

Chironomids from Southern Alpine running waters: ecology, biogeography[★]

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Abstract

The chironomid fauna living in running waters in the Southern Alps was investigated from an ecological and biogeographical point of view: 202 species were identified (not including terrestrial species). It must be emphasised that species identification is tentative within some genera, especially those awaiting revision (e.g., *Boreoheptagyia*, *Chaetocladius*). Although much taxonomic work was done in the past on the chironomid Alpine fauna, there are still many unsolved problems. Most of the species found are widespread in the Palearctic Region, with no evidence of bio-geographical barriers separating different Alpine sectors. Really a relatively high number of species reported from the northern and western side (France, Switzerland, Austria) of the Alps was not captured on the southern side (Italy), whereas most species found on the southern side are also present on the northern one. Very few species are reported from southern side only. Lack of sampling, imperfect taxonomic knowledge and different environmental conditions between the northern and southern sides may be responsible of this result. A comparison of the fauna of the southern Alps with the fauna of the Apennines suggests that the differences are probably more related to ecological conditions (lack of glaciers in the Apennines) than to biogeographical barriers. Different chironomid assemblages colonise manifold habitat types: strict cold-stenothermal species tolerating high current velocity (e.g., *Diamesa latitarsis* – *steinboeckii* group) are almost the sole inhabitants of kryal biotopes, while other cold-stenothermal species are restricted to cold springs (*Diamesa dampfi*, *D. incallida*, *Tokunagaia rectangularis*, *T. tonollii*), there are also species characteristic of hygropetric habitats (*Syndiamesa edwardsi*, *S. nigra*) or restricted to lacustrine habitats (*Corynoneura lacustris*, *Paratanytarsus austriacus*). It must be emphasised that different responses to environmental factors can be observed between species belonging to the same genus (e.g., *Diamesa*, *Eukiefferiella*, *Orthocladius*, *Paratrachocladius*), so species identification is really needed for a good ecological work. Water temperature, current velocity, substrate type are the most critical factors, sometime chironomid species appear to be rather opportunistic and their presence or absence cannot be clearly related to a well defined range of values of environmental variables: be it a lack of knowledge or a real datum will be the task of future studies. The waters of the Alps are still relatively unpolluted, but hydraulic stress due to river damming and canalization is a serious problem for macrofauna conservation, and as the glaciers retreat, the species confined to the glacial snouts are at risk of extinction, some of them possibly even before their existence be discovered.

[★] The complete database with detailed taxonomical, ecological and biogeographical information can be obtained by the senior author to request (e-mail: bruno.rossaro@unimi.it). A table with species response to environmental variables is also available at the web site: <http://users.unimi.it/~roma1999/rossaro.html>, downloading file CHIRDB.)

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Introduction

44 The Chironomidae are the freshwater insect family
45 which comprises the highest number of species,
46 both in lentic and lotic habitats (Cranston, 1995).
47 They are well known indicators of trophic condi-
48 tion in lakes (Brundin, 1974), of organic pollution
49 in running waters (Thienemann, 1953) and are
50 considered an interesting biogeographic material
51 (Brundin, 1966).

52 The numbers of species and specimens are
53 particularly high in alpine freshwaters, making the
54 chironomid taxocoenosis the most important in
55 these biotopes, especially in glacier-fed streams
56 (Ward, 2002). The high altitude lotic habitats host
57 both euryoecious species, adapted to live in a
58 variety of running waters (glacial streams, spring-
59 fed brooks etc.), and truly cold-stenothermal spe-
60 cies confined in reaches close to glacial snouts. The
61 true cold-stenothermal species (e.g., *Diamesa*
62 *steinboeckii*) adapted to tolerate extremely low
63 temperatures (generally lower than 4–6 °C) are
64 able to face high current velocity but are vulner-
65 able to anoxia, even if the risk of oxygen depletion
66 is reduced in very cold, fast running waters (Thi-
67 enemann, 1953). In the uppermost sector of gla-
68 cier-fed streams (metakryal), where the water
69 temperature does not exceed 2 °C, *Diamesa* species
70 are typically the sole inhabitants. Other Diamesi-
71 nae (*Pseudodiamesa*, *Pseudokiefferiella*, *Syndia-*
72 *mesa*), Orthocladiinae (*Tvetenia* and
73 *Euorthocladius*) and Simuliidae, commonly *Pro-*
74 *simulium latimucro* (Enderlein 1925), are able to
75 survive in the hypokryal, where maximum tem-
76 perature is lower than 4 °C (Steffan, 1971; Milner
77 & Petts, 1994; Lods-Crozet et al., 2001a; Maiolini
78 & Lencioni, 2001).

79 Alpine chironomids are interesting from a
80 biogeographical point of view (Serra-Tosio, 1973).
81 Cold-stenothermal species should be unable to
82 cross the geographical barriers formed by high
83 mountains and warmer lowland waters; endemic
84 species were reported in the past in different
85 mountain groups, but more detailed investigations
86 often revealed that species previously thought to
87 live in a restricted area actually had a wider dis-
88 tribution (Rossaro, 1995).

89 Knowledge of invertebrate fauna from Alpine
90 streams, with special reference to chironomids, is

still limited, especially at species level (Lencioni
et al., 2001). 91 92

Thienemann (1936) carried out the first eco- 93
logical surveys on the Alpine chironomid fauna on 94
the northern side of the Alps, in Bavaria. Serra- 95
Tosio (1973) examined the Diamesinae of the 96
French Alps and gave a detailed description of the 97
morphology, ecology and geographical distribu- 98
tion of the species. Kownacka & Kownacki (1975) 99
studied Diamesinae in Tyrolean glacial streams 100
(Ötzaler Alps). Since the '70s chironomid species 101
were collected in high altitude streams in the 102
Southern Alps, focusing particularly on waters in 103
the Ortles and Adamello groups. The chironomids 104
(Diamesinae and Orthocladiinae above all) from 105
these areas were described along with taxonomical 106
and autoecological notes (Ferrarese & Rossaro, 107
1981; Rossaro, 1981, 1982, 1990). From 1980 to 108
1982 faunistic investigations were carried out on 109
the Alpine chironomid communities of the Upper 110
Alz (West Germany) by Caspers (1983), finding a 111
total of 80 species. Saxl (1986) recorded 66 chi- 112
ronomid taxa in the Stocktalbach (Tyrol) between 113
2200 and 2400 m a.s.l. At the end of the '80s, a 114
catalogue of chironomids from the French Alps 115
was compiled (Serra-Tosio, 1991). French Alps 116
include area 4 over 1000 m a.s.l. and part of area 117
13, under 1000 m a.s.l. in the Limnofauna Euro- 118
paea (Fittkau & Reiss, 1978). Three hundred and 119
thirty five species were recorded, about 90 from 120
area 4 (excluding terrestrial species). Kownacki & 121
Kownacka (1994) investigated the drift phenome- 122
non in chironomids in high mountain streams in 123
the Southern Tyrol (Italy). During the last ten 124
years, Crema et al. (1996) studied springs in the 125
southern (Trentino, Alto Adige, Veneto) and 126
northern Alps (Bavaria), collecting respectively 61 127
and 71 chironomid taxa, mainly genera, larval 128
material did not allow determination of species 129
within some genera. Relationships between the 130
environmental factors and the chironomid species 131
were analysed in glacial streams in the Veny Valley 132
(Aosta, western Italian Alps) (Rossaro & Lenci- 133
oni, 2001). The chironomid communities of per- 134
manent or temporal inlets and outlets of 15 lakes 135
in the Central Alps (Piedmont-Italy and Canton 136
Tessin-Switzerland, Pennine-Leponine Alps) were 137
investigated from 1991 to 2000 within the frame- 138
work of the pan-European projects Acidification 139

140 of mountain Lakes: Palaeolimnology and Ecology
 141 (AL:PE), MOuntain Lake Research (MOLAR)
 142 and European Mountain lake Ecosystems: Re-
 143 gionalisation, diaGnostics & socio-economic
 144 Evaluation (EMERGE): 7, 23 and 300 European
 145 lakes were considered respectively in the 3 projects
 146 with the focus on their geographical, morpho-
 147 metrical and chemical characteristics (Fjellheim
 148 et al., 2000; Wathne & Rosseland, 2000). Inlet/
 149 outlet streams of 3 further lakes were studied in the
 150 framework of EU Inter-Reg II Programme (Mar-
 151 chetto et al., 2001); 4 outlets and 1 inlet were
 152 investigated in the '90s by Boggero et al. (1996)
 153 and Boggero & Nobili (1998); in all, 154 chiron-
 154 omid species were identified. Species identification
 155 was aided associating larval material with pupae.
 156 Since 1996 the chironomid fauna from high alti-
 157 tude streams in Trentino (Rhaetian Alps) have
 158 been monitored within the Arctic and Alpine
 159 Stream Ecosystem Research (AASER) and Health
 160 and integrity of high mountain streams in Trentino
 161 (HIGHEST) projects. Six streams (3 glacial, 1
 162 non-glacial and 2 outlets) were selected in the
 163 Adamello-Presanella mountain group (Val Borz-
 164 ago and Val Nambrone, Adamello-Brenta Re-
 165 gional Park), 14 streams (5 glacial, 5 non-glacial
 166 and 4 outlets) and 5 springs in the Ortles-Cevedale
 167 mountain group (Val de la Mare, Stelvio National
 168 Park). Altogether about 130 chironomid taxa were
 169 collected, accounting for 25% of the Italian chi-
 170 ronomid fauna (Lencioni, 2000; Lencioni et al.,
 171 2000; Lencioni & Maiolini, 2002). Some of the
 172 data on glacial systems in Trentino (Maiolini &
 173 Lencioni, 2001) were included in a special issue of
 174 Freshwater Biology (Brittain & Milner, 2001),
 175 devoted to various aspects of the ecology of gla-
 176 cial-fed rivers along a latitudinal gradient (46°–
 177 79° N). Many contributions to our knowledge of
 178 the European chironomid fauna were given.
 179 Among these, Lods-Crozet et al. (2001a, b)
 180 examined the physico-chemical features and ben-
 181 thic macroinvertebrates in glacial and non-glacial
 182 streams in the Swiss Alps, as did Füreder et al.
 183 (2001) in the Austrian Alps. Notes on the Austrian
 184 and German chironomid fauna were also provided
 185 by Orendt (2000) who investigated 30 small
 186 watercourses in Berchtesgaden National Park.
 187 Ninety four taxa were recorded (71% of specimens
 188 were determined to species) from mainly pupal
 189 exuviae.

In the present paper, the chironomid fauna of
 running waters from the southern Italian Alps
 (sites above 800–1000 m a.s.l.) will be reconsid-
 ered, with notes on biogeography and ecology of
 the species. Identification to species is necessary in
 an ecological study, it is a well-known fact that
 different species belonging to the same genus
 (*Diamesa*, *Eukiefferiella*, *Orthocladius* and *Par-
 atrichocladius*) respond differently to the same
 environmental factors (Rossaro & Mietto, 1998).

All the information available about Southern
 Italian Alps, filed in a relational database
 (CHIRDB=chironomid database¹), will be used
 for discussion. The response to environmental
 variables (water temperature, conductivity and
 pH) and factors (food, substrate) will be summa-
 rized for each species using all the data up to date
 available.

The study sites

A total of 125 study sites distributed above 800–
 1000 m a.s.l. were investigated in Alpine running
 waters (Table 1, Fig. 1). Samples were collected
 throughout the year with a monthly frequency in
 the Ortles and Adamello groups of mountains
 (high Camonica valley, Oglio river basin) from
 1978 to 1981. In all the other areas samples were
 collected during summer from June to September
 with at least a monthly frequency. All the infor-
 mation available filed in CHIRDB will be con-
 sidered for discussion and calculations.

The areas investigated fall within longitude
 6° to 12° E (Fig. 1), and include the catchments
 of the major Italian lakes (Maggiore, Como, Iseo,
 Garda) and rivers (Po, Dora Baltea, Sesia, Toce,
 Ticino, Adda, Oglio, Sarca, Adige). A median
 zone of predominantly crystalline rocks (granite,
 diorite, gneiss) and two predominantly calcareous
 external zones in the North and the South are
 distinguished in the Alps. The southern external
 zone, belonging to the Italian Alps, is smaller in
 the west and more extensive in the centre and
 east.

Most of the study sites in protected areas, in
 National and Regional Parks: Val Grande (Pied-
 mont), and Stelvio National Parks (Lombardy,
 Trentino and Alto Adige), Adamello-Brenta and
 Paneveggio Regional Parks (Trentino).

Table 1. Southern Alps: orographic division, regions (P = Piedmont, T = Canton Tessin (CH), AA = Alto Adige), main river basin, rivers, Lat = latitude North, Lg = longitude east, number of sites investigated: G = glacial streams, N = non-glacial streams, S = springs, L = lake outlets, Reference: R = Rossaro, B = Boggero, L = Lencioni, Date = sampling year/s

Sector	Alps	Region	Basin	River	Lat	Lg	G	N	S	L	Ref.	Date
Western	Graie	Aosta Valley	Veny Valley (Mt. Blanc)	Dora di Veny (Dora Baltea)	45° 45'	6° 52'	5	2	5	1	R 2000; Unpubl.	1995/1999
			Ferret Valley	Dora di Ferret (Dora Baltea)	45° 51'	7° 2'	1	1	2		Unpubl.	1995
			Valsavaranche (Gran Paradiso)	Savara (Dora Baltea)	45° 32'	7° 12'	1		1		Unpubl.	1980
Central	Pennine		Valtournenche (Matterhorn-Cervino)	Marmore (Dora Baltea)	45° 58'	7° 38'	1				Unpubl.	1980
			Gressoney Valley (Rosa)	Lys (Dora Baltea)	45° 52'	7° 48'	1				Unpubl.	1980
		P	Ossola Valley	Toce (Ticino)	46° 0'	8° 4'		9	16		B et al. 1996; Unpubl.	1991/2000
		T	Leventina Valley	Ticino	46° 10'	8° 27'		1	5		B et al. 1996; B & Nobili 1998	1991/1994
			Malenco Valley	Mallero (Adda)	46° 18'	9° 48'			1		Unpubl.	2000
Rhaetian		Lombardy	Brembana Valley	Brembo (Adda)	46° 1'	9° 47'			2		Unpubl.	1999
			Viola Valley	Bormina (Adda)	46° 27'	10° 12'	1				Unpubl.	1980
			Valfurva	Frodolfo (Adda)	46° 21'	10° 30'	2				Unpubl.	1978/2003
			Camonica Valley (Ortles-Adamello)	Oglio and tributaries	46° 13'	10° 22'	5	5	15		R 1990; Unpubl.	1978/2000
			Paghera	Paghera (Oglio)	46° 11'	10° 23'			3		R 1990; Unpubl.	1978/1981
			Avio Valley	Coleasca (Oglio)	46° 11'	10° 26'	3		3		R 1990; Unpubl.	1978/1982
		Trentino	Sole Valley	Noce (Adige)	46° 18'	10° 42'	2				R 1990; Unpubl.	1978/1994
			Genova Valley	Sarca (Mincio)	46° 12'	10° 37'	3		1		R 1990; Unpubl.	1995
			Borzago Valley	Sarca tribu-tary (Mincio)	46° 5'	10° 35'	2	1			L et al. 2000	1996/1999
			Nambrone Valley	Sarca di Nambrone (Mincio)	46° 13'	10° 41'	1		2		L et al. 2000	1997/1999
			Val de la Mare	Noce tribu-tary (Adige)	46° 25'	10° 43'	5	5	5	4	Unpubl.	1999/2003
		AA	Martellat	Plimabach (Adige)	46° 29'	10° 41'	1				Unpubl.	1998
Dolomites		Trentino	Travignolo Valley	Travignolo (Avisio, Adige)	46° 18'	11° 40'		1			R 1990; Unpubl.	1990



241 A wide heterogeneity of habitats from large
 242 glacial streams to small spring-brooks and lake
 243 outlets was investigated. The classification of the
 244 habitat sampled included in CHIRDB follows
 245 the criteria proposed by Ward (1994, 2002) and
 246 Füreder (1999). The glacial streams (kryal) have
 247 a maximum discharge and turbidity during the
 248 icemelt period. In summer, the water velocity is
 249 generally above 2 m s^{-1} , water temperature does
 250 not exceed $4\text{--}6 \text{ }^\circ\text{C}$, the channel bed is highly
 251 unstable, the higher aquatic plants are absent
 252 and the biofilm is composed only by Diatoms
 253 and blue-green algae. In this season, the zoo-
 254 benthic community is dominated by Diamesinae.
 255 The non-glacial streams, fed by groundwater
 256 (krenal), snowmelt ('chial') and/or rainfall ('om-
 257 bral') (Lencioni, 2000), are also included. They
 258 are less harsh and host a richer invertebrate
 259 community. The krenal streams considered
 260 originate from the underlying alluvial aquifer
 261 (alluvial springs) and from hill-slope aquifers
 262 that emerge along the edge of the river corridor
 263 (hill-slope springs). The krenal alpine streams are
 264 characterized by clear water. The temperature
 265 changes according to the origin of the ground-

waters, when they originate from glacier melt it
 can be very low in summer, below $2 \text{ }^\circ\text{C}$ (Serra-
 Tosio, 1973), but when the ground-waters are far
 from glaciers and originate mainly from snow-
 melt or rain, the water temperature is higher
 ($5\text{--}15 \text{ }^\circ\text{C}$). The dissolved oxygen is generally
 under saturation and carbon dioxide concentra-
 tion can be very high, favouring the development
 of algae, mosses and hepaticues. The zoobenthic
 community is co-dominated by chironomids
 (Diamesinae and Orthocladinae), Plecoptera,
 Ephemeroptera and Trichoptera. Chial and
 ombral habitats are generally temporary habitats
 with peaks of discharge during the snowmelt
 or after rainfall. In CHIRDB lake outlets are
 also included. They represent a different stream
 type, with physical, hydrological and chemical
 features directly influenced by the upstream lake
 (Hieber et al., 2002). Generally outlets of high
 altitude lakes show higher water temperature and
 lower diel and annual discharge fluctuations than
 inlets of the same lake. Moreover, these waters
 are richer in food (nutrients and planktonic
 drifters) and faunal diversity and abundance is
 higher.

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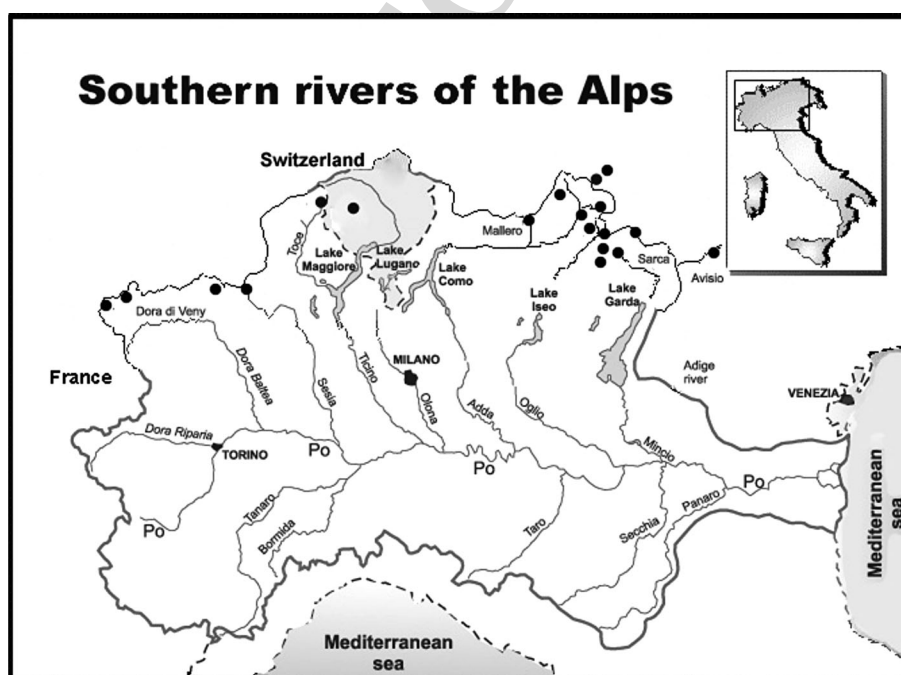


Figure 1. The study area: the most important rivers investigated in the Italian Alps (Po and Adige basins).

291 **Methods**292 *Environmental factors*

293 Point records of water temperature, dissolved
 294 oxygen, pH and conductivity were recorded
 295 with a field multiprobe in all sampling sites,
 296 with the exception of the outlets of the small
 297 alpine lakes where 1 l of water was taken from
 298 each site using a polyethylene bottle and anal-
 299 ysed in the laboratory (Tartari & Mosello,
 300 1997). Nutrients (nitrogen, phosphorous, silica),
 301 the main cations and anions were recorded in
 302 all sites investigated in the AL:PE, EMERGE,
 303 AASER and HIGHEST projects. The last two
 304 projects also required the measurement of sus-
 305 pended sediments and temperature to be per-
 306 formed continuously throughout the year (from
 307 June to August with a monthly frequency), as
 308 well as geo-morphological (e.g., channel stabil-
 309 ity) and hydrological (current velocity, depth,
 310 discharge) factors. More details are in Maiolini
 311 & Lencioni (2001).

312 *Chironomid fauna*

313 In each sampling site, larvae and immature pupae
 314 were collected from different microhabitats (e.g.,
 315 stones, mosses and algal mats) with a pond net
 316 (225–300 μm mesh sizes) (Thienemann, 1936),
 317 while mature pupae and pupal exuviae were taken
 318 with a drift net (300 μm mesh size) (Brundin,
 319 1966). When qualitative samples were collected, at
 320 least 30 (generally more, 100–200) specimens were
 321 examined per sample and mounted on permanent
 322 slides for identification. In the AASER and
 323 HIGHEST sampling sites quantitative kick sam-
 324 ples were taken (in each 15 m-long station, 5–10
 325 replicates were taken, each of them from an area of
 326 0.1 m²). Lake outlets were sampled near the lake
 327 source and 50–100 m downstream.

328 For rearing single larvae and pupae were
 329 transported alive to the laboratory, with moss-
 330 stems or leaf pieces. Some specimens were kept in
 331 Petri dishes (1 cm high, 5 cm diameter) at low
 332 temperature (1–6 °C) till the adults emergence.
 333 Strictly cold-stenothermal species (e.g., *Diamesa*
 334 *latitarsis* and *steinboeckii* group) required water
 335 temperature below 4 °C for rearing. Larvae suc-
 336 cessfully reared in Petri dishes become mature

pupae, but mature pupae often did not moult to
 live imagos under these conditions. Imagos were
 successfully obtained from larvae and pupae
 reared in larger boxes (30×30×30 cm) aerated
 with an aquarium air pump. Under these condi-
 tions, emerging adult mortality was low, but an
 association of single larval and pupal exuviae with
 adults was not possible. Adults were also collected
 occasionally in the field using sweep nets, light and
 emergence traps.

Genera were identified using Wiederholm (1983,
 1986, 1989) keys for Holarctic fauna, species using
 the miscellaneous specialised literature available.

Only species whose identification was based on
 well preserved material mounted on permanent
 slides, stored in the collection of the Department
 of Biology of the University of Milan (Italy), the
 Natural Science Museum of Trento (Italy) and
 the Institute for Ecosystem Study in Pallanza
 (Italy) were included in the checklist (see
 Appendix).

Data analysis

All the data available from the southern Alps
 summarized in Table 1 were filed in a relational
 database (CHIRDB=chironomids database)
 using Microsoft ACCESS (MS) (Rossaro et al.,
 2002). Means of environmental variables weighted
 by species abundances were calculated. Values
 obtained with fixed count sub-samples, generally
 100 specimens, were used as species abundances
 (King & Richardson, 2002). Means of water
 temperature, conductivity, and pH (and other
 variables when available) were calculated, using
 the formula

$$\bar{z}_{jk} = \frac{\sum_{i=1}^n y_{ik} z_{ij}}{\sum_{i=1}^n y_{ik}}$$

where z_{ij} is the value of the environmental variable j
 measured in a locality i , y_{ik} is the abundance of the
 species k in the same locality i and \bar{z}_{jk} is the
 weighted mean value calculated for species j and
 variable k . Weighted standard deviations, mini-
 mum and maximum values were also filed in the
 database. Sites above 900 m a.s.l. were selected for
 calculations. Species for which at least 10 records
 were available for each environmental variable
 were included in Tables 2–4.

Table 2. x =mean water temperature weighted by species abundance, s =standard deviation, n =number of records

Species	x	s	n
Tanypodinae			
<i>Arctopelopia griseipennis</i>	12.13	3.04	14
<i>Macropelopia nebulosa</i>	10.32	5.31	29
<i>Zavrelimyia hirtimana</i>	6.40	4.30	12
<i>Zavrelimyia punctatissima</i>	8.16	2.15	17
Diamesinae			
<i>Diamesa aberrata</i>	4.39	3.26	20
<i>Diamesa bertrami</i>	3.48	1.29	119
<i>Diamesa cinerella</i>	3.64	1.83	111
<i>Diamesa dampfi</i>	3.83	1.45	38
<i>Diamesa goetghebuerti</i>	3.83	3.63	37
<i>Diamesa incallida</i>	5.35	0.94	13
<i>Diamesa latitarsis</i>	2.76	1.96	240
<i>Diamesa steinboeckii</i>	2.68	1.61	208
<i>Diamesa tonsa</i>	7.15	2.57	34
<i>Diamesa zernyi</i>	3.39	2.11	298
<i>Pseudodiamesa branickii</i>	4.90	1.88	112
<i>Pseudodiamesa nivosa</i>	4.45	4.42	11
<i>Pseudokiefferiella parva</i>	3.66	2.06	128
Prodiamesinae			
<i>Prodiamesa olivacea</i>	4.04	3.90	12
Orthoclaadiinae			
<i>Brillia bifida</i>	7.10	2.03	22
<i>Chaetocladius</i> sp.	5.72	2.37	128
<i>Corynoneura edwardsi</i>	5.50	1.71	77
<i>Cricotopus</i> sp.	10.26	4.86	12
<i>Cricotopus fuscus</i>	9.24	4.24	17
<i>Eudactylocladius fuscimanus</i>	3.80	1.48	63
<i>Eukiefferiella brevicealcar</i>	4.24	1.48	204
<i>Eukiefferiella claripennis</i>	5.45	1.46	23
<i>Eukiefferiella fuldensis</i>	4.81	2.28	105
<i>Eukiefferiella minor</i>	4.90	2.41	166
<i>Euorthocladus rivicola</i>	3.81	1.61	205
<i>Euorthocladus thienemanni</i>	3.30	3.18	11
<i>Heleniella serra-tosioi</i>	5.35	2.08	91
<i>Heterotrissocladius marcidus</i>	7.28	2.34	26
<i>Krenosmittia camptophleps</i>	6.94	1.80	82
<i>Metricnemus hygropetricus</i>	5.73	1.93	32
<i>Orthocladus frigidus</i>	4.35	1.98	292
<i>Parametricnemus stylatus</i>	7.31	1.90	93
<i>Paratrithocladus nivalis</i>	6.41	4.13	60
<i>Paratrithocladus rufiventris</i>	5.97	3.03	28
<i>Paratrithocladus skirwithensis</i>	4.60	2.11	254
<i>Parorthocladus nudipennis</i>	4.00	1.32	58
<i>Rheocricotopus effuses</i>	6.37	2.56	31

Table 2. (Continued).

Species	x	s	n
<i>Rheocricotopus fuscipes</i>	10.77	4.42	17
<i>Thienemanniella partite</i>	5.01	1.52	67
<i>Tokunagaia tonollii</i>	4.47	1.76	19
<i>Tvetenia calvescens</i>	4.80	1.91	267
Chironominae			
Tanytarsini			
<i>Micropsectra atrofasciata</i>	5.10	3.04	260
<i>Paratanytarsus austriacus</i>	5.34	1.04	16
<i>Tanytarsus gracilentus</i>	4.11	1.31	13
Chironomini			
<i>Microtendipes pedellus</i>	8.91	2.90	16
<i>Paratendipes nudisquama</i>	3.83	2.84	35

Results

In all, 202 species were captured on the Italian side of the Alps (Appendix 1).

Taxonomy

The present research confirms the importance of identifying species (Rossaro & Mietto, 1998), in fact different species within a genus often have a divergent ecological niche.

Our knowledge of Holarctic genera is well-consolidated (Wiederholm, 1983, 1986, 1989), whereas there are still many unsolved taxonomic problems at the species level. Many genera require revision, e.g., *Boreoheptagyia* and *Chaetocladius*. Species identities must be checked accurately in *Diamesa latitarsis* and *steinboeckii* groups to avoid misidentifications, and there are many open taxonomic questions in other genera; recent revisions (*Orthocladus* s. str., see Langton & Cranston, 1991; Rossaro et al., 2003) have emphasised the existence of incorrect synonymies.

Biogeography

Information about the distribution and ecology of chironomids in the Alps is still fragmentary, despite the large number of studies carried out in the past (see Introduction). Many high altitude stream ecosystems in the Southern Alps are still unexplored or very little known, such as those in the

Table 3. \bar{x} = mean pH weighted by species abundance, s = standard deviation, n = number of records

Species	\bar{x}	s	n
Tanypodinae			
<i>Zavrelimyia hirtimana</i>	8.02	0.31	12
<i>Zavrelimyia punctatissima</i>	6.67	0.45	15
Diamesinae			
<i>Diamesa bertrami</i>	6.11	0.44	93
<i>Diamesa cinerella</i>	6.08	1.06	88
<i>Diamesa dampfi</i>	8.67	0.56	11
<i>Diamesa goetghebueri</i>	6.60	1.16	28
<i>Diamesa latitarsis</i>	7.68	1.38	177
<i>Diamesa steinboeckii</i>	5.77	0.62	183
<i>Diamesa tonsa</i>	7.89	0.38	14
<i>Diamesa zernyi</i>	7.39	1.53	232
<i>Pseudodiamesa branickii</i>	6.82	1.09	77
<i>Pseudokiefferiella parva</i>	5.91	0.92	103
Orthoclaadiinae			
<i>Chaetocladius</i> sp.	6.34	0.56	94
<i>Corynoneura edwardsi</i>	6.46	0.37	68
<i>Eudactylocladius fuscimanus</i>	6.48	0.70	40
<i>Eukiefferiella brevicealcar</i>	6.54	0.68	176
<i>Eukiefferiella claripennis</i>	6.61	0.57	13
<i>Eukiefferiella fuldensis</i>	6.24	0.31	96
<i>Eukiefferiella minor</i>	6.52	0.98	121
<i>Euorthocladus rivicola</i>	6.35	0.98	164
<i>Heleniella serra-tosioi</i>	6.43	0.75	69
<i>Heterotrissocladus marcidus</i>	7.23	1.09	14
<i>Krenosmittia camptophleps</i>	6.21	0.42	77
<i>Metriocnemus hygropetricus</i>	7.45	1.25	18
<i>Orthocladus frigidus</i>	6.43	0.70	226
<i>Parametriocnemus stylatus</i>	6.20	0.59	63
<i>Paratrichocladus rufiventris</i>	7.14	1.37	22
<i>Paratrichocladus skirwithensis</i>	8.45	0.91	69
<i>Parorthocladus nudipennis</i>	6.54	0.64	40
<i>Rheocricotopus effusus</i>	7.05	0.60	22
<i>Smittia Smittia</i>	7.86	1.17	30
<i>Thienemanniella partita</i>	6.33	0.29	57
<i>Tokunagaia tonollii</i>	8.79	0.44	11
<i>Tvetenia calvescens</i>	6.44	0.65	208
Chironominae			
<i>Micropsectra atrofasciata</i>	6.26	0.47	195
<i>Paratendipes nudisquama</i>	8.40	0.71	20

Table 4. \bar{x} = mean conductivity weighted by species abundance, s = standard deviation, n = number of records

Species	\bar{x}	s	N
Tanypodinae			
<i>Macropelopia nebulosa</i>	77.49	51.22	13
<i>Zavrelimyia punctatissima</i>	21.83	8.12	14
Diamesinae			
<i>Diamesa aberrata</i>	176.17	39.07	11
<i>Diamesa bertrami</i>	11.86	27.12	102
<i>Diamesa cinerella</i>	42.61	61.65	94
<i>Diamesa dampfi</i>	274.13	177.13	26
<i>Diamesa goetghebueri</i>	31.80	92.58	28
<i>Diamesa latitarsis</i>	84.17	122.21	194
<i>Diamesa steinboeckii</i>	15.89	41.98	187
<i>Diamesa tonsa</i>	101.20	59.00	16
<i>Diamesa zernyi</i>	88.26	140.27	247
<i>Pseudodiamesa branickii</i>	76.03	133.07	91
<i>Pseudokiefferiella parva</i>	20.05	53.21	108
Orthoclaadiinae			
<i>Brillia bifida</i>	49.58	39.26	12
<i>Chaetocladius</i> sp.	20.94	44.64	110
<i>Corynoneura edwardsi</i>	11.29	7.55	61
<i>Eudactylocladius fuscimanus</i>	22.21	40.92	46
<i>Eukiefferiella brevicealcar</i>	24.14	51.69	186
<i>Eukiefferiella claripennis</i>	35.60	36.81	15
<i>Eukiefferiella fuldensis</i>	11.42	9.57	103
<i>Eukiefferiella minor</i>	33.88	61.11	137
<i>Euorthocladus rivicola</i>	26.19	55.61	180
<i>Heleniella serra-tosioi</i>	24.68	48.09	76
<i>Heterotrissocladus marcidus</i>	99.95	151.41	18
<i>Krenosmittia camptophleps</i>	9.51	2.11	78
<i>Metriocnemus hygropetricus</i>	92.96	107.90	20
<i>Orthocladus frigidus</i>	27.61	45.98	238
<i>Parametriocnemus stylatus</i>	15.07	25.83	66
<i>Paratrichocladus rufiventris</i>	100.12	133.46	23
<i>Paratrichocladus skirwithensis</i>	344.08	186.82	86
<i>Parorthocladus nudipennis</i>	33.19	31.75	53
<i>Rheocricotopus effusus</i>	34.23	20.17	21
<i>Thienemanniella partita</i>	11.15	8.59	65
<i>Tokunagaia tonollii</i>	227.23	122.36	14
<i>Tvetenia bavarica</i>	48.44	12.03	11
<i>Tvetenia calvescens</i>	24.56	39.25	230
Chironominae			
<i>Micropsectra atrofasciata</i>	14.28	25.38	208
<i>Paratanytarsus austriacus</i>	63.92	46.52	16
<i>Paratendipes nudisquama</i>	151.68	110.29	19
<i>Tanytarsus gracilentus</i>	90.54	9.59	11

410 Matterhorn (Cervino), Gran Paradiso, Dolomites
411 and Carnia mountains.

412 Most species are widespread in the Palaearctic
413 Region, with some exceptions: for example *Dia-*
414 *mesa longipes* and *Stilocladius montanus* showed a
415 distribution restricted to very few locations. A
416 comparison of checklists from different countries
417 can be misleading due to dissimilarities in the
418 taxonomic accuracy applied by specialists in spe-
419 cies identification. Different sampling efforts and
420 devices, and differences in the characteristics of the
421 areas investigated also advice caution.

422 A comparison between the list of species from
423 the northern and southern side of the Alps em-
424 phasises that a geographical barrier separating
425 chironomid species is not apparent. Reiss (1968)
426 draw the same conclusion in comparing the fauna of
427 lakes in the Prealps. The fact that a high number of
428 species names is reported from only one side of the
429 Alps seems to contradict the absence of barriers;
430 within the well investigated Diamesinae *Protanypus*
431 spp., *Diamesa wuelkeri* (Serra-Tosio 1964),
432 *D. martae* (Kownacki & Kownacka 1980), *D. no-*
433 *vikiana* (Kownacki & Kownacka 1975), *D. hamati-*
434 *cornis* (Kieffer 1909) were reported from the western
435 and northern side only, and *Syndiamesa nigra* from
436 the southern side only; among the Orthocladiinae,
437 there are many species reported from the northern
438 side only, but the presence of *Unniella multivirga*
439 from the southern side only must be noted. The
440 example of *Boreoheptagyia* is also instructive: four
441 species belonging to the genus *Boreoheptagyia* were
442 reported from the French Alps (Serra-Tosio,
443 1991), three species from the Italian Alps, but only
444 *B. legeri* and *B. rugosa* are common to both;
445 *B. alpicola* (Serra-Tosio, 1989); *B. dasyops* (Serra-
446 Tosio, 1989) are endemic to the French Alps, *B.*
447 *monticola* (Serra-Tosio 1964) is reported from the
448 French Alps, Switzerland, and Macedonia, and
449 there is one still not described species from the
450 Italian Alps. At least three species are known as
451 pupae and larvae only (Serra-Tosio, 1989) as a
452 demonstration of incomplete knowledge of the
453 genus. On the other hand it must be emphasised that
454 there are also species collected in few localities on
455 both sides of the Alps (*Diamesa longipes* and *Stilo-*
456 *cladius montanus* for example); rare species such as
457 *Protanypus* spp., *D. wuelkeri* and *D. starmachi* are
458 also probably present in both sides, but the deter-
459 minations on the southern side must be confirmed.

To sum up incomplete knowledge can be 460
always an explanation of conflicting evidence. 461

An intriguing puzzle is the case of *Diamesa* 462
insignipes: it was never captured on the southern 463
side of the Alps, which is rather surprising because 464
the species is widespread in Europe, common in 465
the French, Bavarian and Austrian Alps; in Italy it 466
is also present and common in the northern 467
Apennines, even though its emergence is restricted 468
in this area to a short period in January. In the 469
central Apennines adults have been captured only 470
in one occasion (a spring near Opi, Sangro river, 471
May 1978); the species was not captured again 472
after that date, despite the intensive sampling in 473
the area between 1990 and 1993. In the southern 474
Alps larvae with a yellow head attributable to this 475
species (Ferrarese & Rossaro, 1981) were rarely 476
captured, so the presence of the species cannot be 477
excluded, but adults were never collected. It must 478
be emphasised that reports from different localities 479
based on larval collection only are not enough to 480
confirm the presence of a species. 481

Ecology 482

The relatively high species richness observed can 483
be explained by the high heterogeneity of the 484
habitats investigated. Most species are typical of 485
mountain streams but there are taxa which are also 486
common in lowland rivers (*Rheocricotopus fuscip-*
487 *es*, *Synorthocladius semivirens*, *Micropsectra*
488 *atrofasciata*, *Tanytarsus* spp., *Polypedilum* spp.,
489 *Chironomus* spp.). 490

Correlation coefficients between environmental 491
variables and the most common species are in Ta- 492
ble 5. Altitude, source distance and water temper- 493
ature were significantly correlated with many taxa, 494
but total phosphorous and ammonia emphasized 495
also significant (often inverse) correlations, Among 496
the species living at high altitude, some appeared to 497
be strictly cold-stenothermal, others eurithermal, 498
most with a range below 12 °C (Table 2), and/or 499
able to tolerate acidic pH (up to 4.5 units) 500
(Table 3). Species records occurred in a wide water 501
conductivity range (2–700 $\mu\text{S cm}^{-1}$ (Table 4). 502

Water temperature is confirmed as the variable 503
which best accounts for species distribution (Brit- 504
tain & Milner, 2001; Castella et al., 2001; Maiolini 505
& Lencioni, 2001). Low temperature is associated 506
to high oxygen concentration. Many species are 507

Table 5. Correlation coefficients between environmental variables and the most frequent species groups and their probability of significance

	<i>D. latitarsis</i>	<i>Tvetenia</i>	<i>D. zernyi</i>	<i>Micropsectra</i>	<i>Ortho-cladius frigidus</i>	<i>E. clari-pennis</i>
Altitude	0.337	-0.008	0.108	-0.068	0.099	0.081
Source distance	-0.059	-0.086	-0.016	-0.093	-0.047	-0.094
Alkalinity	0.074	0.025	-0.032	-0.036	0.054	0.035
Conductivity	-0.118	-0.006	-0.001	-0.056	-0.129	-0.113
N-NH ₄	-0.034	-0.022	0.033	-0.132	-0.160	-0.127
N-NO ₃	-0.124	-0.010	-0.082	-0.145	-0.161	-0.142
O ₂	0.025	-0.081	-0.041	-0.103	-0.117	-0.109
pH	-0.128	0.067	-0.001	-0.057	-0.073	-0.017
Total-p	0.082	-0.206	0.111	-0.261	-0.293	-0.334
Water temperature	-0.399	0.045	-0.168	0.121	-0.082	-0.049
Altitude	0.00	0.86	0.00	0.20	0.00	0.00
Source distance	0.00	0.01	0.78	0.02	0.29	0.00
Alkalinity	0.04	0.49	0.36	0.30	0.13	0.32
Conductivity	0.00	0.48	0.77	0.00	0.00	0.00
N-NH ₄	0.17	0.00	0.09	0.00	0.00	0.00
N-NO ₃	0.00	0.35	0.04	0.00	0.00	0.00
O ₂	0.29	0.01	0.28	0.00	0.00	0.00
pH	0.00	0.03	0.85	0.16	0.08	0.82
Total-p	0.48	0.00	0.00	0.00	0.00	0.00
Water temperature	0.00	0.00	0.00	0.00	0.76	0.28

508 steno-oxybiontic and have an optimum at low
 509 temperatures (Table 2). Brittain & Milner (2001)
 510 added channel stability and turbidity to the vari-
 511 ables that mainly influence the zoobenthic com-
 512 munities in high altitude streams. pH (Table 3),
 513 water conductivity (Table 4), current velocity
 514 and food availability can also be responsible of
 515 different species patterns, but none does seem to be
 516 very limiting. Very low pH values were never ob-
 517 served in the localities examined and no species is
 518 apparently excluded by pH. Conductivity also is
 519 not a limiting factor within the observed ranges.
 520 Hydraulic stress due to river damming and cana-
 521 lization alter the hydrological and thermal pattern:
 522 at present this is probably a serious problem for
 523 freshwater macrofauna conservation in the Alps,
 524 but a quantification of its influence on species re-
 525 sponse is not easy: there is evidence indeed that
 526 there are species able to sustain high current
 527 velocity (more than 2 m s⁻¹): *Boreoheptagyia* spp.,
 528 *D. gr. latitarsis*, *Tvetenia calvescens*, *Eukiefferiella*
 529 *brevicalcar*, *E. minor*, *Eudactylocladius fuscimanus*,
 530 *Euorthocladius rivicola*, *E. frigidus*, *Krenosmittia*
 531 *camptophleps*, *Heleniella serra-tosioi*, *Micropsectra*

atrofasciata: many of them have a wide distribu-
 532 tion range and do not seem to be restricted to fast
 533 flowing streams. The species tolerance to high
 534 current velocity requires further study. Correlation
 535 coefficients emphasized that water temperature is
 536 the variable most frequently correlated with spe-
 537 cies abundance, followed by conductivity and pH
 538 (Table 5). Water velocity was also probably very
 539 important but few measures are available and the
 540 importance of nutrients must be emphasised.
 541

542 Chironomids in alpine streams feed largely on
 543 Diatoms, which live epiphyte on different sub-
 544 strates (rocks, *Hydrurus foetidus*, mosses). Bio-
 545 film chlorophyll *a* concentration and the total
 546 number of chironomids are significantly posi-
 547 tively correlated ($r=0.38$, $p<0.01$, data from
 548 CHIRDB) suggesting that food may be a limit-
 549 ing factor.

550 Waters in the Alps are still relatively unpol-
 551 luted, organic pollution and sewage discharge was
 552 observed only locally in the Alps, organic pollu-
 553 tion does not appear to be a serious problem for
 554 the chironomid fauna; many species can actually
 555 be favoured by moderate organic enrichment.

556 **Conclusion**

557 At present the objective of relating species to
 558 environmental factors in alpine inland waters is
 559 reached only in part, species groups or genera and
 560 not species were generally used in multivariate
 561 analysis carried out to emphasise the species re-
 562 sponse to environment (Ruse & Davison, 2000;
 563 Ruse et al., 2000; Milner et al., 2001); the reason is
 564 that species identification is a very laborious task
 565 and rarely it is matched by the estimation of spe-
 566 cies abundances and measurement of environ-
 567 mental variables. CHIRDB allowed the
 568 calculation of correlations between environmental
 569 variables with species, but the number of samples
 570 available was low for many species resulting in
 571 high standard deviations (see Tables 2–4).

572 CHIRDB mainly refers to Alpine samples col-
 573 lected in summer. Winter samples are available for
 574 a limited number of sites (Camonica, Malenco
 575 valley, see Table 1). Recent findings (e.g., Burgh-
 576 err, 2002; Uehlinger et al., 2002) highlighted that
 577 in some habitats, such as glacial streams, the
 578 winter community is generally richer than that of
 579 the summer, both in species numbers and abun-
 580 dances, because in winter environmental stress is
 581 reduced (lower discharge, higher channel stability
 582 and higher transparency, abundant algae (mostly
 583 Diatoms) growing on mats of *H. foetidus*, etc.).
 584 For a better understanding of the relationships
 585 between fauna and environment, the winter season
 586 should be taken into account in future ecological
 587 research (Füreder et al., 2001).

588 Long term studies should be encouraged,
 589 especially on habitats characterised by strong
 590 seasonality like high altitude streams (Kaufmann,
 591 2002): the reference period of CHIRDB is rather
 592 long (25 years from 1978 to 2005), but long term
 593 studies are restricted to few localities (Camonica
 594 valley). In some localities (i.e. Conca, Niscli,
 595 Cornisello, de la Mare and Careser stream sys-
 596 tems, all in Trentino) series of data with a robust
 597 sampling design are available (2–5 years of records
 598 for the same streams with a 15 days frequency in
 599 summer). In any case the available data do not
 600 highlight trends in species composition. Reduc-
 601 tions in chironomid abundance were emphasised
 602 in the last years in some glacial streams in the
 603 southern Alps. High discharges were observed for
 604 the entire summer, due to unusually high air

temperatures (in summer 2003 above 30 °C during 605
 the day and above 0 °C during all the night above 606
 2500 m of altitude). This climatic situation main- 607
 tained very high discharge with high turbidity and 608
 channel instability for many consecutive months, 609
 hindering the development of a biofilm. The strict 610
 cold-stenothermal species, such as those belonging 611
 to the *Diamesa latitarsis* – *steinboeckii* group, 612
 confined to glacial snouts, are at risk of extinction 613
 as the glaciers retreat. This has probably already 614
 happened in the Apennines, where the recent dis- 615
 appearing of small glaciers ('the Calderone' in the 616
 Gran Sasso group, Abruzzo) reduced the *Diamesa* 617
latitarsis group to only one species, *Diamesa ber-* 618
trami (Edwards 1935). It was captured only in the 619
 upper stretch of the River Mavone on 4/12/92 and 620
 20/3/93, never elsewhere. *Diamesa aberrata* was 621
 also very rarely captured (Tasso stream, National 622
 Park in Abruzzo, 20/5/78, Aso stream, 29/1/79). 623
 The absence of records of *D. insignipes* in the 624
 Central Apennines after 1978 despite a conspicu- 625
 ous sampling effort also deserves attention. 626

627 Spatial and temporal changes of chironomid
 628 fauna in terms of number of individuals and/or
 629 species can be explained through the effects of short
 630 term and long term climate change. Inter-annual
 631 variations can be explained by exceptional climatic
 632 conditions such as an extremely warm summer or
 633 cold winter; they modify physical variables (e. g. an
 634 higher discharge, a shorter or longer snow cover)
 635 promoting a global community response with inter-
 636 species competition. These causal events can be
 637 complicated by stochastic factors such as the
 638 chance that an adult female deposits eggs. There is
 639 enough evidence that the glaciated areas in the
 640 Alps, and cold water habitats in the Mediterranean
 641 region in general, are at serious risk in relation with
 642 the global climatic change.

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895 Appendix

- 896 Chironomid species collected in streams above
897 900 m a.s.l. in the Italian Alps with the number of
898 sites where a species was collected

TANYPODINAE

<i>Arctopelopia griseipennis</i> (van der Wulp, 1858)	16
<i>Conchapelopia pallidula</i> (Meigen, 1818)	42
<i>Krenopelopia binotata</i> (Wiedemann, 1817)	2
<i>Macropelopia fittkau</i> Ferrarese & Ceretti, 1987	3
<i>Macropelopia nebulosa</i> (Meigen, 1818)	70
<i>Nilotanypus dubius</i> (Meigen, 1804)	1
<i>Paramerina cingulata</i> (Walker, 1856)	51
<i>Procladius choreus</i> (Meigen, 1804)	14
<i>Rheopelopia ornata</i> (Meigen, 1838)	1
<i>Telmatopelopia nemorum</i> (Goetghebuer, 1921)	1
<i>Telopelopia fascigera</i> Verneaux, 1970	2
<i>Thienemannimyia carnea</i> (Fabricius, 1805)	5
<i>Thienemannimyia woodi</i> (Edwards, 1929)	4
<i>Trissopelopia longimana</i> (Staeger, 1839)	1
<i>Xenopelopia falcigera</i> (Kieffer, 1912)	3
<i>Zavrelimyia barbatipes</i> (Kieffer, 1911)	8
<i>Zavrelimyia hirtimana</i> (Kieffer, 1918)	2
<i>Zavrelimyia melanura</i> (Meigen, 1804)	5
<i>Zavrelimyia nubila</i> (Meigen, 1818)	5
<i>Zavrelimyia punctatissima</i> (Goetghebuer, 1934)	1
DIAMESINAE	
(°) <i>Boreoheptagyia legeri</i> (Goetghebuer, 1933)	61
(°) <i>Boreoheptagyia rugosa</i> (Saunders, 1930)	1
<i>Boreoheptagyia</i> sp.	3
<i>Diamesa aberrata</i> Lundbeck, 1889	56
<i>Diamesa bertrami</i> Edwards, 1935	176
<i>Diamesa cinerella</i> Meigen in Gistel, 1835	128
<i>Diamesa dampfi</i> (Kieffer, 1924)	72

<i>Diamesa goetghebueri</i> Pagast, 1947	45
<i>Diamesa incallida</i> (Walker, 1856)	35
<i>Diamesa laticauda</i> SerraTosioSerra-Tosio, 1964	3
<i>Diamesa latitarsis</i> (Goetghebuer, 1921)	30
<i>Diamesa lindrothi</i> Goetghebuer, 1931	5
<i>Diamesa longipes</i> Goetghebuer, 1941	1
<i>Diamesa permacra</i> (Walker, 1856)	12
<i>Diamesa steinboeckii</i> Goetghebuer, 1933	218
<i>Diamesa tonsa</i> (Walker, 1856)	161
<i>Diamesa vaillantii</i> SerraTosioSerra-Tosio, 1972	25
<i>Diamesa zernyi</i> Edwards, 1933	384
(°°) <i>Pagastia partica</i> (Roback, 1957)	2
<i>Pothastia gaedii</i> (Meigen, 1838)	6
<i>Pothastia longimanus</i> (Kieffer, 1922)	2
<i>Pseudodiamesa branickii</i> (Nowicki, 1873)	200
<i>Pseudodiamesa nivosa</i> (Goetghebuer, 1928)	19
<i>Pseudokiefferiella parva</i> (Edwards, 1932)	158
<i>Sympothastia spinifera</i> SerraTosioSerra-Tosio, 1968	3
(°) <i>Syndiamesa edwardsi</i> (Pagast, 1947)	2
<i>Syndiamesa nigra</i> Rossaro, 1980	34
PRODIAMESINAE	
<i>Prodiamesa olivacea</i> (Meigen, 1818)	46
ORTHOCLADIINAE	
<i>Allopspectrocladius obvius</i> (Walker, 1856)	2
<i>Brillia bifida</i> (Meigen, 1830)	65
<i>Brillia longifurca</i> Kieffer, 1921	21
<i>Cardiocladius capucinus</i> (Zetterstedt, 1850)	12
<i>Cardiocladius fuscus</i> Kieffer, 1924	33
(°*) <i>Chaetocladius acuticornis</i>	2
(Kieffer in Potthast, 1915)	
(°*) <i>Chaetocladius dentiforceps</i> (Edwards, 1929)	4
<i>Chaetocladius dissipatus</i> (Edwards, 1929)	2
<i>Chaetocladius gelidus</i> Brundin, 1956	2
<i>Chaetocladius laminatus</i> Brundin, 1947	11
(°*) <i>Chaetocladius maeeri</i> Brundin, 1947	3
(°*) <i>Chaetocladius melaleucus</i> (Meigen, 1830)	4
<i>Chaetocladius perennis</i> (Meigen, 1830)	4
<i>Chaetocladius suecicus</i>	3
(Kieffer in Thienemann e Kieffer, 1916)	
(°*) <i>Chaetocladius vitellinus</i>	2
(Kieffer in Kieffer & Thienemann, 1908)	
<i>Corynoneura edwardsi</i> Brundin, 1949	79
<i>Corynoneura fittkau</i> Schlee, 1968	1
<i>Corynoneura lacustris</i> Edwards, 1924	18
<i>Corynoneura lobata</i> Edwards, 1924	42
<i>Corynoneura scutellata</i> Winnertz, 1846	7
<i>Cricotopus algarum</i> (Kieffer, 1911)	2
<i>Cricotopus annulator</i> Goetghebuer, 1927	19
<i>Cricotopus bicinctus</i> (Meigen, 1818)	4



Appendix (Continued)

<i>Cricotopus curtus</i> Hirvenoja, 1973	15	<i>Krenosmittia</i> sp A cfr <i>hispanica</i> Wülker, 1957	5
<i>Cricotopus fuscus</i> (Kieffer, 1924)	41	<i>Metricnemus hirticollis</i> (Stäger, 1839)	3
<i>Cricotopus pulchripes</i> Verral, 1912	3	<i>Metricnemus hygropetricus</i> Kieffer, 1912	68
<i>Cricotopus tibialis</i> (Meigen, 1804)	31	<i>Nanocladius bicolor</i> (Zetterstedt, 1838)	5
<i>Cricotopus tremulus</i> (Linnaeus, 1756)	75	<i>Nanocladius rectinervis</i> (Kieffer, 1911)	7
<i>Cricotopus triannulatus</i> Edwards, 1922	13	<i>Orthocladius excavatus</i> Brundin, 1947	6
<i>Cricotopus trifascia</i> Edwards, 1929	10	<i>Orthocladius oblidens</i> (Walker, 1856)	2
<i>Cricotopus tristis</i> Hirvenoja, 1973	1	<i>Orthocladius rhyacobius</i> Kieffer, 1911	47
<i>Diplocladius cultriger</i> Kieffer, 1908	12	<i>Orthocladius rubicundus</i> (Meigen, 1818)	43
<i>Epoicocladius flavens</i> (Malloch, 1915)	1	<i>Orthocladius ruffoi</i> Rossaro & Prato, 1991	11
<i>Eudactylocladius fuscimanus</i>	122	<i>Orthocladius vaillanti</i> Cranston & Langton, 1991	4
(Kieffer in Kieffer & Thienemann, 1908)		<i>Orthocladius wetterensis</i> Brundin, 1956	11
<i>Eudactylocladius gelidus</i> Kieffer, 1922	2	<i>Paracladius abnobaenus</i> Wülker, 1959	2
<i>Eudactylocladius olivaceus</i> (Kieffer, 1911)	9	<i>Paracladius alpicola</i> (Zetterstedt, 1850)	2
<i>Eukiefferiella brevicar</i> (Kieffer, 1911)	255	<i>Paracladius conversus</i> (Walker, 1856)	5
<i>Eukiefferiella claripennis</i> (Lundbeck, 1890)	65	<i>Paracricotopus niger</i> (Kieffer, 1913)	12
<i>Eukiefferiella clypeata</i> (Kieffer, 1923)	8	<i>Parakiefferiella bathophila</i> (Kieffer, 1912)	14
<i>Eukiefferiella coeruleascens</i>	26	<i>Parakiefferiella gracillima</i> (Kieffer, 1924)	4
(Kieffer in Zavrel, 1926)		<i>Parametricnemus boreoalpinus</i> Gouin	5
<i>Eukiefferiella cyanea</i> Thienemann	18	in Gouin & Thienemann, 1942	
& Harnisch, 1936		<i>Parametricnemus stylatus</i> (Kieffer, 1924)	157
<i>Eukiefferiella devonica</i> (Edwards, 1929)	34	<i>Paratrithocladius nivalis</i> (Goetghebuer, 1938)	60
<i>Eukiefferiella dittmari</i> Lehmann, 1972	1	<i>Paratrithocladius rufiventris</i> (Meigen, 1830)	67
<i>Eukiefferiella fittkau</i> Lehmann, 1972	10	<i>Paratrithocladius skirwithensis</i> (Edwards, 1929)	200
<i>Eukiefferiella fuldensis</i> Fittkau, 1954	129	<i>Parorthocladius nudipennis</i>	87
<i>Eukiefferiella gracei</i> (Edwards, 1929)	1	(Kieffer in Kieffer & Thienemann, 1908)	
<i>Eukiefferiella ilkleyensis</i> (Edwards, 1929)	16	<i>Psectrocladius limbatellus</i> (Holmgren, 1869)	5
<i>Eukiefferiella lobifera</i> Goetghebuer, 1934	16	<i>Psectrocladius octomaculatus</i> Wülker, 1956	5
<i>Eukiefferiella minor</i> (Edwards, 1929)	249	<i>Psectrocladius psilopterus</i> (Kieffer, 1906)	2
<i>Eukiefferiella pseudomontana</i> Goetghebuer, 1935	4	<i>Psectrocladius schliezi</i> Wülker, 1956	3
<i>Eukiefferiella tirolensis</i> Goetghebuer, 1938	26	<i>Psectrocladius sordidellus</i> (Zetterstedt, 1838)	7
<i>Euorthocladius ashei</i> Soponis, 1990	4	<i>Rheocricotopus atripes</i> (Kieffer, 1913)	2
<i>Euorthocladius luteipes</i> Goetghebuer, 1938	13	<i>Rheocricotopus chalybeatus</i> (Edwards, 1929)	7
<i>Euorthocladius rivicola</i> Kieffer, 1921	295	<i>Rheocricotopus effusus</i> (Walker, 1856)	71
<i>Euorthocladius rivulorum</i> Kieffer, 1909	35	<i>Rheocricotopus fuscipes</i> Kieffer, 1909	51
<i>Euorthocladius saxosus</i> (Tokunaga, 1939)	13	<i>Rheocricotopus gallicus</i> Lehmann, 1969	2
<i>Euorthocladius thienemanni</i>	36	<i>Rheocricotopus glabricollis</i> (Meigen, 1830)	2
(Kieffer in Kieffer & Thienemann, 1906)		<i>Stilocladius montanus</i> Rossaro, 1979	21
<i>Eurthocladius frigidus</i> (Zetterstedt, 1838)	427	<i>Symposiocladius lignicola</i> (Kieffer in Potthast, 1915)	4
<i>Heleniella serratosioSerra-tostoi</i> Ringe, 1976	2	<i>Synorthocladius semivirens</i> (Kieffer, 1909)	8
<i>Heterotanytarsus apicalis</i> (Kieffer, 1921)	4	<i>Thienemaniella morosa</i> (Edwards, 1924)	1
<i>Heterotrissocladius marcidus</i> (Walker, 1856)	78	<i>Thienemaniella partita</i> Shlee, 1968	79
<i>Hydrobaenus distylus</i> (Kieffer, 1915)	16	<i>Thienemaniella clavicornis</i> (Kieffer, 1911)	1
<i>Isocladius glacialis</i> (Stäger, 1839)	1	<i>Tokunagaia rectangularis</i> (Goetghebuer, 1940)	13
<i>Isocladius intersectus</i> (Stäger, 1839)	2	<i>Tokunagaia tonollii</i> Rossaro, 1983	21
<i>Isocladius sylvestris</i> (Fabricius, 1974)	26	<i>Tvetenia bavarica</i> (Goetghebuer, 1934)	48
<i>Krenosmittia boreoalpina</i> (Goetghebuer, 1944)	18	<i>Tvetenia calvescens</i> (Edwards, 1929)	356
<i>Krenosmittia camptophleps</i> (Edwards, 1929)	97	<i>Tvetenia discoloripes</i>	3
		(Goetghebuer in Thienemann, 1936)	



Appendix (Continued)

<i>Tvetenia verralli</i> (Edwards, 1929)	2	<i>Tanytarsus nemorosus</i> Edwards, 1929	2
(^{oo}) <i>Umiella multivirga</i> Saether, 1980	10	CHIRONOMINI	2
<i>Zalutschia tatrca</i> (Pagast in Zavrel e & Pagast, 1935)	3	<i>Chironomus plumosus</i> Linnaeus, 1758	4
CHIRONOMINAE		<i>Chironomus riparius</i> Meigen, 1804	4
TANYTARSINI		<i>Cladopelma edwardsi</i> (Kruseman, 1933)	16
<i>Cladotanytarsus atridorsum</i> Kieffer, 1924	4	<i>Cryptochironomus albofasciatus</i> (Stäger, 1839)	2
<i>Krenopsectra fallax</i> Reiss, 1969	2	<i>Dicrotendipes lobiger</i> (Kieffer, 1921)	1
<i>Micropsectra atrofasciata</i> (Kieffer, 1911)	380	<i>Einfeldia longipes</i> (Staeger, 1839)	2
<i>Micropsectra attenuata</i> Reiss, 1969	15	<i>Harnischia fuscimana</i> (Kieffer, 1921)	1
<i>Micropsectra bidentata</i> (Goetghebuer, 1921)	9	<i>Microchironomus tener</i> (Kieffer, 1818)	1
<i>Micropsectra contracta</i> Reiss, 1965	4	<i>Microtendipes chloris</i> (Meigen, 1818)	1
<i>Micropsectra lindrothi</i> Goetghebuer in Goetghebuer & Lindroth, 1931	1	<i>Microtendipes pedellus</i> (de Geer, 1776)	10
<i>Micropsectra notescens</i> (Walker, 1856)	20	<i>Paracladopelma camptolabis</i> (Kieffer, 1913)	28
<i>Micropsectra radialis</i> Goetghebuer, 1939	10	(^o) <i>Paratendipes nudisquama</i> Edwards, 1929	1
<i>Neozavrelia fuldensis</i> Fittkau, 1954	5	<i>Phaenopsectra flavipes</i> (Meigen, 1818)	49
<i>Parapsectra nana</i> (Meigen, 1818)	2	<i>Polypedilum albicorne</i> (Meigen, 1838)	7
<i>Paratanytarsus austriacus</i> (Kieffer in Albrecht, 1924)	46	<i>Polypedilum convictum</i> (Walker, 1856)	5
<i>Paratanytarsus natvigi</i> (Goetghebuer, 1933)	7	<i>Polypedilum laetum</i> (Meigen, 1818)	1
<i>Rheotanytarsus photophilus</i> (Goetghebuer, 1921)	5	<i>Polypedilum nubeculosum</i> (Meigen, 1804)	17
<i>Tanytarsus bathophilus</i> Kieffer, 1911	6	<i>Tribelos dispar</i> (Meigen, 1830)	39
<i>Tanytarsus fimbriatus</i> Reiss & Fittkau, 1971	7	<i>Tripodura scalaenum</i> (Schrank, 1803)	1
<i>Tanytarsus lestagei</i> Goetghebuer, 1922	2		
<i>Tanytarsus lugens</i> (Kieffer in Thienemann e Kieffer, 1916)	1	(^{oo}) New for Palearctic Region.	
		(^o) New for Italian fauna.	
		(^{oo*}) New for West-Palaeartic Region (young larvae, determinations need confirmation).	
		(^{o*}) New for Italian fauna, but the genus <i>Chaetocladius</i> must be revised.	