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Cover photograph: *Protozantaena gigantea* Bilton & Mlambo (right) is portrayed as a "giant among dwarfs". But the dwarfs get up to 1.5 mm and *gigantea* towers at 2! *P. birdi* Bilton (left) is here for comparison. See page 9.
Photograph: David Bilton

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THE UNDERSIDE MATTERS: ELYTRAL CHARACTERS OF SOME WATER BEETLES

Alexander A Prokin, Alexey S Sazhnev

The first author, who recently dissected hundreds of *Ilybius* in order to solve the problem of differences between *Ilybius angustior* (Gyllenhal) and *Ilybius picipes* (Kirby), paid particular attention to well developed thick hair brushes on the underside of the elytral apex. We then examined the apices of several species of *Ilybius* from different groups sensu Nilsson (2000), and our "reinvention of the wheel" grew like a snowball as we looked at more and more beetles. Having realised that the "underside universe" is too large, we halted our investigation at this stage and decided to discuss the results obtained, with the hope of future expansion. The photographs were made by the second author using a Leica MC170 HD digital camera mounted on a Leica M165C stereomicroscope in Papanin Institute for Biology of Inland Waters Russian Academy of Sciences, Borok. The pictures were processed in Helicon Focus 7.7.4 and Sketchbook.

As a result, the Agabinae species studied are characterised by a longitudinal "velvet" protrusion or fold with microtrichia along the suture (Fig. 1: *as*), was interpreted as apico-sutural binding patch (Hammond 1979: Fig. 82). This flange was initially proposed by Marcu (1936) as a plectrum operating with the toothed "pars stridens" of the hind wing for the stridulation of a *Rhantus*. Then Peter Hammond (1979) demonstrated that such wing patches are wing-binding mechanisms, serving to secure the wings under the elytra, as was accepted by Aiken (1985). These structures in Polyphaga are sometimes represented by an oval granulated area on the penultimate row of punctures at the middle of the elytron (Fig. 7).

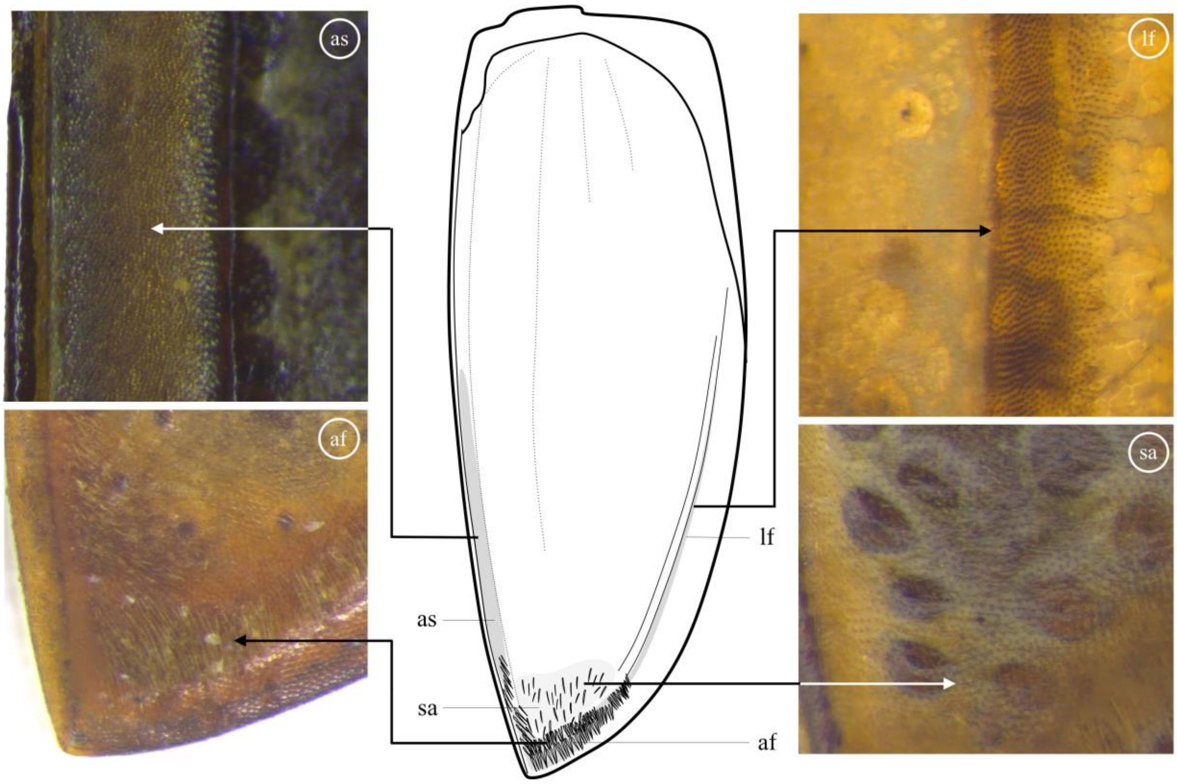


Fig. 1 General pattern of underside structures of the genus *Ilybius*: *as* – apico-sutural binding patch, *lf* – locking flange, *af* – apical flange, *sa* – setiferous area

The second protrusion with a microtrichial field (Fig. 1: *lf*), known as the "locking flange" (Crowson 1981) or "lateral furrow locking with abdominal pleura" (Hammond 1979), runs from the middle of the elytra to the level of the last ventrite base along the outer margin, inwards from the outer row of punctures. This structure is the carinate underside of elytral interval 9. Together with the epipleuron it forms a narrow groove that receives and then locks onto the lateral edges of one to a few abdominal sternites (Fedorenko 2009). The locking flange is known in Georissidae and Hydrochidae (Hansen 1991), Clamboidea (= Eucinetoidea), some Elmidae (Crowson 1981), Elateridae (Johnson 2022), Coccinellidae, Mordellidae, Curculionidae, Byrrhidae, Dryopidae, Histeridae, Hydrophilidae, Buprestidae, Agrytidae, Trachypachidae, Amphizoidae, Hygrobiidae, Carabidae and Rhysodidae (Fedorenko 2009), and has also been described as "the posterior microtrichial field of the elytra" by Gorb (1998) in three species of *Tribolium* (Tenebrionidae). This structure varies strongly in length: it can be either short and pocket-like, situated in the middle of the elytron (middle carina) or long, extended to the elytral apex (Fedorenko 2009).

The third, the apical flange, covered with thick brushes of hair, occupies the apex of the elytron (Fig. 1: *af*). In some species, the area above this flange is covered with long hairs – the setiferous area (Fig. 1: *sa*).

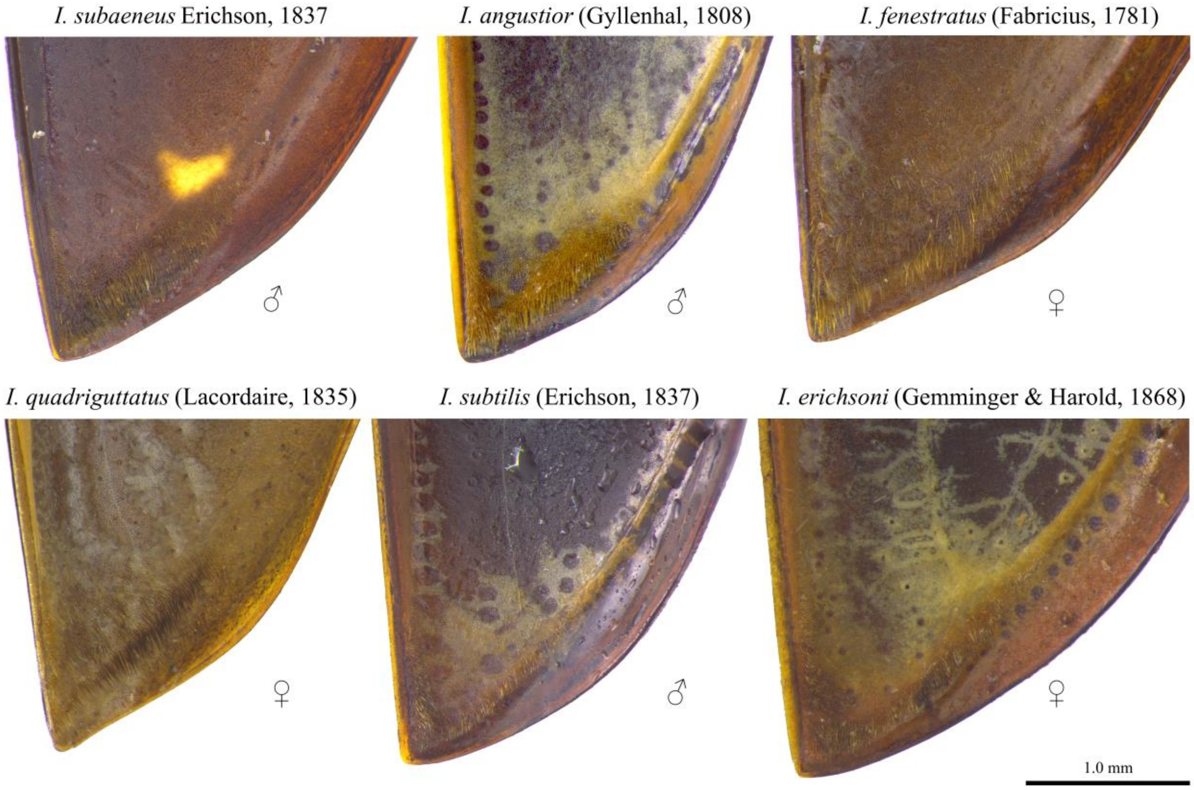
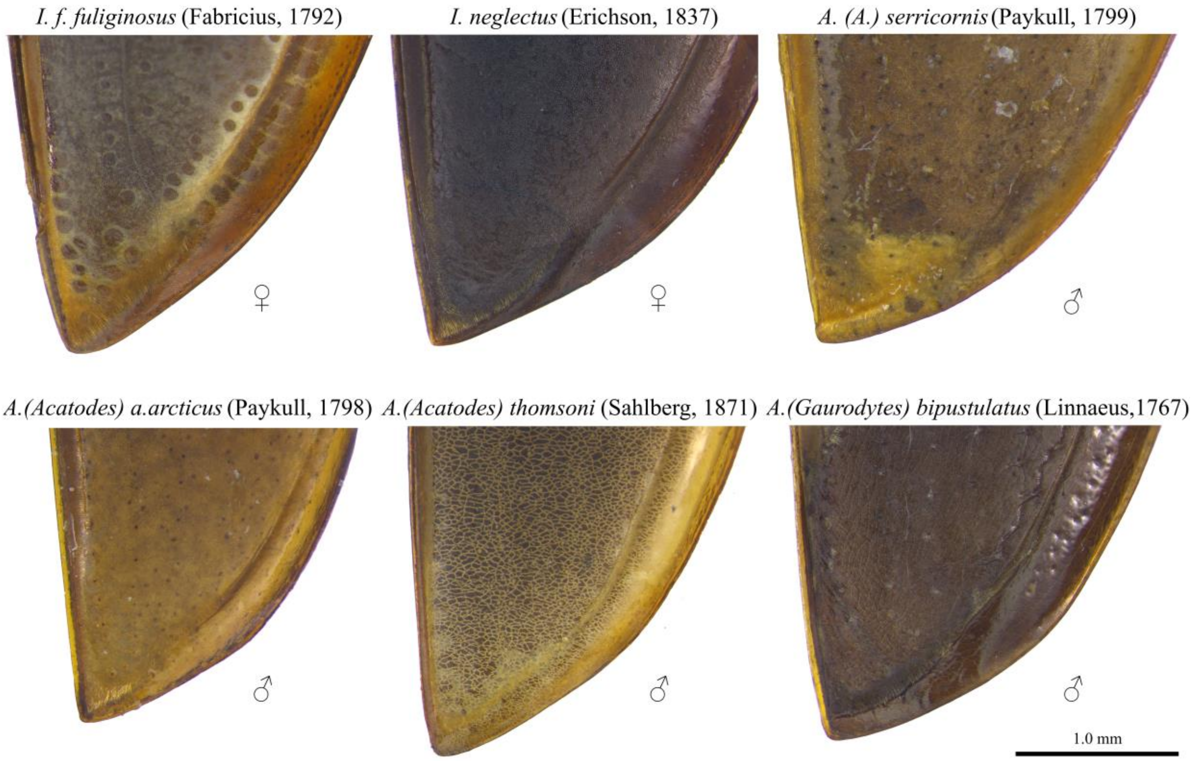

I. subaeneus Erichson, 1837
I. angustior (Gyllenhal, 1808)
I. fenestratus (Fabricius, 1781)
I. quadriguttatus (Lacordaire, 1835)
I. subtilis (Erichson, 1837)
I. erichsoni (Gemminger & Harold, 1868)

Fig. 2 Apices of the elytra of *Ilybius subaeneus*-group and *erichsoni*-group


I. f. fuliginosus (Fabricius, 1792)

I. neglectus (Erichson, 1837)

A. (A.) serricornis (Paykull, 1799)

A.(Acatodes) a.arcticus (Paykull, 1798)

A.(Acatodes) thomsoni (Sahlberg, 1871)

A.(Gaurodytes) bipustulatus (Linnaeus,1767)

Fig. 3 Apices of the elytra of some *Ilybius* and *Agabus*

A smooth area outside the locking flange in Agabinae studied is likely to be analogous to the pseudoepipleura of Polyphaga. The area outside the apical flange is usually covered with cellular microsculpture. Species of the *Ilybius erichsoni*-group and *I. neglectus* (Erichson) from the *chalconatus*-group have a narrower apical flange, with hairs shorter than those in the *subaeneus*-group (Figs 2–3). The setiferous area is well developed in *Ilybius fenestratus* (Fab.) and *I. quadriguttatus* (Lacordaire), as well as in *Platambus maculatus* (L.), with shorter hairs (Fig. 4).

It is well known that species of the *subaeneus*-group, or *Ilybius* in the old sense, are characterised by unequal metatarsal claws and endophytic oviposition with a knife-like ovipositor (Miller & Bergsten 2016), and is well supported as a separate clade by the molecular data (Ribera *et al.* 2004). The molecular data also supported the *P. maculatus* clade as sister to *Ilybius*, but to neither of the *Platambus* studied (Ribera *et al*. 2004). The discussed characters of the elytral underside also distinguish the *subaeneus*-group from its relatives and confirm the affinity of *P. maculatus* to *Ilybius*.

The studied species of *Agabus* differ from those of *Ilybius* by a much less developed apical flange with short hairs and no setiferous area (Fig. 3). The structures under discussion are in *Hydroporus palustris* (Linn.) generally similar to those in Agabinae, with microtrichiae in *lf* (Fig. 4), but in *Nectoporus sanmarkii* (Sahlberg) with poorly developed *lf* without microtrichiae (Fig. 5), possibly due to the respiration through holes in elytra, known for this species and some other running water dytiscids (Madsen 2008). Some other Hydroporinae, such as *Hyphydrus ovatus* (Linn.), *Hygrotus versicolor* (Schaller), and *H. impressopunctatus* (Schaller), all have an almost smooth *lf* protruded as a rib with a remarkable subapical lobe (Fedorenko 2009, Fig. 6), or "extension of a ligula-like shape of the carina on ventral surface of elytra" (Fery & Ribera 2018). Thus, characters of elytral underside appear to be useful in systematics of Dytiscidae, as has already been shown for some other groups of Coleoptera (Hammond 1979; Samuelson 1994, 1996).

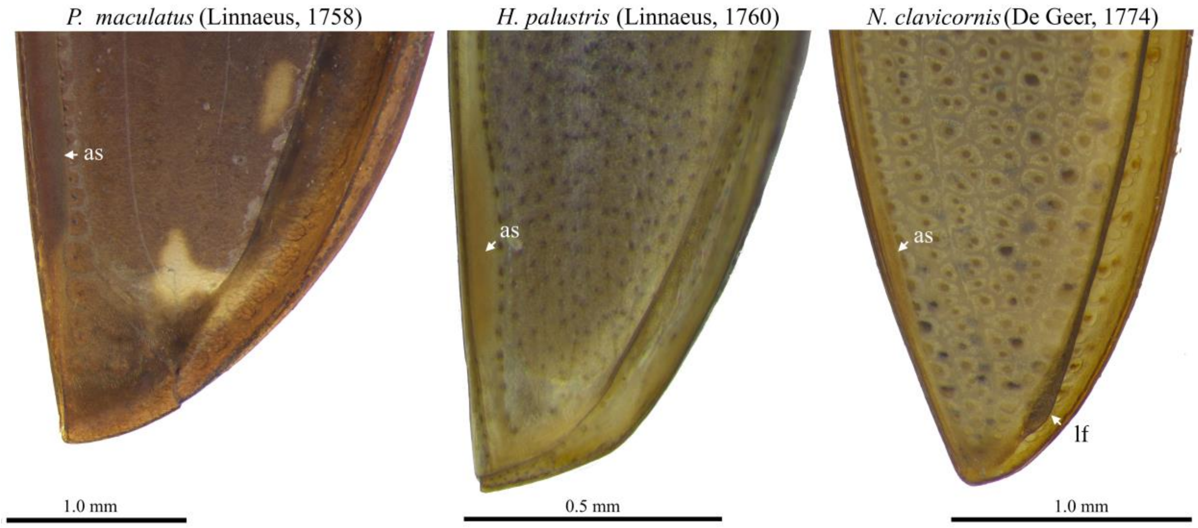


Fig. 4 Apices of the elytra of *Platambus*, *Hydroporus* and *Noterus*

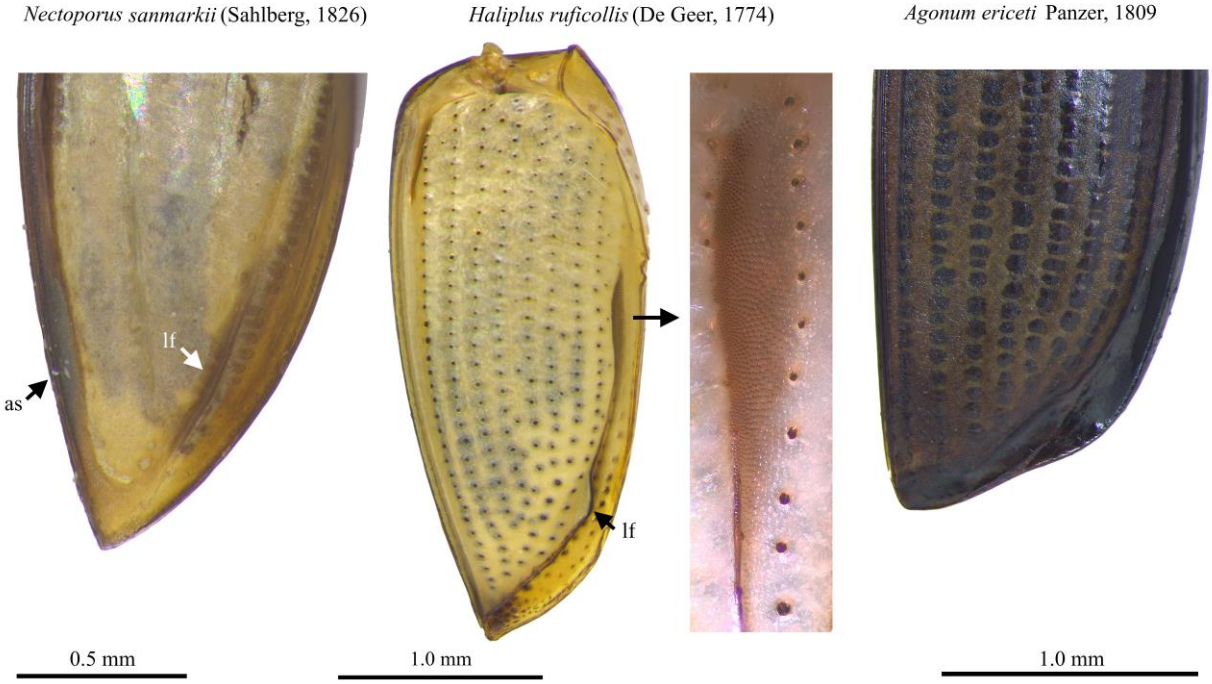


Fig. 5 Elytra of *Nectoporus, Haliplus* and *Agonum*

The example of a carabid, *Agonum ericeti* Panzer), does not have an apico-sutural binding patch (Fig. 5). In *Haliplus ruficollis* (De Geer) (Haliplidae) it is represented by a narrow fold (Fig. 5), and in *Gyrinus natator* Linn. (Gyrinidae) it is already slightly granulated (Fig. 7). According to Hammond (1979), the absence of sub-cubital binding patches of hind wings, which co-opted with *as*, in Carabidae, Haliplidae, Hygrobiidae, Gyrinidae and some Dytiscidae and Noteridae, is always secondary and in close association with smaller size.

The Gyrinidae with their highly movable telescoped abdomen appear to have almost lost the locking flange for secondary reasons (Fedorenko 2009). The base of the locking flange is expanded in *Haliplus ruficollis* and looks like a stridulatory organ (plectrum) (Fig. 5), connecting to the costal vein of the hind wing, but unmodified, without a microtrichial file. The elytral underside in *Noterus clavicornis* (De Geer) resembles that in not only *Canthydrus luctuosus* (Aubé) from the same family Noteridae, depicted by Hammond (1979), but also in *Hyphydrus* and *Hygrotus* in that the locking flange is protruding as a subapical lobe. All Hydroporinae studied, as well as *Haliplus* and *Noterus* have all three flanges. Thus, the structures studied may not only have systematic and phylogenetic significance, but also correspond to the shape of the body, in this case with the functional type 2: small to medium-sized species with spherical body and long femora, considered being adapted to manoeuvring in stagnant waters (Ribera & Nilsson 1995; Ribera *et al*. 1997).

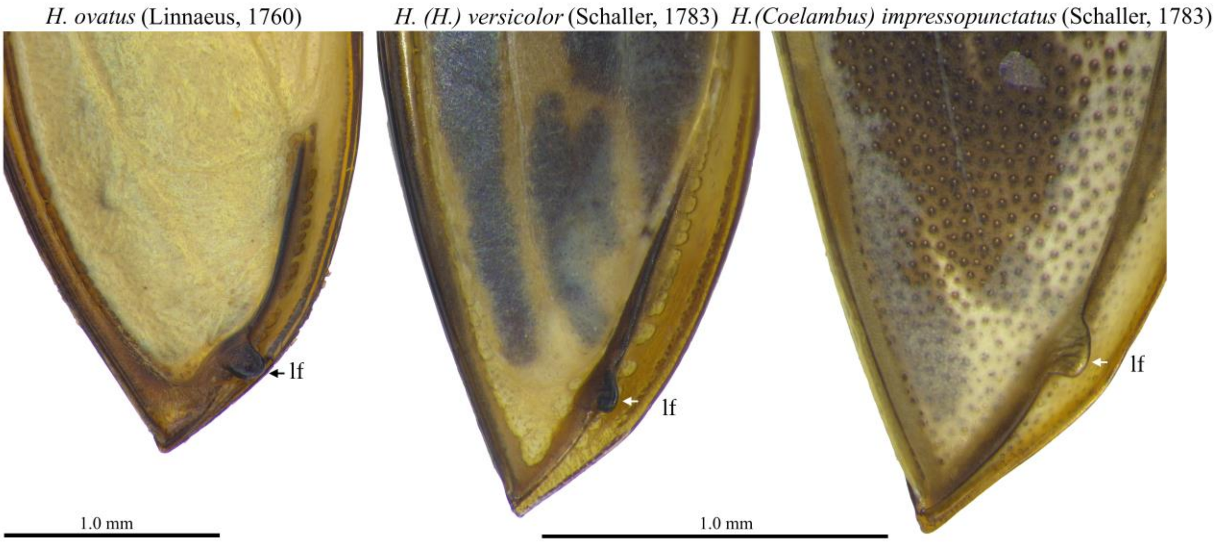


Fig. 6 Apex of the elytra of *Hyphydrus* and *Hygrotus*

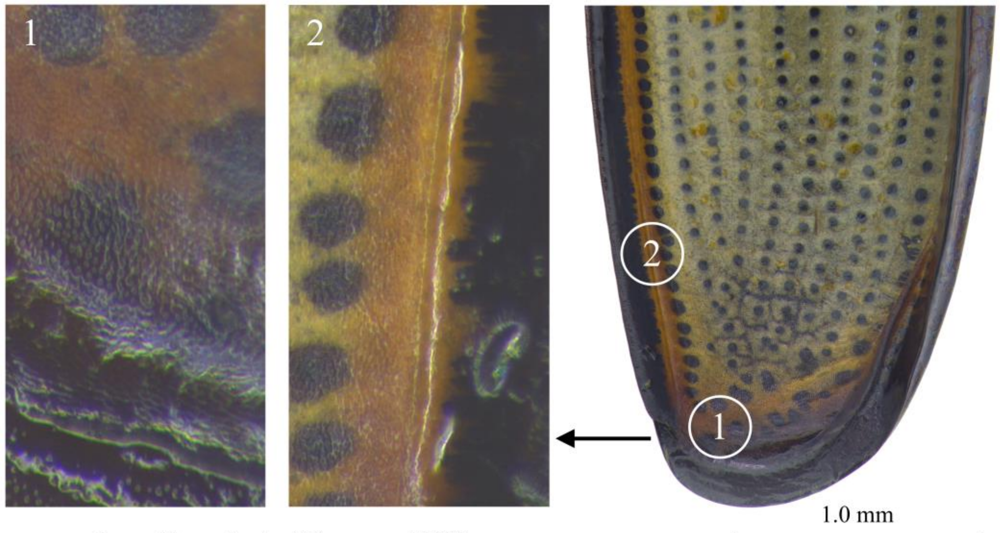
Sexual dimorphism of the flanges and pubescence pattern was not detected in our brief study. The apico-sutural binding patch is a friction patch connecting with a medial fleck on the hind wing (Hammond 1979; Lawrence & Ślipiński 2013). The lateral flange, and possibly including flanges in small-sized Adephaga, is part of the closing mechanism for the subelytral cavity. The apical flange and setiferous area are most possibly used in the air passage to the subelytral space, when the beetle exposes the abdominal apex to the water surface. It is also possible that the apical flange, recorded for Agabinae, somehow corresponds with their functional type, group 1 according to Ribera & Nilsson (1995). The thin edges of the elytra of this group increase resistance, but also increase horizontal stability, allowing them to brake and to turn by shifts in their angle of attack (Nachtigall 1974). It is unlikely that the apical flange is related with pygidial defensive glands sensu Dettner (1985).

Previously, the evolutionary scenario for the locking flange in Adephaga was hypothesised by Fedorenko (2009):- 1) the ground plan is the interval 9 not or barely thickened throughout its length and set apart from the epipleural ridge (*Trachypachus*, Amphizoidae, Hygrobiidae); 2) most other "Hydradephaga" and carabids possess interval 9 modified into a more or less sharp and high carina; 3) the carina becomes differentiated, the caudal part growing to be superior, thereby transforming into a small, rounded, subapical lobe directed outwards; as the lobe progresses, the basal- and apical-most sections of the former carina tend to degenerate.

The fossil elytra with locking flange known since the Permian (Rohdendorf 1961; Ponomarenko 1969, 2004, 2015 and many others are usually described as in the Schizocoleidae Rohdendorf on the base of term “schiza” designating a separate longitudinal “short furrow” at the lateral edge of the elytra (Rohdendorf 1961). This "schiza" is characteristic of †Phoroschizidae (=†Schizophoridae), some †Rhombocoleidae and †Triaplidae, families with controversial systematic positions. The locking flange of the fossil elytra (schiza) may be associated with the aquatic or semi-aquatic habitats of its owners, but it is not a good indicator of these types of habitats (Kirejtshuk & Prokin 2018; Goczał & Beutel 2023) because it is known for representatives of many terrestrial families (see above).

It is generally accepted that the evolutionary success of the order Coleoptera is determined by the main novelty – the formation of the elytra and the tightly sealed subelytral space, creating a separate chamber for air storage. It has been suggested (Gorb 2001) that there are three main areas where elytra are attached to the body: (1) medial margins of both left and right elytra; (2) lateral margins of elytra (*lf*) and pleural area of the pterothorax and anterior abdominal sternites; (3) anteromedial area of elytra, and corresponding structures of tergites of mesothorax and scutellum. The air-filled subelytral cavity provides buoyancy of water beetles, preventing them

Gyrinus natator Linnaeus, 1758



Laccobius minutus (Linnaeus, 1758)

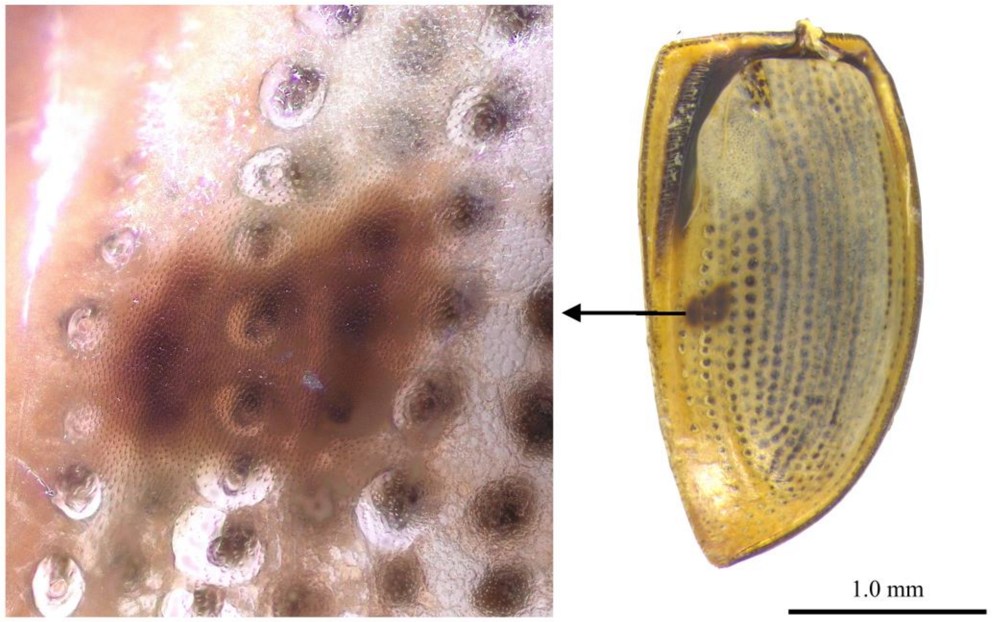


Fig. 7 Elytra of *Gyrinus* and *Laccobius*

from sinking to the bottom, and is also essential for manoeuvrability in gyrinids (Goczał & Beutel 2023). It is therefore interesting to compare evolutionary success in terms of species and other taxa richness of the main beetle groups with their elytral attachment systems and other structures of their "underside universe". It is worth investigating the structure of the elytral underside in water beetles using SEM, studying the water-repellency of the hairs, observing the way in which air enters, etc., as well as studying secondary terrestrial and species living in wet substrates, madicolous habitats rather than in the water column.

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NARTUS GRAPII INTERCEPTED IN FLIGHT TRAP

Arno van Berge Henegouwen writes on how a Malaise Trap was set up in a nature garden near to his house in Zoetermeer, and from which 469 invertebrate species were identified. The few water beetles included *Nartus grapii*, a species known to be expanding its range but with few direct flight observations. The image comes from the local newspaper in which the activity was reported.

van BERGE HENEGOUWEN A 2024. Honderden kleine beestjes geteld tijdens experiment. *Streekblad Zoetermeer*, 4 January 2024 p. 21.