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The Raphidioptera of the Apennines Peninsula: a biogeographical analysis*

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So far, 24 species of Raphidioptera – 21 of Raphidiidae/3 of Inocelliidae – have been found in Italy, 22 (20/2) of these on the mainland only. Five species (4/1) have been detected only in the northernmost parts (Southern Alps), 17 species (16/1) have been recorded from various parts of the Apennines Peninsula (AP). By far most of these are monocentric Adriatomediterranean faunal elements (8/1), 3 species of Raphidiidae are polycentric Adriatomediterranean-Balkanopontomediterranean faunal elements. Four species of Raphidiidae are endemic to the AP. Three of these species, each representing a systematically isolated monotypic genus confined to the south of the AP, are most probably ancient inhabitants of the AP and of Iberian origin: *Italoraphidia solariana*, *Calabroraphidia renate* and *Tjederiraphidia santuzza*. The fourth endemic species, *Phaeostigma (Pontoraphidia) grandii*, although more recent, is possibly a remainder of the old fauna of the Apulian platform. Of the remaining monocentric Adriatomediterranean elements only *Subilla confinis* shows an expansivity which has led to a (mainly postglacial) colonisation of larger parts of Central, western and eastern Europe. The others have hardly extended their distributions beyond the AP (*Raphidia ligurica*, *Parainocellia bicolor*) or they have colonised only small parts of the south of Central Europe, southern France, and northern Spain (*Phaeostigma italogallica*, *Xanthostigma aloysiana*, *X. corsica*). Regarding the polycentric species, two (*Ornatoraphidia flavilabris*, *Venustoraphidia nigricollis*) also inhabit many extramediterranean parts of Europe, but these colonisations occurred from the Balkan Peninsula (BP) and not from the AP. The remaining species (*Dichrostigma flavipes*, *Turcoraphidia amara*, *Raphidia mediterranea*, *Puncha ratzeburgi*) are recent invaders (during the Pleistocene) from the east and/or from the north. The Raphidioptera species presently inhabiting the AP exhibit extensive differences in age and origin reflecting the complex geomorphological history of the peninsula.

Keywords – Raphidioptera, Raphidiidae, Inocelliidae, Apennines Peninsula, Italy, biogeography, endemisms.

Introduction

The Raphidioptera of the Mediterranean parts of Europe have been intensively studied throughout the past decades, in particular, also those of the Apennines Peninsula (AP). Since the latest accounts and biogeographical analyses (H. Aspöck *et al.*, 1991, 2001; [Bernardi] Iori *et al.*, 1995), besides new records of several species, two surprising discoveries have been made on the mainland of Italy, one of them leading to the description of a new species belonging to a new genus (Rausch *et al.*, 2004; Fig. 1), the other

* Gratefully, cordially, and respectfully dedicated to Professor Maria Matilde Principi on the occasion of her 90th birthday (May 4th, 2005). With her papers on Raphidioptera published during the 1950s and 1960s she has initiated a new era in Raphidioptera research. Her studies, descriptions, conclusions, and considerations, and, in particular, also her outstanding drawings have been of utmost influence for our further neuropterological work.

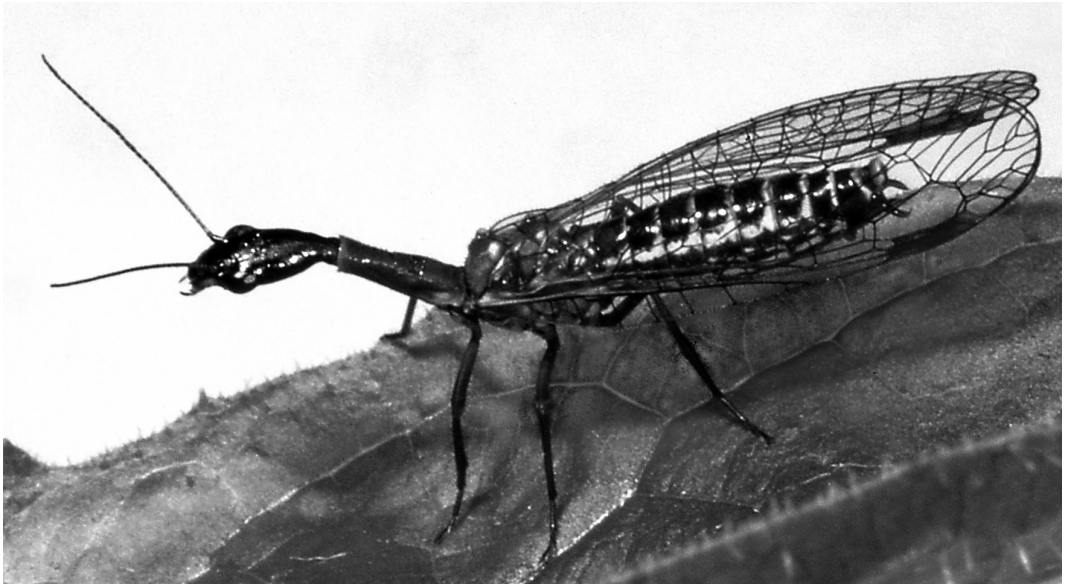

Fig. 1 – *Calabroraphidia renate* Rausch & H. Aspöck & U. Aspöck, 2004, ♂. Italia, Calabria, Cosenza, Sila Grande, near Viváio, 39° 23' 38'' N / 16° 36' 24'' E, 1300 m, 18 June 2005, H. & R. Rausch leg. (Photograph by Hubert Rausch).

representing a species and a genus so far only known from Pontomediterranean regions (Letardi, 2004), and, in addition, a spectacular new species has been detected in Sardinia (Pantaleoni *et al.*, 2005). Moreover, research on the palaeogeography and palaeoclimatology of the Mediterranean has made considerable progress so that the time has come to reconsider the genesis of the Raphidioptera fauna of the AP and to summarise our knowledge on snake-flies of this part of Europe in light of biogeography.

The Raphidioptera (snake-flies) with about 215 valid (and possibly 250 existing) species is the smallest and more ancestral order of the Holometabola. During the Mesozoic snake-flies occurred in a significantly greater diversity than today, and they also inhabited tropical regions (H. Aspöck, 1998, 2004; U. Aspöck & H. Aspöck, 2003, 2004, 2005a). Nowadays they are designated as living fossils, while their present distribution is restricted to arboreal parts of the Northern hemisphere.

The western Palaearctic harbours the highest number of species (about 110), however, most of them are restricted to small areas in mountain ranges of the peninsulas of Southern Europe, northwest Africa, Anatolia, and a few other parts of the Near East respectively. No snake-fly species exists with a distribution comprising all three south European peninsulas, and very few species occur in the AP as well as the Iberian Peninsula (IP) or the Balkan Peninsula (BP).

Snake-flies in general are characterised by an extremely low expansivity. The majority of species from both families on all continents inhabit small areas, in many cases just a few mountain ranges. Several species exist which have been recorded from a single mountain only (stationary species). Rarely do species occupy large distribution areas. Examples are, on one hand, a few Euro-Siberian elements with distributions covering large parts of Europe and northern Asia (they are particularly associated with the belt of the coniferous forests), and on the other hand, several Nearctic species occurring along the Rocky Mountains from the north of Mexico

to the south of western Canada. So far it is unknown why so many Raphidioptera species are markedly stationary although it seems that identical or, at least suitable ecological conditions exist in adjacent regions.

The Raphidioptera of Italy also contain several extremely stationary species (*I. solariana*, *C. renate*, *T. santuzza*) as well as a number of species with very low (e.g. *Ph. grandii*) or modest expansivity (e.g. *Parainocellia bicolor*), but only one really expansive species (*Subilla confinis*).

The biogeographical terminology used in this article follows that in the Biogeography Glossary in H. Aspöck *et al.* (1991).

Annotated list of the Raphidioptera of Italy

At present, the following species have been found in continental parts of Italy; the list is made complete by the addition of comments on the snake-flies of the Italian islands. For distribution maps see H. Aspöck *et al.* (1991); additional records in Italy: Pantaleoni (1990a, 1990b); Letardi (1991, 1993, 1994, 2004); Pantaleoni *et al.* (1994); Hellrigl & Hölzel (1996); Letardi & Pantaleoni (1996); Pantaleoni & Letardi (1998); Güsten (1998a, b, c); Letardi & Maltzeff (2001); Nicoli Aldini & Baviera (2001); Rausch *et al.* (2004); Pantaleoni (2005).

Phaeostigma (Phaeostigma) notata
(Fabricius, 1781)

Widely distributed in extramediterranean parts of Europe. Recorded in Italy only in the northernmost parts, i.e. in the Southern Alps.

Phaeostigma (Phaeostigma) italogallica
(H. Aspöck & U. Aspöck, 1976)

Known only from the south of Italy and from southern France.

Phaeostigma galloitalica
(H. Aspöck & U. Aspöck, 1976)

Recorded from the AP, southern France and Dalmatia.

Phaeostigma (Pontoraphidia) grandii
(Principi, 1960)

Recorded only from the southern half of the

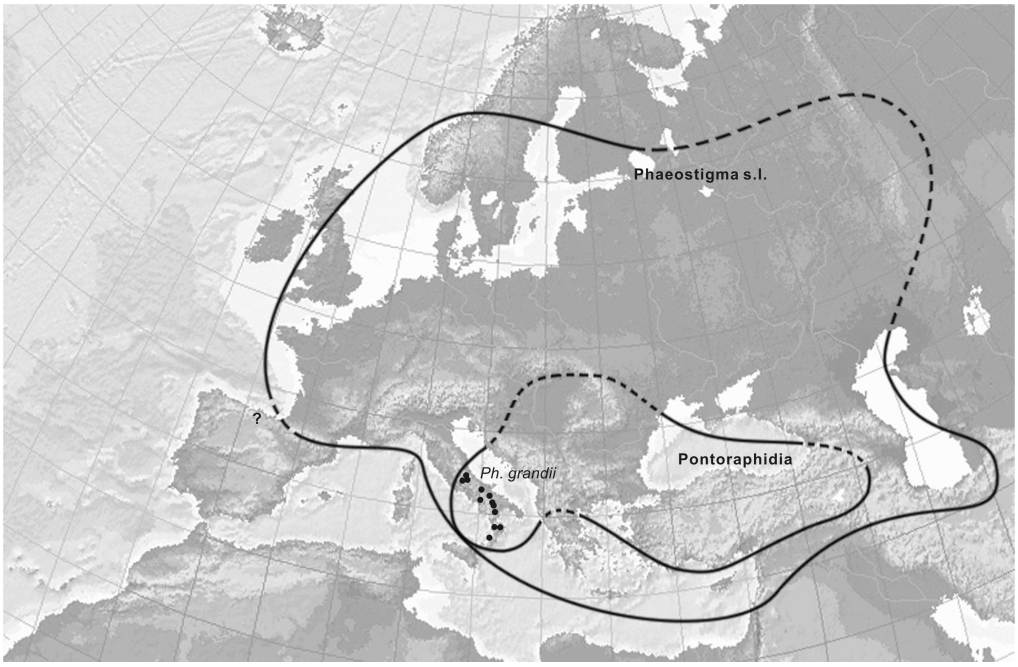

Fig. 2 – Documented distribution of *Phaeostigma (Pontoraphidia) grandii*, of the subgenus *Pontoraphidia*, and of the genus *Phaeostigma*.

AP (Fig. 2).

Dichrostigma flavipes (Stein, 1863)

Widely distributed in the BP and (mainly) eastern extramediterranean parts of Europe. Recorded in Italy only in the north and south to Tuscany and Marche (Bernardi Iori *et al.*, 1995).

Tjederiraphidia santuzza
(H. Aspöck & U. Aspöck & Rausch, 1980)

Known only from the Aspromonte (Fig. 3).

Turcoraphidia amara
(H. Aspöck & U. Aspöck, 1964).

In scattered populations in high altitudes, widely distributed in the BP, the Crimean peninsula and western Anatolia. Recently detected for Italy in the Majella Nat. Park (Abruzzo) (Letardi, 2004) (Fig. 3).

Subilla confinis (Stephens, 1836)

Widely distributed in extramediterranean parts of Europe. Several records in the southern half of the AP. Found probably in scattered populations throughout the whole peninsula. Letardi (1998) and Pantaleoni (1999) question whether the southern Italian populations might represent a distinct subspecies; so far this could not be verified by us.

Ornatoraphidia flavilabris (Costa, 1855)

Widely distributed in the BP, in the AP, in the south of France, and in southern parts of Central Europe.

Xanthostigma xanthostigma (Schummel, 1832)

Widely distributed in extramediterranean parts of Europe and in palaearctic parts of Asia as far as Sachalin. The only record for Italy is from Southern Tyrol (Alto Adige).

Xanthostigma corsica (Hagen, 1867)

In scattered populations widely distributed in the AP, Elba, Giglio, Sicily, Sardinia, Corsica, the south of France and the IP.

Xanthostigma aloysiana (Costa, 1855)

In scattered populations widely distributed in the AP, the south of Central Europe and of France, and the north of Spain.

Raphidia (Raphidia) ophiopsis Linnaeus, 1758

Widely distributed in extramediterranean parts of Europe and palaearctic Asia as far as Irkutsk. In Italy only in the northernmost parts (Southern Alps) (Hellrigl & Hölzel, 1996).

Raphidia (Raphidia) mediterranea
H. Aspöck & U. Aspöck & Rausch, 1977

Widely distributed in the BP, the southeast

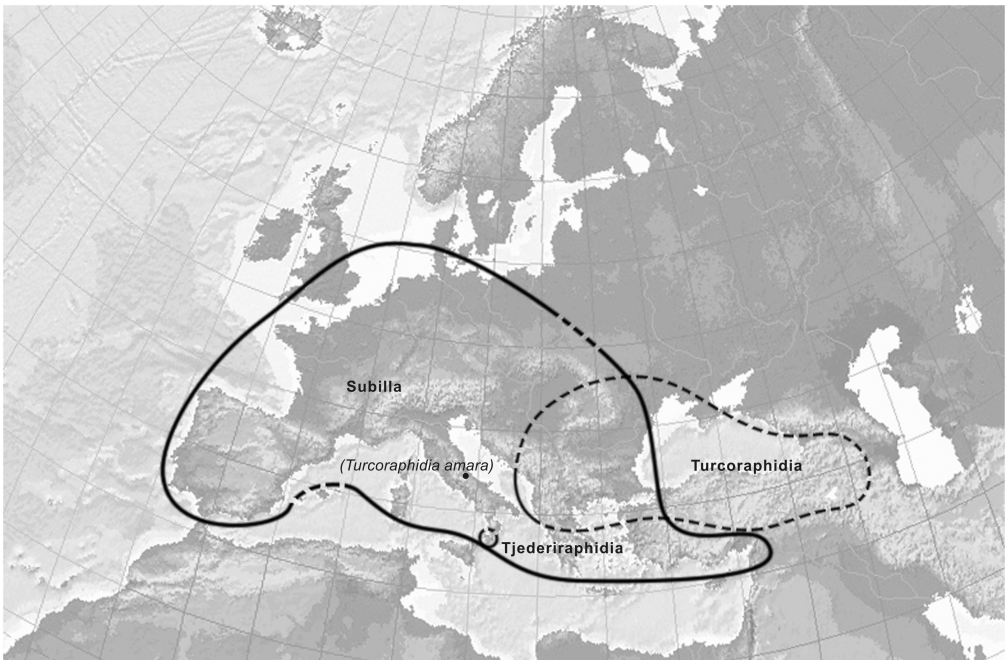

Fig. 3 – Distribution of the genera *Subilla*, *Turcoraphidia* (with the isolated record of *Turcoraphidia amara* in Italy), and *Tjederiraphidia*. – In the Apennines Peninsula and in Central Europe *Subilla* is represented by *S. confinis* only.

of extramediterranean Europe and western Anatolia. In Italy in isolated populations in Apulia (as far north as Gargano), Campania and Lazio.

Raphidia (Raphidia) ulrikae H. Aspöck, 1964

In scattered populations in various extramediterranean parts of Europe. In Italy only in the northernmost parts.

Raphidia (Raphidia) ligurica Albarda, 1891

In isolated populations in Piedmont, Calabria and the south of Switzerland.

Italoraphidia solariana (Navàs, 1928)

Restricted to the southern parts of the AP (Fig. 4).

Puncha ratzeburgi (Brauer, 1876)

Widely distributed in Central and eastern Europe, in isolated populations in the north of the BP and the AP, and southern France (Fig. 4).

Calabroraphidia renate
(Rausch & U. Aspöck & H. Aspöck, 2004)

The discovery of this species (Fig. 1) in a small area in the Sila Grande in 2003 (Rausch *et al.*, 2004) was quite a surprise. It was recaptured in 2005 (Rausch, pers. comm.) and 2006 (unpubl.) in a few localities in the Sila.

Venustoraphidia nigricollis (Albarda, 1891)

Widely distributed in Central and eastern Europe, the BP (north of the gulf of Corinth), and the AP as far south as the Aspromonte.

Inocellia crassicornis (Schummel, 1832)

Widely distributed in extramediterranean parts of Europe and the more northern parts of palaearctic Asia eastwards to Sachalin. In Italy restricted to the northernmost parts, known only from South Tyrol (Alto Adige).

Parainocellia bicolor (Costa, 1855)

Widely distributed in the AP and the south of France and southwestern parts of Central Europe.

The islands belonging to Italy, even the large ones (Sardinia, Sicily) harbour a surprisingly low number of Raphidioptera species. Besides *Xanthostigma corsica*, which has been recorded on several islands (see above), only the following two species have been found:

Subilla principiae
Pantaleoni & U. Aspöck & Cao & H. Aspöck, 2005

This species – one of the recent discoveries – has been found only in a *Quercus pubescens* habitat in the Gennargentu on Sardinia (Pantaleoni *et al.*, 2005).

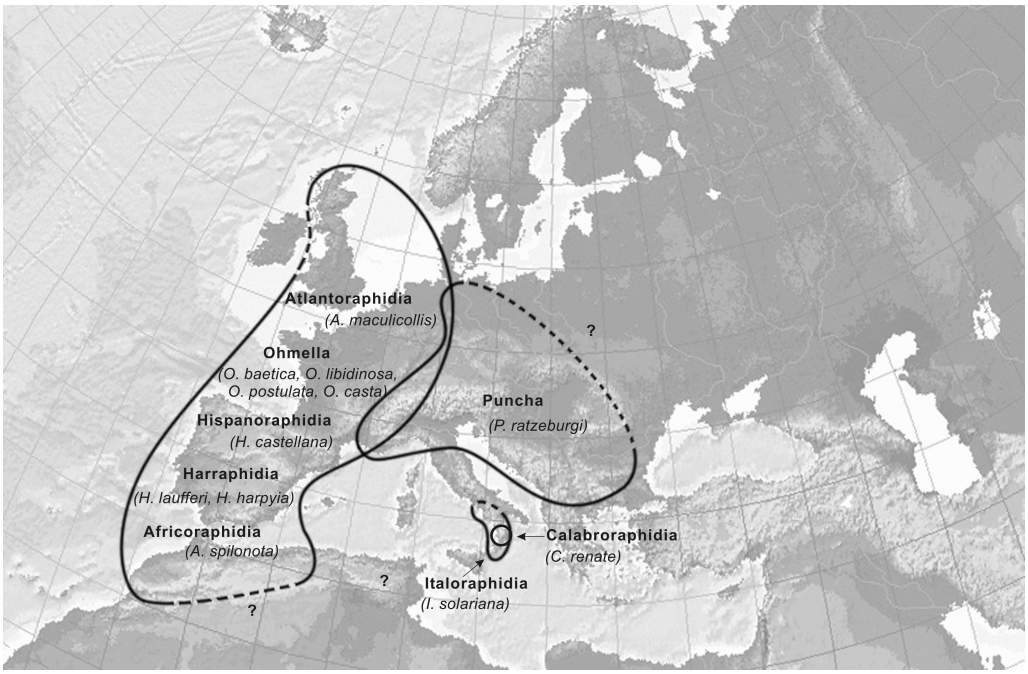

Fig. 4 – Distribution of the genera of group II of Raphidiidae.

Fibla (Fibla) maclachlani (Albarda, 1891)

Recorded only from Sicily, Sardinia and Corsica.

Present state of classification of Raphidioptera

As a precondition to understanding the chorological facts and biogeographical conclusions it would seem necessary to provide a condensed account of the confirmed or suspected relationships of the genera within the families of the Raphidioptera. The order comprises two extant families, Raphidiidae and Inocelliidae. They differ in many morphological and biological characters, presenting a number of striking autapomorphies (H. Aspöck *et al.*, 1991, 2001; H. Aspöck, 2002). Up to the present, the classification of each of the two families has been founded solely on morphological characters; an analysis of relationships based on molecular biology is, however, in progress.

The family Raphidiidae comprises 26 genera, which have been assigned to 7 presumably monophyletic groups (groups I-IV and groups VI-VIII; the dubious group V was revealed as part of group VI) (H. Aspöck *et al.*, 1991, 1998).

Group I comprises 12 Raphidiidae genera with a total of more than 90 species. It is the dominant group in Europe, the Caucasus region, Anatolia, other parts of the eastern Mediterranean, the Near East as well as the northern parts of Asia. In Italy this group is represented by the genera *Phaeostigma* Navás, 1909, *Dichrostigma* Navás, 1909, *Turcoraphidia* H. Aspöck & U. Aspöck, 1968, *Subilla* Navás, 1916, *Ornatoraphidia* H. Aspöck & U. Aspöck, 1968, *Xanthostigma* Navás, 1909, and *Raphidia* Linnaeus, 1758. The monotypic genus *Tjederiraphidia* H. Aspöck & U. Aspöck & Rausch, 1985, endemic to Calabria, was assigned – with some hesitation - to group I (H. Aspöck *et al.*, 1991). In the meantime, we have developed serious doubts regarding its systematic position, and we cannot exclude the possibility that in reality it is closer to group II.

Group II comprises 8 genera with a distribution confined to Europe and the northwest of Africa. Five of these, which have a distribution restricted to western Europe and the northwest of Africa, form a monophyletic clade within group II (Fig. 4). The remaining genera assigned to group II – *Puncha* Navás, 1915, *Italoraphidia* H. Aspöck & U. Aspöck, 1968, and *Calabroraphidia* Rausch & U. Aspöck & H. Aspöck, 2004 – differ in several striking characters and probably constitute the adelphotaxon to the rest of group II. All three occur in Italy, two of them (*Italoraphidia*, *Calabroraphidia*, both monotypic) are even endemic to the south of the AP (Fig. 4).

Group III consists of two markedly different genera, *Mauroraphidia* H. Aspöck & U. Aspöck & Rausch, 1983 (monotypic and endemic to the Atlas mountains) and *Venustoraphidia* H. Aspöck & U. Aspöck, 1968, with two species, one of them confined to the Peloponnisos, the other widely distributed in Central Europe, the BP and the AP.

Groups IV to VIII are not represented in Europe.

The relationships between these 7 groups of Raphidiidae have not yet been verified. The current classification is: (((((II + VII) + IV) + III) + I) + VI) + VIII, despite several weak points; the morphological findings urgently need molecular biological examination (which is currently in progress).

Of particular interest is the genus *Agulla* (group VII), which is restricted to North America and probably is the sistergroup of group II. If this is true, the relationship must date back to the Mesozoic.

The Inocelliidae is a small family comprising 21 described valid species which have been assigned to 6 genera *Fibla* Navás, 1915, with four species, one of them endemic to the islands of Corsica, Sardinia and Sicily. *Parainocellia* H. Aspöck & U. Aspöck, 1968, widely distributed in several southern parts of Europe

(including the AP and the BP), the eastern Mediterranean and Eastern Asia; five species have been described, one of them occurs throughout the whole mainland of Italy. *Inocellia* Schneider, 1843, with 6 species and widely distributed in large parts of Europe and Asia; one species has been found also in the northernmost parts of Italy. *Indianoinocellia* U. Aspöck & H. Aspöck, *Negha* Navás, and *Sininocellia* Yang do not occur in Europe.

The relationships within the family Inocelliidae have not yet been clarified. However, it seems clear that *Fibla* is the sister taxon to the remaining species, and that *Parainocellia* and *Inocellia* are probably sister groups.

Palaeogeography of the Apennines Peninsula

During the past three decades impressive progress has been made in our understanding of the genesis of the Mediterranean basin (Boccaletti *et al.*, 1990; Rögl, 1998; Popov *et al.*, 2005).

The AP is composed of several parts having different provenances and ages. The largest part can be traced back to lands which were primarily united with the Iberian land-mass, but which separated in the Oligocene and drifted eastwards in a rotating movement. In particular, this area encompasses large parts of the Apennines and parts of the present Calabria. Also Corsica, Sardinia, and northern parts of Sicily were once eastern parts of the Iberian land-mass which separated during the Oligocene – about 30 millions years ago – and drifted to the east.

In the east, the Apulian platform existed since the Mesozoic; it also rotated to the northeast during the Miocene and submerged under the Dinarides. Only a small narrow stripe has remained as a part of present-day Apulia and Calabria.

The famous Messinian salinity crisis – caused as a result of the closure of the Mediterranean Sea and its separation from the Atlantic Ocean in the late Miocene (about 6 millions years ago) – led largely to a desiccation of the Mediterranean Sea (lasting about 500.000 years) and to the formation of numerous land bridges and connections. Many of these – particularly those deeply below the old sea level – were, however, of only limited value for migration of animals and plants. They were basins with, at least, a partly lagoon-like character, high concentrations of salt (Sabhka facies) and high temperatures. Nevertheless, the Messinian crisis was of great significance for the faunal exchange within the ancient Mediterranean Sea and the continents.

Another important period for massive changes of land and water in the Mediterranean were the glacial periods of the Pleistocene. The sea level fell to about 100 – 130 m (for short periods possibly even more) below the present sea level. During this period, many land bridges emerged, which again facilitated migrations of organisms on a large scale. It is important to mention that the Northern Adriatic sea had largely dried out resulting in a faunal exchange between southeast Europe and the AP. Thus, it is easily understandable why the Raphidioptera fauna of the AP is markedly heterogeneous from a biogeographical, as well as from a systematic point of view.

Provenance of the Raphidioptera of the Apennines Peninsula

Adriatomediterranean species

Endemic species – Of the 22 species of Raphidioptera found on the mainland of Italy, four are endemic and restricted to the AP: *Italoraphidia solariana*, *Calabroraphidia renate*, *Tjederiraphidia santuzza*, and *Phaeostigma (Pontoraphidia) grandii*. Of these, *I. solariana*, *C. renate* and *T. santuzza* are representatives of monotypic genera with distinctly isolated systematic positions. *Italoraphidia* and *Calabroraphi-*

dia are probably related to *Puncha*, another monotypic genus which is distributed throughout large parts of Central and eastern Europe (Fig. 4).

The sister taxon of *Puncha* + *Italoraphidia* + *Calabroraphidia* is probably a group of genera occurring in the western Mediterranean (Fig. 4). Thus it is reasonable to assume that *Italoraphidia,* as well as *Calabroraphidia*, can be traced back to the ancient invaders coming from Iberia via the drifted platform which nowadays forms part of Calabria. This is comparable to the origin of *Fibla maclachlani* (occurring in Corsica, Sardinia and Sicily) and to *Subilla principiae* (most probably endemic to Sardinia), both of which are apparently ancient Tyrrhenian elements derived from Iberian ancestors.

The origin of *Tjederiraphidia* is not clear. Until now the genus was assigned to group I (see above), but this seems increasingly more doubtful, and it is quite possible that the genus is also an ancient element with ancestors of Iberian origin.

The fourth endemic species, *Ph. (P.) grandii*, belongs to a subgenus (*Pontoraphidia*) which altogether comprises four species and has a range of distribution covering – besides the south of the AP – parts of the southeast of Europe, northern Aegean islands, Anatolia, and the Caucasus region (Fig. 2). Thus, *Pontoraphidia* is of distinctly eastern origin and it cannot be doubted that (the ancestor of) *Ph. (P.) grandii* came from the east. It is certainly much younger than the other three endemic species dealt with above, but it is the sister taxon to the remaining three species of the subgenus and thus certainly is not a recent acquisition to the AP. *Ph. grandii* (or its immediate ancestor respectively) must have reached the peninsula before the glacial periods, i.e. prior to the Pleistocene. Possibly it is the sole remainder of the Raphidioptera fauna of the old Apulian platform.

Adriatomediterranean elements not restricted to the Apennines Peninsula – The origin and biogeographical assignment of these species (*Ph. italogallica*, *Ph. galloitalica*, *S. confinis*, *O. flavilabris*, *X. aloysiana*, *X. corsica*, *R. liguri*ca, *V. nigricollis*, *P. bicolor*) is very different. The two species, *Ph. italogallica* and *Ph. galloitalica*, are related to *Phaeostigma (Ph.) notata* (Fabricius, 1781), a species with a large distribution in extramediterranean parts of Europe, moreover, to *Phaeostigma (Ph.) promethei* H. Aspöck & U. Aspöck & Rausch, 1983, restricted to the Caucasus, and to *Phaeostigma (Ph.) euboica* (H. Aspöck & U. Aspöck, 1976), endemic to mountains of Evia. It is likely that the evolution of these species took place in the BP during the Pleistocene and that *Ph. italogallica* and *Ph. galloitalica* (or their common ancestor) invaded the AP either from the north or from the east via the dried Adria.

Two species, *O. flavilabris* and *V. nigricollis*, occur also in large parts of the BP (moreover, in parts of Central Europe and in the south of France). Per definition they represent polycentric Adriato-Balkanpontomediterranean elements. Maybe they also reached the AP in the Pleistocene in a similar way as the *Phaeostigma* species. It is of interest that both of the two genera, *Ornatoraphidia* H. Aspöck & U. Aspöck, 1968, and *Venustoraphidia* H. Aspöck & U. Aspöck, 1968, comprise a second species, and both occur in very small mountain areas in Greece.

P. bicolor is a typical monocentric Adriatomediterranean faunal element with a distribution throughout the whole mainland of Italy, from the south of Calabria to the Southern Alps, but with very few records in adjacent parts of southern France and Switzerland. *P. bicolor* is the sister species to the closely related *P. braueri* (Albarda, 1891), which occurs in the southeast of Europe. Both are the sister group to *P. ressli* (H. Aspöck & U. Aspöck, 1965), the only Inocelliid species of Anatolia. No doubt, *P. bicolor* is of eastern origin and represents a comparatively recent acquisition to the Raphi-

dioptera fauna of the AP. It is a reasonable assumption that *P. bicolor* (or its ancestor) reached the peninsula from the east in the Pleistocene.

The genus *Xanthostigma* with 5 known species, distributed from the north of the IP to the east of Asia, is most probably an ancient element of the Raphidioptera of the AP. It is likely that it invaded the peninsula from the north some time before the glacial periods, perhaps in the late Pliocene. Both species occurring in Italy, *X. corsica* and *X. aloysiana*, exhibit some degree of expansion by reaching the south of France and the north of the IP.

R. ligurica is a typical monocentric Adriatomediterranean faunal element with a somewhat isolated systematic position. The genus *Raphidia* (with 15 to 18 species, depending on the taxonomic status of some phena) is distributed throughout large parts of Central and southeast Europe, Anatolia, the Caucasus region and in the east as far as the Baikal lake. Thus, the most plausible assumption is that *R. ligurica* (or its ancestor) invaded the AP from the north or from the east before the Pleistocene, possibly during the late Pliocene.

One species remains to be discussed in this chapter: *Subilla confinis*. This species is an Adriatomediterranean faunal element showing a considerable expansivity. It has been found in various parts of the AP and is widely distributed in Central Europe extending to large parts of France, England and Romania. In the IP on one hand and in the BP and Anatolia on the other hand, altogether four other closely related species of the genus occur. It is suggested that all these 5 species evolved in the Pleistocene due to a splitting of a once continuous distribution area of the hypothetic stem species. The AP was colonised by *Subilla* from the north or from the east, possibly in the late Pliocene or early Pleistocene. It is of great interest that, besides the above mentioned 5 species (*confinis*-group), the genus *Subilla* comprises 5 more species which are characterised by more or less similar monstrous-like genitalia. One of these species is the recently discovered *S. principiae*, possibly endemic to Sardinia, the other four species are restricted to the eastern Mediterranean region (Rhodes, southern Anatolia). Pantaleoni *et al.* (2005) have hypothesised that *S. principiae* might be an old Tyrrhenian element of Iberian origin; there is indeed no plausible biogeographical argument which might support a close relationship between *S. principiae* and the other four species of this (probably not monophyletic) group. Molecular biological studies should help clarify the question.

Balkanopontomediterranean elements with recent immigration history

By “recent” we mean invasions to the AP that occurred during the Pleistocene via the Adria bridge.

As discussed above, *O. flavilabris* and *V. nigricollis* are of Balkan origin. Three additional species of Balkan origin invaded the AP recently, i.e. during the glacial period: *Dichrostigma flavipes*, *Raphidia mediterranea*, and *Turcoraphidia amara*.

D. flavipes occurs in Italy only in the northern parts (the southernmost records are in Tuscany and Marche), but the species is widely distributed in the BP north of Middle Greece (Sterea Ellas). Other species of the genus occur in eastern Europe, Anatolia, and the Near East.

R. mediterranea, although a species with a broad ecological spectrum, has been found only in a relatively small part of Italy, mainly in the southeast, but recently also in Lazio. Our previous assumption that it was introduced to Italy by human activities in historic or prehistoric times (H. Aspöck *et al.*, 1991; 2001) seems unlikely now as pointed out by Pantaleoni (2005). Presently, we believe that it has reached the AP via the dried

out Adriatic Sea during (later periods of) the Pleistocene.

T. amara is another impressive example of a recent addition to the Raphidioptera of the AP from the BP via the Adriatic land bridge. *Turcoraphidia* is a genus with a distinct Pontomediterranean distribution (Fig. 3). Five species are currently known. *T. amara* has recently been found in the Majella National Park (Abruzzo) (Letardi, 2004).

Possibly also *Puncha ratzeburgi* reached the AP in the Pleistocene from the BP via the Adriatic land bridge, although it seems more likely that the species was a later immigrant (see below).

Extramediterranean (European or Eurosiberian) and/or Balkanopontomediterranean faunal elements with postglacial immigration

The distribution of few species in Italy is confined to the northernmost parts. Five of them – *Ph. notata*, *X. xanthostigma*, *R. ophiopsis*, *R. ulrikae*, and *I. crassicornis* – have only been found in Italy in the Southern Alps and may have persisted there throughout the later periods of the Pleistocene, at least throughout the last glacial period. Three of these (*X. xanthostigma*, *R. ophiopsis*, *I. crassicornis*) are Eurosiberian faunal elements with high expansivities and large distribution areas ranging throughout northern Asia and northern, eastern and Central Europe. They may have evolved in Europe or in northern Asia in the Pliocene.

Puncha, however, is a very old European monotypic genus and systematically isolated. It is nonetheless probably related to *Italoraphidia* and *Calabroraphidia* and is assigned to group II (see above). *P. ratzeburgi* is an Extramediterranean European faunal element which persisted south of the Alps during the last glacial period and possibly enlarged its distributional area in the AP somewhat to the south as far as Emilia Romagna.

Finally, it cannot be excluded that *D. flavipes* also immigrated (or partially so) into Italy from the north during postglacial periods.

Significance of the Apennines Peninsula for the Raphidioptera fauna of other parts of Europe

Compared to the BP, the AP has contributed only sparingly to the Raphidioptera fauna of other (particularly northern) parts of Europe. Most Adriatomediterranean species are either endemic or are characterised by an extremely low expansivity. Only a single species – *Subilla confinis* – has extended its distribution in the postglacial period and reached the northern borders of Central Europe (records in Denmark); moreover, its present distribution covers large parts of France, England and eastern Europe.

Few species (*Ph. italogallica*, *X. aloysiana*, *X. corsica*) have colonised parts of southern France and the north of the IP. It is unlikely that all these events should have occurred after the last glacial period. *X. corsica* e.g. may have reached the IP already in earlier periods in the Pleistocene.

In the Raphidioptera fauna of Central Europe, the Adriatomediterranean faunal elements play – with the exception of *Subilla confinis* – a rather insignificant role. There are a few records of *X. aloysiana*, *R. ligurica* and *P. bicolor* in the southernmost parts. The occurrence of *O. flavilabris* as well as *V. nigricollis* can most probably be traced back to postglacial immigrations from the BP rather than from the AP. *O. flavilabris* occurs in several parts of eastern Austria, but has not yet been found in the southwest of Central Europe. *X. aloysiana*, *R. ligurica*, *P. bicolor*, and *O. flavilabris* reach the northern borders of their ranges in the south of Central Europe, where they serve as bioindicators for climatically favoured and

particularly rich, but vulnerable biocoenoses which merit protection (U. Aspöck & H. Aspöck, 2005b).

Outlook

The Raphidioptera fauna of Italy can be regarded as largely comprehended, although a few additional species so far recorded from regions outside the AP will certainly be found. It is, however, unlikely – although it cannot be excluded – that new species might be detected in isolated mountainous regions in higher altitudes.

Forthcoming biogeographical studies will particularly be based upon the results of molecular biological investigations. This concerns the clarification of the relationships of the genera (and subgenera) on one hand and the provenance of certain populations on the other hand.

Phylogeography will become an important tool also to clarify open questions on structure and biogeographical history of the snake-flies of Italy.

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