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Centipede assemblages (Chilopoda) in forest habitat of the Anti-Apennines (Central Italy): species composition and quantitative structure

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SUMMARY

Species composition and structure of Chilopoda assemblages were studied between 1992 and 1997 by hand collecting and pitfall trapping in three seminatural forest habitats of the Lepini Mountains area, Central Apennines, Lazio, Italy: *Quercus ilex* forest (3 sites), *Q. cerris* forest (1 site) and *Fagus sylvatica* forest (3 sites). Analyses of species composition, chorotype spectrum, dominance structure, and diversity were performed. A total of 30 species were collected (about half of the species thus far identified in Lazio). The greatest species diversity, 21 species, was found in beechwoods; meanwhile slightly fewer species were found in holm oak, 17-20 species, and in Turkey oakwoods, 17 species. From a zoogeographical point of view, the species recorded mostly belong to the European and Mediterranean main chorotypes. The ratio of European species was higher in *Fagus* dominated sites (52.4-61.9%), whereas the ratio of Mediterranean species was higher in *Quercus ilex* (20.0-30.0%) and *Q. cerris* (23.5%) woods; the ratio of Holoarctic (Asiatic-European) species was low in all of the tested sites (4.8-11.8%). In hand collecting sampling, the Apennine endemic *Eupolybothrus fasciatus* (Newport, 1845), a forest thermophilous species, was found to be the dominant species at the *Quercus ilex* and *Q. cerris* sites, whereas the south-European *Lithobius castaneus* Newport, 1844, which inhabits a wide range of forest habitats in Italy, was found to be the dominant species in beechwoods. The studied assemblages are almost homogeneous as far as concern the biodiversity values and the structure of dominance, which is generally complex. Some differences were recorded in evens values, probably due to edaphic or anthropic factors.

INTRODUCTION

Numerous studies on the composition and the structure of centipede assemblages in Italy have been carried out in recent years. Such studies have mainly been done in the North-oriental regions, where North Adriatic coastal habitats (Glerean, 2003), Padano-venetian flatland plain woods (Minelli, 1982; Zapparoli, 2004), mountain woods and alpine prairies of the Oriental Alps (Minelli, 1981, 1988) have been investigated. Despite some national and regio-

nal syntheses (Minelli and Iovane, 1987; Zapparoli, 1992b, 2006a), knowledge about the subject remains patchy. Knowledge is especially lacking for peninsular and insular regions, about which, besides a study on agroecosystems of the northern Lazio (Zapparoli, 1996), only the Mediterranean and montane forest of Central Italy have been analyzed thus far (Minelli and Zapparoli, 1986; Zapparoli, 1992a; Zapparoli and Biondi, 2007).

The aim of this work is to show the results of a pluriannual analysis of the assemblages of these arthropods inhabiting a particular area of the central Apennines, namely the Lepini Mountains. This is an area of particular naturalistic interest because several geological, paleontological, vegetational and faunistic occurrences (Corsetti, 2006).

STUDY AREA AND SAMPLING SITES

The Lepini Mountains are located in southern Lazio (provinces of Rome, Frosinone and Latina) and are delimited by the saddleback of Lariano and Valmontone, on the northwest, a series of depressions aligned in the southeast direction from the Sacco River to Colle del Vento, on the north, the Valle Fratta and the course of the Amaseno River, on the east, and the Pontina Plain on the southern edge (Landi Vittorj, 1989) (Fig. 1). They encompass an area of approxi-

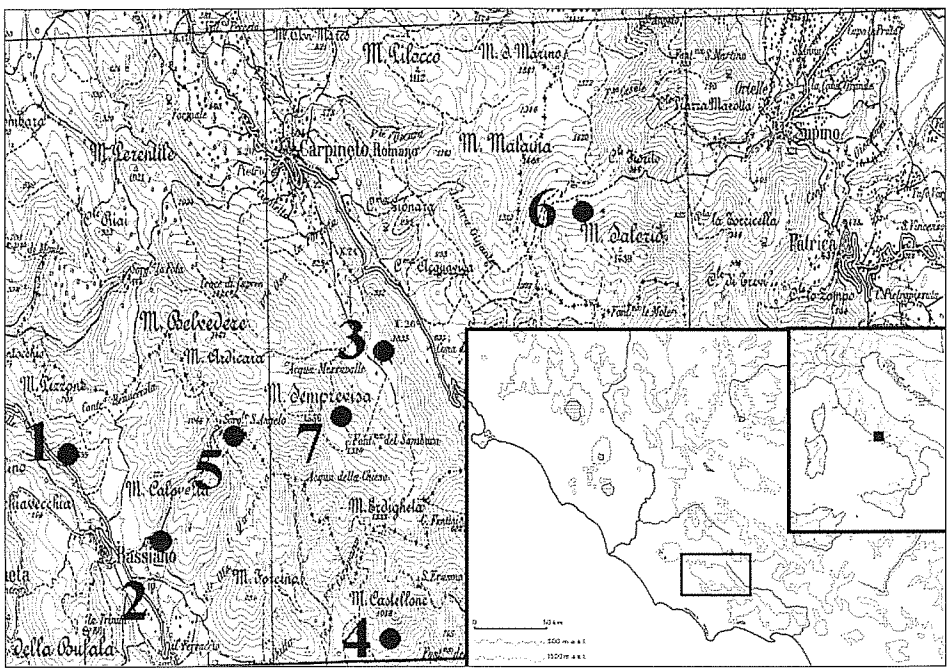

Fig. 1 - Chilopoda assemblages in forest habitats of the Lepini Mountains: study area and sampling sites

mately 800 km^2 (maximum elevation: 1,536 m above sea level, Mount Semprevisa) of Mesozoic origin essentially constituted by Cretaceous calcareous rocks pertaining to the Lazio-abruzzese series, mostly in facies of carbonate platform.

According to the phytoclimatic subdivision of the Lazio proposed by Blasi (1994), the area investigated herein is included into the two following regions:

1) Temperate Region, of which the following three phytoclimatic units are represented:

- "Lower mountain thermotype, superior humid/inferior hyperhumid umbrotype, cold mesaxeric/axeric region (hypomesaxeric and temperate cold subregion)", in the upper part of the studied mountain system (Pizzo dei Briganti, Mount Lupone, Mount Gemma, Mount Semprevisa); the climate here is characterized by abundant precipitation (mean per year 1955-1985: 1,247-1,558 mm); summer rains comprise between 160-205 mm of the annual rainfall; absence of summer aridity (possible period of sub-aridity in July and August), rather intense cold in winter, which goes from October to May, average of the minimum temperatures of the coldest month always below 0 °C; the sampling sites FB, FS, and FC refer to this unit (see below);
- "Upper hilly (submountain) thermotype, inferior hyperhumid umbrotype, mesaxeric region (hypomesaxeric subregion)", in the pedemountain areas between the above mentioned relieves; this region receives abundant precipitation (mean per year 1955-1985: 1,431-1,606 mm) and frequent summer episodes of rainfall (173-200 mm); the average daily temperature ranges between 12.0 and 13.6 °C; summer aridity absent, intense cold during winter; average of the minimum temperatures of the coldest month above 0 °C; the sampling site LC refers to this unit (see below);
- "Lower/upper hilly thermotype, superior humid/inferior hyperhumid umbrotype, mesaxeric region (hypomesaxeric subregion)", in the north-east side of the study area; no sampling sites were in this unit;

2) Temperate Transition Region, of which the following phytoclimatic unit is represented:

- "Lower meso-Mediterranean (or thermo-hilly) thermotype, inferior humid umbrotype, xeroteric region (meso-Mediterranean subregion)", in the south-east side of the study area; this district receives abundant precipitation (mean per year 1955-1985: 1,132-1,519 mm), sporadic summer rains (96-139 mm), weak summery aridity concentrated in July and August, not intense cold in winter from November to March with significant cold episodes in April; the average of the lower temperatures in the coldest month is 4.4 °C; the sampling sites BM, LB1 and LB2 refer to this unit (see below).

The seminatural forests of the investigated region cover an area of approximately 23,000 hectares. Meanwhile another 3,000 hectares are involved in allochthonous conifer reforestation. Open habitats (pastures and meadows) extend for approximately 16,000 hectares. For more details about the study

area see Amori et al. (2002), Corsetti (2006) and the references included.

Samples were collected at the following seven sites (Fig. 1), listed in progressive order of altitude; vegetational, forest management, exposure and soil main features as well as sampling method used are also given for each site (for sites 1, 2, 4-6 see also De Liberato, 1994):

1. BM: 2 km northwest of Bassiano (Latina province), Predarea, 420 m above sea level: mixed forest with a prevalence of *Quercus cerris* accompanied by *Q. pubescens, Q. ilex, Ostrya carpinifolia, Fraxinus ornus*, and *Acer campestre*; aged coppiced wood, arboreal cover 80-90%; southwest exposure; slope about 20 °; complex of rendzinas and lithosols, surface stoniness about 5%, rockiness 20-25%; samples were taken with pitfall-traps and by hand collection;

2. LB1: 1 km northeast of Bassiano (Latina province), Fosso Sant'Angelo, 600 m above sea level: *Quercus ilex* forest; transitory high forest, arboreal cover 90%; northwest exposure; slope of about 30°; complex of rendzinas and lithosols, surface stoniness 30%, rockiness 30%; samples were taken with pitfall-traps and by hand collection;

3. LC: 3 km southeast of Carpineto Romano (Rome province), Occhio del Bue, 650 m above sea level: *Quercus ilex* forest; highly disturbed coppiced wood with abundance of standards and shrubby tree stumps, arboreal cover 70-80%; northeast exposure; slope of about 30°; complex of rendzinas and lithosols, surface stoniness 60%, rockiness 10%; samples were hand collected;

4. LB2: Bassiano (Latina province), southwest side of Mount Castellone, 850 m above sea level: mixed *Quercus ilex* forest with old individuals of *Ostrya carpinifolia, Acer* sp. gr. *opalus* and *Fagus sylvatica*; high forest derived from ancient conversions (many plants are free sprouts), arboreal cover 90%; nothwest exposure; slope of 20 °; complex of rendzinas and lithosols, surface stoniness 30%, rockiness 20%; samples were taken by pitfall-traps and by hand collection.

5. FB: Bassiano (Latina province), southwest side of Mount Semprevisa, Camporosello, 1,100 m above sea level: *Fagus sylvatica* forest; quite disturbed sparse high forest with branchy and poor bearing plants, tree stumps with few free sprouts are also present, arboreal cover 60%; northwest exposure; slope of about 35 °; complex of rendzinas and lithosols, surface stoniness 30%, rockiness 60%; samples were taken by pitfall-traps and by hand collection;

6. FS: Supino (Frosinone province), north side of Mount Salerio, Pian della Croce, 1,120 m above sea level: *Fagus sylvatica* forest; sparse mature high forest, arboreal cover 80%; north exposure; slope of about 20°; complex of rendzinas and lithosols, surface stoniness 30%, rockiness 5%; samples were taken by pitfall-traps and by hand collection;

7. FC: Carpineto Romano (Rome province), northeast side of Mount Semprevisa, 1,200 m above sea level: *Fagus sylvatica* forest; mature and well developed high forest with large individuals of *Taxus baccata* and *Ilex aquifolium*, arbo-

real cover 80%; northeast exposure; slope of about 25°; complex of rendzinas and lithosols, surface stoniness 5-10%, rockiness 0%; samples were hand collected.

MATERIALS AND METHODS

Monthly samplings were carried out at each sites with pitfall traps (March-November 1992), using 500 cc plastic cups (6 cups in each site) partially filled with a mixture of vinegar and 5% formalin (see De Liberato, 1994) and by hand (May 1996-April 1997), looking for centipedes in the litter, under stones and fallen tree bark for a standard time of 45-60 minutes by the same operator (MP). Pitfall trap collections are being held at the Museum of Zoology of the Università degli Studi di Roma "La Sapienza", Italy. The hand collected material is being conserved in the collection of M. Zapparoli (Dipartimento di Protezione delle Piante, Università degli Studi della Tuscia, Viterbo, Italy).

The materials collected by both methods were used for faunistic and zoogeographic analysis. The hand collected material was also used for ecological analysis of the assemblages. The chorotypes (distribution patterns) of each species were deduced from Zapparoli (2006a); chorotypes classification follows Vigna Taglianti et al. (1992, 1999). Species are listed according to Zapparoli and Minelli (2006) and Zapparoli (2006a). Available nomenclatural updating (Bonato and Minelli, 2008) are also considered. To describe the quantitative structure of the assemblages and the relative abundance of each species, the index of dominance (d) was calculated as follows: $Dj = nj/N \times 100$, where nj is the number of specimens captured of j species and N is the total number of the specimens captured in the assemblages. The dominance classes defined by Wytwer (1990) were adopted. That is: $Dj \geq 50\%$: eudominant species; Dj = 10.1-50.0%: dominant species; Dj = 5.1-10.0%: influential species; Dj = 2.1-5.0%: recedent species; $Dj < 2.1\%$: subrecedent species.

Assemblages differences with regard to species composition and dominance structure were estimated using the index of Jaccard (J) (Jaccard, 1912) and the index of Morisita (m) (Horn, 1966), respectively. The values of these indices were converted in a distance matrix; the analyses were carried out in a cluster analysis (method UPGMA) using MVSP 3.12d software (Kavach Comp. Serv., 1985-2001). The diversity (H', loge) and the eveness (J') of each assemblages were calculated with the index of Shannon-Weaver (Shannon and Weaver, 1949) and of Pielou (Pielou, 1966), respectively.

RESULTS AND DISCUSSION

The centipedes species collected at the seven sampling sites in the study period and the respective numbers of individuals, according to the employed methods, are listed in Tab. I. Thirty species were recorded in all, including a

Tab. I - Chilopoda assemblages in forest habitats of the Lepini Mountains: list of the species, their chorotypes and number of individuals captured by hand (v) and by pitfall traps (*t*) in the sampling sites (see text for abbreviations); abbreviations used for the main chorotypes and the Italian endemic species (see Vigna Taglianti et al., 1992, 1999 for definition): chorotypes of species widely spread in the Holoarctic Region, CAE = Centralasiatic-European, TUE = Turano-European; chorotypes of species more or less widely spread in Europe, EUR = European, CEU = Centraleuropean, SEU = S-European; chorotypes of species more or less widely spread in the Mediterranean countries, MED = Mediterranean, WME = W-Mediterranean; endemic Italian elements (with affinity): ITAL = Italian endemic; ALWA = W-Alpino-Apenninic endemic; APPE = Apenninic endemic; TYRR = Tyrrhenian endemic

Species	Sites and sampling methods													Chorotype
	BM		LB1		LC	LB2		FB		FS		FC		
	v	*t*	v	*t*	v	v	*t*	v	*t*	v	*t*	v		
Lithobiomorpha														
1. *Eupolybothrus fasciatus* (Newport, 1845)	33	29	56	11	29	45	12	7	1	-	–	1		SEU.APPE
2. *Eupolybothrus grossipes* (C. L. Koch, 1847)	–	–	–	–	–	38	–	15	54	3	–	19		CEU
3. *Lithobius cassinensis* Verhoeff, 1925	1	2	3	3	5	7	–	–	–	4	3	–		SEU.APPE
4. *Lithobius castaneus* Newport, 1844	24	9	8	5	–	38	3	30	1	36	23	59		SEU
5. *Lithobius forficatus* (Linnaeus, 1758)	–	–	–	–	–	–	–	3	1	–	–	–		EUR
6. *Lithobius infossus* Silvestri, 1894	–	–	2	–	1	2	–	1	–	5	–	2		WME.TYRR
7. *Lithobius lapidicola* Meinert, 1872	1	4	2	–	4	6	–	1	–	3	–	1		CEU
8. *Lithobius* sp. cfr. *lucifugus* L. Koch, 1862	–	–	–	–	–	–	–	3	–	1	–	3		CEU.APPE ?
9. *Lithobius micropodus* Matic, 1980	4	–	1	–	6	8	–	2	–	1	–	–		SEU
10. *Lithobius microps* Meinert, 1868	–	–	–	–	–	–	–	1	–	2	–	–		EUR
11. *Lithobius tricuspis* Meinert, 1872	7	2	–	–	–	–	–	3	1	–	–	4		CEU
12. *Lithobius tylopus* Latzel, 1882	–	–	–	–	13	–	–	10	33	12	67	5		SEU.APPE
Scolopendromorpha														
13. *Cryptops anomalans* Newport, 1844	–	–	7	–	–	2	–	3	1	32	–	25		SEU
14. *Cryptops hortensis* (Donovan, 1810)	12	–	6	–	5	23	–	18	1	2	–	7		CAE
15. *Cryptops parisi* Brölemann, 1920	8	2	37	3	4	22	4	11	5	10	1	14		SEU
16. *Cryptops trisulcatus* Brölemann, 1902	2	1	10	1	1	5	–	–	–	–	–	–		MED
Geophilomorpha														
17. *Himantarium gabrielis* (Linnaeus, 1767)	3	–	15	2	2	13	2	–	–	4	–	–		MED
18. *Stigmatogaster gracilis* (Meinert, 1870)	–	–	1	–	–	4	–	6	–	–	–	–		MED
19. *Henia bicarinata* (Meinert, 1870)	–	–	1	–	–	–	–	–	–	–	–	–		MED
20. *Henia vesuviana* (Newport, 1845)	6	–	6	2	5	13	2	1	–	23	–	3		WME
21. *Schendyla apenninorum* Brölemann and Ribaut, 1911	–	–	–	–	–	–	–	–	–	–	–	5		SEU.APPE
22. *Schendyla nemorensis* (C.L. Koch, 1836)	3	–	9	1	7	28	–	7	1	23	–	28		EUR
23. *Clinopodes flavidus* C.L. Koch, 1847	20	1	18	–	4	31	–	–	–	32	–	19		TUE
24. *Geophilus carpophagus* Leach, 1815	–	–	–	–	–	–	–	1	–	–	–	2		EUR
25. *Geophilus insculptus* Attems, 1895	–	–	–	–	3	2	–	–	–	4	–	4		EUR
26. *Geophilus richardi* (Brölemann, 1904)	8	1	3	–	10	–	–	–	–	–	–	–		MED
27. *Stenotaenia romana* (Silvestri, 1896)	3	–	15	–	1	2	–	2	–	5	–	5		SEU.ALWA
28. *Stenotaenia sorrentina* (Attems, 1903)	9	–	4	–	9	9	–	–	–	5	–	1		EUR. ITAL
29. *Strigamia acuminata* (Leach, 1815)	–	–	–	–	–	–	–	1	10	1	2	4		CEU
30. *Strigamia crassipes* (C.L. Koch, 1835)	1	–	3	28	–	1	–	7	–	2	2	2		EUR
Total number of individuals (1.653)	145	51	207	56	109	299	23	133	109	210	98	213		
Total number of species (30)	17		20		17	20		21		21		21		

total of 1,653 individuals of which 1,316 were hand collected, and 337 were collected with pitfall traps. Therefore, the number of species sampled herein corresponds to 77.0% of the centipedes species known to inhabit the Lepini Mountains (39: Zapparoli, 2007b). The species collected in this study represent 50.8% of the species recorded in Lazio (59: Zapparoli, 2006b; 2007a) and 44.8% of those quoted in the Central Apennines (67: Zapparoli, 2007b).

Nine species, also known to be present in the study area, were not sampled in the present study (Zapparoli, 2006a; 2007b): four species (*Scutigera coleoptrata* (Linnaeus, 1758); *Lithobius romanus* Meinert, 1872; *Scolopendra cingulata* Latreille, 1829; *Dignathodon microcephalus* (Lucas, 1846)) are all thermophilous and typical of open Mediterranean habitats, but less common in the Apennine forest habitat; five species (*Lithobius aleator* (Verhoeff, 1925); *L. sphinx* (Verhoeff, 1942); *Cryptops umbricus* (Verhoeff, 1931); *Schendyla montana* (Attems, 1895); *Geophilus oquidatum* (Brölemann, 1909)) are rather localized in the area and have heterogenous and poorly known habitat preferences.

Considering that, based on the limited knowledge available (Minelli and Iovane, 1987; Zapparoli, 1992a), the number of reported species in the Chilopoda assemblages of the forests of peninsular Italy ranges from 4 to 9 in the beechwoods, from 3 to 10 in the *Quercus ilex* woods and from 3 to 8 in the other oakwoods and in the mixed broadleaved forests, and that in the forest habitats of other better studied Italian areas, the number of reported species can be as high as 20 species (e.g.: Bosco della Fontana, Lombardy, Mantova province, Querco-Carpinetum boroitalicum: Zapparoli, 2004), the information collected on the qualitative composition of the assemblages object of this study, can be considered sufficiently comprehensive.

The FB, FS, FC *Fagus sylvatica* high forest sites were found to have the greatest species diversity (21 species). The number of species collected in LB1 and LB2 *Qurcus ilex* high forest sites was slightly less (20 species). In the BM (mixed forest with prevalence of *Q. cerris*) and LC *Quercus ilex* woods, both coppices, inhabit the fewest number of species (17). The highest number of hand captured specimens, nearly 300, approximately a quarter of all the samples obtained with this method, were collected at site LB2; this may be due to more favorable soil conditions (moisture, fertility) at this location. Notably, the number of specimens collected by pitfall trapping at the FB and FS sites was two-four times higher than that collected with the same technique in *Quercus* spp. formations at BM, LB1, LB2. This distinction indicates a greater "density of activity" (cfr. Brandmayr and Brunello Zanitti, 1982) of these arthropods at the FB and FS sites.

Table II shows the values of Jaccard's index of similarity (J) in the comparison between the specific composition of assemblages in the seven sampling sites. The obtained dendrogram of similarity (Fig. 2) shows two main groups. One of

Tab. II - Chilopoda assemblages in forest habitats of the Lepini Mountains: values of the index of Jaccard (*J*) and Morisita (M) when comparing the specific composition and the relative abundance of the species in the sampling sites (see text for abbreviations)

	BM		LB1		LC		LB2		FB		FC	
	J	M	*J*	M	*J*	M	*J*	M	*J*	M	*J*	M
LB1	*0.76*	0.79										
LC	*0.68*	0.73	*0.82*	0.75								
LB2	*0.70*	0.82	*0.68*	0.72	*0.68*	0.62						
FB	*0.41*	0.60	*0.46*	0.39	*0.52*	0.33	*0.36*	0.74				
FC	*0.46*	0.56	*0.46*	0.34	*0.58*	0.17	*0.46*	0.69	*0.68*	0.80		
FS	*0.52*	0.54	*0.58*	0.38	*0.71*	0.28	*0.58*	0.62	*0.62*	0.57	*0.68*	0.85

these main groups was constituted by the *Quercus* sp. sites, whose J value ranged from 0.68 (LB2-BM, LB1-LC) to 0.82 (LB1-LB2); the other group was constituted by the *F. sylvatica* sites, where the J value ranged from 0.71 (FC-FB) to 0.62 (FS-FB).

From a faunistic point of view, the *Quercus* spp. sites were characterized by at least four species: two endemic Apenninic species, *Eupolybothrus fasciatus* and *Lithobius cassinensis*, which are frequent in the thermophilous and thermomesophilous *Quercus* spp. formations of the Italian peninsula and that generally live between 5-1,500 m above sea level in Central Italy (Zapparoli, 1992a, 2006), both also recorded at *Fagus sylvatica* FB and FS sites, but in negligible to modest numbers; and two Mediterranean species, *Cryptops trisulcatus* and *Geophilus richardi*, which are common in Italian thermophilous forests. *Cryptops trisulcatus* is also commonly found in open and shrubby areas within 900 m above sea level. Both the Mediterranean species are regularly present in all the oakwoods sampled, except for *Geophilus richardi*, which is absent in LB2.

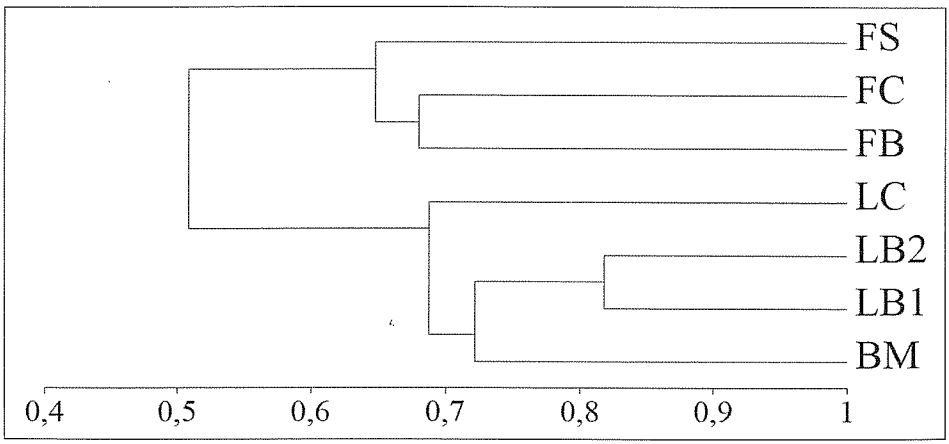

Fig. 2 - Chilopoda assemblages in forest habitats of the Lepini Mountains: dendrogram of similarity of the species composition; see text for abbreviations of the sampling sites

In all four *Quercus* spp. sites, *Henia vesuviana*, which Italian population show preference mostly for oakwoods (see for example, Minelli and Iovane, 1987; Zapparoli, 2006), was also present. This species inhabits however many other habitats, not only forests, from sea level to 1,700 m. In the study area it was also found at the *Fagus sylvatica* sites, although in low numbers, except at FS where the sample was numerically rather consistent.

Another species that was found at all of the *Quercus* spp. forest sites was *Himantarium gabrielis*; it was particularly numerous at LB1 and LB2; in contrast, this species was not frequent (found only in one site out of three, FS) and scarce (only 4 captured individuals in more that 500 hand captured individuals in the sample) in the examined beechwoods sites.

LB1 was the only sampling site in which *Henia bicarinata* was found. *H. bicarinata* is a Mediterranean thermophilous species, whose habitat preferences in Italy are relatively wide. It is present from coastal habitats to broadleaved forests (*Quercus*, *Ostrya*) up to 700 m above sea level, and in all the samples, only one individual was collected.

The *Fagus sylvatica* sites were characterized by the presence of *Eupolybothrus grossipes* and *Strigamia acuminata,* both Centraleuropean species. In the Central Apennines, these centipedes generally live at altitudes in the 800-1,500 m above sea level range, and they manifest a strong preference for this type of forest (Zapparoli, 1992a, 2006a, 2007b). It is important to note, however, that the hand captured *S. acuminata* specimens at the three sites, was never numerically high, especially relative to the pitfall trap samples, which were generally more consistent. The number of *E. grosspies* specimens captured with both methods in FS, was altogether quite modest. On the other hand, *E. grosspies* was highly numerous at LB2 where, based on the findings collected in the sampling from 1996-1997 (hand collected), it cohabits with *E. fasciatus*. In the samplings carried out with pitfall traps in the same site during March-November 1992, *E. fasciatus* was not found.

Apparently related to the *Fagus sylvatica* forests of the study area are also some other species which the total number of specimens captured was however quite limited. They include *Lithobius* sp. cfr. *lucifugus*, which is known in several sites of Central Italy, mostly in *Fagus sylvatica* forests, and whose taxonomic identity must be further studied (Zapparoli, 2006a, 2007b), *Schendyla apenninorum*, Apennine endemic, and *Geophilus carpophagus*, European species. Other forest species present in all the three beechwoods and in one-two of the four sampled *Quercus* spp. forests were *L. tylopus*, likely hygrophilous, and *Cryptops anomalans*. *L. tricuspis*, a species tendentially tied to mesophilous forests, was also found in the mixed forest, in two of the three beechwoods, and it was absent in the *Quercus ilex* woods. *Lithobius microps* was found only at FB and FS; its spectrum of habitat preferences in Italy is however quite large, from Mediterranean scrub formations to broadleaved forests (Minelli and Iovane, 1987; Zapparoli, 2006a).

The centipede assemblages of all the sampling sites also included some species that in Italy colonize a range of forest habitats wider than the other species previously mentioned. In particular, *Lithobius castaneus, Cryptops hortensis, C. parisi, Schendyla nemorensis* and *Strigamia crassipes*, all very common, and *L. infossus* and *Stigmatogaster gracilis*, less frequent species.

A few species, rather euriecious, were common to all sites, e.g. *L. lapidicola, L. micropodus, Clinopodes flavidus. Geophilus insculptus* and *Lithobius forficatus* were less frequently sampled, the latter was especially related to habitats subject to anthropic disturbances and found only in FB.

The analysis of the main chorotypes across all of the sites (Fig. 3) showed a prevalence of species with wide distribution in Europe (29.4-62.0%), while species with wide distribution in the Mediterranean region were not as well represented (4.8-30.0%), and those with wide distribution in the Holoarctic region were even less prevalent (4.8-11.8%). The presence of Italian endemic species varied from 23.5% to 35.3%. Analyzing the chorotype spectrum of the assemblages of each sampling site (Fig. 3), it was observed that the species with wide distributions in Europe had the higher percentage values in *Fagus sylvatica* forests FB, FC and FS (52.4-61.9%), while those with the lowest percentage values were observed in *Quercus ilex* woods LC and LB1 (29.4 and 35.0% respectively); higher values were observed in the mixed forest BM and in the *Quercus ilex* site LB2 (41.2 and 45.0% respectively). In contrast, the species with wide distributions in the Mediterranean area showed higher values in *Quercus ilex* sites (20.0-30.0%) and in the mixed forest site BM (23.5%), while the lowest

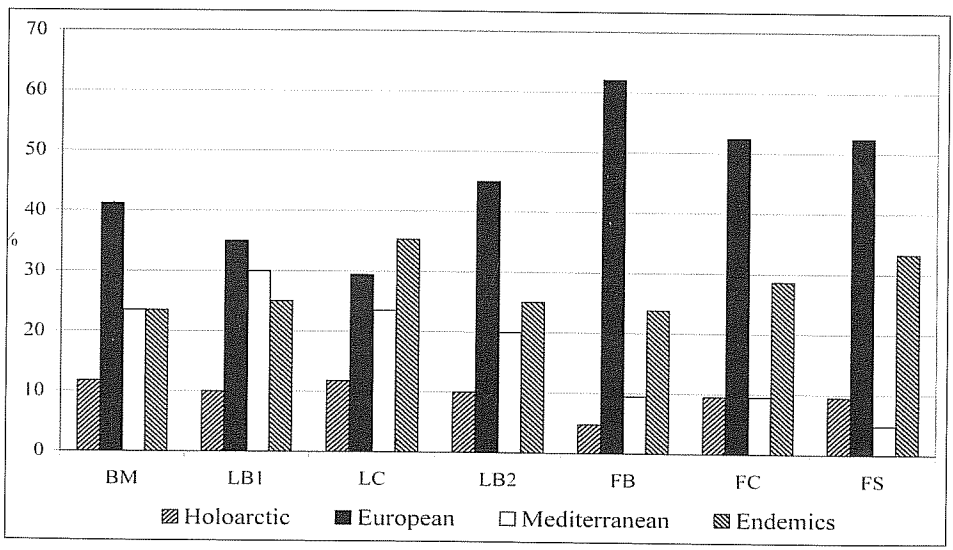

Fig. 3 - Chilopoda assemblages in forest habitats of the Lepini Mountains: percent division of chorotype classes (Holoarctic, European, Mediterranean) and Italian endemic elements; see text for abbreviations of the sampling sites

values were observed in beechwoods (4.8-9.5%). The percentage value of the species with a wide distribution in the Holoarctic region was generally consistent across the seven sites analyzed and ranged between 9.5 and 11.8%, with the exception of FB where this value was markedly lower (4.8%).

The analysis of the structure of dominance (Tab. III, Fig. 4) underlies some complexity of the assemblages in all seven sites and also the absence of eudo-

Tab. III - Chilopoda assemblages in forest habitats of the Lepini Mountains: values of the index of dominance in the hand sampling (see text for abbreviations of the sampling sites)

Species	Sampling sites						
	BM	LB1	LC	LB2	FB	FS	FC
Lithobiomorpha							
1. *Eupolybothrus fasciatus* (Newport, 1845)	22.8	27.1	26.6	15.1	5.3	–	0.5
2. *Eupolybothrus grossipes* (C.L. Koch, 1847)	–	–	–	12.7	11.3	1.4	8.9
3. *Lithobius cassinensis* Verhoeff, 1925	0.7	1.4	4.6	2.3	–	1.9	–
4. *Lithobius castaneus* Newport, 1844	16.6	3.9	–	12.7	22.6	17.1	27.7
5. *Lithobius forficatus* (Linnaeus, 1758)	–	–	–	–	2.3	–	–
6. *Lithobius infossus* Silvestri, 1894	–	1.0	0.9	0.7	0.8	2.4	0.9
7. *Lithobius lapidicola* Meinert, 1872	0.7	1.0	3.7	2.0	0.8	1.4	0.5
8. *Lithobius* sp. cfr. *lucifugus* L. Koch, 1862	–	–	–	–	2.3	0.5	1.4
9. *Lithobius micropodus* Matic, 1980	2.8	0.5	5.5	2.7	1.5	0.5	–
10. *Lithobius microps* Meinert, 1868	–	–	–	–	0.8	1.0	–
11. *Lithobius tricuspis* Meinert, 1872	4.8	–	–	–	2.3	–	1.9
12. *Lithobius tylopus* Latzel, 1882	–	–	11.9		7.5	5.7	2.3
Scolopendromorpha							
13. *Cryptops anomalans* Newport, 1844	–	3.4	–	0.7	2.3	15.2	11.7
14. *Cryptops hortensis* (Donovan, 1810)	8.3	2.9	4.6	7.7	13.5	1.0	3.3
15. *Cryptops parisi* Brölemann, 1920	5.5	17.9	3.7	7.4	8.3	4.8	6.6
16. *Cryptops trisulcatus* Brölemann, 1902	1.4	4.8	0.9	1.7	–	–	–
Geophilomorpha							
17. *Himantarium gabrielis* (Linnaeus, 1767)	2.1	7.2	1.8	4.3	–	1.9	–
18. *Stigmatogaster gracilis* (Meinert, 1870)	–	0.5	–	1.3	4.5	–	–
19. *Henia bicarinata* (Meinert, 1870)	–	0.5	–	–	–	–	–
20. *Henia vesuviana* (Newport, 1845)	4.1	2.9	4.6	4.3	0.8	11.0	1.4
21. *Schendyla apenninorum* Brölemann and Ribaut, 1911	–	–	–	–	–	–	2.3
22. *Schendyla nemorensis* (C.L. Koch, 1836)	2.1	4.3	6.4	9.4	5.3	11.0	13.1
23. *Clinopodes flavidus* C.L. Koch, 1847	13.8	8.7	3.7	10.4	–	15.2	8.9
24. *Geophilus carpophagus* Leach, 1815	–	–	–	–	0.8	–	0.9
25. *Geophilus insculptus* Attems, 1895	–	–	2.8	0.7	–	1.9	1.9
26. *Geophilus richardi* (Brölemann, 1904)	5.5	1.4	9.2	–	–	–	–
27. *Stenotaenia romana* (Silvestri, 1896)	2.1	7.2	0.9	0.7	1.5	2.4	2.3
28. *Stenotaenia sorrentina* (Attems, 1903)	6.2	1.9	8.3	3.0	–	2.4	0.5
29. *Strigamia acuminata* (Leach, 1815)	–	–	–	–	0.8	0.5	1.9
30. *Strigamia crassipes* (C.L. Koch, 1835)	0.7	1.4	–	0.3	5.3	1.0	0.9

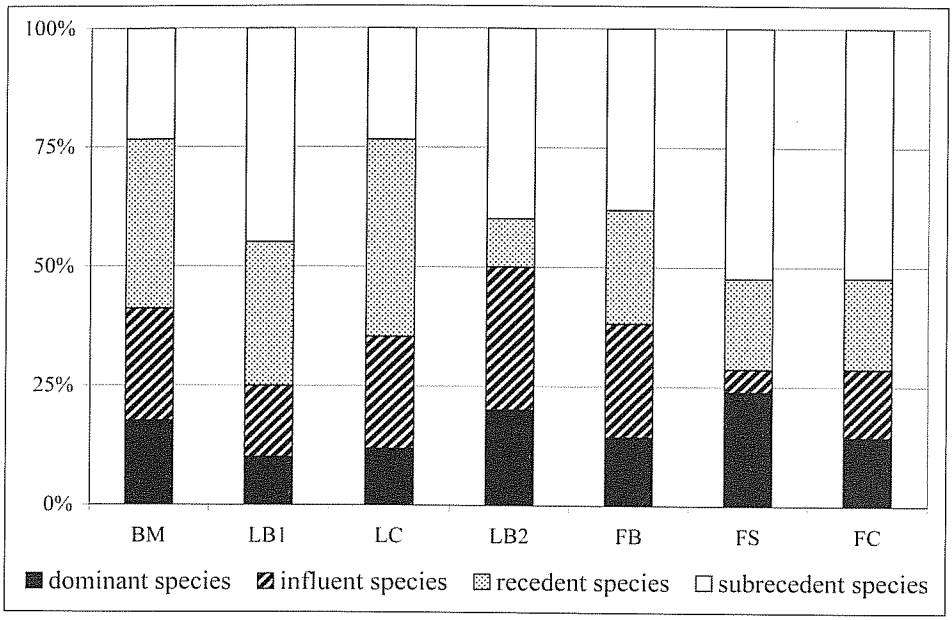

Fig. 4 - Chilopoda assemblages in forest habitats of the Lepini Mountains: percent division of dominance classes; see text for abbreviations of the sampling sites

minant species. *Eupolybothrus fasciatus* was always dominant at *Quercus* spp. sites (BM, LB1, LC, LB2), with a variable percentage from 15% (LB2) to >25% (LC, LB1). *Lithobius castaneus* and *Clinopodes flavidus* (BM, LB2), *Eupolybothrus grossipes* (LB2), *L. tylopus* (LC), *Cryptops parisi* (LB1) were also dominant within these sites. Meanwhile, *Lithobius castaneus* was always dominant at *Fagus sylvatica* sites; its value ranged from 17% in FS to almost 28%

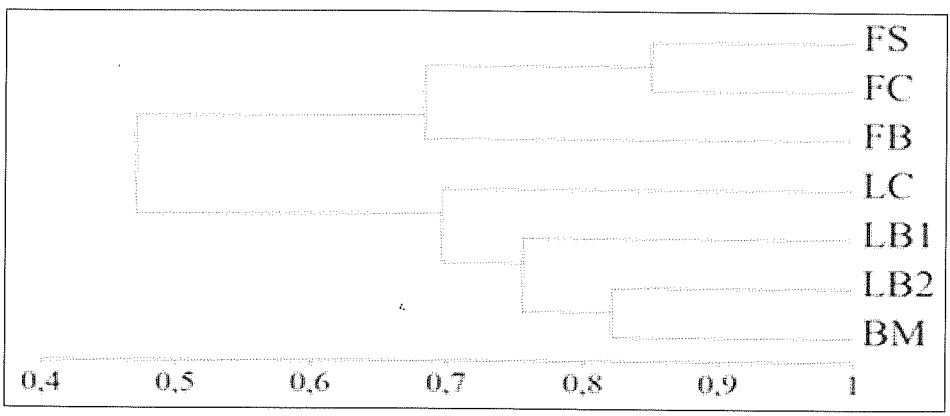

Fig. 5 - Chilopoda assemblages in forest habitats of the Lepini Mountains: similarity dendrogram of the structure of dominance; see text for abbreviations of the sampling sites

in FC. *Cryptops anomalans, Schendyla nemorensis* (FS, FC), *Cryptops hortensis* (FB), *Eupolybothrus grossipes* (FB), *Clinopodes flavidus* (FS), *Henia vesuviana* (FS) were also dominant in these formations.

Table II shows the similarity index value of the structure of dominance of Morisita (M) calculated for the seven sampling sites. The obtained dendrogram (Fig. 5) shows two main groups, one represented by the *F. sylvatica* sites, whose M value ranged from 0.85 (FS-FC) to 0.57 (FS-FB), and the other represented by the *Quercus* sp. sites, where the M value ranged from 0.82 (BM-LB2) to 0.61 (LC-LB2).

Table IV shows the diversity index values calculated for the seven sampling sites. Although the assemblages of the *F. sylvatica* sites (FB, FS, FC) showed the highest number of species (and consequently the greater value of Hmax) and the *Quercus* spp. sites (BM, LB1, LC, LB2) a slightly lower number, the values of the index of diversity (H') and eveness (J') showed a different trend in the two groups of sites. Except for BM, which assemblages is charachterized by the lowest value of H' (2.39) and a relatively high J' value (0.84), the centipede taxocenoses at the *Q. ilex* (LB1, LC, LB2) and at the *F. sylvatica* sites (FB, FS, FC) did not show a spectrum of diversity values very different each other, as they ranged from 2.41 (LB1) to 2.58 (LB2) and from 2.41 (FC) to 2.55 (FB). On the contrary, the eveness value (J') differ substantially between the two groups of assemblages. The *Quercus ilex* sites were characterized by Chilopoda communities with relatively higher values, ranging from 0.80 (LB1) to 0.87 (LC), meanwhile the centipede assemblages at *Fagus sylvatica* sites had J' values between 0.79 (FC, mature high forest) and 0.84 (FB, disurbed high forest).

The collected data revealed how the analyzed habitats host Chilopoda assemblages with a clearly nemoral character, largely constituted by forest species. Moreover, these assemblages are almost homogeneous as far as concern the structure of dominance, which is generally complex, and the biodiversity values (H'). Some differences in eveness (J') could be due to edaphic factors, such as temperature, moisture and fertility of the soil, or to anthropic causes, such as grazing and forest management. Each vegetal formation can be characterized by the presence of assemblages recognizable for their quali-quantitative com-

Tab. IV - Chilopoda assemblages in forest habitats of the Lepini Mountains: number of species (S) and values of the diversity indexes (Hmax = log2 S. H') and of eveness (J') taken in the sampling sites (see text for abbreviations of the sampling sites)

	Sampling sites						
	BM	LB1	LC	LB2	FB	FS	FC
S	17	20	17	20	21	21	21
H max	2.83	2.99	2.83	2.99	3.04	3.04	3.04
H'	2.39	2.41	2.46	2.58	2.55	2.49	2.41
J'	0.84	0.80	0.87	0.86	0.84	0.82	0.79

position, its chorotype spectrum, and for the presence of species with different thermoigrometric requirements, useful as bioindicators, at least at a local or regional level.

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REFERENCES

AMORI G., CORSETTI L., ESPOSITO C. 2002 - Mammiferi dei Monti Lepini. Quaderni di Conservazione della Natura, Ministero dell'Ambiente e della Tutela del Territorio, Istituto Nazionale per la Fauna Selvatica, 11: 210 pp.

BLASI C. 1994 - Fitoclimatologia dl Lazio. Università degli Studi di Roma "La Sapienza", Regione Lazio, 56 pp.+2 maps.

BONATO L., MINELLI A. 2008 - *Stenotaenia* Koch, 1847: a hitherto unrecognized lineage of western Palaearctic centipedes with unusual diversity in body size and segment number (Chilopoda: Geophilidae). Zool. J. Linn. Soc., 153.

BRANDMAYR P., BRUNELLO ZANITTI P. 1982 - Dinamica della comunità a Coleotteri Carabidi (Coleoptera Carabidae) nei pascoli magri dell'alta pianura friulana ("magredi"). Atti del I Congresso Nazionale della Società Italiana di Ecologia, pp. 41-45.

CORSETTI L. (ed.) 2006 - Lepini, anima selvaggia del Lazio. Edizioni Belvedere, Latina, 248 pp.

DE LIBERATO C. 1994 - Entomocenosi a Coleotteri Carabidi di alcune formazioni forestali dei Monti Lepini (Preappennino Laziale). Università degli Studi di Roma "La Sapienza", Tesi di Laurea, A.A. 1993-94 (relatore A. Vigna Taglianti), 136 pp.

GLEREAN P. 2004 - Coleotteri Carabidi e altri Artropodi di una costa sabbiosa dell'Alto Adriatico: aspetti faunistici ed ecologici (Valle Vecchia, Caorle, Venezia) (Coleoptera, Chilopoda). Gortania, Atti Mus. Friulano Stor. Nat., 25 (2003): 261-323.

HORN H.S. 1966 - Measurement of "overlap" in comparative ecological studies. Am. Nat., 100: 419-424.

LANDI VITTORJ R. (ed.) 1989 - Appennino Centrale. Volume I. Club Alpino Italiano, Touring Club Italiano, Milano: 452 pp.

MAGURRAN A.E. 1988 - Ecological diversity and its measurement. Princeton University Press, Princeton, NJ, 179 pp.

MINELLI A. 1981 - Distribution, taxonomy and ecology of some centipedes from the provinces of Trento and Bolzano, Northern Italy (Chilopoda). Stud. Trentini Sci. Nat., Acta Biol., 57 (1980): 83-93.

MINELLI A. 1982 - I Chilopodi nell'ambiente dei boschi planiziali padano-veneti. Quaderni "Struttura delle zoocenosi terrestri" 4. I boschi della pianura padano-veneta. Collana P.F. "Promozione della qualità dell'ambiente", CNR, Roma: 125-135.

MINELLI A. 1988 - Chilopodi di ambienti montani e alpini delle Dolomiti. Stud. Trentini Sci. Nat., Acta Biol., suppl., 64: 431-440.

MINELLI A., IOVANE E. 1987 - Habitat preferences and taxocenoses of Italian centipedes (Chilopoda). Boll. Mus. Civ. Stor. Nat. Venezia, 37 (1986): 7-34.

MINELLI A., ZAPPAROLI M. 1986 - I Chilopodi di alcuni ambienti costieri medio-tirrenici con particolare riguardo al Parco Nazionale del Circeo (Chilopoda). Atti del Convegno "Aspetti faunistici e problematiche zoologiche del Parco Nazionale del Circeo", Sabaudia, 1984, 25-36.

MULTIVARIATE STATISTICAL PACKAGE (MVSP) 3.12D 1985-2001 - Kavach Computing Services. www.Kavcomp.com.

PIELOU E.C. 1966 - The measurement of diversity in different type of biological collections. J. Theor. Biol., 13: 131-144.

SHANNON C.E., WEAVER W. 1949 - The mathematical theory of communication. University of Illinois, Press Urbana.

VIGNA TAGLIANTI A., AUDISIO P.A., BELFIORE C., BIONDI M., BOLOGNA M.A., CARPANETO G.M., DE BIASE A., DE FELICI S., PIATTELLA E., RACHELI T., ZAPPAROLI M., ZOIA S. 1992 - Riflessioni di gruppo sui corotipi fondamentali della fauna W-paleartica ed in particolare italiana. Biogeographia, Lav. Soc. Ital. Biogeog. (n.s.), 16: 159-179.

VIGNA TAGLIANTI A., AUDISIO P.A., BIONDI M., BOLOGNA M.A., CARPANETO G.M., DE BIASE A., FATTORINI S., PIATTELLA E., SINDACO R., VENCHI A., ZAPPAROLI M. 1999 - A proposal for a chorotype classification of the Near East fauna, in the framework of the Western Palearctic region. Biogeographia, Lav. Soc. Ital. Biogeog. (n.s.), **20**: 31-59.
WYTWER J. 1990 - Chilopoda of linden-oak-hornbeam (*Tilio-Carpinetum*) and thermophilous oak forests (*Potentillo albae-Quercetum*) of the Mazovian Lowland. Fragm. Faun., **34**: 73-94.
ZAPPAROLI M. 1992a - Preliminary data on centipedes communities of Quercetea ilicis and Fagetalia sylvaticae in Central Italy. In: E. Meyer, K. Thaler, W. Schedl (eds.), Advances in Myriapodology. Proceedings of the 8th International Congress of Myriapodology. Ber. Natwiss-Med. Ver. Innsbr., Suppl., **10**: 197-204.
ZAPPAROLI M. 1992b - I Chilopodi negli ambienti forestali italiani. Monti e Boschi, Bologna, **5**: I-XII.
ZAPPAROLI M. 1996 - Centipedes in Italian agroecosystems and their possible value as pest control agents. In: J.J. Geoffroy, J. P. Mauriès, J. Nguyen Duy (eds), Acta Myriapodologica, 9th International Congress of Myriapodology. Mem. Mus. Nat. Hist. Nat., Paris, **169**: 657-662.
ZAPPAROLI M. 2004 - Structure and diversity of centipede taxocoenoses (Chilopoda). In: P. Cerretti, F. Mason, G. Nardi, M. Tisato, M. Zapparoli (eds.), Invertebrati di una foresta della Pianura Padana, Bosco della Fontana. II Contributo. Centro Nazionale per lo Studio della Biodiversità Forestale Bosco della Fontana; Corpo Forestale dello Stato; Servizio Conservazione della Natura, Ministero dell'Ambiente e della Tutela del Territorio, 15-27.
ZAPPAROLI M. 2006a - A catalogue of the centipedes (Chilopoda) of Central Apennines (Italy). Boll. Mus. Civ. Stor. Nat. Verona, Bot. Zool., **30**: 165-274.
ZAPPAROLI M. 2006b - Chilopodi della Maremma laziale e considerazioni sulla fauna del Monumento naturale "Palude di Torre Flavia". In: C. Battisti (ed.), Biodiversità, gestione e conservazione di un'area umida del litorale tirrenico: la Palude di Torre Flavia. Provincia di Roma, Assessorato alle Politiche dell'Ambiente Agricoltura, Caccia e Pesca. Gangemi Editore, Roma, 217-229 pp.
ZAPPAROLI M. 2007a - Aspetti faunistici ed ecologici del popolamento dei Chilopodi (Chilopoda) della Riserva Naturale Provinciale di Monte Catillo e del territorio adiacente. In: A. Guidi (ed.), La Riserva Naturale di Monte Catillo. Provincia di Roma, Assessorato alle Politiche dell'Agricoltura, dell'Ambiente, Caccia e Pesca. Tipografia Mattei, Tivoli, pp. 186-194.
ZAPPAROLI M. 2007b - Faunistic and zoogeographic aspects of central Apennines centipede fauna (Chilopoda). Biogeographia, Lav. Soc. Ital. Biogeog. (n.s.), **28**: 299-326.
ZAPPAROLI M., BIONDI I. 2007 - Chilopodi della Riserva Naturale Regionale Monte Rufeno e aree adiacenti (Lazio, Italia centrale) (Chilopoda). Boll. Assoc. Rom. Entomol., **62**: 1-40.
ZAPPAROLI M., MINELLI A. 2006 - Chilopoda. In: S. Ruffo, F. Stoch (eds), Checklist and distribution of the Italian fauna. Mem. Mus. Civ. Stor. Nat. Verona, 2a serie, Sez. Sci. Vita, **17**: 123-125 with data on CD-ROM.