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Key for the separation of *Halyomorpha halys* (Stål) from similar-appearing pentatomids (Insecta: Heteroptera: Pentatomidae) occurring in Central Europe, with new Swiss records

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The introduced brown marmorated stink bug *Halyomorpha halys* (Stål, 1855) (Insecta, Heteroptera, Pentatomidae) is superficially similar to several native European pentatomids. The present work provides an identification key including photographs of all discussed pentatomid species. In Switzerland *H. halys* is now recorded not only from the canton Zürich, but also from Basel-Stadt, St. Gallen and Schaffhausen.

Keywords Heteroptera, Pentatomidae, *Halyomorpha halys*, faunistics, identification key.

INTRODUCTION

The East-Asian brown marmorated stink bug *Halyomorpha halys* (Stål, 1855) (Heteroptera, Pentatomidae) was first recorded in Europe from Switzerland, based on material collected in 2007 (Wermelinger *et al.* 2008). Later Arnold (2009) provided a record of *H. halys* collected by light-trap in Liechtenstein already in 2004. *Halyomorpha halys* is indigenous to China, Korea, Japan (Rider 2006) and Taiwan (Esaki 1926). Within the genus *Halyomorpha* Mayr, 1864 there are 37 species recognised (Rider 2010) with Afrotropical and Oriental distribution and spreading into the Eastern Palaearctic Region (Hoebeke & Carter 2003).

The superficial similarity of *H. halys* to several native European pentatomids makes an accurate identification difficult. This introduced pentatomid species can occur in enormous population densities, which can cause significant damage to its host plant. *H. halys* is a serious impending danger to horticultural crops such as stone fruit and pomes as well as exotic ornamentals (Gyeltshen *et al.* 2005; Wermelinger *et al.* 2008; Nielsen & Hamilton 2009a,b). Trying to identify *H. halys* using available Central European standard insect/Heteroptera keys one will end up with *Pentatoma rufipes* (Linnaeus, 1758) as species name. Therefore, a dependable identification key of the species is required.

The selection of the similar-appearing pentatomids is based on discussions with entomologists and non-entomologists, working in pest managements. To get a wider overview of the species numbers of the discussed genera in Switzerland and Central Europe see Tab. 1.

A diagnosis and redescription of *H. halys*, and colour photographs of the discussed Central European pentatomid species, as well as an identification key are provided. In addition, new records of this alien pest are also listed. All characters

discussed in the present study are adult characters. A detailed study of the morphology of *H. halys* is given by Hoffmann (1931), Kobayashi (1956, 1967), Hoebeke & Carter (2003) and Jones & Lambdin (2009) including egg, egg cluster and all five larval instars. Nielsen & Hamilton (2009a) investigated the relationship of *H. halys* and its host plants. The influence of photoperiod, temperature and aging on the pigmentation are studied by Niva & Takeda (2002). Niva & Takeda (2003) discussed as well the effects of photoperiod, temperature and melatonin on the nymphal development, polyphenism and reproduction of *H. halys*. The influence of temperature on the egg and nymphal development was studied by Nielsen *et al.* (2008b). Studies on the toxicity of insecticides to *H. halys* are provided by Nielsen *et al.* (2008a). Various aspects of the biology and its pest status were studied also by Funayama (2002, 2004), Hoebeke (2002), Hoebeke & Carter (2003), Bernon (2004), Toyama *et al.* (2006), and Jones & Lambdin (2009).

MATERIAL AND METHODS

Nomenclature and systematics follow Rider (2006), for details see Tab. 1. The specimens were investigated with a 20x/13 Wild stereo microscope. The species

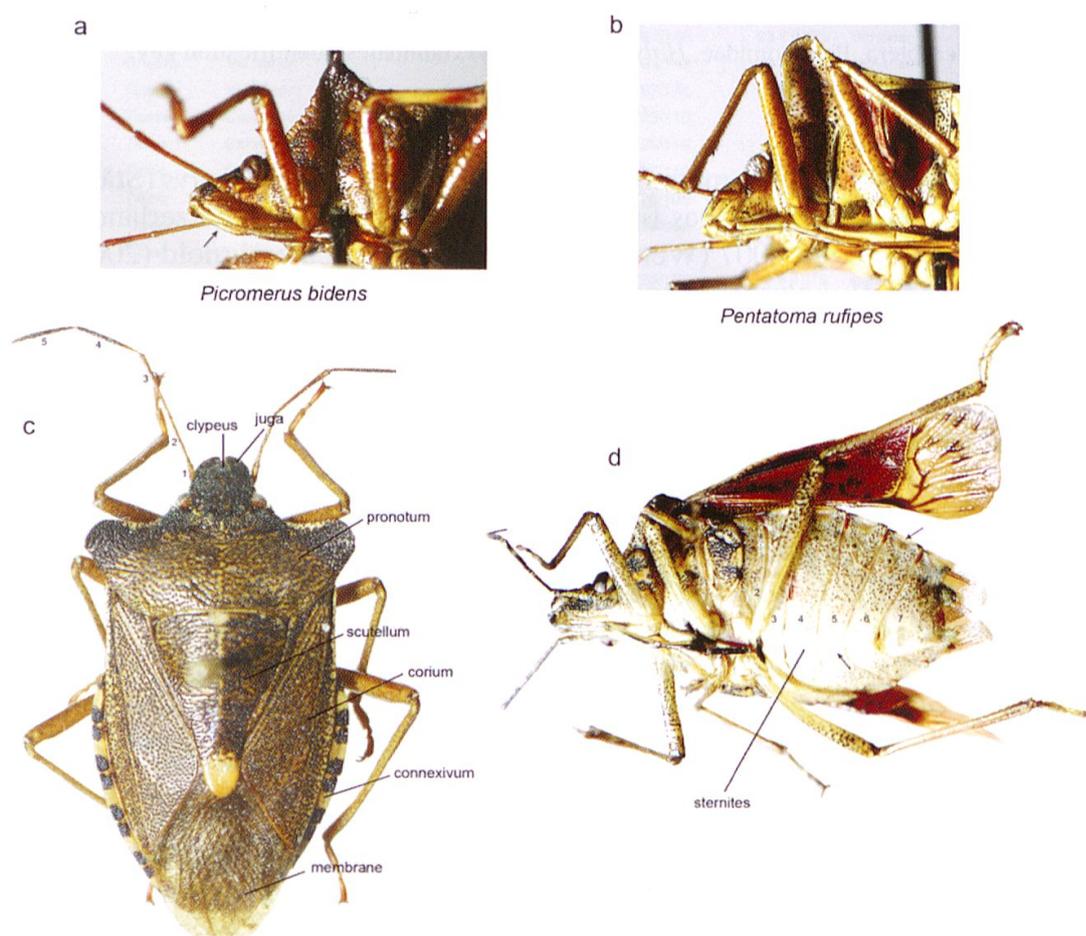


Fig. 1: **a.** *Picromerus bidens* (Pentatomidae, Asopinae), lateral view. — **b.** *Pentatoma rufipes*, lateral view (Pentatomidae, Pentatominae). — **c.** Character terminology: *Pentatoma rufipes*, dorsal view. — **d.** Character terminology: *Halyomorpha halys*, ventral view.

Tab. 1. Recorded species from Switzerland and Central Europe of the discussed genera (species not occurring in Switzerland are marked by asterisk) (Rider 2006; Belousova 2007; Ribes *et al.* 2008).

subfamily and tribe	genus	species recorded from Switzerland
Asopinae	<i>Arma</i> Hahn, 1832	<i>A. custos</i> (Fabricius, 1794) * <i>A. insperata</i> Horváth, 1899
	<i>Picromerus</i> Amyot & Serville, 1843	<i>P. bidens</i> (Linnaeus, 1758) <i>P. conformis</i> (Herrich-Schaeffer, 1841) <i>P. nigridentis</i> (Fabricius, 1803)
	<i>Pinthaeus</i> Stål, 1868	<i>P. sanguinipes</i> (Fabricius, 1781)
	<i>Troilus</i> Stål, 1868	<i>T. luridus</i> (Fabricius, 1775)
Pentatominae		
Cappaeini	<i>Halyomorpha</i> Mayr, 1864	<i>H. halys</i> (Stål, 1855)
Carpocorini	<i>Carpocoris</i> Kolenati, 1846	<i>C. fuscispinus</i> (Boheman, 1851) * <i>C. melanocerus</i> Mulsant & Rey, 1852 <i>C. pudicus</i> (Poda, 1761) <i>C. purpureipennis</i> (De Geer, 1773)
	<i>Dolycoris</i> Mulsant & Rey, 1866	<i>D. baccarum</i> (Linnaeus, 1758)
	<i>Holcostethus</i> Fieber, 1860	<i>H. sphaelatus</i> (Fabricius, 1794)
	<i>Peribalus</i> Mulsant & Rey, 1866	<i>P. strictus strictus</i> (Fabricius, 1803) = <i>Holcostethus vernalis</i> (Wolff, 1804)
Pentatomini	<i>Pentatoma</i> Olivier, 1789	<i>P. rufipes</i> (Linnaeus, 1758)
	<i>Rhaphigaster</i> Laporte, 1833	<i>Rh. nebulosa</i> (Poda, 1761)

specific characters used in the keys are all visible with a commercial hand lens with an at least 10x magnification. Fig. 1c (dorsal view) and Fig. 1d (ventral view) illustrate the character terminology used in the key.

RESULTS

With the exception of one record from Liechtenstein (Arnold 2009), all European records of *H. halys* are from Switzerland (Wermelinger *et al.* 2008). Until now, *H. halys* has been recorded from nine Swiss communities: Adliswil (canton Zürich = ZH), Balgach (canton St. Gallen = SG), Basel (canton Basel-Stadt = BS), Dietlikon (ZH), Erlenbach (ZH), Kilchberg (ZH), Schaffhausen (canton Schaffhausen = SH), Zollikon (ZH) and Zürich (ZH).

The distinguishing characters used in the present study of the subfamilies is based on the recent key of Derjanschi & Péricart (2005). The Asopinae species can be distinguished from all remaining Pentatomidae by the first labial segment being thickened and clearly prominent (Fig. 1a). Within Pentatominae the species can be separated by using the tribal characters, especially the Pentatomini can easily be distinguished from the others by the second sternite bearing a protuberance or thorn.

The genitalic characters would provide additional characters to distinguish the discussed species in a detailed and definite way. The aim of the present work, however, is to provide a key which can be used fast and easily, and enable identification with simple implements. This constriction of not using the genitalic characters within the present work makes the species determination for *Carpocoris* Kolenati, 1846 impossible, however, two detailed identification keys for this genus were published (see Ribes *et al.* 2007; Ribes & Pagola-Carte 2009). Recently the species

Holcostethus vernalis (Wolff, 1804) became a junior synonym of *H. strictus strictus* (Fabricius, 1803) (Ribes *et al.* 2006, 2008), and subsequently the genus *Holcostethus* Fieber, 1861 was divided into two genera, *Holcostethus* s. str. and *Peribalus* Mulsant and Rey, 1866 (Belousova 2007; Ribes *et al.* 2008).

In Tab. 1 the numbers of species within the mentioned genera occurring in Switzerland and Central Europe are listed (Rider 2006), providing a wider overview.

IDENTIFICATION KEY

1. First labial segment thickened, clearly prominent (Fig. 1a, arrow) **Asopinae 2**
 — First labial segment not distinctly thickened, hidden between bucculae (Fig. 1b), not prominent **Pentatominae 5**
2. Lateral angles of pronotum elongate and distinctly pointed **3**
 — Lateral angles of pronotum just slightly elongate with lateral margin more rounded **4**
3. Juga not surpassing clypeus apically (Fig. 2); profemur with ventral denticle (Fig. 3, arrow); antennal segments bright orange with last segment slightly darkened apically; tibia with light band medially; scutellum with distinct apical slender lunate yellowish band (Fig. 3) ***Picromerus bidens* (Linnaeus, 1758)**
 — Juga surpassing clypeus apically (Fig. 2); profemur missing ventral denticle; second and third antennal segments dark with small yellowish orange ring apically, fourth segment with yellowish orange ring basally and last segment unicoloured orange; scutellum orange-brown (Fig. 3) ***Arma custos* (Fabricius, 1794)**
4. Juga distinctly surpassing clypeus apically; lateral margin of pronotum denticulate (Fig. 2); antennal segments dark with fourth segment yellowish apically; scutellum brownish (Fig. 3) ***Troilus luridus* (Fabricius, 1775)**
 — Juga with lateral margin concave enclosing clypeus apically (Fig. 2); lateral margin of pronotum distinctly angulate, only slightly denticulate; pronotum concave basally (Fig. 2); antennal segments dark with last segment orangish yellow basally; scutellum with bright lunate mark apically (Fig. 3) ***Pinthaeus sanguinipes* (Fabricius, 1781)**
5. Second apparent abdominal sternite (i.e. sternite III) bearing protuberance or thorn **Pentatomini 6**
 — Second apparent abdominal sternite flat, not bearing any thorn-like structure **7**
6. Membrane unicoloured brown (Fig. 2); pronotum with distal lateral margin slightly denticulate and distinctly elongate lateral angle (Fig. 2); connexivum with yellow medial spots round (Fig. 2); scutellum and pronotum with light slender band medially (Fig. 3); hind tibia unicoloured (Fig. 3); second sternite with protuberance medially ***Pentatoma rufipes* (Linnaeus, 1758)**
 — Membrane vitreous with dark round spots, arranged irregularly (Fig. 2); pronotum with lateral margin rounded, not elongate (Fig. 2); connexivum with yellow medial spots rectangular (Fig. 2); scutellum and corium irregularly

black and light brownish patterned; hind tibia with dark ring apically and basally (Fig. 3); second sternite bearing long and massive thorn medially, almost reaching procoxa *Rhaphigaster nebulosa* (Poda, 1761)

7. General aspect of head rectangular with lateral margin distinctly concave (Fig. 2); membrane with distinct longitudinal dark marks on veins (Fig. 2); pronotum with anterior angle distinctly thorn-like (Fig. 2)
 *Halyomorpha halys* (Stål, 1855)

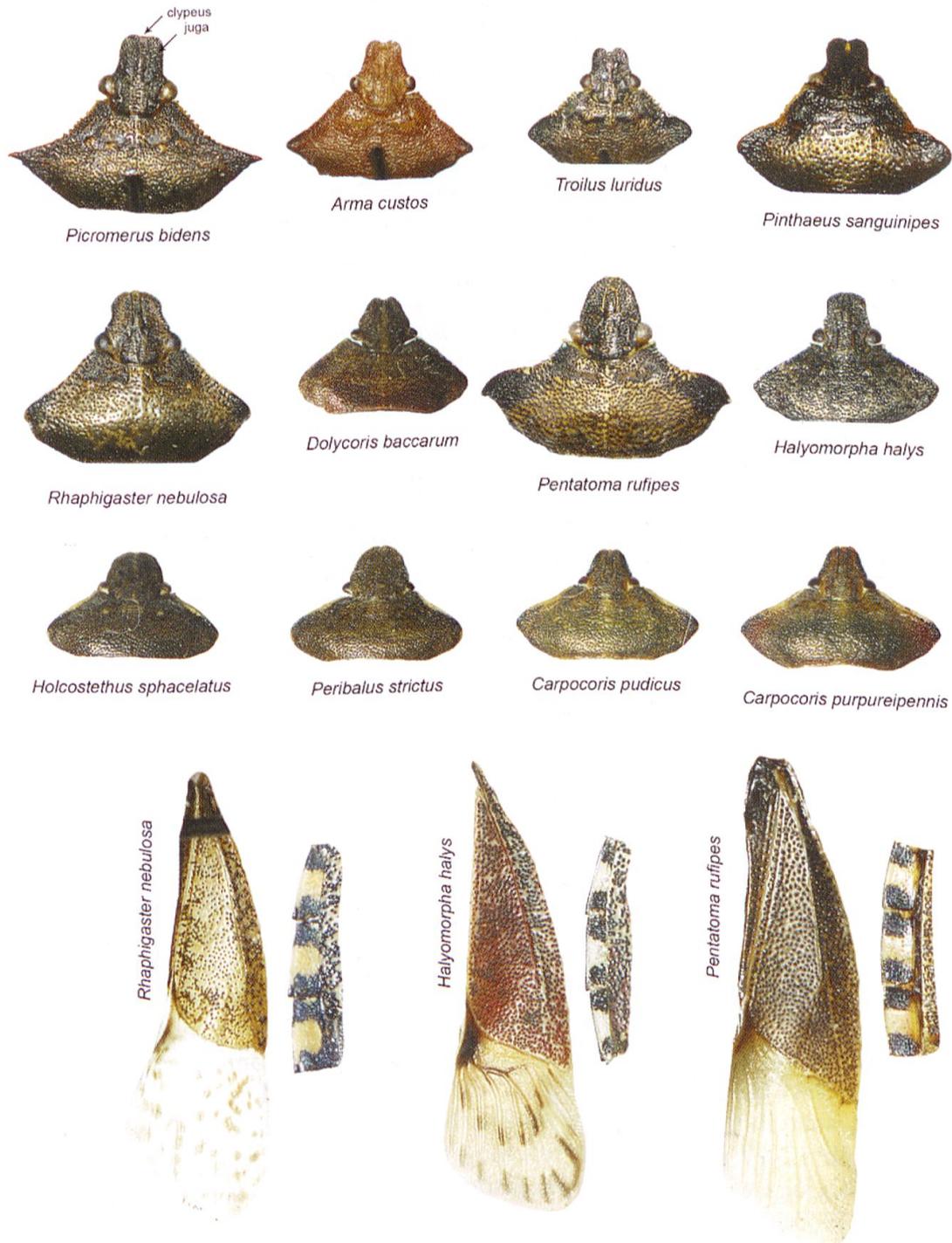


Fig. 2: Head and pronotum (dorsal view) of all discussed species, including details of corium and connexivum of *Rhaphigaster nebulosa*, *Halyomorpha halys* and *Pentatoma rufipes*.

- General aspect of head triangular or ovate (Fig. 2); membrane unicoloured or dark with light median band (Fig. 3); anterior angle of pronotum not distinctly thorn-like **Carpocorini 8**
8. Pronotum with round, not elongate lateral angle (Fig. 2); corium and basal part of pronotum reddish (Fig. 2); surface with distinct erect long setae (hairy impression); first antennal segment yellow, second segment yellow basally with longitudinal black mark laterally and black ring apically, topped with yellow ring; third segment black with yellow ring apically and basally; fourth and fifth segment black with wide yellow ring basally, and small yellow ring apically (Fig. 3, arrows) ***Dolycoris baccarum* (Linnaeus, 1758)**
- Character combination different, body surface not hairy **9**
9. Second antennal segment not distinctly longer than third segment; apical part of head small and acute (Fig. 3) ***Carpocoris* spp.**
- Second antennal segment visibly longer than third segment (at least 1.30 x); apical part of head wide and rounded (Fig. 3) **10**
10. Clypeus anteriorly enclosed by juga ***Peribalus strictus strictus* (Fabricius, 1803)**
- Clypeus anteriorly free, not enclosed by juga ***Holcostethus sphacelatus* (Fabricius, 1794)**

***Halyomorpha halys* (Stål, 1855)**

Diagnosis. Most similar to *Rhaphigaster nebulosa* and *Pentatoma rufipes* in size and colouration (Fig. 3), but distinguished in membrane with distinct longitudinal dark marks on veins, second apparent abdominal sternite (sternite III) flat, missing any thorn or protuberance, and connexivum with yellow medial spot slightly triangular (Fig. 2). Most recognisable by fourth antennal segment brown with distinct yellow ring apically and basally (Fig. 3); head elongate and rectangular with lateral margin distinctly concave medially, and prominent red ocelli; sternites impunctate medially (Fig. 1d, arrow) and lunate impunctate spots laterally (Fig. 1d, arrow); pronotum with anterior angle distinctly thorn-like (Fig. 2).

Redescription. COLORATION: Head ochraceous, with clypeus black laterally, and juga sometimes with reddish spots laterally; labium pale yellow with last segment black; pronotum and scutellum ochraceous; corium ochraceous, sometimes with reddish shade; membrane with distinct longitudinal dark marks on veins; first and second antennal segment pale yellow with dark spots or second segment almost entirely dark, third segment entirely dark, fourth segment dark with yellow ring apically and basally, fifth segment dark with yellow ring basally; venter pale yellow; femora, tibia, and tarsus ochraceous, blackish apically and sometimes with reddish shade. SURFACE AND VESTITURE: Dorsal surface callous with distinct dark punctures; scutellum with lateral yellowish orange calli basally. STRUCTURE: Body length 12–17 mm; rostrum reaching to second apparent abdominal sternite (sternite III); juga with lateral margin distinctly concave, eyes situated near anterior margin of pronotum.

Material examined. The listed records from Zürich are the result of a newspaper article asking for *H. halys* specimens in and around Zürich. They are mainly

specimen records, but a few records are based on photographs. SWITZERLAND: BS: Basel: Schützenmattstrasse (26.ix.2009); SG: Balgach: Weinbergstrasse (17.xii.2009); SH: Schaffhausen: Tobelweg (21.v.2008); ZH: Dietlikon: Sonnenbühlstrasse (10.iv.2008); Erlenbach: Im Unterdorf (04.v.2008, 27.i.2010, 15.ii.2010), Kilchberg: (9.ii.2009), Zollikon: Alte Landstrasse (12.iv.2008), Seestrasse (iv.2008, 7.i.2009, 19.vi.2009, 18.i.2010, 16.vii.2010), Zürich: Albisriederstrasse (iv.2008), Am Wettingertobel, Azurstrasse (11.iv.2008), Burstwiesenstrasse (iv.2008), Dachslersstrasse (iv.2008), Fellenbergstrasse (iv.2008, 02.v.2008),



Fig. 3: Colour photographs of all discussed species (dorsal view).

Fichtenstrasse (iv. 2008), Gloriamstrasse (08.v.2008), Gutstrasse (iv.2008), Hammerstrasse (iv.2008), Hölderlinstrasse (iv.2008), Hottingerstrasse (iv.2008), Im eisernen Zeit (iv.2008), Klosbachstrasse (iv.2008), Leimbachstrasse (iv.2008), Luggwegstrasse (iv.2008), Neptunstrasse (iv.2008), Neumarkt (iv.2008), Saumackerstrasse (iv.2008), Seestrasse (v.2008), Siewerdstrasse (11.iv.2008), St. Moritz-Strasse (iv.2008), Steinhaldenstrasse (10.iv.2008, 04.vii.2008), Weinbergstrasse (iv.2008), Witikonstrasse (iv.2008), Wuhrstrasse (iv.2008). On Wachtelstrasse in Zürich there is a mass occurrence since more than two years (2008–2010) observed on *Campsis grandiflora* (Bignoniaceae), where the species successfully develops and shows an enormous population buildup.

Distribution. Indigenous in Eastern China, Japan, Korea (Rider 2006), and Taiwan (Esaki 1926, as *H. picus*; D. Rédei, pers. comm.). Introduced into North America (Hoebeke & Carter 2003; Jones & Lambdin 2009), Switzerland (Wermelinger *et al.* 2008; Rabitsch 2010) and Liechtenstein (Arnold 2009).

Comments. The tribal affiliation of *H. halys* is controversial; according to Rider (2006) it belongs to the tribe Cappaeini, according to Hoebeke & Carter (2003) to the Pentatomini. However, there is no consensus in definitions of Pentatominae tribes among different authors – cf. Pentatomini s. l. of Rolston & McDonald (1981), evidently accepted by Hoebeke & Carter (2003), versus Pentatomini s. str. of Rider (2006). As a result, the whole tribal arrangement within the Pentatominae is currently chaotic and in need of complex phylogenetic treatment (see Rider 2006).

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