

# Hind wings of selected water boatmens (Heteroptera, Corixidae, Cymatiainae, Corixinae) from Central Europe<sup>1</sup>

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**Abstract:** We studied the hind wing venation of twenty two species of water boatmen (Corixidae) from Central Europe. The patterns we found are compared and figured. Although the architecture of the hind wings of Cymatiainae and Corixinae is relatively uniform, we found interspecific differences in both characters and morphometrics among genera and subgenera. Differences between congeneric species are small. We found no distinct hind wing autapomorphies for genera and subgenera, but noted possible anagenetic trends for wing structure in these clades. We propose a reinterpretation of corixid hind wing venation linked to the hind wing morphology of the Hemineoptera.

**Key words:** Central Europe, Corixidae, hind wing, venation.

## Introduction

The hind wings of Hemineoptera and Endopterygota have been reduced through evolutionary time. Wings of many taxa have lost most of their ancestral veinal branches and cross-veins but, numerous fusion braces and cross-vein braces have been added. Larger forewings have assumed the primary role in flight and the hind wings have been selected to contribute to a unitary flight surface by mechanisms that couple the hind wings to the forewings (e.g. WOOTTON & KUKALOVÁ-PECK 2000; KUKALOVÁ-PECK & LAWRENCE 2004). Water bug (Nepomorpha) wings including the Corixidae conform to these general evolutionary trends (see PAPÁČEK & TŘISKA 1992). PUCHKOVA (1961, 1967) studied the hind wing morphology of several aquatic and semiaquatic bugs and reported that their hind wings are reduced in many respects by comparison with homologous structures in other insects. She figured the axillary region of the hind wing of *Sigara striata* (PUCHKOVA 1961: 83, fig.1) and of *Sigara linnaei* (= *Hesperocorixa linnaei*) (PUCHKOVA 1967: 125-126, figs 1.1, 2.2) to exemplify her views. Later students of water bug morphology and phylogeny offer only

modest departures from her interpretations of wing venation in the Nepomorpha and Gerromorpha (POPOV 1971; PETR 1987; MAHNER 1993; PAPÁČEK & PETR 1993). More recently however; the studies of HAAS & KUKALOVÁ-PECK (2001: fig. 16) and KUKALOVÁ-PECK & LAWRENCE (2004: fig. 2) posit a somewhat different interpretation and homologize hind wing venation in the Hemineoptera + Endopterygota. The contrasting views of Puchkova's and Kukalová-Peck et al. concerning corixid and hemineopteran hind wings is presented in Table 1.

Nearly twenty years ago, PETR (1987) briefly studied hind wing venation in water bugs samples from the fauna of the former Czechoslovakia. However, this study was based on single specimens or at most a few examples of each species and may not have encompassed the full range of intraspecific variation. Consequently, we undertook this present study which is based on a larger number of specimens collected over an extended period of time representing each of the species. This larger study was motivated by three objectives: (i) report on possible intergeneric, intersubgeneric, and interspecific differences of hind wing venation, (ii)

<sup>1</sup> This paper is dedicated to the eminent Austrian heteropterist Ernst Heiss on the occasion of his 70<sup>th</sup> birthday.

create a schema for the hind wing venation of the most common Central European species of Cymatiinae and Corixinae, and (iii) bring our synthesis of current knowledge to the reinterpretation of hind wing venation in the Nepomorpha.

## Material and Methods

### Species studied

Our study included the most common Central European species of Corixidae (see e.g., JANSSON 1986, 1995; KMENT & SMÉKAL 2002; RABITSCH 2004; ZETTEL 1995) and some less common species that were reasonably represented in our collections. All of the specimens we examined were macropterous. Table 2 gives a list of the species examined for this study.

### Method of examination

Both alcoholic and pinned specimens were relaxed in hot water or glycerol and their hind wings removed. Wings were unfolded with the aid of insect pins and mounted on slides with glycerol or Euparal, Merck. The mounted specimens were examined and measured with a Leica MZ 9.5 stereoscope and Olympus BX41 compound microscope at magnifications of from 10x to 200x. We paid special attention to folds and venation. Axillaria were not studied in detail. Seven characters were measured (Tab. 3, Fig. 1): hind wing “length” (= bas-rem), hind wing “width” (= rm-ana), two distances on veins in remigial lobe of hind wing (= Dis1, Dis2), and angles between wing folds and margins (= a1, a2, a3).

Three indices were calculated as ratios using quantitative data: I1 is the ratio of body length to hind wing length; I2 is the ratio of hind wing length to width and I3 is the ratio of Dis1 to Dis2. A microfilm reader (Documator, Carl Zeiss, Jena) and a camera lucida were employed to produce drawings of wing structures. Right wings were figured in dorsal view. The original drawings were scanned and finished for publication in Coreldraw 11.

We occasionally looked for intraspecific, intersexual, geographic and temporal differences in hind wing venation among speci-

men arrays that would permit such comparisons. The numbers of specimens examined for each species are provided in Table 3. Due to unequal sample size among species, collection localities, and collecting date, we did not attempt to perform statistical analyses, but simply report ranges (minimum and maximum).

### Terminology, abbreviations and degree of sclerotization coding

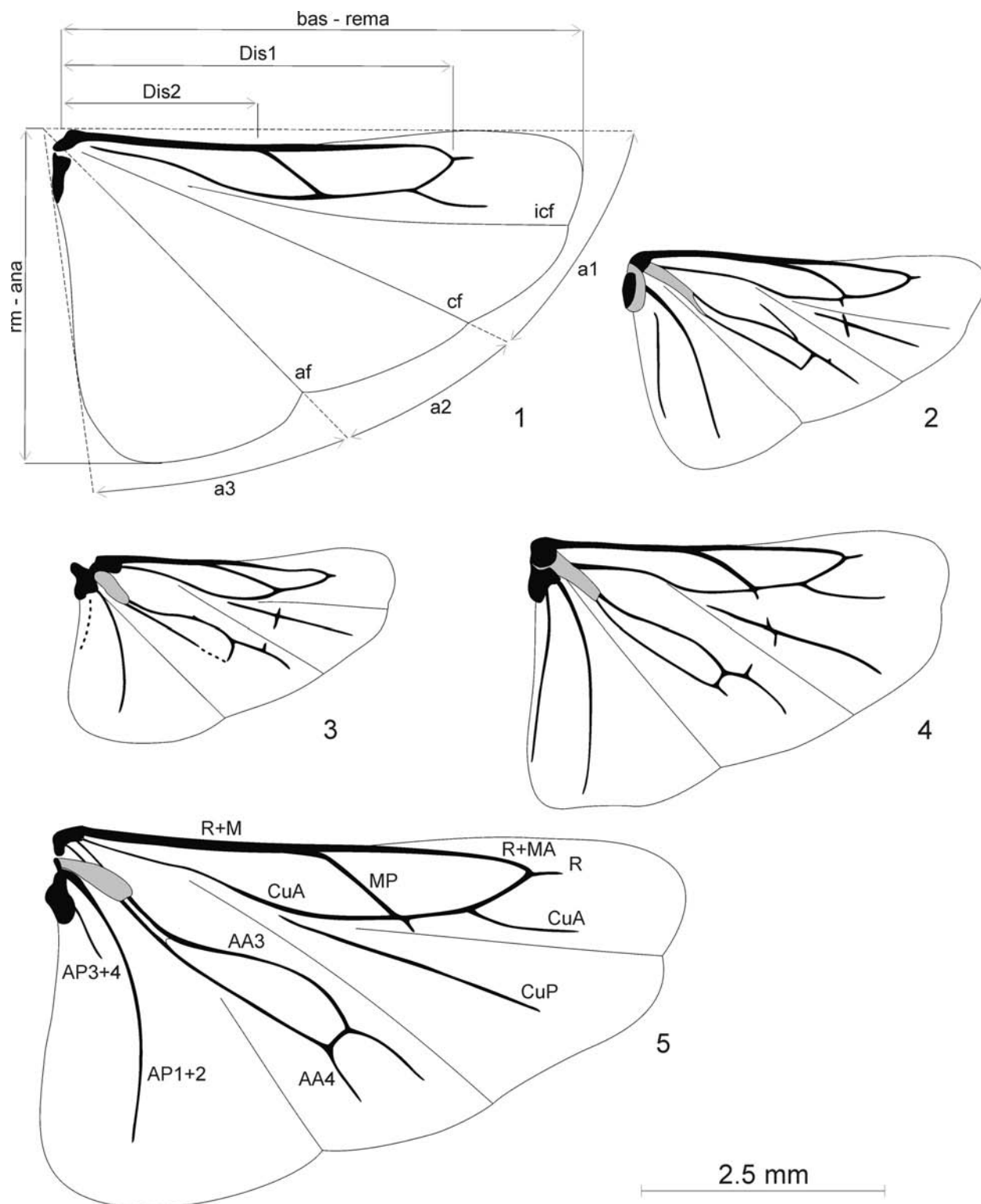
Our terminology and reinterpretation of hind wing venation for the Hemineoptera follows HAAS & KUKALOVÁ-PECK (2001) and KUKALOVÁ-PECK & LAWRENCE (2004). Abbreviations are explained in Fig. 1, Tab. 1 and Tab. 3. “Rudiments of crossing veins” are abbreviated as “cv” in the text. Our convention for specimen orientation is as follows: Anteriorly = toward the radial margin of the wing; Posteriorly = toward the anal margin of the wing. Wings’ axillary sclerites and veins exhibit different degrees of sclerotization as evidenced by density and degree of pigmentation. We encoded this information in drawings as follows: blackish = heavily sclerotized; gray = modestly sclerotized; and white = lightly sclerotized. Veins that are lightly sclerotized are represented by broken lines; normally sclerotized veins are represented by solid lines.

## Results

Hind wing morphology of the examined species is illustrated in Figs 2-23. Morphometric data as well as selected morphological characters are presented in Table 3. Below, we provide descriptions that emphasize diagnostic characters for species or higher taxa.

### Cymatiinae

**Cymatia** (Figs 2-4). Wings triangular (*C. bonsdorffii*) to trapezoidal. Terminal (distal) part of R+MA straight (*C. bonsdorffii*), slightly (*C. rogenhoferi*) to distinctly (*C. coleoptrata*) concave. *C. coleoptrata* (Fig. 3) with relatively long wings and reduced venation (reduced veins: Rtb, CuAtb, AA4, AP3+4). *C. rogenhoferi* (Fig. 4) with sometimes indistinguishable icf, but with distinct marginal incision. The presence of AA vein of unclear origin situated anterior of AA3+4



**Figs 1-5:** Hind wings of *Cymatia* and *Glaenocoris* spp. (1) hind wing scheme including morphometrical characters measured (only R+M+CuA complex of veins illustrated, folds and other veins omitted): a1 - angle between fore ("radial") margin of the wing and claval fold, a2 - angle between claval and anal fold, a3 - angle between anal fold and inner ("jugal") margin of the wing, bas-rema - distance from the base of R+M to the apex of remigium (= length of the wing), Dis1 - distance from base of R+M to the branching of R, Dis2 - distance from the base of R+M to the branching of MP, rm-ana - distance from the radial (anterior) margin of the wing to the anojugal posterior apex (= width of the wing) (2) *Cymatia bonsdorffii* (3) *Cymatia coleoprata* (4) *Cymatia rogenhoferi* (5) *Glaenocoris propinqua*.

is a unique character for *C. bonsdorffii* (Fig. 2) within the *Cymatia* spp. examined. Inconspicuous and shallow marginal anojugal incision present only in *C. rogenhoferi*. Small intraspecific variability of venation was noted only in the reduction of AP3+4 in *C. coleoptrata*.

## Corixinae

### Glaenocorisini

*Glaenocorisa propinqua* (Fig. 5). Wing distinctly trapezoidal, relatively long. Complex of axillary sclerites and basal part of AA3+4 (= Mediale 2 (Me2) sensu POPOV (1971); = anal anterior basivenale 3+4 (BA3+4) sensu HAAS & KUKALOVÁ-PECK (2001) and associated sclerites, and basal part of AA3 + 4) distally distinctly broader than proximally. CuP without cv, AP3+4 short, reduced. More or less without intraspecific variability.

### Corixini

*Callicorixa praeusta* (Fig. 9). Wing trapezoidal. Complex of axillary sclerites and basal part of AA3+4 distally distinctly broader than proximally. CuA posterodistally with cv. AA3 anterodistally with cv. Incision of anojugal margin present. Minute intraspecific variability of venation was noted only in the reduction of terminal part AA4 and AP1+2.

*Corixa* (Figs 6, 7). Wing triangular with broadly rounded remigial apex and shallow (unconspicuous) icf marginal incision. CuA posterodistally with cv. *Corixa dentipes* (Fig. 6) with relatively longer hind wing and more complete venation than *C. punctata* (Fig. 7) (Rtb, AA4tb, and anterodistal cv of AA3 reduced). Anojugal marginal incision absent. Minute intraspecific variability was noted only in the reduction of terminal part AA4.

*Hesperocorixa* (Figs 10-13). Wing triangular (*H. castanea*) to irregularly trapezoidal (*H. moesta*), relatively long in all examined species, longest in *H. castanea*. Differential characters of wing venation in species as follows: *H. castanea* (Fig. 10): Rtb, CuPcv reduced, AA vein of unclear origin situated anterior of AA3+4 (unique character within examined *Hesperocorixa* spp.). *H. linnaei* (Fig. 11): Rtb distinctly shorter than CuAtb, AA4 strongly reduced, cell formed by

AA3+4 distally open. *H. moesta* (Fig. 12): Rtb convex, approximately the same length as CuAtb, MP branching slightly concave, CuPcv reduced. *H. sahlbergi* (Fig. 13): presence of minute posterior cv on CuAtb, MP branching distinctly concave, Rtb convex distinctly longer than CuAtb. Shallow anojugal marginal incision present in *H. linnaei* and *H. moesta*, absent in *H. castanea* and *H. sahlbergi*. Small intraspecific variability was noted in the reduction of AA4tb.

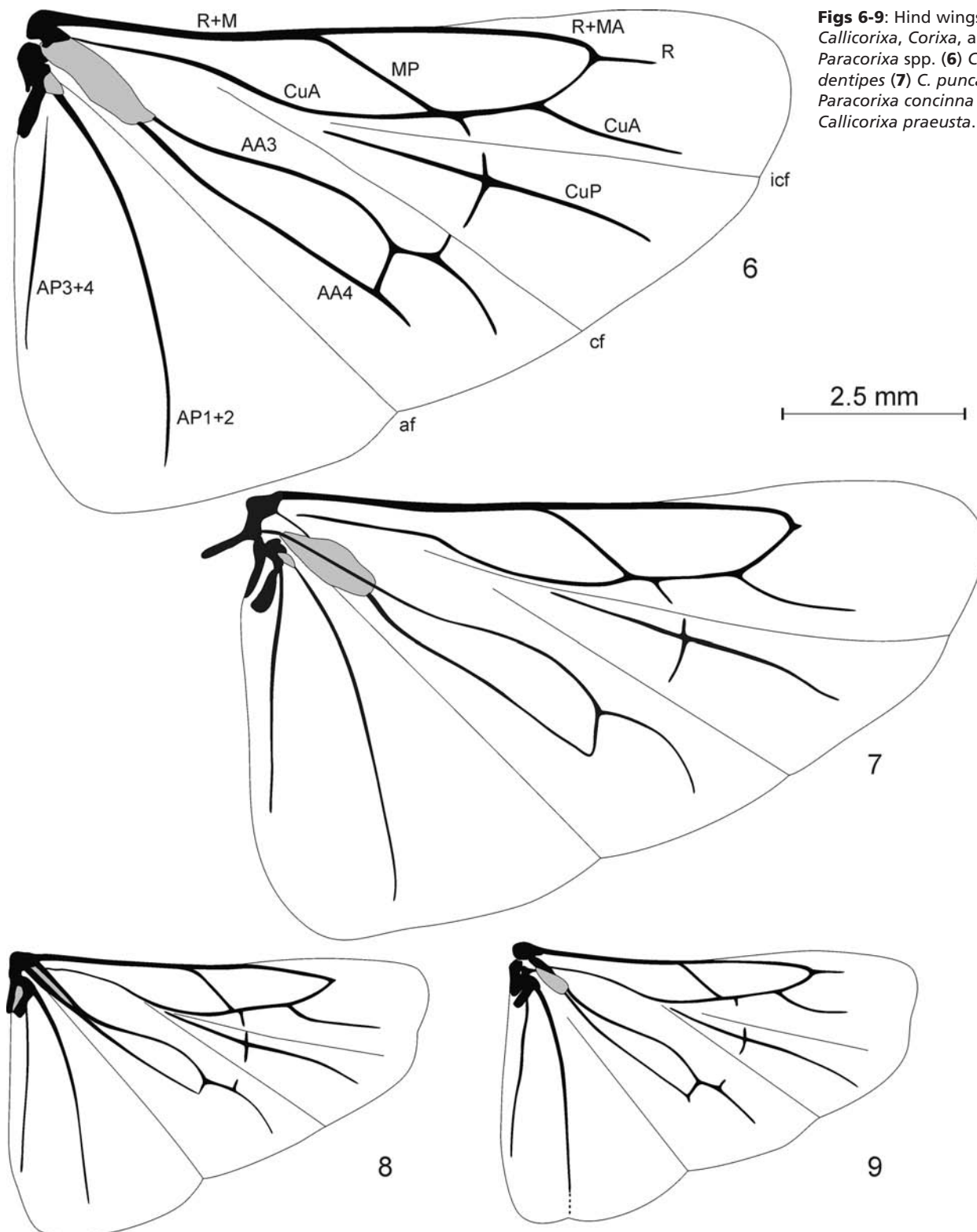
*Paracorixa concinna* (Fig. 8). Wing trapezoidal. CuA posterodistal and AA3 anterodistal cv present. Anojugal marginal incision absent. Only small intraspecific variability in the reduction of AA4tb was noted.

*Sigara (Microsigara) hellensii* (Fig. 23). Wing trapezoidal. Relatively long and narrow. CuA with posterior cv, CuP with three cv (two anterior). CuP, AA4, and AP3+4 reduced. Without variability within the specimens examined.

*Sigara (Pseudovermicorixa) nigrolineata* (Fig. 14). Wing trapezoidal. MP branching distinctly concave, CuA posterodistal cv present, cell formed by AA3+4 distally open. AP3+4 proximally desclerotized. Incision of anojugal margin absent. Extent, sclerotization and pigmentation of distal part of AA4 and proximal part of AP3+4 with some intraspecific variability.

*Sigara (Retrocorixa)* (Figs 16, 17). Wing trapezoidal. Anterior ("radial") margin of remigium declines anteriorly by distinct concave line from R+M in *S. limitata* (Fig. 16). This line declines gradually in *S. semistriata* (Fig. 17). MP branching slightly concave. Distally localized cv on CuA and A3 present. *S. limitata* with relatively long hind wing, partly or fully reduced icf but marginal incision of remigium distinct. Marginal remigial incision shifted anteriorly from termination of icf, AP3+4 distally slightly reduced in *S. semistriata*.

*Sigara (Sigara) striata* (Fig. 18) Wing trapezoidal. Shallow remigial marginal incision localized anterior from the distal termination of icf. Posterodistal CuA cv and anterodistal A3 cv present. Cell formed by AA3+4 distally closed or almost open.



**Figs 6-9:** Hind wings of *Callicorixa*, *Corixa*, and *Paracorixa* spp. (6) *Corixa dentipes* (7) *C. punctata* (8) *Paracorixa concinna* (9) *Callicorixa praeusta*.

**Sigara (Subsigara)** (Figs 19-22). Wing trapezoidal. AA4 reduced to different degree in individual species. The greatest degree of vein reduction was noted in *S. falleni* (Fig. 20); cv absent, only proximal short part of AA4 is well-developed in most specimens of this species. Most specimens of *S. fossarum*

with unclear icf, but its corresponding marginal incision is always distinguishable. *S. distincta* (Fig. 19), *S. fossarum* (Fig. 21) and *S. longipalis* (Fig. 22) with distinct posterodistal CuA cv as well as anterodistal AA3 cv. Basal part of AP3+4 is reduced and unpigmented in *S. fossarum* and *S. longipalis*.



**Tab. 1.** Interpretations of hemipteran hind wing venation by different authors. Original interpretation in Corixidae by PUCHKOVA (1961, 1967), somewhat derived interpretation in Nepomorpha by POPOV (1971), by PETR (1987) (in Nepomorpha) and PAPÁČEK & PETR (1993) (in Notonectidae), and reinterpretation used in this paper (derived from HAAS & KUKALOVÁ-PECK (2001) and KUKALOVÁ-PECK & LAWRENCE (2004) and their explanation of hemineopteran hind wing venation). Note: PAPÁČEK & TRÍSKA (1992) also described the hind wing of *C. coleoptrata* but their interpretation of veins was incorrect.

PUCHKOVA (1961, 1967)	Abbrev.	POPOV (1971)	Abbrev.	PETR (1987) PAPÁČEK & PETR (1993)	Abbrev.	This study	Abbrev.
Radius	R	Radius	R	Radius	R	Radius	R
Radius + Media	R+M	Radius + Media	R+M	Radius + Media	R+M	Radius	+
Media anterior	R+MA	Media	M	Media	M	Media	M
Media posterior	MP						
Cubitus	Cu	Cubitus anterior	CuA	Cubitus	Cu	Cubitus anterior	CuA
vein of unclear nature	?	Cubitus posterior	CuP	Cubitus posterior	CuP	Cubitus posterior	CuP
Postcubitus	PCu	1 <sup>st</sup> Anale	A1	1 <sup>st</sup> Anale	A1	3 <sup>rd</sup> and 4 <sup>th</sup> Anale anterior	AA3+4
Vena arcuata/ Anale	v. arc./An	2 <sup>nd</sup> Anale	A2	2 <sup>nd</sup> Anale	A2	3 <sup>rd</sup> and 4 <sup>th</sup> Anale anterior	AA3+4
Vena cardiaca/Jugale	v.card/J	1 <sup>st</sup> Jugale	J1	1 <sup>st</sup> Jugale	J1	1 <sup>st</sup> and 2 <sup>nd</sup> Anale posterior	AP1+2
-	-	2 <sup>nd</sup> Jugale	J2	2 <sup>nd</sup> Jugale	J2	3 <sup>rd</sup> and 4 <sup>th</sup> Anale posterior	AP3+4
fore anal fold	Paa	Plica anterior analis	paa	Plica praeanalisis	pp	Intracubial fold	icf
anal fold	Pa	Plica analis	pa	Plica analis	pa	Claval fold (line)	cf
jugal fold	Pj	Plica jugalis	pj	Plica jugalis	pj	Anal fold	af

The latter species with the longest and narrowest hind wings relative to their body size within the examined species of the subgenus.

*Sigara (Vermicorixa) lateralis* (Fig. 15). Wing trapezoidal. Posterodistal cv on CuA and anterodistal cv on A3 present. Cell formed by AA3+4 distally open. Basal part of AP3+4 unpigmented, reduced to a small degree in different specimens.

Note: Anojugal marginal incision absent in all examined *Sigara* species. Posterior ano-

jugal margin is slightly concave in *S. (Microssigara) hellensii*, so that this species differs from all other examined species of the genus.

## Discussion

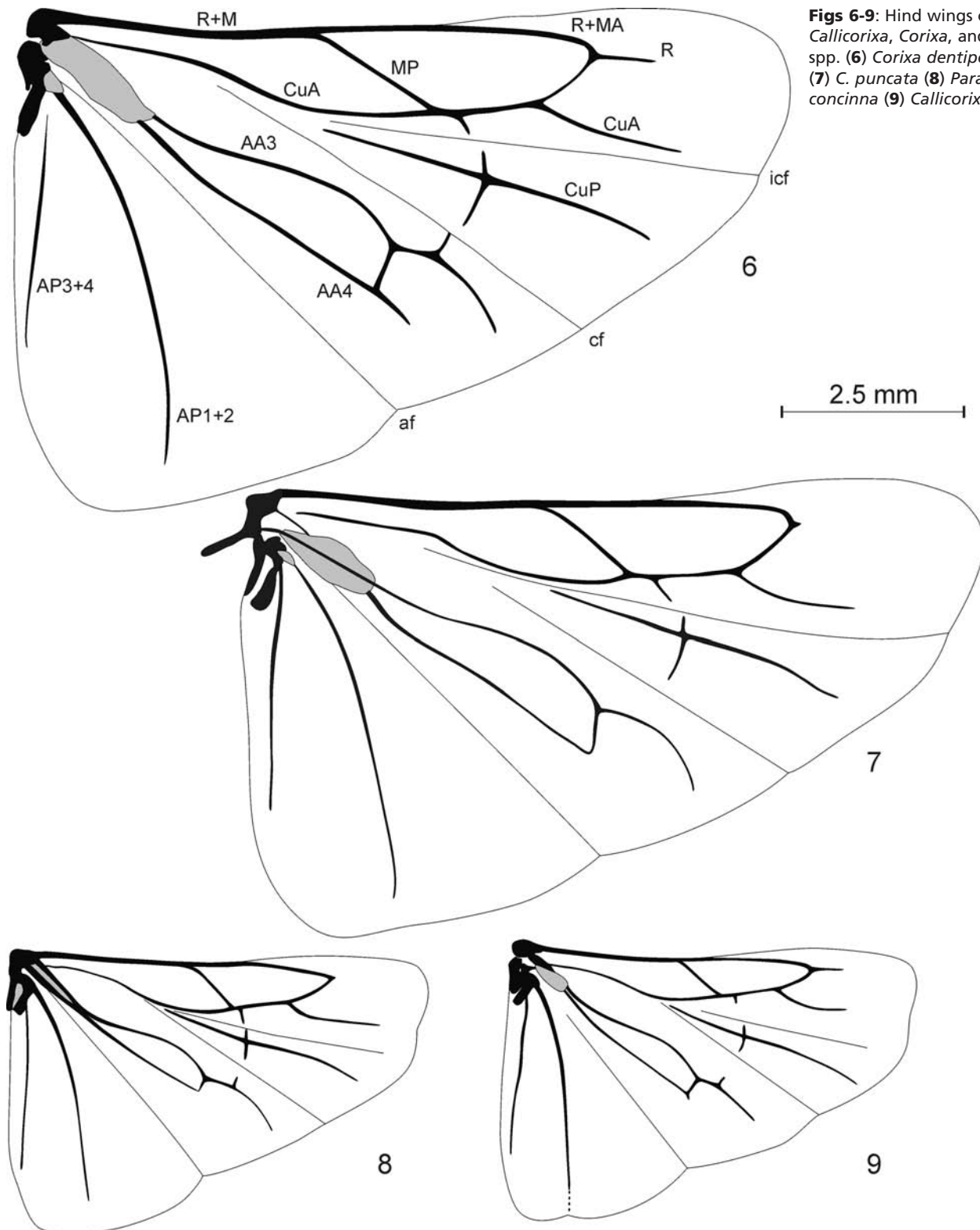
### Ground plan of hind wing venation of Cymatiinae and Corixinae

The hind wings of Cymatiinae and Corixinae have relatively uniform architecture including their venation. The hind wing is subdivided by three folds: the icf, the cf, and the af and by three marginal incisions corresponding to the folds. The icf that subdivides the remigium into two parts is reduced by different degrees in a few species (Figs 2, 16, 19) but its marginal incision is invariably present. The fourth marginal incision is distinguishable in the anojugal margin in some species where it is localized opposite to the termination of AP1 + 2 or slightly more to the anterior. The basic shapes of the hind wing is irregularly triangular (e.g. in *Corixa* spp.) or trapezoidal (e.g. in *Sigara* spp.). The basic shape of the wing is defined by the shape and bilateral proportional size of the distal remigial lobules (= lobulus localized anteriad from the icf and lobulus localized posteriad from this fold) (Figs 2, 4, 5).

The R+M, R+MA, MP, and CuA form the characteristic “bicellular figure” in the anterior part of remigium in Cymatiinae

**Tab. 2.** Alphabetical list of examined species in this study.

Cymatiinae	<i>Cymatia bonsdorffii</i> (C.R. SAHLBERG 1819)
	<i>Cymatia coleoptrata</i> (FABRICIUS 1777)
	<i>Cymatia rogenhoferi</i> (FIEBER 1864)
Corixinae	<i>Callicorixa praeusta praeusta</i> (FIEBER 1848)
	<i>Corixa dentipes</i> THOMSON 1869,
	<i>Corixa punctata</i> (ILLIGER 1807)
	<i>Glaenocoris propinqua propinqua</i> (FIEBER 1860)
	<i>Hesperocoris castanea</i> (THOMSON 1869)
	<i>Hesperocoris linnaei</i> (FIEBER 1848)
	<i>Hesperocoris moesta</i> (FIEBER 1848)
	<i>Hesperocoris sahlbergi</i> (FIEBER 1848)
	<i>Paracoris concinna concinna</i> (FIEBER 1848)
	<i>Sigara (Microssigara) hellensii</i> (C.R. SAHLBERG 1819)
	<i>Sigara (Pseudovermicorixa) nigrolineata nigrolineata</i> (FIEBER 1848)
	<i>Sigara (Retrocorixa) limitata limitata</i> (FIEBER 1848)
	<i>Sigara (Retrocorixa) semistriata</i> (FIEBER 1848)
	<i>Sigara (Sigara) striata</i> (LINNAEUS 1758)
	<i>Sigara (Subsigara) distincta</i> (FIEBER 1848)
	<i>Sigara (Subsigara) falleni</i> (FIEBER 1848)
	<i>Sigara (Subsigara) fossarum</i> (LEACH 1817)
	<i>Sigara (Subsigara) longipalis</i> (J. SAHLBERG 1878)
	<i>Sigara (Vermicorixa) lateralis</i> (LEACH 1817)



**Figs 6-9:** Hind wings of *Callicorixa*, *Corixa*, and *Paracorixa* spp. (6) *Corixa dentipes* (7) *C. punctata* (8) *Paracorixa concinna* (9) *Callicorixa praeusta*.

and Corixinae. The R and CuA branches terminally from this bicellular figure complex (=Rtb, CuAtb see Tab. 3). One or both of these terminal branches may be reduced in length and degree of sclerotization (compare Figs 2, 3, 8). A small posterior cv is evident on the CuA (distal from the MP branch).

The posterior part of the remigium (subdivided from anterior ones by icf) includes only the distal part of CuP with the cv (see Fig. 6, = CuPcv in Table 3) or only the CuP without any cv (see Fig. 5). The partial anojugal lobe (separated from the remigium by cf) is subdivided only by the af. The anterior part of the

**Tab. 3.** Selected morphometrical measurements and morphological characters of the hind wings of Corixidae. bas-rem = minimum and maximum of hind wing length (in mm), rm-ana = minimum and maximum of hind wing width (perpendicular to bas-rem) (in mm), I1 = average ratio of body length to hind wing length, I2 = average ratio of hind wing length to width, I3 = average ratio of Dis1 to Dis2 (see Fig. 1), a1, a2, a3 = average size of angles 1, 2, and 3 in degrees (see Fig. 1), Rtb = R terminal branch, CuAtb = CuA terminal branch, CuPcv = rudiments of CuP crossing veins, AA4tb = AA4 terminal branch; + = present, r = fully reduced, (r) = partly reduced, n = sampling size.

Taxon		n	Morphometrical measurements								Morphological characters			
			bas-rema	rm-ana	I1	I2	I3	a1	a2	a3	Rtb	CuAtb	CuPcv	AA4tb
Cymatiinae														
<i>Cymatia</i>	<i>bonsdorffii</i>	8	3.54-3.75	2.15-2.25	1.58	1.62	1.31	32	14	36	+	r	+	r
	<i>coleoprata</i>	30	2.86-3.12	1.85-1.92	1.28	1.55	1.27	32	14	53	r	r	+	r
	<i>rogenhoferi</i>	5	4.12-4.28	2.72-2.84	1.78	1.50	1.43	38	16	42	+	+	+	+
Corixinae														
Glaenocorisini														
<i>Glaenocoris</i>	<i>propinqua</i>	14	6.31-6.55	3.82-3.98	1.23	1.65	1.52	38	18	39	+	+	r	+
Corixini														
<i>Callicorixa</i>	<i>praeusta</i>	20	5.60-5.86	3.70-3.80	1.32	1.47	1.40	33	17	40	+	+	+	(r)
<i>Corixa</i>	<i>dentipes</i>	12	10.34-10.62	6.50-7.00	1.33	1.50	1.25	34	11	45	+	+	+	+
	<i>punctata</i>	10	9.87-11.23	6.00-6.42	1.45	1.64	1.41	34	13	41	r	+	+	r
<i>Hesperocorixa</i>	<i>castanea</i>	4	5.00-5.25	3.10-3.18	0.97	1.60	1.38	30	18	39	(r)	+	r	r
	<i>linnaei</i>	6	5.62-5.85	3.82-3.94	1.25	1.45	1.46	32	19	42	+	+	+	r
	<i>moesta</i>	5	4.68-4.96	2.80-2.74	1.16	1.66	1.44	33	21	42	+	+	r	+
	<i>sahlbergi</i>	18	5.93-6.22	3.84-4.00	1.31	1.53	1.36	37	15	37	+	+	+	+
<i>Paracorixa</i>	<i>concinna</i>	16	5.60-5.84	3.78-3.88	1.32	1.44	1.40	35	16	41	r	+	+	r
<i>Sigara</i> ( <i>Microsigara</i> )	<i>hellensii</i>	3	6.50-6.54	3.40-3.46	0.76	1.91	1.43	33	16	49	+	+	(r)	r
<i>S. (Pseudovermicorixa)</i>	<i>nigrolineata</i>	30	4.30-4.52	2.75-2.96	1.31	1.56	1.39	34	18	41	+	+	+	r
<i>S. (Retrocorixa)</i>	<i>limitata</i>	4	5.90-6.04	3.70-3.82	1.05	1.58	1.57	42	19	32	+	+	+	+
	<i>semistriata</i>	5	4.32-4.40	2.80-2.84	1.37	1.56	1.46	43	13	32	+	+	+	+
<i>S. (Sigara)</i>	<i>striata</i>	12	5.60-5.80	3.85-3.91	1.24	1.45	1.52	32	19	41	+	+	+	r
<i>S. (Subsigara)</i>	<i>distincta</i>	17	5.90-6.09	3.82-4.06	1.43	1.53	1.49	44	19	32	+	+	+	+
	<i>falleni</i>	20	5.30-5.41	3.22-3.37	1.39	1.65	1.47	38	16	29	+	+	r	r
	<i>fossarum</i>	20	4.48-4.62	3.10-3.18	1.33	1.44	1.42	40	16	30	+	+	+	r
	<i>longipalis</i>	3	6.25-6.29	3.72-3.78	1.20	1.66	1.54	39	17	32	+	+	+	r
<i>S. (Vermicorixa)</i>	<i>lateralis</i>	14	3.75-3.85	2.37-2.40	1.46	1.57	1.44	32	22	38	+	+	+	r

anajugal lobe includes the AA3 + 4 complex forming the “unicellular figure,” with two terminating branches (AA3 and AA4 = AA4tb in Table 3) distally.

In some species a small cv, directed anteriorly can be localized in AA3. The branch AA4 may be reduced to different degree and the cell formed by AA3+4 may be open distally (compare Figs 2, 3, 5). The presence of an anal vein anterior to the AA3+4 cell in *Cymatia bonsdorffii* and *Hesperocorixa castanea* is unique in the species of the present study. The basal part of this vein is completely reduced, the distal part is fused with the AA3+4 complex (AA3 respectively). The origin of this vein is unclear. It could be a remnant of AA1+2 (which is usually reduced in Hemiptera (see HAAS & KUKALOVÁ-PECK 2001; KUKALOVÁ-PECK & LAWRENCE 2004), or a branch of AA3. The vein AP1+2 always is well-developed,

whereas the vein AP3+4 may be reduced to different degree (Figs 3, 5, 23).

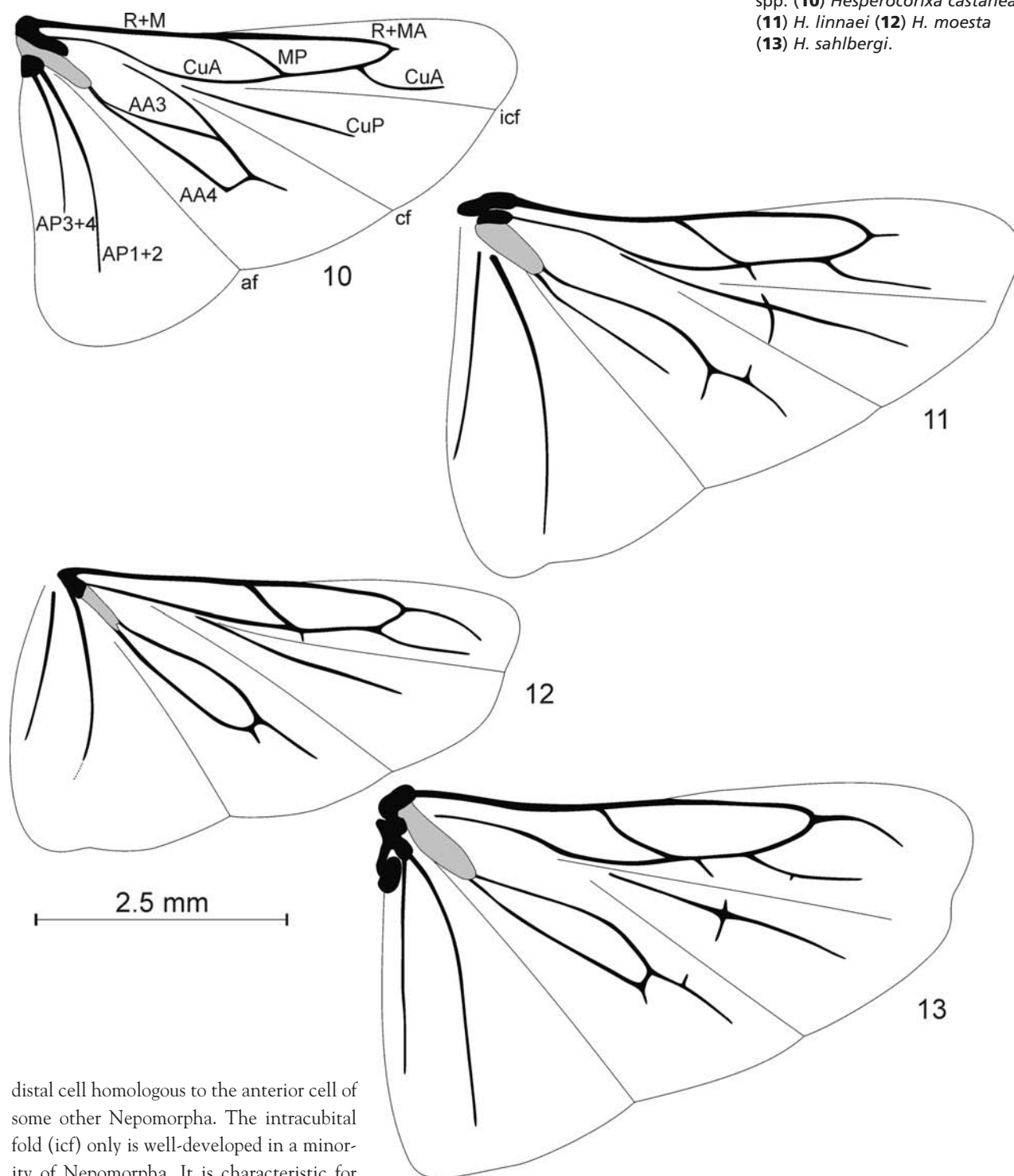
### Hind wing venation of Cymatiinae and Corixinae compared with other Nepomorpha

The bicellular structure with an anterior and a posterior cell formed by R+M+CuA in the hind wing is known in four nepomorphan families (Nepidae, Belostomatidae, Naucoridae, Notonectidae) (cf. POPOV 1971; MAHNER 1993). These cells are divided from each other by a gradually branching MP, which is fused proximally or adjoins to R (R+MA). MP branches from the bicellular structure by a sharp break in Ochteridae and some Corixidae (Cymatiinae + Corixinae).

This is the reason why these cells are parallel in these groups. The proximal cell is homologous to the posterior cell and the



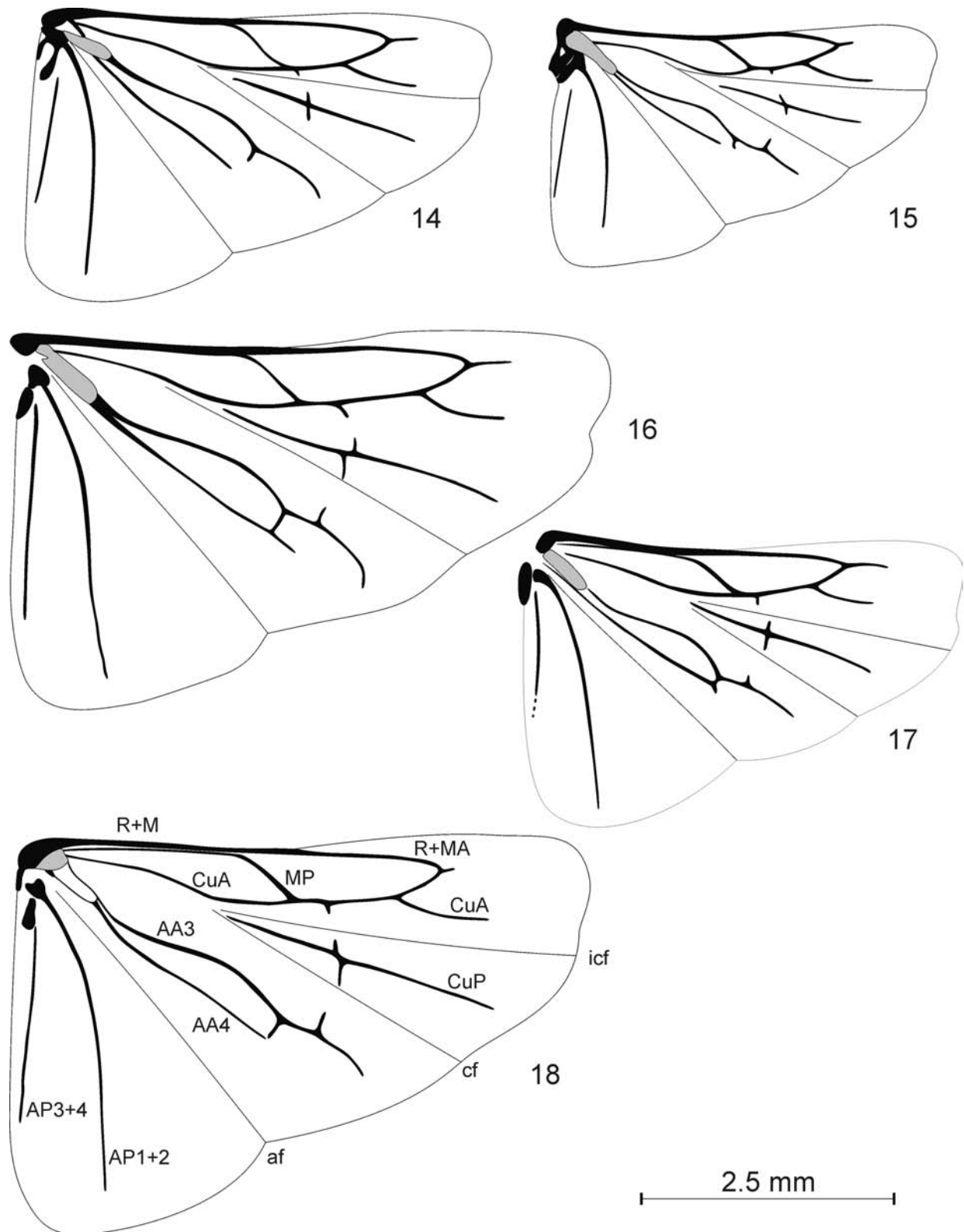
**Figs 10-13:** Hind wings of *Hesperocorixa* spp. (10) *Hesperocorixa castanea* (11) *H. linnaei* (12) *H. moesta* (13) *H. sahlbergi*.



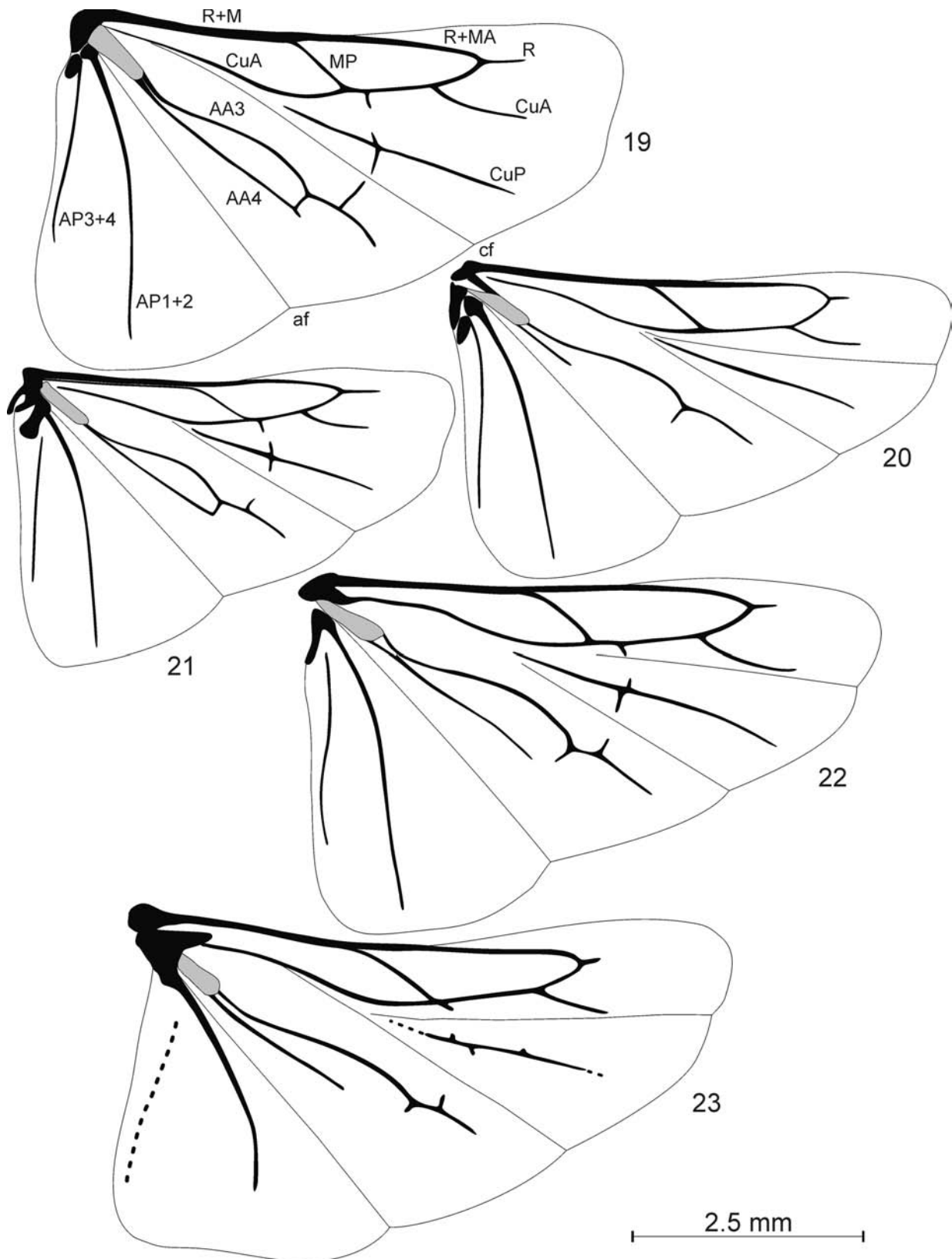
distal cell homologous to the anterior cell of some other Nepomorpha. The intracubital fold (icf) only is well-developed in a minority of Nepomorpha. It is characteristic for Cymatiinae and Corixinae, but absent in Ochteridae. But the icf also is well-developed in the hind wing of macropterous specimens of the Pleidae, which have a quite different hind wing shape, type of folding and venation (PAPÁČEK 1986).

Macropterous specimens of *Microneecta* also have different hind wings compared

with Cymatiinae and Corixinae. The hind wings are irregularly elliptic and have an extremely reduced venation: only the two anterior veins R+MA and MP are distinguishable in the remigial region. AA3+4(?) only form the small, basal cell in the anojugal lobe. The icf is absent (cf. PETR 1987).



**Figs 14-18:** Hind wings of *Sigara* spp. (14) *Sigara* (*Pseudovermicorixa*) *nigrolineata* (15) *S.* (*Vermicorixa*) *lateralis* (16) *S.* (*Retrocorixa*) *limitata* (17) *S.* (*Retrocorixa*) *semistriata* (18) *S.* (*Sigara*) *striata*.



**Figs 19-23:** Hind wings of *Sigara* spp. (19) *Sigara* (*Subsigara*) *distincta* (20) *S.* (*Subsigara*) *falleni* (21) *S.* (*Subsigara*) *fossarum* (22) *S.* (*Subsigara*) *longipalis* (23) *S.* (*Microsigara*) *hellensii*.

### Inter- and Intraspecific variability of hind wing venation of Cymatiinae and Corixinae

Although the venation in all examined species is relatively uniform, some interspecific differences were found. However, only the combination of morphological characters and morphometrics can be used for reliable separation of species (Tab. 3). For example, the hind wings of *Callicorixa praeusta* and *Paracorixa concinna* are almost identical and a separation of these species by their hind wings is very difficult.

Local populations of individual species can probably differ from each other by minute differences (e.g., PUCHKOVA 1967: 126, fig. 2.2, based probably on material of *Hesperocorixa linnaei* from the Ukraine and Fig. 11 in this paper). In this study, however, we have not found local differences between populations. Also, intraspecific variability of the hind wing venation was very low. In some cases a small reduction of the terminal part of AA4 and AP1+2 or the basals and terminal parts of AP3+4 was observed. No differences were found between sexes.

We found no distinct hind wing autapomorphies for genera and subgenera, but noted possible anagenetic trends (sensu PAPÁČEK et al. 1990) for wing structure in these clades:

*Cymatia* – trend to form slightly to distinctly concave R+MA distal from the branching of MP

*Glaenocorisa* – trend to form trapezoidal hind wings with round and large post-icf lobulus of remigium (and a complete reduced AP3+4 into a short, well-sclerotized and pigmented vein?)

*Callicorixa* and *Paracorixa* – with no substantial difference and observed trend

*Corixa* – trend to form broadly triangular hind wings

*Hesperocorixa* – with no distinct common character or observed trend

*Sigara* – trend to form trapezoidal hind wings with small distinctly asymmetrical post-icf lobulus of remigium

We also did not find any substantial differences within the clades at the subgeneric

level. Only the hind wing of *S. (Microsigara) hellensii* is conspicuously different from ones in other subgenera of the genus, especially (i) by the round posteriorly domed latero-posterior wing margin, (ii) by the preservation of more numerous cv's on the CuP that (iii) are arranged in a different figure than is a "crucifix shaped" structure produced by the CP + and its cv, in most of the species we examined.

### Relative length of hind wings and vagility of species

SAVAGE (1989) briefly summarized the problems of flight polymorphism and migration in water bugs. He concluded that the dispersal and migratory ability of a species depends not only on the proportion of macropterous individuals in the populations, but also and perhaps primarily, on the dispersal capacity of the macropterous morphs. For example, some macropterous individuals lack wing muscles and are thus unable to fly. This was the case for some macropterous corixids in our collections. Therefore, macropterous morphs cannot all be assumed to be "flyers". BROWN (1951) demonstrated that colonization of a new pond was more related to the quality of the new aquatic habitat rather than the abundance of corixids in the surrounding area.

We performed no experiments to determine the ability to fly of corixids from our collection localities. However, we found that the species with the longest wings were also those with the most stringent habitat requirements (see SAVAGE 1989). In our study set of species, macropterous *Hesperocorixa castanea* and *Sigara hellensii* had the longest hind wings proportional to body length ( $I1 < 1.0$ ). Significantly, these are rare species in Central Europe found only in a few localities and apparently special habitats in the Czech Republic (see KMENT & SMÉKAL 2002). We thus assume these species have evolved high mobility to find habits that fit their more narrowly defined requirements. The patterns of their geographic distribution (see JANSSEN 1995) also suggest they are able dispersers. Additional species with relatively long wings are *Cymatia coleoptrata*, *Glaenocorisa propinqua*, *Hesperocorixa linnaei*, *H. moesta*, *Sigara limitata*, *S. striata*, and *S. longipalis* ( $I1 < 1.3$ ). These are likewise species

that prefer aquatic habitats at a particular stage of ecological succession. We can make no definitive statement about the dispersal abilities of macropterous morphs of species with relatively short wings. However, we propose the hypothesis that relatively long trapezoidal hind wings are correlated with good dispersal abilities in the Corixidae.

## Acknowledgements

We are most grateful to Wolfgang Rabitsch (Department of Evolutionary Biology, University of Vienna) for inviting us to contribute to this special issue in honour of the eminent Austrian heteropterist Ernst Heiss and for his valuable editorial help, and to Robert L. Smith (Department of Entomology, University of Arizona, Tucson) who kindly made numerous helpful suggestions to improve the readability of the paper. We are also indebted to Pavel Štys (Department of Zoology, Charles University, Prague) for the gift of some specimens from his collection, to Jan Kubečka and Jaroslav Vrba (Institute of Hydrobiology, Czech Academy of Sciences, České Budějovice) for material of *Glaenocoris propinqua* collected during their hydrobiological research in Czech and Austrian lakes. This study was supported by the grant No. MSM 7006665801 of The Czech Ministry of Education.

## Zusammenfassung

Die Hinterflügeladerung von 22 mitteleuropäischen Ruderwanzenarten (Corixidae) wurde verglichen und abgebildet. Obwohl die Struktur der Hinterflügel der Cymatiinae und Corixinae relativ einheitlich ist, wurden zwischenartliche Unterschiede für morphologische und morphometrische Merkmale festgestellt. Eine innerartliche Variabilität der Hinterflügeladerung wurde nur in geringem Maße festgestellt. Keine eindeutigen Autapomorphien der Hinterflügel für die einzelnen Gattungen und Untergattungen wurden gefunden, aber mögliche anagenetische Trends in der Evolution der Hinterflügel in diesen Gruppen oder Taxa werden erwähnt. Eine Neuinterpretation der Hinterflügeladerung der Corixiden im Zusammenhang mit der Hinterflügelmorphologie der Hemiptera wird präsentiert.

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Autor(en)/Author(s): Petr Jan, Papacek Miroslav

Artikel/Article: [Hind wings of selected water boatmens \(Heteroptera, Corixidae, Cymatiinae, Corixinae\) from Central Europe 543-556](#)