TRICHOPTERAN FAUNA OF THE ITALIAN SPRINGS

by

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ABSTRACT

Research carried out over many years (1950-1996) on Italian springs in the Alps, along the Apennine chain, and in the islands, at different altitudes, supplied interesting ecological and faunistic information on the Trichopteran fauna.
To date 397 springs of different types have been investigated and 136 species have been found. Rheocrenous springs are the most numerous and rich in species (112). 43 of these seem to be true crenobionts, since all the known findings have been in springs and spring-brooks. The most widespread in Italian regions are *Catagapetus nigrans* and *Crunoecia irrorata*. 22 crenobionts are endemic to Italy, the majority belonging to the genera *Drusus* (*D. aprutiensis, D. camerinus, D. improvisus*) and *Chaetopteryx* (*C. euganea, C. gessneri tomaszewskii, C. trinacriae, C. vulture*) and to the family Beraeidae (*Beraea crichtoni, B. ilvae, Ernodes nigroauratus siculus*). There are also several endemic crenoxenes, many of which belong to the genera *Wormaldia, Tinodes, Potamophylax* and *Silo*.
The limnocrenous and helocrenous springs are more seldom and inhabited by lentic species of the genus *Limnephilus* and by *Glyphotaelius pellucidus*.
In the rheo-limnocrenous systems of the central Apennines, which are often the remainder of ancient lakes, species of different ecological categories are found.
Parasites and epibionts are found in the larvae of some spring Trichoptera species. Gregarina are the most widespread symbionts.

Introduction

Data on the Trichoptera living in the Italian springs can be found in several chorological catalogues devoted to the Trichoptera of the Alps (Moretti *et al.*, 1976; Cianficconi & Moretti, 1987, 1992), Apuanian Alps (Moretti *et al.*, 1970), Prealps (Cianficconi *et al.*, 1993), Apennines (Moretti, 1950; Campadelli *et al.*, 1990; Cianficconi *et al.*, 1986, 1994) and in publications on Sardegna (Moretti & Cianficconi, 1983; Cianficconi & Moretti, 1990; Moretti *et al.*, 1990), Sicilia (Botosaneanu *et al.*, 1986), Elba (Moretti *et al.*, 1981) and Capraia (Moretti & Pirisinu, 1969). A preliminary study of the Apennine springs was published in 1975 by Moretti & Cianficconi.
Parasites and epibionts of the larvae of some rheocrenous species have also been observed (Corallini Sorcetti, 1981, 1986; Corallini Sorcetti & Moretti, 1987, 1988; Moretti & Corallini Sorcetti, 1976, 1981).
Even though investigation on spring Trichoptera is still in progress in Italy, the present knowledge is sufficient for attempting a faunistic, ecological and zoogeographical account.

Springs investigated

Italy abounds in different types of springs, rheocrenous, limnocrenous and helocrenous, which are often modified by human intervention. During investigations carried out from 1950 (G.P. Moretti) to date, 397 springs have been examined. The highest number was in Lombardia (48, especially in the Prealps); Toscana (45, including the Apuanian Alps); Umbria (43) and Marche (38) (Table I). Some springs were observed occasionally and others regularly with seasonal sampling, various parameters being considered.
The springs are located at different altitudes (from 5 to 2300 m a.s.l.) in forested zones or open grounds. They have different flow rates (from 1 to 36 l/') and aquifers in contact with intrusive (granite, etc.) or sedimentary rocks (dolomite, sandstone, limestone, clay).
The most significant physico-chemical parameters

* Emeritus Professor G.P. Moretti, outstanding representative of Italian entomology and limnology, passed away on 9th April 1997, while the present paper was in press. The editor.

Fig. 1: Toscana: Mount Sant' Egidio. Sant' Egidio spring, 950 m a.s.l. Typical rheocrenous spring in the central Apennines. Trichoptera found: *Catagapetus nigrans, Wormaldia occipitalis, Diplectrona magna, Tinodes maclachlani, Drusus improvisus, Sericostoma pedemontanum, Beraea maurus, Helicopsyche sperata.*

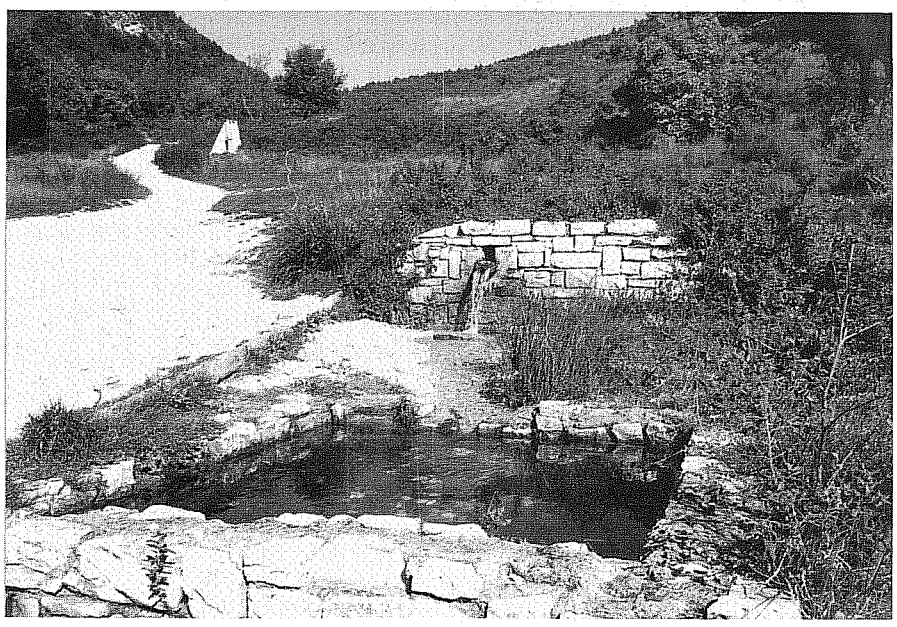

Fig. 2: Umbria. Example of a spring modified by man: Mount Serrasanta, Capodacqua spring, 630 m a.s.l. Pipe installed for drinking water.

Fig. 3: Umbria. Example of a spring modified by man: Mount Subasio, 600 m a.s.l. Troughs ("Trocchi") for drinking water for cattle.

Fig. 4: Emilia- Romagna: Mount Fumaiolo. Spring of River Tiber, 1268 m a.s.l. The spring was enclosed using large stones, without damaging the larvae of the Trichoptera found: *Rhyacophila tristis, Catagapetus nigrans, Philopotamus ludificatus, Drusus improvisus, Potamophylax nigricornis, Chaetopteryx gessneri tomaszewskii.*

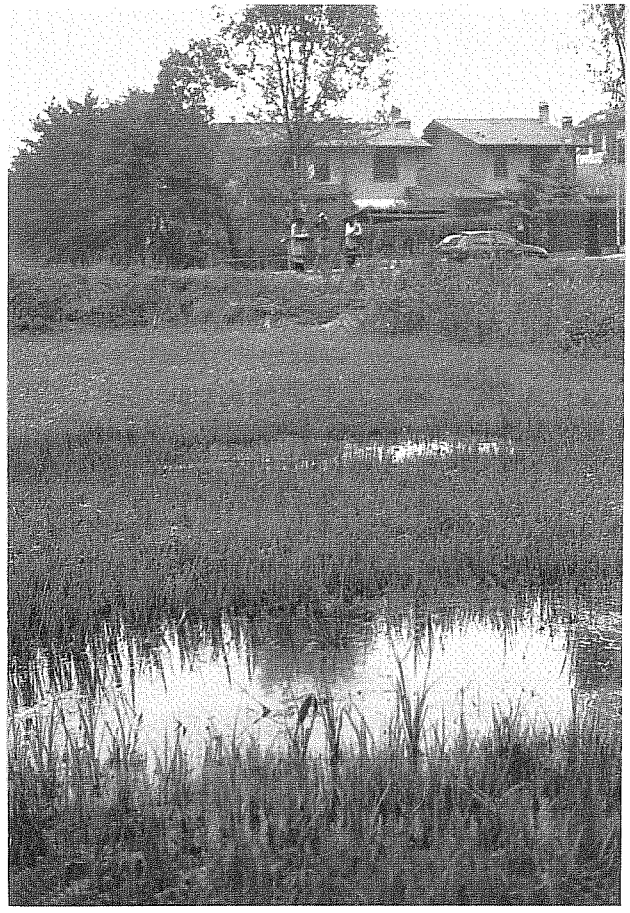

Fig. 5: Lombardia. Brianza, Calendoni, 320 m a.s.l. Two helocrenous springs emerging into cultivated fields. The beds are covered with fallen leaves used by the larvae of *Glyphotaelius pellucidus* for food and construction of cases.

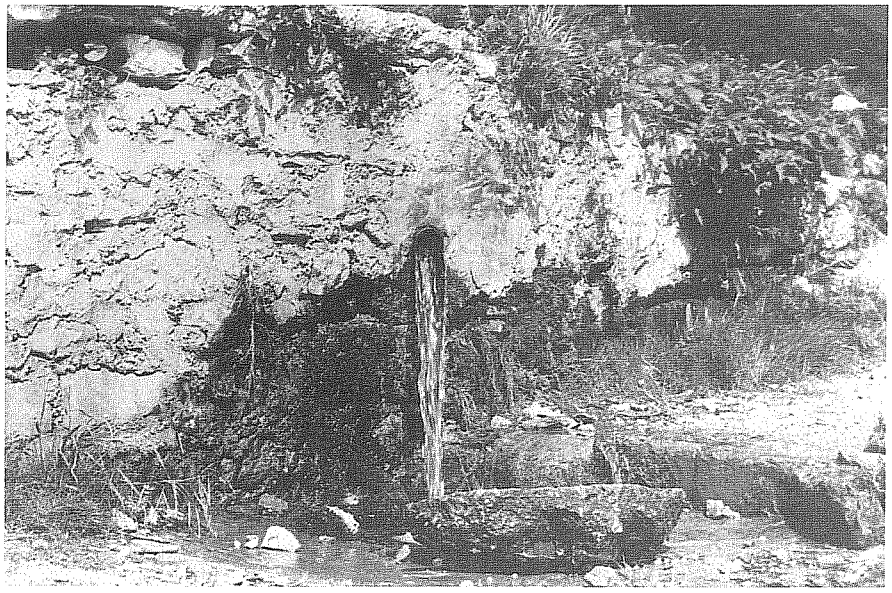

Fig. 6: Umbria: "Marcite di Norcia", 570 m a.s.l. One of several rheocrenous springs feeding the meadows.

Fig. 7: Umbria: "Marcite di Norcia", 570 m a.s.l. Irrigation furrows.

are: nearly uniform temperature throughout the year and the concentration of O_2 usually below saturation point; different levels of water hardness (from 5-7 French degrees on granitic substrate in the Western Alps, Calabria and Sardegna to 10-35 Fr. dgr. on calcareous substrate) and of pH (from 5.5-6.5 on granitic substrate to 7-8 on calcareous substrate).

The majority of the springs studied are rheocrenous with varying characteristics. Most springs rise directly from fissures in the mountain slopes (Fig. 1) or emerge from beds of pebbles and gravel. They are often accompanied by hygropetric habitats.

Algae (especially Bacillariophyceae, Chlorophyceae), mosses of different species (*Cratoneuron filicinum* (Hedw.) Spruce, *Palustriella commutata* (Hedw.) Ochyra, *Rhynchostegium riparioides* (Hedw.) C.E.O. Jens, *Chiloscyphus polyanthos* (L.) Corda, *Fontinalis hypnoides* C. Hartm.) and also

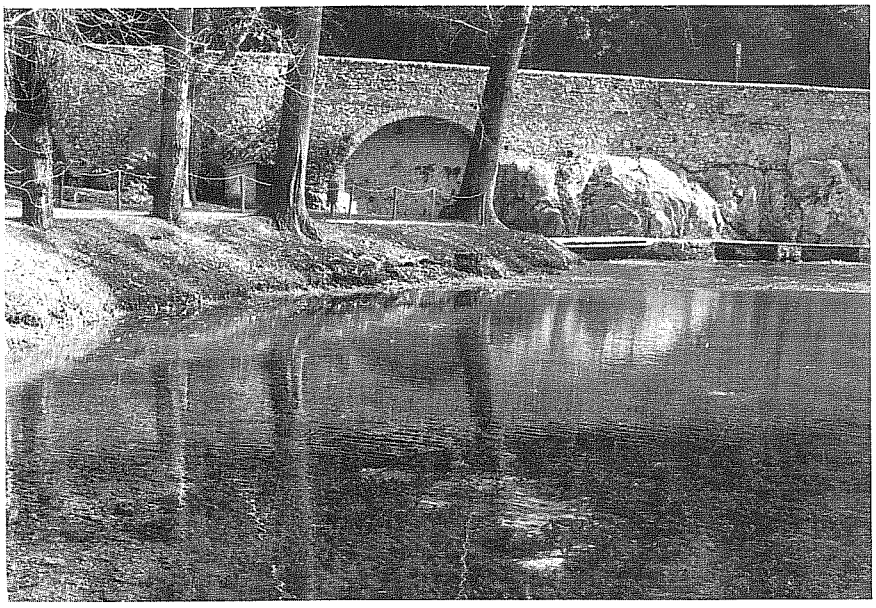

Fig. 8: Umbria: Fonti del Clitunno, 225 m a.s.l. Spring brooks discharging into the pond.

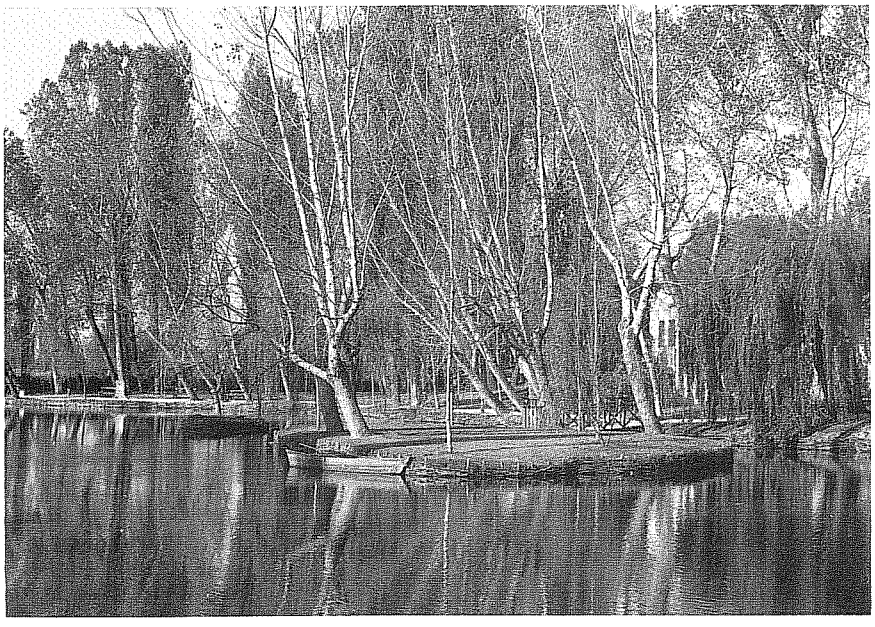

Fig. 9: Umbria: Fonti del Clitunno, 225 m a.s.l. Pond fed by springs emerging from the bed.

phanerogams rooted in the pebbles (*Veronica beccabunga*) may be present.

Resurgences are common in the peninsula. Sulphurous springs (H_2S up to 14 mg/l) with filamentous thiobacteria (*Thiotrix* spp., *Beggiatoa alba*) are frequent in the central Apennines (*e. g.* along the River Nera in Umbria and the River Sentino in Marche). Brackish springs (Cl^- up to 800 mg/l), emerging near sea level, are present in Puglia (River Chidro, River Tara, River Galeso).

Many springs are greatly modified by man in order to provide drinking water for both humans (pipes, fountains, cisterns, aqueducts) and animals (troughs), causing a marked decrease in habitat stability (Figs 2-3-4).

Fewer limnocrenous and helocrenous springs have been studied. Subterranean waters discharging into depressions give rise to limnocrenous ponds, often with growth of aquatic plants (*Ceratophyllum, Potamogeton*), sometimes discharging into streams.

Subterranean water emerging into plains gives rise to helocrenous reed-filled marshes with no drain (Fig. 5).

Some spring systems are difficult to classify.

– The "fontanili" are typical spring habitats found in the Padana and Venetian Plains. They are superficial aquifers brought to the surface by man for irrigating the fields and rice paddies. Small "fontanili" called "lamacchioni" are also found in northern Lazio (Piana di Rieti, 395 m a.s.l.). This plain is the remainder of a Pleistocene lake and is characterized by rheocrenous springs, one of which is canalized (spring Santa Susanna) and by marshes and limnocrenous ponds.

– Spring waters are diverted to irrigate meadows of the Lombard plain and the plain of Santa Scolastica (Umbria: Marcite di Norcia, 570 m a.s.l.). In the "Marcite di Norcia" a great variety of ecotopes is found: rheocrenous springs and spring-brooks, springs issuing from pipes and from stone troughs, limnocrenous springs, hygropetric habitats and small irrigation furrows (Figs 6-7).

– Some springs are both limnocrenous and rheocrenous. For instance, in the "Fonti del Clitunno" (Umbria, 225 m a.s.l.) the deep pond, invaded by submerged hydrophytes, is fed by bubbling springs emerging from the bed and by spring-brooks along the banks, the deep pond discharges into the River Clitunno (Figs 8-9). Likewise, Lake Ninfa, situated in the Lazio Plain (30 m a.s.l.) is a pond fed by spring-brooks.

Trichoptera found

The caddisflies were sampled as larvae, pupae and adults. The adults were collected in daylight and sometimes during the night with light traps. Some larvae were reared in captivity to study the biological cycles of the respective species.

Most species were found in the rheocrenous springs (Table I), but many of them cannot be considered eucrenic because they also inhabit madicolous niches, hypocrenal and rhithral zones, but never rivers and larger streams. Thus, the spring biocenosis is composed not only of crenobionts, but also of crenoxenes and crenophiles. The population differs according to the characteristics of the habitats listed below.

Some crenobionts inhabit the small springs accompanied by hygropetric habitats, (*Oxyethira pirisinui, Microptila minutissima, Crunoecia irrorata, Beraea maurus, Tinodes apuanorum, Ernodes nigroauratus siculus, Helicopsyche sperata*).

The larvae of several species (*e.g. Ptilocolepus granulatus, Rhyacophila pubescens, R. tristis*) prefer springs covered with mosses used both for food

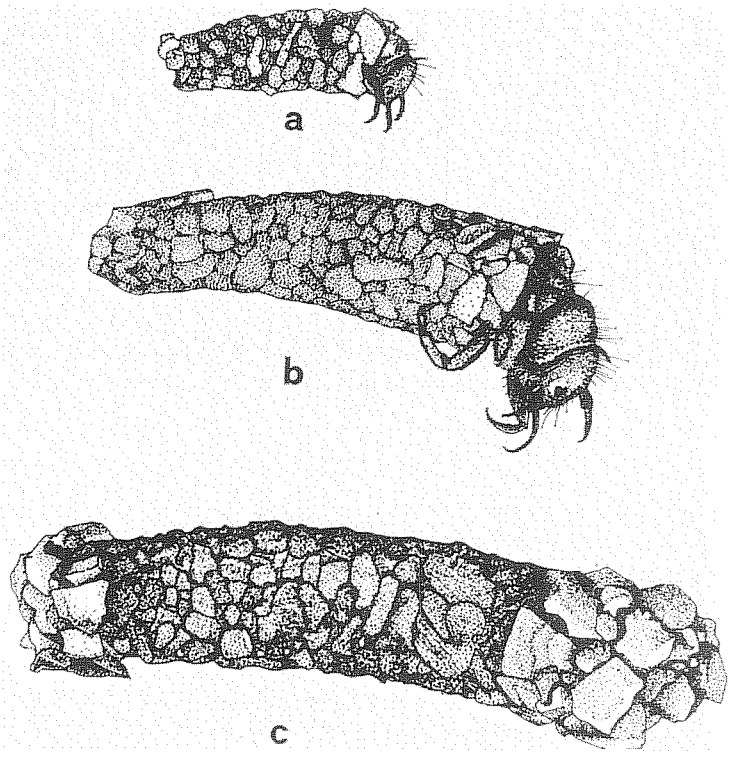

Fig. 10: *Drusus camerinus* young larva (a), full grown larva (b), pupal case (c).

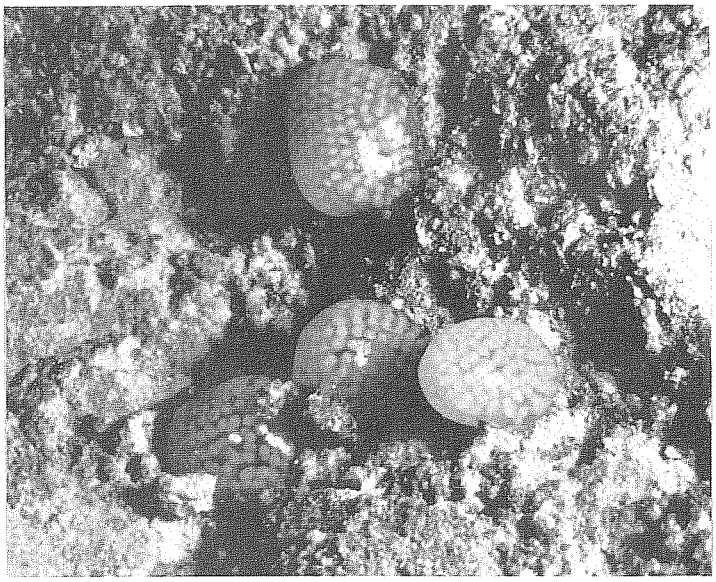

Fig. 11: Egg-masses of *Drusus camerinus*.

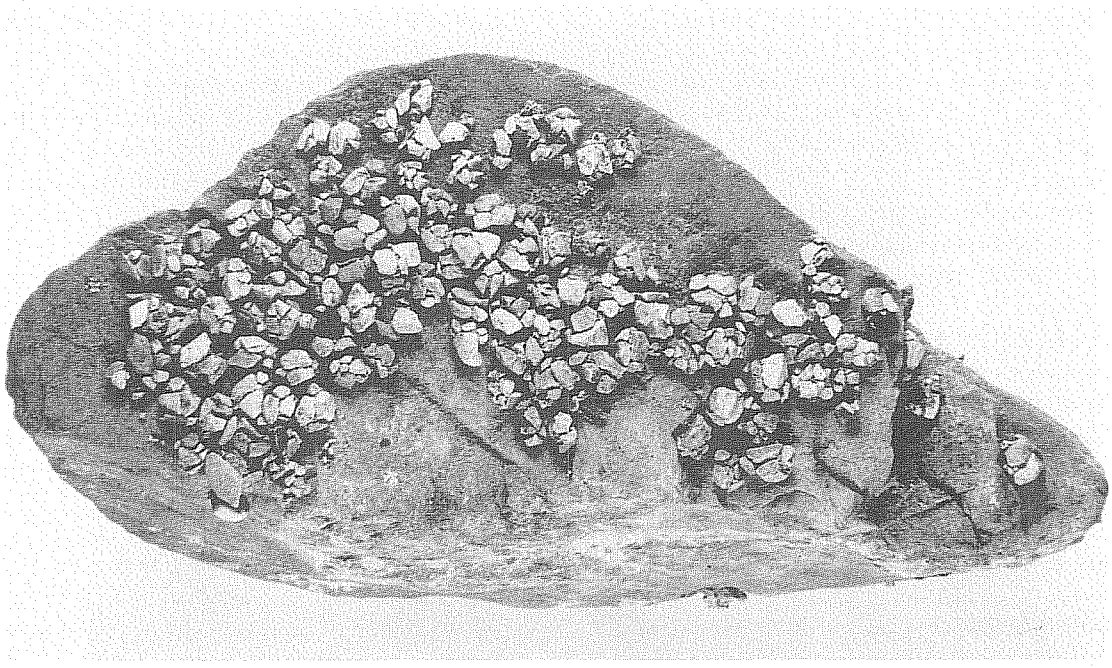

Fig. 12: *Catagapetus nigrans*: cluster of pupal cases on the side of a submerged stone facing the current.

and shelter. The larvae of *P. granulatus* are often found on the moss *Palustriella commutata* which is also used for the construction of cases.

On the sandy bottom of these springs, some larvae are interstitial in their first instars (*Rhyacophila producta, Drusus discolor, Sericostoma pedemontanum*), while they inhabit other zones of the watercourses in the subsequent instars. It was also observed that the last instar larvae of *Drusus camerinus* (Fig. 10:a) and *D. improvisus*, interstitial during daytime (burrowing 20 cm), become epigeal and move up stream at night (Moretti & Cianficconi, 1974).

The larvae of rheocrenous species (*Catagapetus nigrans, Chaetopteryx gessneri tomaszewskii*) are also present along the streams where resurgent waters occur, sometimes masking the longitudinal zonation.

The larvae of *Lasiocephala basalis* may inhabit sul-

phurous springs and feed on filamentous thiobacteria which often cover their cases, head and legs (Cianficconi *et al.*, 1994).
Triaenodes ochreellus lefkas and *Hydroptila sparsa* were found in brackish springs (Cianficconi *et al.*, 1991).
In drinking troughs, larvae of *Tinodes maclachlani* can be found on the walls. Sometimes larvae of *Stenophylax, Allogamus, Sericostoma and Potamophylax* are found on the bottom. Larvae of *Plectrocnemia conspersa, P. geniculata corsicana* and, sometimes of Stenophylacinae are found in the slow-flowing waters coming from the pipes.
Larvae of some Trichoptera species which are cavernicolous as adults may be present, the following examples being of particular interest: *Monocentra lepidoptera*, belonging to a monotypical endemic genus, lives in rheocrenous springs of the western Alps (*e.g.* Piemonte: spring of River Po, Piano del Re, 2020 m a.s.l.) but the adults were also found in Ligurian caves at low altitudes (Cianficconi & Moretti, 1992). *Philopotamus ludificatus*, crenophilous in the central-northern Apennines, has hypogeal aquatic instars and adults in Friuli - Venezia Giulia (this phenomenon was observed for five consecutive years in Grotta di Attila - Moretti & Cianficconi, 1993).
There are few species living in limnocrenous and helocrenous springs. In the former, lentic species are prevalent; the most common are: *Limnephilus helveticus, L. lunatus, L. rhombicus rhombicus, L. rhombicus reseri*. In the latter, in addition to the above species, *Glyphotaelius pellucidus* can be found.
In spring systems of difficult typology, species belonging to different ecological categories were found. The "fontanili" can host crenobionts (*Agapetus nimbulus, Chaetopteryx gessneri, Helicopsyche sperata*), rhithrobionts (*Odontocerum albicorne, Silo nigricornis, Sericostoma personatum, Anabolia lombarda*) and lentic species (*Limnephilus lunatus*) (Moretti, 1934). Similarly in the "Piana di Rieti" there are crenobionts (*A. nimbulus, Hydroptila martini, Tinodes maclachlani, C. gessneri tomaszewskii, Crunoecia irrorata, Beraea maurus, H. sperata*), rhithrobionts (*Silo mediterraneus saturniae, Sericostoma italicum*) and lentic species (*Limnephilus helveticus, L. lunatus, L. rhombicus rhombicus*) (Cianficconi *et al.*, 1985).
In the "Marcite di Norcia" the presence of species varies according to the different habitats: *Crunoecia irrorata, Agapetus nimbulus, Adicella cremisa* inhabit the springs; *Wormaldia occipitalis, Odontocerum albicorne* and *Sericostoma italicum* the irrigation furrows and *Limnephilus lunatus* the ponds (Cianficconi & Moretti, 1988).
Rheocrenous species (*Agapetus nimbulus, Hydroptila martini, Tinodes maclachlani, Chaetopteryx gessneri tomaszewskii,Silo mediterraneus saturniae, Plectrocnemia conspersa*) and lentic species (*Limnephilus lunatus, L. rhombicus reseri*) cohabit in the spring system of " Fonti del Clitunno". In some small areas of this system *Beraeodes minutus* and *Erotesis baltica* were found (Moretti, 1949).
In Lake Ninfa crenophilous species (*Plectrocnemia conspersa, Wormaldia occipitalis, Silo mediterraneus saturniae*) coexist with lentic species (*Tinodes waeneri, Leptocerus tineiformis*) and with *Glyphotaelius pellucidus*.
Some aspects of the behaviour of rheocrenous Trichoptera may be mentioned here. The adults of some crenobionts do not move far from the biotopes which they inhabit as aquatic instars, and they are not attracted by lighttraps (*Catagapetus nigrans, Crunœcia irrorata*). Species which emerge in winter (*Drusus camerinus*) (Fig. 11), in autumn (*Chaetopteryx gessneri tomaszewskii*), in summer (*Catagapetus nigrans*) or throughout the year (*Wormaldia mediana, W. occipitalis*), were found in the springs.
Finally, there are crenobionts which can be considered as mountain species (*Monocentra lepidoptera, Chaetopteryx vulture*), as high hill species (*Drusus improvisus*), or as low hill species (*D. camerinus, Adicella cremisa*).

Ecological and chorological remarks

In Table I the species found in springs in the various Italian regions are listed as in the Limnofauna Europaea (Botosaneanu & Malicky, 1978), and their ecological valence is shown.
In almost all the regions, there is a strong correlation between the number of species found and the number of springs examined.
To date 117 species and 19 subspecies belonging to 47 genera and 17 families have been found. 46 taxa are endemic to Italy (marked E in Table I). All families of the Italian fauna, except Ecnomidae and Phryganeidae, are present in crenal biotopes.
Of the 129 species found in rheocrenous springs, 43 can be considered true crenobionts, 22 of which are endemic to Italy. The highest number of creno-bionts belongs to the Beraeidae family (9 of the 17 species found in Italy) and the genera *Drusus* (Fig. 13) and *Chaetopteryx* (Fig. 14). The highest number of crenoxenes belongs to the genera *Wormaldia* (10 species), *Tinodes* (7), *Potamophylax* (5) and *Silo* (4).
Among the crenobionts, the most widespread and most frequently found in the Italian regions are *Catagapetus nigrans* (86 springs in 12 regions) (Fig. 12) and *Crunoecia irrorata* (75 springs in 12 regions),

Table 1: List of Italian spring Trichoptera updated to 1996. The numbers indicate total number of springs in the regions where each species was found. The symbols in the last column indicate the ecological valence of each species found. ● only in the rheocrenous springs; ■ in rheocrenous springs associated with hygropetric habitats; ▲ in limnocrenous springs; no symbol indicates species also present in other zones of the watercourses

		REGIONS AND ISLANDS / TAXA	Piemonte	Valle d'Aosta	Liguria	Lombardia	Trentino A. Adige	Veneto	Friuli V.Giulia	Emilia Romagna	Toscana	Umbria	Marche	Lazio	Abruzzo	Molise	Campania	Puglia	Basilicata	Calabria	Sicilia	Sardegna	Elba	Capraia	Total springs	Ecological valence
		Rhyacophilidae																								
E	1	Rhyacophila appennina McL.			1						5														6	●
	2	R. aquitanica McL.				4	1	1																	6	
	3	R. aurata Brauer				2	2		1																5	
	4	R. bonaparti Schmid				2	1																		3	
E	5	R. foliacea Moretti										2	5	2	2	2									13	
	6	R. hirticornis hirticornis McL.						1	1																2	
E	7	R. hirticornis orobica Moretti				3																			3	●
	8	R. kelnerae Schmid	5								3														8	
	9	R. laevis Pictet				2	1				1														4	●
	10	R. meyeri McL.	6								6														12	
	11	R. producta McL.				3			1																4	
	12	R. pubescens Pictet			2						1	6	3	1	1				2						16	
	13	R. trifasciata Mosely																				1			1	
	14	R. tristis Pictet	5	2		5			4	5	10	3	3	1	3				3						44	
		Glossosomatidae																								
E	15	Catagapetus nigrans McL.	2		10					5	16	9	17		4	1	1		4	16			1		86	●
	16	Synagapetus dubitans McL.				2		1																	3	
	17	Agapetus cymensis Mosely																				4			4	
	18	A. fuscipes Curtis						7							1										8	
	19	A. nimbulus McL.										2	4	1	5				1		3				16	●
		Hydroptilidae																								
	20	Ptilocolepus granulatus Pictet	1		2	11	1				14		3						2						36	
	21	Oxyethira falcata Morton												1				1			1				3	
E	22	O. hartigi Moretti																				2			2	●
	23	O. pirisinui Moretti																				1		1	2	■
	24	Hydroptila martini Marshall										1		2											3	
	25	H. sparsa Curtis																3							3	
	26	Microptila minutissima Ris				2																			2	■
		Philopotamidae																								
	27	Philopotamus ludificatus McL.	8			8			2	2	6		8		1										35	
E	28	P. montanus siculus Hagen																	1	8	14				23	
E	29	Wormaldia copiosa botosaneanui M.								1	3	2	4												10	
	30	W. copiosa copiosa McL.	3			3			14		3														23	
	31	W. mediana mediana McL.									6				3	1									10	
E	32	W. mediana nielseni Moretti																	2	8	2				12	
E	33	W. occipitalis morettii Viganò								2	4		3												9	
	34	W. occipitalis occipitalis Pictet	2			13		2	1	1	21	9	3	1	3				4	6					66	
E	35	W. pulla marlieri Moretti									1														1	
	36	W. pulla pulla McL.				2					1														3	
	37	W. triangulifera McL.	1								1														2	
E	38	W. variegata denisi Moretti																					1		1	●
E	39	W. variegata maclachlani Kimmins	1																						1	●
	40	W. variegata variegata Mosely																				6			6	
		Hydropsychidae																								
	41	Diplectrona atra McL.	1		1	11																			13	
	42	D. magna Mosely									6								1	4			2		13	●
		Polycentropodidae																								
	43	Plectrocnemia appennina McL.									2									1					3	●
	44	P. brevis McL.													1										1	●
	45	P. conspersa Curtis	1			1						6	1	1	4	1									15	
E	46	P. geniculata calabrica Malicky																	4	1					5	●
	47	P. geniculata corsicana Mosely	1			5						10	5	1	4	1						2	1	1	31	●
E	48	P. geniculata factiosa Moretti																			4				4	
		Psychomyidae																								
E	49	Lype phaeopa meridionalis Moretti																		4	4				8	
	50	L. reducta Hagen										4			1						2				7	
E	51	Tinodes antonioi Bots. & Viganò Tat.									3	5	1		1	1			1						12	
E	52	T. apuanorum Moretti									4														4	■
E	53	T. bruttius Moretti																		1					1	
E	54	T. dives consiglioi Botosaneanu			3					1	5	1	1	2	5	1									19	
	55	T. dives dives Pictet		1		6			1																8	
E	56	T. locuples McL.																			3				3	
	57	T. maclachlani Kimmins	1			2		8			30	9	6	4	2			3		4	3	5	1		78	
	58	T. pallidulus McL.							1																1	
	59	T. sylvia Ris			1	1				1					1										4	●
		Brachycentridae																								
	60	Micrasema morosum McL.				8			2		1		3	1	4				1						20	
		Limnephilidae																								
	61	Apatania fimbriata Pictet	2	2																					4	
E	62	A. volscorum Moretti												1											1	●
E	63	Drusus aprutiensis Moretti												1	9										10	●
	64	D. biguttatus Pictet				3			1																4	
E	65	D. camerinus Moretti										6	12												18	●
	66	D. discolor Rambur	6			4			1																11	
E	67	D. improvisus McL.								3	18	9	9	1	1										41	●
	68	D. melanchaetes McL.	1	1		1																			3	
	69	D. monticola McL.				1																			1	
	70	D. nigrescens Meyer-Dür				3																			3	

		TAXA \ REGIONS AND ISLANDS	Piemonte	Valle d'Aosta	Liguria	Lombardia	Trentino A. Adige	Veneto	Friuli V.Giulia	Emilia Romagna	Toscana	Umbria	Marche	Lazio	Abruzzo	Molise	Campania	Puglia	Basilicata	Calabria	Sicilia	Sardegna	Elba	Capraia	Total springs	Ecological valence
	71	Ecclisopteryx guttulata Pictet				1					2	1	1			1			1						7	
	72	E. madida McL.							1																1	
	73	Leptodrusus budtzi Ulmer																				4			4	
E	74	Monocentra lepidoptera Rambur	9		1						3														13	
	75	Limnephilus helveticus Schmid												3	2		1								6	▲
	76	L. lunatus Curtis							1			6	1	1	1	1			3	1	1				16	▲
	77	L. rhombicus rhombicus L.												1	2										3	▲
	78	L. rhombicus reseri Malicky					1					1													2	▲
	79	Glyphotaelius pellucidus Retz.				1						1													2	▲
	80	Anabolia lombarda Ris.				1																			1	
	81	Rhadicoleptus alpestris Kol				1																			1	
	82	Potamophylax cingulatus alpinus Tob	2			2	2		1																7	
E	83	P. gambaricus gambaricus Malicky																	3	4	2				9	
E	84	P. gambaricus spinulifer Moretti				1				1	7	11	8	3	4	3		1							39	
E	85	P. inermis Moretti & Cianficconi											1	3	3										7	
	86	P. nigricornis Pictet				1				1	3														5	
	87	Halesus rubricollis Pictet	1	1		1																			3	
	88	Melampophylax melampus McL.								1	1	2	7		4					2					17	
E	89	M. vestinorum Moretti													1					1					2	●
	90	Parachiona picicornis Pictet	1	1			1	1																	4	●
	91	Stenophylax mitis McL.			1					1	1	8	3		1						1				16	
	92	Micropterna sequax McL.				2				1	1	2			1	1				1					9	
	93	M. wageneri Mal.								1	3														4	
	94	Allogamus antennatus McL.										3													3	
E	95	A. illiesorum Botosaneanu																				3			3	
	96	A. mendax McL.	2																						2	
	97	A. uncatus Brauer		1																					1	
E	98	Chaetopteryx euganea Moretti & Mal						1																	1	●
	99	C. fusca Brauer							1																1	●
	100	C. gessneri gessneri McL.	1			1																			2	
E	101	C. gessneri tomaszewskii Moretti								3	1	2	8	3	8	2									27	●
E	102	C. trinacriae Bots.Cianf.& Moretti																			3				3	●
E	103	C. vulture Malicky																	1	4					5	●
		Goeridae																								
	104	Lithax niger Hagen	1																						1	
E	105	Silo mediterraneus mediterraneus McL.																				1			1	
E	106	S. mediterraneus saturniae Moretti									7	5	6	4	6	3									31	
	107	S. nigricornis Pictet	1			6	5	6	3										1	4					26	
	108	S. pallipes Fabricius							1																1	
	109	Silonella aurata Hagen																				5			5	
		Thremmatidae																								
	110	Thremma sardoum Costa																				2			2	
		Lepidostomatidae																								
	111	Lasiocephala basalis Kol.										2								1					3	
	112	Crunoecia irrorata irrorata Curtis				6		8	2		18	15	11	2	4	1			1	6	1				75	■
E	113	C. irrorata sarda Malicky																				4			4	●
		Leptoceridea																								
	114	Triaenodes ochreellus Iefkas Mal.																3							3	
	115	Erotesis baltica McL.										1													1	▲
	116	Adicella cremisa Malicky							1			1													2	●
	117	A. filicornis Pictet		1		3					6														10	●
		Sericostomatidae																								
E	118	Sericostoma italicum Moretti										3		2	12	4									21	
E	119	S. maclachlanianum Costa																				7			7	
E	120	S. pedemontanum McL.								5	14	12	10						1				1		43	
	121	S. personatum Spence				1	1																		2	
E	122	S. siculum McL.																	8	14	11				33	
		Beraeidae																								
E	123	Beraea botosaneanui Moretti																				2			2	
E	124	B. crichtoni Moretti																	3	2					5	●
	125	B. dira McL.				1		6	1																8	●
E	126	B. ilvae Moretti																					1		1	●
	127	B. maurus Curtis	1			5		2			6	7	4	1	5									1	32	■
	128	Beraeodes minutus L.										1													1	▲
	129	Ernodes articularis Pictet				1			1																2	●
	130	E. botosaneanui Vaillant			1																				1	●
	131	E. nigroauratus nigroauratus Mosely								1	11								1	1	1				15	●
E	132	E. nigroauratus siculus Malicky																			2				2	■
	133	E. vicinus McL.			1	7		1																	9	●
		Helicopsychidae																								
	134	Helicopsyche revelieri McL.																				2		1	3	●
E	135	H. sperata McL.									7	2	2	1	2				5	7	6		1		33	■
		Odontoceridae																								
	136	Odontocerum albicorne Scop.	2			5			1		12	5	2		1		1		2	9	4				44	
		Total species	27	8	11	45	10	13	23	19	42	37	31	26	36	15	3	5	23	25	19	16	8	4		
		Total springs	9	4	9	48	5	17	9	5	45	43	38	11	33	8	3	3	8	34	30	30	4	1	397	

Table 2: Trichoptera and their symbionts

TRICHOPTERA	ENDOPARASITES	EPIBIONTS
Rhyacophila foliacea	Asterophora mucronata Léger	
Rhyacophila tristis	Asterophora mucronata Léger	
● Catagapetus nigrans	Gregarina pusilla Baudoin	
● Diplectrona magna	Gregarina sp.	
● Tinodes maclachlani	Gregarina pusilla Baudoin	
● Apatania volscorum	Pileocephalus sinensis Schneider Asterophora heeri Koliker	Epistylis breviramosa Stiller ROTATORIA: Philodina sp.
● Drusus aprutiensis	Gregarina fontinalis Zwetkow Gregarina mystacidarum Frantzius	
● Drusus camerinus	Gregarina fontinalis Zwetkow	
● Drusus improvisus	Gregarina fontinalis Zwetkow Gregarina mystacidarum Frantzius Gregarina pusilla Baudoin Gregarina sp. Pileocephalus lanceatus Baudoin TREMATODA: cyst	Epistylis breviramosa Stiller ROTATORIA: Philodina sp.
Leptodrusus budtzi	Gregarina limnophili Zwetkow Gregarina stenophylacis Zwetkow	
Limnephilus rhombicus	Gregarina limnophili Zwetkow	
Limnephilus rhombicus reseri	Gregarina limnophili Zwetkow	Epistylis rotans Sveç ROTATORIA: Philodina sp.
Potamophylax gambaricus gambaricus	Pomania cianficconii Corallini Sorcetti NEMATOMORPHA: cyst	
Potamophylax gambaricus spinulifer	Pileocephalus caudatus Corallini Sorcetti	
Potamophylax inermis	Pomania morettii Corallini Sorcetti	Epistylis breviramosa Stiller
Potamophylax nigricornis	Gregarina stenophylacis Zwetkow	
□ Potamophylax sp.	Gregarina stenophylacis Zwetkow Pileocephalus agilis Geus Pileocephalus glyphotaeli Stein	Epistylis breviramosa Stiller
□ Micropterna sp.	Gregarina fontinalis Zwetkow Gregarina limnophili Zwetkow Pileocephalus sinensis Schneider	Epistylis plicatilis Ehremberg ROTATORIA: Philodina sp.
□ Allogamus antennatus	Gregarina stenophylacis Zwetkow Pileocephalus glyphotaeli Stein Pileocephalus lanceatus Baudoin Pomania sp.	
□ Allogamus sp.	Gregarina limnophili Zwetkow Pileocephalus sinensis Schneider	Epistylis breviramosa Stiller
● Chaetopteryx gessneri tomaszewskii	Gregarina limnophili Zwetkow	
Silonella aurata		Epistylis breviramosa Stiller
Lasiocephala basalis	Pileocephalus agilis Geus	Vorticella sp. Carchesium polipinum Linnè Epistylis breviramosa Stiller Epistylis rotans Sveç
Sericostoma pedemontanum	Gregarina sericostomae Baudoin	
Sericostoma personatum	Gregarina sericostomae Baudoin	
Odontocerum albicorne	Gregarina sericostomae Baudoin Pileocephalus lanceatus Baudoin Asterophora tiaroides Baudoin	

● Crenobiont
□ in "drinking troughs"

and among the crenoxenes *Tinodes maclachlani* (78 springs in 12 regions) and *Wormaldia occipitalis* (62 springs in 12 regions). On the contrary, some species, even though present in several regions, were found only in a few springs (*Tinodes antonioi, Ecclisopteryx guttulata, Micropterna sequax*). Others were found in a limited number of springs and regions (*Tinodes sylvia, Potamophylax nigricornis, Adicella cremisa*).

By analyzing the geographical distribution, some observations can be made.

– 34 species were found in springs only in northern Italy, some of them with a restricted distribution: *Drusus monticola, D. nigrescens, Anabolia lombarda* and *Rhadicoleptus alpestris* in Lombardia; *Lithax niger* in Piemonte; *Silo pallipes* in Friuli-Venezia Giulia, *Chaetopteryx euganea*, endemic to Veneto; *Rhyacophila hirticornis orobica*, endemic to Lombardia; *Wormaldia variegata maclachlani* endemic to Piemonte. Some species of northern Italy extend into Toscana (Apuanian Alps): *Rhyacophila appennina, R. laevis, Monocentra lepidoptera.*

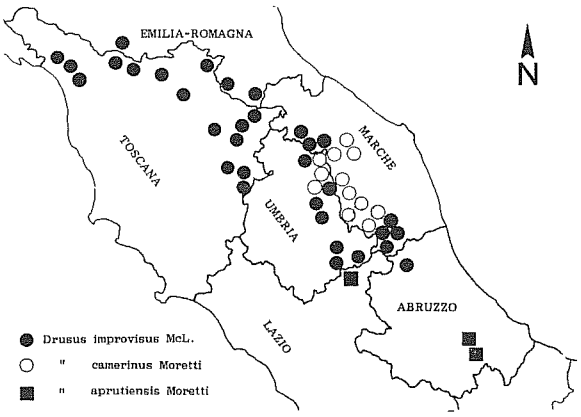

Fig. 13: Geographical distribution of three species of the genus *Drusus* in central Italy.

– 22 taxa were found in springs only in central Italy; of these 7 species and 4 subspecies are endemic to Italy: *Tinodes apuanorum* and *Wormaldia pulla marlieri* to Toscana; *Apatania volscorum* to Lazio; *Drusus camerinus* to Umbria and Marche; *Drusus aprutiensis* to Lazio and Abruzzo; *Potamophylax inermis* to Marche, Lazio and Abruzzo; *Drusus improvisus* and *Chaetopteryx gessneri tomaszewskii* from Emilia- Romagna to Molise; *Wormaldia occipitalis morettii* from Emilia-Romagna to Marche; *Silo mediterraneus saturniae* from Toscana to Molise; *Sericostoma italicum* from Umbria to Molise.

– 5 species and 3 subspecies are endemic only to southern Italy: *Tinodes bruttius* to Calabria; *Plectrocnemia geniculata calabrica, Chaetopteryx vulture* and *Beraea crichtoni* to Basilicata and Calabria; *Philopotamus montanus siculus, Wormaldia mediana nielseni, Potamophylax gambaricus gambaricus, Sericostoma siculum* to Basilicata, Calabria and Sicilia.

– 6 species were found in springs only in central-southern Italy: *Diplectrona magna, Tinodes sylvia, Plectrocnemia appennina, Ernodes nigroauratus, Helicopsyche sperata* and *Melampophylax vestinorum* endemic to Abruzzo and Calabria.

– 15 species and 4 subspecies are limited to the islands: *Plectrocnemia geniculata factiosa, Tinodes locuples, Chaetopteryx trinacriae* and *Ernodes nigroauratus siculus* to Sicilia; *Rhyacophila trifasciata, Agapetus cyrnensis, Oxyethira hartigi, Wormaldia variegata variegata, Leptodrusus budtzi, Silo mediterraneus mediterraneus, Silonella aurata, Thremma sardoum, Crunoecia irrorata sarda, Sericostoma maclachlanianum* and *Beraea botosaneanui* to Sardegna; *Wormaldia variegata denisi* and *Beraea ilvae* to Elba; *Oxyethira pirisinui* and *Helicopsyche revelieri* to Sardegna and Capraia.

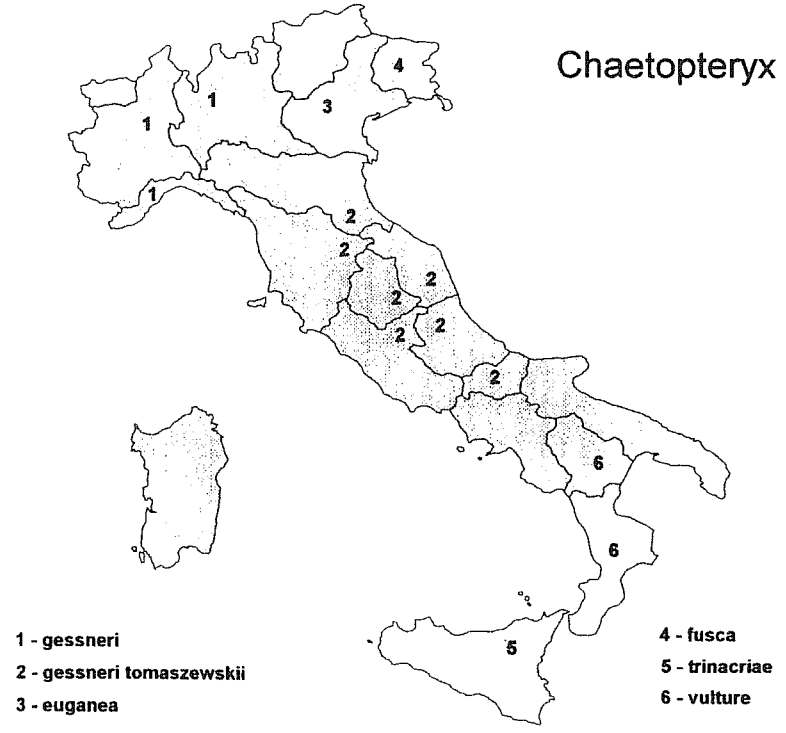

Fig. 14: Geographical distribution of 6 vicariant species of the genus *Chaetopteryx* present in Italian springs.

Parasites and Epibionts

In the larvae of some species of Trichoptera collected from spring waters, the presence of symbionts was observed. These are endoparasites such as Protozoa Gregarinida, cysts of Trematoda and Nematomorpha, and epibionts such as Protozoa Peritricha and Rotatoria. Table II, updated to 1996, shows the Trichoptera infested and their symbionts.

While numerous observations were made of species which inhabit central and southern Italy and the islands, no observations were made of larvae of species belonging to the following genera: *Rhyacophila, Microptila, Tinodes, Apatania, Drusus, Rhadicoleptus, Lithax, Beraea, Ernodes*, which are present only in the springs of northern Italy (see Table I).

Infested larvae were found in various types of springs except those with brackish water. It has been observed that larvae of the same species collected in springs or streams, do not show any difference as far as symbiotic phenomena are concerned.

Among the crenobionts, the species *Catagapetus nigrans* and *Diplectrona magna* are those less infested, while *Drusus improvisus* acts as host to a great number of symbionts, 56% of the larvae collected from the springs of the River Tiber having gregarines and among these larvae 27% being infested by several species at the same time. In the successive larval instars of *Drusus improvisus* the parasites repeat their cycles thus causing phenomena of reinfection; 266 protozoans were found in one larva of this species. In the case of *Apatania volscorum* more than 50% of the larvae were found to be infested by two species of gregarines with a maximum density of 60 - 70 protozoans per host.

Crenobiont Trichoptera with endoparasites are infested almost exclusively by gregarines belonging mainly to the genus *Gregarina*; the presence of cysts of Trematoda was noted only in one larva of *Drusus improvisus.*

Epistylis breviramosa is the peritrichous ciliate which has been most frequently observed up to now on both crenophile-crenoxene and crenobiont species. *E. breviramosa* is characterized by small colonies with few ramifications and short stalks and usually colonizes case-making caddis larvae.

Lasiocephala basalis, collected from sulphurous waters, acts as host to 4 species of peritrichous ciliates which form large and dense colonies in spite of the presence of a case, probably because of the Thiobacteria present in the water. These bacteria provide abundant food and can cover the larvae.

Philodina sp. is the only genus of Rotatoria which colonizes larvae. It is found either near the mouth or the anal opening of the host, feeding on its food or faeces.

Larvae inhabiting "drinking troughs" also present phenomena of symbiosis. They can act as hosts to several species of Gregarinida at the same time and infestation can reach high levels (80 - 100 gregarines per host in the case of *Micropterna* sp.). Larger colonies of Peritricha can be observed during the spring owing to the presence of algal blooms and higher quantities of organic matter.

Concluding remarks

The high number and diversity of the springs investigated (rheocrenous, limnocrenous, helocrenous etc., often modified by man), together with the large number of samplings in various microhabitats allow us to describe the composition and the ecological specialization of the populations.

The presence of Trichoptera in the springs depends on ecological factors (altitude, water temperature, flow rate, vegetation, type of substrate and of food available), and on historical factors (ancient origin of Italian fauna from various continental plates, subsequent isolation and Pleistocene glaciations).

In the rheocrenous springs the Trichoptera coenosis is composed of taxa with high ecological specialization (crenobionts), of taxa which, though abundant, are not exclusive to this environment (crenophiles) and of transitional elements equally present in the Crenal and Rhithral zones (crenoxenes). The number of true crenobionts in the Italian springs is high (43), because it includes both species with European distribution (21) and Italian endemic species (22) with more or less limited distribution. It is possible that species presently considered as crenobionts will be found in other ecotopes in the near future.

The known distribution of some non-endemic crenobionts is limited in Italy to the Alpine chain (*Parachiona picicornis, Chaetopteryx fusca, Beraea dira, Ernodes articularis, E. botosaneanui, E. vicinus*) and to the Prealps (*Microptila minutissima*).

The endemic crenobionts are found in the Islands (Sardegna 2, Sicilia 2, Elba 2), in the northern Regions (3), but above all in the central-southern Apennines in small isolated and well preserved springs characterized by cool waters. The speciation process during the post-glacial period may have been active in some of these springs, speciation being the result of the isolation of European elements which arrived in the peninsula via the Alps during the Pleistocene glaciations.

Unfortunately, in some springs human impact (grazing, canalization, etc.) can lead to reduction and even disappearance of endemic crenobionts and crenophilous species. To safeguard them, it is indispensable, during canalization, to leave at least one small

spring watercourse in order to ensure the survival of the aquatic stages of these insects.

The larvae of Trichoptera present in springs and involved in symbiotic phenomena act as hosts mainly for gregarines. Among the crenobionts, *Drusus improvisus* presents not only the highest number of symbionts but also a massive infestation by gregarines. Probably the presence of the larval stages of the host throughout the year favours the completion of continuous cycles of the parasites and thus reinfections.

The most widespread genera are *Gregarina* and *Pileocephalus*. Generally there is no parasitic specificity but up to now *Pomania cianficconii and Pomania morettii* have been found only in the endemic Italian *Potamophylax gambaricus gambaricus* and *Potamophylax inermis*, respectively.

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