



Gorareduvius gajarrangarnang, a new species of resin-using assassin bug (Hemiptera: Reduviidae: Harpactorinae) from Australia, with notes on its behaviour

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Abstract

A new species of assassin bug, *Gorareduvius gajarrangarnang* sp. nov. is described from the Kimberley region, Western Australia, using digital images, scanning electron micrographs and X-ray microtomography. Natural history and prey capture by this species is described, revealing the use of sticky *Triodia* resin in prey capture. This is only the second documented instance of resin use by an Australian reduviid.

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Introduction

Assassin bugs (Reduviidae) comprise over 6600 species, making them one of the largest families of True Bugs (Hemiptera: Heteroptera) (Weirauch 2008). Harpactorinae is the largest subfamily of Reduviidae, with around 320 genera and 2330 described species worldwide, found mostly in tropical and subtropical regions (Swanson 2020). A review of the Australian Harpactorinae (Malipatil 1991) recognised 59 species in 30 genera. Since then, several additional species have been identified, and at the time of writing the Australian Harpactorinae fauna is represented by 76 known species in 33 genera (Australian Faunal Directory,

accessed 19 March 2024). New species continue to be discovered, both through collecting and in existing museum collections.

Of particular interest within Harpactorinae are species associated with resinous plants, i.e. plants that possess sticky glandular trichomes (Ávila-Nuñez et al. 2016; Zhang et al. 2016). Some species feed on prey items that are trapped on the surface of these plants (Zhang et al. 2016), while others gather and apply the adhesive compounds onto themselves (Forero et al. 2011; Zhang et al. 2016). Resin is used in predation, i.e. 'sticky trap predation' (Zhang & Weirauch 2014; Soley & Herberstein 2023) or for coating the egg masses (Forero et al. 2011; Forero & Weirauch 2017). In addition to this evolved

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dependence on resinous plants (Zhang & Weirauch 2014; Zhang et al. 2016), some harpactorines fabricate adhesive compounds themselves (Zhang & Weirauch 2013). Hence, 'resin bugs' can be categorized into three groups according to the way by which they acquire or use adhesive substances: exogenous collectors (species that collect resins from plants), exogenous scavengers (species that feed on prey stuck in sticky plant exudates), and endogenous resin users (species that produce sticky secretions themselves) (Zhang & Weirauch 2014; Zhang et al. 2016).

The association of assassin bugs with sticky plants is thought to have evolved several times, with independent origins in New World and Old World lineages (Zhang et al. 2016). However, this interpretation is contingent on information gleaned from species descriptions and limited documentation of natural history, as cautioned by Zhang et al. (2016). Until recently, *Undiareduvius aquilonius* Malipatil was the only Australian assassin bug species where resin use has been documented, with individuals reported to collect resin from the leaves of *Triodia* grasses (Malipatil 1991a). A second genus and species, *Gorareduvius westraliensis* Malipatil, was described in the same publication based on material from Bedford Downs Homestead, Perry Creek, and Beverly Springs Homestead, all located in the Kimberley region of Western Australia. Even though resin use of the latter was not reported by Malipatil (1991a), from our studies of the new species of *Gorareduvius* described herein as well as observations of *G. westraliensis*, it is apparent that both members of this genus also collect resins from plants, and that this resin facilitates prey capture (Soley & Herberstein 2023). Neither of these genera were included in a phylogenetic study tracing the evolution of sticky trap predation in assassin bugs (Zhang et al. 2016), and as a consequence this study did not account for resin use in the Australian fauna. In the present manuscript, we describe *Gorareduvius gajarrangarnang* sp. nov. from the Kimberley region, and provide notes on its natural history, including discussion of exogenous resin use in this genus.

Methods

Specimens

Most specimens were collected by FGS and ISC in May 2018 from Saddleback Ridge and its immediate surroundings, at El Questro Station in the East Kimberley region of Western Australia, with a pair of specimens collected in the Cockburn Ranges, 18 km to the north-east. This land is now recognized as part of the Wandjina-Wungur Native Title claim. Additional specimens, also from the Kimberley region, were subsequently identified in the Western Australian Museum (WAM) insect collection, and in 2022 a single specimen was collected during a Bush Blitz Biodiversity survey (Preece et al. 2015) in the Wilinggin Indigenous Protected Area. These were compared with specimens of *G. westraliensis*

collected by FGS in 2011, as well as with older specimens in the WAM collection. All specimens examined are deposited in the WAM entomology collection, with each specimen assigned a unique specimen identifier (USI). Each USI comprises the prefix WAME (denoting WAM Entomology) followed by a unique number. These data are publicly available through the Atlas of Living Australia (www.ala.org.au).

As part of a behavioural study of these insects (see Soley & Herberstein 2023), detailed behavioural and environmental observations were recorded at El Questro Station, 50 km west of Kununurra and south of Wyndham (see Braby 2012 for a detailed locality description). This area is under a semi-arid, tropical monsoonal climate, where most rainfall occurs between November and March during the wet season (Braby 2012). The dry season extends from April to October, and it was during this time that specimens were collected and observations were made, specifically between May and August 2018. Behavioural observations were recorded in the field and at the nearby campsite from collected individuals housed in plastic cups. Environmental conditions where bugs were found were also recorded. Light incidence was measured by holding a QM1587 Light Meter (Digitech, China) horizontally at the specific sites of the 'spinifex' hummocks (*Triodia* spp.) where individual bugs were found and recording the maximum value over a period of 30 s. Ambient temperature and relative humidity were measured at each site with a handheld XC-0424 Temperature and Humidity Data Logger (Digitech, China). For further information on the behaviour of these insects see Soley & Herberstein (2023).

Imaging, dissections and measurements

Habitus photographs of the holotype male, as well as a specimen of *G. westraliensis* for comparison, were taken using a Passport II imaging system, which utilises a Canon 7D Mark II SLR camera mounted on an automated rail system to take a series of images at different focal points. These photographs were concatenated into a final image using Helicon focus 7.6.1 software (www.Heliconsoft.com). Scale bars were placed using Adobe Photoshop (www.adobe.com). Additional images of specimens in the field are also presented.

Measurements of specimens (Table 1) were taken using a Dino-Lite Edge AF4915 digital microscope and associated DinoCapture 2.0 software (www.dinolite.us).

Specimens were examined and dissected using a Leica MZ205C dissecting microscope. Antennal segments are referred to as A1 through A4, visible labial segments as L1 to L3, and abdominal tergites as T1 to T8.

Male genitalia were dissected by first removing the pygophore from ethanol-stored specimens, and placing this in a 10% KOH solution. After approximately 15 minutes, the pygophore was then repeatedly squeezed gently to force out macerated tissue. By gently squeezing

the pygophore, poking a probe into the anterior opening, and pulling with forceps, the aedeagus was eventually exerted out of the pygophore. The dissection was then rinsed in distilled water before being placed back into ethanol. Two dissections of both *G. westraliensis* and *G. gajarrangarnang* sp. nov. were completed: one with the endosoma at rest and a second partially inflated. We initially attempted to inflate the genitalia via osmotic pressure (Singh-Pruthi 1925; Kelton 1959), but as others have found (e.g. Ahmad 1986; Forero & Weirauch 2012) this was met with little success. Ultimately, partial inflation of endosomal lobes was achieved through a combination of gently squeezing and releasing the aedeagus and carefully pulling the various lobes using fine forceps, similar to procedures outlined by Forero & Weirauch (2012). Interpretation of genital structures was informed by Forero and Weirauch (2012), and Berniker et al. (2011).

Scanning electron micrographs (SEM) were taken using a Hitachi TM 3030 desktop SEM of uncoated specimens under low vacuum (<https://www.hitachi-hightech.com/>), with cropping and contrast adjustments completed in Adobe Photoshop CC (www.adobe.com).

X-Ray microtomography (microCT) was undertaken in the University of Western Australia's Centre for Microscopy and Microanalysis (CMCA). One female (whole body and undissected genitalia) and the dissected genitalia of two males of *G. gajarrangarnang* sp. nov., plus the genitalia of two males of *G. westraliensis* were imaged using a Zeiss Versa 520 XRM X-ray imaging system. Prior to scanning, specimens were stained for a minimum of 24 hours in I2E (1% iodine by weight dissolved in 100% ethanol) to improve contrast (Metscher 2009). Before scanning, they were rinsed in 100% ethanol, then sealed in 2.5 mL pipette tips filled with 100% ethanol. All scans were taken with the X-ray source set at 60 kV and 5 W, with 2001 images taken through 360° of rotation using the 4X scintillator-objective lens. Exposure times and voxel resolution varied across scans, and are listed in Table 2. Micro-CT datasets were automatically reconstructed in XMRConstructor (v11.1.5707.17179) using default settings. Visualisation and imaging were conducted using Drishti 2.6.5 (Windows) and Drishti 2.6.4 (OSX) (Limaye 2012).

Results

At El Questro Station, *Gorareduvius gajarrangarnang* sp. nov. was commonly found on spinifex grasses (*Triodia* spp., not to be confused with the genus *Spinifex*), usually resting on dried inflorescences, or on the leaves or stems of these plants (Figure 1B-C). There were at least three species of *Triodia* at the sites explored around Saddleback Ridge (*T. bitextura* Lazarides, *T. racemigera* C.A.Gardiner, and *T. wiseana* C.A.Gardiner). It is difficult to distinguish among these plants during the dry season when they lack inflorescences, but the species *T. bitextura* was the most abundant at our site. The main habitat

at this site is savannah woodland, with a *Triodia*-dominated groundcover and small patches of exposed sandstone (fig. 1A). Above the grass cover lay scattered shrubs (e.g. *Acacia*, *Calytrix*), and trees (e.g. *Eucalyptus miniata*, *E. confertiflora*, *Erythrophleum* sp., *Lysiphyllum* sp., *Melaleuca* sp., *Grevillea* sp., *Cochlospermum* sp.). *Gorareduvius gajarrangarnang* sp. nov. was found in areas where the groundcover was dominated by *T. bitextura* hummocks instead of other grasses (e.g., speargrass). This habitat had not been burnt recently (i.e., within the five years prior). Similar habitat lying adjacent to Saddleback Ridge, but on the other side of the Pentecost River, had, on the contrary, been burnt two years before we visited; we did not find any specimens there, despite comparable search efforts. As noted above, in 2010 FGS collected *G. westraliensis* on the west side of the Pentecost River.

The assassin bugs that we observed and collected were those that were visible on the outer *Triodia* grass blades, while bugs inside the hummocks most likely escaped detection. Occasionally, *G. gajarrangarnang* sp. nov. were also found on nearby shrubs, speargrass, or tree saplings amidst the spinifex hummocks. Environmental variables at the sites where assassins bugs were found are summarised as follows (n=57): mean brightness: 58155 lux (range: 3210-140400 lux); mean ambient temperature 36.1°C (range: 28.9 - 40.2°C); and 42.6% mean relative humidity (range: 37-53%).

Individuals (n = 80) were almost always found covered in the sticky *Triodia* exudate, which they were observed to actively collect in the field (n = 9). The only instances in which individuals were not observed covered with resin (n = 8) was when they had just moulted, with the resin coating left behind with the shed exuvia, necessitating individuals to re-apply resin after each moult. It was also observed that eggs laid by captive insects were also covered in resin, suggesting *G. gajarrangarnang* sp. nov. females use resin they have previously gathered to coat their eggs, as has been observed in other resin-bugs (Weirauch 2006; Choe et al. 2007; Avila-Nuñez et al. 2016; Takeda et al. 2020). To collect resin, *G. gajarrangarnang* sp. nov. scrape the leaves of *Triodia* plants, apparently using the spatulate setae on the apices of the foretibiae (Figure 5C-D). We also observed individuals transferring resin between legs while standing on these plants (n = 11). Resin from *Triodia* leaves was also readily collected by assassin bugs kept in a tent at a nearby campsite, and these assassin bugs also transferred resin between legs, alternating between bouts of resin collection and resin transfer (first-instar, n = 8; second-instar, n = 6; third-instar n = 9; fourth-instar, n = 20; fifth instar, n = 18; male adults, n = 15; female adults, n = 16). First-instar individuals were also observed collecting resin from their eggshells (n = 5) or, when they hatched in the presence of a female (n = 3), they also collected resin by scraping the body of the female (a situation that is unlikely to happen under natural con-

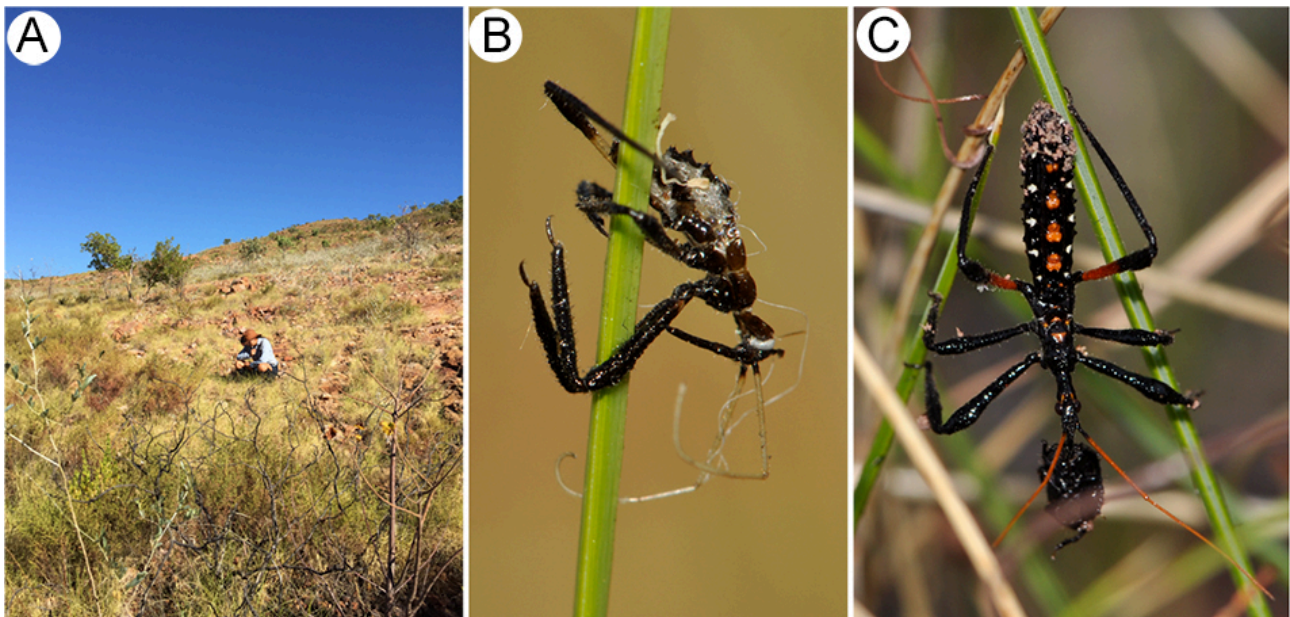


Figure 1. Field observations of *Gorareduvius gajarrangarnang* sp. nov. in the East Kimberley region. A) Shows the characteristic spinifex hummocks (*Triodia* spp.) where *G. gajarrangarnang* sp. nov. is usually found. B) Shed exuvia of *G. gajarrangarnang* sp. nov. clinging on to a grass blade (resin deposits still visible, especially in forelegs). C) Adult female feeding on a scarab beetle; note debris adhering to the sticky body, particularly on the terminal segments of the abdomen. The shiny aspect in B and C is due to the resin coating.

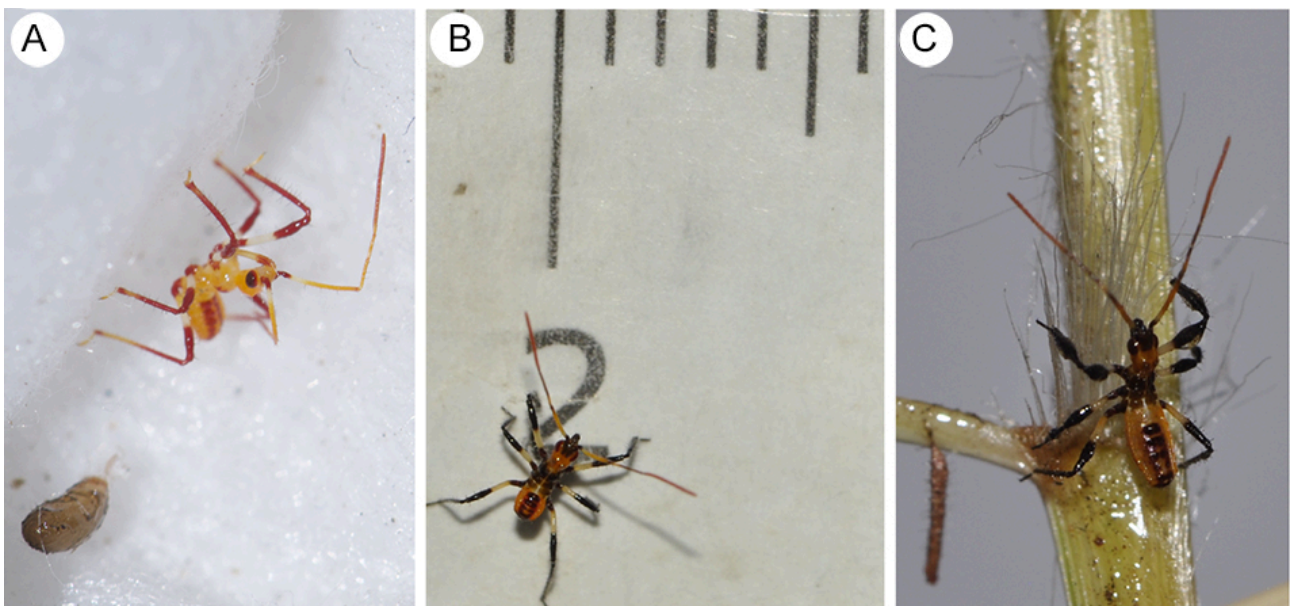


Figure 2. First-instar nymphs of *Gorareduvius gajarrangarnang* sp. nov. A) Recently emerged nymph with resin-covered egg in bottom left of the image; note that the nymph is devoid of resin. The light colours of the nymph will darken within some hours as the exoskeleton hardens. B) Dorsal image of a nymph walking on a paper ruler; each line denotes a millimetre. C) First-instar nymph collecting resin from a leaf of *Triodia bitextura* that was offered at the campsite. Note resin deposits on the femora of forelegs.

ditions). Later instar individuals (fourth and fifth) were also observed collecting resin from their recently shed exuvia ($n = 4$). Virtually all individuals observed in the field or kept in the tent eventually covered themselves in resin. Resin was also found on *G. westraliensis* specimens previously collected by FGS in 2008 and 2010, by NJT in 2014, and on pre-existing WA Museum specimens

($N=17$), indicating this species uses resin as well.) The resin lends a shiny aspect to the bugs (fig. 1C), and dabs of resin were clearly distinguishable on their legs, particularly the forelegs. If picked up by hand, one could smell the spinifex scent on the bugs themselves. It was also common to find shed exoskeletons attached to the veg-

WAM Registration Number	Sex	Total body length (from clypeus)	Head - anterior lobe	Head - posterior lobe	Head - total length	Eye - length	Interocular distance	Labium - L2	Labium - L3	Labium - L4	Antenna - A1	Antenna - A2	Antenna - A3	Antenna - A4
E106351	m	16.525	1.658	1.504	3.163	0.692	0.645	1.146	2.001	0.363	6.042	2.778	2.624	3.172
E106353	m	17.082	1.767	1.532	3.299	0.721	0.758	1.215	2.001	0.433	5.741	2.893	3.000	3.316
E76643	m	16.888	1.628	1.514	3.141	0.712	0.658	1.215	1.973	0.429	5.429	2.844	2.579	3.271
E76441	m	17.583	1.742	1.568	3.310	0.754	0.690	1.267	2.214	0.461	5.999	2.702	2.845	-
E106361	m	17.200	1.873	1.611	3.484	0.781	0.664	1.179	2.230	0.443	6.005	2.924	2.645	3.239
E106360	f	16.591	1.621	1.504	3.125	0.653	0.663	1.319	1.944	0.438	5.290	2.391	2.308	2.807
E106359	f	17.045	1.736	1.543	3.279	0.644	0.630	1.146	1.957	0.451	5.027	2.416	2.385	2.799
E106358	f	18.071	1.819	1.546	3.365	0.665	0.729	1.216	2.172	0.434	5.779	2.731	2.349	2.751
E106357	f	17.796	1.873	1.513	3.386	0.789	0.75	1.221	2.046	0.364	5.589	2.737	2.260	2.762
Male Avg		17.188	1.753	1.556	3.299	0.742	0.693	1.219	2.105	0.442	5.794	2.8408	2.767	3.275
Female avg		17.376	1.762	1.527	3.289	0.688	0.693	1.2255	2.0298	0.422	5.421	2.5688	2.326	2.780

Table 1. Measurements of *Gorareduvius gajarrangarnang* sp. nov. All measurements in mm.

Species	Sex	WAM Registration Number	Voltage (kV)	Wattage (W)	Magnification	Filter	Exposure time (sec)	# Frames	Resolution (µm)	Stain	Scan Date	Description
<i>G. gajarrangarnang</i> sp. nov.	male	E106362	60	5	4	LE1	2	2001	3.2642	I2E	1/1/2020	uninflated genitalia and pygophore
<i>G. gajarrangarnang</i> sp. nov.	male	E106361	60	5	4	LE1	0.75	2001	3.8700	I2E	19/5/2020	inflated genitalia and pygophore
<i>G. gajarrangarnang</i> sp. nov.	female	E106358	60	5	4	LE1	2	2001	4.2713	I2E	17/1/2020	apex of abdomen and genitalia
<i>G. gajarrangarnang</i> sp. nov.	female	E106358	60	5	4	LE1	1.2	2001	11.587	I2E	17/1/2020	whole body
<i>G. westraliensis</i>	male	E106381	60	5	4	LE1	2.25	2001	3.2642	I2E	1/1/2020	uninflated genitalia
<i>G. westraliensis</i>	male	E106381	60	5	4	LE1	1.5	2001	3.7200	I2E	1/1/2020	pygophore
<i>G. westraliensis</i>	male	E106380	60	5	4	LE1	1.5	2001	4.5827	I2E	19/5/2020	partially inflated genitalia and pygophore

Table 2. X-Ray microtomography settings using Zeiss X-Radia 520 Versa.

etation, still covered and smelling of *Triodia* resin (Figure 1B).

It is unclear if *G. gajarrangarnang* sp. nov. extracted resin from one or several species of *Triodia*. The most abundant spinifex grass at our El Questro study sites was *T. bitextura*, and when offered leaves of this plant at the campsite, individuals readily scraped the resin with their foretibiae and smeared it on the dorsal surface of their midlegs, or the anterodorsal surface of the opposing foreleg femur. Large blobs of resin were accumulated at these sites before the bugs began distributing the resin all over their bodies, similar to what has been observed in *Heniartes stali* (Wygodzinsky) (Avila-Nuñez *et al.* 2016). First-instar nymphs in captivity (Figure 2) scraped resin from the three sources they had in their containers: leaves of *T. bitextura* (n = 6), eggshells (n = 2), and the body and legs of adult female (n = 3).

Discussion

Within the Harpactorinae, the collection and application of plant resins is usually ascribed to the tribes Apiomerini, Diaspidiini, and Ectinoderini, the so-called 'resin bugs' (Roepke 1932; Usinger 1958; Davis 1969). However, little biological information relating to resin use has been recorded for other harpactorines, and many accounts are largely anecdotal (as noted by Forrero *et al.* 2011; Zhang & Weirauch 2014). The evolution of sticky-trap predation is further complicated by the fact that some assassin bugs, e.g. the Bactrodinae genus *Bactrodes* Stål frequent resin-producing plants but do not collect resin, instead scavenging on prey trapped by sticky trichomes (Weirauch *et al.* 2021), while others produce resin themselves, such as the Harpactorini genus *Zelus* Fab. (Barth 1953; Edwards 1966) and at least a dozen other genera (Zhang & Weirauch 2013). The molecular analysis of

Zhang *et al.* (2016) revealed that the evolution of sticky trap predation is indeed complex, suggesting sticky trap predation has evolved at least seven times in assassin bugs. According to such analyses, scavenging on plants with sticky trichomes arose independently up to four times, while resin gathering evolved twice, and endogenous stickiness once. At present it is unclear where the Australian genera *Undiareduvius* and *Gorareduvius* fit within this evolutionary framework, which is the subject of ongoing studies.

The functions that resin convey to assassin bugs are not fully understood and may vary across species. Recent behavioural experiments (Ávila-Nuñez *et al.* 2017), including on the species described herein (Soley & Herberstein 2023), show that resin use provides a predatory advantage, as initially suspected by several authors (*e.g.*, Wygodzinsky 1947; Miller 1959; Johnson 1983; Adis 1984: reviewed in Forrero *et al.* 2011; Zhang & Weirauch 2014; Zhang *et al.* 2016). There is also support for an egg-protective function (Choe & Rust 2007; Weirauch *et al.* 2021; Takeda *et al.* 2020), and protection from parasites (Gil-Santana & Forero 2010). It is possible that the use of resin evolved under one selective pressure and was later co-opted for other functions, as suggested by Forero *et al.* (2011), or that it has evolved multiple times fulfilling different functions.

The dependency on resinous plant material may have limited the dispersal and establishment capabilities of assassin bugs that rely on exogenous resin sources (Zhang *et al.* 2016). It is worth noting that while *Gorareduvius* is associated with sticky *Triodia* grasses, species of which can be found widely distributed across northern Australia (Andersen *et al.* 2019), it currently is only known from the Kimberley region of WA. Future survey efforts may yet extend the distribution of

Gorareduvius into other states and territories, though this remains to be seen. Both *Undiareduvius* and *Gorareduvius* are apterous, and a close association with sticky *Triodia* habitats may have also been responsible for the loss of functional wings in these assassin bugs, with the possession of wings while living among dense, sticky grasses perhaps proving to be a liability, and selective pressure for dispersal further attenuated by this vast, seemingly homogenous habitat. However, we note that we have observed other winged harpactorine species which also appear to be associated with sticky *Triodia*, and their biology warrants further study. With ongoing habitat loss and increasing fire frequency, wing loss in *Undiareduvius* and *Gorareduvius* may ultimately prove costly to these taxa. At our field site in El Questro, *G. gajarrangarnang* sp. nov. were only found in areas that had not been recently burnt, and they appeared to be absent from adjacent, recently burnt areas. Wing loss almost certainly hinders the ability of these insects to escape fire, and also impedes their ability to recolonize burnt areas.

To our knowledge, resin-collecting behaviour has previously only been described in detail for the Apiomerini species *Apiomerus flaviventris* Herrich-Schaeffer (Forero et al. 2011) and *Heniartes stali* (Avila-Nuñez et al. 2016). Future studies should compare resin-related behaviours and associated morphology of these disparate taxa, as well as explore potential resin use in other taxa, in order to help us untangle the evolution of this tool-using behaviour.

Taxonomy

Gorareduvius gajarrangarnang sp. nov.

Figures 1, 2, 3A-B, 4-5, 6A-D, 7, Tables 1-2

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Holotype: ♂ AUSTRALIA: WA: El Questro Station, near campground 16.008495°S 127.981042°E, 15/06/2018 F.G. Soley & I.S. Chacón. Bug 60. Collected as 5th instar, moulted 8/06/2018, died 19/07/2018. (WAME106351) (WAM).

Paratypes: ♂ AUSTRALIA: WA: El Questro Station, near campground 16.008495°S 127.981042°E, 10/05/2018 F.G. Soley & I.S. Chacón. Bug 25. Collected as 5th instar, moulted 11/05/2018, died 4/07/2018. (WAME106352) (WAM); ♂ AUSTRALIA: WA: El Questro Station, near campground 16.008495°S 127.981042°E, 27/08/2018 F.G. Soley & I.S. Chacón. Bug 141. Collected as adult. (WAM E106353) (WAM); ♀ AUSTRALIA: WA: El Questro Station, near campground 16.008495°S 127.981042°E, 14/06/2018 F.G. Soley & I.S. Chacón. Bug 72. Collected as 5th instar, moulted 21/06/2018. (WAM E106354) (WAM); ♂ AUSTRALIA: WA: El Questro Station, Saddleback trail 16.001261°S 127.983215°E, 27/04/2018, F.G. Soley & I.S. Chacón. (WAM E106355) (WAM); ♂ AUSTRALIA: WA: El Questro Station, near campground 16.008495°S 127.981042°E, 8/06/2018, F.G. Soley & I.S. Chacón. Bug 62. Collected as 5th instar, moulted 12/06/2018, died 7-19/07/2018. (WAM E106356) (WAM); ♀ AUSTRALIA: WA: El Questro Station, near

campground 16.008495°S 127.981042°E, 1/07/2018, F.G. Soley & I.S. Chacón. Bug 95. Died 15/08/2018. (WAME106357); ♀ AUSTRALIA: WA: El Questro Station, near campground 16.008495°S 127.981042°E, 20/07/2018, F.G. Soley & I.S. Chacón. Bug 102. (WAME106358); ♀ AUSTRALIA: WA: El Questro Station, near campground 16.008495°S 127.981042°E, 6/07/2018, F.G. Soley & I.S. Chacón. Bug 96. Died 13/07/2018. (WAME106359); ♀ AUSTRALIA: WA: El Questro Station, Saddleback Ridge 16.001261°S 127.983215°E, 4/05/2018, F.G. Soley & I.S. Chacón. Bug 13. (WAME106360); ♂ AUSTRALIA: WA: El Questro Station, near campground 16.008495°S 127.981042°E, 13/06/2018, F.G. Soley & I.S. Chacón. Bug 70. Died 17-19/07/2018 (WAME106361); ♂ AUSTRALIA: WA: El Questro Station, near campground 16.008495°S 127.981042°E, 4/05/2018, F.G. Soley & I.S. Chacón. Bug 10. Died 7/06/2018. (WAME106362); ♀ AUSTRALIA: WA: Cockburn Ranges via Gibb River Rd 15.902120°S 128.109292°E, 7/08/2018, F.G. Soley & I.S. Chacón. Bug 155. Died 10/08/2018 (WAME106363); ♀ AUSTRALIA: WA: El Questro Station, near campground 16.008495°S 127.981042°E, 08/2018, F.G. Soley & I.S. Chacón. Bug 134. (WAME106364); ♀ AUSTRALIA: WA: El Questro Station, Saddleback Ridge 16.001261°S 127.983215°E, 27/04/2018, F.G. Soley & I.S. Chacón. "Pareja 1" Died 24/06/2018. (WAME106365); ♂ WA: 1.5 km W Mt Bell, 17°10' S 125°17'E, 25 July 1988, T.F. Houston 704 (WAM E 76441); ♀ WA: Hill overlooking Cockburn Range, ca. 15°49'S 127°50'E, 8 June 1992, NT-20, M. S. Harvey et al. (WAM E 76642) (WAM); ♂ WA: Hill overlooking Cockburn Range, ca. 15°49'S 127°50'E, 8 June 1992, NT-20, M. S. Harvey et al. (WAM E 76643) (WAM); ♀ WA: Charnley River-Artesian Range Wilderness Camp: 18.8 km NW of Tabletop Mountain, 16.42055°S 125.04875°E, 25 July 2022, NT22-188, P. Doughty & M. Hutchinson (WAM E1136130); ♀ WA: Beverley Springs Homestead, 16°43'S 125°28'E, 26/05/1979, B.G. Muir (WAM E76418); ♀ WA: El Questro Champagne Springs trail 1hr walking from station 112744 16.051083°S 127.971370°E 04/09/2022, S.G. Soley, 'Bug 33' (WAM E112744).

Similar to *G. westraliensis*, being mostly black in colouration, apterous, with an elongate and parallel-sided body, elongate limbs with swollen femoral apices, but distinguished by its somewhat smaller size, by the broad yellow to orange metafemoral annulation (vs yellow to orange profemoral annulation in *G. westraliensis*), the yellow to orange antennae (vs black with yellow apices) the more prominent and erect tubercles on the abdominal tergites, and by the structure of the male aedeagus.

Description: Total length ♂ 17.06 (N=5), ♀ 17.38 (N=4). **General Structure** (Figures 3A-B, 4A-B): Both sexes apterous, body long, narrow and cylindrical with elongate limbs and antennae. Typically found covered in resin, lending the animal a shiny appearance. **Head** (Figures 3A-B, 4A-B, 5A): elongate, more than twice as long as width across eyes, postocular portion slightly longer than antocular portion (excluding clypeus); dorsally with transverse sulcus behind eyes; covered with short, conical, apically setigerous tubercles, denser on anteocular portion; eye almost as tall as head when viewed laterally; ocelli absent; antennae 4-segmented, A1 longest, about as long as head and thorax combined; A2, A3 and A4 each almost ½ as long as A1; A3 and A4 curved; labi-

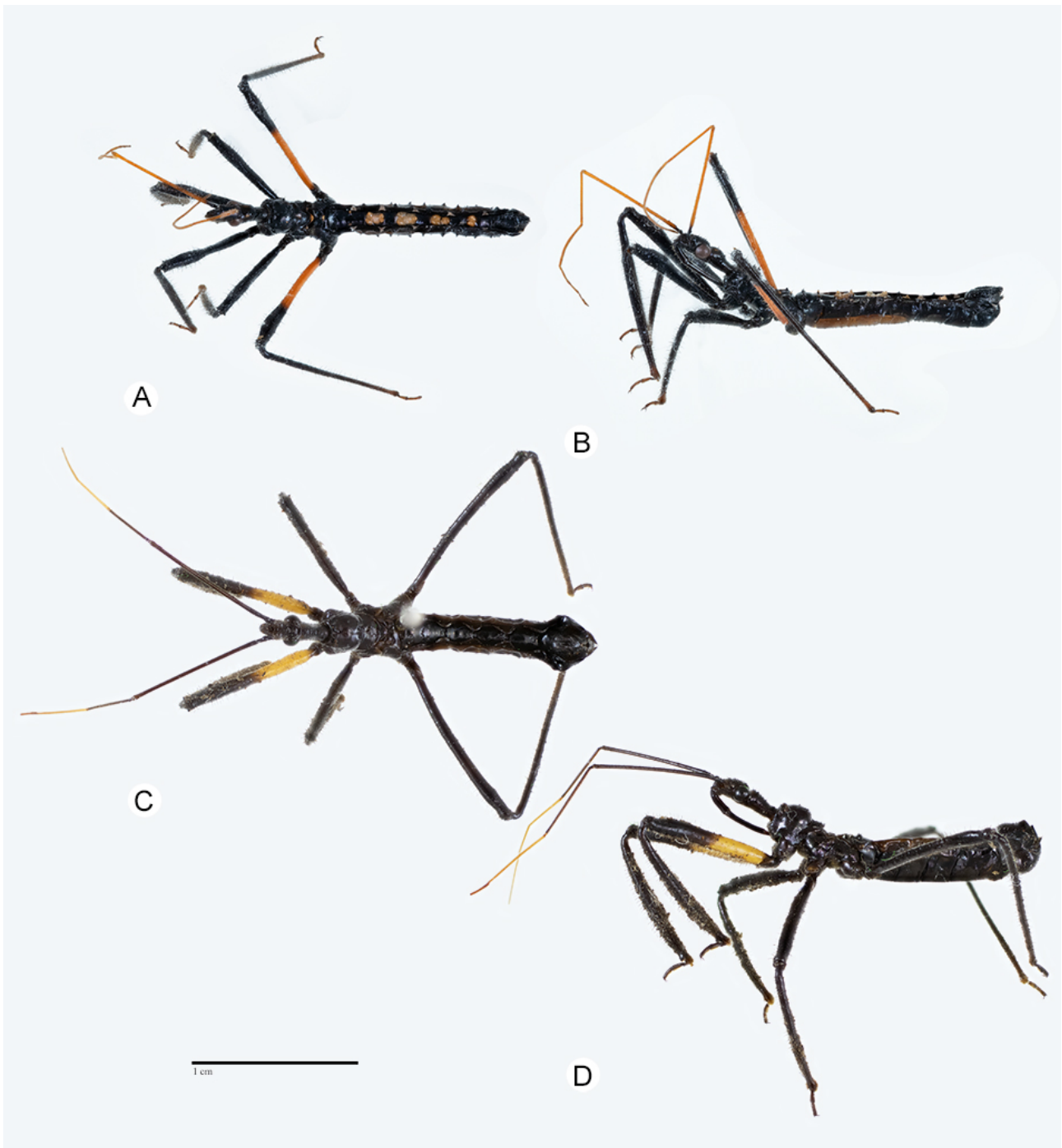


Figure 3. Dorsal and lateral images of *Gorareduvius*. *Gorareduvius gajarrangarnang* sp. nov. holotype male, A) dorsal, B) lateral. *Gorareduvius westraliensis* male, C) dorsal, D) lateral.

um reaching middle of prosternum, L2 around twice the length of L1; L3 extremely short. **Thorax** (Figures 3A-B, 4A, 5A-B): with sparse distribution of short, conical, apically unisetigerous tubercles, particularly on anterior lobe of pronotum and laterally on meso- and metapleura; pronotum with narrow collar, laterally with setigerous tubercles; anterior lobe of pronotum globulose with shallow medial sulcus, at least twice as long as posterior lobe, lobes divided by transverse sulcus, posterior margin of pronotum weakly concave; mesonotum with posterior margin forming a U-shaped, upright cari-

na; anterior of metanotum longitudinally sulcate, medially with prominent upturned U-shaped carina bearing lateral and submedial setigerous tubercles; prosternal stridulatory furrow distinct, bordered with erect setae. **Abdomen** (Figures 3A-B, 4A-C, 5A, E-F): spiracles of first segment dorsal, others on lateral, setigerous tubercles; abdominal tergites with prominent setigerous tubercles singly or in pairs; T7 with large posteromedial tubercle, in males large and upright, caudally conforming to medial process (mp) of pygophore, in females rounded, sometimes medially cleft, occasionally appearing as two

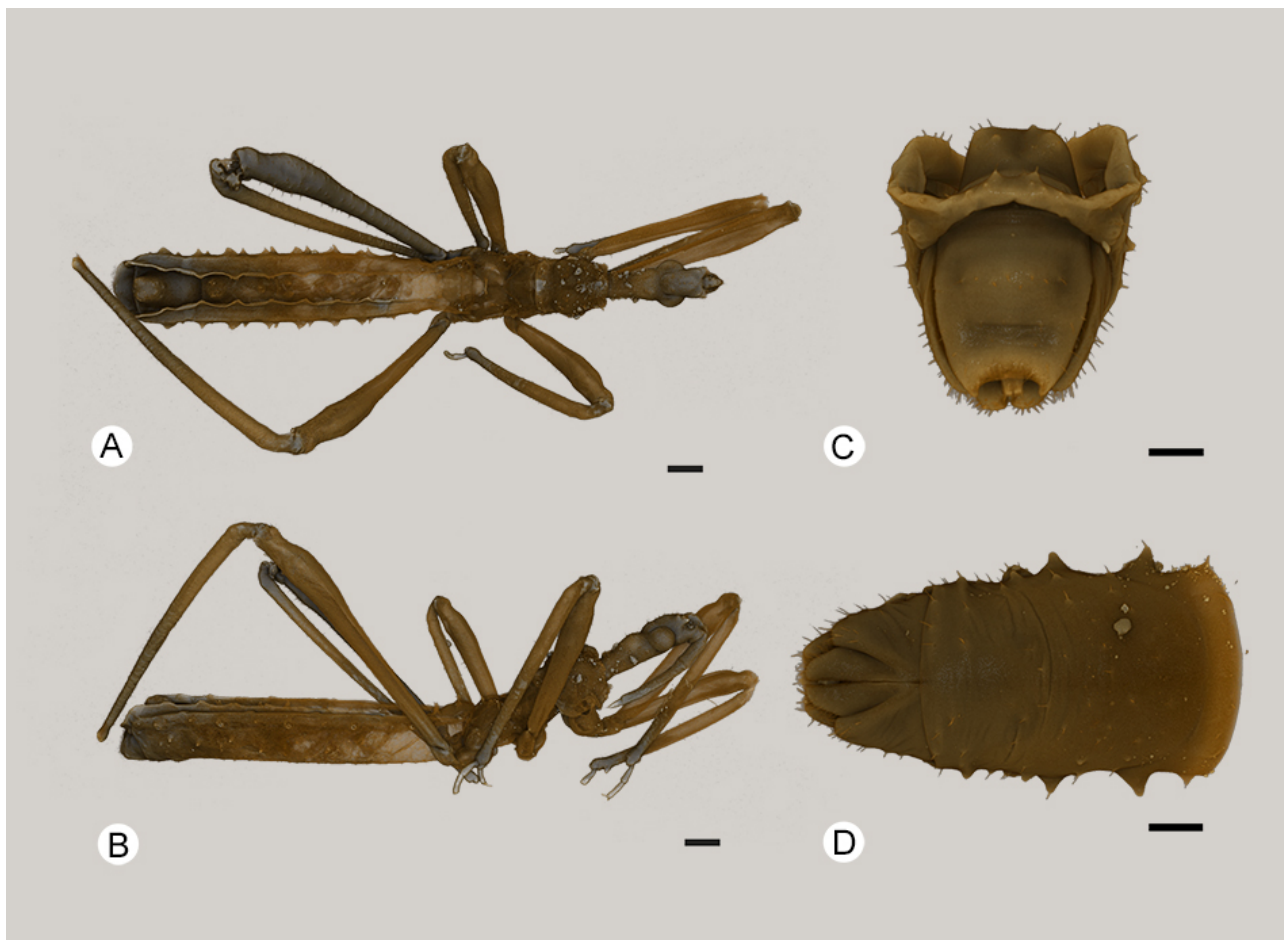


Figure 4. Micro-CT imaging of female *G. gajarrangarnang*. A) dorsal view; B) lateral view; C) caudal view of abdomen; D) ventral view of external genitalia. Scale bars: A, B = 1 mm; C, D = 0.5 mm.

distinct tubercles, and crowned with irregular, spinelike setae; connexiva folded inwards and upwards, giving abdomen elongate, parallel-sided appearance. **Legs** (Figures 3A-B, 4A-B, 5C-D): elongate; with mix of longer and shorter spinose setae, setae most dense on foretibia; fore- and mesocoxae nearly touching at midline, metacoxae separated; all legs with apex of femur swollen; foretibiae laterally compressed, slightly broader than meso- and metatibiae, narrowing slightly basally and apically; tibial comb on minor swelling; apex of foretibia behind tarsal insertion with dense patch of thick setae, those central in patch flattened, concave and paddle-like; tarsi 3-segmented. **Male genitalia** (Figure 6A-D): pygophore with sparse distribution of spinose setae; median process (mp) broad, projecting caudally and upwards, tapering to blunt apex; parameres simple, elongate and curved, with sparse distribution of spinose setae; endosoma dorsally with median basal sclerite (mbs) forming paired, paddle-shaped processes; beyond mbs a pair of elongate, membranous dorsolateral lobes (dll) and a larger, more apically sclerotized pair of ventrolateral processes (vlp); laterally with paired, lateral sclerotized processes (lsp) with narrowing, curved tips; at rest, these endosomal lobes and processes folding together. **Colouration** (Figures 3A-B,

8C): mostly black, with some orange to yellow and/or white markings, rarely almost entirely black. **Head:** black, often with thin orange to yellow markings behind eyes; antennae basally black, the remainder orange to yellow, A3 and A4 appearing slightly paler due to abundance of very short, adpressed white setae. **Thorax:** near uniform black, sometimes with small orange to yellow markings. **Abdomen:** mostly black, dorsally with some tubercles (typically those most caudal on segment) demarcated with orange to yellow, in some specimens this forms broad coloured sections crossing intersegmental margins, connexiva sometimes with small yellow, orange or white bands dorsolaterally. Legs mostly black, basal half of metafemur usually orange to yellow; metatibia sometimes becoming somewhat orange towards apex; tarsi orange. Rarely with legs all black, or with dark orange colouration on all legs.

Etymology: The specific epithet *gajarrangarnang*, derived from the Miriwoong language, spelled 'gajarrangarnang' meaning 'spinifex dweller,' refers the grass (*Triodia* spp.) from which these assassin bugs extract resin. Miriwoong was once commonly spoken near the region where the type specimen was found, but is now a critically endangered language. This name alludes to both the fact that these assassin bugs are usually found

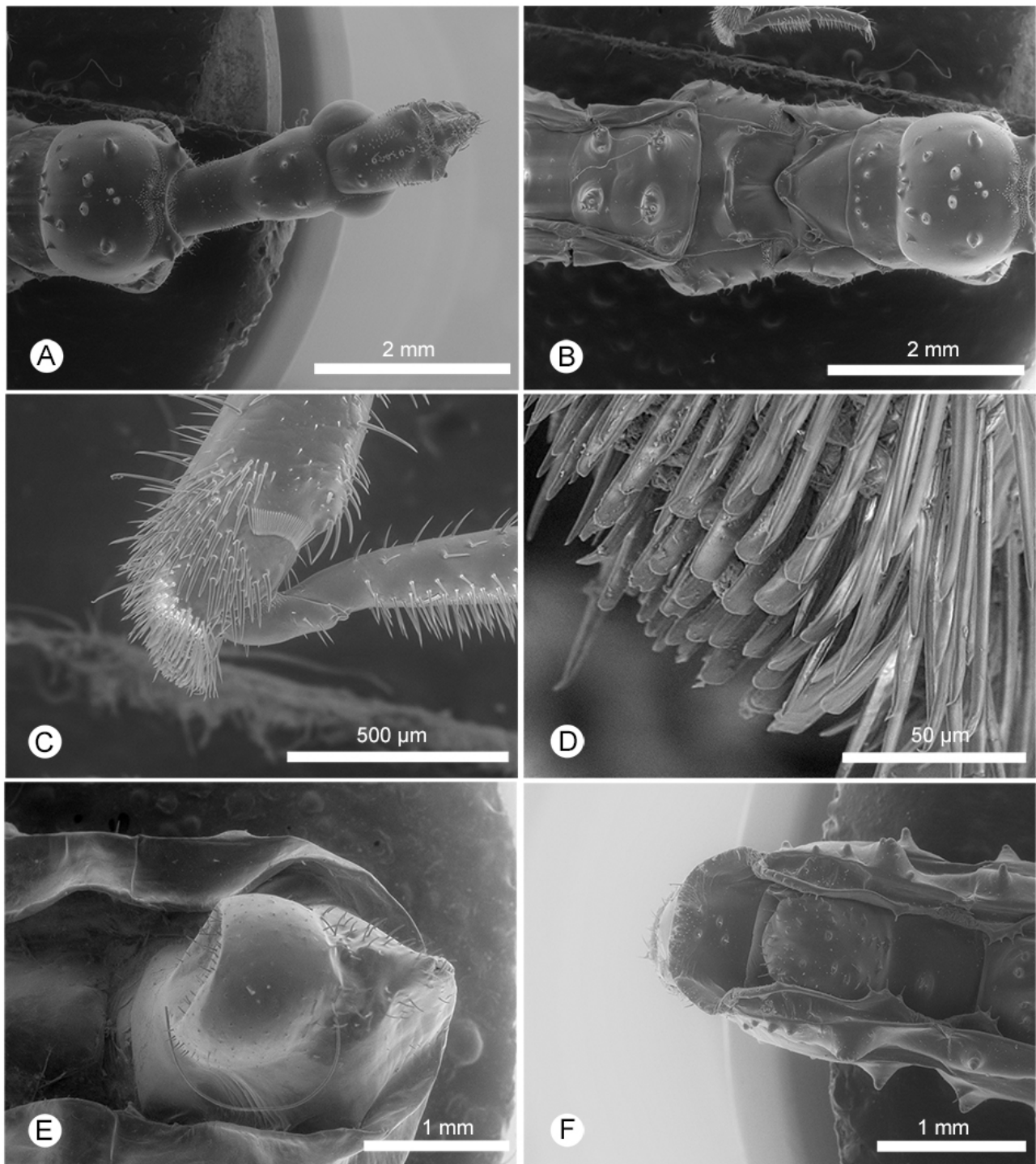


Figure 5. Scanning electron micrographs of *Gorareduvius gajarrangarnang*. A-D, F) female, WAM E106364; E) male, WAM E106361. A) head and anterior of pronotum, dorsal view; B) pronotum and anterior of abdomen, dorsal view; C) anterior of foretibia; D) detail of spatulate setae on foretibia; E) apex of male abdomen; F) apex of female abdomen.

associated with resinous species of *Triodia*, and that they cover themselves with resin from these plants. This name was suggested and approved by the Elders and language consultants who were contacted through the Mirima Dawang Woortlab-gerring Language and Culture Centre (<https://mirima.org.au>).

Measurements (in mm, range, with average in parentheses), see Table 1:

Male (N=5): length 16.53-17.58 (17.06); head length 3.14-3.48 (3.28); eye length 0.69-0.78 (0.73); interocular distance 0.66-0.76 (0.68).

Female (N=4): length 16.59-18.07 (17.38); head length 3.13-3.39 (3.29); eye length 0.64-0.79 (0.69); interocular distance 0.63-0.75 (0.69).

Distribution: Known from the Kimberley region of Western Australia (Figure 7).

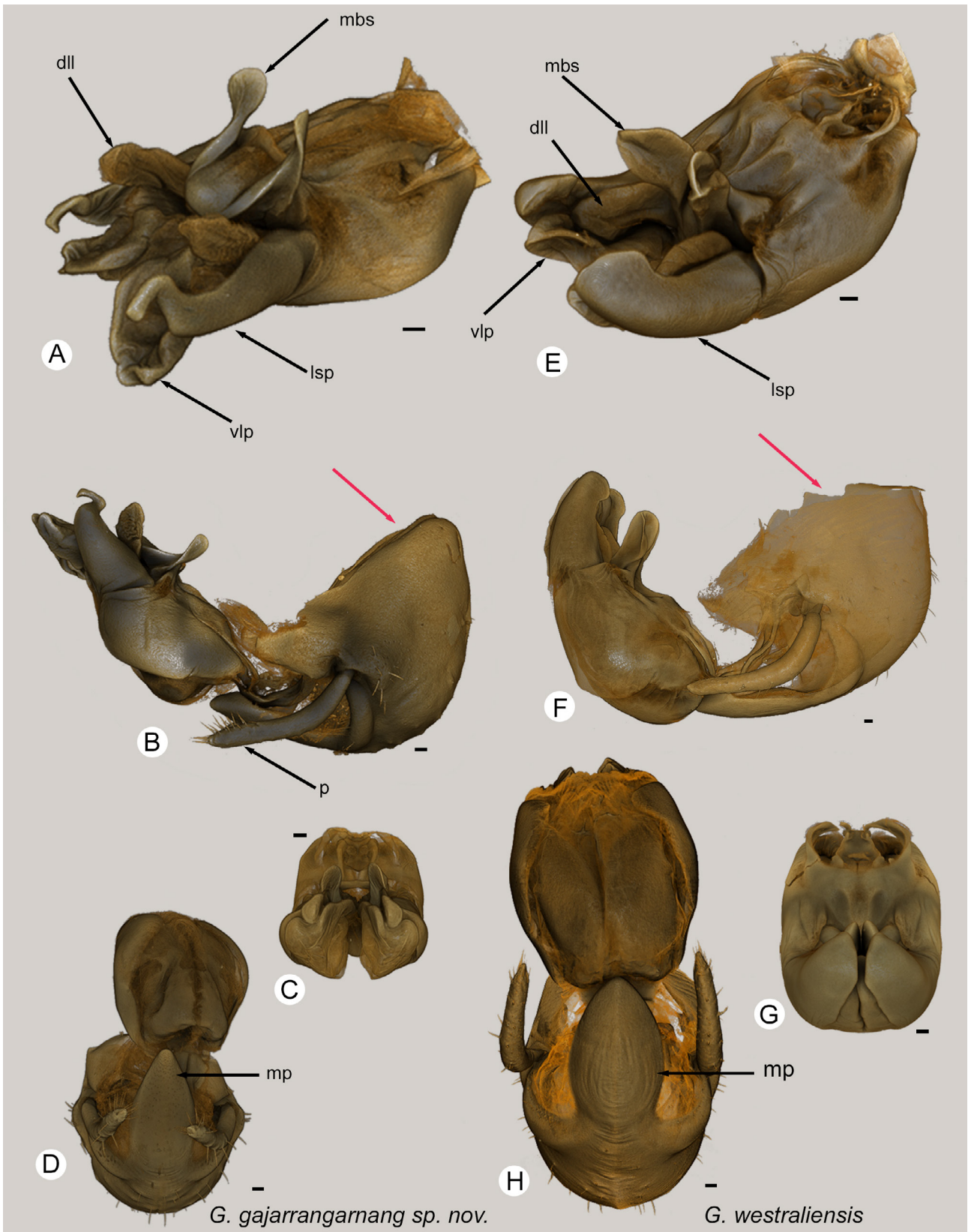


Figure 6. Micro-CT imaging of male genitalia. A-D) *Gorareduvius gajarrangarnang* sp. nov., E-H) *G. westraliensis*. A and E) dorsolateral view of partially inflated aedeagus; B and F) lateral view of partially inflated aedeagus and pygophore (red arrows indicate anterior of pygophore); C and G) anterior view of uninflated aedeagus; D and H) posterior view of pygophore with uninflated aedeagus. Scale bars = X μ m. dll = dorsolateral lobe, lsp = lateral sclerotized process, mbs = median basal sclerite of endosoma; vlp = ventrolateral process; mp = median process of pygophore; p = paramere. Scale bars = 100 μ m

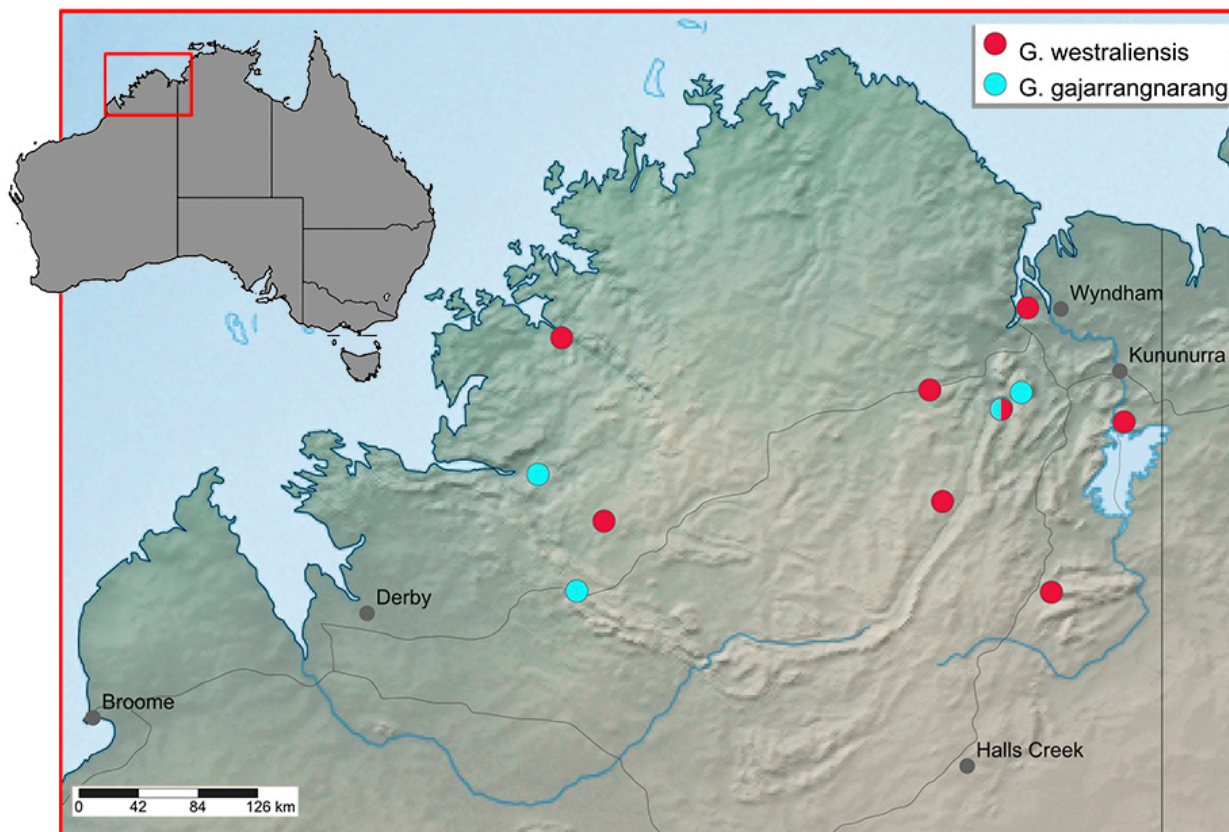


Figure 7. Map of *Gorareduvius gajarrangarnang* sp. nov. and *G. westraliensis* collecting localities (inset) based on specimens deposited in the Western Australian Museum. Red circles denote *G. westraliensis*, while light blue circles denote *G. gajarrangarnang* sp. nov.

Remarks: *Gorareduvius gajarrangarnang* sp. nov. and *G. westraliensis* are superficially quite similar, however several characters clearly separate the two. Most obviously, *Gorareduvius westraliensis* is generally larger (20.86 mm vs 17.06 mm total length) and nearly always has yellow and black forefemora (Figure 3C-D), while *G. gajarrangarnang* sp. nov. is smaller and typically has orange and black metafemora (Figures 3A-B, 8C). Both species may show some variation in this colouration, with nearly all-black specimens of both species observed. These, however, can be separated by their antennal colouration, with *G. gajarrangarnang* sp. nov. bearing yellow to orange antennae (Figures 3A-B, 8C), while those of its congener are black with yellow apices (Figure 3C-D). Additionally, many of the dorsal abdominal tubercles, which are prominent and often coloured in *G. gajarrangarnang* sp. nov. (Figure 8C), are more rounded and relatively smaller or entirely absent in *G. westraliensis*. The male genitalia are also diagnostic for each species (see Figure 6A-H). Both *G. gajarrangarnang* sp. nov. and *G. westraliensis*, exhibit a median basal sclerite (mbs) with paired, spatulate processes. In *G. westraliensis*, these have a midline carina on the outer surface and are positioned close together (Figure 6E), while in *G. gajarrangarnang* sp. nov. they lack a carina and are more widely separated (Figure 6A). Additionally, the apices of the lat-

eral sclerotized processes (lsp) of *G. gajarrangarnang* are hooked and articulate with paired conjunctival ventrolateral processes (vlp) (Figure 6A-C), unlike in *G. westraliensis*, where the lsp are broad, rounded and almost touching along the midline when at rest (Figure 6E-G).

The general structure of the male genitalia in *Gorareduvius* is similar to that of *Undiareduvius* (Malipatil 1991a figures 7-10) and *Trachylestes* Stål (Malipatil 1991b figure 3), which are also characterised by the paired spatulate lobes of the medial basal sclerite and paired conjunctival and lateral lobes. This is in contrast to most other Australian Harpactorines, where the aedeagus is typified by an eversible sac-like endosoma armed with fields of small sclerotised spines (see Malipatil 1991b). This suggests these three genera share a common ancestry distinct from most other known Australian harpactorines, however this remains to be tested in a phylogenetic framework.

Both *G. westraliensis* and *G. gajarrangarnang* sp. nov. are found in the Kimberley region of Western Australia (Figure 7). Though distribution data is limited, it is worth noting that both species were found by FGS at El Questro, with *G. westraliensis* on the west side of the Pentecost River and *G. gajarrangarnang* sp. nov. on the east. Similarly, two specimens of *G. westraliensis* and one of

G. gajarrangarnang sp. nov. were found in the WA Museum collection, all three collected at Mt Bell 26 July 1988 by T. F. Houston, with identical locality data (though with separate collector codes, suggesting separate collecting events in the same vicinity). At present there is not enough information to determine how the two species might diverge ecologically while maintaining overlapping distributions.

Disclosures

The authors declare no conflicts of interest.

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