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The Chironomidae (Diptera) fauna of Greece: ecological distributions and patterns, taxalist and new records

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Abstract – For the first time, a faunistic list of the Chironomidae fauna of Greece is presented along with its ecological distribution. Chironomidae larvae and pupal exuviae were collected from 61 locations in mainland Greece during 2006–2008. 76 taxa (genera to species) were recorded. The genera *Potthastia*, *Brillia*, *Euorthocladius*, *Synorthocladius*, *Tvetenia* and *Xenochironomus* are recorded for the first time from Greece. Furthermore, 12 species are new for Greece and five are new for mainland Greece. Chironomidae collected from running waters were analysed with ordination techniques. The results revealed that Chironomidae assemblages were distinguished into three ecoregions with distinct climatic, geological and hydrochemical features. Running waters in Northwestern Greece were generally dominated by species tolerant to water acidification. Chironomids typical of eastern uplands preferred relatively slow current and soft bottom sediments. Assemblages of the southern Peloponnese Peninsula were represented by species of relatively fast flowing, warm streams. However, these are only preliminary results and many more data are needed to justify this ecological distinction of Chironomidae assemblages. This is the first study contributing to the knowledge of a rather neglected insect group of the Greek fauna. It is expected that more species remain to be identified and recorded and future works will contribute to this initial faunal list.

Key words: Chironomidae / Diptera / ecogeography / taxalist / new records / Greece

Introduction

The family Chironomidae is a cosmopolitan group of Diptera insects, which occur in all zoogeographical regions of the world, including Antarctica. The fauna of the Palaearctic, in particular the western Palaearctic, has been intensively studied (Ashe *et al.*, 1987) and is well known (Reiss, 1977). The first wider faunistic lists of the Mediterranean Chironomidae were published few decades ago (Reiss, 1977; Laville and Reiss, 1992). The Southern–Eastern Mediterranean region constitutes a link between the temperate Palaearctic, Mediterranean, Afrotropical and Near East non-biting midge fauna (Laville and Reiss, 1992). In spite of this biogeographical significance, the chironomid fauna of Greece is relatively poorly known and studied (Saether and Spies, 2013).

Our recent knowledge of the Greek dancing midge fauna is restricted to a few freshwater bodies and in most studies carried out at the surface waters of Greece, Chironomidae are used as a subject for water quality assessment and are thus mainly identified at a family level. Thus, studies with detailed faunistic data on Greek Chironomidae are very limited.

In this study, Chironomidae specimens from various field expeditions and freshwater monitoring projects are assembled and identified in order to enhance the knowledge of the Chironomidae fauna of Greece. The specific aims of this work are: (a) present the first faunistic list of the Greek Chironomid fauna, (b) document new species records and (c) to assess the ecological distribution of Chironomidae assemblages throughout mainland Greece.

Materials and Methods

Study area

Greece is a Mediterranean mountainous country with an area of *ca.* 132 000 km^2 and is divided in mainland and surrounding island archipelagoes. As a consequence of its

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recent geological morphology, (*i.e.*, tectonic, volcanic and sea level changes activity), Greece is characterized by a multitude of basins drained mainly by small and medium-sized rivers. Most rivers run through narrow mountain valleys, have a flashy and erosive behaviour and descend abruptly to the coast. There are 765 recorded rivers, 45 of which are registered as permanently flowing (Ministry for Development, 2003). Lotic environments in the entire country range from small streams in the highlands and in semi-arid grasslands and islands, to medium and large rivers and from ephemeral streams to perennial rivers. The largest rivers in Greece are Aliakmon, followed by Acheloos, Pineios, Evros and Nestos. Furthermore, there are 21 lakes which total in 59 890 ha in area (and 14 artificial lakes), whereas the 33 deltas of the Greek rivers cover 327 100 ha.

Most catchments in Western and Southern Greece are dominated by carbonate rocks (average 60%) and mainly calcareous flysch and molasse deposits (average 24%) with lacustrine sediments also present (average 8%). In parts of Central and Northeastern Greece, catchment geology is dominated by silicate rocks (average 60%) followed by carbonate rocks (average 24%). The rivers in that areas have relatively low conductivity (average 297 $\mu S.cm^{-1}$) and total hardness (average 172 $mg.L^{-1}$ $CaCO_3$) while waters in western and southern basins are characterized by relatively higher levels of conductivity (average 428 $\mu S.cm^{-1}$), total hardness (average 367 $mg.L^{-1}$ $CaCO_3$) and alkalinity (average 3.41 $mval.L^{-1}$) (Skoulikidis *et al.*, 1998, 2006).

Due to the topography and geological history of Greece, endemism is particularly high in mainland Greece and its island complexes. Many endemic species have been discovered within other insect groups (*i.e.*, Trichoptera – Malicky, (2005); Coleoptera – Yunakov and Germann, (2012); however, endemic species with small distribution areas very rarely occur within the European Chironomidae (Reiss, 1977).

Chironomidae collection, processing and identification

Chironomidae larvae and pupal exuviae were collected from 61 locations from different water bodies including springs, streams, rivers, ponds, ditches and lakes distributed throughout mainland Greece (Fig. 1). Sampling sites were chosen to represent the main types of flowing water habitats and most of the main river basins of the country. Furthermore, samples were also collected from several large lakes. Chironomidae larvae and exuviae were collected during the spring and summer of 2006, winter 2007 and summer 2008 from the localities and preserved into plastic vials using either 90% ethanol or 4% formaldehyde. Fourteen species were recorded only as a pupal exuviae while 65 only as a larvae. Three species were recorded as a pupal exuviae and larvae. Larval material was collected using a rectangular hand net of 25 cm × 25 cm with a mesh size of 500 μm nytex screen. Chironomidae specimens were collected within the framework of different field expeditions therefore sampling methods varied. Two methods were used are: (a) the STAR-AQEM method (AQEM Consortium, 2002), which is based on a multi-habitat scheme designed for sampling major habitats proportionally according to their presence within a sampling reach and (b) the 3-min kick sample and a 1-min manual search which involves the collection of individual specimens from the water surface, submerged rocks, logs and vegetation. Each macroinvertebrate habitat in the sampling area was sampled proportionally to its cover. Exuviae collection was random and was based on exuviae availability during sampling.

All material (3592 specimens) was mounted on permanent slides in Euparal® and is deposited in collection of Department of Invertebrate Zoology and Hydrobiology (University of Lodz, Poland). Identification of larvae was performed following mainly the keys of Wiederholm (1983), Klink and Moller Pillot (2003), Brooks *et al.* (2007) and pupal exuviae keys of Langton (1984), Langton and Visser (2003), Wilson and Ruse (2005). Ecological preferences and characteristics of Chironomidae species was based mainly on Vallenduuk and Moller Pillot (2007), Moller Pillot (2009a, 2009b), Moller Pillot (2013) and authors' personal observations.

Statistical analysis

Margalef's index was used as a simple measure of species richness (Margalef, 1958). It has a good discriminating ability and estimates the numbers of species present in a given area for a given number of individuals. Non-metric multidimensional scaling (NMDS) was used as an ordination procedure to illustrate differences among sites in relation to their Chironomidae community composition. The NMDS ordination method is based on ranked Bray–Curtis dissimilarity distances and is not susceptible to problems associated with zero truncation. Chironomidae species data were transformed to presence–absence data to make the dataset comparable due to the different sampling methods as the overall purpose of this analysis was to detect distinct ecological regionalization of the assemblages and species variation. The aim of the analysis of communities' distribution was rather to find main boundaries of flowing water ecoregions in the same meaning used by Paunović *et al.* (2012) rather than to recognize zoogeographical regionalization. In addition, SIMPER analysis was used to detect those species that contribute to Chironomidae variation among sites. Statistical analysis was performed using the PRIMER 5 software (Clarke and Gorley, 2001).

Results

Taxalist and new species records

3592 specimens belonging to 76 Chironomid taxa were identified and recorded (28 Orthocladiinae,

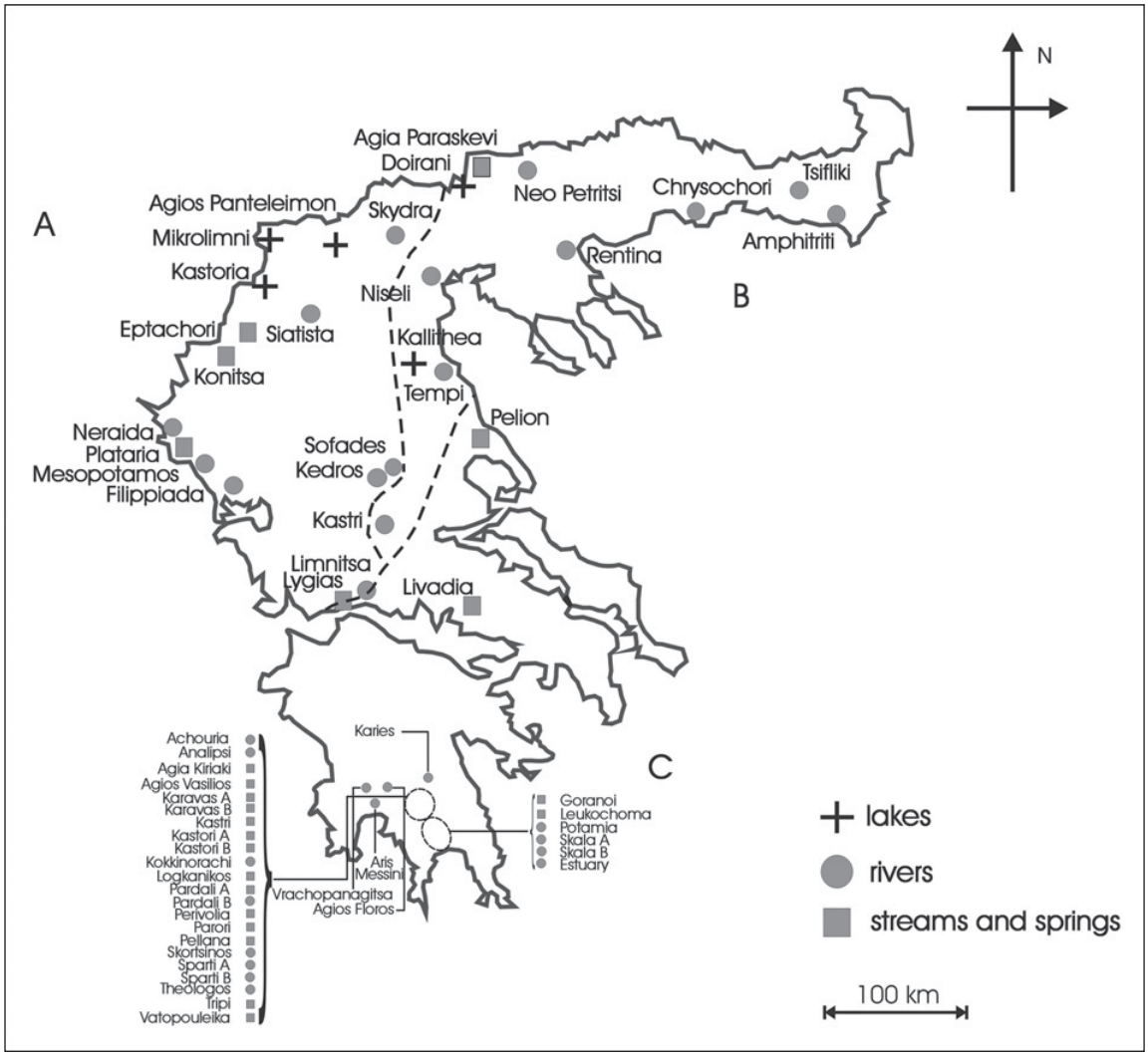

Fig. 1. Map illustrating the study sites and the three distinct ecoregions (A, B, C).

23 Chironomini, 13 Tanytarsini, 9 Tanypodinae, 2 Diamesinae, 1 Prodiamesinae). A detailed list of species records and their collection localities are presented in Table 1. According to the Fauna Europaea database (Sæther and Spies, 2013), 12 species are new for Greece and five are new for the Greek mainland.

Symbols used for new genus and species records:

** – new genus and species for Greece

* – new species for Greece

°° – new genus and species for mainland Greece

° – new species for mainland Greece.

Tanypodinae

Ablabesmyia monilis (Linnaeus 1758)*

Species widespread in Europe, not recorded only in few small countries and regions. 13 larvae recorded from: Mesopotamos (Acheron R.) 15.08.2008; Limnitsa (Mornos R.) 16.08.2008; Kastri (Spercheios R.) 18.08.2008; Kedros (Sofaditis R.) 19.08.2008; Sofades (Sofaditis R.) 19.08.2008; Skala A (Vasilopotamos R.) 21.09.2006; Skala B (Evrotas R.) 21.09.2006, 17.03.2007; Vrachopanagitsa (Pamisos R.) 30.06.2002; Agios Floros (Pamisos R.) 29.06.2002. Medium-sized streams and rivers with relatively fast flowing waters and stony substrate with low pollution levels. In the literature, *Ablabesmyia monilis* is reported from stagnant waters and from small- to medium-sized rivers (Vallenduuk and Moller Pillot, 2007).

Ablabesmyia phatta (Egger 1864)*

Species widespread in Central and Northern Europe. From the Mediterranean Region is recorded only in Spain and France. From the Balkan Peninsula is recorded only in Serbia and European part of Turkey. Five larvae recorded from: Pellana (Voutikiotis S.) 12.05.2006, 10.03.2007 and Aris (Pamisos R.) 29.06.2002. Medium-sized rivers of relatively fast water current, stony substrate and low pollution levels. *A. phatta* has been associated

Table 1. List and specimen numbers of chironomids recorded at the 61 sampling sites. ° – species new to Greece, * – species new to Greek mainland, 1– morphotypes defined by Brooks *et al.* (2007), 2 – species aggregations defined by Klink and Moller Pillot (2003).

Study sites of Northern Greece L – lake R – river S – stream	L – larvae; P – pupal exuviae	**Prespa L.**	**Kastoria L.**	**Vegoritis L.**	**Doirani L.**	**pond n. Kallithea Elassonos**	**Aliaknonas R.**	**Aoos R.**	**Kalamas R.**	**Acheron R.**	**Louros R.**	**Lygias S.**	**Pinios R.**	**Aliaknonas R.**	**Aliaknonas R.**	**Road ditch**	**Strymonas R.**	**Richios R.**	**Nestos R.**	**Lissos R.**	**Maistros R.**
Location		**Mikrolimni**	**Kastoria**	**Agios Panteleimon**	**Doirani**	**Kallithea**	**Eptachori**	**Konitsa**	**Neraida**	**Mesopotamos**	**Filippiada**	**Lygias**	**Tempi**	**Niseli**	**Siatista**	**Agia Paraskevi**	**Neo Petritsi**	**Rentina**	**Chrysochori**	**Tsifliki**	**Amphitriti**
Study site code		PL	KL	VL	DL	PK	ARE	ARK	KRN	ARM	LRF	LSL	PRT	ARN	ARS	DAP	SRNP	RRR	NRC	LRT	MRA
Latitude (N)		40°44.704'	40°30.877'	40°44.316'	41°11.893'	39° 58'42"	40°13.712	40°03.677'	39°31.952'	39°14.835'	39°10.496'	38°25.096'	39°52.700'	40°35.930	40°17.332'	41°15.769	41°16.909'	40°39.263'	40°56.202'	41°03.187'	40°53.298'
Longitude (E)		21°06.853	21°16.107'	21°45.276'	22°46.412	22°11'39"	20°58.274'	20°48.529'	20°26.461'	20°31.829'	20°53.063'	21°45.171'	22°35.073'	22°27.962'	21°27.068'	22°51.212'	23°19.940'	23°36.700'	24°41.985'	25°37.097'	25°54.201'
Altitude (m a.s.l.)		864	510	290	152	508	768	1169	45	7	5	133	35	7	553	224	63	60	28	27	29
Date		10.08.2008	11.08.2008	12.08.2008	23.08.2008	10.08.2008	12.08.2008	12.08.2008	14.08.2008	15.08.2008	15.08.2008	16.08.2008	20.08.2008	22.08.2008	12.08.2008	23.08.2008	23.08.2008	23.08.2008	25.08.2008	25.08.2008	25.08.2008
Tanypodinae																					
Ablabesmyia longistyla (Fittkau 1962)	P																			2	
Ablabesmyia monilis (Linnaeus 1758)°	L									1											
Clinotanypus Kieffer 1913 sp.	L																	1			
Conchapelopia melanops (Meigen 1818)*	P																			17	
Procladius Skuse 1889 spp.	L								1												
Procladius choreus (Meigen 1804)	P														1		1			6	
Tanypus punctipennis (Meigen 1818)	P																6			1	3
Zavrelimyia Fittkau 1962 sp.	L								3											1	
Orthocladiinae																					
Cricotopus bicinctus-type[1]	L								3						3					1	
Cricotopus cylindraceaus-type[1]	L			36											1					2	
Cricotopus intersectus-type[1]	L				5				1												
Cricotopus laricomalis-type[1]	L	1																		1	

Nanocladius Kieffer 1913 sp.	P																			1	
Orthocladius trigonolabis-type[1]	L						1														
Paraphaenocladius (Thienemann 1924)	L							1													
Rheocricotopus chalybeatus (Edwards 1929)	L, P																			7	
Smittia Holmgren 1869 sp.	L						12														
Chironominae																					
Chironomini																					
Chironomus Meigen 1803 sp.	P													177			2			2	
Chironomus anthracinus-type[1]	L				5		2														
Chironomus plumosus-type[1]	L				14	1	1		2												
Cryptochironomus rostratus (Kieffer 1921)°	P																1			8	
Dicrotendipes nervosus (Staeger 1839)	L			37	37																
Dicrotendipes notatus (Meigen 1818)	L, P																			2	
Glyptotendipes pallens-type[1]	L		1		31	43												9			
Kiefferulus tendipediformis (Goetghebuer 1921)°	L, P																	7			41
Microtendipes chloris agg.[2]	L								12				1		4						
Microtendipes pedellus agg.[2]	L								92	1					9						
Parachironomus Lenz 1921 sp.	P																			1	
Phaenopsectra flavipes-type[1]	L										1				1						
Polypedilum nubeculosum-type[1]	L					400			84	3					12	1	3		1	14	20
Polypedilum nubifer-type[1]	L					88															
Tribelos Townes 1945 sp.	L																				1
Xenochironomus xenolabis (Kieffer 1916)*	L, P										1										
Tanytarsini																					
Cladotanytarsus type 1[2]	L																1				
Cladotanytarsus mancus-type[1]	L					11			7						1		4				
Paratanytarsus austriacus gr.[2]	L	1															1				
Paratanytarsus dissimilis gr.[2]	L														1		1				4
Paratanytarsus type 1[2]	L											1					1				
Rheotanytarsus Thienemann & Bause 1913 sp.	L																2				
Tanytarsus mendax-type[1]	L						1		4						4		3				1
Virgatanytarsus triangularis (Goetghebuer 1928)	P																			11	

Table 1. *(Contd.)*

Study sites of Central Greece L – lake R – river S – stream	L – larvae; P – pupal exuviae	**Mornos R.**	**Erkyna R.**	**Spercheios R.**	**Spring in Pelion Mt.**	**Drainage channel**	**Sofaditis R.**	**Sofaditis R.**
Location		**Limnitsa**	**Livadia**	**Kastri**	**Pelion**	**Plataria**	**Kedros**	**Sofades**
Study site code		MRL	ERL	SpRK	SPM	DCP	SoRK	SoRS
Latitude (N)		38°30.435'	38°25.984'	38°56.607'	39°23.608	39°26.509'	39°10.572'	39°19.486'
Longitude (E)		21°59.959'	22°52.534'	22°12.706'	23°02.597'	20°16.465'	22°02.759'	22°05.604'
Altitude (m a.s.l.)		170	323	80	1123	0	230	118
Date		16.08.2008	17.08.2008	18.08.2008	20.08.2008	14.08.2008	19.08.2008	19.08.2008
Tanypodinae								
Ablabesmyia monilis (Linnaeus 1758)°	L	1		2			1	4
Procladius Skuse 1889 spp.	L	1		9			19	
Zavrelimyia Fittkau 1962 sp.	L	1		5				
Orthocladiinae								
Brillia bifida (Kieffer 1909)**	L				3			
Cricotopus bicinctus-type[1]	L		4					
Cricotopus cylindraceaus-type[1]	L		4				1	
Cricotopus laricomalis-type[1]	L	12						
Cricotopus trifascia (Edwards 1929)*	L, P						7	
Eukiefferiella claripennis (Lundbeck 1898)*	L						1	
Eukiefferiella Thienemann 1926 spp.	L		1					

Orthocladius rivulorum (Kieffer 1909)*	P						1	
Paracricotopus Brundin 1956 sp.	L		1					
Parametriocnemus (Goetghebuer 1932)	L		1		2			
Paratrichocladius rufiventris (Meigen 1830)*	P						2	
Rheocricotopus chalybeatus (Edwards 1929)	L, P		5				1	
Rheocricotopus fuscipes-type[1]	L				2			
Chironominae								
Chironomini								
Chironomus anthracinus-type[1]	L	339						
Chironomus plumosus-type[1]	L	414		2				
Dicrotendipes nervosus (Staeger 1839)	L	17					2	
Dicrotendipes notatus (Meigen 1818)	L, P			4				
Glyptotendipes pallens-type[1]	L	1						
Kiefferulus tendipediformis (Goetghebuer 1921)°	L, P							4
Microtendipes chloris agg.[2]	L		1	2			1	1
Microtendipes pedellus agg.[2]	L	8		4			19	5
Paratendipes albimanus (Meigen 1818)	L	1					25	1
Phaenopsectra flavipes-type[1]	L			1				
Polypedilum nubeculosum-type[1]	L	1				4		5
Stictochironomus Kieffer 1919 sp.	L						2	
Synendotendipes gr. *dispar* [1]	L						2	
Xenochironomus xenolabis (Kieffer 1916)*	L, P						1	
Tanytarsini								
Cladotanytarsus mancus-type[1]	L						1	
Micropsectra atrofasciata (Kieffer 1911)°	P			1				
Micropsectra pallidula-type[1]	L				1			
Paratanytarsus dissimilis gr.[2]	L		1					1
Paratanytarsus type 1[2]	L	4		29				
Rheotanytarsus Thienemann & Bause 1913 sp.	L		46					
Tanytarsus brundini agg.[2]	L						6	
Tanytarsus mendax-type[1]	L			90			20	3
Tanytarsus pallidicornis type 2[1]	L						2	

Table 1. *(Contd.)*

Study sites of Southern Greece L – lake R – river S – stream	Location	Study site code	Latitude (N)	Longitude (E)	Altitude (m a.s.l.)	Date	**Tanypodinae**	*Ablabesmyia monilis* (Linnaeus 1758)°	*Ablabesmyia phatta* (Egger 1864)*	*Conchapelopia* Fittkau 1957 sp.	*Procladius* Skuse 1889 spp.	*Thienemannimyia* (Fittkau 1957)
Pamisos R.	**Messini**	PRM	37° 20' 27"	22° 01' 10"	13	29.06.2002						
Pamisos R.	**Aris**	PRA	37° 05' 36"	22° 06' 69"	35	29.06.2002			2			
Pamisos R.	**Agios Floros**	PRAF	37° 10' 8"	22° 10' 00"	67	29.06.2002		1		33		
Pamisos R.	**Vrachopanagitsa**	PRV	37° 14' 47"	21° 54' 18"	90	30.06.2002		1				
Evrotas R.	**Estuary**	EvRE	36° 48' 44"	22° 41' 43"	4	09.03.2007				1		
Evrotas R.	**Skala B**	EvRSkB	36° 51' 13"	22° 40' 31"	20	21.09.2006; 17.03.2007		1		2	1	2
Vasilopotamos R.	**Skala A**	VRSkA	36° 50' 31"	22° 38' 47"	18	21.09.2006		1				3
Rasina S.	**Leukochoma**	RSL	36° 58' 55"	22° 32' 14"	120	09.03.2007						
Yerakaris S.	**Potamia**	YSP	36° 55' 26"	22° 29' 59"	225	12.03.2007						
Yerakaris S.	**Goranoi**	YSG	36° 54' 39"	22° 25' 55"	521	14.06.2006; 12.03.2007						
Evrotas R.	**Sparti B**	EvRSpB	37° 4' 26"	22° 26' 49"	180	14.03.2007				1		
Evrotas R.	**Sparti A**	EvRSpA	37° 4' 26"	22° 26' 49"	180	15.05.2006; 11.03.2007				5		
Evrotas R.	**Analipsi**	EvRAn	37° 5' 35"	22° 25' 25"	200	16.05.2006; 11.03.2007				3		7
Kotitsanis S.	**Logkanikos**	KSL	37° 13' 14"	22° 15' 25"	756	15.05.2006						
Evrotas R.	**Achouria**	EvRAc	37° 14' 50"	22° 19' 32"	320	12.05.2006; 10.03.2007				4		
Voutikiotis S.	**Pellana**	VSP	37° 13' 44"	22° 19' 22"	334	12.05.2006; 10.03.2007			3	1		
Kardaris S.	**Pardali B**	KSP	37° 10' 56"	22° 21' 31"	280	11.05.2006; 10.03.2007						
Evrotas R.	**Pardali A**	EvRP	37° 11' 32"	22° 21' 53"	284	12.05.2006				1		
Xerilas S.	**Perivolia**	XSP	37° 11' 50"	22° 19' 7"	364	16.05.2006; 10.03.2007						
Nikova S.	**Karavas B**	NSK	37° 8' 0"	22° 23' 7"	256	15.05.2006; 15.03.2007				1		
Perdikaris S.	**Karavas A**	PSK	37° 6' 58"	22° 24' 29"	220	15.05.2006				8		
Mylopotamos S.	**Agia Kiriaki**	MSAK	37° 2' 30"	22° 26' 45"	180	15.05.2006						
Paroritis S.	**Parori**	PSP	37° 3' 37"	22° 22' 47"	380	01.05.2006						
Lagkada S.	**Vatopouleika**	LSV	37° 5' 30"	22° 22' 59"	300	11.03.2007						
Lagkada S.	**Tripi**	LST	37° 5' 52"	22° 20' 32"	419	21.09.2006; 11.03.2007						
Lagkada S.	**Agios Vasilios**	LSAV	37° 4' 46"	22° 17' 9"	912	15.05.2006; 11.03.2007						
Oinous R.	**Theologos**	ORT	37° 7' 5"	22° 27' 12"	843	02.03.2007; 13.05.2006				8		
Oinous R.	**Kokkinorachi**	ORKo	37° 6' 28"	22° 26' 3"	560	08.03.2007						
Oinous R.	**Karies**	ORKa	37° 17' 22"	22° 30' 36"	400	13.05.2006; 08.03.2007						
Evrotas R.	**Skortsinos**	EvRS	37° 16' 50"	22° 12' 59"	519	10.03.2007					1	
Vrysiotiko S.	**Kastori B**	KSKB	37° 10' 22"	22° 18' 2"	486	20.09.2006						
Kastaniotis S.	**Kastori A**	KSKA	37° 10' 2"	22° 18' 29"	466	14.05.2006				13	1	
Kardaris S.	**Kastri**	KSK	37° 9' 23"	22° 19' 0"	477	13.03.2007						
L – larvae; P. – pupal exuviae								L	L	L	L	L

Zavrelimyia (Fittkau 1962)	L			1	3																												
Diamesinae																																	
Diamesa (Meigen 1835)	L		2																		4												
Potthastia gaedii (Meigen 1838)*	L																			1												1	
Prodiamesinae																																	
Prodiamesa olivacea (Meigen 1818)	L			3																2				1									
Orthocladiinae																																	
Brillia bifida (Kieffer 1909)*	L	12	15	71		9		4	38		1	2	2		9	15		2			30		7		8							2		
Brillia flavifrons-type[1]	L								1																								
Cardiocladius (Kieffer 1912)	L		2					2																1									
Chaetocladius piger agg.[2]	L																				4												
Cricotopus bicinctus-type[1]	L							5					1	1				1	1			4	1	5			1		4			32		1
Cricotopus cylindraceaus-type[1]	L					3				1			1												2		3		8					1
Cricotopus intersectus-type[1]	L																						1						3					
Cricotopus laricomalis-type[1]	L																						4									1	1	7
Cricotopus trifascia (Edwards 1929)*	L, P							1						1									17							3				
Eukiefferiella claripennis (Lundbeck 1898)*	L		8						3																								
Eukiefferiella Thienemann 1926 spp.	L																						1									1		
Eukiefferiella gr. *fittkaui*[1]	L																			1														
Limnophyes Eaton 1875 sp.	L												7																					
Orthocladius type S[1]	L			1									1					2				4	1	18	1		1		5			5	3	1
Parametriocnemus Goetghebuer 1932 sp.	L		5			6			1							1						2	1	1					4					
Paratrissocladius Zavrel 1937 sp.	L					2		1										1													1			
Rheocricotopus chalybeatus (Edwards 1929)	L, P		2				1							1								3	3	1				2	4	1				
Rheocricotopus effusus-type[1]	L			2												1			1															
Smittia Holmgren 1869 sp.	L																						3							1				
Synorthocladius semivirens (Kieffer 1909)*	L																															1		

Table 1. *(Contd.)*

Tvetenia tshernovskii (Pankratova 1968)	L																					12		1						3		4		
Tvetenia verralli (Edwards 1929)*	L																					5												
Chironominae																																		
Chironomini																																		
Chironomus plumosus-type[1]	L			2	9			10					42	1									1											
Dicrotendipes tritomus (Kieffer 1916)	L																																	122
Microtendipes chloris agg.[2]	L																														4			
Microtendipes pedellus agg.[2]	L				1										1								1								15			
Microtendipes rydalensis (Edwards 1929)**	L					1																												
Paratendipes nudisquama (Edwards 1929)°	L				1																													
Phaenopsectra flavipes-type[1]	L		2		1									1															1					
Polypedilum convictum-type[1]	L		24	2		2		8	11	2	3		1		2	2	1	16		2		10	3			2			14	1		12		
Polypedilum nubeculosum-type[1]	L			11	1	1										1			1			10							5					
Polypedilum sordens-type[1]	L														1						1		7						2					
Synendotendipes gr. *dispar*[1]	L			3																		1												
Tanytarsini																																		
Micropsectra pallidula-type[1]	L			1																	1													
Rheotanytarsus Thienemann & Bause 1913 sp.	L						1			5												2										2		
Tanytarsus pallidicornis type 1[1]	L																									6								
Tanytarsus pallidicornis type 2[1]	L					1										1													1					

with stagnant waters, rarely recorded from slow-flowing lowland streams (Vallenduuk and Moller Pillot, 2007).

Conchapelopia melanops (Meigen 1818)*

Species widespread in Europe. Not recorded from the southeastern part of the continent. On Balkan Peninsula recorded only from Serbia; in Montenegro larvae of a Conchapelopia species were found. 17 pupal exuviae recorded from: Tsifliki (Lissos R.) 25.08.2008. Ubiquistic species living in large stagnant waters and diverse running waters (Vallenduuk and Moller Pillot, 2007).

Diamensinae

Potthastia gaedii (Meigen 1838)**

Widespread species, recorded from nearly all European regions including the Balkan Peninsula. Two larvae recorded from Pellana (Voutikiotis S.) 12.05.2006, 10.03.2007 and Aris (Pamisos R.) 29.06.2002. Medium-sized rivers of relatively fast water current, stony substrate and low pollution levels. Klink and Moller Pillot (2003) report the species from large rivers on stony substrate with strong current.

Orthocladiinae

Brillia bifida (Kieffer 1909)**

Widespread in Europe including the Balkan Peninsula. 230 larvae recorded from Pelion (Spring in Pelion Mt.) 20.08.2008; Kastri (Kardaris S.) 13.03.2007; Kastori A (Kastaniotis S.) 14.05.2006; Kastori B (Vrysiotiko S.) 20.09.2006; Karies (Oinous R.) 13.05.2006, 08.03.2007; Theologos (Oinous R.) 02.03.2007, 13.05.2006; AgiosVasilios (Lagkada S.) 15.05.2006, 11.03.2007; Vatopouleika (Lagkada S.) 11.03.2007; Parori (Paroritis S.) 01.05.2006; Agia Kiriaki (Mylopotamos S.) 15.05.2006; Karavas B (Nikova S.) 15.05.2006, 15.03.2007; Perivolia (Xerilas S.) 16.05.2006, 10.03.2007; Pardali B (Kardaris S.) 11.05.2006, 10.03.2007; Logkanikos (Kotitsanis S.) 15.05.2006; Sparti A (Evrotas R.) 15.05.2006, 11.03.2007; Goranoi (Yerakaris S.) 14.06.2006, 12.03.2007; Agios Floros (Pamisos R.) 29.06.2002. Small streams and brooks ranging from headwaters to lowland streams and rivers (Moller Pillot, 2013).

Cricotopus trifascia (Edwards 1929)*

Widespread in Europe including the northern Balkan Peninsula. 29 specimens (larvae and pupal exuviae) recorded from: Kedros (Sofaditis R.) 19.08.2008; Theologos (Oinous R.) 02.03.2007, 13.05.2006; Karavas A (Perdikaris S.) 15.05.2006; Sparti A (Evrotas R.) 15.05.2006, 11.03.2007; Estuary (Evrotas R.) 09.03.2007. Medium to large lowland rivers with relatively slow-flowing waters with moderate levels of pollution. Klink and Moller Pillot (2003) report the species from solid substrates in upland rivers.

Eukiefferiella claripennis (Lundbeck 1898)*

Species widespread in whole Europe. Recorded from the northern and central Balkan region. 13 larvae were collected from Kedros (Sofaditis R.) 19.08.2008; Kastori A (Kastaniotis S.) 14.05.2006 and Agios Vasilios (Lagkada S.) 15.05.2006, 11.03.2007. Fast flowing streams of clean waters with stony substrate (Moller Pillot, 2009b).

Orthocladius (*Euorthocladius*) *rivulorum* (Kieffer 1909)**

Species widespread in Western Europe. On Balkan Peninsula recorded from Serbia and Montenegro. One pupal exuviae collected from Kedros (Sofaditis R.) 19.08.2008. Slow-flowing moderately polluted floodplain stream with stony and muddy substrates. Species found in slow-flowing streams (Moller Pillot, 2009b).

Paratrichocladius rufiventris (Meigen 1830)*

Species widespread in all Europe including Balkan Peninsula. Two pupal exuviae collected from Kedros (Sofaditis R.) 19.08.2008. Slow-flowing moderately polluted floodplain stream with stony and muddy substrate. It inhabits a range of habitats from fast flowing streams to large lowland rivers (Moller Pillot, 2009b).

Synorthocladius semivirens (Kieffer 1909)**

Species widespread in all Europe, including northern Balkan Peninsula. One larva found in Agios Floros (Pamisos R.) 29.06.2002. Headwaters of medium-sized river with stony substrate and rich aquatic vegetation with minimum pollution levels. *Synorthocladius semivirens* lives mainly in small and large slow-flowing waters (Moller Pillot, 2009b).

Tvetenia verralli (Edwards 1929)**

Species widespread in Northern and Western Europe. Five larvae were found in Analipsi (Evrotas R.) 16.05.2006, 11.03.2007. Medium- to large-sized river with stony substrate with medium levels of pollution. Species associated with large rivers (Klink and Moller Pillot, 2003).

Chironominae

Chironomini

Cryptochironomus rostratus (Kieffer 1921)°°

Species widespread in all Europe, on Balkan Peninsula recorded from Republic of Macedonia. Recorded previously from Rhodes. Nine pupal exuviae recorded from: Neo Petritsi (Strymonas R.) 23.08.2008 and Tsifliki

(Lissos R.) 25.08.2008. Medium- to large-sized rivers with relatively slow-flowing waters. *Cryptochironomus rostratus* is one of the most common species from the genus found exclusively in flowing waters (Moller Pillot, 2009a).

Kiefferulus tendipediformis (Goetghebuer 1921)°°

Species widespread in Western and Central Europe. Recorded from eastern Balkan Peninsula. Previously recorded from Rhodes. 52 larvae and pupal exuviae were recorded from: Sofades (Sofaditis R.) 19.08.2008; Rentina (Richios R.) 23.08.2008; Amphitriti (Maistros R.) 25.08.2008. Medium-sized rivers with slow-flowing waters, stony substrate and moderate levels of pollution. Species living in small stagnant waters and less often in flowing waters (Moller Pillot, 2009a).

Microtendipes rydalensis (Edwards 1929)*

Species recorded from Western and Northern Europe, as well as from Romania. One larva was found in Karies (Oinous R.) on 08.03.2007. Small stream with stony substrate, coarse particulate organic matter and clean cold water. This relatively rare species was found only in flowing waters including brooks and streams with strong current (Moller Pillot, 2009a).

Paratendipes nudisquama (Edwards 1929)°

Species widespread in Europe, recorded from many countries on the Balkan Peninsula. It has been previously recorded from Crete. One larva found in Skortsinos (Evrotas R.) on 10.03.2007. Headwater stream with fast flowing good water quality and stony substrate. In Northern Europe it lives mainly on peat moorlands but has also been recorded in streams (Moller Pillot, 2009a).

Xenochironomus xenolabis (Kieffer 1916)**

Species widespread in nearly all Europe, including northern Balkan Peninsula. One pupal exuvia and one larva are recorded from Filippiada (Louros R.) 15.08.2008 and Kedros (Sofaditis R.) 19.08.2008. Medium-sized rivers with slow and fast flowing waters, stony substrate and moderate levels of pollution. Species reported to inhabit medium to large stagnant and flowing waters (Moller Pillot, 2009a).

Tanytarsini

Micropsectra atrofasciata (Kieffer 1911)°°

Species widespread in Northern and Western Europe. Recorded from the eastern Balkan Peninsula. Recorded previously from Crete. One pupal exuviae found in Kastri (Spercheios R.) 18.08.2008. This *Micropsectra* species lives in middle and lower reaches of large streams and large rivers. It is tolerant to low oxygen levels (Klink and Moller Pillot, 2003).

Ecogeographical distribution

The collected material revealed that Chironominae were the most frequent subfamily. Chironomini occurred on 49 and Tanytarsini on 26, from a total of 61 sites. *Polypedilum nubeculosum*-type in northern and *Polypedilum convictum* in the southern Greek mainland was the most important component of Chironomini in terms of species frequency. Orthocladiinae were the second most dominant group in terms of species occurrence. They occurred on 42 sites, mostly localized in Southern and Central Greece. *Brillia bifida* in the upper Evrotas River stretch (South-East Peloponnese) and *Cricotopus bicinctus*-type in middle and lower Evrotas stretches were the most frequent Orthocladiinae species. Tanypodinae appeared evenly in northern as in the southern river systems. *Conchapelopia* on the Peloponnese Peninsula, while *Ablabesmyia monilis* and *Procladius* in Central Greece were the most frequent taxa among this subfamily. Chironomini (mainly *Polypedilum*, *Glyptotendipes* and *Dicrotendipes*) and *Cricotopus cylindraceaus*-type dominated in water bodies of Peloponnese and Central Greece.

The ordination analysis separated the running waters of mainland Greece into three main ecoregions based on Chironomidae assemblages (Fig. 2). Region A extends from Pindos Mountains in the south towards the coast of northwestern part of the Greek mainland. Representative taxa of region A as confirmed by SIMPER analysis include *Polypedilum nubeculosum*-type, *Tanytarsus mendax*-type and *Chironomus* spp. (Table 2). Taxa from ecoregion A included species of diverse ecological preferences; however, they were mostly associated with medium and larger rivers, with relatively slow current, fine detritus bottom and moderate to high saprobity. They often appeared also in stagnant waters. *Microtendipes pedellus* agg., *Ablabesmyia monilis* and *Phaenopsectra* prefer medium-sized streams to large rivers. *Phaenopsectra* and *Ablabesmyia monilis* often appear on plants. *Microtendipes pedellus* agg. occurs on fine substrate bottom. The aforementioned taxa are generally sensitive to organic pollution, high saprobity (*Tanytarsus*, *Polypedilum*, *Microtendipes*) and to low oxygen saturation but are more tolerant to water acidification. The fauna of region A was the least diverse of all three regions (34 taxa represented by 1271 specimens, Margalef index: 4.62, Table 3).

Ecoregion B lies in Western Thessaly, Central and Eastern Macedonia to southwestern Thrace. Assemblages from this region were mainly represented by *Polypedilum* species. *Kiefferulus tendipediformis* and *Tanypus punctipennis* are typical to stagnant waters and appear usually only in slow-flowing lowland rivers and streams (Vallenduuk and Moller Pillot, 2007; Moller Pillot, 2009a). These species separated ecoregion B from A. They are detrivorus and live on soft bottom with fine

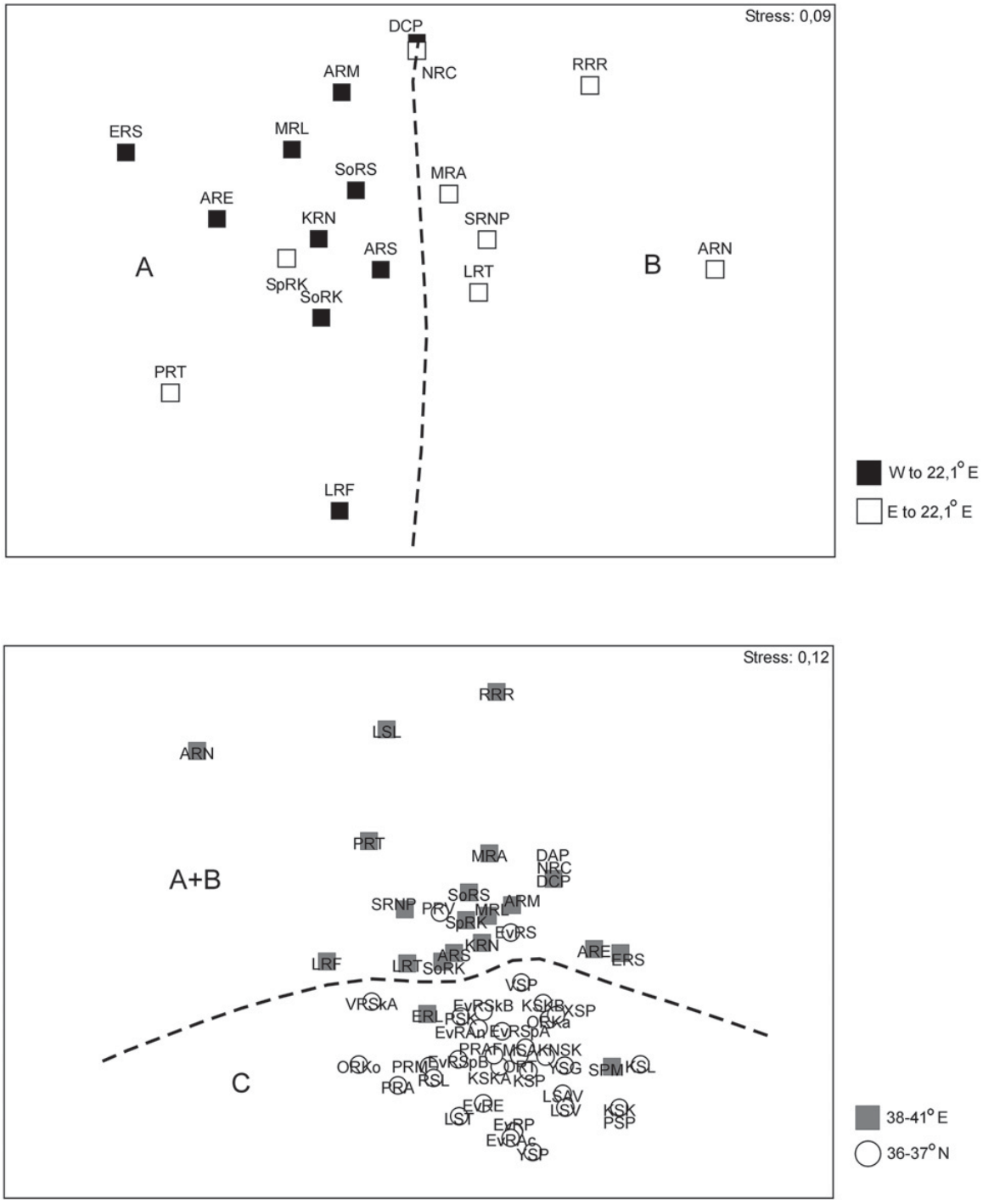

Fig. 2. NMDS ordination analysis showing the distinction of Chironomidae assemblages into three ecoregions.

particulate organic matter. *Tanypus punctipennis* and many *Chironomus* species are resistant to organic pollution and high saprobity but the other taxa (Table 2) typical for assemblages of region B are less tolerant. Nevertheless these taxa prefer mesosaprobic and polysaprobic conditions (Bick, 1963). The presence of species sensitive to acidification (*K. tendipediformis* and *T. punctipennis*) indicated neutral to slightly alkaline conditions. Ecoregion B was characterized by species richness on similar level to ecoregion A (33 taxa represented by 517 specimens, Margalef index: 5.12, Table 3).

The most distinct was the southern Greek mainland – ecoregion C (average dissimilarity from B: 97.51 and average dissimilarity from A: 95.62, Table 3). It ranges from the Peloponnese Peninsula through Central Greece to Thessaly. All taxa characteristic of the Evortas river basin in C region were associated with well-oxygenated waters with relatively strong current and higher pH. Small

Table 2. Results of the SIMPER analysis.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Group A					
Average similarity: 13.74					
Polypedilum nubeculosum-type	1.96	4.83	0.45	35.14	35.14
Microtendipes pedellus agg.	2.30	2.85	0.64	20.77	55.91
Tanytarsus mendax-type	1.12	1.62	0.50	11.76	67.66
Chironomus anthracinus-type	2.69	0.91	0.23	6.65	74.32
Chironomus plumosus-type	2.58	0.83	0.35	6.07	80.38
Microtendipes chloris agg.	0.75	0.64	0.36	4.68	85.06
Ablabesmyia monilis	0.50	0.64	0.31	4.64	89.70
Phaenopsectra flavipes-type	0.20	0.23	0.15	1.69	91.38
Group B					
Average similarity: 8.48					
Polypedilum nubeculosum-type	1.33	5.31	0.31	62.68	62.68
Kiefferulus tendipediformis	1.01	0.63	0.17	7.45	70.14
Chironomus	1.79	0.61	0.29	7.14	77.27
Tanypus punctipennis	0.58	0.52	0.27	6.17	83.44
Tanytarsus mendax-type	1.36	0.49	0.29	5.77	89.21
Microtendipes chloris agg.	0.27	0.18	0.17	2.09	91.30
Group C					
Average similarity: 14.63					
Brillia bifida	1.48	4.27	0.43	29.19	29.19
Polypedilum convictum	1.16	3.87	0.48	26.44	55.64
Conchapelopia	0.76	1.33	0.33	9.07	64.70
Cricotopus bicinctus-type	0.64	0.97	0.35	6.64	71.34
Orthocladius type S	0.55	0.86	0.31	5.84	77.18
Rheocricotopus chalybeatus-type	0.40	0.66	0.24	4.53	81.71
Parametriocnemus	0.40	0.51	0.26	3.46	85.17
Cricotopus cylindraceaus-type	0.35	0.47	0.20	3.22	88.39
Polypedilum nubeculosum-type	0.35	0.25	0.18	1.73	90.12
Groups A & C					
Average dissimilarity = 95.62					
Groups A & B					
Average dissimilarity = 89.94					
Groups C & B					
Average dissimilarity = 97.51					

Table 3. Number of taxa, specimens and their diversity according to the Margalef index in the three distinct Chironomidae ecoregions.

	A	B	C
No. of taxa	34	33	49
No. of specimens	1271	517	1089
Margalef index	4.62	5.12	6.86

brooks were inhabited by taxa characteristic of woodland streams with coarse organic matter (*Brillia bifida* and *Polypedilum convictum*) (Table 2). Middle and lower river stretches were represented by *Conchapelopia*, *Cricotopus bicinctus*, *Orthocladius* type S, *Parametriocnemus*, and *Rheocricotopus chalybeatus*. *Conchapelopia* and the aforementioned orthoclads are typical to warm, α-mesosaprobic rivers, where they live on macrophytes and stones. *Parametriocnemus* inhabits also smaller flowing waters and appear on organic bottom. This region is distinguished by the highest species richness (49 taxa represented by 1089 specimens in the dataset, Margalef index: 6.86).

It should be mentioned that regions A and B were clearly divided only when samples from group C were removed from the ordination analysis and were less dissimilar from each other (average dissimilarity: 89.94). These groups were also less coherent internally (group A average similarity: 13.74 and group B average similarity: 8.48).

Discussion and Conclusions

Ecogeographical distribution of Chironomidae in Greece

The results of the ordination analysis revealed three relatively distinct ecozones based on Chironomidae assemblages (Fig. 1). However, it must be noted that many

more extensive data on Chironomidae species distribution are required to support this finding. Nevertheless Skoulikidis *et al.* (2009) provided detailed environmental classification of running waters in Greece. They found that macroinvertebrate communities composition change longitudinally from west to east according to Illies (1978) zonation. From the 72 measured variables in their study, altitude, slope of the valley floor, catchment area and river bedrock were the most significant factors influencing benthos composition. Altitude and slope differ between Eastern and Southern Greek catchments (upland areas) and Central Greece (mountainous areas). Central Greek mountain streams are relatively colder and faster than in the south and east of the country. Acid silicate rocks and mafic silicate rocks dominate in northern and eastern Greece, whereas carbonate rocks dominate in Peloponnese. This geological variation influences conductivity and total hardness which was twice higher in southern as in northern Greece. MDS analysis performed by Skoulikidis *et al.* (2009) proposes distinction of three zones. This geographical distinction is partly supported from the results of this study (Figs. 1 and 2) but there are some differences. Ecoregion A covers most of sites from Zone 2 (Skoulikidis *et al.*, 2009). Taxa dominated in ecoregion A like *Ablabesmyia monilis*, *Microtendipes chloris* agg. and *Microtendipes pedellus* agg., are generally tolerant to acidification while they prefer slow-flowing waters of the lower river sections. Communities of ecoregion B covering Zone 1 (Skoulikidis *et al.*, 2009) are taxa typical of lower altitudes and slightly alkaline conditions. Ecological characteristic of Zone 3 (mainly Peloponnese) corresponds well to the habitat preferences of midge taxa distributed in ecoregion C (alkaline conditions and higher water temperature). Distribution of the zones performed by Skoulikidis *et al.* (2009) does not agree merely with the ecological division presented in this paper. As mentioned earlier, the regionalization presented here is based on relatively small dataset and have only preliminary character. More detailed analysis should resolve doubts of the above disputed territory.

The latest faunistic study on the Chironomidae fauna of Greece was presented by Mora and Csabai (2008) from their work on Rhodes Island which they identified 34 species new to Rhodes Island (Dodecanese Archipelago). Much more (60) taxa have been recorded from the rivers of Eastern Thrace (Özkan and Camur-Elipek, 2006; Özkan *et al.*, 2010). These rivers flow in the European part of Turkey, but close to the Greek boundaries and provide some information on the midge fauna of the region. Petridis and Sinis (1995) recorded eight Chironomidae taxa from Lake Mikri Prespa: *Einfeldia dissidens*, *Chironomus plumosus*, *Microchironomus tener*, *Polypedilum nubeculosum*, *Cladopelma lateralis*, *Tanytarsus* sp., *Tanypus punctipennis* and *Procladius* (*Holotanypus*) and 13 from Tavropos reservoir (Petridis and Sinis 1993). Their material consisted of samples from 127 stations from Mikri Prespa and 111 from Tavropos reservoir in a broad depth range. This study recorded *Cricotopus laricomalis*-type and *Paratanytarsus austriacus* gr. from the Mikri Prespa Lake despite the fact that only one small sample was taken from the littoral zone. Samples taken from other lakes in this study (Kastoria L., Vegoritis L., Doirani L.) add to this short list other six taxa: *Cricotopus cylindraceaus*-type, *Cricotopus intersectus*-type, *Chironomus anthracinus*-type, *Chironomus plumosus*-type, *Dicrotendipes nervosus*, *Glyptotendipes pallens*-type. The apparent paucity of the lake fauna presented here seems to be an effect of the sampling methods. Lakes being large and diverse macrohabitats need more complex sampling efforts that include samples from the diverse zones of macrophyte vegetation as well as bottom of littoral and profundal zones. Otherwise singular samples of larvae are enough only when subfossils from a lake bottom are collected (Brodersen and Lindegaard, 1997).

Concluding remarks

This is among the first studies that contribute to the knowledge of the Chironomidae fauna of Greece. The composition and distribution of the chironomid fauna in mainland Greece is presented and many genera and species are recorded for the first time. As mentioned previously, the given ecogeographical division certainly requires more data and can only be indicative. Because the material in this study were mainly immature stages, many specimens could not be successfully identified as the larva of many Chironomid species remain unknown. As the Diptera fauna of the Southern Balkan Peninsula, including Greece, has been poorly investigated, more records and perhaps new species are waiting to be discovered. Finally, it is anticipated that new collected material will give more insights into the relatively unknown Chironomid fauna of Greece.

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