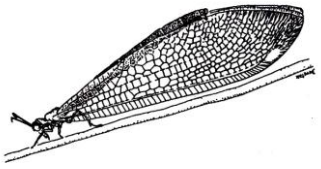

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Comparative zoogeographical analysis of Neuropterida of the Apennine and Balkan peninsulas

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Abstract. The Apennine Peninsula (AP) proper with Sicily and the Balkan Peninsula (BP) proper harbour 255 taxa of Neuropterida (155 taxa in AP and Sicily; 223 taxa in BP). The fauna of BP is richer than that of AP by one family, 6 genera and 68 species and subspecies. The Balkan taxa not occurring in AP are 3 times more in genera and 3.1 times more in species than the Apennine taxa not occurring in BP. The share of the southern species is higher in AP than in BP in all groups except Chrysopidae. The number of expansive northern species entered in BP is 1.5 times higher than their number in AP. The Holomediterranean species are better represented in AP (33 %) than in BP (23 %). Pontomediterranean taxa in BP are 3.5 times more than the Adriatomediterranean taxa in AP. The species of all secondary Mediterranean centres of dispersion are more in the Balkan fauna (38 %) than those in the Apennine fauna (30 %). Routes of dispersal (13 types) in main categories of origin are outlined. Areas of higher rate of endemism are listed. BP is characterized by richer fauna of Neuropterida than AP because of its larger territory, its long land border with Central Europe, the absence of high mountain transverse barriers on its border with Central Europe, its long-term history in Neogene as land, the presence of many centres of fourth and fifth level of speciation for Raphidioptera.

Key words: Neuropterida, Apennine Peninsula, Balkan Peninsula, species diversity, zoogeography, endemism, origin, dispersal

Introduction

The Balkan and Apennine peninsulas shelter two of the three richest faunas in Europe. Higher is the species diversity only of the Iberian Peninsula. This is valid for most taxonomic group of animals, including the order Neuroptera (Popov, 2007) and related orders (superorder Neuropterida). Between the two discussed faunas, Balkan and Apennine, exists close relationship. Both peninsulas are located on places of mixing of various zoogeographical elements. Quite evident is the difference in comparison with North and wide parts of Central Europe with their much more homogeneous in zoogeographical respect (and much poorer) faunas. Because of that the recent composition of both faunas is a result of paleogeographical, paleoclimatic, paleoecological, phytogeographical and anthropogenic changes.

The species diversity of the Apennine and Balkan peninsulas is in general sufficiently studied (Aspöck *et al*., 1980, 1991, 2001; [Bernardi] Iori *et al*., 1995). Although the intensive investigations during the last 20 years in Italy and 40 years in some Balkan countries revised considerably our knowledge about the number of species and their distribution, remarkable new records were published up to now. Examples of this in the Apennine Peninsula are *Calabroraphidia*, a new endemic and relict genus of snakefly (Rausch *et al*., 2004) and the first record of the genus *Turcoraphidia* (Letardi, 2004), known by that time from the Pontomediterranean area and the Caucasus. In other parts of Italy, new findings are the establishing of the family Nevrorthidae for the first time in the Alps (Letardi *et al*., 2006), of *Cunctochrysa bellifontensis* Leraut in the same region (Nicoli Aldini,

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2005), of *Subilla principiae* Pantaleoni, Aspöck, Cao et Aspöck, a new species of snakefly from Sardinia (Pantaleoni *et al*., 2005), of *Coniopteryx loipetsederi* Aspöck in Apennine Peninsula, Sicily and Sardinia (Letardi & Maltzeff, 2008), etc. In the Balkan Peninsula, such taxa are two new species of *Sisyra* (Rausch & Weissmair, 2007), first records of the genus *Bubopsis* in the continental part of the peninsula (Letardi, 1991; Popov, 2004) and finding of *Phaeostigma knappi* (Aspöck et Aspöck) and *Raphidia ambigua* (Aspöck et Aspöck) in European Turkey (Dobosz, 2007), which are also first records of both species in Europe.

The good exploration of the territories of both peninsulas and accumulated new data make possible a zoogeographical comparison of the two faunas of Neuropterida.

Geographical scope

In most cases, when it is speaking about the Apennine Peninsula, one comprehends the entire territory of Italy, and under Balkan Peninsula one understands the territory of all Balkan countries. While such an interpretation is suitable in political aspect, for zoogeographical purposes the treatment of the territory within the geographical borders of each peninsula is necessary. A consensus exists between the geographers regarding the northern border of the Balkan Peninsula. It follows the rivers of Soča (Isonzo), Sora, Sava and the Danube (Popov, 1992). The matter does not stand so however with the land border of the Apennine Peninsula. Logically, it has to lead between the plain of Lombardy and the northernmost spurs of Apennines but a precise interpretation cannot be found in the literature. Therefore, for a border of the Apennine Peninsula we accept here the line between North and South Italy used in the Checklist delle specie della fauna italiana ([Bernardi] Iori *et al*., 1995). This is the southern border of Liguria and Emilia Romagna (North Italy), which is at the same time northern border of Tuscany and Marche (peninsular Italy). Most likely, the real border of the peninsula has to be fixed a little further north in order to include the northeastern slopes of the Apennines in the regions of Liguria and Emilia Romagna, the so called Appennino Ligure and Appennino Tosco-Emiliano.

From the above mentioned, it is obvious that Italy consists of three parts:
a) Apennine Peninsula proper, including Sicily and circumpeninsular and circumsicilian islets;
b) northern part, consisting of the Alps and Po Valley;
c) Sardinia and circumsardinian islets.
Sicily is included to the Apennine Peninsula as very closely located although not wholly connected geologically to the Apennine Peninsula proper.

Some Balkan countries consist of territories in and outside the border of the Balkan Peninsula. The parts of Slovenia, Croatia, Serbia and Romania beyond the northern border of the peninsula as well as the Greek Aegean islands closely located to the Anatolian Coast: Lesbos, Chios, Samos and Dodecanese, were not taken into consideration in the present paper. From Turkey, of course, only the European part is treated.

Species diversity

Apennine Peninsula. So far, 192 species are established in Italy (Table 1). The species number published in the Checklist of Italian fauna ([Bernardi] Iori *et al*., 1995) is 177 according to up-to-date taxonomic interpretation. Later, the following 15 species are added: Raphidiidae – *Turcoraphidia amara* (Aspöck et Aspöck), *Subilla principiae* Pantaleoni, Aspöck, Cao et Aspöck, *Calabroraphidia renate* Rausch, Aspöck et Aspöck; Inocelliidae – *Inocellia crassicornis* (Schummel); Nevrorthidae – *Nevrorthus apatelios* Aspöck, Aspöck et Hölzel; Chrysopidae – *Dichochrysa abdominalis* (Brauer), *Cunctochrysa bellifontensis* Leraut, *Chrysoperla pallida* Henry, Brooks, Duelli et Johnson, *Chrysoperla agilis* Henry, Brooks, Duelli et Johnson, *Brinckochrysa chlorosoma* (Navás); Coniopterygidae – *Helicoconis hispanica* Ohm, *Coniopteryx loipetsederi* Aspöck, *Coniopteryx tjederi* Kimmins; Dilaridae – *Dilar duelli* Aspöck et Aspöck; Ascalaphidae – *Ascalaphus* sp. Among the Italian species, 37 occur only in the northern (non-peninsular) part of the country and/or in Sardinia. In order to find the number of species in the region of our interest, we have to add the number of species in the Apennine Peninsula proper to these which occur in Sicily (but not in the peninsular part of Italy).

Balkan Peninsula. So far, 244 taxa are established in the Balkan countries. The taxa from Anatolia are not included in this number (Table 1). From them, we have to take 9 species, not occurring to the south of the areas in the northern Balkan countries beyond the peninsula borders, and 12 species distributed in Greece only on the following Greek Aegean islands close to the Anatolian Coast: Lesbos, Chios, Samos, Icaria, Kos, Rhodes and Karpathos. The result of deduction is the number of the taxa in the region of our interest, the Balkan Peninsula proper.

Table 1. Species diversity of Neuropterida in the Apennine and Balkan countries.

Geographical areas	Taxa
Italy	192
including:	
Apennine Peninsula proper	144
in Sicily but not in the Apennine Peninsula	11
Apennine Peninsula proper + Sicily	155
in Italy only in the Alps and Po Valley	31
in Italy only in Sardinia	6
Balkan countries (except Anatolia)	244
including:	
Balkan Peninsula proper	223
only in parts of Slovenia, Croatia, Serbia and Romania outside the peninsula	9
only in the Greek Aegean Anatolian islands	12
Total in Balkan countries and Italy	287
Total in Balkan and Apennine peninsulas + Sicily	255

Table 2. Comparison between the two peninsulas by families, genera and species of Neuropterida.

Taxa	Apennine Peninsula	Balkan Peninsula	Both peninsulas
Families	14	15	15
Genera	65	71	74
Species	155	223	255

Both peninsulas. The total number of taxa in Italy and Balkan countries (again without Anatolia) is 287.

Numbers taken into consideration in the present analysis are: 155 species in the Apennine Peninsula proper and Sicily, 223 taxa in the Balkan Peninsula proper and 255 taxa in the two peninsulas and Sicily (Table 1).

Comparison between the two peninsulas according to the faunistic diversity

The Balkan fauna is richer than that of Apennine one by one family, 6 genera and 68 species and subspecies (Table 2).

By families. All European families of the three orders (Raphidioptera, Megaloptera and Neuroptera) occur in the Balkan Peninsula. The only difference in the Apennine Peninsula is the lack of Nemopteridae because of paleogeographical reasons. As a result of a marine transgression, the present-day Italy has been submerged by a sea stretched between Tyrrhenide in the west and Aegeide in the east from the Middle Eocene to Late Miocene. The family range of Nemopteridae in Europe is located on these two ancient lands (Popov, 1971).

By genera. Only three of the Apennine genera of Neuropterida lack in the Balkan Peninsula. All of them belong to Raphidiidae. Due to the presence of these three old relict monotypic genera, endemic for Southern Italy, the Apennine genera prevail over the Balkan ones only in Raphidiidae. Contrariwise, the Balkan genera prevail over the Apennine ones in five families. This predominance is highest in Myrmeleontidae. All genera of the two peninsulas occur in the Balkan Peninsula in fourteen families, while in the Apennine Peninsula, in only nine families.

By species (and subspecies). The Apennine species predominate over the Balkan ones only in Dilaridae and Ascalaphidae. Concerning Dilaridae, this is due to the occurrence of *Dilar corsicus* Navás on Zannone Island, which is a part of continental South Italy, and to the better presence of Dilaridae in Western (eleven species) than in Eastern (two species) Mediterranean. Concerning Ascalaphidae, Western Mediterranean is a centre of speciation for this family while in the Balkan Peninsula took place only dispersion of species from Anatolia. At first sight, the Apennine Peninsula seems richer in species than the Balkan one also as regards Nevrorthidae. Three species of this relict family are distributed in Italy compared to one in the Balkan Peninsula (*Nevrorthus apatelios* Aspöck, Aspöck et Hölzel) but only *Nevrorthus iridipennis* Costa from the Italian species occurs in the Apennine Peninsula proper. On the contrary, the Balkan species predominate over the Apennine species in nine families. The Balkan species prevail to a large degree in Raphidiidae with 34 taxa more in the Balkan than in the Apennine Peninsula, and considerably in Hemerobiidae.

Table 3. Taxa of Neuropterida specific or common to both peninsulas.

	Families		Genera		Species	
	n	%	n	%	n	%
Specific to Apennine Peninsula	–	–	3	4	32	13
Specific to Balkan Peninsula	1	7	9	12	100	39
Common to both peninsulas	14	93	62	84	123	48

The Balkan taxa not occurring in the Apennine Peninsula are 3 times more in genera and 3.1 times more in species than the Apennine taxa not occurring in the Balkan Peninsula (Table 3). This demonstrates once again that the Balkan fauna of Neuropterida is richer and diverse.

Endemism

The endemism in the treated region is from subspecies up to genus level (Table 4).

Endemic genera, all belonging to Raphidiidae, are: *Parvoraphidia* (Balkan Peninsula) and *Tjederiraphidia*, *Italoraphidia* and *Calabroraphidia* (Apennine Peninsula). The ranges of the last three genera, as it was mentioned above, are limited to Southern Italy, mainly to Calabria. All three genera are monotypic. This is a further indication that they are remnants from an ancient fauna.

Endemic subgenera inhabit only the Balkans from the analysed peninsulas. They all belong to the two families of Raphidioptera: *Graecoraphidia* and *Miroraphidia* (Raphidiidae) and *Reisserella* (Inocelliidae). The last two subgenera are monotypic.

Table 4. Endemic taxa of Neuropterida in the Balkan and Apennine peninsulas.

Taxa	Apennine Peninsula	Balkan Peninsula
Genera	3	1
Subgenera	–	3
Taxa (species + additional subspecies)	8	40
Species	8	34
Subspecies	–	8

The endemic species and subspecies are five times more in the Balkan Peninsula than in the Apennine Peninsula (Table 4). Apennine endemic taxa are one species in Sicily, *Libelloides siculus* (Angelini), and seven species in the peninsula proper (among them *Nevrorthus iridipennis* Costa distributed also in Sicily and *Dilar parthenopaeus* Costa distributed also in Sardinia). Other endemics in the region are not taken into consideration because occur beyond the peninsulas proper: two species from the non-Balkan part of Romania, five species from the Greek Anatolian islands (Chios) and Dodecanese (Rhodes and Karpathos) and one species from Sardinia (*Subilla principiae* Pantaleoni, Aspöck, Cao et Aspöck).

Zoogeographical belonging

A complete list of taxa, occurring in the Apennine Peninsula proper with Sicily and in the Balkan Peninsula proper, and their zoogeographical belonging are shown in Table 5.

The main zoogeographical categories proposed by de Lattin (1967) were used for arrangement of taxa in groups according to origin. To them were added also the categories introduced or interpreted by Aspöck *et al.* (1976, 1977, 1980) and Malicky *et al.* (1983). Zoogeographical belonging of many of the species is after Aspöck *et al*. (1980, 2001) but in some cases it is changed. Thus for example, *Hemerobius contumax* Tjeder, *Hemerobius micans* Olivier and *Megalomus hirtus* (Linnaeus) are interpreted here not as Siberian but as Central European–Mediterranean species; *Brinckochrysa chlorosoma* (Navás), not as Eremial but as Afrotropical species. Categories of polycentric Mediterranean species of 10 families with localization of centre of dispersal (the secondary Mediterranean centre) are determined more precisely. Categories of species indeterminated or not included by Aspöck *et al*. (2001) were defined.

Table 5. Distribution and zoogeographical belonging of the taxa in the Apennine and Balkan peninsulas.

Taxa	Apennine Peninsula	Balkan Peninsula	Zoogeographical categories
RAPHIDIOPTERA			
Raphidiidae			
Phaeostigma notata		+	Central European
Phaeostigma italogallica	+		Adriatomediterranean (stationary)
Phaeostigma galloitalica	+	+	Adriatomediterranean (expansive eastwards)
Phaeostigma euboica		+	Pontomediterranean: Balkan (stationary)
Phaeostigma pilicollis		+	Pontomediterranean: Balkan (stationary)
Phaeostigma divina divina		+	Pontomediterranean: Balkan (stationary)
Phaeostigma divina simillima		+	Pontomediterranean: Balkan (stationary)
Phaeostigma divina retsinata		+	Pontomediterranean: Balkan (stationary)
Phaeostigma hoelzeli		+	Pontomediterranean: Balkan (stationary)
Phaeostigma albarda		+	Pontomediterranean: Balkan (stationary)
Phaeostigma knappi		+	Pontomediterranean: Anatolian
Phaeostigma major		+	Pontomediterranean: Balkan (expansive northwards)
Phaeostigma wewalkai		+	Pontomediterranean: Balkan (stationary)
Phaeostigma flammi		+	Pontomediterranean: Balkan (stationary)
Phaeostigma horticola		+	Pontomediterranean: Balkan (stationary)
Phaeostigma klimeschi		+	Pontomediterranean: Balkan (stationary)
Phaeostigma setulosa setulosa		+	Pontomediterranean: Balkan (expansive northwards)
Phaeostigma setulosa aegea		+	Pontomediterranean: Balkan (stationary)
Phaeostigma rhodopica		+	Pontomediterranean: Balkan (stationary)
Phaeostigma grandii	+		Adriatomediterranean (stationary)
Phaeostigma biroi		+	Cretan
Phaeostigma thaleri		+	Pontomediterranean: Balkan (stationary)
Phaeostigma holzingeri		+	Pontomediterranean: Balkan (stationary)
Phaeostigma longicauda		+	Pontomediterranean: Balkan (stationary)
Phaeostigma auberti		+	Pontomediterranean: Balkan (stationary)
Phaeostigma rauschi		+	Pontomediterranean: Balkan (stationary)
Phaeostigma mammaphila		+	Pontomediterranean: Balkan (stationary)
Phaeostigma minois		+	Cretan
Phaeostigma curvatula		+	Pontomediterranean: Balkan (stationary)

Table 5. *Continued*.

Dichrostigma flavipes	+	+	Pontomediterranean: Balkan (expansive northwards)
Tjederiraphidia santuzza	+		Adriatomediterranean (stationary)
Turcoraphidia amara	+	+	Pontomediterranean: Balkan (expansive westwards)
Subilla confinis	+		Adriatomediterranean (expansive northwards)
Subilla artemis		+	Pontomediterranean: Balkan (stationary)
Subilla xylidiophila		+	Pontomediterranean: Balkan (stationary)
Ornatoraphidia flavilabris	+	+	Pontomediterranean: Balkan (expansive westwards)
Ornatoraphidia christianodagmara		+	Pontomediterranean: Balkan (stationary)
Xanthostigma xanthostigma		+	Siberian
Xanthostigma corsica	+		Adriatomediterranean (expansive westwards)
Xanthostigma aloysiana	+		Adriatomediterranean (expansive westwards)
Parvoraphidia microstigma		+	Pontomediterranean: Balkan (stationary)
Parvoraphidia aluada		+	Pontomediterranean: Balkan (stationary)
Parvoraphidia aphaphlyxte aphaphlyxte		+	Pontomediterranean: Balkan (stationary)
Parvoraphidia aphaphlyxte aganippe		+	Pontomediterranean: Balkan (stationary)
Ulrike attica		+	Pontomediterranean: Balkan (stationary)
Raphidia ophiopsis ophiopsis		+	Siberian
Raphidia ophiopsis alcoholica		+	Pontomediterranean: Balkan (stationary)
Raphidia mediterranea	+	+	Pontomediterranean: Balkan (expansive westwards)
Raphidia beieri		+	Pontomediterranean: Balkan (expansive northwards)
Raphidia ambigua		+	Pontomediterranean: Anatolian
Raphidia ariadne		+	Cretan
Raphidia ulrikae		+	Central European
Raphidia huettingeri		+	Pontomediterranean: Balkan (stationary)
Raphidia ligurica	+		Adriatomediterranean (stationary)
Italoraphidia solariana	+		Adriatomediterranean (stationary)
Puncha ratzeburgi	+	+	Central European
Calabroraphidia renate	+		Adriatomediterranean (stationary)
Venustoraphidia nigricollis	+	+	Pontomediterranean: Balkan (expansive westwards)
Venustoraphidia renate		+	Pontomediterranean: Balkan (stationary)
Inocelliidae			
Fibla maclachlani	+		Tyrrhenian
Fibla pasiphae		+	Cretan
Parainocellia braueri		+	Pontomediterranean: Balkan (stationary)
Parainocellia bicolor	+		Adriatomediterranean (stationary)
MEGALOPTERA			
Sialidae			
Sialis lutaria	+	+	Central European–Mediterranean
Sialis morio		+	Siberian
Sialis fuliginosa	+	+	Siberian
Sialis nigripes	+	+	Central European–Mediterranean
NEUROPTERA			
Nevrorthidae			
Nevrorthus iridipennis	+		Adriatomediterranean (stationary)
Nevrorthus apatelios		+	Pontomediterranean: Balkan (stationary)
Osmylidae			
Osmylus fulvicephalus	+	+	Holomediterranean (expansive northwards)
Chrysopidae			
Nothochrysa fulviceps	+	+	Central European
Nothochrysa capitata	+	+	Central European–Mediterranean
Hypochrysa elegans	+	+	Holomediterranean (expansive northwards)
Italochrysa italica	+	+	Holomediterranean (stationary)

Table 5. *Continued*.

Nineta flava	+	+	Central European
Nineta principiae	+	+	Pontomediterranean: Balkan (expansive westwards)
Nineta vittata		+	Siberian
Nineta inpunctata	+	+	Central European
Nineta pallida	+	+	Central European
Chrysotropia ciliata	+	+	Siberian
Chrysopa perla	+	+	Siberian
Chrysopa walkeri	+	+	Siberian
Chrysopa dorsalis	+	+	Pontomediterranean: Balkan (expansive northwards)
Chrysopa hungarica		+	Pontomediterranean: Balkan (expansive northwards)
Chrysopa abbreviata	+	+	Siberian
Chrysopa commata		+	Siberian
Chrysopa formosa	+	+	Siberian–Mediterranean
Chrysopa dubitans		+	Eremial
Chrysopa phyllochroma		+	Siberian
Chrysopa viridana	+	+	Holomediterranean (expansive northwards)
Chrysopa nigricostata	+	+	Holomediterranean (expansive northwards)
Chrysopa pallens	+	+	Siberian–Mediterranean
Dichochrysa flavifrons	+	+	Holomediterranean (expansive northwards)
Dichochrysa picteti	+		Atlantomediterranean
Dichochrysa inornata	+	+	Central European–Mediterranean
Dichochrysa mariana	+		Adriatomediterranean (expansive northwards)
Dichochrysa prasina	+	+	Siberian–Mediterranean
Dichochrysa abdominalis	+	+	Central European
Dichochrysa zelleri	+	+	Pontomediterranean: Balkan (expansive westwards)
Dichochrysa ventralis	+	+	Central European
Dichochrysa ariadne		+	Cretan
Dichochrysa genei	+	+	Holomediterranean (stationary)
Dichochrysa venusta	+	+	Adriatomediterranean (expansive eastwards)
Dichochrysa clathrata	+	+	Holomediterranean (stationary)
Cunctochrysa albolineata	+	+	Siberian
Cunctochrysa baetica	+	+	Holomediterranean (stationary)
Peyerimhoffina gracilis	+	+	Central European–Mediterranean
Chrysoperla carnea	+	+	Siberian
Chrysoperla lucasina	+	+	Holomediterranean (expansive northwards)
Chrysoperla pallida	+	+	Central European
Chrysoperla agilis	+	+	Holomediterranean (stationary)
Chrysoperla mediterranea	+		Atlantomediterranean
Chrysoperla mutata		+	Holomediterranean (expansive only eastwards)
Chrysoperla renoni		+	Holomediterranean (expansive northwards)
Brinckochrysa chlorosoma	+	+	Afrotropical
Brinckochrysa nachoi	+		Atlantomediterranean
Rexa lordina	+	+	Atlantomediterranean
Rexa raddai		+	Pontomediterranean: Balkan (stationary)
Suarius nanus		+	Pontomediterranean: Anatolian
Hemerobiidae			
Hemerobius humulinus	+	+	Siberian–Nearctic
Hemerobius simulans		+	Siberian–Nearctic
Hemerobius stigma	+	+	Siberian–Nearctic
Hemerobius pini		+	Siberian
Hemerobius contumax	+	+	Central European–Mediterranean
Hemerobius fenestratus		+	Siberian
Hemerobius atrifrons		+	Siberian
Hemerobius nitidulus	+	+	Siberian

Table 5. *Continued*.

Hemerobius schedli		+	Central European
Hemerobius handschini	+	+	Holomediterranean (expansive northwards)
Hemerobius micans	+	+	Central European–Mediterranean
Hemerobius lutescens	+	+	Siberian
Hemerobius gilvus	+	+	Holomediterranean (expansive northwards)
Hemerobius zernyi		+	Pontomediterranean: Anatolian
Hemerobius marginatus		+	Siberian
Wesmaelius concinnus		+	Siberian
Wesmaelius quadrifasciatus		+	Siberian
Wesmaelius fassnidgei		+	Central European
Wesmaelius nervosus	+	+	Siberian–Nearctic
Wesmaelius malladai		+	Oreotundral Arctoalpine (Oreal)
Wesmaelius tjederi	+	+	Central European
Wesmaelius subnebulosus	+	+	Holomediterranean (expansive northwards)
Wesmaelius ravus	+	+	Siberian–Mediterranean
Wesmaelius navasi		+	Eremial
Wesmaelius persimilis		+	Pontomediterranean: Balkan (stationary)
Wesmaelius mortoni		+	Siberian
Wesmaelius mongolicus		+	Eremial
Sympherobius pygmaeus	+	+	Holomediterranean (expansive northwards)
Sympherobius luqueti	+		Adriatomediterranean (stationary)
Sympherobius elegans	+	+	Holomediterranean (expansive northwards)
Sympherobius fallax	+	+	Afrotropical
Sympherobius fuscescens	+	+	Siberian
Sympherobius pellucidus	+	+	Holomediterranean (expansive northwards)
Sympherobius klapaleki	+	+	Holomediterranean (expansive northwards)
Psectra diptera	+	+	Siberian–Nearctic
Megalomus tortricoides	+	+	Holomediterranean (expansive northwards)
Megalomus hirtus	+	+	Central European–Mediterranean
Megalomus tineoides	+	+	Holomediterranean (stationary)
Megalomus pyraloides	+	+	Adriatomediterranean (expansive westwards)
Drepanepteryx phalaenoides	+	+	Siberian
Micromus variegatus	+	+	Siberian
Micromus angulatus	+	+	Siberian–Nearctic
Micromus paganus	+	+	Siberian
Micromus lanosus	+	+	Central European
Sisyridae			
Sisyra nigra	+	+	Siberian–Nearctic
Sisyra terminalis		+	Siberian
Sisyra bureschi		+	Pontomediterranean: Balkan (stationary)
Sisyra corona		+	Pontomediterranean: Balkan (stationary)
Coniopterygidae			
Aleuropteryx loewii	+	+	Holomediterranean (expansive northwards)
Aleuropteryx juniperi	+	+	Holomediterranean (expansive northwards)
Aleuropteryx umbrata		+	Pontomediterranean: Anatolian
Helicoconis lutea		+	Siberian–Nearctic
Helicoconis hirtinervis	+		Central European
Helicoconis pseudolutea	+	+	Holomediterranean (expansive northwards)
Helicoconis hispanica	+		Atlantomediterranean
Helicoconis aptera		+	Pontomediterranean: Anatolian
Vartiana necopinata		+	Pontomediterranean: Anatolian
Coniopteryx loipetsederi	+	+	Holomediterranean (stationary)
Coniopteryx atlasensis		+	Holomediterranean (expansive only eastwards)
Coniopteryx aspoecki		+	Siberian

Table 5. *Continued*.

Coniopteryx borealis	+	+	Holomediterranean (expansive northwards)
Coniopteryx pygmaea	+	+	Siberian–Mediterranean
Coniopteryx hoelzeli		+	Central European
Coniopteryx tineiformis	+	+	Siberian–Nearctic
Coniopteryx haematica	+	+	Holomediterranean (expansive northwards)
Coniopteryx drammonti	+	+	Holomediterranean (expansive northwards)
Coniopteryx renate	+		Adriatomediterranean (expansive northwards)
Coniopteryx arcuata	+	+	Holomediterranean (expansive northwards)
Coniopteryx esbenpeterseni	+	+	Holomediterranean (expansive northwards)
Coniopteryx lentiae	+	+	Holomediterranean (expansive northwards)
Coniopteryx tjederi	+	+	Holomediterranean (expansive northwards)
Parasemidalis fuscipennis	+	+	Siberian–Nearctic
Hemisemidalis pallida	+	+	Eremial
Conwentzia pineticola	+	+	Siberian–Mediterranean
Conwentzia psociformis	+	+	Central European–Mediterranean
Semidalis aleyrodiformis	+	+	Siberian–Mediterranean
Semidalis pseudouncinata	+	+	Holomediterranean (expansive northwards)
Semidalis vicina	+	+	Holomediterranean (expansive northwards)
Dilaridae			
Dilar corsicus	+		Tyrrhenian
Dilar parthenopaeus	+		Adriatomediterranean (expansive westwards)
Dilar turcicus		+	Pontomediterranean: Anatolian
Mantispidae			
Mantispa styriaca	+	+	Holomediterranean (expansive only eastwards)
Mantispa perla	+	+	Holomediterranean (expansive only eastwards)
Mantispa aphavexelte	+	+	Holomediterranean (expansive only eastwards)
Nampista auriventris		+	Eremial
Berothidae			
Isoscelipteron fulvum	+	+	Pontomediterranean: Anatolian
Nemopteridae			
Nemoptera coa		+	Pontomediterranean: Anatolian
Nemoptera sinuata		+	Pontomediterranean: Anatolian
Myrmeleontidae			
Palpares libelluloides	+	+	Holomediterranean (stationary)
Acanthaclisis occitanica	+	+	Holomediterranean (expansive northwards)
Synclisis baetica	+	+	Holomediterranean (expansive northwards)
Myrmecaelurus trigrammus	+	+	Holomediterranean (expansive northwards)
Nohoveus punctulatus		+	Eremial
Cueta lineosa	+	+	Eremial
Cueta beieri		+	Eremial
Myrmeleon formicarius	+	+	Siberian
Myrmeleon noacki		+	Pontomediterranean: Anatolian
Myrmeleon immanis		+	Mongolian
Myrmeleon inconspicuus	+	+	Holomediterranean (expansive northwards)
Myrmeleon hyalinus	+	+	Eremial
Euroleon nostras	+	+	Central European–Mediterranean
Dendroleon pantherinus	+	+	Siberian
Macronemurus appendiculatus	+	+	Holomediterranean (stationary)
Macronemurus bilineatus		+	Pontomediterranean: Balkan (stationary)
Delfimeus irroratus		+	Pontomediterranean: Anatolian
Neuroleon arenarius	+	+	Holomediterranean (stationary)
Neuroleon tenellus		+	Eremial
Neuroleon ochreatus	+		Atlantomediterranean

Table 5. *Continued*.

Neuroleon egenus	+	+	Holomediterranean (stationary)
Neuroleon nemausiensis	+	+	Holomediterranean (expansive northwards)
Neuroleon assimilis		+	Pontomediterranean: Anatolian
Neuroleon microstenus	+	+	Holomediterranean (stationary)
Distoleon tetragrammicus	+	+	Holomediterranean (expansive northwards)
Distoleon annulatus	+	+	Eremial
Nicarinus poecilopterus	+	+	Pontomediterranean: Anatolian
Creoleon lugdunensis	+	+	Atlantomediterranean
Creoleon plumbeus	+	+	Pontomediterranean: Anatolian
Creoleon aegyptiacus	+		Holomediterranean (expansive only eastwards)
Creoleon corsicus	+		Tyrrhenian
Nedroledon anatolicus		+	Pontomediterranean: Balkan (stationary)
Megistopus flavicornis	+	+	Holomediterranean (expansive northwards)
Megistopus mirabilis	+		Holomediterranean (stationary)
Gymnocnemia variegata	+	+	Holomediterranean (expansive only eastwards)
Ascalaphidae			
Bubopsis agrionoides	+		Atlantomediterranean
Bubopsis andromache		+	Pontomediterranean: Anatolian
Deleproctophylla australis	+	+	Pontomediterranean: Balkan (expansive westwards)
Deleproctophylla variegata		+	Pontomediterranean: Anatolian
Libelloides coccajus	+		Adriatomediterranean (expansive northwards)
Libelloides lacteus	+	+	Pontomediterranean: Balkan (expansive westwards)
Libelloides longicornis	+		Atlantomediterranean
Libelloides macaronius		+	Pontomediterranean: Anatolian
Libelloides rhomboideus rhomboideus		+	Pontomediterranean: Anatolian
Libelloides rhomboideus cretensis		+	Cretan
Libelloides latinus	+		Adriatomediterranean (stationary)
Libelloides siculus	+		Adriatomediterranean (stationary)
Libelloides corsicus	+		Tyrrhenian

Zoogeographical belonging of the taxa is determined on the basis of analysis of the ranges, ecology and related species. Number of taxa by categories in each peninsula is shown in Tables 6-7. The Oreal species is placed among the northern, the several Eremial species, among the southern species. Siberian–Nearctic are named the species with Holarctic distribution. Holarctic is too wide term for a centre of origin or dispersal. Because of that, more suitable is a term similar to Siberian–Mediterranean and Central European–Mediterranean.

Polytypic species with more than one subspecies in discussed region are treated further in the zoogeographical analysis as subspecies (four species of Raphidiidae and one species of Ascalaphidae) while the species with one subspecies each in the region are interpreted zoogeographically as species: *Nineta guadarramensis* (Pictet), *Dichochrysa flavifrons* (Brauer) and *Myrmeleon hyalinus* Olivier.

Comparison between the faunas of the two peninsulas shows the presence of 19 groups (12 categories, three of which include 10 subcategories) in the Apennine Peninsula (Table 6) and of 20 groups (14 categories, three of which include 9 subcategories) in the Balkan Peninsula (Table 7) or 23 groups (15 categories, three of which include 11 subcategories) altogether. The subcategories (they are not listed in Tables 6-7) are as follows:

1. Holomediterranean faunal elements:
   a) stationary;
   b) expansive northwards or northwards and eastwards;
   c) expansive only eastwards.
2. Adriatomediterranean faunal elements:
   a) stationary;
   b) expansive northwards;
   c) expansive to Tyrrhenian or Atlantomediterranean centre;
   d) expansive to Pontomediterranean centre.

3. Pontomediterranean faunal elements:
 a) stationary; of Balkan origin;
 b) expansive northwards; of Balkan origin;
 c) expansive to Adriatomediterranean centre; of Balkan origin;
 d) of Anatolian origin.

Table 6. Zoogeographical belonging of Neuropterida in the Apennine Peninsula.

Zoogeographical categories	Number of taxa
Northern origin	
Siberian–Nearctic	8
Siberian	15
Siberian–Mediterranean	7
Central European	11
Central European–Mediterranean	10
Southern origin	
Holomediterranean (3 subcategories)	51
Atlantomediterranean	9
Tyrrhenian	4
Adriatomediterranean (4 subcategories)	21
Pontomediterranean (3 subcategories)	13
Afrotropical	2
Eremial	4
Total	**155**

Table 7. Zoogeographical belonging of Neuropterida in the Balkan Peninsula.

Zoogeographical categories	Number of taxa
Northern origin	
Oreotundral Arctoalpine (Oreal)	1
Siberian–Nearctic	10
Siberian	30
Siberian–Mediterranean	7
Mongolian	1
Central European	15
Central European–Mediterranean	10
Southern origin	
Holomediterranean (3 subcategories)	52
Atlantomediterranean	2
Adriatomediterranean (2 subcategories)	3
Pontomediterranean (4 subcategories)	73
Cretan	6
Afrotropical	2
Eremial	11
Total	**223**

Table 8. Species of southern origin in the two peninsulas according to families or groups of families.

Groups	Apennine Peninsula			Balkan Peninsula		
	n	Share	Total	n	Share	Total
Raphidioptera	17	94 %	18	47	90 %	52
Myrmeleontidae	23	88 %	26	27	87 %	31
Megaloptera and diverse Neuroptera	16	80 %	20	19	76 %	25
Coniopterygidae	16	70 %	23	18	67 %	27
Chrysopidae	20	51 %	39	23	51 %	45
Hemerobiidae	12	41 %	29	15	35 %	43
Total	104	67 %	155	149	67 %	223

In the Apennine Peninsula, most numerous is the category of Holomediterranean faunal elements. Second place far to it is taken by Adriatomediterranean followed by Siberian faunal elements. If we include the subcategories, the Holomediterranean species expansive northwards (33 species) top the list followed by Siberian (15 species) and stationary Holomediterranean species (13 species). In the Balkan Peninsula, the list of categories is headed by Pontomediterranean, Holomediterranean and Siberian faunal elements. According to both, categories and subcategories, the position of the first three is the same but the Pontomediterranean are represented by stationary taxa of Balkan origin (39 species) and Holomediterranean, by expansive northwards species (34 species).

If we compare the large ecological-zoogeographical complexes (biochores or biomes), the Oreotundral fauna is represented only with 0.4 % in the Balkan Peninsula, and Eremial fauna, with 3 % in the Apennine and 5 % in the Balkan Peninsula. The rest belongs to the Arboreal fauna.

Share of the species of southern and northern origin in the two peninsulas

Zoogeographical categories in Tables 6-7 are separated in those of northern and of southern origin. Division according to origin is made on the basis of location of the centre of dispersion towards the border between the Central European and Mediterranean centres.

Neuropterida are classified for conclusions in the present analysis on practical grounds in six groups:
a) Raphidioptera (Raphidiidae and Inocelliidae) – 63 taxa;
b) Chrysopidae – 49 species;
c) Hemerobiidae – 44 species;
d) Coniopterygidae – 30 species;
e) Myrmeleontidae – 35 species;
f) Megaloptera (Sialidae) and diverse families of Neuroptera with low species diversity (Nevrorthidae, Osmylidae, Sisyridae, Dilaridae, Mantispidae, Berothidae, Nemopteridae, Ascalaphidae) – 34 taxa.

The share of the species of southern origin in both peninsulas by chosen taxonomic groups is given in Table 8. In Neuropterida as a whole, it is the same in the Apennine and Balkan peninsulas (67 %). It strikes one that the ranking of the selected systematic groups according to the share of southern species is wholly identical in both peninsulas: from Raphidioptera (maximum) to Hemerobiidae (minimum). In all groups, the number of the species of southern origin in the Balkan Peninsula is higher than that in the Apennine Peninsula. The difference between them is highest in Raphidioptera (30 taxa) and lowest in Coniopterygidae (2 species). The same is valid for the northern species. The difference here is highest in Hemerobiidae (11 species) and lowest in Myrmeleontidae (1 species). The share of the southern species is higher in the Apennine Peninsula than in the Balkan Peninsula in all taxonomic groups; only in Chrysopidae the share is the same (51 %).

Routes of dispersal

The recent fauna of Neuropterida of the Balkan and Apennine peninsulas is perhaps the most interesting in Europe because it is a result of species dispersal from the primary centres of speciation in Northern Palearctic,

from secondary Mediterranean centres and in some cases from far away located centres and even from centres beyond the border of Palearctic. This dispersal was limited by climatic and sea barriers in some periods of geological past but in other periods was advantaged during changes in climate, relief and coastal lines (temporary bridges between two mainlands). The recent distribution of Raphidioptera in the Apennine Peninsula was discussed in detail in the light of paleogeography of the region by Aspöck & Aspöck (2007).

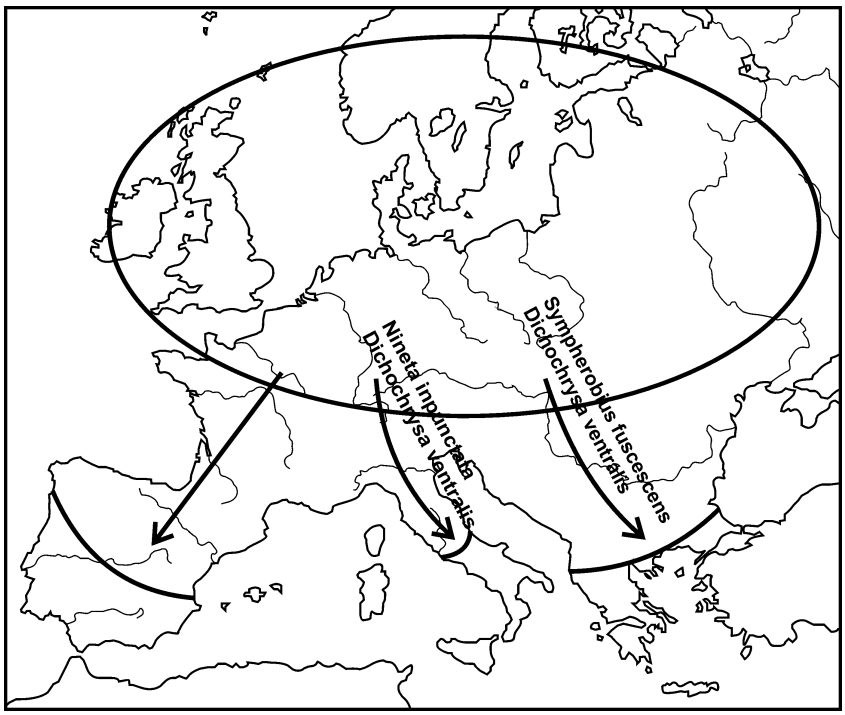

Fig. 1. Dispersal of expansive species of northern origin.

Dispersal from north to south (Fig. 1) is typical for species of two centres of speciation: Siberian and Central European. A part of species of the Siberian centre of dispersion has originated from the Manchurian or Ussurian centres of origin. The expansive northern species which have reached both peninsulas (as well as Iberian Peninsula) are Siberian–Nearctic, e.g. *Hemerobius humulinus* Linnaeus; Siberian, e.g. *Myrmeleon formicarius* Linnaeus; Central European, e.g. *Nineta flava* (Scopoli); Siberian–Mediterranean, e.g. *Semidalis aleyrodiformis* (Stephens); Central European–Mediterranean, e.g. *Sialis lutaria* (Linnaeus). The species of the first three categories occur only in mountains or in mountains and lowlands. The last two categories consist of species dispersed additionally from refuges and inhabiting now most parts of the territory of the two peninsulas, including the sea coasts. The same rate of species has invaded in both peninsulas but the number of species entered in the Balkan Peninsula is 1.5 times higher than those in the Apennine Peninsula. This can be explained with the fact that the Balkan Peninsula is open from north both for lowland and for mountain species, while the Alps are a barrier for the penetration of some lowland species to the Apennine Peninsula.

Expansive Holomediterranean elements have extended their ranges in two directions: northwards and eastwards (Fig. 2). All of them have begun their expansion from the three South European peninsulas. Farthest away in the north, up to the limit marked off in Fig. 2, reach the ranges of *Osmylus fulvicephalus* (Scopoli), *Dichochrysa flavifrons* (Brauer), *Sympherobius pygmaeus* (Rambur), *Sympherobius elegans* (Stephens) and *Coniopteryx borealis* Tjeder. Among the species with expansion only eastwards, the range of *Gymnocnemia variegata* (Schneider) reaches Tajikistan. The Holomediterranean species from all three subcategories (stationary, expansive northwards and expansive eastwards) altogether are better represented in the Apennine Peninsula (33 %) than in the Balkan Peninsula (23 %). This is due to the central location of the Apennine Peninsula between Iberian and Balkan peninsulas.

The routes of dispersal of the expansive species from the secondary Mediterranean centres (Fig. 3-6) are very diverse. Shown in the maps are examples for dispersal of Adriatomediterranean and Pontomediterranean

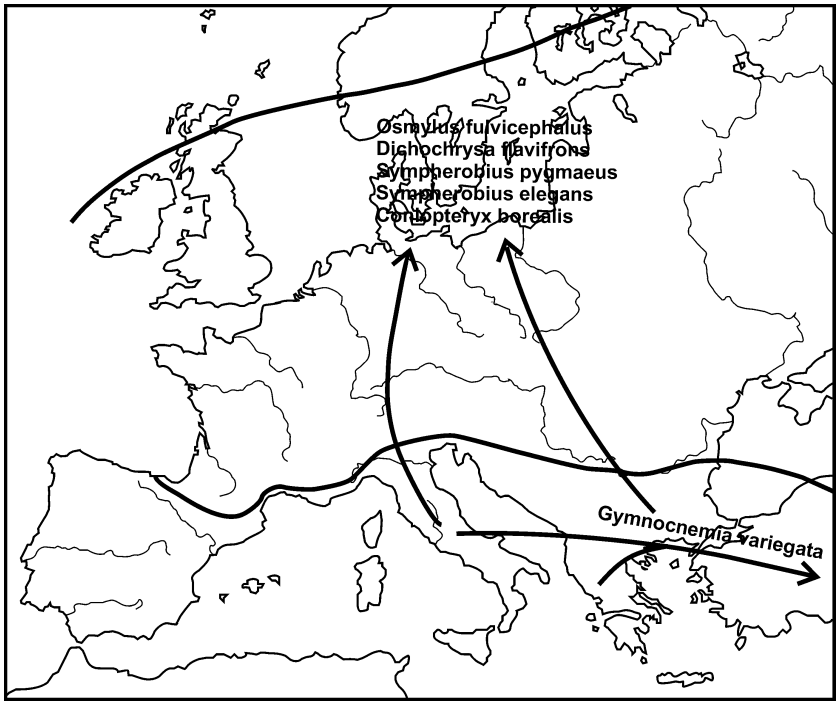

Fig. 2. Dispersal of expansive Holomediterranean faunal elements northwards and eastwards.

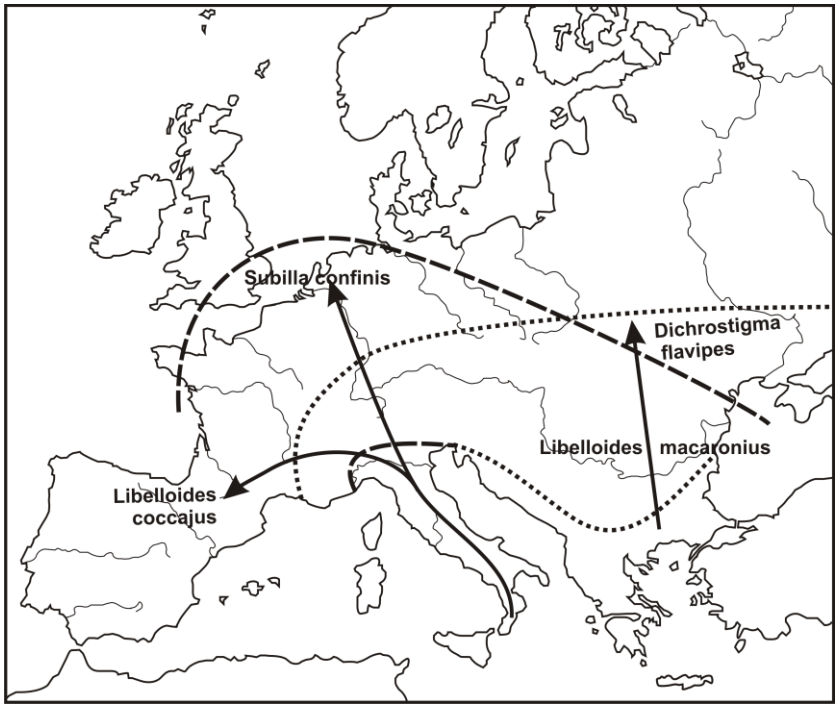

Fig. 3. Dispersal of Adriatomediterranean (*dashed line*) and Pontomediterranean (*stippled line*) faunal elements, expansive northwards. Northern borders of ranges of *Subilla confinis* (*northern dashed line*) and *Dichrostigma flavipes* (*northern stippled line*) are outlined.

faunal elements northwards, of Western Mediterranean species (Atlantomediterranean eastwards; the very rare case of Tyrrhenian elements eastwards; Adriatomediterranean westwards and rare eastwards), of species of Transadriatic distribution (Pontomediterranean westwards and northwestwards; the rare case of Adriatomediterranean elements eastwards), of Pontomediterranean elements of Balkan origin eastwards and northeastwards and of Anatolian origin westwards. The last two types of dispersal illustrate the expansion within the Pontomediterranean centre.

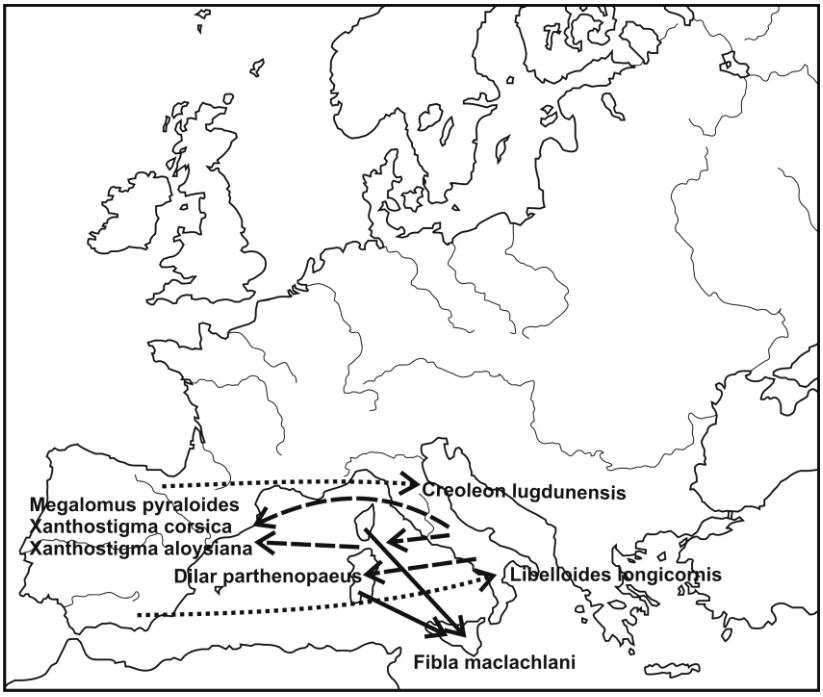

Fig. 4. Dispersal of expansive Western Mediterranean species: routes of Atlantomediterranean faunal elements eastwards (*stippled lines*), Tyrrhenian faunal elements eastwards (*solid lines*) and Adriatomediterranean faunal elements westwards (*dashed lines*).

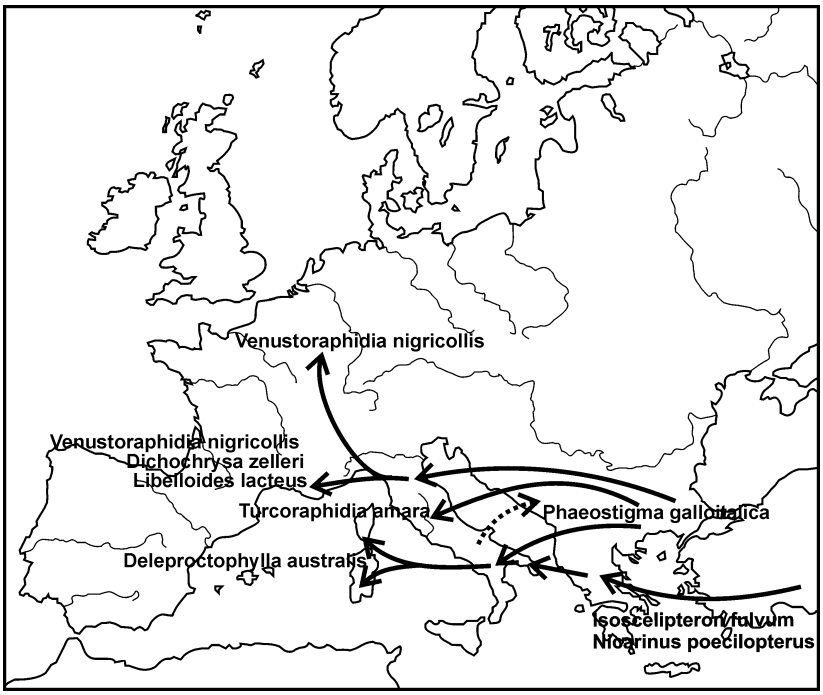

Fig. 5. Dispersal between the Apennine and Balkan peninsulas: routes of Adriatomediterranean faunal elements eastwards (*stippled line*) and Pontomediterranean faunal elements westwards and northwestwards (*solid lines*).

Pontomediterranean taxa (without Cretan taxa) of Neuropterida in the Balkan Peninsula are 3.5 times more than the Adriatomediterranean taxa in the Apennine Peninsula. This is due to the fact that the Balkan Peninsula covers only a part of the Pontomediterranean centre and its species diversity is enriched by taxa of Anatolian origin. The species of all secondary Mediterranean centres of dispersion are more in the Balkan fauna (38 %) than those in the Apennine fauna (30 %). This can be explained by the fact that the Pontomediterranean centre is a much larger undivided land than the Adriatomediterranean centre.

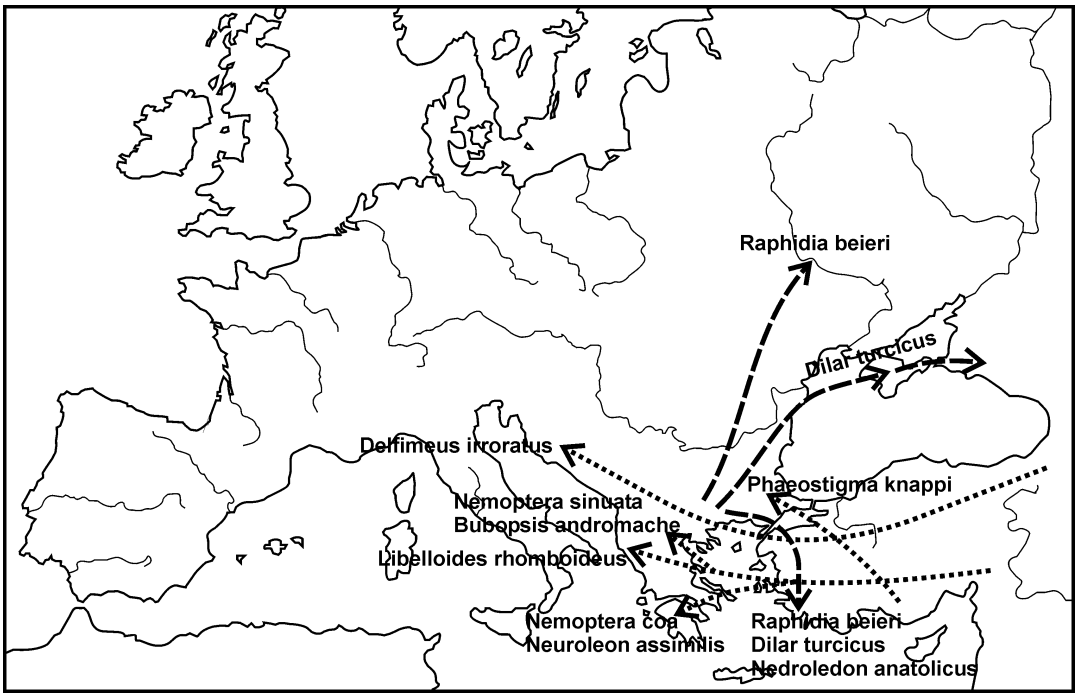

Fig. 6. Expansion within the Pontomediterranean area: routes of dispersal of Pontomediterranean faunal elements of Balkan origin eastwards and northeastwards (*dashed lines*) and Pontomediterranean faunal elements of Anatolian origin westwards (*stippled lines*).

Fig. 7. Endemic ranges in the Apennine (*solid lines*) and Balkan (*dashed lines*) peninsulas. Apennine Peninsula: entire peninsula; Southern Italy; Calabria; Sicily. Balkan Peninsula: entire peninsula; Eastern Balkan Peninsula; Montenegro, Albania and Northern Greece; Central Greece; Peloponnesos; Crete.

The ranges of the taxa endemic for each of the two peninsulas can be arranged in several groups (Fig. 7). When we neglect the entire peninsulas in this scheme, the remaining areas represent the tertiary centres of speciation. An exception is the Cretan centre which according to de Lattin (1967) is a secondary centre. Here are listed these territories of higher rate of endemism with examples of some of endemic taxa inhabiting them.

Apennine Peninsula

- Entire Apennine Peninsula and adjacent territories of France: *Phaeostigma italogallica* (Aspöck et Aspöck) – subendemic, *Parainocellia bicolor* (Costa) – subendemic, *Libelloides latinus* (Lefèbvre), etc.;
- Southern Italy: *Phaeostigma grandii* (Principi), *Italoraphidia solariana* (Navás);
- Calabria: *Tjederiraphidia santuzza* (Aspöck, Aspöck et Rausch), *Calabroraphidia renate* Rausch, Aspöck et Aspöck;
- Sicily: *Libelloides siculus* (Angelini).

Balkan Peninsula

- Entire Balkan Peninsula: *Phaeostigma pilicollis* (Stein), *Nevrorthus apatelios* Aspöck, Aspöck et Hölzel – subendemic;
- Eastern Balkan Peninsula: *Phaeostigma rhodopica* (Klapálek), *Sisyra corona* Rausch et Weissmair;
- Montenegro, Albania and Northern Greece: *Phaeostigma setulosa aegea* Aspöck, Aspöck et Rausch, *Wesmaelius persimilis* (Ohm), etc.;
- Central Greece: many *Phaeostigma* (especially *Magnoraphidia*), *Ornatoraphidia christianodagmara* (Aspöck et Aspöck), *Ulrike attica* (Aspöck et Aspöck), etc.;
- Peloponnesos: many *Phaeostigma* (especially *Graecoraphidia*), *Parvoraphidia*, etc.;
- Crete: *Fibla pasiphae* (Aspöck et Aspöck), *Dichochrysa ariadne* (Hölzel), *Libelloides rhomboideus cretensis* (Van der Weele), etc.

Conclusions

The Balkan Peninsula is characterized by richer fauna of Neuropterida than the Apennine Peninsula because of:

a) its larger territory;
b) its long land border with Central Europe;
c) absence of high mountain transverse barriers on its border with Central Europe;
d) its long-term history in Neogene as land;
e) presence of many centres of fourth and fifth levels of speciation for Raphidioptera (centre of third level is the entire Balkan Peninsula as well as Anatolia); as a result the Balkan Peninsula harbours a quarter of the snakefly species of the World (this is an unique case among the animal taxonomic groups) and the Pontomediterranean elements in the Balkan Peninsula are much more than all species from secondary Mediterranean centres in the Apennine Peninsula.

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