

RESEARCH PAPER

# *Halyomorpha halys* fixed as the type species of the genus *Halyomorpha* (Hemiptera: Heteroptera: Pentatomidae)

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**Abstract.** The genus *Halyomorpha* Mayr, 1864 (Hemiptera: Heteroptera: Pentatomidae: Pentatominae: Cappaeini) was established based on a single species, *Halys timorensis* Westwood, 1837 (currently a junior subjective synonym of *Halyomorpha picus* (Fabricius, 1794)). The examination of the voucher specimens identified as *Halyomorpha timorensis* by Mayr, a syntype of *Halys timorensis*, and syntypes of *Pentatoma halys* Stål, 1855 revealed that: i) *Halyomorpha timorensis* (Westwood), stat. restit., must be reinstated as a valid species, and not considered as a junior subjective synonym of *H. picus*; ii) Mayr's specimens belong to two different species, *Halyomorpha halys* (Stål) and *H. picus*. The problem of double misidentification of the type species of *Halyomorpha* is resolved by action of the first revising author(s) according to the Article 70.3 of the ICZN (1999): we fix here *Pentatoma halys* Stål, 1855 (= *Halys timorensis* sensu Mayr, nec Westwood) as the type species of *Halyomorpha* Mayr, 1864. A list of 36 valid species currently placed in *Halyomorpha* and their synonyms is compiled. We also issue a warning concerning the use of the citizen science approach for monitoring *H. halys* in Southeast Asia (which may also apply to other taxa): It is necessary to keep in mind that *H. halys* belongs to a group of habitually similar species (distributed from Pakistan and southern China to Indonesia and the Philippines) which cannot be identified with certainty without examination of their male genitalia; records merely based on observations or habitus photographs cannot be accepted as reliable.

**Key words.** Hemiptera, Heteroptera, Pentatomomorpha, Pentatomidae, brown marmorated stink bug, action of first reviser, nomenclature, taxonomy, type species fixation, China, Timor, Oriental Region, Palearctic Region

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## Introduction

Shield bugs (Pentatomidae) are the third most diverse family of Heteroptera, including nine subfamilies, 950 genera and nearly 5000 described species (RIDER et al. 2018, ROCA-CUSACHS et al. 2021a). While recent papers have given a first insight into the phylogenetic relationships among the included taxa (GENEVCIUS et al. 2021, ROCA-CUSACHS et al. 2021a, XU et al. 2021), promising a revolution in the internal classification of the family, poor knowledge on the alpha-taxonomy still renders identification of many species impossible. While the situation concerning the New World fauna has improved significantly in the past sixty years

due to the work primarily of Herbert Ruckes (1895–1965), Lawrence H. Rolston (1922–2008), Jocelia Grazia and the next generation of hemipterists inspired by their work (e.g., ROLSTON & RIDER 1985, RIDER & EGER 1995, GRAZIA et al. 2015, RIDER et al. 2018, GUIDOTI et al. 2021), the knowledge of Pentatomidae systematics in the Old World tropics is more than unsatisfactory. Since 2015, we register only eight papers dealing with Pentatomidae fauna of the Afrotropical Region (KMENT 2015, KMENT & BAENA 2015, KMENT & RIDER 2015, KMENT & GARBELOTTO 2016, RIDER 2016, KMENT & RÉDEI 2018, ROELL et al. 2019, SILVA et al. 2021), 24 papers concerning the fauna of the Oriental Region (including southern China) (GHATE 2015; SALINI



& VIRAKTAMATH 2015; SHAIKH et al. 2015; HASSAN et al. 2016; ZHAO et al. 2016; SALINI 2016a,b, 2017a,b, 2019; RÉDEI 2017; ROCA-CUSACHS et al. 2018, 2019; SALINI & SCHMIDT 2018; AHMAD et al. 2019; ISHIKAWA & MORIYA 2019; ROCA-CUSACHS & JUNG 2019; RÉDEI & TSAI 2021; ROCA-CUSACHS et al. 2021b; SALINI et al. 2021a,b,c,d; SALINI & KMENT 2021; SALINI & ROCA-CUSACHS 2021), and only two on Australia (FAÚNDEZ & RIDER 2018, 2019). However, none of the taxonomic papers mentioned above provided a revision of a species-rich genus.

Such an unsatisfactory situation concerns also *Halyomorpha* Mayr, 1864, a quite large genus currently containing 35 valid species (KMENT et al. 2021; a checklist is provided in the present paper), the monophyly of which has never been demonstrated. It is indigenous to the tropical and subtropical areas of the Old World from Senegal and South Africa in the west to Japan and New Caledonia in the east. Although the entire genus has never been revised, three regional revisions are available: that of LINNAVUORI (1982) concerning west and central Africa, that of AHMAD & ZAIDI (1989) for the Indo-Pakistan subcontinent, and the work of HASAN (1993) for the Malayan subregion. The latter two papers, however, are taxonomically highly problematic (cf. KMENT et al. 2021). One of the included species, *Halyomorpha halys* (Stål, 1855), also known as the brown marmorated stink bug, has recently been introduced to North America, the West Palearctic Region and Chile, and it is actively expanding to new areas (e.g., HOEBEKE & CARTER 2003, WERMELINGER et al. 2008, FAÚNDEZ & RIDER 2017, HAMILTON et al. 2018, LESKEY & NIELSEN 2018, GARIPEY et al. 2021, VAN DER HEYDEN et al. 2021). As a serious emerging pest, *H. halys* was attracting much attention in the last decade with dozens of papers published on various aspects of its biology every year (e.g., HAMILTON et al. 2018, LESKEY & NIELSEN 2018). The male and female genitalia, necessary for a reliable identification, were accurately described and illustrated for *H. halys* only by VÉTEK et al. (2014), and for *H. picus* (Fabricius, 1794) by SALINI et al. (2021a) and KMENT et al. (2021). Recent doubtful records of the invasive *H. halys* from regions where other species of *Halyomorpha* are native (e.g., India – NIKAM & MORE 2016 [corrected by SALINI et al. 2021a] and Nigeria – BORISADE et al. 2017), suggest that a taxonomic revision and compilation of a reliable identification key to distinguish species of the genus are urgently needed. During the first steps of this revisional work, we noticed a strange discrepancy concerning the type species of the genus: according to MAYR (1864, 1866), the type species of *Halyomorpha* is, by monotypy, *Halys timorensis* Westwood, 1837 (currently considered a junior subjective synonym of *H. picus*) described from Timor Island (Lesser Sunda Islands). However, MAYR (1864, 1866) based his description of the new genus on material collected in southern China, an area currently known to host only *H. halys* (cf. RIDER 2006, VÉTEK et al. 2014). In this paper, we revise the original material examined by MAYR (1864, 1866) as well as the available syntypes of *H. timorensis* and *H. halys*, and provide the required nomenclatural changes.

## Material and methods

Photographs were made partly using a Canon MP-E 65 mm macro lens attached to a Canon EOS 550D camera (Figs 1–3, 15–23) and partly with an AF-S Micro Nikkor 60 mm f/2.8G ED lens attached to a Nikon D90 camera (Figs 24–26). Final images were stacked from multiple layers using the Helicon Focus 5.1 Pro software. Uncoated specimens were examined by a Hitachi S-3700N environmental scanning electron microscope at the Department of Palaeontology, National Museum, Prague.

The following dimensions were measured in dorsal view: body length (from apex of mandibular plates to apex of membrane), head length (from apex of mandibular plates to anterior margin of pronotum), head width (including compound eyes), interocular width (between mesal margins of compound eyes), length of each antennomere, length of each labiomere, pronotum length (medially, from anterior to posterior margin of pronotum), pronotum width (maximum width between humeri), scutellum length (medially, from base to apex), scutellum width (maximum width between basal angles of scutellum), and abdomen width (maximum width across posterolateral angles of segment III). The measurements were subsequently standardized to provide absolute lengths. Morphological terminology follows TSAI et al. (2011), KMENT et al. (2019), ZHOU & RÉDEI (2020) and SALINI & KMENT (2021).

In quoting the labels of the material examined, a slash (/) is used to divide data on different rows of one label, a double slash (//) is used to divide the data on different labels, authors' comments are given in square brackets [ ], and the following abbreviations are used: [hw] = hand written, [p] = printed. Unless stated otherwise, the described labels are off-white.

Specimens deposited in the following museums were examined:

NHMW	Naturhistorisches Museum, Vienna, Austria;
NHRS	Naturhistoriska Riksmuseet, Stockholm, Sweden;
OXUM	Oxford University Museum, Hope Entomological Collections, Oxford, United Kingdom;
RMNH	Naturalis (former Nationaal Natuurhistorisch Museum), Leiden, the Netherlands;
ZMUC	Zoological Museum, University of Copenhagen, Denmark.

## Results

### *Halyomorpha* Mayr, 1864

*Halyomorpha* Mayr, 1864: 911 (original description). Type species: *Halys timorensis* Westwood, 1837, by monotypy.

*Halyomorpha*: MAYR (1866): 47–50 (redescription, differential diagnosis); STÅL (1868a): 515 (key to genera); STÅL (1876): 57 (key to genera), 74–75 (key to species, catalog); ATKINSON (1888): 23 (diagnosis); LETHIERRY & SEVERIN (1893): 117–118, 267 (World catalog); DISTANT (1902): 148 (key to genera), 152 (diagnosis); OSHANIN (1906): 106 (Palearctic catalog); BERGROTH (1908): 161 (catalog); KIRKALDY (1909): 49–50 (World catalog); OSHANIN (1912): 12 (Palearctic catalog); JEANNEL (1913): 61, 67–68 (diagnosis, key and catalog of African species); BERGROTH (1921): 4–8 (systematics, possible placement in *Halyini*); HOFFMANN (1932): 7 (checklist); TANG (1935): 313–314 (Chinese catalog); BEIER (1938): 2187 (list); CACHAN (1952): 397, 402 (key, redescription; included in *Carpocorini*); VILLIERS (1952): 68 (diagnosis); STICHEL (1961): 752 (Palearctic catalog); STICHEL

(1962): 233 (Palearctic catalog); AHMAD et al. (1974): 22, 77 (key to genera); HSIAO et al. (1977): 102 (key to genera); MEDLER (1980): 125 (Nigeria, checklist); AHMAD (1981): 21 (key to genera); LINNAVUORI (1982): 114–118 (key to genera, diagnosis, species-groups and key to Afrotropical species); ABBASI (1986): 28 (key to genera), 65–66 (diagnosis); AHMAD & ZAIDI (1989): 238–239 (redescription, key to Indo-Pakistan species), 248–253 (phylogenetic relationships); ZAIDI et al. (1990): 41–47 (phenetics); HASAN (1993): 209–210 (redescription, key to species of Malayan subregion); LIN & ZHANG (1993): 119 (key to genera); ZAIDI & SHAUKAT (1993): 60–65 (phenetics); CHAKRABORTY & GHOSH (1999): 392 (list), 397 (key to genera); GADALLA (2004): 49 (diagnosis); LIU & WANG (2004): 183 (key to genera); WANG & LIU (2005): 285 (key to genera); RIDER (2006): 261 (Palearctic catalog); BISWAS & BAL (2007): 313 (key to genera); RIDER (2012): 330 (key to genera); SWANSON (2012): 297 (list); AUKEMA et al. (2013): 448 (Palearctic catalog); SALINI & VIRAKTAMATH (2015): 12, 16–17 (key to genera, checklist, India); RIDER et al. (2018): 76, 100, 105–106, 134, 197, Fig. 2.28 (systematic placement); ROCA-CUSACHS & JUNG (2020): 37, 46 (in key, fauna of South Korea); SALINI (2020): 129 (key).

*Halyomorpha* [incorrect subsequent spelling]: NONNAIZAB (1986): 117 (key to genera), 206 (diagnosis).

*Cappaea* [misidentification]: MEDLER (1980): 124 (Nigeria, checklist).

**Material examined.** *Halyomorpha halys*: 2 ♂♂ 1 ♀, 'Novara Exp. / China. [hw] // timorensis [hw] / det. Mayr [p, black line submarginally] // SPECIMEN USED / FOR DESCRIPTION / OF HALYOMORPHA / MAYR, 1864 [p] // HALYOMORPHA / HALYS / (Stål, 1855) / det. P. KMENT 2021 [p]' (NHMW). Body lengths: ♂♂ 12.80 mm (Fig. 1) and 13.17 mm, ♀ 14.92 mm.

*Halyomorpha picus*: 1 ♂ (Fig. 2), 'Novara Exp. / China. [hw] // timorensis [hw] / det. Mayr [p, black line submarginally] // SPECIMEN USED / FOR DESCRIPTION / OF HALYOMORPHA / MAYR, 1864 [p] // HALYOMORPHA / PICUS / (Fabricius, 1794) / det. P. KMENT 2021 [p]' (NHMW). Body length: 14.63 mm.

**Nomenclature.** The exact date of publication of the paper containing the original description of the genus *Halyomorpha* is uncertain. The manuscript was presented by G. L. Mayr at the meeting (Sitzung) of the Kaiserlich-Königliche Zoologisch-Botanische Gesellschaft in Wien [= Imperial and Royal Zoological and Botanical Society in Vienna] on the 7th of December 1864 (cf. MAYR 1864: 903). The receipt of a published preprint of the article was mentioned in the record of the meeting of the Mathematisch-Naturwissenschaftliche Classe der Kaiserlichen Akademie der Wissenschaften [= Imperial Academy of Sciences, Branch of Mathematics and Natural Sciences] on the 9th of February 1865 (cf. *Sitzungsberichte der Mathematisch-Naturwissenschaftliche Classe der Kaiserlichen Akademie der Wissenschaften*, vol. 51, issue 2, p. 135). The first traceable record of the entire published volume (vol. 14, for 1864) of *Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien*, consisting of three issues (1–2, 3 and 4), mentioned it with the date of 23 February 1865 (cf. vol. 15, p. 17 of the same journal); the *Allgemeine Bibliographie für Deutschland* recorded it on p. 68 of issue 9 of its 1865 volume, published on 2 March 1865. Mayr's article (contained in issue 4) was certainly published and distributed as a preprint after 7 December 1864 but before 9 February 1865, possibly only in early 1865. Because a publication in late December 1864 cannot be excluded, the date printed on the front page of the volume (1864) is, however, accepted. The correct publication date of MAYR (1866) was discussed by HIGGINS (1963).

*Halyomorpha* was established for a single included species (i.e., type species by monotypy), cited as '*Halyomorpha timorensis* Hope' (MAYR 1864); however, this taxon name must be attributed to J. O. Westwood (see KIRKALDY 1907). Subsequently, MAYR (1866) provided a detailed redescription of *Halyomorpha* and compared it with *Pentatoma* Olivier, 1789 and *Oncocoris* Mayr, 1866; he listed the single included species as '*Halys timorensis* Westwood'. The original description and subsequent redescription of the genus and the included species (MAYR 1864, 1866) were all said to be based on specimens from Hongkong and Shanghai, China. STÅL (1876) listed both *Halyomorpha timorensis* and *H. halys* (the latter species described from China) as junior subjective synonyms of *H. picus*. His taxonomic framework was almost universally accepted for the following one hundred years, and *H. picus* was accordingly considered as a species widely distributed in eastern and southeastern Asia (e.g., DISTANT 1902, KIRKALDY 1909, HSIAO & ZHENG 1977). However, starting with ESAKI (1955: 165), most Japanese authors of the 20th century distinguished the Japanese populations of *Halyomorpha* as a separate species, *H. brevis* Walker, 1867, originally described also from Hongkong (WALKER 1867a). JOSIFOV & KERZHNER (1978) examined representative material of *Halyomorpha* specimens from the Palearctic East Asia (Japan, Korea and east China), and concluded that they belong to a single species, distinct from *H. picus* distributed in the Oriental Region. Accordingly, they resurrected *H. halys* as the oldest available name for the East Palearctic species, but they accepted *H. timorensis* as a junior synonym of *H. picus*. All subsequent authors accepted *H. picus* as the type species of *Halyomorpha* (NONNAIZAB 1986, AHMAD & ZAIDI 1989, HASAN 1993, GADALLA 2004, RIDER 2006), despite the fact that MAYR (1864, 1866) purportedly based the generic description on specimens from southeast China, where only *H. halys* is known to occur (see HSIAO & ZHENG 1977, as *H. picus*; JOSIFOV & KERZHNER 1978; RIDER et al. 2002; RIDER 2006; VÉTEK et al. 2014; HAMILTON et al. 2018).

To elucidate the contradiction concerning the identity of the type species of *Halyomorpha*, we borrowed the voucher specimens from Mayr's collection, now housed in the Naturhistorisches Museum in Vienna. Due to the courtesy of Herbert Zettel, we examined four specimens bearing the original locality labels of Novara Expedition and identification labels by Mayr. Among them we identified two males and one female of *H. halys* (male and female external genitalia corresponding with illustrations in VÉTEK et al. 2014 and SALINI et al. 2021a) and one male of *H. picus* (external male genitalia corresponding with SALINI et al. 2021a, KMENT et al. 2021, and a male syntype of *H. picus* in ZMUC – P. Kment, pers. observ.). Concerning the presence of *H. picus* among the examined material from 'China', we were convinced about the mislabelling of the specimen, originating most probably from Ceylon [= Sri Lanka] or Madras [= Chennai, India], areas that were also visited and sampled during the Novara Expedition (SCHERZER 1861a,b). We further examined the only avail-



Figs 1–3. Specimens of *Halyomorpha* Mayr, 1864 from Mayr collection (NHMW): 1 – *Halyomorpha halys* (Stål, 1855), male (body length 12.80 mm); 2 – *Halyomorpha picus* (Fabricius, 1794), male (14.63 mm); 3 – labels. Orig. P. Kment.

able syntype of *Halys timorensis* held in the collection of the Oxford University Museum. Based on its examination we accept *H. timorensis* as a valid species distinct from *H. picus* (see below).

These discoveries result in a rather unusual case of double misidentification of the type species of *Halyomorpha*. In such a situation, Article 70.3 of the ICZN (1999) applies, and we are supposed to select, and thereby fix as type species, the species that will best serve stability and universality of zoological nomenclature, either i) the nominal species previously cited as type species (i.e., *Halys timorensis* Westwood, 1837, Art. 70.3.1) or ii) the taxonomic species actually involved in the misidentification (i.e., either *Cimex picus* Fabricius, 1794 or *Pentatoma halys* Stål, 1855, Art. 70.3.2). As *H. timorensis* is a poorly known species with male characters unknown, and there is no doubt that the description of *Halyomorpha* (MAYR 1864, 1866) was based on a study of other species, we consider the first possibility as inadvisable. Of the two remaining

taxa, we prefer to choose *H. halys*, the species native in Hongkong and Shanghai area and currently by far the best known and intensively studied species of *Halyomorpha* (cf. HAMILTON et al. 2018). Therefore, we fix here *Pentatoma halys* Stål, 1855 [= *Halys timorensis* (non Westwood, 1837): MAYR (1864) (partim), misidentification] as the type species of *Halyomorpha* Mayr, 1864 acting as first revisers according to the Article 70.3 of the ICZN (1999).

***Halyomorpha timorensis*  
(Westwood, 1837), stat. restit.**

(Figs 15–20, 22)

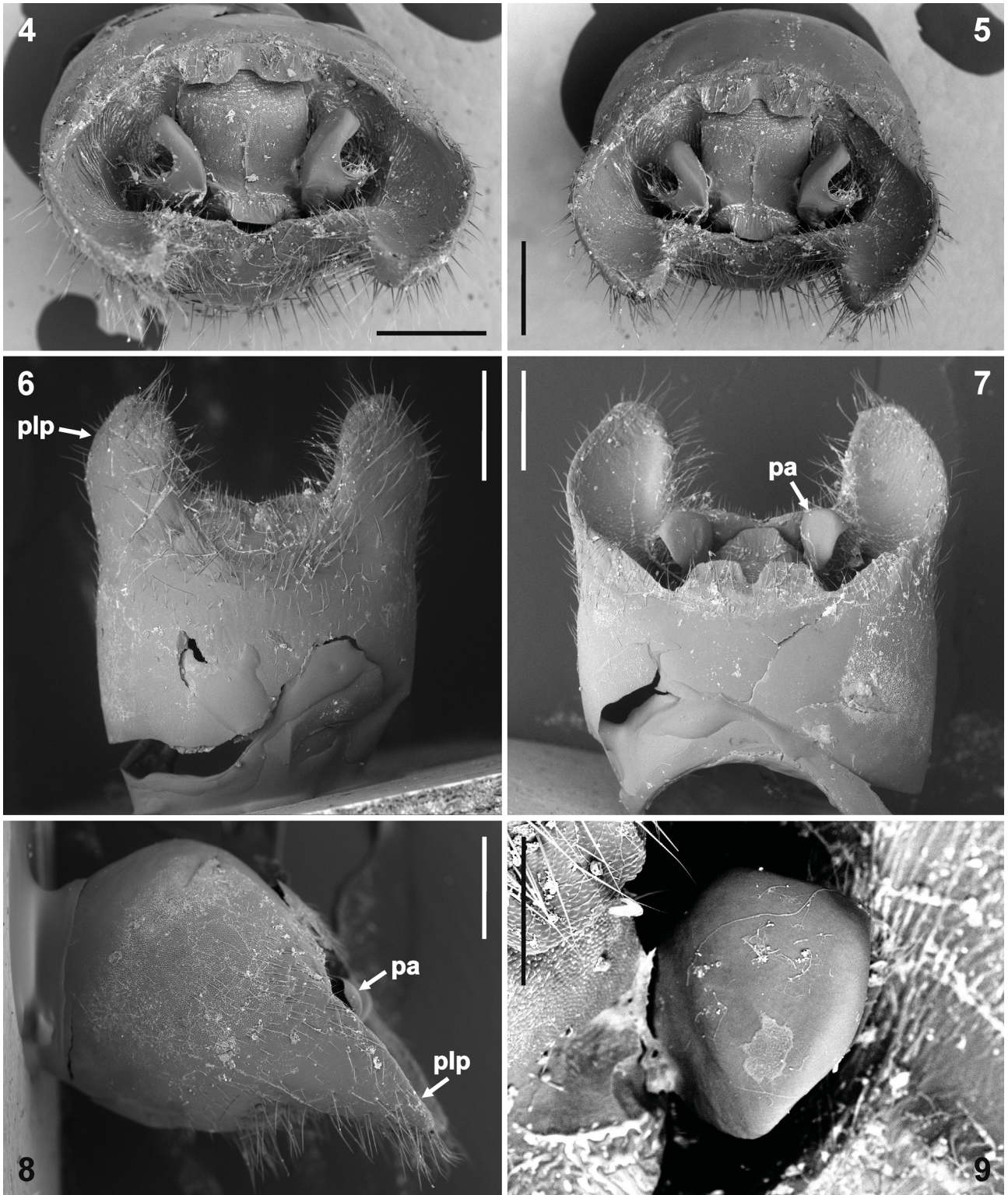
*Halys timorensis* Westwood, 1837: 6, 22 (original description).

*Cappæa timorensis*: STÅL (1865): 170 (new combination).

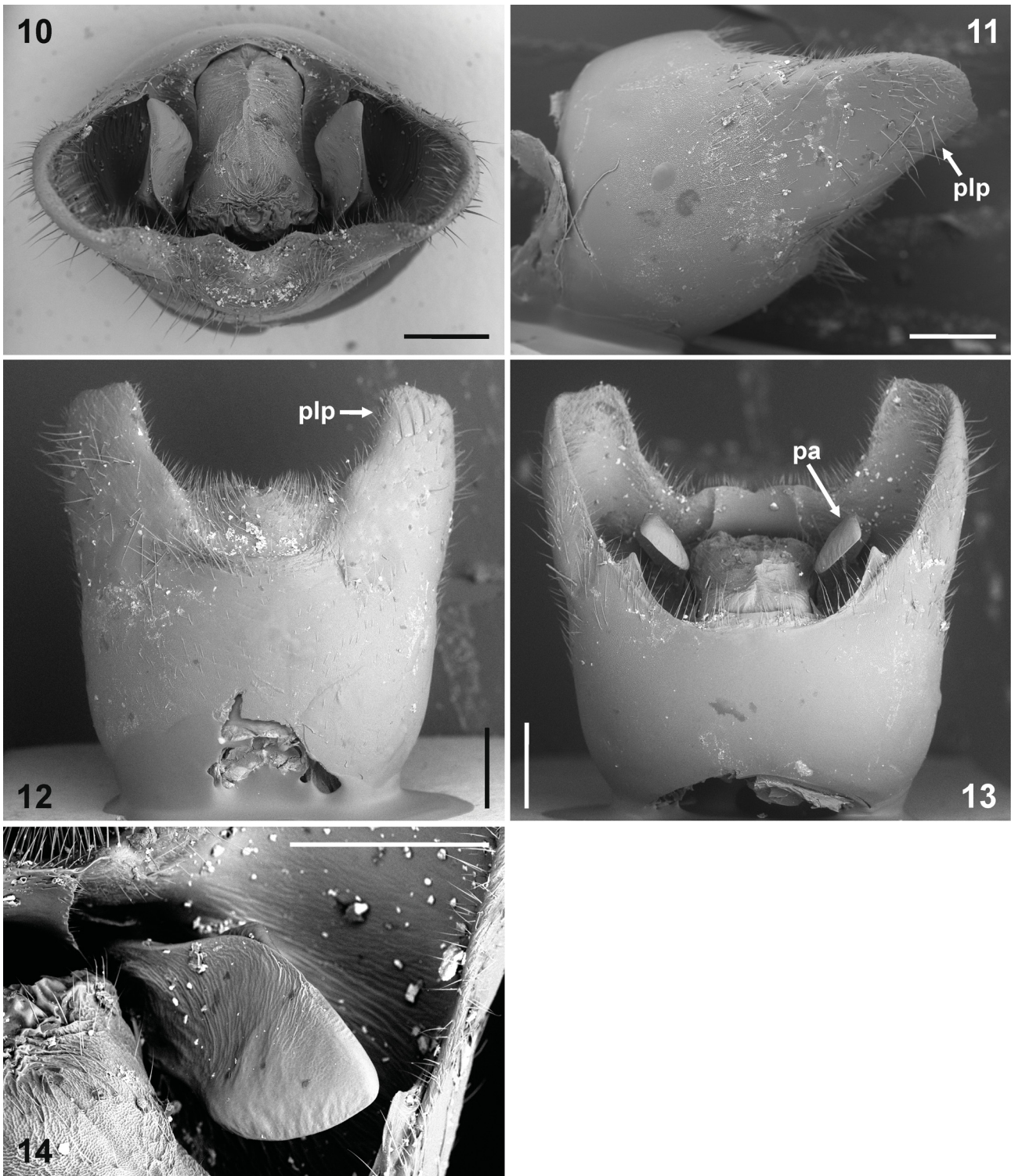
*Halyomorpha timorensis*: STÅL (1876): 75 (as junior subjective synonym of *H. picus*).

The following bibliographic records of *H. timorensis* are based on misidentifications and pertain to other species:

*Pentatoma timorensis* [misidentification of *H. picus*]: DALLAS (1851): 242 (new combination, distribution); HERRICH-SCHÄFFER (1853):



Figs 4–9. *Halyomorpha halys* (Stål, 1855), male genitalia of the specimen from Mayr collection (NHMW). 4–8 – genital capsule (4 – posterior view, magnification 55×; 5 – dorsoposterior view, 47×; 6 – ventral view, 35×; 7 – dorsal view, 37×; 8 – lateral view, 47×); 9 – paramere in posterior mediolateral view (170×). Abbreviations: pa – parameres, plp – posterolateral lobes of genital capsule. Scale bars: 4–8 – 0.5 mm, 9 – 0.2 mm. Orig. P. Kment.



Figs 10–14. *Halyomorpha picus* (Fabricius, 1794), male genitalia of the specimen from Mayr collection (NHMW). 10–13 – genital capsule (10 – posterior view, magnification 42×; 11 – lateral view, 42×; 12 – ventral view, 30×; 13 – dorsal view, 32×); 14 – paramere in posterior mediolateral view (100×). Abbreviations: pa – parameres, plp – posterolateral lobes of genital capsule. Scale bars: 0.5 mm. Orig. P. Kment.



Figs 15–17. *Halys timorensis* Westwood, 1837, female syntype (OXUM) (body length 15.4 mm): 15 – dorsal view, 16 – ventral view, 17 – labels. Orig. P. Kment.

159 (list, distribution); DOHRN (1859): 15 (catalog, distribution); MOTSCHULSKY (1863): 74 (checklist).

*Pentatoma Timorensensis* [incorrect subsequent spelling; misidentification of *H. picus*]: WALKER (1859): 292 (list).

*Halyomorpha timorensis* [misidentification of *H. halys* and *H. picus*]: MAYR (1864): 912 (new combination, distribution); MAYR (1866): 50, pl. 1: figs 7a,b (redescription, figures, distribution).

*Halyomorpha timorensis* [misidentification of *H. picus*]: WALKER (1867b): 299 (distribution).

*Halyomorpha timorensis* [misidentification of *H. halys*]: SIGNORET (1881): 46 (list).

**Material examined.** SYNTYPE: ♀ (Figs 15–16), ‘Timor [hw] // 187. [hw] // Halyomorpha / picus / Fabr. [hw] // Type [p, white circle with red margin] // TYPE. / = = / WESTW. (HOPE) / C. Hemipt. 1837 / Part I, page [p] 22 [hw] / Distant, P.Z.S., / 1900, p. 807–825. [p, black frame submarginally] // TYPE [p] HEM.: NO 89 / HALYS TIMORENSIS / WESTWOOD [hw] // HOPE DEPT. OXFORD [p, black frame submarginally] // SYNTYPE / HALYOMORPHA / TIMORENSIS / (Westwood, 1839) / det. P. KMENT 2021 [p. red label]’ (OXUM). Specimen pinned through scutellum, missing the following parts: right antennomeres II–IV, left antennomeres III–IV, right protarsomeres II–III, left protarsomere III, right mesotarsomeres II–III, and all metatarsomeres.

**Redescription. Colour, integument and vestiture** (Figs 15–16). Head above, pronotum, scutellum, clavus and exocorium yellowish, endocorium partly brownish, with variegated pattern formed by more or less densely distributed black punctures (Fig. 15), sometimes so dense, and with dark interspaces, to form black-appearing spots (especially on midlength of clypeus, submarginally on anterolateral angles of pronotum, on humeral angles, and at frenal incisions laterally on scutellum); yellowish interspaces between punctures in some places swollen to form callosities, most prominent ones on calli and behind them, on scutellum one in each anterolateral corner, one anteromesially, and in apical portion of scutellum (Fig. 15). Connexival segments with about anterior and posterior third black with purple metallic shine, middle third and posterolateral margin narrowly yellowish, with concolorous punctures (Fig. 15). Membrane brownish, translucent, basal angle dark brown. Antennae yellowish with small brown spots, on scape partly coalescent.

Ventral side of body yellowish with scattered minute brown spots (Fig. 16). Head and thorax ventrally with large, deep punctures, often with green or purple metallic shimmer, forming larger irregular spots around antenniferous tubercles and on pro-, meso-, and metapleuron, especially on humeral angles. Labiomere I yellowish, II and III yellowish with black stripe ventrally, IV black. Abdominal venter, including laterotergites VIII and IX and valvifers VIII, with scattered brown punctures, becoming denser towards lateral margins; ventrite VI with small and VII with large dark brown spot anteromesally (Fig. 16); spiracles surrounded by black ring; ventrites laterally with small dark brown spots in anterior and lateral angles and semicircular spot of translucent cuticle in the middle, the latter being surrounded by yellowish C-shaped spot nearly devoid of punctures (Fig. 16). Legs yellowish, femora and tibiae with scattered brown spots (those becoming denser towards apex), anterior ridge on dorsal surface of tibiae emarginated by reddish line (Fig. 16).

Scutellum, connexivum, and ventral side of the body shining, head dorsally and pronotum submatte, calli on pronotum, corium, and evaporatorium of the metathoracic scent efferent system matte. Body glabrous, femora, tibiae and external female genitalia with short pale pilosity.

**Structure** very similar to *H. halys* and *H. picus*. Head anteriorly widely parabolic, apex of clypeus slightly surpassing apices of mandibular plates; lateral margins parallel in middle (Fig. 15), insinuate in front of eyes, antenniferous tubercles visible from above. Anterolateral margins of pronotum carinate, slightly concave in anterior half; humeral angles subrectangular, narrowly rounded (Fig. 15). Scape reaching rounded portion of head margin (Fig. 15), length of antennomeres: IIb > IIa > I. Labium reaching ventrite III (Fig. 16). Peritreme of metathoracic scent gland ruga-shaped, pointed apically (Fig. 18). Dorsal surface of all tibiae flattened, laterally carinate. Abdomen slightly wider than pronotum across humeral angles.

External female genitalia (Figs 19–20, 22) with posterior margins of valvifers VIII nearly straight (Fig. 20); laterotergites IX in apical half parabolic, narrowly rounded (Fig. 20); posterior margins of laterotergites VIII obtusangulate, each angle provided with a small denticle (Fig. 20: yellow arrows, 22: red arrows).

**Measurements** (mm). Body length 15.23; head: length 3.04, width 3.14, interocular width 1.72; lengths of antennomeres: scape (I) 0.83, basipedicellite (IIa) 1.47, distipedicellite (IIb) 2.21, basiflagellum (III) and distiflagellum (IV) missing; lengths of labiomeres: I – 1.37, II – 2.40, III – 1.81, IV – 1.72; pronotum: length 3.09, width 8.29; scutellum: length 5.54, width 5.15; abdomen: width 8.63.

**Differential diagnosis.** The examined specimen fits in its structure, coloration and measurements within the known variability of *H. halys* and *H. picus*. The external female genitalia of *H. timorensis* resemble those of *H. halys* in having laterotergites IX in apical half parabolic, narrowly rounded (Fig. 20) and posterior margins of laterotergites VIII obtusangulate, each angle provided with a small black denticle (Fig. 20: yellow arrows, 22: red arrows; VÉTEK et al. 2014: fig. 15; SALINI et al. 2021a: fig. 1g). In

*H. picus*, the laterotergites IX are less parabolic and more broadly rounded, and the posterior margins of laterotergites VIII are nearly regularly rounded, apically blackened but without a denticle (KMENT et al. 2021: fig. 6; SALINI et al. 2021a: fig. 1f).

**Distribution.** Lesser Sunda Islands: Timor (WESTWOOD 1837).

**Comments.** In the original description of *Halys timorensis*, WESTWOOD (1837) gave only a single measurement, but provided no other indication concerning the number of examined specimen(s). We were able to examine a single female syntype located in OXUM. As identification of females of this species complex is currently problematic, we refrain from designating the available female syntype as lectotype, leaving more opportunity for a later selection of a potentially more suitable specimen.

The examination of the syntype revealed that *H. timorensis* is very similar in coloration, structure and measurements to *H. halys* and *H. picus*, except the characters of the external female genitalia. The shape of the laterotergites VIII and IX of *H. timorensis* matches that of *H. halys*, but it clearly differs from *H. picus* and therefore *H. timorensis* must be removed from synonymy of the latter species. Further, our examination of the available male specimens of *Halyomorpha* from Indonesia and the Philippines has not revealed a single specimen of *H. halys*, but that area is inhabited by several other habitually similar species, described or not. In this situation we refrain from proposing *H. timorensis* **stat. restit.** as a junior synonym of *H. halys* and prefer to treat it as a dubious but valid species, until corresponding male specimens from Timor Island can be examined.

### *Halyomorpha halys* (Stål, 1855)

(Figs 1, 24–26)

*Pentatoma halys* Stål, 1855: 182 (original description).

For a list of synonyms see RIDER (2006) and the checklist below.

**Type material examined.** SYNTYPE: ♀ (Figs 24–26), ‘China. [p] // Hamb [hw] // ♀ [p] // halys / Stål / Typ. [hw] // Typus [p, red, with black frame] // 182 [p] / 69 [hw in blue]’ (NHRS). Specimen pinned through scutellum, left metatarsus missing, right antenna broken between basi- and distiflagellites but repaired by previous worker using glue (NHRS). SYNTYPE: ♀, ‘China. [p] // Hamb [hw] // ♀ [p]’. Specimen pinned through scutellum, left antenna and left protarsomeres II–III missing (NHRS).

**Additional specimens examined.** 1 ♀, ‘Hongkong [hw] // Stål. [p] // Typ. [p] // Cappaea / halys Stål. [hw]’ (NHRS). 1 ♀, ‘Japonia [hw] // Mus. / Leyden [hw] // Pentatoma / dalpadoides / Voll. Typ. [hw] // Paratypus [p, red, with black frame]’ (NHRS).

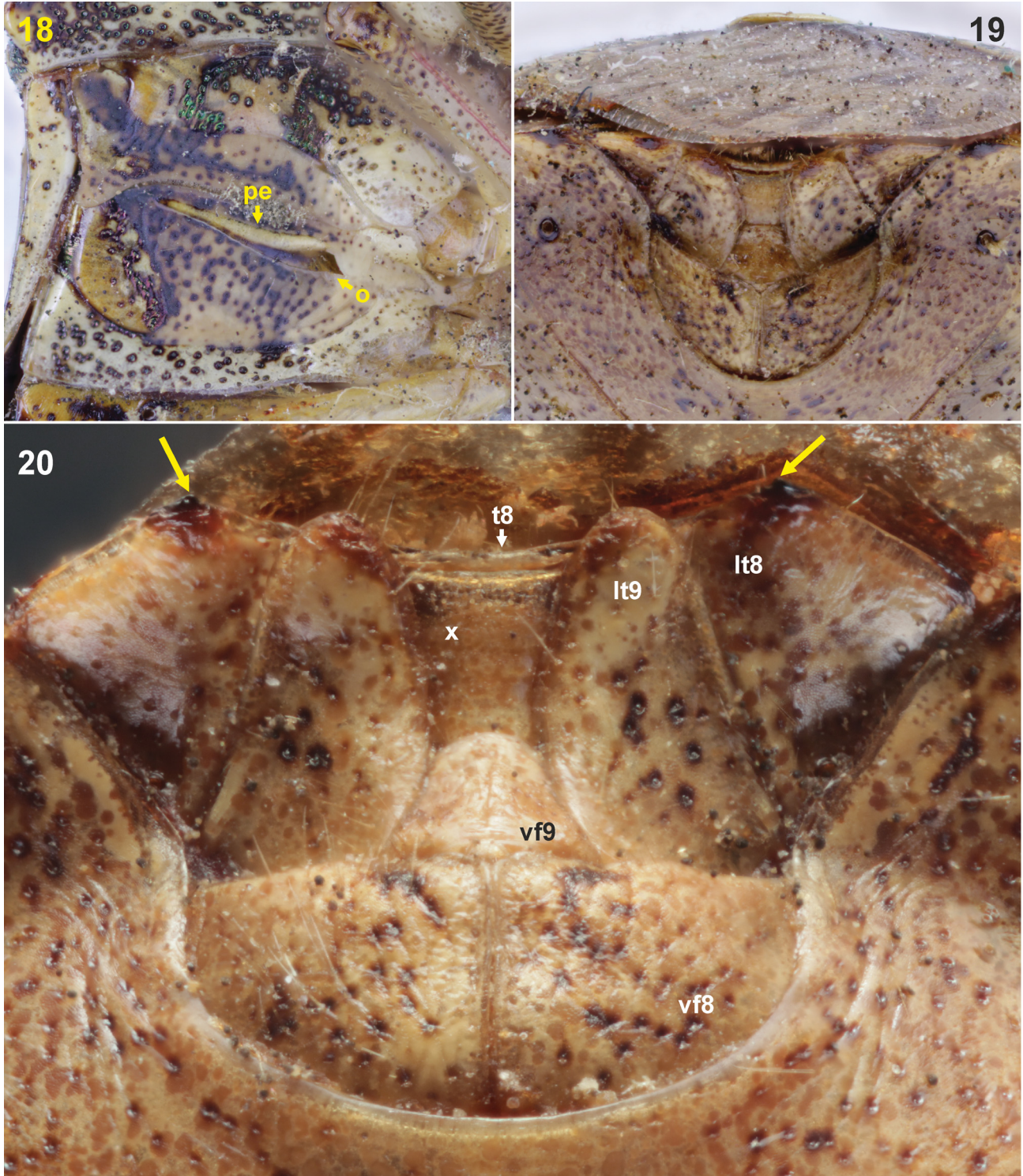
**Comments.** As *H. halys* is fixed in this paper as the type species of *Halyomorpha*, its identity is of particular interest. The species was described based on an unspecified number of specimens (syntypes) from ‘China’; a subsequent paper (STÅL 1856) stated that the specimens were provided by ‘Dom. [= Mr.] Hamberg’. Two females from the same lot of specimens, matching the original description (STÅL 1855) and information subsequently provided by the same author (STÅL 1856) and certainly belonging to the type material of *Pentatoma halys*, have been located in NHRS; to facilitate a revision of the genus, the one in better condition is illustrated here (Figs 24–26). Both specimens are consistent with the identification of



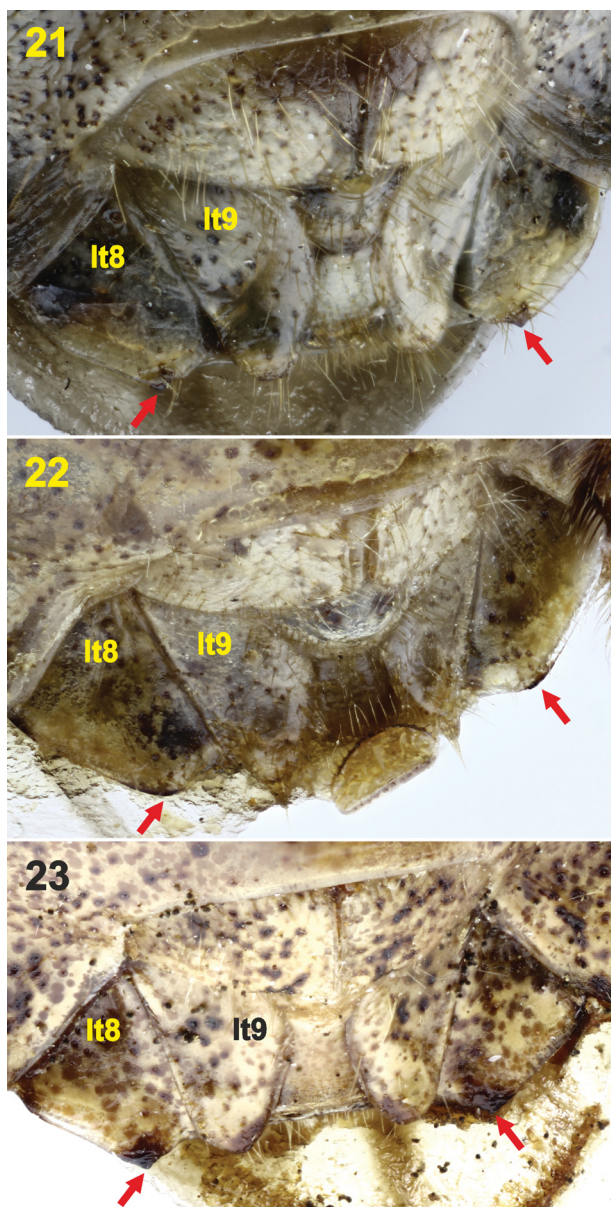
this species by recent authors (e.g., JOSIFOV & KERZHNER 1978 or VÉTEK et al. 2014).

Two additional females, one from ‘Hongkong’ and one from ‘Japonia’ [= Japan], were labelled as types and pinned together with the above listed two syntypes of *H. halys*, but as they are not from the type locality of *H. halys* as listed by STÅL (1855, 1856), they are considered as having no

type status. One of them is provided with a handwritten label ‘*Pentatoma dalpadoides* Voll[enhoven]’, which is apparently an unpublished name; *Gynenica dalpadoides* Vollenhoven, 1867 (currently *Platynopus dalpadoides*) is an unrelated species belonging to Asopinae (THOMAS 1994), its type material is deposited in RMNH and has been seen by us (D. Rédei, pers. observ.).



Figs 18–20. *Halyomorpha timorensis* (Westwood, 1837), female syntype: 18 – external scent efferent system of the metathoracic scent gland; 19–20 – external genitalia (19 – posterior view, 20 – ventral view, angle on posterior margin of lt8 shown by yellow arrows). Abbreviations: lt8–9 – laterotergites 8–9, o – ostiole, pe – peritreme in form of peritremal ruga, t8 – tergite 8, vf8–9 – valvifers 8–9, x – segment X. Orig. P. Kment.



Figs 21–23. *Halyomorpha* Mayr, 1866, external female genitalia in ventrolateral view (angle on posterior margin of lt8 shown by red arrows): 21 – *H. halys* (Stål, 1855), Czech Republic: Praha, botanical garden of the Charles University; 22 – *H. picus* (Fabricius, 1794), Pakistan: Islamabad, National Institute of Health colony; 23 – *H. timorensis* (Westwood, 1837), syntype. Abbreviations: lt8–9 – laterotergites 8–9. Orig. P. Kment.

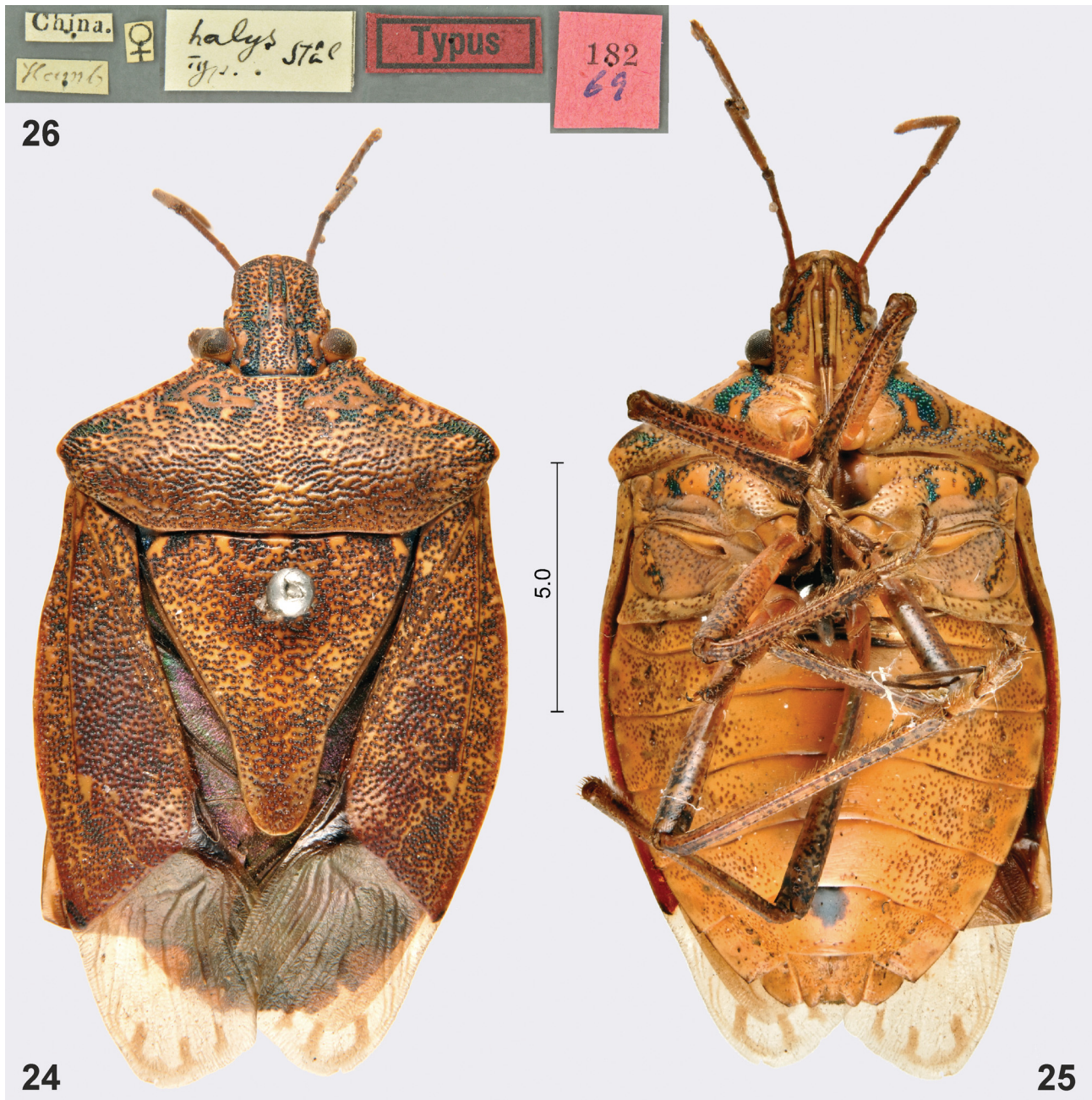
### List of species currently included in *Halyomorpha*

- Halyomorpha angusticeps* Bergroth, 1914: 451 [tropical Africa]  
*H. angustisecta* Linnavuori, 1982: 115, 117 [Ivory Coast]  
*H. annulicornis* (Signoret, 1858): *Pentatoma annulicornis* Signoret, 1858 in FAIRMAIRE & SIGNORET (1858: 284) [tropical Africa]  
*H. bimaculata* Bergroth, 1892: 160 [tropical Africa]  
*H. canalana* Distant, 1914: 374, pl. XII: fig. 7 [New Caledonia]  
*H. capeneri* Leston, 1952: 513 [South Africa]  
*H. carmona* Linnavuori, 1982: 115, 116 [Angola]  
*H. collocata* (Walker, 1867): *Dalpada collocata* Walker, 1867a: 221 (syn. with *H. picus* suggested by DISTANT (1893: 393), treated as valid by HASAN 1993: 211) [Indonesia: Java, Sumatra]  
*H. distanti* Jeannel, 1913: 71 [tropical Africa, Yemen]  
*H. fletcheri* Distant, 1918: 129 [Myanmar]

- H. guttula* (Ellenrieder, 1862): *Halys guttula* Ellenrieder, 1862: 144, pl. II: fig. 12. [Indonesia: Sumatra]  
*H. halys* (Stål, 1855): *Pentatoma halys* Stål, 1855: 182 (syn. with *H. picus* by STÅL 1876: 75, restored as valid species by JOSIFOV & KERZHNER 1978: 172) [native: China, Japan, Korea, Taiwan, Vietnam; introduced: West Palearctic: Europe, Transcaucasia, Turkey, Kazakhstan, North Africa; Nearctic: Canada, USA; Neotropical: Puerto Rico, Chile; Oceania: Guam; Afrotropical: ? Nigeria].  
= *Poecilometis mistus* Uhler, 1860: 223 (syn. with *H. picus* by DISTANT 1893: 394, with *H. halys* by JOSIFOV & KERZHNER 1978: 172).  
= *Dalpada brevis* Walker, 1867a: 226 (syn. with *H. picus* by DISTANT 1893: 394, with *H. halys* by JOSIFOV & KERZHNER 1978: 172).  
= *Dalpada remota* Walker, 1867a: 227 (syn. with *H. picus* by DISTANT 1880: 201 and 1893: 394, with *H. halys* by JOSIFOV & KERZHNER 1978: 172).  
*H. hasani* Rider & Rolston, 1995: 847 (new substitute name for *H. punctata* Hasan, 1993) [Malaysia: Malaya]  
= *Halyomorpha punctata* Hasan, 1993: 214 (junior primary homonym of *H. punctata* Cachan, 1952)  
*H. javanica* Hasan, 1993: 212 [Indonesia: Java]  
*H. lata* Breddin, 1899: 162, fig. 2 [Indonesia: Lesser Sunda Islands: Lombok]  
*H. leopoldi* Schouteden, 1933: 50 [Indonesia: Kalimantan]  
*H. longiceps* Breddin, 1900a: 143, pl. IX: fig. 3 [Indonesia: Maluku Islands: Ternate]  
*H. malleata* (Distant, 1890): *Atelocera malleata* Distant, 1890: LIII, LV [Democratic Republic of the Congo]  
*H. mayumbeensis* Villiers, 1967: 1791 [Republic of the Congo]  
*H. murrea* Distant, 1887: 344, pl. XII: fig. 5 [India]  
*H. ornativentris* Breddin, 1900b: 296 [Indonesia: Borneo, Sumatra]  
*H. philippina* Black, 1968: 567 [Philippines: Balabac]  
*H. picoides* Linnavuori, 1975: 87 [tropical Africa]  
*H. picticornis* Bergroth, 1915: 171 [India]  
*H. picus* (Fabricius, 1794): *Cimex Picus* Fabricius, 1794: 115 [India, Pakistan, Sri Lanka, ? SE Asia]  
= *Cimex marmoreus* Fabricius, 1798: 534 (syn. STÅL 1868b: 24)  
= *Cimex cinnamomeus* Wolff, 1802: 99 (syn. STÅL 1868b: 24)  
= *Pentatoma trivialis* Dohrn, 1860: 400 (syn. ATKINSON 1888: 23)  
? = *Dalpada proxima* Walker, 1867a: 227 (syn. DISTANT 1893: 394; the synonymy requires confirmation)  
= *Halyomorpha punjabensis* Ahmad & Kamaluddin, 1977: 72 (syn. KMENT et al. 2021: 431, 434)  
= *Halyomorpha azhari* Ahmad & Zaidi, 1989: 239, 240 (syn. KMENT et al. 2021: 431, 434)  
*H. punctata* Cachan, 1952: 402, pl. XIII: fig. 6 [Comoros Islands]  
*H. reflexa* (Signoret, 1858): *Pentatoma reflexa* Signoret, 1858 in FAIRMAIRE & SIGNORET (1858: 284) [tropical Africa]  
*H. rugosa* Schouteden, 1913: 190 [tropical Africa]  
*H. schoutedeni* Bergroth, 1913: 237 [Central African Republic]  
*H. scutellata* Distant, 1879: 51 [India]  
*H. seyidiensis* Jeannel, 1913: 67, 69, pl. II: fig. 20 [Kenya]  
*H. sinuata* Hasan, 1993: 210 [Malaysia: Sabah]  
*H. timorensis* (Westwood, 1837) **stat. restit.**: *Halys timorensis* Westwood, 1837: 22 [Lesser Sunda Islands: Timor]  
*H. viridescens* (Walker, 1867): *Atelocera viridiscens* [sic!] Walker, 1867a: 215 [tropical Africa]  
= *Pentatoma (Cappaea) praetoria* Gerstaecker, 1892: 46 (syn. JEANNEL 1913: 70)  
= *Halyomorpha erlangeri* Schouteden, 1905: 12 (syn. JEANNEL 1913: 70 (with question mark), BERGROTH 1921: 7)  
= *Halyomorpha magnifica* Bergroth, 1921: 6 (syn. LESTON 1955: 702)  
*H. viridinigra* Breddin, 1901: 11, 43 [Indonesia: Sulawesi]  
*H. yasumatsui* Abbasi & Ahmad, 1974: 72 [Bangladesh]

### Discussion

This contribution, along with the recent paper by KMENT et al. (2021) synonymizing two poorly described species from Pakistan, represents the first step towards a revision of *Halyomorpha*. Further taxonomic and nomenclatural



Figs 24–26. *Pentatoma halys* Stål, 1855, female syntype (NHRS): 24 – dorsal view, 25 – ventral view, 26 – labels. Scale bar in mm. Orig. D. Rédei.

problems have already been detected and will be treated in subsequent papers, including a test of the monophyly of *Halyomorpha* in its present sense and reconsideration of the identity of many of the included species, as well as descriptions of new ones. However, as the invasive *H. halys* became one of the most intensively studied species of true bugs in the last two decades, we would like to note at least one major problem which may negatively influence its research. It is necessary to keep in mind that *H. halys* belongs to a group of habitually similar species one could identify with certainty only by examination of their male genitalia, especially the structure of the genital capsule and paramere. Of this group, only the male genitalia of three species have been adequately described: *H. halys* (VÉTEK et al. 2014, SALINI et al. 2021a, this paper), *H. picus*

(KMENT et al. 2021, SALINI et al. 2021a, this paper), and *H. yasumatsui* (ABBASI & AHMAD 1974); the remaining ones are waiting for redescription. Recently, citizen science has become a rather popular tool for studying the distributions of various conspicuous species all around the world, and it has been applied also for *H. halys* (e.g., ÇERÇİ et al. 2021, CHARTOIS et al. 2021, VÉTEK et al. 2021). Although this approach might be feasible in the expanding areas where the non-native *H. halys* is the only species of *Halyomorpha* present, the existence of a complex of externally indistinguishable species makes it inapplicable in south and southeast Asia, ranging from Pakistan and India to southern China, the Philippines, and the Malay Archipelago to the Lesser Sunda Islands. The situation in the latter vast area is further complicated by the imperfectly known distributi-

onal range of the described species, unresolved taxonomic problems, including the presence of undescribed species, furthermore by a potential introduction of *H. halys* to further areas in the region. Future human-mediated introductions and invasions of other species of *Halyomorpha* into any area, including those already colonized by *H. halys*, also cannot be excluded unless they are prevented by a priority effect (e.g., FUKAMI 2015). Therefore all identifications of similarly looking species must be confirmed by examinations of genitalia, with involvement of an experienced taxonomist specialist if necessary. Photographs from areas like tropical Africa, Papua New Guinea, the Solomon Islands and New Caledonia inhabited by other *Halyomorpha* species must also be considered very carefully.

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