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Article

Occurrence and distribution of aquatic midges (Diptera: Chironomidae) inhabiting coastal and temporary ponds near Cabras (Sardinia, Italy)*

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Key words

- non-biting midges
- lagoons
- wetlands
- winds
- flight paths
- salinity
- western Sardinia

Parole chiave

- chironomidi
- lagune
- aree umide
- venti
- modalità di volo
- salinità
- Sardegna occidentale

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Summary

During 2010-2011, the main basins present near Cabras (Western Sardinia, Province of Oristano, Italy) were studied. Nuisance phenomena due to the massive presence of adult chironomids have been observed in this area. The study was carried out in two fresh and four brackish water, one hyperhaline basin and three evaporitic ponds during three sampling campaigns at a total of 38 stations. For each station benthos samples were collected and depth, temperature, transparency, salinity, percentage of dissolved oxygen were determined. A total of 16 chironomid taxa were identified whose total number, in each basin, is negatively correlated to water salinity. *Chironomus plumosus* gr. and *C. thummi* gr. prevailed in fresh water environments, with *Tanypus kraatzi* (Kieffer, 1912), *Cladopelma viridulum* gr. sensu Moller Pillot, and *Paratanytarsus* Thienemann & Bause, 1913, as secondary taxa; *C. salinarius* Kieffer, 1915, prevailed in brackish water environments and *Baeotendipes noctivagus* (Kieffer, 1911), in hyperhaline ones. *C. plumosus* gr., *C. thummi* gr., *Procladius choreus* (Meigen, 1804), *Cricotopus (Isocladius) sylvestris* (Fabricius, 1794), are present in temporary environments. The conditions favourable to the passive transport of the chironomids from breeding sites towards the towns, and the flight paths followed, have been identified.

Riassunto

I principali bacini attorno a Cabras (Sardegna occidentale) sono stati studiati nel periodo 2010-2011, in seguito alla comparsa di fenomeni di molestia dovuti all'eccessiva presenza di chironomidi. La ricerca è stata svolta in tre campagne di raccolta su un totale di 38 stazioni ripartite in 10 ambienti caratterizzati da diversa salinità e regime delle acque (permanenti e temporanee). Accanto alla composizione della comunità dei chironomidi sono stati valutati alcuni parametri quali profondità, trasparenza, temperatura e percentuale di ossigeno disciolto. Sono stati complessivamente identificati 16 taxa di chironomidi la cui distribuzione nei bacini è risultata dipendente dalla salinità: *Chironomus plumosus* gr. e *C. thummi* gr. predominano negli ambienti oligo-mesoalini, seguiti da *Tanypus kraatzi* (Kieffer, 1912), *Cladopelma viridulum* gr. sensu Moller Pillot e *Paratanytarsus* Thienemann & Bause, 1913. Nei bacini meso-polialini prevale *C. salinarius* Kieffer, 1915, mentre negli ambienti iperalini domina *Baeotendipes noctivagus* (Kieffer, 1911). Negli ambienti temporanei sono presenti *C. plumosus* gr., *C. thummi* gr., *Procladius choreus* (Meigen, 1804), *Cricotopus (Isocladius) sylvestris* (Fabricius,1794). Lo studio dei venti ha permesso di individuare i sentieri di volo seguiti dai chironomidi durante il loro trasporto passivo dalle aree di riproduzione verso i centri abitati.

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Introduction

Sardinia is a large Italian island in the Mediterranean Sea. It has a coastline about 2,000 km long and covers nearly 24,000 km^2. There are numerous lentic and lotic environments in the island, partly protected by the Ramsar Convention as well as by regional legislation. The flora and the fauna of these environments, which are an ecological heritage of great interest, are unfortunately still not adequately investigated. This is especially true for aquatic chironomids (Diptera: Chironomidae). During the mid 90's, some areas in Sardinia were severely affected by the invasion of pestiferous adult chironomid midges in astronomical numbers. The midge-affected zones were those of Cagliari (with great discomfort at the local airport), and Oristano, where great discomfort was caused by pestiferous midges for the resident population during the periodic outdoor events scheduled during the summer period and businesses, tourism-related in particular. In response to the midge discomfort phenomena, the Region of Sardinia financed a research investigation on the midge breeding areas. In this investigation, water basins located in the neighbourhood of Cagliari were studied first (Ceretti et al. 1994) and, afterwards this investigation was expanded to the main wetlands located in the Province of Oristano (Ceretti et al. 1996; Ceretti et al. 1997; Grim et al. 1997). More recently, during summer 2009 and 2010, the midge nuisance emerged in Cabras (location: 39°55'48" N; 8°31'53" E), in the Province of Oristano. Following this event, the Province of Oristano sponsored a new research program with the aim of elucidating chironomid breeding areas and evaluating possible methods of midge control. As a part of this more extensive research, the occurrence and distribution of chironomids (Diptera: Chironomidae) inhabiting selected wetlands located near Cabras, during the period of October 2010 to July 2011 are presented below. The data on the presence of chironomids in this vast area (about 30 km^2) are currently the only ones available for most of the environments studied, and can provide a contribution for future studies on the evolution of these environments.

Study area

Field samplings of immature chironomids was carried out in autumn (October 2010), spring (May 2011) and summer (July 2011) at a total of 38 stations. As previously reported, the research aimed to identify the main larval breeding areas and to evaluate the possible methods for their control. During the survey conducted in 1996, some areas of Stagno di Cabras had particularly high larval densities (between 6,000 and 16,000 larva m^{-2}) and represented important larval foci. Therefore, during the campaign of October 2010, the situation in this environment was first verified, with particular attention to the known foci. At the same time, a study on the direction of the predominant winds in the area was conducted, with the aim of identifying the flight paths of chironomids from the foci to the human inhabited area. Another aim was to identify some areas where plan monitoring/capture systems in anticipation of the intense swarms expected for summer 2011. Adult chironomids are generally not strong fliers: their migration from the foci to human inhabited areas occurs mainly due to their passive transport by winds (Syriämäkj 1964; Hilsenhoff 1966) or attraction to light sources (Ali et al. 1994). Before reaching human-inhabited areas, adult chironomids rest and accumulate along the riparian vegetation near the foci. The identification of these areas before the beginning of the emergences allows to carry out on time the installation of adult monitoring (pre-alarm) or capture/abatement systems. The capture of chironomids in limited areas where dense populations of adult midges are present, can significantly reduce the nuisance in residential areas (Ali & Lobinske 1999). At the end of October 2010, a substantial decline in the presence of chironomids larvae was observed in Stagno di Cabras: the obtained chironomid flight path was exploited to expand the study area by identifying other basins. In subsequent sampling periods, other midge habitats were also sampled in addition to Stagno di Cabras (C). These habitats include some smaller ponds Mare 'e Pauli (MP) and Pauli 'e Sali (PS), one of the tributaries of Stagno di Cabras (Riu Tanui: RT), the C emissaries (Canali Scolmatori Peschiera Pontis: CS), Riu Bau Mannu (BM), a peripheral area of the lagoon of Mistras (M), and some temporary basins (Pauli Trottas: PT, Pauli Cuccuru Sperrau: PCS and Su Pangarazzu: P). Figure 1 shows the location of these habitats and Table 1 shows their general characteristics.

Materials and Methods

Benthic samples were collected with an Eckman dredge (15x15 cm) or with a Surber net (mouth 25x10 cm, mesh 500 µm, trajectory about 1 meter), depending upon the nature of habitat. Two samples were taken from each of the selected areas; the material from each pair of samples was subsequently combined to give a more complete picture of the structure of the populations. Each sample was immediately washed through a sieve (mesh opening: 500 µm) and the residue on the sieve containing immature chironomids was collected, appropriately labelled, preserved in 75% alcohol, and taken to the laboratory for identification to the lowest possible taxonomic level (Pinder 1983). Three environmental variables, chosen among those routinely measured in biological studies, were considered. Water temperature and dissolved O_2, were measured with the field probe OxiCal G7 WTW-Germany, salinity with YSI Salinometer S-5000 or with an Abbe refractometer.

The identification of the flight paths was based on the data of intensity and direction of the winds during the nuisance period (July – September, 2009-2010) obtained from the nearby weather station of Oristano. Particular attention to wind direction was paid during the emergence periods (dawn and sunset times) as these two time periods are most likely responsible for the passive transport of adult chironomids towards the inhabited areas (Syriämäkj 1964).

Data processing

Data were processed by a hierarchical classification and an ordination analysis to verify the degree of similarity existing between different basins as regards the structural aspects of the chironomid assemblages. Before the analysis, the data of Table 2 have been summed and the percentages of participation of the taxa in each basin have been calculated. Processing was performed on data normalized using a similarity matrix between environments obtained through Bray-Curtis (1957) coefficient. The classification was made with the average linkage method, while ordination was performed extracting eigenvectors and eigenvalues from the similarity matrix. We also calculated on this matrix the Minimal Spanning Tree, which represents the pattern of nearest neighbourhood existing among the environments. Principal component analysis (PCA) was also used to verify simultaneously the trends of the biotic components with regard to the groups of basins identified through classification. Before this analysis was performed, the biological data were restructured by averaging the single values within the groups considered.

Statystical analyses were performed using PAST 3.20 package (Hammer et al. 2001).

Results

Chemical and physical parameters

The mean and SD values of the chemical and physical parameters measured at the water surface and, where possible, near the bottom are shown in Table 1. As before reported, the climate has a strong influence on the chemical characteristics in the larger basins as well. In May, after a period of rainfall and windy weather

Tab. 1 - Main chemical and physical features of the studied habitats. / Principali caratteristiche chimico-fisiche degli ambienti studiati.

Code	Habitat	Surface ha	Mean - max. depth m	Date		T°C	S‰	O_2 %	N
C	F	2228	1.5 - 3.0	Oct, 2010	surface	18.7±0.6	19.6±1.9	86.3±17.8	15
					bottom	19.7±0.7	26.5±9.2	49.7±29.8	
				May, 2011	surface	19.9±0.5	7.8±1.8	98.5±22.9	
					bottom	19.8±0.5	7.9±1.8	83.3±16.7	
				July, 2011	surface	23.1±0.2	12.0±4.1	65.1±7.6	
					bottom	22.6±1.7	11.2±3.7	56.2±12.0	
MP	P	61	0.5 - 1.50	May, 2011	surface	20±0	0.5±0		2
					bottom	19.8±0	0.5±0		
				July, 2011	surface	27.5±0.7	3.75±3.2	41.0	
					bottom	27.5±0.7	3.75±3.2		
PS	P	31	0.5 - 1.5	May, 2011	surface	20.0	5.0		3
					bottom	19.8	5.0		
				July, 2011	surface	24.0	21.0	82.0	
					bottom	24.0	21.0	82.0	
RT	I		0.7/1.5	May, 2011	surface	19.3±0.6	0.8±0	60.7±18.4	3
					bottom	19.0±0.8	0.8±0	60.1±34.6	
				July, 2011	surface	23.7±1.3	0.8±0	9.8±8.7	
					bottom	23.1±0.8	1.0±0.3	4.1±5.6	
CS	E		0.7 - 1.5	May, 2011	surface	20.5±1.6	14.6±5.6	128.5±10.7	4
					bottom	20.1±1.7	14.7±5.7	134.8±30.7	
				July, 2011	surface	22.7±0.8	26.3±8.5	77.3±16.6	
					bottom	22.8±0.3	32.0±3.6	64.1±21.6	
BM	C		0.5 - 1.0	May, 2011	surface	19.1±0.1	5.0		2
					bottom				
				July, 2011	surface	21.0	4.5	49.2	
					bottom	23.5	14.0	25.0	
M	F	450	0.5 - 1.0	May, 2011	surface	21.0±0	57.8±14.7		6
					bottom				
				July, 2011	surface	29.0±0	71.7±0.6		
					bottom				
P	T	0.5	0.3 - 0.8	July, 2011	surface	26.8	63.0	40.0	1
					bottom				
PT	T	22	0.4 - 1.0	May, 2011	surface	20.0	14.5		1
					bottom	19.8	14.5		
				July, 2011	surface	22.0	33.0	27.0	
					bottom				
PCS	T	13	0.4 - 1.0	May, 2011	surface	20.0	14.0		1
					bottom	19.8	14.0		
				July, 2011	surface	23.0	44.5	9.4	
					bottom				

C: Stagno di Cabras; MP: Mari 'e Pauli; PS: Pauli 'e Sali; RT: Riu Tanui; CS: Canali Scolmatori Peschiera Pontis; BM: Bau Mannu; M: Mistras lagoon; P: Su Pangarazzu; PT: Pauli Trottas; PCS: Pauli Cuccuru Sperrau. F: fishery; P: ponds; I: one of the tributary of Stagno di Cabras; E: system of the natural emissaries of Stagno di Cabras; C: channel; T: temporary ponds. N: number of sampling stations per basin./C: Stagno di Cabras; MP: Mari 'e Pauli; PS: Pauli 'e Sali; RT: Riu Tanui; CS: Canali Scolmatori Peschiera Pontis; BM: Bau Mannu; M: laguna di Mistras; P: Su Pangarazzu; PT: Pauli Trottas; PCS: Pauli Cuccuru Sperrau. F: valle da pesca; P: stagno; I: immissario dello Stagno di Cabras; E: emissari dello Stagno di Cabras; C: canali; T: stagni temporanei. N: numero delle stazioni di campionamento nei singoli bacini.

Tab. 2 - *Distribution and density (N. arvae m^{-2}) of chironomid taxa. / Distribuzione e densità (N. larve m^{-2}) dei taxa di chironomidi identificati.*

		C			MP		PS		RT		CS	
Code	**Taxon**	**Oct. 2010**	**May 2011**	**July 2011**	**May 2011**	**July 2011**	**May 2011**	**July 2011**	**May 2011**	**July 2011**	**May 2011**	**July 2011**
1	*Procladius choreus* (Meigen, 1804)				16							
2	*Tanypus kraatzi* (Kieffer. 1912)				84	24				110		
3	*Tanypus punctipennis* Meigen, 1818				4	100						
4	*Halocladius (Haloc.) varians* (Staeger, 1839)			22								
5	*Cricotopus (Isocl.) sylvestris* (Fabricius, 1794)				8	68						
6	*Psectrocladius psilopterus* gr. Kieffer, 1906				8							
7	*Paratanytarsus* Thienemann & Bause, 1913				28	4			22			
8	*Tanytarsus* van der Wulp, 1874				16							
9	*Chironomus plumosus* gr.	489	1555	264	292				1578	836		
10	*Chironomus thummi* gr.				620				1044			
11	*Chironomus salinarius* Kieffer, 1915	22	44	110				594			5111	44
12	*Chironomus halophilus* gr.				32		4		44			
13	*Baeotendipes noctivagus* (Kieffer, 1911)											
14	*Cladopelma viridulum* gr. s. Moller Pillot, 2009				52				133			
15	*Dicrotendipes* Kieffer, 1913								22			
16	*Glyptotendipes* Kieffer, 1913				8							

		BM		M		P	PT		PCS	
Code	**Taxon**	**May 2011**	**July 2011**	**May 2011**	**July 2011**	**July 2011**	**May 2011**	**July 2011**	**May 2011**	**July 2011**
1	*Procladius choreus* (Meigen, 1804)						16		12	184
2	*Tanypus kraatzi* (Kieffer. 1912)									
3	*Tanypus punctipennis* Meigen, 1818									
4	*Halocladius (Haloc.) varians* (Staeger, 1839)									
5	*Cricotopus (Isocl.) sylvestris* (Fabricius, 1794)						8			
6	*Psectrocladius psilopterus* gr. Kieffer, 1906								8	
7	*Paratanytarsus* Thienemann & Bause, 1913									
8	*Tanytarsus* van der Wulp, 1874									
9	*Chironomus plumosus* gr.							20	20	
10	*Chironomus thummi* gr.									420
11	*Chironomus salinarius* Kieffer, 1915	800	3216							60
12	*Chironomus halophilus* gr.								8	
13	*Baeotendipes noctivagus* (Kieffer, 1911)			6220	5808	372				
14	*Cladopelma viridulum* gr. s. Moller Pillot									
15	*Dicrotendipes* Kieffer, 1913									
16	*Glyptotendipes* Kieffer, 1913									

C: Stagno di Cabras; MP: Mari ‘e Pauli; PS: Pauli ‘e Sali; RT: Riu Tanui; CS: Canali Scolmatori Peschiera Pontis; BM: Bau Mannu; M: Mistras lagoon; P: Su Pangarazzu; PT: Pauli Trottas; PCS: Pauli Cuccuru Sperrau..

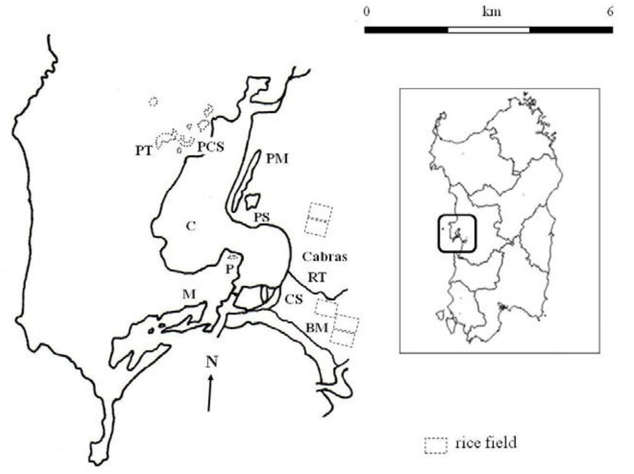

Fig. 1 *- Study area. C: Stagno di Cabras; MP: Mari 'e Pauli; PS: Pauli 'e Sali; RT: Riu Tanui; CS: Canali Scolmatori Peschiera Pontis; BM: Bau Mannu; M: Mistras lagoon; P: Su Pangarazzu; PT: Pauli Trottas; PCS: Pauli Cuccuru Sperrau. / Area di studio. C: Stagno di Cabras; MP: Mari 'e Pauli; PS: Pauli 'e Sali; RT: Riu Tanui; CS: Canali Scolmatori Peschiera Pontis; BM: Bau Mannu; M: laguna di Mistras; P: Su Pangarazzu; PT: Pauli Trottas; PCS: Pauli Cuccuru Sperrau*

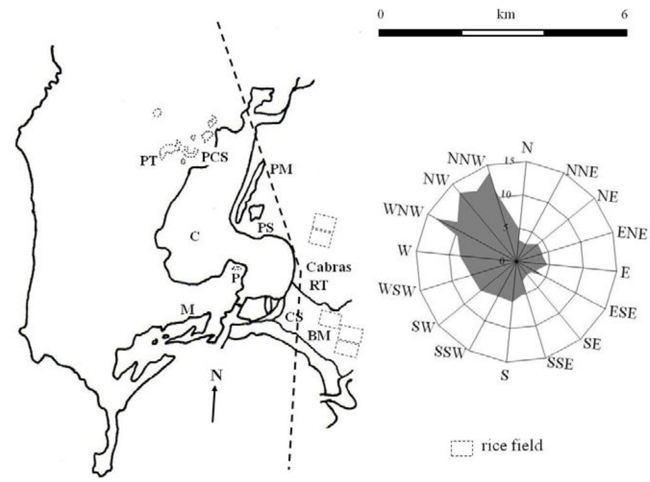

Fig. 2 *- Direction and intensity of the predominant winds during the nuisance periods (July-September 2009 and July-September 2010) and the preferential flight corridor of the chironomids from the breeding sites to the inhabited area of Cabras (dotted line). C: Stagno di Cabras; MP: Mari 'e Pauli; PS: Pauli 'e Sali; RT: Riu Tanui; CS: Canali Scolmatori Peschiera Pontis; BM: Bau Mannu; M: Mistras lagoon; P: Su Pangarazzu; PT: Pauli Trottas; PCS: Pauli Cuccuru Sperrau. / Direzione ed intensità dei venti predominanti durante il periodo delle molestie (Luglio-Settembre 2009 e 2010) e corridoio preferenziale di volo dei chironomidi dalle aree di sviluppo verso il centro abitato (linea punteggiata). C: Stagno di Cabras; MP: Mari 'e Pauli; PS: Pauli 'e Sali; RT: Riu Tanui; CS: Canali Scolmatori Peschiera Pontis; BM: Bau Mannu; M: laguna di Mistras; P: Su Pangarazzu; PT: Pauli Trottas; PCS: Pauli Cuccuru Sperrau.*

conditions, recorded salinity values were the lowest, while dissolved oxygen values were the highest when compared with other sampling occasions. Generally, the oxygen saturation values were lower than 100%, with the exception of May in CS, with values around 130%, due to the high turbulence of water flow leaving C after the rainy period. The summer decline in dissolved oxygen levels observed in RT, PT and PCS (9.8%, 27%, and 9.4% respectively), and near the bottom of the BM (25%) was noteworthy. In C and in CS, an increase in salinity levels near the bottom was observed in October 2010 and July 2011, probably due to laminating phenomena.

Chironomids distribution

The qualitative and quantitative composition of chironomid populations in each basin is shown in Table 2. A total of 16 chironomid tolerant taxa was identified (Coffman & Ferrington 1996). The number of taxa was higher in May (15 taxa) than in the other months (2 and 8 taxa in October 2010 and July 2011, respectively). The single communities were composed of up to 12 taxa (MP) to only 1 taxon (CS, BM, P and M): the best distributed taxa were *Chironomus plumosus* gr. and *C. salinarius* Kieffer 1915 (5 sites), *Chironomus halophilus* gr. (4 sites), followed by *Chironomus thummi* gr. and *Procladius choreus* (Meigen, 1804) (3 sites). The densities of the taxa were generally contained: high values, which may represent larval foci, have been reached only by *C. salinarius* with a density of 5,111 larvae m^{-2} in CS in May 2011 and a density of 3,216 larvae m^{-2} in BM in July of the same year and especially by *Baeotendipes noctivagus* (Kieffer, 1911) in M (values above 5,800 larvae m^{-2} in May and July 2011).

Flight path

The direction of predominant winds during the nuisance periods 2009-2010 was mainly from the NNW-SSE. Winds from NNW-WNW tended to have a higher intensity than those from southern dials (10-15 km h^{-1} and 5-10 km h^{-1}, respectively). The results gathered were used to obtain a rose of the winds that, centered on the town of Cabras, allowed to delimit a flight path with an angle of about 160 degrees (Figure 2). Within this area, 6 guarded areas located away from inhabited areas or tourist facilities where to place light attraction systems or suction fan systems, were identified.

Comparison between ponds

The results of the classification and ordination analysis (Figure 3A and B) shows a strong similarity among the communities found in M and P (with the exclusive presence of *B. noctivagus*) and among the communities of CS, BM and PS, almost exclusively composed by *C. salinarius*. A high similarity was found among the population of PCS, MP, PT, RT and C that supported a better structured midges community. The genus *Chironomus* was dominant, with *C. plumosus* gr., *C. thummi* gr. and *C. salinarius*, followed by *Procladius choreus*, *Tanypus kraatzi* (Kieffer, 1912), *Cricotopus (Isocladius) sylvestris* (Fabricius, 1794) and *Cladopelma. viridulum* gr. sensu Moller Pillot, 2009. The hierarchical classification and ordination techniques agree on identifying three groups of wetlands: group 1 composed by MP, PCS, RT PT and C, group 2 composed by CS, BM and PS and group 3 composed by M and P. The reciprocal ordering of the three groups of basins and of the chironomids (Figure 4) is given by the first two principal components which explain over 90% of the total variance. The biplot (Figure 4) makes clear the distance among the groups on the basis of their chironomid community and identifies the taxa that can explain this separation: *C. plumosus* gr and *C. thummi* gr for the group 1, *C. salinarius* for the group 2, e *B. noctivagus* for the group 3.

Discussion and Conclusions

The structure of midge populations in the group of wetland identified is related to the salinity. Group 1 includes oligo-mesohaline basins, with *C. plumosus* gr., *C. thummi* gr., *P. choreus*, dominant species and *T. kraatzi*, *Cladopelma viridulum* gr. and *C. halophilus* gr. as secondary taxa. The second group is formed by meso-polihaline basins, with the clear predominance of *C. salinarius*. The third

A

B

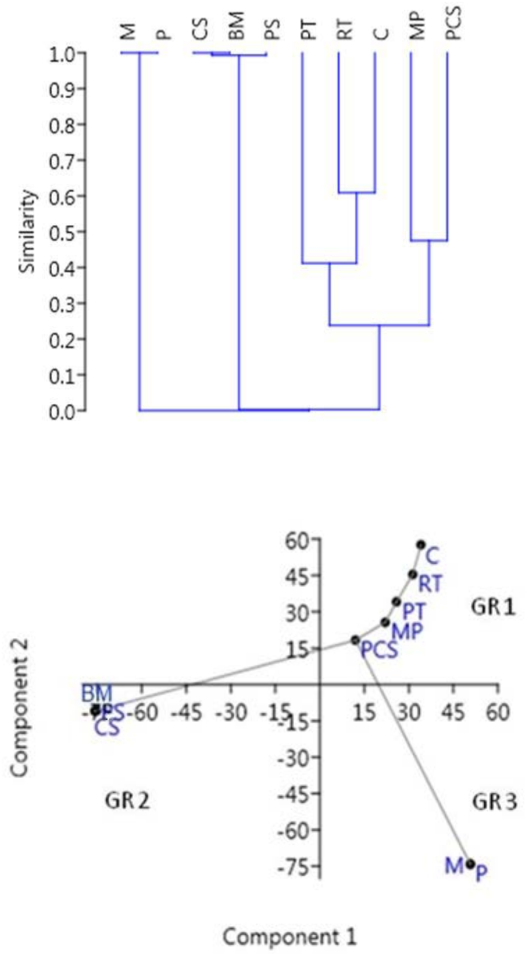

Fig. 3 - Ordination (A) and hierarchical classification (B) of the environments on the basis of their chironomid population. C: Stagno di Cabras; MP: Mari 'e Pauli; PS: Pauli 'e Sali; RT: Riu Tanui; CS: Canali Scolmatori Peschiera Pontis; BM: Bau Mannu; M: Mistras lagoon; P: Su Pangarazzu; PT: Pauli Trottas; PCS: Pauli Cuccuru Sperrau. / Ordinamento (A) e classificazione gerarchica (B) dei bacini sulla base del loro popolamento a chironomidi. C: Stagno di Cabras; MP: Mari 'e Pauli; PS: Pauli 'e Sali; RT: Riu Tanui; CS: Canali Scolmatori Peschiera Pontis; BM: Bau Mannu; M: laguna di Mistras; P: Su Pangarazzu; PT: Pauli Trottas; PCS: Pauli Cuccuru Sperrau.

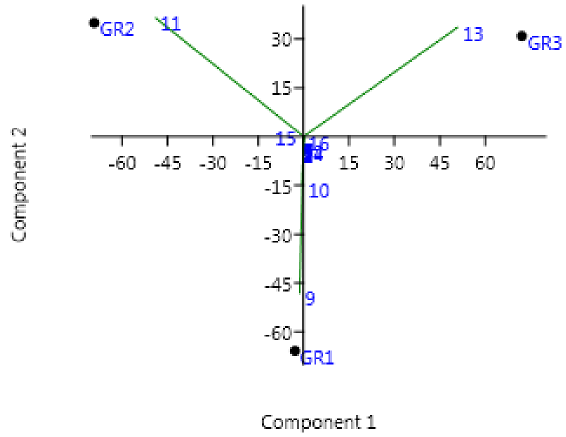

***Fig. 4** - PCA biplot of the component scores of taxa (numbers and green lines) and groups (dots). Codes: 9:* Chironomus plumosus *gr.; 10:* Chironomus thummi *gr.; 11:* Chironomus salinarius*, Kieffer, 1915; 13:* Baeotendipes noctivagus *(Kieffer, 1911). / Biplot dei valori delle componenti dei taxa (numeri e linee verdi) e dei gruppi (punti) ottenuti con la PCA. Riferimenti: 9:* Chironomus plumosus *gr.; 10:* Chironomus thummi *gr.; 11:* Chironomus salinarius *Kieffer, 1915; 13:* Baeotendipes noctivagus *(Kieffer, 1911).*

group includes two hyperhaline basins that have a population only composed by *B. noctivagus*. A similar distribution of taxa related to the increase of salinity was also described by Krebs (1982). However, even the type of these environments and the reduced ecological quality of habitats, altered by human activities and pollution, could explain the midges distribution. The studied coastal area is subject to continuous pressure of agricultural activity, and the studied wetlands have generally reached a high trophic level (Sechi 1982). In the early '90s, a great anthropic impact affected C because of the creation of a new emissary channel, much larger than the natural ones. The new channel and some works carried out on the main tributary led to the penetration of a salty lamination at the bottom and caused periodic mortality due to anoxia and collapse of the high productivity of fish that characterized C. These environmental modifications can contribute to explaining the drastic decline in the chironomid population levels in this environment compared to those observed in 1996 (Ceretti et al. 1996). The chironomid community in temporary basins is composed by a reduced number of taxa, usually present with low densities. Other works on temporary basins found similar results and explained this low chironomids taxa number to physiological stress due to the water chemistry (Zerguine 2014). The cyclic drying habitat is responsible for various adaptive strategies of organisms and generates an original fauna, distinct from the fauna of permanent ecosystems (Culioli et al. 2014). Adaptations for the utilization of temporary habitats can be divided into two main groups. In situ resistance adaptations are a complex of physiological and behavioural adaptations that enable individuals to overcome adverse conditions in situ (Frouz et al. 2003). Aquatic chironomid larvae dwelling in temporary pools can survive dry periods by migration into the deeper, or built cocoons, which reduce water loss by transpiration. The second group includes adaptations based on recolonization: population persistence is ensured by the colonization of new pools. The fittest larvae are those with the shortest development time, which enables them to emerge from pools before desiccation. The fittest adults (particularly females) are the largest, as large size is associated with both high fertility and good migration ability (Frouz et al. 2003). The combination of permanent but sub-optimal habitats and suitable and temporary habitats may ensure population persistence (Frouz & Kindlman 2001): these habitats are densely colonized by larvae of the genus *Chironomus* (Frouz et al. 2003). This could be the situation in PCS and PT, where the presence of the genus *Chironomus* represents respectively 70% and 45% of their population, followed by *P. choreus*, a species less linked to sediments and with a short development time. The area around PT and PCS is well stocked with other smaller temporary environments and small freshwater canals located in private areas. These environments can facilitate the exchange of chironomids necessary for the recolonization of PT and PCS. Pond P does not have other environments nearby: colonization probably occurs through adults of *B. noctivagus* coming from the relatively near M, transported by the wind.

The collected data form a first database on the density and distribution of larval chironomids in this vast area. The principal foci have been identified: the larval density in the foci must be periodically controlled as well as the adults occurrence in the monitoring areas that has been identified through the study of the flight paths, to prevent future nuisances. The studied area is subject to continual pressures due to agricultural activity and rice cultivation. Further targeted studies are needed to investigate and safeguard the biodiversity of these interesting environments.

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