

## Distribution and phylogenetic relationships of the genus *Rhadiopteryx* (Plecoptera, Taeniopterygidae) in Slovakia

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A comprehensive comparative morphological and distributional study of stoneflies of the genus *Rhadiopteryx* (Plecoptera, Taeniopterygidae) resulted in the identification of 10 species. Cladistic methods were applied to develop a phylogenetic system of this genus. Four usual lineages, involving *R. neglecta* gr. representing the initial branch, were confirmed. Phylogenetic and evolutionary trends of the genus *Rhadiopteryx* were depicted. A dispersal-vicariance analysis was used, which reconstructs the ancestral distribution in a given phylogenetic tree without any prior assumptions about the form of area relationships. The genus *Rhadiopteryx* demonstrates an Anatolian-European distribution pattern. Ancestors of this genus appear to be of Anatolian-Balkanian origin. Four species of the genus *Rhadiopteryx* are found in Slovakia. Among these, *Rhadiopteryx acuminata* Klapálek, 1905 was first recorded in Slovakia.

Key words: Plecoptera, *Rhadiopteryx*, phylogeny, biogeography, distribution, Slovakia, Europe.

### Introduction

The genus *Rhadiopteryx* is a well-established, distinct monophyletic lineage of taeniopterygid stoneflies consisting of a small group (10 nominal species) distributed in Europe and Anatolia. ZWICK (1973) recognised the family Taeniopterygidae (Plecoptera, Nemouroidea) as having two subfamilies: Taeniopteryginae and Brachypterainae (including *Rhadiopteryx*). Brachypterainae have amazingly complex male terminalia: the cercus has a large appendix to an enlarged basal segment and reduced distal segments, 9<sup>th</sup> sternite is enlarged, normally covering the entire abdominal tip from below, and has an elevated rim so that it is scoop-shaped; the

epiproct is sclerotised; the basal bulb contains one to three coiled chitinous filaments; an internal drum-like sclerite with a narrow duct to a tiny pore is on the posterior erect finger-shaped portion of the epiproct; the inner paraprocts lobes are complicated, of obligate asymmetry. Nymphs lack gills but have large soft areas on the anterior abdominal sternites, which are densely covered with coniform chloride cells (ZWICK, 2000). Nymphs are scraping sprawlers with a rasp of combed setae on the apex of the galea (WICHARD et al., 1995). Relationships (primitive and derived form) between the genera were analysed by RICKER & ROSS (1975). BANARESCU (1992) provided distribution maps of many genera.

*Rhabdiopteryx* has been proposed as a new genus (Klapálek, 1902), having the following characteristics: wings of normal length; costal crossvein one or two; radius sector with two or three branches; vesicle absent; hind margin of 9<sup>th</sup> sternite either with corners rounded, or produced; sclerotization of 10<sup>th</sup> tergite broken; basal plate of epiproct with large light-coloured triangular holes between the median and lateral struts; prong of epiproct short and bifurcated, or more elongate and divided toward the tip into an anterior and a posterior portion; cerci with three to five segments or more; basal process of cercus with one or two lobes (RICKER & ROSS, 1975). Phylogeny and relationships with the closely related genus *Taenionema* (Nearctic and eastern Palearctic distribution) were analysed by STANGER & BAUMAN (1993).

Descriptions of the genus *Rhabdiopteryx* by ILLIES (1957) and VINÇON & RAVIZZA (1999) differ in several taxonomic characteristics (mainly of males) among the four groups: *neglecta* (*Rhabdiopteryx alpina* Kühtreiber, 1934, *R. doiranensis* Ikomov, 1983, *R. neglecta* Albarda, 1889), *thienemanni* (*R. thienemanni* Illies, 1957, *R. triangularis* Braasch et Joost, 1971), *acuminata* (*R. acuminata* Klapálek, 1905, *R. navicula* Theischinger, 1974), and *christinae* (*R. antoninoi* Vinçon et Ravizza, 1999, *R. christinae* Theischinger, 1975).

In the 1950s, Hennig proposed a method to organise taxonomy (systematics) by reconstructing the phylogeny of life. The branching diagram above is called a cladogram. Cladograms are constructed by sorting out the simplest (most parsimonious) arrangement of shared derived characteristics, inferred to best represent the evolutionary branching arrangements. The purpose of this study was to revise the species of the genus, and hypothesise their phylogeny and historical biogeography.

## Material and methods

For the purpose of hypothesising the phylogeny of the genus *Rhabdiopteryx* well known morphological descriptions of their male adults and larvae observed by several authors (KLAPÁLEK, 1905; BRAASCH & JOOST, 1972; ILLIES, 1957; ZWICK, 1973; THEISCHINGER, 1974, 1975; IKONOMOV, 1983; VINÇON & RAVIZZA, 1999) were used. Known characteristics such as the hind margin of the 9<sup>th</sup> male sternite, the posterior lobes on the hind margin of the male 10<sup>th</sup> tergite, the epiproct, and the subgenital plate of male larvae were focused on. Several structures are incompletely known (especially for the Balkan species) and they are mainly associated with female adults, larvae and para-procts of male adults, so they could not be used.

The cladogram constructed in this study is based upon the cladistic philosophy of HENNIG (1966). Characteristic states were derived and were used to determine monophyletic arrangements of sister/group species. Monophyletic pairs of a sister-group share at least one apomorphic, or derived, and one plesiomorphic, or primitive, characteristic state and have at least one apomorphic characteristic in one pair member which is plesiomorphic in the other.

In Tables 1 and 2 the cladogram (Fig. 1), apomorphic characteristic states supporting monophyly of taxa are numbered. Cladistic characteristics and characteristic states were used (Tab. 2) according to BAE & MCCAFFERTY (1991). The plesiomorphic characteristic states are listed as characteristic state 0; single apomorphic state for a characteristic is listed as characteristic state 1; when two characteristic states for a characteristic represented unrelated bipolar transitions, they are considered bi-directional apomorphy and are listed as -1 and +1 to make this distinction; and when two or more apomorphies for a characteristic represent a stepwise unidirectional transition they are listed as characteristic states 1, 2 etc. (phenoclinical apomorphy).

Biogeographic methods according to RONQUIST (1997) and dispersal-vicariance analysis, which reconstructs the ancestral distribution in a given phylogenetic tree without any prior assumptions about the form of area relationships were used. Speciation (sympatric or allopatric) is assumed to subdivide the ranges of widespread species into vicariant components; the optimal ancestral distributions are those that minimise the amount of implied dispersal between two separate areas or extinction events (a group of organisms is missing from an area where it is expected to occur). Historical biogeography (RONQUIST, 1998) can be used to infer the distribution history of organisms and to identify common geological events that have affected evolution of many different groups of organisms inhabiting the same areas. The pattern of vicariance and disjunction (dispersal, relict distribution, or origin of barriers subdividing formerly continuous ranges) is influenced by decreasing taxonomic rank and geographic scale (ZWICK, 2000). Due to Plecoptera ecology, long-distance dispersal during single events is improbable.

## Results and discussion

The parsimonious cladogram generated from the data matrix (Tab. 1) is presented in Fig. 1. Synapomorphies are listed downward the stem of the lineage to which they apply. The numbers represent the characteristics (Tabs 1, 2), and subscripts appearing with these numbers represent the apomorphic state of the characteristics that are shared by all members of the lineage.

The presence of an epiproct prong tip that is divided into the anterior and posterior portion of male adults (synapomorphy 1) is considered as

Table 1. Comparative characteristics and assumed polarities of characteristic states (BAE & MCCAFFERTY, 1998) used for formatting the alternative cladogram of the subgroup relationships of *Rhabdiopteryx*.

Characteristic	Characteristic state
1. Male epiproct prong tip	0. Bifurcated 1. Divided into anterior and posterior portion
2. Male hind margin of ninth sternite	-1. Process is absent 0. Process rounded 1. Process is produced
3. Male epiproct (Fig. 2)	0. Complicated structure of sclerites 1. Simple structure of sclerites
4. Male larvae hind of subgenital plate (Fig. 3)	0. Wide and rounded or trapezium 1. Triangular 2. Strongly elongated
5. Male epiproct prong tip (Fig. 2)	0. Crooked ahead 1. Straight
6. Posterior lobe on the hind margin of the tenth tergite	0. Present 1. Absent
7. Male epiproct prong (Fig. 2)	0. Closely connected 1. Widely separated

Key: 0 = plesiomorphy; +1 = apomorphy; +2 = phenoclinical apomorphy; +1 and -1 = bidirectional apomorphy.

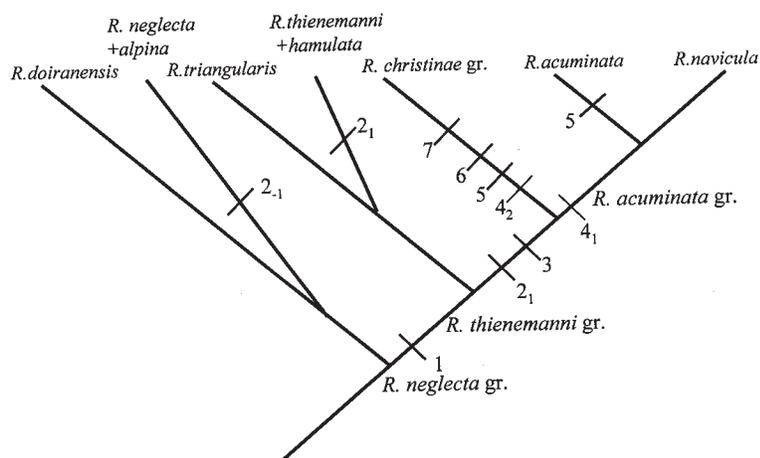


Fig. 1. *Rhabdiopteryx* cladogram.

apomorphy unique to the lineages *R. gr. thienemanni*, *R. gr. acuminata*, and *R. gr. christinae*. It is typical of *R. gr. neglecta* and other *Rhabdiopteryx* groups dichotomy. A shallowly bifurcated tip of the epiproct prong in the *R. neglecta* lineage is considered as plesiomorphy. The simple structure of the epiproct sclerites of male adults and elongation of the subgenital plate in the male larvae (synapomorphy 3 and 4 are considered apomorphies unique to the lineage *R. gr. acuminata*, and *R. gr. christinae* (*R. gr. thienemanni* - *R. gr. acuminata*, and *R. gr. christinae* dichotomy). The absence of a posterior lobe on the hind margin of the 10<sup>th</sup> tergite (synapomorphy 6) and wide separation of the epiproct prong into two por-

tions (synapomorphy 7) are considered as unique apomorphies of the lineage *R. christinae* (*R. gr. acuminata* - *R. gr. christinae* dichotomy).

The cladogram shows that *R. alpina* and *R. neglecta* are more closely related (share a more recent common ancestor) than they are related to *R. doiranensis*. The same is typical of *R. thienemanni* and *R. hamulata* with respect to *R. triangularis*. *R. doiranensis* could be considered the most plesiotypic in that it demonstrates little change from the common ancestor. The main differences among closely related species are as follows: *R. neglecta* and *R. alpina* (*R. neglecta* lineage) according to RAVIZZA & FOCHETTI (1999) have different basal lobes of the male cercus (*R. neglecta*

Table 2. Matrix of characteristic state distribution among *Rhabdiopteryx* groups and species.

	Characteristic						
	1	2	3	4	5	6	7
<i>neglecta</i> + <i>alpina</i>	0	-1	0	0	0	0	0
<i>doiranensis</i>	0	0	0	?	0	0	0
<i>thiennemanni</i> + <i>hamulata</i>	1	1	0	0	0	0	0
<i>triangularis</i>	1	0	0	?	0	0	0
<i>navicula</i>	1	0	1	1	0	0	0
<i>acuminata</i>	1	1	1	1	1	0	0
<i>christinae</i> gr.	1	1	1	2	1	1	1

For explanation see key to Table 1.

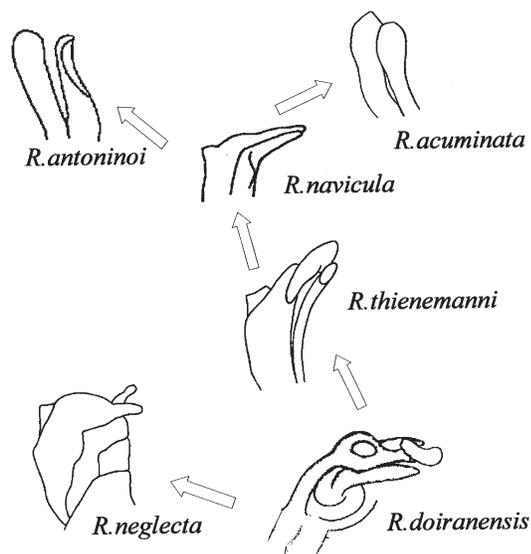


Fig. 2. General trends in the evolution of form of male epiproct prong in *Rhabdiopteryx* (drawings according to ILLIES, 1957; THEISCHINGER, 1974; IKONOMOV, 1983; VINÇON & RAVIZZA, 1999).

has two and *R. alpina* only one); *R. thienemanni* and *R. hamulata* (*R. thienemanni* lineage) have differently shaped 10<sup>th</sup> tergite; and *R. christinae* and *R. antonoi* (*R. christinae* lineage) according to VINÇON & RAVIZZA (1999), have differently shaped paraproctal structures.

The accumulated phylogenetic morphological data allowed hypothesise trends in the evolution of the male epiproct (Fig. 2) and the male larva subgenital plate (Fig. 3). Beginning with an *R. doiranensis*-like prototypic epiproct, complicated

form, which is common in the plesiotypic lineage (*R. neglecta* gr.), there are some major tendencies toward the simplification of the structure of sclerites, their anterior and posterior orientation, and straight direction of the epiproct prong. There are some tendencies in the evolution of the male larval subgenital plate from a wide and straight trapezium form distally, to an elongated, strongly narrowing form toward the tip (Fig. 3).

The original distribution of *Rhabdiopteryx* species in Europe listed by ILLIES (1978) was updated (Tab. 3) according to the most recent contributions (IKONOMOV, 1983; SIVEC, 1980; SOLDÁN et al., 1998; VINÇON & RAVIZZA, 1999; RAVIZZA & FOCHETTI, 1999; KAZANCI, 2000; KRNO, 2000, 2002; RŮŽIČKOVÁ & KOTRBOVÁ, 2000; KOVÁCS et al., 2002; TIerno DE FIGUEROA et al., 2003). During the period 2000–2002 some new sites with *Rhabdiopteryx* occurrence were noticed in Slovakia. The most common time of adult emergence for *Rhabdiopteryx* in Slovakia is spring to early summer (usually March–June). The adults are often found on willows (*R. navicula*) along stream banks when the young willow buds begin to open, or on spruce (*R. neglecta*). Nymphs are collected from boulders (*R. alpina* and *R. neglecta*), or from stony bottom.

Among these, *Rhabdiopteryx acuminata* Klapálek, 1905 was first recorded in Slovakia. It was found at one site: Veselovianka stream (685 m a.s.l.), Orava river basin (49°26'24" N, 19°24'15" E), 29.IV.1996, 2 larvae, leg det. et coll. Krno.

*Rhabdiopteryx neglecta* inhabits the whole region of the Tatra Mts and lives in mountain torrents (750–1110 m a.s.l.). It is a cold stenothermic species. The flight period is in May. The species was newly found in the Belá river (950 m a.s.l.), Váh river basin (49°08'42" N, 19°54'35" E), 9.V.2002, 4♂♂, 6♀♀, 3 larvae, all leg det. et coll. Krno.

*Rhabdiopteryx navicula* inhabits the southern part of the Carpathians. It can live in medium altitude brooks and torrents (168–560 m a.s.l.), surrounded by willow and beech trees. The flight period extends from March to April. The species was found at four new sites: the Litava river (168 m a.s.l.), Ipeľ river basin (48°10'57" N, 19°01'15" E), 29.III. 2000, 1♂ and 1 larva; the Ipeľ river (460 m a.s.l.) (48°33'57" N, 19°43'15" E), 30.III. 2000, 2 larvae; the Topľa river (440 m a.s.l.), Bodrog river basin (49°16'55" N, 21°05'28" E), 5.III.2000, 1♂, ♀♀, 5 larvae; the Okna stream (320 m a.s.l.), Bodrog river basin (48°51'48" N, 22°11'41" E), 4.III. 2000, 2 larvae, all leg det. et coll. Krno.

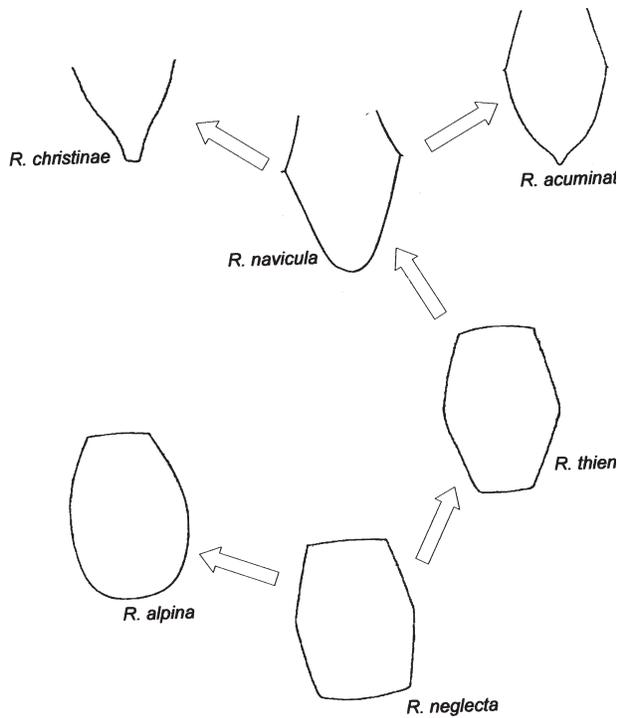


Fig. 3. General trends in the evolution of form of male larvae subgenital plate in *Rhabdiopteryx*.

Table 3. Distribution of the genus *Rhabdiopteryx* in the Limnofauna regions (ILLIES, 1978) of Europe.

Taxa	WM 1	Al 4	Balkan 5 6 7	CE 8 9	Ca 10	D 11	Lowland r. 13 14 15 16	GB 18	NE 23	An	Habitat
<i>Rhabdiopteryx neglecta</i> Albarda, 1889		+	+	°	+	+	°				3 (4)
<i>Rhabdiopteryx alpina</i> Kührtreiber, 1934		+	+	°		+				°	3a
<i>Rhabdiopteryx doiranensis</i> Ikonomov, 1983			+								° 3
<i>Rhabdiopteryx hamulata</i> Klapálek, 1902				+			+				4
<i>Rhabdiopteryx triangularis</i> Braasch et Joost, 1971				+							3
<i>Rhabdiopteryx thienemanni</i> Illies, 1957		+								°	4
<i>Rhabdiopteryx navicula</i> Theischinger, 1974			+	+	+						3b
<i>Rhabdiopteryx acuminata</i> Klapálek, 1905			°			°	°		°	+	3b
<i>Rhabdiopteryx christinae</i> Theischinger, 1975	+										3
<i>Rhabdiopteryx antoninoi</i> Vincon et Ravizza, 1999		+									3a

Key: WM – West-Mediterranean region, Al – Alpine, Lowland r. – Lowland regions of W, C and E Europe, CE – C European r., Ca – Carpathian r., D – Danubian r., GB – Great Britain r., NE. – North-eastern r., An – Anatolian r.; 1–23 number of Europe region according to ILLIES (1978); habitat: 3 – rhithral, 3a – epirhithral, 3b – metarhithral, 4 – potamal; ° – marginal occurrence.

In the above cases, cladograms 1–3 are all equivalent: they represent the same information.

In historical biogeography, the area cladogram of the genus *Rhabdiopteryx* (Fig. 4) will illustrate the different steps in the calculations and some other important points. The first step in the optimisation is to restrict the set of possible dis-

tributions for each ancestral node according to the two optimisation rules (RONQUIST, 1997). When both descendants are restricted to the same area, the optimal distribution must be that area. This way, the optimal distributions of nodes are given directly (Fig. 4). When both descendants occur in single but different unit areas, the optimal an-

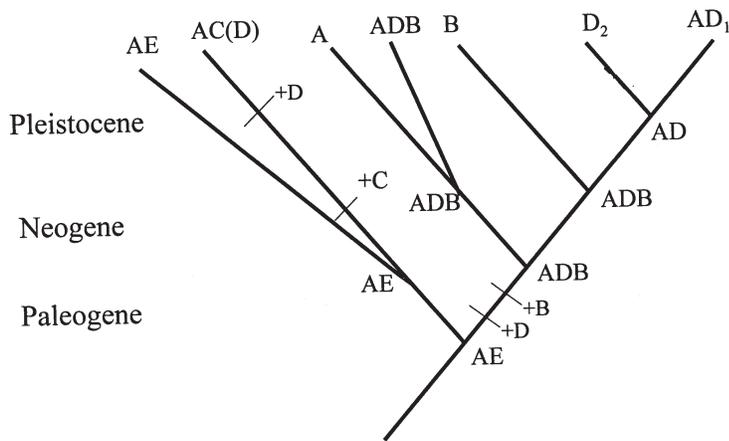


Fig. 4. Optimal reconstruction of the biogeographic history of the genus *Rhabdiopteryx* (cf. Fig. 1 and Tab. 2): A – Balkan, B – Iberian peninsula, C – Apennine peninsula, D – C Europe, D<sub>1</sub> – the Danube river basin, D<sub>2</sub> – the Rhine, the Labe, and the Vistula river basins, E – Anatolia.

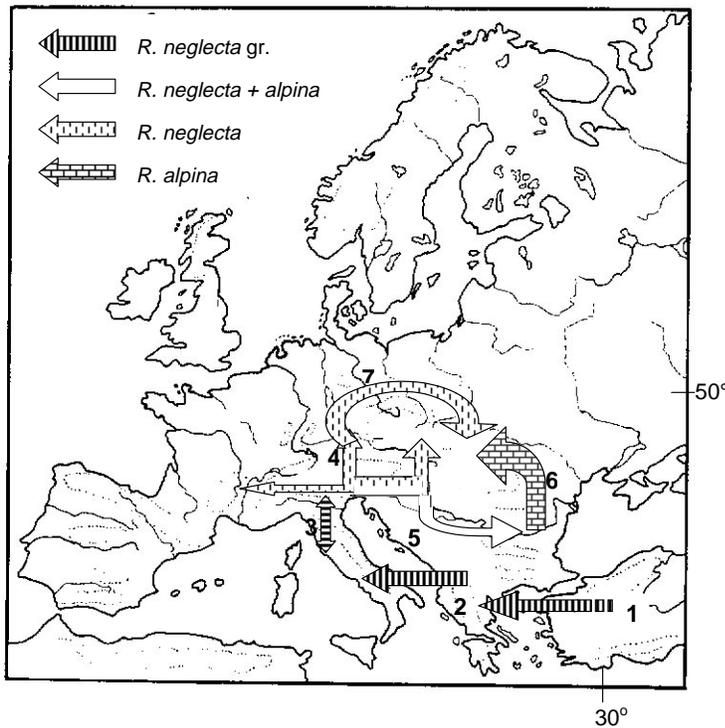


Fig. 5. Distribution of species of *R. neglecta* gr. in Europe (1–7 time sequence tracks of spreading).

central distribution must be the combination of those areas. This gives the optimal distributions for node 3. According to optimal reconstruction of the biogeographic history of the *R. neglecta* lineage (RONQUIST, 1997), minimal dispersal-extinction cost (the final pass, which starts with the ambiguous nodes closest the terminals) for a given distribution (Fig. 5) was 4, and according to the Cenozoic geology of Europe (BANARESCU, 1992)

for node 6 it could be Balkan and Anatolia.

Seven characteristics and their homologous plesiomorphic and apomorphic characteristic states were used the cladistic analysis of the genus *Rhabdiopteryx* (Tabs 1, 2) that support the classification by VINÇON & RAVIZZA (1999) and therefore they essentially define the four groups of *Rhabdiopteryx*: *neglecta*, *thienemanni*, *acuminata*, and *christinae*.

ILLIES (1957) and MENDL (1968) consider that one montane, submontane and lowland species existed in C Europe at the end of the Tertiary period and the other montane and submontane species occurred in Scandinavia. According to these authors the Scandinavian montane species became extinct, and the submontane species (ancestor of *R. acuminata*) retreated to south and returned after the retreating of the glaciers. The C European montane oligostenothermic species (*R. alpina*) extended to edge of the Alps during the Pleistocene, and the submontane species (*R. neglecta*) penetrated then into the mountain ranges adjacent the Alps. The lowland eurythermic species (*R. gr. thienemanni*) split into the eastern (*R. hamulata*) and western form (*R. thienemanni*). According to some authors the patterns of distribution of the genus *Rhabdiopteryx* did not change markedly later, because the submontane form (*R. neglecta*) may have avoided the regressive migration of the species *R. thienemanni*, and *R. acuminata* to C Europe.

However, the view presented in this paper significantly differs from that of ILLIES (1957), especially regarding the origin of the genus *Rhabdiopteryx*, which is probably of eastern sub-Mediterranean stem. The earliest fossil specimens of extant Plecoptera families belonging to the Taeniopterygidae are presumed to be Jurassic (SINITSHEKOVA, 1987). Taeniopterygidae are strictly Holarctic. Asian and American disjunctions originated in various times between the Tertiary and Pleistocene (STEWART & STARK, 1988). There is a good fit between speciation and Asian and American palaeogeography of Arctoperlaria (NELSON, 1988). The European *Rhabdiopteryx* is a sister-group of transberingian *Strophopteryx* + *Taenionema* (RICKER & ROSS, 1975). Disjunct American-European groups are less numerous (Perlodidae, Leuctridae, Taeniopteryginae) (STEWART & STARK, 1988; ZWICK, 2000). Among the Brachypterinae, *Oemopteryx* (amphi-atlantic) is a sister-group of the European *Brachyptera*. Some montane rheophilic aquatic insects have a peculiar, disjunct or perhaps continuous distribution from High Asia to the Euro-Mediterranean region (BANARESCU, 1992). They are able to fly short distance from one river drainage to another or use minor captures of mountain brooks, which frequently occur at high altitudes. The closest relatives of the European Perlinae (Perlodini), *Xanthoperla* (Amphinemurinae) suggest dispersal along a route between the Himalaya and the Caucasian-Anatolian-Balkan highlands (ZWICK, 2000). It is probable that the

ancestor of the genus *Rhabdiopteryx* was spread throughout Central High Asia, and subsequently it became isolated in the Balkan-Anatolia island (BANARESCU, 1992) and originated the *R. neglecta* group there during the Paleogene.

The genus *Rhabdiopteryx* can be considered to have a strictly European-Anatolian distribution. When the phylogenetic relationships of this genus are considered in the light of its primary geographic affinities, some idea of the biogeographic origin of the *Rhabdiopteryx* may be visualised.

Anatolia belonged for most of the late Mesozoic and Cenozoic period to SE Europe, being separated from the northern bulk of the continent by various sea arms (BANARESCU, 1992; STAMPFLI et al., 1998). During the Eocene the ancestor of the *R. neglecta* lineage penetrated to the Italian peninsula via landmass connection with the Balkan (Fig. 5), possibly the same way as the transadriatic species *Taeniopteryx stankovichi* (Plecoptera, Taeniopterygidae) (RAVIZZA & FOCHETTI, 1999).

During the Neogene, the Paratehys gradually reduced its surface, fragmented, and the Danube river basin extended. The ancestors of *R. thienemanni* and subsequently the *R. acuminata* lineages dispersed via the Danube basin from the Balkan to C and W Europe (Fig. 6). Then the common ancestor of the two lineages could have spread to the Iberian Peninsula (*R. gr. christinae*) and other parts of temperate Europe (*R. gr. acuminata*) during the Neogene. This vicariant event involved the geographic isolation of these lineages. The division of the *R. acuminata* lineage apparently involved a vicariant event during which populations in NW and SE Europe became isolated during the Pleistocene.

The original warm stenothermic species of the lowland communities (*R. gr. thienemanni*) either died out in situ or receded to European refuge areas in SE or SW Europe. These associated components then returned again to C Europe after the continental glacier had receded during the Neogene. The evolution of the communities in Scandinavia proceeded in a different way (RAUŠER, 1971; LILLEHAMMER, 1988). Their present picture is the result of the action of the continental glacier, which destroyed the original rich communities. In their present day structure, euryoecious species penetrating to North during its recession stage are abundant. ILLIES (1953) points to the occurrence of several "eastern and western" species of stoneflies in C Europe, which are absent from the narrow unglaciated belt (extinction during the Ice Ages), but being present in the Middle Danube river basin and in the Rhone and the Rhine river

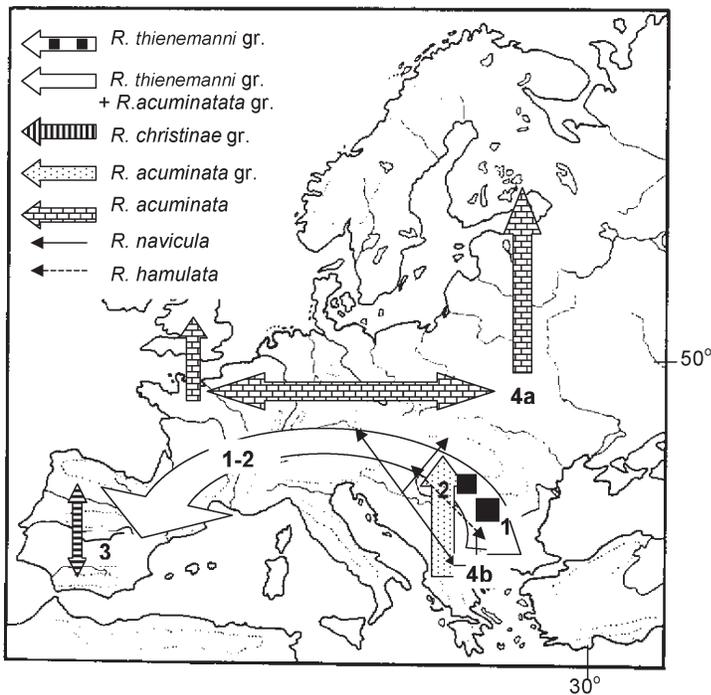


Fig. 6. Distribution of species of *R. thienemanni* gr., *R. acuminata* gr., and *R. christinae* gr. in Europe (1–4 time sequence tracks of spreading).

basins (*R. gr. thienemanni*). A connection between the Danube, the Rhine and the Rhone was also present in the Pliocene (FINK, 1966) and connection between the Rhine and the Thames was during the Pleistocene. Pleistocene glaciation apparently displaced or restricted the original European fauna to Mediterranean areas. Nowadays, Europe north of the Alps is inhabited by species returning from Pleistocene Mediterranean refugia (DINODAL or arboreal) and by circumpolar species (MALICKY, 1999; ZWICK, 2000). The postglacial warming and the melting of the northern and montane ice caps were rapidly followed first by the colonisation of the formerly glaciated areas from more southern, eastern and western unglaciated refuges (ZWICK, 1981). The cold stenothermic forms of *R. gr. neglecta* penetrated from the Italian peninsula (Apennine peninsula) to the W and E Carpathians via the C European or the Balkan mountain ranges (Fig. 5). *R. acuminata* penetrated from C Europe to N Europe during the postglacial period by two ways (MENDL, 1968). Its present distribution is associated with the river basins of the North Sea and Baltic Sea (MENDL, 1968; KITTEL, 1981; SOLDAN et al., 1998), excluding the Danube upstream region (connection of the Rhine and the Danube in the Pleistocene – RAUŠER (1960)) and the Upper Orava river

basin (N Slovakia, which is near to the Vistula river basin). The related *R. navicula* has similar ecological requirements (THEISCHINGER, 1975). It lives in shallower submontane and strongly shaded rocky streams. The current distribution of *R. navicula* (KRNO, 2000) is disjunctive in the SW Balkan (the Morava and the Vardar river basins), as well as in the upper part of the Danube river basin, where it penetrated via the Danube during the postglacial era.

The present distribution of *Rhabdiopteryx* species in Slovakia is a result of events during a short geological period (the Pleistocene); all species are postglacial invaders from southern refugia and they undoubtedly included C European species as well (Fig. 7). The northern part of the Danube basin represents the northern border of occurrence of the species *R. hamulata* (KOVÁCS & WEINZIERL, 2003) and *R. navicula* in Europe. According to LISICKÝ (1991) Silesian, E Carpathian, and Illyrican immigrants can be recognised among Slovak species of the genus *Rhabdiopteryx* (Fig. 7). RAUŠER (1965) also mentioned the species *R. hamulata* from the Slovak part of W Carpathians, but later he failed to include it in the check list from Slovakia (RAUŠER, 1977). Originally, the author found the species also from the upper course of the Ipel river, where

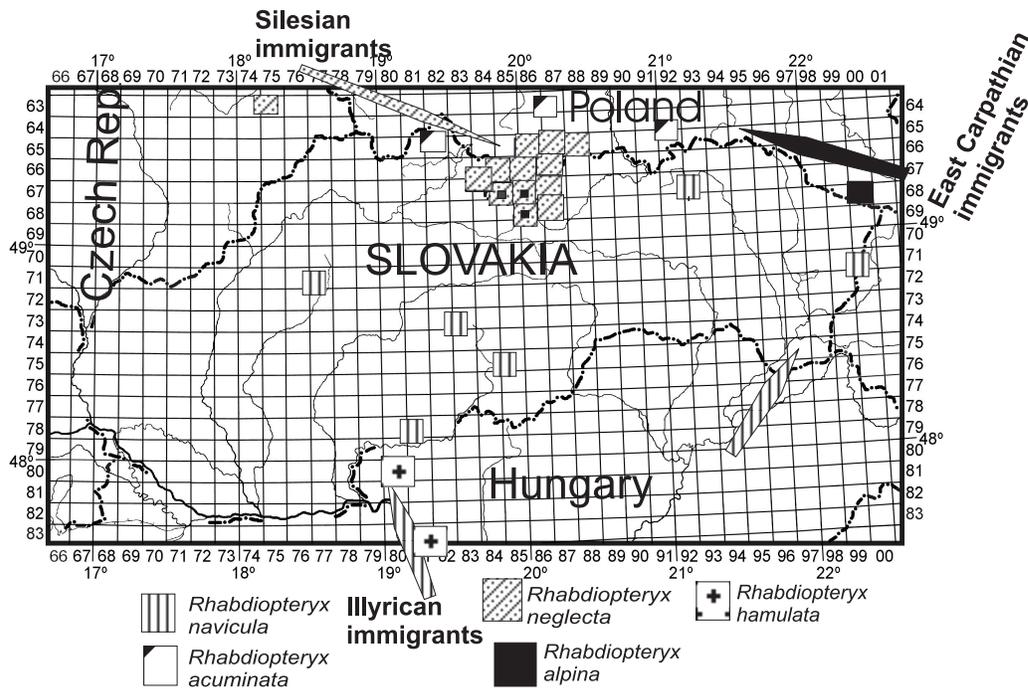


Fig. 7. Distribution of species of the genus *Rhabdiopteryx* in Slovakia.

only the species *R. navicula* was found during this study. ÚJHELYI (1969) mentioned this species in the vicinity of the western Slovak-Hungarian border, close to the Danube river. Its distribution was probably possible only from the SW part of Slovakia (the Danube and its tributaries).

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