

A review of Ephemeroptera species distribution in Italy: Gains from recent studies and areas for future focus

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Abstract

In Italy much faunistic, taxonomic and ecological information for the Ephemeroptera remains to be discovered. This situation is paralleled in much of Southern Europe. Here we report the current mayfly taxa known for each of the Italian regions and demonstrate the positive impact of the European Union's AQEM project on this data. This project has, for the targeted regions, brought about a dramatic increase in knowledge, including extensions to species ranges, discoveries of new species for Italy and conservation relevant information about the status of endemic species. It has also highlighted groups of taxa where species identification is currently dubious and/or where species new to science wait to be described. Some general conclusions are reported concerning the main research needs on mayflies in Italy and South Europe, especially linked to applied issues for biological monitoring.

Keywords: Southern Europe, WFD, AQEM, endemic species, rivers, taxonomy, ecology

Introduction

In large areas of Southern Europe, mayfly knowledge has to be improved: there are insufficient data on the taxonomy, distribution and ecology of most species present in Italy (e.g., Buffagni and Belfiore, 1994; Buffagni *et al.*, 2001). In recent years, new endemic species have been described (e.g., Belfiore, 1995; Belfiore *et al.*, 1997) and a number of others have been reported in Italy for the first time (e.g., Belfiore and Buffagni, 1994; Belfiore and Desio, 1995; Buffagni, 1997; 1998; Buffagni and Desio, 1998). Additional new taxa are known to exist, but have yet to be described or recorded for the first time (Belfiore and Buffagni, unpublished data).

The EU Water Framework Directive (WFD; EU, 2000) requires riverine ecosystems to be investigated in detail with respect to benthic invertebrates. The biotic component has explicitly become the target for environmental assessment and management plans. This itself calls for renewed attention to be paid to aquatic insects (e.g. mayflies), as they will be used to assess biodiversity status and ecosystem functioning. Currently applied methodologies to classify rivers into quality classes have to be tested and harmonised at the European scale and new invertebrate metrics must be defined and employed. A EU funded project involving 8 European countries, named AQEM (The Development and Testing of an Integrated Assessment System for the Ecological Quality of Streams and Rivers throughout Europe using Benthic Macroinvertebrates, www.aqem.de), was designed to put the WFD into practice (details on the project can be found in Hering *et al.*, 2001; *in press*). Focussing on mayflies, preliminary and expected findings of AQEM have been recently presented (Buffagni *et al.*, 2001), including examples of the range and habitat selection of two species of Ephemeroptera endemic to Italy, as well as data on interesting species found in the Apennine areas.

The potential benefits of the AQEM project not only for biomonitoring, but also for ecology, taxonomy and conservation, in Italy and for the South of Europe in general, are clear (e.g. Buffagni *et al.*, *op cit*). The present paper aims to give a general overview of mayfly data for Italy pre- and post-AQEM and their national and international significance. This paper features:

- a summary of the knowledge of mayfly species distribution in Italy, focussing on data availability and completeness and the areas in

Italy where more studies on mayflies are needed

- the data obtained within the AQEM project for the four areas sampled in Italy, from the Alps to South and their significance to the Italian situation
- a brief discussion of the mayfly species occurrence in the four AQEM study areas and of potentially rewarding subjects for future study
- a list of selected references on mayfly species distribution in Italy.

Study areas and Methods

The distribution of species in the Italian regions (Table 1) has been derived partly from the literature (see Annex I) and partly from the authors' collections (together the ticks in Table 1). The AQEM project data (new findings at the region-level shown as dots in Table 1) were collected in four areas of Italy: two located in the Northern (region of Emilia Romagna, provinces of Piacenza and Parma) and Southern Apennine (region of Campania, Province of Salerno), one in the lowlands of the Po valley (Piemonte region, province of Novara) and one in the Alpine area (Trentino Alto Adige region, province of Bolzano) (Fig. 1). A total of 11-13 sites were selected in each area and sampled twice (late spring and late summer/autumn). A third sampling campaign was performed during late winter 2001, but the mayfly data are not included in the present paper because they are not concluded. The selection of study sites was made to keep all locations for each area within one single river type (as defined by the WFD System A, see Buffagni *et al.*, 2001 and Buffagni *et al.*, 2002). For each river type and area, three reference sites were identified and sampled, while the remaining sites covered a range of degradation types and severities. According to the WFD, they approximately corresponded to the following degradation classes: reference site (3 sites); probably 'good status' (3); probably 'moderate status' (3); probably 'poor status' (1); probably 'bad status' (1). Sites of Northern Apennines and Alpine area were predominantly affected by hydromorphological alterations and no significant water pollution was observed; in Southern Apennines and Po lowlands, sites presented both organic pollution and hydromorphological degradation (see also Hering *et al.*, 2001; Buffagni *et al.*, 2001; Buffagni *et al.*, *in press*). A list of the investigated

sites with a general description is reported in Buffagni *et al.*, 2002.



Fig. 1 - Italian regions and stream types investigated in Italy within AQEM Project. Project codification is reported. I01: small-sized stream in the Southern silicate Alps (Trentino-Alto Adige); I02: small-sized, calcareous mountain streams in the Southern Apennines (Campania); I03: mid-sized calcareous streams in the Northern Apennines (Emilia-Romagna); I04: small streams in the lowlands of the Po valley (Piemonte).

Results and Discussion

The Italian situation and AQEM results

Table 1 reports the mayfly species (taxa) known for Italy. The species are ordered in the table according to the number of Italian regions (political boundaries) they have been found up to now. Close to the bottom of the table, the most common species are listed, while the rarest ones are towards the top of the table. The top taxa were not known in Italy before the AQEM sampling. Along the x-axis, the Italian regions are ordered according to the number of sites investigated. On the left side, the less studied regions are reported, while on the right one the best known are listed. In the table, the ticks refer to existing information, from the literature, while the dots indicate a species found by AQEM in a region for the first time.

Considering the data as a whole, a number of points are obvious. Firstly, some regions of Italy are far better known than others. Compared to the 200 sites for which information is available from Sicily, the 3 sites of Val d'Aosta (on the opposite end of the table as well as of Italy) seem to be a joke. Although additional data are available (Buffagni, unpublished), the extremity of the information lack for this region is striking. In Puglia as well, few mayfly species have been reported and only 3 sites have been studied. In this case, however, it does not only reflect a lack of effort, but also the paucity of surface waters in this calcareous region of Southern Italy. At the opposite end of the axis, some regions have been far more extensively sampled: Friuli Venezia Giulia, Sardegna, Lombardia, Lazio and Campania. The higher number of sites visited in these areas often reflects the places where "Mayfly researchers (*searchers*)" live or spent holidays (see Table 1). Excluding Sicily and Sardinia for biogeographical reasons, the positive trend between the number of species found in the different Italian regions and the number of sites investigated is clear (Fig. 2). The fact that the trend, although increasing less steeply with greater numbers of sites studied, does not reach a plateau, suggests that, even for the 'well' studied areas, the situation is inadequate. The increase in information with AQEM is indicated for each of the four areas (the 'AQEM effect') and these increases are, in themselves, instructive. Emilia Romagna, previously the least studied region (among the four AQEM regions) increased most sharply, with over 16 species added to the regional list. Trentino Alto Adige also increased significantly, with 8 new taxa (some of which were new for Italy). It is interesting to note that it has a low number of species found relative to the number of sites studied, perhaps reflecting a naturally lower biodiversity in this predominantly mountainous area, especially considering that the streams sampled for AQEM were restricted to those over 800 m. Piemonte, already having a comparatively high number of recorded species, increased these slightly by three. Campania, the best studied of the regions selected for AQEM and with high numbers of recorded species also increased slightly, by 4.

Moving from the quantity of the information collected to its quality, regarding Piemonte, while only 3 new species (at the region level) were found, one of these (*Ephemera* sp. cfr. *zettana* KIMMINS, 1937) has an unclear taxonomic status (and is thus potentially interesting). Many of the

species (taxa) collected in Alto Adige are noteworthy (e.g. *Rhithrogena nivata* (EATON, 1871), *Ecdyonurus* cfr. *austriacus* (BURMEISTER, 1839), *Ecdyonurus* cfr. *parahelveticus* HEFTI, TOMKA & ZURWERRA, 1986, *Rhithrogena* gr. *hercynia*, etc.) because they were collected for the first time or are considered relatively rare. An exact specific attribution of these taxa is likely to take some time, as the Heptageniidae of the Southern Alps is a potential *Pandora's box* nobody wants to open.

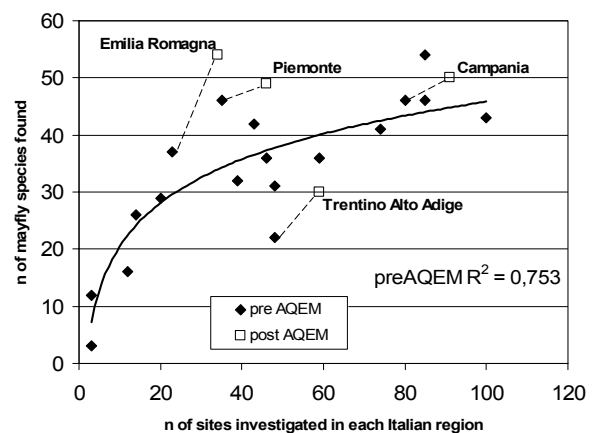


Fig. 2 - Relationship between number of sites investigated and number of species found per region, pre- and post-AQEM.

In the two Apennine areas, the recent AQEM collections gave even more interesting results. The known distribution area of many species dramatically changed: species like *Electrogena lunaris* BELFIORE & SCILLITANI, 1997, *Caenis belfiorei* MALZACHER, 1986 and *Habroleptoides pauliana* (GRANDI, 1959), formerly reported in Southern or Tirrenian regions only (see also Buffagni *et al.*, 2001), were collected much further North in river systems into the Po catchment, where they meet an invertebrate fauna closer to the transalpine Europe one (e.g. populations of the lowlands of the Po valley). The Northern Apennine area (in Emilia Romagna) appears now to be the richest area for mayflies in Italy (together with Lombardia, which contains a large portion of high altitude Alpine streams). Independently from the AQEM activities, a new *Ecdyonurus* species was described recently, *Ecdyonurus belfiorei* HAYBACH & THOMAS, 2002 (Haybach and Thomas, 2002), and was found to be present in AQEM samples too. The distribution of the related *Ecdyonurus aurantiacus* (BURMEISTER, 1839) in Italy has then to be unequivocally checked in the future (the data provided in Table 1 are thus preliminary).

In Southern Italy, over the last few decades, many mayfly species have been recorded for the first time in the area or described as new to science (e.g. Belfiore, 1994a; 1995; Belfiore *et al.*, 1997). This area, therefore, should be relatively well known and it would be unsurprising if the AQEM project found no new species for Italy. This, however, may not actually be the case as it is probable that new and undescribed taxa were collected, e.g., *Baetis* sp. gr. *alpinus* and *Baetis* sp. gr. *vernus* (see also Buffagni *et al.*, 2001). The investigation of mayfly taxonomy in the South of Italy (and elsewhere in Southern Europe) is more difficult than in the Northern Italy, where the boundaries of adjacent countries are relatively close (e.g. Belfiore and Buffagni, 1994; Buffagni, 1994; 1997; 1998), meaning that suitable literature is available. In the South, species sometimes reach their distribution limit, forced into geographical “one-way corridors” such as the Italian peninsula, and show increased morphological differentiation

and/or variability. The paucity of literature from neighbouring areas (a result of very low levels of project funding on such topics in Southern countries) then further complicates the process of securely identifying and describing new taxa.

Mayfly abundance and rarity results in the four AQEM study areas

In Figures 3-6, mayfly species collected in the four Italian areas during the AQEM project are shown, according to the percentage of the total number of samples for an area in which the animal was found. The same graphs also show the average density (ind·m⁻²) at which the species were found, when they were present in the sample. Thus, species both abundant and cosmopolitan (e.g. *Serratella ignita* (PODA, 1761) in Campania) can be compared with those occurring only regionally and at low densities (e.g. *Choroiterpes borbonica* BELFIORE, 1988).

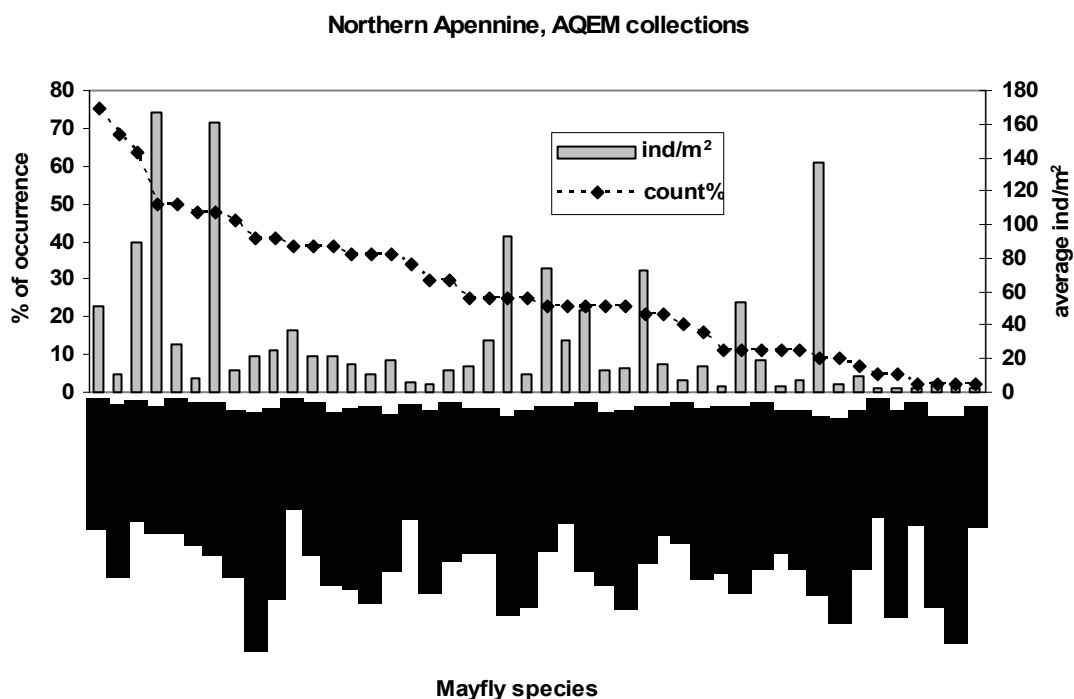


Fig. 3 - Ephemeroptera species ordered according to their percentage of occurrence in the Northern Apennine area. Average nymphal density, for the sites at which they occurred is also reported. Scattered lines between dots support an easier reading of the distribution pattern.

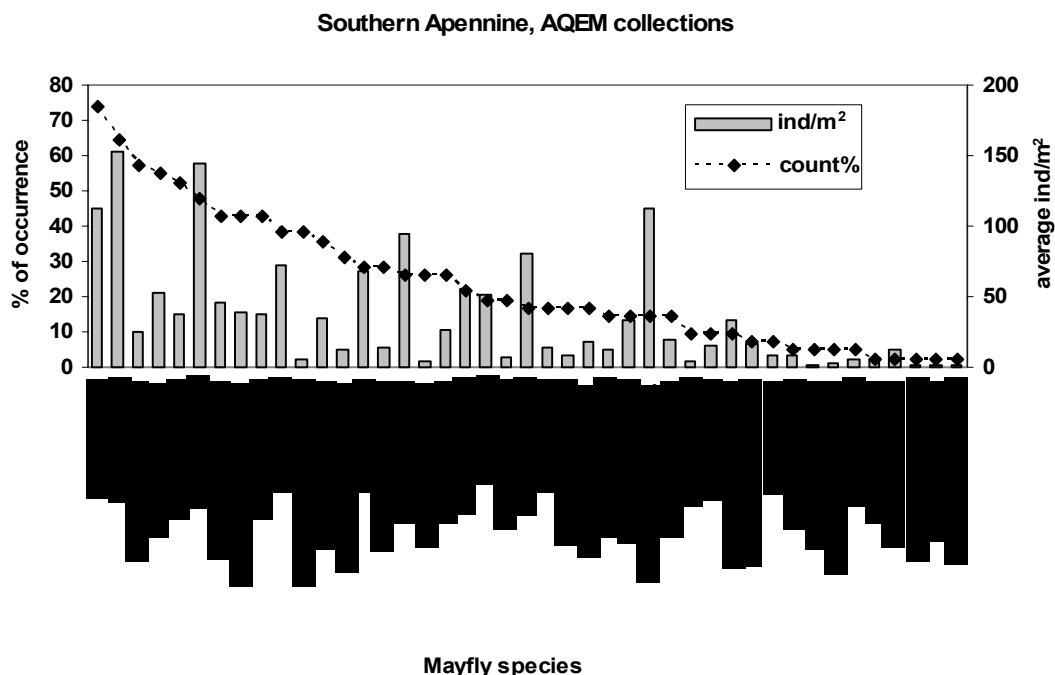


Fig. 4 - Ephemeroptera species ordered according to their percentage of occurrence in the Southern Apennine area. Average nymphal density, for the sites at which they occurred is also reported.

Comparing the situation of the species endemic to Italy, a contrast was found between the Northern and Southern Apennines. In the North, in fact, after the most common, often dominant, species (left side of Fig. 3), there were a number of ancillary species. These species, including the endemic and/or interesting ones were fairly common and in some cases abundant (with occurrence frequencies of around 20-25%, e.g., *E. lunaris*, *H. pauliana*, *C. belfiorei*). In the South (Fig. 4), in contrast, the most interesting or endemic species, e.g. *Electrogena calabra* BELFIORE, 1995, *Rhithrogena siciliana* BRAASCH, 1989, *H. pauliana* and *C. borbonica*, were positioned towards the right end of the x-axis, showing very low frequencies (around 5% or less, apart from *E. calabra*), thus being quite “rare” species. Although the timing of the species’ life cycle may have affected the likelihood of detecting nymphs (e.g., for *C. borbonica*), the status of these species is perhaps precarious. This result suggests that it would be prudent to study the ecology of these species of the South, to possibly determine whether this situation is a cause for concern, i.e. perhaps they are uncommon because of anthropogenic impacts. The situation for the Northern Apennine appears to give less cause for concern as their uncommon species seem not to be endangered. The difference between the species distribution patterns in the two Apennine areas may be linked to the

prevailing anthropogenic impact types. In fact, as already mentioned, in the Northern Apennine a single, main impact type, specifically morphological degradation, was evident, while water quality was good or fairly good at all sites (see Buffagni *et al.*, 2002). In contrast, in the Southern Apennine area, both morphological degradation and organic pollution (occasionally heavy) affected rivers. The combination of the two impact types may thus be partly responsible for the different population characteristics of the mayfly species in the two areas. More detailed studies focussing on the microhabitat preference and pollution tolerance of these species, both in Northern and Southern Apennine, could provide information useful to prevent their decline in the only area where they are known to occur.

In the Alpine sites investigated in the province of Bolzano (Alto Adige) (Fig. 5), many interesting but rare Heptageniidae taxa were collected. Again, further in-depth investigation is needed in this area.

Concerning the lowland small streams investigated in the Po valley (Fig. 6), apart from the *Ephemera* species already cited, additional uncommon species were collected (e.g. *Nigrobaetis niger* (LINNÉ, 1761) and, as for the species mentioned above, accurate habitat definition will support a better understanding of their conservation status.

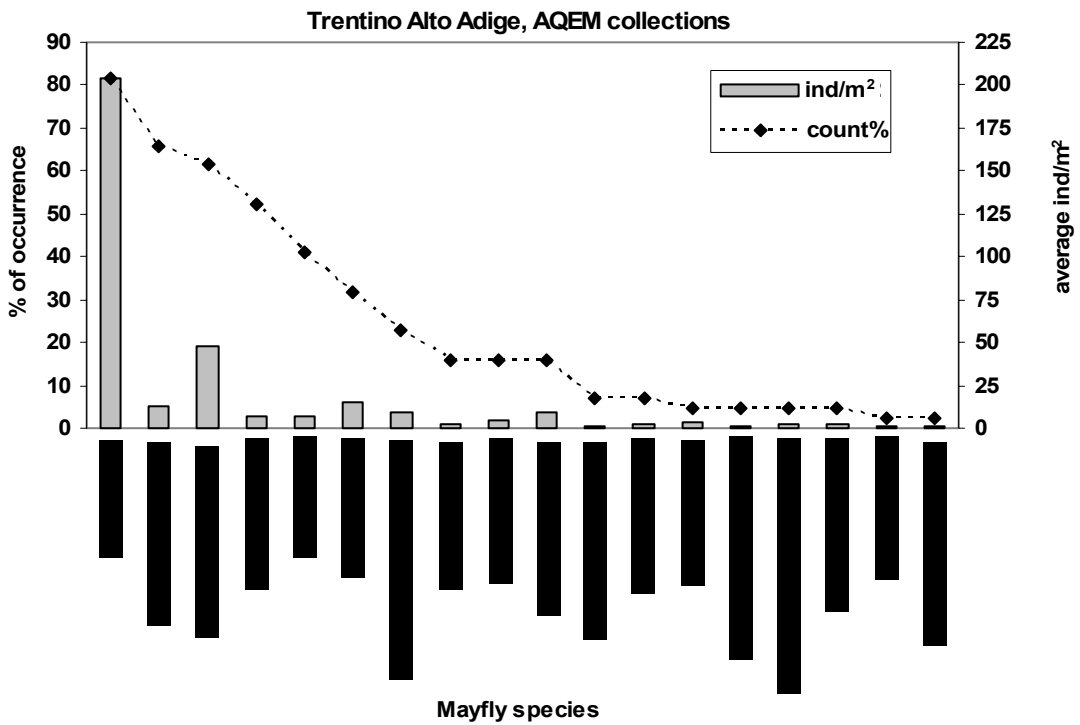


Fig. 5 - Ephemeroptera species ordered according to their percentage of occurrence in the Trentino Alto Adige area. Average nymphal density, for the sites at which they occurred is also reported.

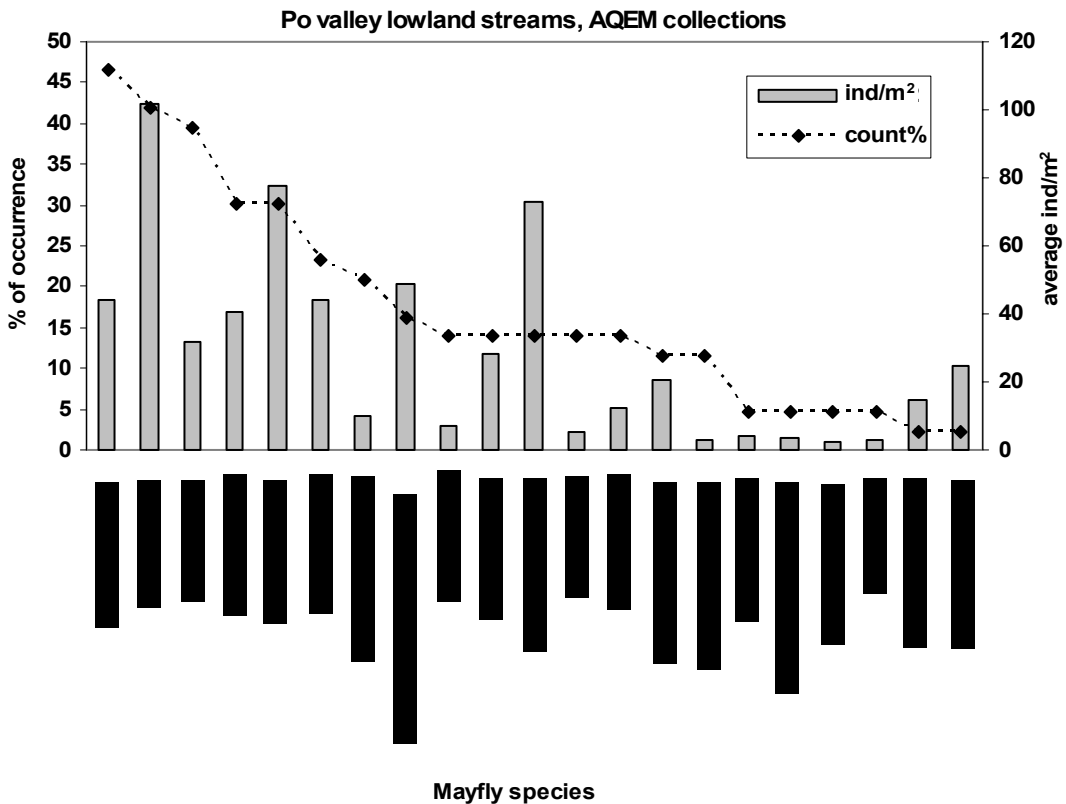


Fig. 6 - Ephemeroptera species ordered according to their percentage of occurrence in the Piemonte area. Average nymphal density, for the sites at which they occurred is also reported.

Conclusions

The distribution of species reported in Table 1 refers only to the data the authors were able to verify directly or derived by selected literature. A huge quantity of “grey” literature has been produced all over Italy (e.g. EIA reports, degree thesis, biomonitoring releases, etc.), sometimes mentioning mayfly species. Nevertheless, this information, anyway difficult to be gathered, does not offer adequate warranty of identification accuracy, partly due to the limited level of taxonomic expertise on mayflies (and aquatic insects in general) spread across Italy. The general scenario derived by Table 1 is then apparently provisional and most species listed are expected to enlarge their distribution in future years, following further investigation. However, particularly for the best studied areas of Italy, the picture on mayflies given here might reveal especially useful for large-scale studies. For instance, in Italy a typology for rivers is presently unavailable (Buffagni *et al.*, 2001). Such a typology, for the aims of the WFD, should better include the definition of sound bio-ecoregions (e.g. Bonada *et al.*, *in press*; Hering *et al.*, *in press*). A high proportion of the collected mayfly species has been recorded in a few regions only (top of Table 1), thus providing suitable information for regionalisation purposes and biogeographical studies (e.g. Belfiore, 1994b) besides being essential for global biodiversity evaluation in rivers and their catchments.

The widely spread species (bottom of Table 1) are largely proficient for bioassessment and their inclusion in monitoring tools should be principally conceived. In general terms, benthic invertebrate taxonomy and distribution must be better understood to improve the effectiveness of bioassessment as a water resource management tool. This is urgent work considering that under the WFD a fully comparable application of methods and principles all over Europe should be implemented. In addition, any investigation aimed at assessing the impact of climate change on aquatic communities (e.g. due to the modification of water temperature) would gain unvaluable information from updated reports of taxa occurrence and dispersal. As concerns mayflies in Italy and South Europe, comprehensive summaries are uncommon, and large research projects like AQEM, STAR, etc., support important improvements from the biogeographical, ecological and taxonomical point of view. For Italy, it is noteworthy that the

description of new species belonging to a number of genera (e.g. *Baetis*, *Proclleon*, *Rhithrogena*, *Siphonurus* and *Caenis*) is expected, together with the first collection for Italy of already known species, and the total number of mayfly taxa is awaited to increase greatly. Nevertheless, more emphasis might be placed on the dissemination of results in areas of study not always considered as high priority in Southern Europe, such as the taxonomy and ecology of species (currently ‘out of fashion’ in Europe?). Available information is predominantly restricted to specialist journals, or worse, known only to single labs and/or work groups. In addition, identification keys, where available, are often not up-to-date.

Still, in Italy and Southern Europe, mayfly faunistic, taxonomic and ecological information is unquestionably on the increase, thanks in great part to the funding of E.U. projects. On the other hand, it remains clear that more studies are needed to build upon the achievements of single researchers and a move is needed towards more objective research planning.

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