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A new species of *Parorectis* Spaeth from the north-central United States, with notes on prothoracic and head morphology of the genus (Coleoptera: Chrysomelidae: Cassidinae: Cassidini)

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Abstract. A new species of tortoise beetle from the north-central United States, *Parorectis arenaria* **new species** (Coleoptera: Chrysomelidae: Cassidinae: Cassidini), is described and illustrated. Comparative remarks and a key are provided to distinguish the new species from the three other species comprising the genus. Adults and larvae of the new species feed on *Physalis* L. (Solanaceae). The circum-foraminal ridge and antennal groove of the prothorax are described in detail. The pars stridens (file) of the stridulatory apparatus on the male cranium of the new species is illustrated. The pars stridens is present only in males of *Parorectis* Spaeth species. A patch of spicules is located centrally on the dorsal surface of the cranium in both males and females of *Parorectis*. The spicule patch is believed to function as a head-to-body binding patch.

Key words. Leaf beetle, plant association, sand prairie, stridulation, taxonomy.

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Introduction

The genus *Parorectis* Spaeth, 1901 (Coleoptera: Chrysomelidae: Cassidinae: Cassidini) ranges across the southern United States from South Carolina and Florida to Arizona and south to Costa Rica. It is presently composed of three recognized species: *Parorectis rugosa* (Boheman, 1854) broadly distributed from Mexico to Costa Rica (Borowiec 1999); *P. callosa* (Boheman, 1854) from South Carolina and Florida west to Texas (Barber 1946) and adjacent Tamaulipas, México (Niño-Maldonado et al. 2014); and *P. sublaevis* (Barber, 1946) from Texas to Arizona and Sonora, México (Riley 1986). Despite the broad geographic ranges, specimens of the two later-mentioned species are uncommon in collections. All *Parorectis* species have been associated with plants of the family Solanaceae, namely the genera *Chamaesaracha* (A. Gray) Benth., *Physalis* L. and *Solanum* L., with the *Physalis* association common to all three species (Noguera 1988; Clark et al. 2004). A fourth species of *Parorectis* occurring in the north-central United States is described below. It is also associated with *Physalis*.

Materials and Methods

The methods of study and terminology used for the tarsal claws follow Riley (1986). Heads were removed from specimens to study the circum-foraminal ridge, antennal grooves, and the dorsal surface of the cranium. These structures were examined with conventional light microscopy in all four *Parorectis* species; only those of *P. arenaria* **new species** were examined with scanning electron microscopy. Light microscopy images and measurements were taken with a Keyence VHX-7000 digital imaging system. Scanning electron microscopy images were taken with a Hitachi TM4000Plus desktop system. Adobe Photoshop Elements v. 14 was used for post-capture image processing, and the map was produced with ArcGIS Desktop (version 10.4). Specimens examined are deposited in the following collections: Arthur J. Gilbert Collection (private), Clovis, California [**AJGC**]; Monte L. Bean Life Science Museum, Brigham Young University, Provo, Utah [**BYUC**]; Edward G. Riley Collection (private), College Station, Texas [**EGRC**]; North Dakota State University Insect Reference Collection, Fargo, North Dakota [**NDSU**]; Texas A&M University Insect Collection, College Station, Texas [**TAMU**]; and the United States

National Museum, Washington, DC [**USNM**]; University of Wisconsin Insect Research Collection, Madison, Wisconsin [**UWRC**]. Plant voucher specimens are deposited in the Tracy Herbarium, Texas A&M University, College Station, Texas.

Parorectis Spaeth, 1901

Orectis Spaeth 1901: 346. Type species: *Cassida rugosa* Boheman, 1854, original designation, [not Lederer (Insecta: Lepidoptera)].

Parorectis Spaeth 1901: 346 (as subgenus of *Orectis*). Type species: *Cassida callosa* Boheman, 1854, original designation.

Generic diagnosis. The following combination of characters will distinguish the genus *Parorectis* among the New World genera of the tribe Cassidini: Prothorax with circum-foraminal ridge forming inner margin of antennal groove for reception of antennomeres 2–3 (Fig. 7–10: CFR); pleuron lateral to circum-foraminal ridge with elevated lateral ridge forming outer margin of antennal groove for reception of antennomers 2–3 (Fig. 7–10: LR). Elytron with anterior margin distinctly crenulate (Fig. 6), disc tuberculate or strongly punctate. Pro-, meso- and metatarsal claw-pairs symmetrical in both sexes; each claw simple (without basal tooth), with basal angle rounded (Fig. 21: BA); pectens present (Fig. 13, 21: PE), inconspicuous (micropectens) and symmetrical (equally developed on respective internal and external surfaces of each claw, as in Fig. 21). Claw segment (tarsomere IV) with lateral flanks not projected below claws.

Systematic position. Riley (1986) classified *Parorectis* with the other North American genera that possess crenulate anterior elytral margins, all claw-pairs symmetrical in both sexes, and pectens, when present, symmetrical.

Antennal grooves and circum-foraminal ridge. *Parorectis* has been reported to possess antennal grooves (Borowiec and Świętojańska 2018 [in key]; López-Pérez and Zaragosa-Caballero 2018 [in key]; Riley 1986 [in key]; Riley et al. 2002 [in key]). This is a reference to what superficially appears to be a discontinuity or break in an anterior extension of the ridge forming the edge of the prosternal collar. The genera *Deloyala* Chevrolat and *Chiridopsis* Spaeth have similar apparent discontinuities accompanied by a groove-like channel at this position. This channel is wider and more strongly developed in these genera than in *Parorectis*. It is likely that living adults of all three genera are capable of flexing their antennae backward, seating the narrowest antennomeres (III and IV) in this channel or break. Among preserved specimens of *Parorectis*, only the occasional individual will have an antenna in this position.

In *Parorectis*, the circum-foraminal ridge is continuous and encircles the entire anterior prothoracic foramen, but almost all of it can only be viewed after removal of the head (Fig. 7–10: CFR). Scanning electron microscopy reveals that the true circum-foraminal ridge is accompanied by a fine line of setae (Fig. 9–11: CFR). The apparent discontinuity is not a break in the circum-foraminal ridge, but the result of a separate structure, a lateral ridge located laterad on the thoracic pleuron (Fig. 7–10: LR). The lateral ridges begin at the apparent break on each side of the anterior foramen, arch forward and ultimately dissipate anteriorly. They could easily be mistaken for part of the circum-foraminal ridge if the head were not removed. The origin of the lateral ridge, either an entirely novel structure or a detached and off-set anterior extension of the prosternal collar, is undetermined at this time. At the point of the apparent break, the anterior portions of the true circum-foraminal ridge extend upward on each side onto the ceiling of the foramen and arch forward to meet anteriorly. Basally, the circum-foraminal ridge is located internal to the edge of the prosternal collar (Fig. 10: CFR). At its distal and uppermost point, the ridge is augmented by a smooth crescent-shaped, platform-like structure (Fig. 7–11: PL). This structure likely serves as the plectrum (scraper) of the stridulatory mechanism and possibly engages with the cephalic binding patch (see below).

Stridulation mechanism. A vertico-pronotal type of stridulatory device is said to be widespread among taxa of the Cassidinae, including the former Hispinae (Schmitt 1991, 1994). This type of stridulatory mechanism consists of a presumed plectrum (scraper) located on the thorax and a pars stridens (file) located on the posterodorsum of the cranium. López-Pérez et al. (2018: table S1) recorded a stridulatory file in the male sex of 33 genera of Cassidini (this tribe including the Aspidimorphini and Ischyrosonychini). In *Parorectis*, the platform-like crescent-shaped structure likely functions as the plectrum (Fig. 7–11: PL). Other than the circum-foraminal ridge, which is weakly developed at this position, there are no other structures on the ceiling of the anterior foramen that could serve as a plectrum. The pars stridens consists of an elongate patch of very fine transverse ridges that

is tapered at both ends (Fig. 3, 4: PS). While the plectrum portion of the mechanism is present in both sexes in *Parorectis*, the pars stridens is only present in males; the corresponding location on the cranium is smooth in females.

The sexual dimorphism of the pars stridens, present in males and absent in females, raises the interesting question: what function does stridulation serve these beetles? It is unlikely that defense is the primary function of stridulation, although it could be a secondary function in males. More likely, the function of stridulation is somehow sexual in nature, probably involving male-to-male competition or male-to-female courtship behavior.

Cephalic binding patch. At the center of the cranial dorsal surface of *Parorectis* species is a dense patch of spicules located just anterior to the position occupied by the pars stridens. An inexperienced observer using normal light microscopy could easily mistake the reflectivity of this patch for a pars stridens. The individual spicules of the patch are short, pointed or multi-pointed, inclined forward, and their arrangement is confused (Fig. 5, 12). It is probable that head-to-thorax binding is the function of this patch; thus, the term cephalic binding patch is proposed here. This binding mechanism, however, is different from that of the better-known elytron-to-body binding patches where there are interdigitating patches on corresponding body parts (Samuelson 1996). In *Parorectis,* there are no corresponding spicules on the ceiling of the anterior prothoracic foramen. The spicules of the cephalic binding patch likely engage with the thoracic surface including the structure here called the plectrum. In *Parorectis*, both males and females possess equally developed cephalic binding patches, and both sexes have a "plectrum" suggesting that the two structures function in head-to-thorax binding. Head-to-thorax binding, where the head can be withdrawn and locked in a safe position within the prothorax, is likely part of a broad suite of defensive behaviors in adult tortoise beetles.

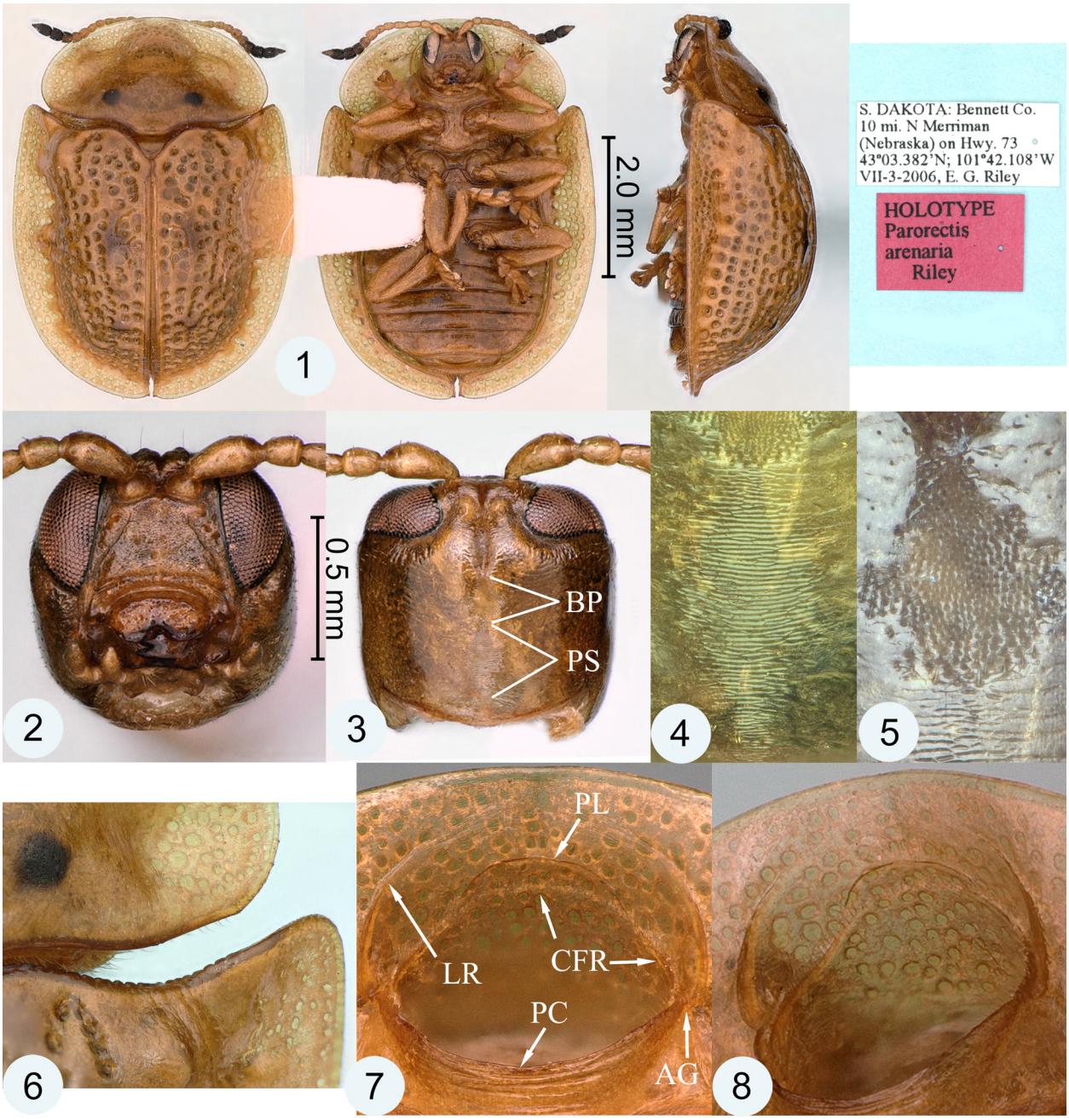
Parorectis arenaria Riley, new species

(Fig. 1–21, Map 1)

Holotype (Fig. 1). Sex undetermined, labeled "S. DAKOTA: Bennett Co. |10 mi. N Merriman | (Nebraska) on Hwy. 73 | 43°03.382′N; 101.42.108′W | VII-3-2006, E. G. Riley || [red label] HOLOTYPE | Parorectis | arenaria | Riley". Deposited in TAMU. The holotype is in excellent condition, not dissected, with all appendages intact.

Paratypes (Total 50). MINNESOTA: Clay Co., 3 mi. E, 2 mi. S Felton, 47°02.77′N 96°25.24′W, Tsct FLT B-B123 b-bl, VII-13-2000, P. B. Beauzay, sweep on mesic prairie [1 NDSU]. NEBRASKA: Cherry Co., 2.9 mi. N Merriman on Hwy. 61, VI-29-1992, E. G. Riley [1 EGRC]; same data except, reared from late-instar larvae taken on *Physalis* sp. [2 EGRC]; 17 km. E Merriman, 42.9215°N, 101.4947°W, reared from larva; adult reared from larva collected on VI-25-2018, E. G. Riley, on *Physalis hispidus* (Waterf.) Cronquist [9 EGRC]. Sheridan Co., 10 mi. E Alliance, 3600 ft., 42.0765°N, 102.6746°W, VII-14-2016, A. J. Gilbert [1 AJGC]; Trail 358, 7.5 km. E Hwy. 250, 43.3592°N, 102.3385°W, VI-23-2018, E. G. Riley, on *Physalis hispidus* (Waterf.) Cronquist [1 EGRC]. SOUTH DAKOTA: Bennett Co. same data as holotype [7 EGRC, TAMU]; 12.5 (rd.) km. S Martin on Hwy. 73, 43.0661°N, 101.7031°W, VI-27-2016, E. G. Riley, sandhills [1 EGRC]; same data, except collected as larva on *Physalis* sp. [1 EGRC]; 11 km. N Merriman (Nebraska), 43.0179°N, 101.7022°W, reared from larva; adult reared from larva collected on VI-24-2018, E. G. Riley, on *Physalis hispidus* (Waterf.) Cronquist [20 AJGC, BYUC, EGRC, TAMU, USNM]. WISCONSIN: Columbia Co., T12N R8E Sec. 32, VIII-9-1997, A. H. Williams, feeding on leaf of *Physalis heterophylla*, 4 PM, hazy, 80°F [1 UWRC]. Dane Co., Walking Iron Prairie, T8N/R6E/Sec.8NW, VI-22-1995, R. A. Henderson, DNR study 053 [1 UWRC]. Grant Co., Hwy. 133, sandy prairie, T8N R3W Sec.24, VII-8-2001, A. H. Williams, spiny pupa, with dung on "tail", atop leaf of *Asclepias viridiflora*, adult emerged July 16 [1 teneral, UWRC]. Sauk Co., Green Spring Prairie –E, T8N/R4E/Sec.6NE, V-31-1996, R. A. Henderson, DNR study 053 [1 UWRC]; Green Spring West, T9N R3E S35/NE, VII-22-1997, DNR study 053, sweep net [1 UWRC]. WYOMING: Platte Co. Glendo, VI-1-1961, R. J. Lavigne [1 USNM].

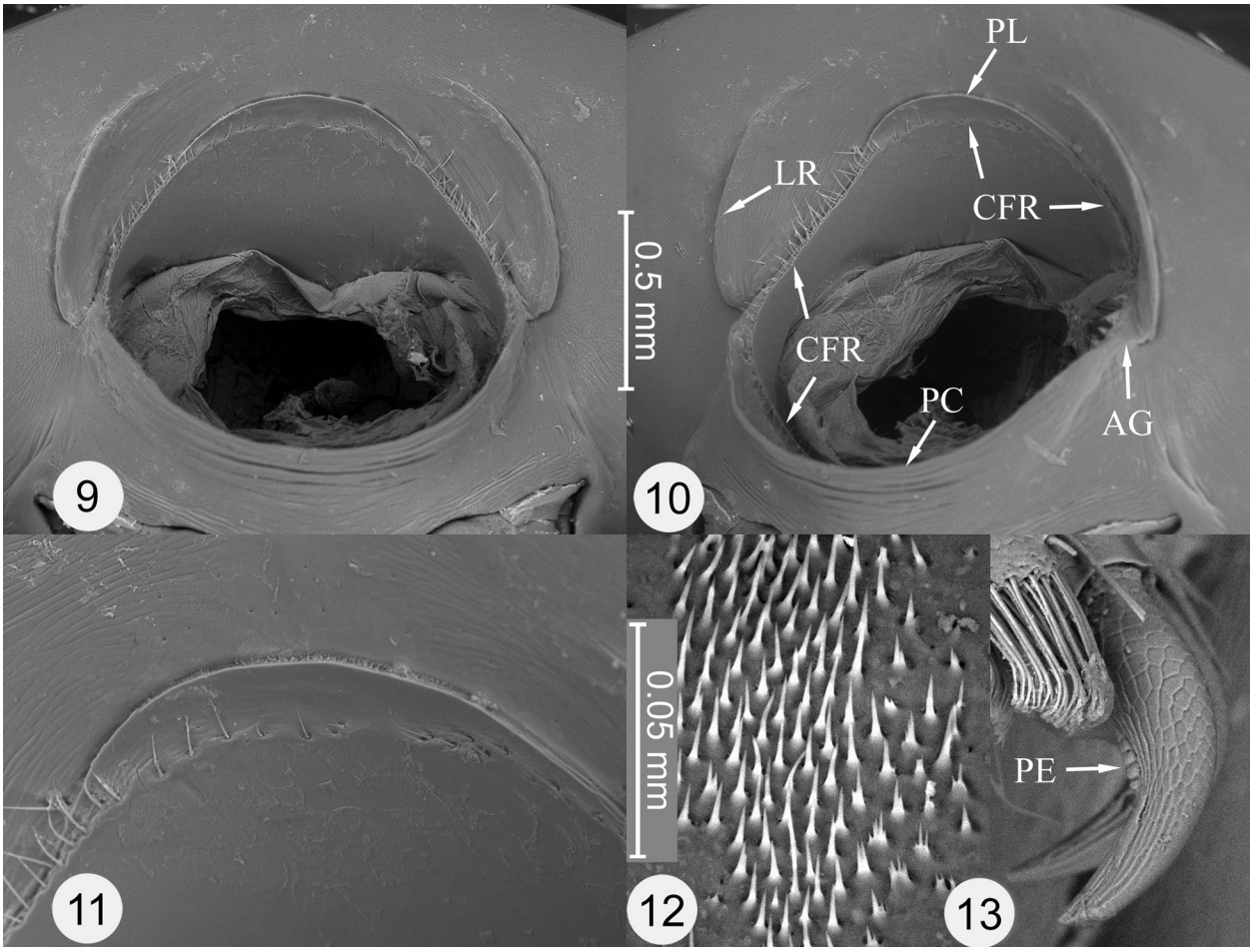
Description. General. Oblong, subparallel-sided in dorsal view, broadly arched in lateral view with dorsal crest at approximately midlength of body. Body length 4.8–6.4 mm (avg. = 5.55, n = 12), greatest width more-or-less at midlength of body 3.6–4.56 mm (avg. = 4.15, n = 11). **Color (non-teneral, non-reared specimens).** Dorsum yellowish-brown; pronotum with pair of small, round, black spots near center of disc, variable in size, rarely irregular in shape; elytral disc with faint dark smudge on largest swelling on second interval; explanate margins of pronotum and elytra with small semi-transparent cells. Venter brownish-yellow, except metasternum on each



Figures 1–8. *Parorectis arenaria* new species **1)** Holotype and holotype labels. **2)** Male head, face. **3)** Male head, dorsum of cranium: BP = cephalic binding patch, PS = pars stridens. **4)** Pars stridens. **5)** Cephalic binding patch. **6)** Base of pronotum and anterior margin of elytron. **7)** Anterior prothoracic foramen with head removed, ventral view: AG = antennal groove, CFR = circum-foraminal ridge, LR = lateral ridge, PC = prosternal collar, PL = plectrum. **8)** Anterior prothoracic foramen with head removed, ventrolateral view.

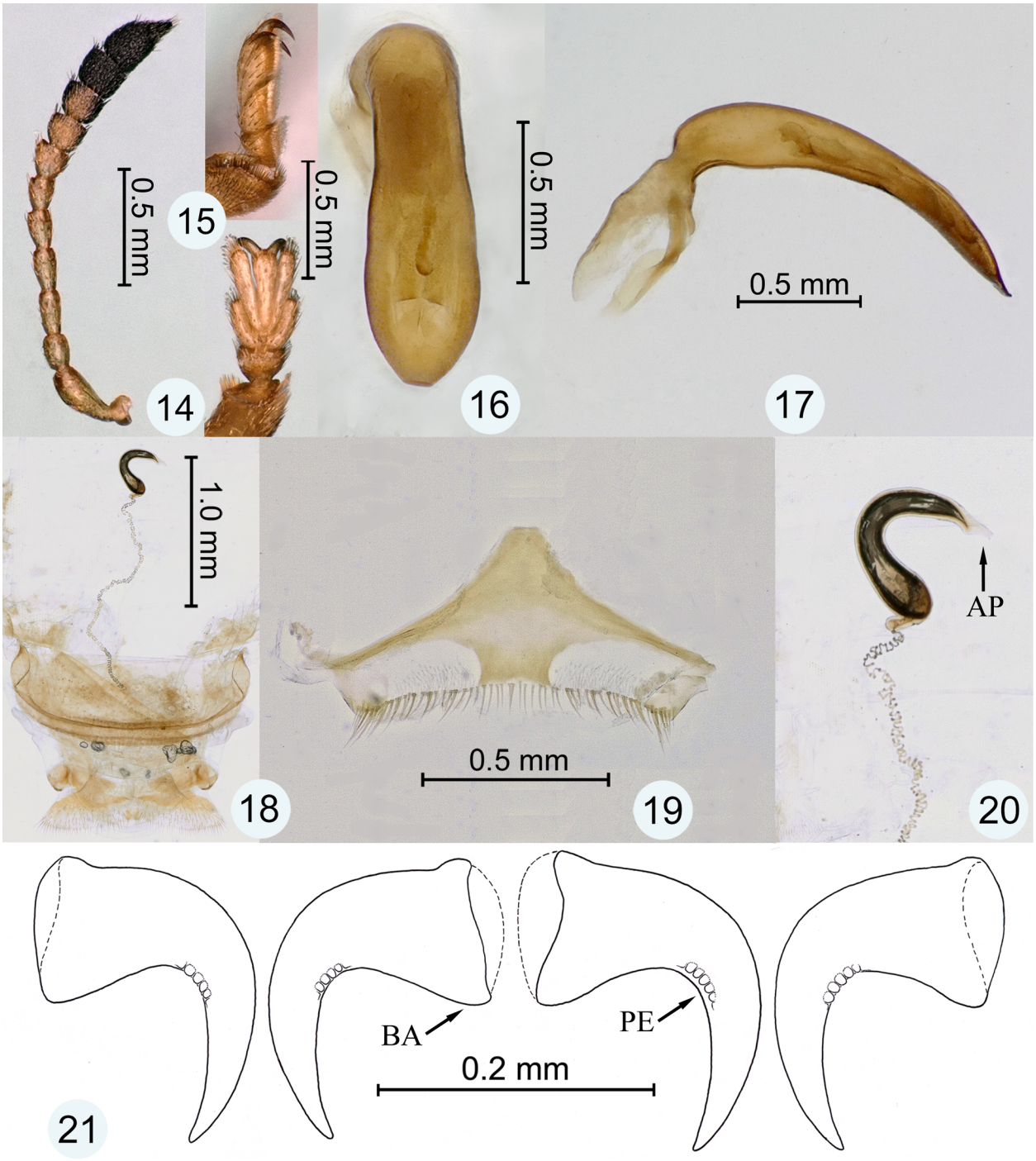
side usually with large brownish smudge faded toward margins. Terminal three or rarely terminal two antennomeres dark brown to black; legs pale.

Form. Head. Clypeus flat with faint medial impression and lateral grooves, surface shagreened, base ill-defined laterally and at basal corners (Fig. 2). Dorsum of cranium with longitudinally elongated fusiform pars stridens at base in male (Fig. 3, 4), absent in female; round binding patch present, positioned centrally in both sexes, anterior



Figures 9–13. *Parorectis arenaria* new species, scanning electron microscopy images. **9)** Anterior prothoracic foramen with head removed, ventral view. **10)** Anterior prothoracic foramen with head removed, ventrolateral view: AG = antennal groove, CFR = circum-foraminal ridge, LR = lateral ridge, PC = prosternal collar, PL = plectrum. **11)** Plectrum. **12)** Spicules of cephalic binding patch. **13)** Mesotarsal claws, lateral view: PE = pecten.

to pars stridens of male (Fig. 3, 5). Eyes moderately large, not especially bulging, length of genal space subequal to maximum width of antennal scape. Antenna moderate in length, exceeding lateral pronotal margin by terminal two antennomeres; pedicle (antennomere II) shorter than III, nearly as wide as scape; first two flagellar segments (antennomeres II–IV) slightly longer and narrower than last two flagellar segments (antennomeres V–VI); terminal antennomeres commencing with antennomere VII, formed into a weak antennal club (Fig. 14). **Pronotum.** Wider than long (avg. W/L ratio1.66, n = 12); anterior margin and lateral margins broadly and evenly rounded; posterior margin shallowly emarginate on each side before short, median truncate lobe. Surface impunctate, shining to finely shagreened; disc transverse, with broad anterolateral lobe on each side; margin with evenly distributed, closely spaced, semi-transparent cells; extreme margin with no apparent marginal bead. **Elytra.** Subparallel, broadly, evenly rounded distally. Each elytron with basal margin finely crenulate from near scutellum to beyond humeral umbo (Fig. 6), humeral umbo prominent; disc punctate striate, with 10 more-or-less well developed striae, slightly irregular over central portion of disc; punctures of striae large and deep, separated on average by spaces roughly equal to their diameters; punctures of outermost stria larger and transverse; sutural interval and interval II slightly elevated, other intervals slightly expanded and elevated at various points, especially near dorsal crest where a weakly raised transverse elevation partially disrupts regularity of striae I and II. Explanate margin broad, moderately deflexed anteriorly, horizontal and extended shelf-like at apex, with semi-transparent cells as in pronotal margin; surface impunctate, uneven, shiny; anterolateral corner right-angled, blunt; extreme



Figures 14–21. *Parorectis arenaria* new species, body parts. **14)** Male antennae. **15)** Male protarsus, lateral and dorsal. **16)** Male genitalia, en-face view. **17)** Male genitalia, lateral view. **18)** Female genitalia tract and pygidium. **19)** Female sternite VIII. **20)** Spermatheca and adjacent duct: AP = appendix. **21)** Male mesotarsal claws, exterior and interior surfaces of posterior claw on left, interior and exterior surfaces of anterior claw on right: BA = basal angle, PE = pecten.

marginal bead well-developed, strong to apex; internal ridge of epipleuron meets suture before elytral apex. **Venter.** Prosternum with apex moderately expanded post-coxae, apex bluntly rounded; surface weakly impressed, irregular; metasternum and abdominal ventrites smooth, shining. **Legs.** Tarsomere IV mostly embedded in lobes of tarsomere III (Fig. 15). Claws divergent, each claw simple, ventral basal angle of claw rounded (Fig. 21: BA). Pectens of meso- and metatarsal claws symmetrical *sensu* Riley (1986) (Fig. 13, 21: PE). **Genitalia.** Male genitalia in en-face view spatulate with subtruncate tip (Fig. 16), shaft of median lobe evenly weakly bowed in lateral view (Fig. 17); endophallus not studied. Female sternite VIII (internal) with sclerotized portion cross-shaped, lateral arms narrow; each side with broad membranous fenestra; distal margin transverse, with distinct fringe of long setae; basal stem short and broad (Fig. 19). Female genitalic tract with spermathecal duct frail, tightly coiled, long, composed of ca. 133–149 coils, avg. = 140 (n = 3) (Fig. 18); spermatheca simple, c-shaped, with terminal appendix (Fig. 20: AP).

Comparative remarks. The new species is separated from *P. callosa* and *P. rugosa* by obvious differences in body coloration and shape. These two species are much more strongly arched in profile and the elytral discs sport a mix of distinctly elevated large and small tubercles. Also, the elytral discs of these two species are dark, with that color extended anteriorly and posteriorly onto the semi-transparent explanate margins and reaching the extreme elytral edges. The new species is most similar to *P. sublaevis* which is uniformly yellowish-brown above but lacks the pair of black spots on the pronotal disc, dark smudges on the elytral disc and dark smudges on the sides of the metasternum. The elytral punctation of *P. sublaevis* is more crowded than in the new species, and it is also smaller in body size, ranging in length from 4.72 to 5.6 mm (avg. 5.13 mm, n = 16).

Some of the reared specimens possess a greater amount of darkening of the raised elytral areas, this often extended over most of the disc. This more extensive darkening is thought to be in some way related to the rearing environment, as this color variation is not seen in any of the wild-caught adult specimens.

Etymology. This species is named for its association with sandy habitats, its name derived from *arena,* Latin for sand. Gender feminine.

Range. North-central United States (Map 1). One additional specimen (non-paratype) is known through examination of a website photo. This specimen is misidentified as *Deloyala guttata* (Olivier) in the photo gallery of insect specimens collected from Cedar Creek Ecosystem Science Reserve near East Bethel, Minnesota (Haarstad 2002). This locality is plotted on Map 1 along with localities from the specimens examined.

Biological remarks. Andrew H. Williams (*in litt*. to EGR) describes the known Wisconsin localities as "sand prairies." The Cedar Creek Minnesota locality includes sand prairie, savanna and other habitat types (Haarstad 2002). The Nebraska and South Dakota localities are part of the Sandhill Region of these states, the largest sand dune system in North America consisting mostly of dunes stabilized by the sandhills mixed-grass prairie type (Bleed and Flowerday 1990; Joern and Keeler 1995). All specimens collected by the writer were taken in this region at localities of deep sand and were associated with *Physalis* (Solanaceae), either by rearing larvae to adults or by collecting adults from this plant. Associated *Physalis* specimens were later identified as *P. hispidus* (Waterf.) Cronquist. One of the Wisconsin specimens was observed feeding on a leaf of *Physalis heterophylla* (A. H. Williams label data). The examined Minnesota specimen is labeled as having been taken by sweeping mesic prairie. Living adults are non-metallic. Larvae are unremarkable in general appearance, being pale greenish in life, with semi-transparent lateral scoli.

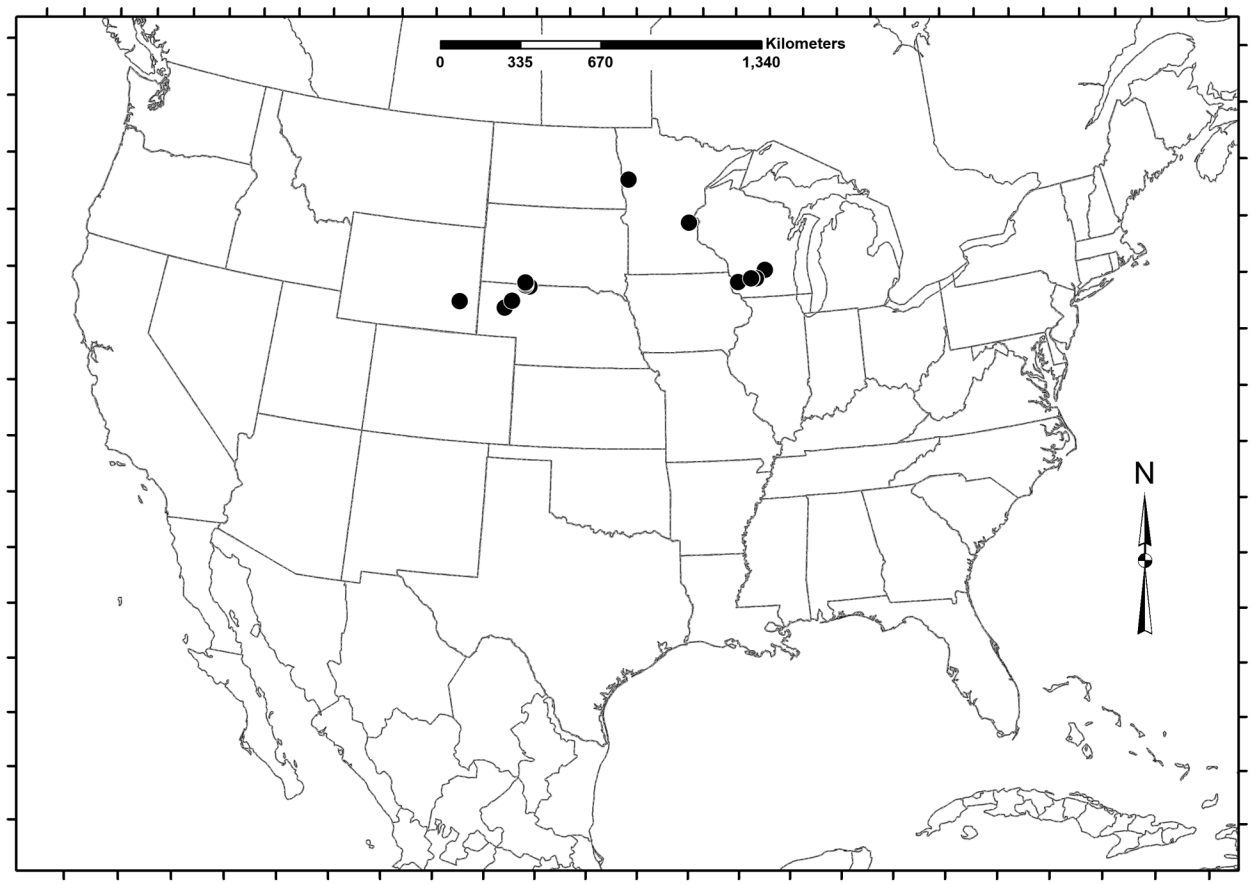
Key to the species of *Parorectis* Spaeth

1. Elytral disc tuberculate, with dark coloration extended onto anterior and posterolateral portions of explanate margin **2**

— Elytral disc rugosely punctate without distinct tubercles; explanate elytral margin entirely pale **3**

2. Dark dorsal coloration piceous, coverage on explanate margin extensive, leaving small pale spot at mid-length and before suture; body larger, length 4.56–6.4 mm (avg. = 5.69 mm, n = 16) . . . . . ***P. rugosa* (Boheman)**

— Dark dorsal coloration brownish, coverage on explanate margin minimal, leaving large pale spot at mid-length and before suture; body smaller, length 4.0–5.36 mm (avg. = 4.81 mm, n = 19) . . . . . ***P. callosa* (Boheman)**



Map 1. Known distribution of *Parorectis arenaria*, new species, based on specimens examined and Haarstad (2002) (see text).

3. Disc of pronotum with pair of dark maculae, elytral disc and metasternum often with dark smudges; body slightly larger, length 4.8–6.4 mm (avg. = 5.55 mm, n = 12) ..... ***P. arenaria* Riley, n. sp.**

— Disc of pronotum immaculate, elytral disc and metasternum entirely pale; body slightly smaller, length 4.7–5.6 mm (avg. 5.13 mm, n = 16) ..... ***P. sublaevis* Barber**

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