically different from *M. laticornis*. Until such time, synonymisation, as proposed by Smirnov (1992) is better delayed. Smirnov (1976) identified a female from a pond in Iraq as *M. bialatus*, which he synonymized with *M. laticornis* in 1992.

41. *Macrothrix hirsuticornis* Norman & Brady 1867.

Palaearctic (Smirnov, 1992).
Small stagnant waters with muddy bottom and vegetation. Nectobenthic, macrophytophilic. SX?

Literature record.

Only a general reference to groundwater in 'Limnofauna Europaea' (HR).

42. *Neothrix* sp.

The genus is Australian.

Literature record.

Sailor falls near Melbourne: a hairy macrothricid, seen live in a CK-sample, was lost upon fixation, such that its specific status remains uncertain (DM3). SB?

Bosminidae (Baird 1845) Sars 1865.

43. *Bosmina longirostris* (O.F. Müller 1785).

Quasi cosmopolitan.
Large and small stagnant waters, usually in small eutrophic, also in slow flowing rivers. Not seldom in hyporheic waters, wells, standpipes, caves, and piping systems. Planktonic but mildly macrophytophilic as well. SF?

Material examined.

Romania - Valley of Somesu Mic at Gherla: well, 2°C, pH 7, 20.III.1965, 1 ♀ ad. (*similis*) (PC); Danube valley at Braila: in drinking water pipes, 23.VII.1956, 4 ♀ juv. and ov. (*similis*) (NS).
Austria. - Danube valley at Lobau (Vienna), floodplain, standpipe samples D3 at depths of 4 m and 7.5 m., 10 liters of water, 16.I.1992, 5 ♀ juv., ad. (*similis*), D4 at 2 m and at 4 m depth, 10, liters of water, 16.I.1992, 2 ♀ juv, ov. (*similis*) (DD).
Belgium. - Cave of Han, main lake, June 1965, several adult ♀ (D.H.).

Literature records.

Central Asia, South Kazakhstan at Cyolpon-Ata: well of biological station, 2 ♀ (MN); valley of Somesu Mic: well (NG); Braila: water pipe (NG); caves of Postojna-Planina: 'Adelsberg cave' (WL); idem: small lakes in 'Black cave', 19–27.VIII.1930, numerous ♀ ad. (*typica*) (RM); alluvial floodplain of the upper French Rhône, in sandy banks and dead arms: BR samples at 0.6 m in gravels, 1975–1978 (GB2, CR1); idem, at Brégnier: BR pump samples in gravel at 0.5 m deep, VIII-IX.1988, max. 2 ex. (in benthos none) (CR1); idem, 25 km downstreams of Lyon: BR pumpings in gravel at 0.2–0.5 m deep 26.IX.1990, 12 ex. (SC).

44. *Bosmina coregoni* Baird 1857.

Holarctic.
Stagnant waters (lakes, ponds) and slow flowing rivers. Occasionally in hyporheic water. Planktonic. SX.

Literature record.

Alluvial floodplain of the upper French Rhône, in sandy banks: BR pump samples (CR1).

Chydoridae Stebbing 1902.

45. *Eurycercus lamellatus* (O.F. Müller 1785).

Holarctic, but also recorded from South Africa and Argentina.

Large stagnant and slow-flowing waters rich in vegetation. Also in interstitial water of rivers and lakes, sometimes in caves. Macrophytophilic. SF?

Material examined.

Wales (U.K.). - In sandy beach of lake Llyndanas (C.K. sample), numerous ♀ juv., ad., VII.1991 (M.J.).

Literature records.

Sava river at Tomacevo - Ljublijana: BR pumpings at 0.8 m in gravel, numerous ♀ (BR 3); caves of Postojna-Planina: 'Magdalena cave' (WL); idem, puddles in drying bed of subterranean river Pivka in 'Black cave' (ST); - alluvial floodplain of the upper French Rhône in banks and dead arms: BR pumpings at 0.6 m in gravel, 1975–1978 (GB2, CR1); idem, at Miribel and Donzère: BR pumpings in gravel at 0.5 m, VIII-IX.1988, max. 2 ♀ at Donzère (153 ex in benthos), and I-II.1989 (max. 3 ex. but none in benthos) (CR1); idem, channel with gravel, pebbles and sand: BR pumping at 0.5 m, 1 ex.: per sample (same in benthos) (CR2).

46. *Pleuroxus aduncus* (Jurine 1820).

Quasi cosmopolitan.

Eutrophic stagnant water rich in vegetation, with muddy, detritic bottom; slow rivers; often in hyporheic water, sometimes in caves, wells, and springs. Macrophytophilic, pelophilic. SF.

Material examined.

Romania. - Neajlov valley at Corbii Ciungi: limnocrene with muddy bottom 0.2 m depth, 13°C, 29.IX;1959, 1♀ ad. (NS).

Literature records.

Central Asia, South Kazakhstan: underground water pit and collections of spring waters in district Nurata, and well Sultan-Bibi, 6–30 ♀ per sample (MN); valley of Neajlov: well (NG); cave system of Postojna-Planina, in underground river Pivka over 9 km: numerous ♀ ov.in puddles remaining after floods (BR3); alluvial floodplain of the upper French Rhône: BR pumpings at 0.6 m deep in gravels of shores and in dead arms, 1975–1978 (GB2, CR1); idem, at Donzère: BR pumpings at 0.5 m depth, VIII-IX.1988, max. 4 ex. (in benthos 173 ex.); no specimens during winter (CR1); valley of the Riera Major, an affluent of the Ter, alt 470 m, Catalonia: BR pumpings in sand and gravel at 0.1–0.5 m depth, II.1983 - II.1984, but present from VIII-II., max. 279 ex. per 50 l in December (SB).

47. *Pleuroxus trigonellus* (O.F. Müller 1785).

Holarctic, oriental.

Small and large stagnant waters with detritus-rich bottom and vegetation; also slow running water. Sometimes in the hyporheic and in springs. Pelophilic, macrophytophilic with a preference for life on the bottom rather than active swimming. SX?

Material examined.

Romania. - Neajlov valley at Corbii Ciungi: limnocrene, 22.IX.1959, 1 ♀ eph. (NS).

Literature records.

Neajlov valley: spring (MT1, NG); Lille: well (MZ); alluvial floodplain of the upper French Rhône: BR pumping in banks and river gravels (CR1).

48. *Pleuroxus laevis* Sars 1862.

Quasi cosmopolitan.

Small and large waters with muddy bottom, rich in vegetation; sluggish rivers; often in hyporheic waters and sometimes in the phreatic and caves. Pelophilic, macrophytophilic. Prefers crawling to swimming. SF?

Material examined.

Austria. - Danube valley at Lobau (Vienne), floodplain: standpipe LB3 at 0.4–0.5 m depth, 3 liters of water, 17.IV.1980, ♀ ad. (DD).

Literature records.

Caves of Postojna-Planina: 'Magdalena cave' (WL); idem, small lakes in 'Black cave' 19–27.VIII.1930, 1 ♀ ad (RM); alluvial floodplain of the upper French Rhône: BR pump samples in gravels of shores (CR1); idem, channel with gravels, pebbles and sand plates: BR pumpings at 0.5 m, up to 5 ex. per sample (while lacking in the benthos of the channel) (CR2); idem, at Brégnier and Miribel: BR pumpings in gravel at 0.5 m deep, VIII-IX.1988, up to 7 ex at Brégnier (1 ex. in benthos at Miribel) and none during winter (CR1).

49. *Pleuroxus denticulatus* Birge 1879.

'France, England, N. and S. America, Africa, East China' (Smirnov, 1971).

Stagnant water rich in vegetation, as well as slow running rivers. Often in the hyporheic. Macrophytophilic. SF.

Literature records.

Alluvial floodplains of the upper French Rhône: BR pump samples in gravels of shores (CR1); idem, at Brégnier, Miribel and Donzère: BR pumpings in gravel at 0.5 m depth, VIII-IX.1988, up to 9 ex. at Donzère (4544 ex. in benthos), and I-II.1989 at Miribel, 1 ex (also 1 ex. in benthos at Brégnier) (CR1); idem, 25 km downstreams of Lyon: BR pumpings in gravels at 0.2–0.5 m depth, 29.IX.1990, 42 ex. (SC); valleys of the Riera Major (alt. 470 m), and Riera de Rupit (alt. 840 m), affluents of the River Ter, Catalonia: BR pumpings in gravel and sand at 0.1–0.5 m, pH 7.7, II.1983-II.1984, but present from IX till II, with a maximum of 182 ♀ ad. per 50 l. in January (SB).

50. *Pleuroxus striatus* Schoedler 1858.

Holarctic, afrotropical.

Lakes, ponds, swamps, temporary waters, hyporheic waters. Pelophilic. SX?

Literature record.

Coxing Kill (SE of New York), in hyporheic waters, 0.1 ex per 3 l (SR).

51. *Pleuroxus uncinatus* Baird 1850.

Palaearctic.

Stagnant eutrophic waters with muddy bottom, rich in vegetation; slow rivers; rice fields. Often in the hyporheic of the Rhône. Pelophilic, macrophytophilic. Crawls, rarely swims. SF.

Literature records.

Alluvial floodplain of upper French Rhône, in river banks and dead arms: BR pumpings at 0.6 m depth in gravel, 1975–1978 (GB2, CR1); idem, at Donzère: BR pumpings in gravel at 0.5 m depth, VIII-IX.1988, up to 6 ex. per sample (1374 ex. in the benthos), but none in winter (CR1); idem, channel with plates of gravel, pebbles and sand: BR pumpings at 0.5 m depth, up to 5 ex. per sample (in the benthos: 24 ex.) (CR2); idem, 25 km downstreams of Lyon: BR pump samples in gravel, 0.2–1.0 m deep, 29.IX.1990, max. 131 ex. at 0.2 m depth (SC).

52. *Pleuroxus truncatus* (O.F. Müller 1785).

Palaearctic.

Stagnant and slow flowing, small and large eutrophic waters with vegetation; occasional in wells and springs. Macrophytophilic. SX?

Literature record.

Germany: helocrenes (FL); France, Lille: wells (MZ).

53. *Pleuroxus piger* (Sars, 1862)

Holarctic, afrotropical, neotropical. Probably not a *Pleuroxus* s. str., and forming a conglomerate of related species.

Oligotrophic, dystrophic and mildly eutrophic stagnant waters with muddy bottom; often in the hyporheic, in caves and wells. Pelophilic. SF.

Literature record.

Cave system of Postojna-Planina: 'Magdalena cave' (WL: *Chydorus piger*); idem, puddles in drying bed of subterranean river Pivka in 'Black cave', IX.1930 (ST: *C. piger*); Timavo prov. of Slovenia, Monticello village: helocrene, IX.1930 (ST: *C. piger*); River Pavin at Besse-en-Chandesse, Auvergne, 1000–1050 m alt., CK sampling in sandy banks at 0.5 m depth, 21–26.VI.1982, 1 ♀ ad. (crawling, not swimming) (DM1); Sweden: samples from gravel and beach sands of rivers (HS: *Chydorus piger*); several stations SE of New York filtrate of groundwater, 0.1 ex. per 3 l (SR: *C. piger*); Great Douk Cave, Chapel-le-Dale, U.K. (Fryer, 1993).

54. *Pleuroxus pigroides* (Lilljeborg 1900).

Only recorded from Sweden (Frey 1976), where it was found in a single helocrene. SB?

Literature record.

Sweden, Malma near Uppsala (now absorbed by Uppsala): swamp fed by groundwater, 3.IX.1890, 20.IX-15.X.1895, 14.X.1896, 57 ♀ parth., leg. W. Lilljeborg (FR, DM1, DM3).

Note. The species has a reduced eye and ocellar size. Attempts to rediscover it using Beladjal traps in streams around Uppsala by B. Pejler have, so far, failed.

55. *Alonella excisa* (Fischer 1854).

Quasi cosmopolitan.

Stagnant eutrophic water rich in vegetation, as well as oligotrophic and dystrophic ponds and slow running rivers. Occasional in the hyporheic. Macrophytophilic. SX.

Material examined.

Wales. UK. - Lake Llyndanas, VIII.1991 (MJ): numerous ♀♀ in CK sample from sandy beach.

Literature record.

Alluvial floodplain of upper French Rhône, in channels with gravel, pebble and sand plates: BR pumping at 0.5 m deep, 1 ex. in a single sample (2 ex. in benthos) (CR2).

55a. *Alonella cf. excisa* (Fischer 1854).

Literature record.

Valley of the Wapping brook (SE of New York): hyporheic samples, 0.9 ex per 3 l (SR); several stations SE of New York: in filtrate of the groundwater, up to 3,1 spec. per 3 l (SR).

Note. *A.* cf *excisa* differs from *A. excisa* by its smaller ocelli and eyes. *A.* cf *excisa*, with *Alona rustica*, was the commonest cladoceran in the hypogean waters of the state of New York, reaching a maximum density at the end of spring and in summer (SR). SB?

56. *Alonella exigua* (Lilljeborg 1853).

Holarctic, afrotropical.

Stagnant waters rich in vegetation; sometimes in hyporheic waters and springs. Macrophytophilic. SXR?

Literature records.

Alluvial floodplain of upper Rhône: BR pump samples in river gravel (CR1); idem, channel with sandy gravel plates: BR pumpings at 0.5 m deep, up to 2 ex per sample (8 in the benthos) (CR2); helocrenes in Germany (FL).

57. *Alonella nana* (Baird 1843).

Holarctic.

Water of stagnant or slow running nature, rich in vegetation and detritus; rather frequent in hyporheic and phreatic waters. Macrophytophilic, pelophilic. Frequently 'walks' on plants and in interstices rather than swimming. SF?

Austria. - Danube valley at Lobau (Vienna), floodplain:station LB (Freze), 0–0.2 m depth, 4.IX.1980, 1 ♀ ad. (DD); standpipe D3, 4 m depth, 5 liters of water, 15.IV.1993, 1 ♀ ad., D4 at 5 m depth, 5 liters of water, 16.I.1992, 1 ♀ ad., D9 at 4 m depth, 5 liters of water, 19.I.1993, 1 ♀ ov., R4 d, 2.8m depth, 5 liters of water, 14.IV.1993, 3 ♀ ov., and R8, 1.8 m depth, 5 liters of water, 14.IV.1993, 11 ♀ juv. and ov. (DD).

Literature records.

Alluvial floodplain of upper French Rhône, river banks and dead arms: BR pump samples at 0.6 m depth in gravely substrate (CR1).

58. *Disparalona rostrata* (Koch 1841).

Holarctic.

Lakes and ponds with sandy or silty bottom, rich in detritus; slow-running rivers. Often in hyporheic waters and in caves. Pelophilic.

Poor swimmer, which prefers to crawl or dig into mud. SF. Literature records. Cave system of Postojna-Planina: 'Adelsberger' cave and 'Magdalena cave' (WL: *Rhynchotalona rostrata*); idem, remaining puddles in bed of underground river Pivka in 'Black cave' and 'Lower cave', (ST: *R. rostrata*); idem, small lakes in 'black cave', 19–27.VIII.1930, 1 ♀ ad. (R.M.: *R. rostrata*); alluvial floodplain of upper French Rhône, banks and dead arms: BR pumping at 0.6 m depth in gravel, 1975–1978 (GB 2, CR 1); idem, at Donzère: BR pump samples in gravels at 0.5 m depth, VIII-IX.1988, up to 2 ex. (in benthos: 165 ex) and none in winter (CR1); idem, 25 km downstreams of Lyon: BR pump samples in gravel at 0.2–1.0 m depth, 26.IX.1990, 112 ex. (SC).

59. *Chydorus sphaericus* (O.F. Muller 1776), emend. Frey 1980 (s.str).

Range imperfectly known, because *C. sphaericus* is a complex of related species. *C. sphaericus* s.str., redescribed by Frey (1980 b) from its *terra typica*, Denmark, is with certainty known only from Europe.

Large and small stagnant waters of different trophy, slow running rivers. Sometimes abundant in hyporheic waters, caves (inclusive in hyporheic of caves), pelophilic wells, standpipes, cisterns, water systems, sand filters, and springs. Macrophytophilic, pelophilic, psammophilic, occasionally planktonic. Ramps, swims and digs into sediment. SF.

Material examined.

Romania - Coastele valley at Josani (Apuseni mounts): karstic spring, 29.III.1973, 39 ♀ (PC); Pestera de la Vadu Crisului (Apuseni Mts): CK sample, 30.III.1973, 6 ♀ (PC); valley of Somesu Mic at Gherla: well, 2°C, pH 7, 20.III.1965, 2 ♀ ad (PC); Cerna valley at Sapte Izvoare Reci, near Baile Herculane: limnocrene, 17.XII.1956, 174 ♀ juv., ov (NS); Belareca valley at Mehadia: wells, 11–14°C, 2.VIII.1956, 7 ♀ ov., and 14.IX.1957, 6 ♀ ov. (CI); valley of Motru at Glogova: limnocrene, 27.III.1974, 4 ♀ ad. (RI); Danube valley at Pristol: well 20.IX.1970, 4 ♀ ad. (RI); Oltet valley at Branet: rheocrene, 5.III.1990, 54 ♀ juv., ov. (RI); Desnatui valley at Radovanu, limnocrene, 6.III.1970, 9 ♀ ad (RI); Jiu at Teasc: well, 23.X.1970, 3 ♀ ad. (RI); valley of Teleorman at Izvoru de Sus, in forest, alt. 145 m: small limnocrene Zlotea, 13°C, 12.VI.1959, 6 ♀ ov. (NS); Cotmeana valley at Vlascauta, alt. 170 m: helocrene Balta Popii, 20°C, pH 6.6, 21.V.1960, 1 ♀ ov (NS); Calnistea valley at Naipu: limnocrene, 16.5°C, pH 7.8, 26.VII.1959, 2 ♀ ov (NS); Dambovita valley at Plataresti: limnocrene, 11°C, 24.IV.1960, 2 ♀ ov (NS); Colentina valley at Pantelimon: forest spring, 29.X.1945, 172 ♀ juv., ov. (OT); Dambovita valley in Bucarest: sand filters of the Arcuda, 25.I.1957, 2 ♀ ad, and 7.VI.1957, 3 ♀ ad (NS); drinking water pipe system, 9.XI.1957, 1 ♀ ad, and 28.XI.1957, 1 ♀juv. (NS).

Austria. - Danube valley at Lobau (Vienna), floodplain: standpipe samples D3 at 6 m depth, 5 liters of water, 15.IV.1993, 1 ♀ ad, D9 at 4 m depth, 19.I.1993, 3 ♀ ov., D 15 at 10 m depth, 5 liters of water, 16.I.1992, 1 ♀ ad., R 1, 1.7 m depth, 5 liters of water, 14.IV.1993, 2 ♀ ad., and R 2, 1.7 m depth, 5 liters of water, 14.IV.1993, 1♀ ov. (DD).

Literature records.

Bogata valley at Racos: CK sample, 7.5°C, 24.IX.1946, 9 ♀ ad (MT2); Somesu Mic, Belareca, Danube and Jiu valleys: wells (NG); valleys of the Cerna, Motru, Oltet, Desnatui, Teleorman, Cotmeana, Calnistea, Dambovita and Colentina: springs (NG); Bucarest: sand filters and water pipes (NG); Karst of Moravia: small lakes in 'Stirfel cave' (SP); Sava river at Tomacevo-Ljubljana: BR pump samples in gravels at 1.0–1.2 m depth, numerous ♀ (1 ex per liter), together with Cyclopoids and *Niphargus* sp. (BR3); karsts of Bosnia-Herzegovina and Istria: wells and cisterns, 1 ex per sample (PL); cave system of Postojna-Planina, in course of subterranean river Pivka over 9 km: numerous ♀ ov. at all stations in summer after floods, and few ♀, but well fed, in winter (thus, a permanent population) (BR3); Cerniko Polje, in cave 'Jasovica jama': puddles in vestibular zone, IX.1987 (BR3); Germany: springs and water accumulated in hollow trees (FL); Sweden: in gravel and sands of river banks (HS); Belgium: basket trap collections in various rivers, e.g. the Vesdre, 4.XI.1990, 25 ex and 14.IX.1991, 515 ex. (BL); alluvial floodplain of upper French Rhône, banks and dead arms of river: BR pump samples at 0.6 m depth in gravels, 1975–1978 (GB2, CR1); idem, at Miribel and Donzère: BR pumpings in gravels at 0.5 m depth, VIII-IX.1988, max. 11 ex at Donzère (1561 ex in benthos) and, I-II.1989, max 1 ex. at Miribel (3 ex per sample in benthos) (CR1); idem, channels with plates of gravel, pebbles and sand: BR pumpings at 0.5 m depth, up to 6 ♀ per sample (4 ex in benthos) (CR2); idem, 25 km downstreams of Lyon: BR pumpings at 0.2–1.0 m depth in gravel, 26.IX.1990, up to 7 ex at 0.2 m deep (SC); Ireland, near Rathmore, Co Meath: 'thermal spring' with *C. sphaericus* the dominant crustacean (Grainger & Davies, 1966); Catalonia, valleys of the Riera Major (alt. 470 m) and Freser (alt. 1200 m), affluents of the Ter: BR pumpings in gravels and sand at 0.1–0.5 m depth, pH 7.4, II.1983-II.1984, max. 24 ex per 50 l in December (SB).

Note. The following specific appartainance of extra-European records are in need of specification beyond that of the *C. sphaericus* group: Central Asia, South Kazakhstan, spring water collector in district Nurata, underground water pit at Poustynoi Stantzy and wells Ayak-Goujoumdy, Sarykiariz and Ucikoudouk, 2–10 ♀ per sample (MN); Australia, CK-samples on banks of three rivers with swift current near Canberra and Melbourne, XI.1983 (DM3: *C. sphaericus*-group).

60. *Chydorus ovalis* Kurz 1875.

North-holarctic.

Large and small acid stagnant waters, oligo- to mesotrophic; occasional in hyporheic waters and springs. Nectobenthic. SX.

Literature records.

Sava river at Tomacevo-Ljubljana: BR pump samples in gravels up to 1.0–1.2 m deep, several ♀ (BR3); Slovenia, Timavo prov., Sasseto village, helocrene (ST).

61. *Chydorus parvus* Daday 1898.

Afrotropical and Indo-malaysian (Smirnov, 1971).
Stagnant and hyporheic waters. Pelophilic? SX?

Material examined.

Malawi. - Lake Malawi, Senga Bay, CK sample in sandy beach, 4.VIII.1992, few ♀ (DH).

Note. First record from groundwater.

62. *Chydorus herrmanni* Brehm 1933.

Java, Philippines, West Africa, Ferghana and Kizil-koum (Smirnov, 1971).
Stagnant and hyporheic waters. Pelophilic? SX?

Literature record.

Central Asia in south part of Kizil-koum desert: CK samples for 'old waters' (dead arms?) at Poustynoi Stantzy, 14 ♀ (MN).

63. *Chydorus cf. brevilabris* Frey 1980.

Nearctic.
Probably in same types of environments as *C. sphaericus*.

Literature records.

Valley of Wapping brook (SE of New York): hyporheic, 0.3 ex per 3 liters (SR); several stations SE of New York: filtrate of subterranean water, 0.2 ex per 3 liters. SX?

64. *Pseudochydrous globosus* (Baird 1843).

Holarctic, afrotropical, oriental and australian.
Large and small stagnant waters rich in submerged vegetation; slow flowing rivers; sometimes in the hyporheic. Macrophytophilic, detritivorous, necrophagous. SX?

Literature records.

Alluvial floodplain of upper French Rhône: BR pump samples in gravely river banks (CR1); idem, 25 km upstreams of Lyon: BR pumpings at 0.2–0.5 m deep, in gravel, 26.IX.1990, 2 ♀ (SC).

65. *Alona quadrangularis* (O.F. Müller 1785).

Holarctic, afrotropical, oriental, neotropical.
Large and small stagnant waters with muddy or sandy bottom with detritus and rich in vegetation, and rivers with slow current. Frequent, sometimes abundant in hyporheic waters, caves, wells, and springs.
Pelophilic and macrophytophilic. Crawls on vegetation or benthos rather than swimming. SF.

Material examined.

Romania. - Strei valley at Ponor: well, 1.7–1.9 m deep (with 0.4–0.7 m of water), 6.5–7.5°C, pH 6.5–7, 29.X.1957, 42 ♀ juv, ov. ♂, 27.II.1958, 14 ♀ ad. 3.III.1958, 54 ♀ ad. and 11.IV.1959, 211 ♀ juv. ad. (NS); valley of Paros-Strei: lake in cave Gura Cetatii, 21.VI.1924, 14 ♀ juv. ov. (CA); valley of Cerna at Sapte Izvoare Reci, near Baile Herculane: limnocrene, 17.XII.1956, 1 ♀ ad. (NS).
Austria. - Danube valley at Lobau (Vienna), floodplain, in benthic stations only: LA.OF, 13.VI.1978, 5 ♀♀ juv., ov.; LE(2), 24.XI.1978, 1 ♀ ov.; LB3, 17.IV.1980, 3 ♀ ad. (DD).

Note. Adult females had the ocellus smaller than the eye, except one at station LE where the reverse was true. This is also the case in *Alona macrops* Motas & Orghidan, 1948, described after a single female from the hyporheic of Bistritza valley (Romania), and considered a synonym of *A. quadrangularis* by Negrea (1983). In the absence of a type and of other differences, the female of station LE now seems to confirm the correctness of this synonymy.

Literature records.

Bistritza valley at Brosteni: CK sample, 14°C, 21.IX.1946, 1 ♀ with embryo (MT2: *Alona macrops* n.sp.); valley of the Strei: well (OR2); Gura Cetatii cave: lake (NG); valley of the Cerna: spring (NG); cave system Postojna-Planina: 'Adelsberg cave' and 'Magdalena cave' (WL); idem, puddle in drying up bed of subterranean river Pivka in the 'Black' and 'Lower' caves (ST); Sweden: in samples from gravels and sands of river banks (HS); Belgium: collections with 'basket trap' in bed of Vesdre river, 4.XI.1990, 2 ex and 14.IX.1991, 78 ex (BL); alluvial floodplain of the upper French Rhône, in river banks and dead arms: BR pump samples at 0.6 m depth in gravels (CR1); idem, at Brégnier, Miribel and Donzère: BR pumpings in gravel at 0.5 m depth, VIII-IX 1988, up to 7 ex. at Donzère (205 ex in benthos), and I-II 1989, up to 6 ex at Miribel (13 ex in benthos) (CR1); idem, channel with plates of gravel, sand and pebbles: BR pumpings at 0.5m depth, up to 43 ex per sample (in the benthos: 66 ex per sample) (CR2); idem, 25 km downstreams of Lyon: BR pumpings at 0.2–1.0 m in

gravels, 26.IX.1990, 170 ex at 0.2 m (SC); valley of the Riera Major (alt. 470 m) and Riera de Rupit (alt. 840 m), affluents of the Ter, Catalonia: BR pumpings in gravel and sand at 0.1–0.5 m depth, pH 7.7, from II.1983-II.1984, species present between VI and II, max. 493 ex per 50 l in December (SB); Europe: springs (HR); USA: stations SE of New York: filtrate of groundwater, 0.1 ex. per 3 l (SR); Australia, Sailor falls near Melbourne: CK samples in banks of river with rapid flow (DM3).

66. *Alona affinis* (Leydig 1860).

syn. *Biapertura affinis* (Leydig 1860).

Quasi cosmopolitan.

Large and small stagnant and slow-running waters, where the species lives in sandy zones rich in detritus and mud, less in vegetation-rich zones. Frequent and often abundant in hyporheic and phreatic water, often in caves, sometimes in springs. Psammo-, detrito-, pelo- and macrophytophilic; both ramps and swims. SF.

Material examined.

Austria. - Danube valley at Lobau (Vienna), floodplain: station LB (Freze), 0–0.2 m depth, 4.IX.1980, 1 ♀ ov. (DD); standpipe samples at 0.4–0.5 m depth: LA (2 and 3), 2 liters of water, 24.XI.1978, 2 ♀ ad., LB (1,2 and 3), 3 liters, 17.X.1980, 3 ♀ juv., ad., LA1, 3 liters, 12.II.1980, 1 ♀ ov., LB3, 3 liters, 17.IV.1980, 12 ♀ juv., ov., LC1 and LC2, 6 liters, 12.II.1980, 6 ♀ juv., ov. (DD); standpipe LC120 at 1.2 m, 3 liters of water, 12.II.1980, 1 ♀ ad. (DD).

Literature records.

Sava river at Tomacevo-Ljubljana: BR pumpings in gravels up to 0.8 m deep, numerous ♀ (BR3); Slovenia, at Zuzemberk: karstic spring Tomincev Studenc, few ♀ around the year, in the company of stygobitic and crenobitic species (BR3); cave system of Postojna-Planina, in the course (9 km) of the subterranean river Pivka: numerous ♀ at all stations in summer after floods (BR3); Cernicko Polje, in Jasovica cave: puddles in vestibular area (BR3); Sweden: in samples in gravels and sand of river banks (HS); alluvial floodplain of upper French Rhône, banks and plates of the river and its dead arms: BR pump samples at 0.6 m in gravels, 1975–1978 (GB2 and CR1); idem, side channel with plates of gravel, pebbles and sand: BR pumpings at 0.5 m depth, up to 58 ex per sample (358 in the benthos) (CR2); idem, at Brégnier, Miribel and Donzère: BR pumpings in gravels at 0.5 deep, VIII-IX.1988, up to 14 spec. per sample at Donzère (up to 2400 ex in the benthos) and I-II.1989, up to 3 ex at Miribel (19 ex in the benthos) (CR1); idem, 25 km downstreams of Lyon: BR pumpings at 0.2–1.0 m depth in gravels, 26.IX.1990, 172 ex in a sample at 0.2 m depth (SC); Ireland, Boho cave, Co Fermanagh, in water puddle remaining after a flood (Hazelton, 1974).

67. *Alona intermedia* (Sars 1862).

syn. *Biapertura intermedia* Sars 1862.

Almost cosmopolitan.

Small waters, rich in vegetation; littoral zone of mountain lakes; slow running rivers. Occasional in hyporheic waters. Pelophilic. SX?

Literature record.

Sweden. - In gravels and sand of river banks (HS).

68. *Alona rectangula* Sars 1862.

Palaearctic, afrotropical, oriental.

Large and small stagnant waters with muddy bottom, rich in detritus and with submerged vegetation; slow running rivers. Frequent, sometimes abundant in hyporheic waters, in wells, standpipes, caves, underground storage reservoirs, sand filters, and springs. Macrophytophilic, pelophilic. Capable of swimming, but prefers to crawl. SF.

Material examined.

Romania. - Metaliferi mountains at Ormindea, in cave 'Pestera Gaunoasa din Valea Bobii': lake, 24.VI.1924, 3 ♀ ov (*coronata*) (CA); Dambovita valley in Bucarest: sand filters of the Arcuda, 19.XI.1957, 7 ♀ ad (*coronata*) (NS).

Austria. - Danube valley at Lobau (Vienna), floodplain: standpipe sample R2, 1.7 m depth, 5 liters of water, 18.I.1993, 1 ♀ ad (DD).

Literature records.

Central Asia, S. Kazakhstan: spring in bank of river Kara-su at Agalyk, underground water pit and spring water collectors in district Nurata, 7–10 ♀, ad., eph., ♂ (MN); 'Pestera Gaunoasa din Valea Bobii 'cave': lake (NG); Dambovita valley: sand filters (NG); cave system of Postojna-Planina: 'Magdalena cave' (WL); idem, remaining puddles in drying bed of underground river Pivka in 'Black cave' (ST); Basel: water reservoir and well (Chappuis, 1922); Germany: springs (FL); Sweden: in gravels and sands of river banks

(HS); France, alluvial floodplain of upper Rhône, river banks and dead arms: BR pump samples in gravels (CR1); idem, 25 km upstreams of Lyon, BR pumpings at 0.2–1.0 m depth in gravel, 26.IX.1990, 3 ex at 0.2 m deep (SC); Côte d'Or: quarry of Vry (WL); Catalonia, valley of the Riera Major (alt. 470 m), affluent of the Ter: BR pump samples in gravel and sand at 0.1-0.5 m depth, from II.1983 till II.1984, species only present from December till February, with a maximum 89 ♀ ad. per 50 l in December (SB); Pisuerga river: sample in gravel of banks (SB).

69. *Alona elegans* Kurz 1875.

Palaearctic.

In same types of waters as the preceding species with which it is rather closely related. Sometimes in hyporeic waters. SF?

Material examined.

Algeria. - Well of Tesnou (2 m deep), (24°43', 04°39'E); 18.III.1977, numerous females (DH). Mauretania. - Well of Touâjîl (22°10'N, 12°40'W), 27.V.1975, few females (DH).

Literature records.

Note. First record of this species from subterranean water. Both are from man-made wells in an area where this species is rather widespread at the surface. Contamination from such sources cannot be excluded.

70. *Alona rustica rustica* Scott 1895.

Palaearctic?

Oligo- to mesotrophic acid and cold waters; prefers springs (and spring water collecting systems) of mountaineous areas in central and south Europe. Frequent, sometimes abundant in the hyporheic and in springs. Benthic. Good crawler, poor swimmer. SF.

Material examined.

Romania. - Valley of the Iad at Dealu Mare: CK sample, 29.IV.1965, 27 ♀ juv. ov. (PC); valley of the River Aries at Biharia-Garda de Sus: spring in boggy area, 12.X.1951, 24 ♀ ov (BL); Padis plateau at Tomasca shelter (alt. 1080 m): CK sample, 21.IX.1956, 3 ♀ ov (PC); valley of the Frasincea at Cornereva: rheocrene, 16.X.1957, 1 ♀ ov (BL). Belgium. - Basket trap collections in the underflow of the River Vesdre, 4.XI.1990, 1♀ , 14.X.1991, 13♀ (DH). France. - River Pavin ('Couze Pavin') at Besse-en-Chandesse, Auvergne (alt. 1045m), CK sample in sandy banks, 0.5 m deep, 21-26.VI.1982, 3 ♀ juv. ad., poor swimmers (DH).

Literature records.

Romania: valley of the Iad and Padis plateau, hyporheic (NG); valleys of the Aries and Frasincea: springs (NG); Sweden: in gravels and sands of river banks (HS); Belgium: in underflow of River Vesdre (BL); France, Couze Pavin, Auvergne: hyporheic (DM1); Catalonia: BR samples in gravels of River Ter (alt. 1400 m) at 0.1–0.5 m depth, pH 7.5, 40 ex.per 50 l (SB).

70a. *Alona rustica* ssp. 1 (*americana*?)

Literature records.

Valley of the Wapping brook (SE of New York): hyporheic samples, 0.1 ex per 3 l (SR); Coxing Kill (S. of New York): hyporheic, 0.7 ex per 3 l (SR); filtrate of groundwater at various stations SE of New York, 0.1 ex per 3 l (SR) SXR?

70b. *Alona rustica* ssp. 2

Literature record.

Central Brasil: groundwater sample from a wetland ('Campo umido') at 5–6 cm deep in sediment, 23.VIII.1979 (no specimens at surface) (RD) SX?

71. *Alona diaphana* King 1853.

Tropical-subtropical species, but range imperfectly known. Cited from the Balkan peninsula and Italy.

Found in small stagnant waters, rice fields, and in a cave. SX?

Literature record.

Herzegovina, Cernicko Polje, 'Jasovica cave': residual puddles in vestibular zone, IX.1987, 2 ♀ ad (BR1, BR3).

72. *Alona sketi* Brancelj 1992.

Known from one cave in Slovenia. Stagnant water in cave. SB.

Literature record.

Slovenia, 'Osapska cave', at 2 km from Adriatic Sea, at c. 100 alt., in small pools of clear water, poor in organic material, 12°C, 9.V.1990, 12 ♀ ad (type series), in the company of *Sphaeromides virei*, *Troglocaris* sp., *Troglodiaptomus sketi*, Cyclopoids and harpacticoids (BR2).

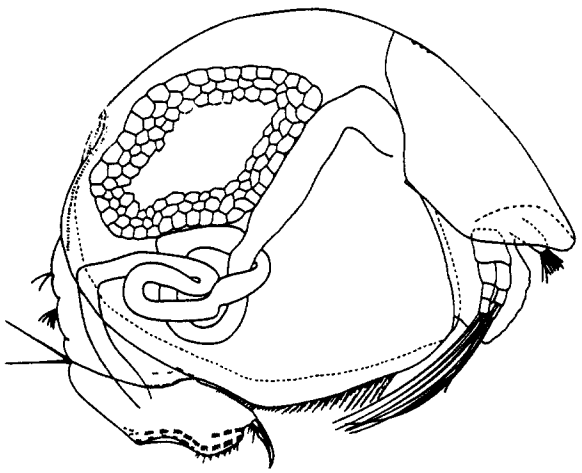

Figure 1. Alona hercegovinae Brancelj 1990 (after the author), adult parthenogenetic female, length 0.54 mm.

Note. This blind species resembles *Alona diaphana* (cf. supra).

73. *Alona herzegovinae* Brancelj 1990 (Figure 1).

Known only from caves in Herzegovina.
Stagnant water in cave. SB.

Literature records.

Herzegovina, Dabarsko Polje, 'cave Ljeljesnica': small, shallow clearwater lakes, with gravely and sandy bottom, 17.IX.1987, 1 ♀ ad (holotype), 67 ♀ juv, ad. (paratypes), 21.VII.1988, 29 ♀ juv, ad (BR1); idem, 'Susica cave', deep lake-syphon, IX.1987, 3 ♀ juv. (BR1); Fatnicko Polje, 'Obod cave': deep clear lake-well, 1 ♀ ad (BR1).

Note. This blind species, apparently derived from *A. diaphana* (cf. supra), was the first certified blind species discovered in subterranean waters.[1]

74. *Alona costata* Sars 1862.

Holarctic, afrotropical, oriental, neotropical.
Stagnant waters of different sizes and slow running waters, rich in vegetation. Occasional in wells and springs. Macrophytophilic. Ramping in vegetation rather than swimming. SX.

Literature record.

Central Asia, S. Kazakhstan, Kara-su river: spring in river bank, 3 ♀ (MN); France, Lille: well (MZ).

75. *Alona guttata* Sars 1862.

Cosmopolitan, but almost certainly a conglomerate of related species.
Stagnant and slow running waters, usually associated with periphyton or in mud of benthos of zones rich in vegetation. Frequent and sometimes abundant and even dominant in various types of groundwater: wells, standpipes, sand filters, water pipes, springs, and the hyporheic. Macrophytophilic-pelophilic. Good crawler, poor swimmer. SF.

Material examined.

Romania. - Valley of Somesu Mic at Gherla: well, 2°C, pH 7, 20.III.1965, 1♀ ov. (BL); valley of Frasincea at Cornereva: rheocrene, 16.X.1957, 2 ♀ ov. (BL); valley of Neajlov at Corbii Ciungi: rheo-holocrene, 16.VII.1959, 5 ♀ juv. ov. (NS); valley of Dambovita at Bucarest: sand filters of the Arcuda, 16.VI.1957, 1♀ ad, drinking water pipe system 9.VII.1954, 2 ♀ ad, 23.VII.1957, 37 ♀ ov., juv, 8.X.1957, 14 ♀ juv, ov., 3.III.1958, 7 ♀ ad, 24.IV.1958, 5 ♀ juv., ad., 16.V.1958, 17 ♀ juv., ad. and 13.VII.1965, 12 ♀ ov. (NS); valley of the Danube at Braila: drinking water pipe, 23.VII.1956, 2 ♀ juv. (NS).

Austria. - Danube valley at Lobau (Vienna), floodplain: standpipe samples LA (2,3), 0.4–0.5 m depth, 2 liters of water, 24.XI.1978, 17 ♀ juv, ov, LC1, 0.4–0.5 m depth, 31.VII.1980, 1 ♀ ov.; LC2, 04.-0.5 m depth, 3 liters of water, 12.II.1980, 1 ♀ ad., LA 40(3), 0.4–0.5 m depth, 1 liter of water, 24.XI.1978, 1 ♀ ov., T3, 2.5 m depth, 20.X.1992, 5 liters of water, 2 ♀♀ ad. (DD).

Note. The ocellus in Austrian adult specimens is smaller or only as large as the eye.

Belgium. - Collections using a Beladjal trap in bed of the river Vesdre, 4.XI.1990, ♀; 14.IX.1991, 2 ♀ (DH).

Wales (U.K.). - Interstitial of the sandy beach of Lake Llyndanas, VIII.1991 (M.J.). Numerous females.

Literature records.

Central Asia, S. Kazakhstan, Kara-su river at Agalyk: spring in the river bank, 3–6 ♀ (MN); Romania, valley of the Somesu Mic: well (NG); valley of the Aries at Biharia and valley of the Frasincea: springs (NG); valley of the Strei at Ponor: well (OR2); water pipe systems and sand filters of Bucarest (NG); water

[1] In 1995, A. Brancelj (in preparation) discovered a third blind *Alona* species in a cave near Ljubljana, Slovenia

pipe system of Braila (NG); valley of the Neajlov: spring (MT1, NG); Slovenia, River Sava at Tomacevo-Ljubljana: BR samples in gravel up to 0.4 m depth, numerous ♀ (BR3); Italy, valley of the Torre (Julian Prealps): BR pumping at 1 m depth in gravels, 6 liters of water, 18.IX.1992, 1 ♀ (SO); Germany, springs (Pavisic, 1941); Sweden, in gravel and sand of river banks (HS); Belgium, in underflow of Vesdre River (BL); France: alluvial floodplain of upper Rhône, in banks and dead arms: BR pumpings at 0.6 m depth in gravels, 1975–1978 (GB2, CR1); idem, channel with gravely plates, pebbles and sand: BR pumpings at 0.5 m depth, 4 ex (2 ex in benthos) (CR2); Catalonia, four stations in the river Ter: T10 (alt. 925 m), T27 (alt. 470 m), T 30 (alt. 160 m) and T38 (alt. 98 m), BR pump samples in gravel and sand at 0.1–0.5 m, pH 7.7,from II.1983 till II.1984, species present from March 1983 till Feb. 1984 with maximum 514 ♀ juv., ad. per 50 l in December; Australia, Canberra and Melbourne (Sailor falls): CK samples in sandy banks of three rivers in 1983 (DM3: *Alona* cf. *guttata*).

76. *Alona bessei* Dumont 1983.

Related to the preceding, and only recorded from Besse-en-Chandesse, Auvergne.

Hyporheic waters; good crawler, poor swimmer. SB?

Literature record.

France, Couze Pavin brook in Auvergne, at 1.000–1.050 m a.s.l.: CK samples in sandy shores, c. 0.5 m depth, 21–26.VI.1982, 2 ♀ (holotype, paratype) (DM1).

Note. As stated earlier, *A. guttata* is a species-group in need of revision. In particular, geographically separated populations of *A. guttata* should be carefully checked against true *A. guttata*, using modern standards, to establish their taxonomic position.

77. *Alona protzi* Hartwig 1900.

West Palaearctic.

Stagnant and slow flowing waters, in silt and algae. Frequent, often abundant, in interstitial waters of rivers and lakes, water piping systems and other underground waters. Pelophilic, phytophilic. SF.

Material examined.

Romania. - Danube floodplain, lake Crapina: standpipes samples at 0.05–0.1 m deep in silt covered by algae, 29.VII.1956, 1 ♀ ov (NS).

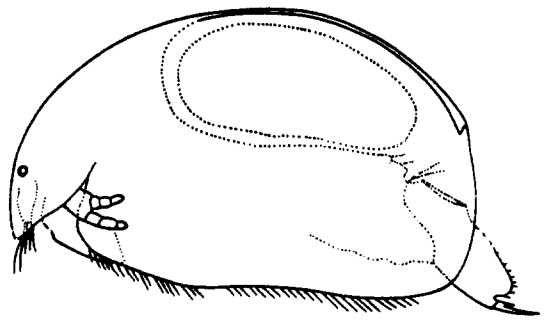

Figure 2. Alona smirnovi Petkovski & Flössner 1972 (after the authors), adult parthenogenetic ♀, length 0.38 mm.

Turkey. - Canal leading to lake Aksehir, with stone block lining, but water seeping in through the fissures between the blocks, partly covered by *Cordylophora*, VII.1972, several ♀ (DH).

Literature records.

Turkey: canal with underground water (DM1); Ochrid lake near St. Naum monastery: sample from gravels covered by periphyton, VII.1955, numerous ♀ parthen. (PT); lake Crapina: in mud (NG); alluvial floodplain of upper French Rhône: BR pump samples in gravels (DM3, CR1); England: numerous specimens in underground water pipe (Frey, unpublished, cited in DM1); idem: River Ant, Norfolk, 12.IX.1920, specimens washed from *Cordylophora* on woodwork of Ludham bridge (GR).

78. *Alona smirnovi* Petkovski & Flössner 1972 (Fig 2).

Endemic of Lake Ochrid basin?
Limnostygal (mesopsamal). SB.

Literature record.

Near monastery of St. Naum at Lake Ochrid on South shore where the outflow of a strong karstic spring enters the lake: sample in sandy beach, IX.1963, numerous parthenogenetic ♀♀ ov. or not (PT).

Note. This stygobitic species, without eye but with an ocellus, belongs to the *protzi* group, like *A. phreatica* (DM 1,3).

79. *Alona phreatica* Dumont 1983 (Figure 3).

France (basins of Loire and Rhône), and Spain (basin of Ter and Gerona).

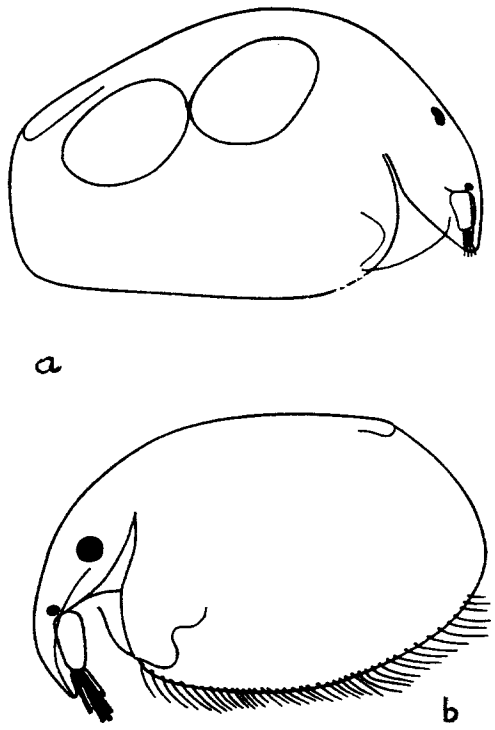

Figure 3. Alona phreatica Dumont 1983 (after the author): a = adult parthenogenetic ♀, length 0.46 mm; b = *neonate*, length 0.22 mm.

Hyporheic. Good crawler, not capable of swimming. SB.

Literature records.

Discovered in Couze Pavin, a brook flowing into the Allier, part of the Loire basin, at Besse-en-Chandesse (Auvergne), 1.000–1.050 m a.s.l.: CK sampling in sand plates at 0.5 m depth, 21-26.VI.1982, 1 ♀ (holotype) and 9 ♀ parthen. and neonata, paratypes (DM1); France, alluvial floodplain of the upper Rhône: BR pumpings in banks of gravel (CR1); Catalonia, Gerona Province, CK samples in river gravels (pers. comm. of M. Alonso to H.Dumont in DM3); four stations in River Ter basin in: T10 (alt. 925 m), T27 (alt. 470 m), T30 (alt. 160 m), and T38 (alt. 98 m), BR pumpings in gravel and sand at 0.1–0.5 m depth, pH 7.7, from II.1983-II.1984, species present from III till XII, max. 799 ♀ juv., ov., eph., ♂ per 50 l in June (in T27) (SB).

Note. In this member of the *A. protzi* group, the eye and ocellus are reduced in size, but not absent. Discovered in the company of subterranean Harpacticoids, Cyclopoids, Ostracods and Amphipods (DM1, DM2, DM3).

80. *Alona cambouei* De Guerne & Richard 1893.

Oriental, afrotropical, australian, neotropical (Smirnov, 1971).

Stagnant and slow-running waters? Springs. Pelophilic? SX?

Literature record.

Central Asia, S. Kazakhstan, Kara-su river: spring in river bank, 1 ♀ (MN).

81. *Alona alsafadii* Dumont & Brancelj 1994.

Only recorded from Yemen, Arabian Peninsula, in the hyporheic. SB.

Literature record.

Found in river gravels (CK sample at c. 0.3 m depth) of the Wadi Surdud, a permanent mountain river in Yemen, in rather great abundance (79 ♀♀ juv., ad., 4 ephippial females, but no males), on 12.II.1993 (15°17'N, 43°38'E) (DM4).

Note. Like *A. smirnovi*, the eye but not the ocellus has disappeared; however, this species is of the *A. karua* group, quite distinct from the *A. protzi* group. It is noteworthy for its primitiveness.

82. *Acroperus harpae* (Baird 1834).

Holarctic, afrotropical, oriental, neotropical.

Large and small stagnant waters rich in vegetation; rivers with slow current. Rather frequent but not abundant in the hyporheic and phreatic; rather common in springs. Macrophytophilic; pelophilic. Good crawler but not a good swimmer. SF.

Material examined.

Austria. - Danube valley at Lobau (Vienna), floodplain: standpipes LA(2,3), 0.4–0.5 m depth, 2 liters of water, 24.XI.1978, 7 ♀ juv, ov., LB(1), 0.4–0.5 m, 1 liter, 17.X.1980, 1 ♀ ad., LA 1, 0.4–0.5 m depth, 3 liters, 12.II.1980, 1 ♀ ov., LB1, 0.4–0.5 m depth, 3 liters, 12.II.1980, 1 ♀ ov., LB3, 0.4–0.5 m depth, 3 liters, 17.IV.1980, 8 ♀ juv., ov., LC120, 1.2 m depth, 3 liters, 12.III.1980, 1 ♀ ad. (DD).

Literature records.

Central Asia, S. Kazakhstan, Kara-su river, spring in riverbanks, 8 ♀ (MN); Slovenia, Sava river at

Tomacevo-Ljubljana: BR pumpings in gravel up to 0.8 m depth, numerous ♀ (BR3); France, alluvial floodplain of upper Rhône, river banks and plates, dead arms: BR pumpings at 0.6 m depth in gravels, 1975–1978 (GB2, CR1); idem, channel with sand-gravel plates: BR pumpings at 0.5 m deep, 1 ex per sample (in benthos: the same) (CR2); idem, at Miribel and Donzère: BR pumpings in gravels up to 0.5 m depth, VIII-IX.1988, max 5 ex. per sample (in benthos up to 587 ex per sample), and in I-II.1989, max. 1 ex per sample (same in benthos) (CR1); idem, 25 km downstreams of Lyon: BR pumpings at 0.2 m deep in gravel, 26.IX.1990, 1 ♀ (SC).

83. *Acroperus elongatus* (Sars 1862).

Palaearctic.

Stagnant, cold, large oligotrophic water, vegetation-poor; slow running rivers; sometimes in the hyporheic. Nectobenthic. Good crawler and swimmer. SX.

Literature record.

Sweden: samples in gravels and sands of river banks (HS: *Alonopsis elongata*).

84. *Camptocercus rectirostris* Schoedler 1862.

Palaearctic and oriental. Afrotropical?

Large stagnant waters with mud, rich in vegetation and detritus, oligo- or dystrophic, rather acidic. Sometimes in slow running rivers, the hyporheic, and even in wells. Macrophytophilic, pelophilic. Good crawler and swimmer. SXR.

Literature records.

France, Lille: wells (MZ); alluvial floodplain of upper Rhône: BR samples in gravel banks of river (CR1); idem, at Donzère: BR pumpings in gravels up to 0.5 m depth, VIII-IX.1988, max 6 ex per sample (997 ex in benthos), none in winter (CR1); idem, 25 km downstreams of Lyon: BR pumpings at 0.2–0.5 m deep in gravel, 26.IX.1990, 12 ex (SC).

85. *Leydigia leydigi* (Schoedler 1863).

Holarctic, neotropical, afrotropical, oriental.

Large and small stagnant waters with muddy, detritus-rich bottom, slow flowing rivers. Often in the hyporheic and in springs, sometimes in caves, reservoirs of water and wells. Typical pelophilic, good crawler, poor swimmer. SF.

Material examined.

Romania. - Valley of the Neajlov at Corbii Ciungi: limnocrenes with muddy bottom, 13.8–14.5°C, 14.VII.1959, 33 ♀ juv., ov. (NS); valley of the Neajlov at Comana, in forest: spring in bed of Alisteu brooklet, 10.5°C, pH 6.7, 12.X.1959, ♀ ad. (NS).

Literature records.

Valley of the Bogata at Racos: CK sample in gravel, 7.5°C, 24.XI.1946, numerous ♀ ad (MT2); valley of the Neajlov: springs (MT1, NG); cave system of Postojna-Planina: 'Magdalena cave' (WL); idem, puddles in drying up bed of underground river Pivka in 'Black cave' and 'Lower cave' (ST); Slovenia at Zuzemberk: karstic spring Tomincev Studenek, some ♀ present around the year, in the company of other stygobitic and crenobitic species (BR3); Germany: helocrenes (FL); Basel: water reservoir and wells close to the city (Chappuis, 1922); France: alluvial floodplain of upper Rhône, in banks and plates: BR pumpings in gravels (CR1); channels with numerous gravel and sand plates: BR pumpings at 0.5 m depth, up to 2 spec. per sample (1 ex in benthos) (CR2); idem, at Brégnier, Miribel and Donzère: BR pumpings at 0.5 m depth in gravel, VIII-IX.1988, maximum at Brégnier with 3 ex per sample (19 ex in benthos at Donzère) and I-II 1989, max. 1 ex at Miribel (none in benthos) (CR1); idem, 25 km downstreams of Lyon: BR pumping at 0.2–1.0 m in gravel, 14.XI.1990, 35 ex at 0.2 m depth (SC).

86. *Leydigia acanthocercoides* (Fischer 1854).

Holarctic, neotropical, afrotropical, oriental.

Large and small stagnant waters with muddy, detritic bottom; slow flowing rivers; sometimes in the hyporheic and springs. Pelophilic. SXR?

Literature records

Central Asia, S. Kazakhstan: spring water collectors in mountains 45 km from Nurata, 1 ♀ (MN); alluvial floodplain of upper French Rhône, in banks and plates: BR pump samples in gravels (CR1); idem at Donzère: BR pumpings in gravels at 0.5 m depth, VIII-IX.1988, 1 ex (none in benthos), and none in winter (CR1); idem, 25 km downstreams of Lyon: BR pumpings at 0.2–1.0 m in gravel, 26.IX.1990, 8 ex at 0.2 m, 7 ex at 0.5 m depth (SC).

87. *Tretocephala ambigua* (Lilljeborg 1900).

Palaearctic.

Small waters with muddy bottom and detritus, lakes rich in vegetation, slow flowing rivers; sometimes frequent and even abundant in wells, accidental in the hyporheic. Pelo-, detrito-, macrophytophilic. SF? (Algeria) and SX? (Europe)

Material examined.

Algeria. - Saida prov., Ain Mocta Deli (natural spring area, rich in man-made wells): well close to main road Bechar-Oran, c. 2 m deep, V.1980, numerous females (DH); same place, 8 wells, 1.4-1.6 m deep (of which 0.5 m water), 8.IV.1981, 72 ♀ juv, ad (LR); same province, well with windmill between Bougtob and Mecheria, 25 m deep (of which 2 m water), 7.IV.1981, 52 ♀ ov, eph; idem, at Bir Sénia, 26 m deep (4 m water), 7.IV.1981, 86 ♀ ov, eph; idem, besides El Biod, 8 m deep (3 m water), 7.IV.1981, 47 ♀ juv, ad; idem, besides Krebazza, 5.5 m deep (1.5 m water), 7.IV.1981, 62 ♀ juv, ov, eph; idem, 12 km after Aïn Sefra, on road to Mecheria, 8.IV.1981, 75 ♀ ov, eph; idem, about 1 km further north, 20 m deep (11 m water), 8.IV.1981, 29 ♀ juv, ov; idem, between Mecheria and Aïn Deli, 42 m deep (38 m water), 8.IV.1981, 12 ♀ juv, ad.(all samples: LR).

Literature record.

Sava river near Zagreb: samples in gravel (Mestrov, 1960: *Alonopsis ambigua*).

88. *Rhynchotalona falcata* (Sars 1862).

North holarctic.

Large and small lakes with sandy and stony bottom with some detritus; sometimes in bog-like environments. Also in phreatic and interstitial water of lakes. Psammo- and lithophilic. Good crawler, poor swimmer. SX?

Material examined.

Austria. - Danube valley at Lobau (Vienna), floodplain: standpipe sample LB3, 0.4–0.5 m depth, 3 liters of water, 17.IV.1980, 1 ♀ ad. (DD).

Note. The three females (1 of standpipe and 2 of benthos) had the ocellus distinctly larger than the eye.

Wales (UK). - Lake Lljanganas, 4.VIII.1991, CK sample in sandy beach, numerous females (MJ).

Table 1. Total number of Cladoceran taxa in different types of subterranean waters.

Families	A	B	Interstitial waters				Other water	
			C	D	E	F	G	H
Leptodoridae	1	1	0	0	0	0	0	0
Sididae	3	0	0	2	1	1M	0	0
Daphniidae	25	9	0	14	12	2L	4	9
Moinidae	6	0	0	6	1	0	2	1
Ilyocryptidae	3	1	0	1	3	0	0	1
Macrothricidae	5	1	0	0	5	0	0	1
Bosminidae	2	1	0	1	2	0	1	0
Chydoridae	49	14	1	15	40	5L	5	18
Total	94	27	1	39	64	8	12	30

Legend.
A: Total number of subterranean species and subspecies;
B: Karstostygal (stagnant water of caves);
C: Troglorhythrostygal;
D: Eustygal (phreatic s.str.);
E: Rhythro- and potamostygal (hyporheic, hyporheal);
F: Limnostygal and Marine beach (psamal);
G: Water pipes, sand filters, cisterns, water reservoirs;
H: Springs; spring water collectors.

89. *Oxyurella tenuicaudis* (Sars 1862).

Holarctic, neotropical, oriental.

Large and small stagnant waters rich in vegetation; occasional in hyporheic waters, wells and caves. macrophytophilic. SXR?

Literature records.

Central Asia, S. Kazakhstan, underground water pit in district Nurata, and in wells Ucikoudouk, Shaydaraz, Djingilkoudouk and Sultan-Bibi, up to 30 ♀ parthen. per sample (MN); cave system of Postojna-Planina: puddles in drying bed of subterranean river Pivka in 'Black cave' (ST).

90. *Monospilus dispar* Sars 1862.

Holarctic and afrotropical.

Stagnant and slow flowing waters with sandy or muddy bottoms, periphyton and detritus. Frequent but not abundant in hyporheic water; sometimes in phreatic and wells. Psammo- and pelophilic. Good crawler, poor swimmer. RS?

Material examined.

Austria. - Danube valley at Lobau (Vienna), floodplain: standpipe sample LA40 (3), 0.4–0.5 m depth, 1 liter of water, 24.XI.1978, 1 ♀ ad. (DD).

Literature records.

Central Asia, S. Kazakhstan, Nurata district at Kyariz: well Sultan-Bibi, 2 ♀ (MN); France: alluvial floodplain of upper Rhône, in banks and dead arms: BR samples at 0.6 m depth, in gravels, 1975–1978 (GB2, CR1); idem, channel with gravel-sand plates: BR samples at 0.5 m depth, up to 56 ex per sample (1 ex in benthos) (CR2); idem, at Miribel: BR sample in gravel at 0.5 m, VIII-IX.1988, up to 2 ex per sample (absent in the benthos, but 12 ex at Donzère), in I-II.1989, 1 ex (none in benthos) (CR1); idem, 25 km downstreams of Lyon: BR samples at 0.2–1.0 m depth, 26.IX.1990, 9 ex at 0.2 m, 7 ex at 0.5 m (SC).

The subterranean environments with Cladocera

At present, the count of cladoceran taxa which have been found in one or the other of the various types of underground waters stands at 94 (Table 1); only the Polyphemoids are lacking from the list. It is absolutely certain that more species, of various types, will be added in the future.

Two thirds (64) were recorded from the hyporheic (rhythro- and potamostygal according to Botosaneanu, 1986, and hyporheal according to Danielopol, 1980). About 39 species occur in wells and other phreatic habitat (eustygal) (most of those were not included in Dumont, 1995, because of the hybrid nature offered by man-made wells - see further), 27 in stagnant waters in caves (karstostygal), 12 in water ducts, sand filters, cisterns and underground reservoirs, and 30 species from springs and collecting systems of spring water. There is still a dearth of data on the interstitial water of lakes (limnostygal, 7 species), seas (1 species), and cave rivers (troglorhythrostygal, 1 species).

Except for one doubtful case (*Leptodora pellucida*), all carnivorous cladocerans are lacking, and there is an absolute predominance of benthic, 'scrapers', over filtrators. Thus, the chydorids are best represented (49 species)(Table 1), while the Daphniids-Bosminids-Sidids and Moinids, being more typically planktonic, are together represented by the mediocre number of 36 species. It is remarkable that the Macrothricidae-Ilyocryptidae, whose benthic mode of life predisposes them to invade the groundwater, are represented by only 8 species, but most of the Macrothricid diversity is situated in the tropics, where – to date – only little work on groundwater cladocerans has been carried out.

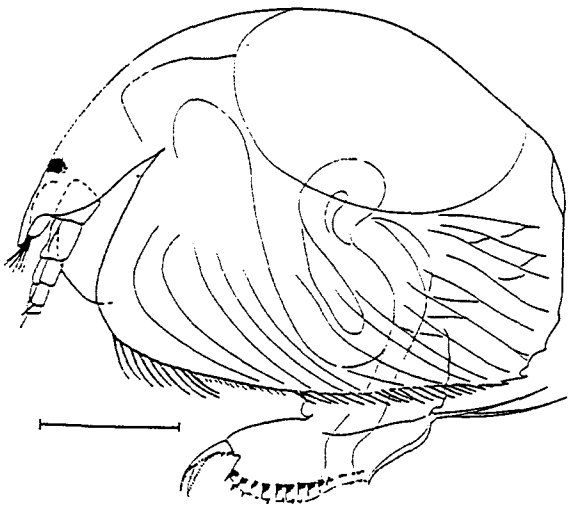

Figure 4. Alona alsafadii Dumont & Brancelj, 1994 (after the authors), adult parthenogenetic ♀, length 0.37 mm.

Ecological categories of groundwater-living cladocerans

We distinguish four categories, based upon morphological and behavioral traits, the presence or absence of ovigerous females in belowground environments, their frequency of occurrence, and their densities (Table 2).

Stygobitic species

These live and reproduce only in groundwaters. An occasional specimen may rarely be carried to the surface, passively. They may or may not stand out by morphological and physiological adaptations, but they have a typical behaviour (such as loss of swimming capacity), and a feeding mode (fine particles) adjusted to what is available in hypogeic aquatic environments.

In this category, the Chydoridae are by far dominant (8 spp. out of 12) (Table 2), and, within the family, it is the genus *Alona*, with 6 spp, which takes the lead.

Two species (*A. hercegovinae* - Figure 1 -, and *A. sketi*) have lost the eye and the ocellus and live in caves, as part of a biocenosis composed exclusively of other stygobites (Brancelj, 1992). *Alona smirnovi* (Figure 2) and *A. alsafadii (Figure 4)*, from the interstitial of a lake (Ochrid) or a river (Wadi Surdud) have lost the eye but not the ocellus. *Alona phreatica* (Figure 3) has conserved both the eye and the ocellus, but they regress from the neonate stage onwards.

Table 2. Total number of Cladoceran species in subterranean waters, by ecological categories.

Families	Total	Stygobionts		Stygophiles		Regular stygoxenes sfygoxenes		Stygoxenes	
		SB	SB?	SF	SF?	SXR	SXR?	SX	SX?
Leptodoridae	1	0	1	0	0	0	0	0	0
Sididae	3	0	0	0	0	0	0	0	3
Daphniidae	25	0	1	2	1	0	8	7	6
Moinidae	6	0	0	0	1	0	0	2	3
Ilyocryptidae	3	0	0	1	1	0	0	0	1
Macrothricidae	5	0	2	1	0	0	0	0	2
Bosminidae	2	0	0	0	1	0	0	1	0
Chydoridae	49	5	3	14	6	1	4	4	12
Total	94	5	7	18	10	1	12	14	27

Typical for all these species, and a character which they share with other stygobitics, is that they are point-endemics. Only *A. phreatica* is presently known from a somewhat more extensive, but coherent range, comprising the basin of the Loire and Rhône rivers (France), and the River Ter (Catalonia).

Apart from these five undisputed stygobites, there exist three other stygobites, with ocular adaptations. *Leptodora pellucida* has not been seen since its description, and, hence, was called a science fiction animal by Sket (1994). This remains a strange case, however, since Joseph (1882) claims to have found it across the year, with sexual and non-sexual generations, and larval stages as well. If a case of fraud, this really is a strong one; the alternative seems to be that the species went extinct in the two caves where it used to live. *Pleuroxus pigroides* from a helocrene at Uppsala, now destroyed, also shows reduced eyes and ocelli, and *Alonella* cf *excisa* from New York has eyes and ocelli smaller than the true, surface-dwelling *A. excisa*. It is one of the commonest subterranean Cladocera of the State of New York (Strayer, 1988).

Four other species are probably stygobitic. *Alona bessei* from Auvergne has normal eyes and ocelli and belongs to the *guttata*-group, which forms a cluster of species. *Macrothrix bialatus* from the Bogata brook, Romania, has normal eyes, and seems to be a close ally of *M. laticornis*. *Neothrix* sp. from Melbourne area, only seen in one specimen, was lost before it could be described. *Ceriodaphnia laticaudata deserticola*, with normal eyes, described from a wells in Kazakhstan may simply be a stygobitic subspecies of a *C. laticaudata*. Eye loss, however convincing at first sight, is an indication of a stygobitic way of life, but not of the genetic nature of this adaptation, which may in fact be reversible (Dumont, 1995). Other evident adaptations, except for generally small size and flattened bodies (in interstitially living species) are absent (Negrea, 1994). However, in *A. alsafadi* there are indications of the conservation of a number of primitive characters (type of adornment along the ventral valve rim; pectens on the end-claw of the postabdomen), which suggest that the protective nature of the hypogeic environment *vis-à-vis* lakes and rivers (absence of surf and currents, reduced predation pressure, and lessened risk of drying up) may reduce extinction risk. The likeliness of the conservation of 'living fossils' in the groundwater therefore extends not only to certain groups of copepods and to the syncarids, but to cladocerans as well.

Stygophilic species

Stygophilic species lead an ambivalent way of life, and may actively migrate between the epigean and the hypogean aquatic environment, while showing a more or less pronounced preference for one of both. Again, the chydorids are dominant in this group (20 out of 28) (Table 2). Interestingly, *Alona* (7 species) is again (with *Pleuroxus*, 5 species) among the best represented genera. It may also be expected to yield most additional species in the future. Here, *Alona eximia* Kiser immediately comes to mind: this 'riverine' species is usually recorded in isolated specimens, in disjunct situations (Smirnov, 1971, Van de Velde & Dumont, 1982), but it could also be that these are specimens washed out from the hyporheic, their true environment. The paucity of studies on the tropics and subtropics prevents us from evaluating this situation more fully at the present time.

The following 18 species and subspecies are stygophilic according to present insights:

Fam. Chydoridae: *Pleuroxus aduncus, P. denticulatus, P. uncinatus, P. piger, Disparalona rostrata, Chydorus sphaericus, Alona quadrangularis, A. affinis, A. rectangula, A. rustica rustica, A. guttata, A. protzi, Acroperus harpae, Leydigia leydigii.*

Fam. Macrothricidae: *Macrothrix laticornis.* Fam. Ilyocryptidae: *Ilyocryptus sordidus sordidus.* Fam. Daphniidae: *Simocephalus vetulus, Ceriodaphnia cornuta* ('hairy').

We class as probable stygophiles, the following 10 species and subspecies: the chydorids *Eurycercus lamellatus, Pleuroxus laevis, Alonella nana, Alona elegans, Tretocephala ambigua* (Algerian form), and *Monospilus dispar*; the ilyocryptid *Ilyocryptus agilis*; the bosminid *Bosmina longirostris*, the moinid *Moina macrocopa macrocopa*, and the daphniid *Ceriodaphnia reticulata. Tretocephala ambigua*, widespread *only* in Algeria, in a limited area along the road Oran-Bechar, where it has been recorded in numerous man-made wells, raises the possibility of passive dispersal by man (e.g. nomads watering cattle at these wells, or filling water sacks in one well, and contaminating it with species collected at another place). The Saharian distribution of species like *Moina macrocopa, M. brachiata*, and *Alona elegans*, with numerous records in surface waters, and few in wells, is also suggestive of such a phoresis.

Regular stygoxenic and stygoxenic species

Here, there is a scala ranging from species that regularly venture into the hyporheal, to some that hardly ever occur there, and cannot reproduce there (i.e. embryos leaving the brood pouch in the hypogean space are bound to die); *regular stygoxenes* are animals carried accidentally into caves by flash floods, and surviving there for a while afterwards; *Stygoxenes* s.s. are all animals that have only once or twice, and in small numbers, occurred in one or another type of subterranean water. As soon as repeated observations (especially in the same locality) are available, we consider them as possible stygophiles (Table 2).

Origin of the subterranean Cladocera

So far, there is no evidence of marine Cladocera or Ponto-Caspian polyphemoids having entered hypogean or cave (including anchialine) environments.

All species known are of freshwater origin, and all belong to genera with numerous surface-dwelling species. Dumont (1995) argues that within *Alona*, there are three species groups which have produced lines leading to a subterranean way of life: the *protzi, diaphana*, and *karua* groups, the latter having conserved, with *A. alsafadii*, one of the most primitive *Alona* known.

In the case of the cavernicolous *Alona* from the Balkan, their relationship with the tropical-subtropical *A. diaphana* suggests (Negrea, 1993, 1994) that both found a refuge in the local caves - and speciated there during the quaternary climate cooling, when their *A. diaphana*-like ancestor became extinct at the surface.

Geographic distribution

In general, and like in other stygobitic groups, stygobites tend to show restricted ranges, often consisting of a single cave, or river, or spring.

Only *A. phreatica* has, at present, been found in at least three adjacent river systems.

Evidently, such animals are not easily available for active or passive transportation, and tend to evolve, remain and become extinct *in situ*.

The more stygoxenic, the larger their ranges become, at least apparently, because at the present state of morphological resolution, many of the widespread species come up for revision.

Finally, a map showing the occurrence of stygobitic Cladocera (Figure 5) shows that, even in Europe, only limited work has been done (in France, Spain, Belgium, Sweden, Slovenia, Hercegovina, Macedonia, Romania and Austria). All other continents should be considered as quasi virgin territory. The tropics have virtually not been touched (except Cuba).

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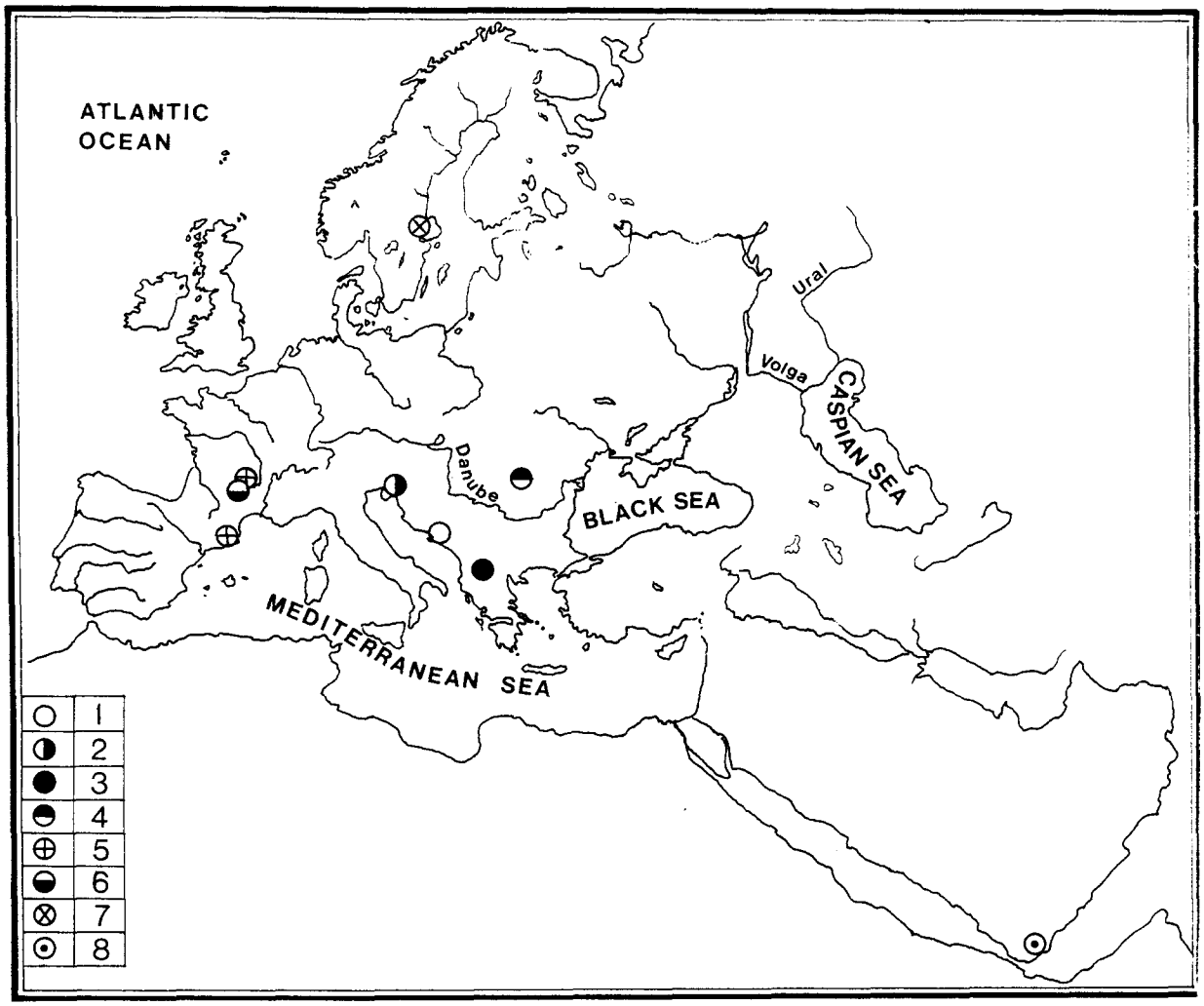

Figure 5. Distribution of stygobitic or probably stygobitic Cladocera known to date from different parts of the world. 1 = *Alona hercegovinae* Brancelj, 2 = *A. sketi* Brancelj and *Leptodora pellucida* Joseph, 3 = *A. smirnovi* Petkovski & Flössner, 4 = *Macrothrix bialatus* Motas & Orghidan, 5 = *Alona phreatica* Dumont, 6 = *A. bessei* Dumont, 7 = *Pleuroxus pigroides* (Lilljeborg). 8 = *Alona alsafadii* Dumont & Brancelj. *Ceriodaphnia laticaudata deserticola* Manuilova from Kazakhstan, *Neothrix* sp. from Melbourne and *Alonella* cf. *excisa* from New York are, perhaps, also stygobitic species.

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