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Discovery through iNaturalist: new species and new records of oak gall wasps (Hymenoptera: Cynipidae: Cynipini) from Texas, USA

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Abstract

A new species of the genus *Druon* Kinsey, 1937, *D. laceyi* Zhang, Sasan & O'Kennon **sp. nov.** is described on host plant *Quercus laceyi* Small from central Texas. We also re-establish *Andricus lustrans* Beutenmüller, 1913 **comb.rev.**, and transfer *Striatoandricus aciculatus* (Beutenmüller, 1909) **comb. nov.** from *Andricus*. Finally, we report a new state and host record for *Druon gregori* Melika, Nicholls & Stone, 2022. All observations were first shared on the social platform iNaturalist, highlighting the potential of cybertaxonomy in uncovering overlooked biodiversity.

Key words: Citizen Science, cybertaxonomy, *Druon, Striatoandricus, Andricus*

Introduction

The oak gall wasps (Hymenoptera: Cynipidae, Cynipini) are the most species-rich group of gall wasps, with ~1,000 species worldwide in around 51 genera (Melika & Abrahamson 2002, Melika *et al.* 2021b, Cuesta-Porta *et al.* 2022). Their diversity is likely much higher, especially in regions such as North America where the highest number of oaks and other Fagaceae are found (Hipp *et al.* 2020). Despite this diversity, relatively few recent studies have been published describing new species in North America (but see Melika *et al.* 2021a).

Andricus Hartig, 1840 is the largest genus of oak gall wasps (Cynipidae: Cynipini) with >400 species known across the Holarctic region (Melika & Abrahamson 2002, Melika *et al.* 2021b, Cuesta-Porta *et al.* 2022). The genus currently lacks synapomorphies due to its polyphyletic relationship, but can generally be recognized based on the following characteristics: 1) Fully developed wing with a nearly straight R vein; 2) a long acuminate hypopygeal spine with only a few setae that ordinarily do not extend past the apex; 3) no coarse cross-striation on mesoscutum, usually with a tooth on the claw and cilia on the margin of the wing; 4) the notauli is usually complete; and 5) no malar groove on the malar space (Melika & Abrahamson 2002, Zimmerman 2018, Melika *et al.* 2021a). Much of the confusion between *Andricus* and another large genus *Callirhytis* Förster, 1869 stems from the erroneous generic concept of *Callirhytis* by Weld (1952), in which he assigned many species to *Callirhytis* despite not having the transversely rugose scutum which is the diagnostic character of the genus (Melika & Abrahamson 2002). Therefore, currently there are many North American *Callirhytis* species that should be moved to *Andricus* or other related genera (Melika & Abrahamson 2002, Ward *et al.* 2022). In addition, both Weld (1952) and Melika & Abrahamson (2002) have synonymized multiple genera into *Andricus*, rendering it polyphyletic and difficult to classify. In recent years, a significant effort was undertaken by various cynipid taxonomists to rectify this chaotic genus, which resulted in the resurrection of erroneous synonymizations (Pujade-Villar & Melika 2014, Pujade-Villar & Ferrer-Suay 2015, Pujade-Villar *et al.* 2017, Zimmermann 2018), and the establishment of new genera (Nicholls *et al.* 2018, Cuesta-

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Porta *et al.* 2020, 2022, Melika *et al.* 2021b). The majority of recent taxonomic studies of Cynipini in the US have focused on southern regions such as Arizona, California, Florida, and Texas, where there are higher diversities of oak species (Brandão-Dias *et al.* 2022, Cuesta-Porta *et al.* 2022, Cooke-McEwen & Gates 2020, Melika & Nicholls 2021, Melika *et al.* 2021a, Melika *et al.* 2021b, Nicholls *et al.* 2018, 2022, Zhang *et al.* 2021).

Druon Kinsey, 1937 is one of these Nearctic genera that was erroneously sunken into *Andricus* by Weld (1952), but reinstated by Cuesta-Porta *et al.* (2022) based on a combination of morphological and molecular differences. *Druon* now contains a total of 15 species from USA, Mexico, and Costa Rica, forming galls on the leaves of oaks in the sections *Quercus* and *Virentes* (Kinsey 1937, Cuesta-Porta *et al.* 2022). *Striatoandricus* Pujade-Villar, 2020 is a newly described genus that includes nine species found in Mexico, Panama, and isolated mountain ranges in Arizona, USA (Cuesta-Porta *et al.* 2020, 2022). *Druon* can be distinguished from the morphologically similar *Striatoandricus* as the metasoma of the latter is matte, and tergites striate and/or reticulate instead of shiny (Cuesta-Porta *et al.* 2022). *Druon* can be also be distinguished from *Andricus* by combination of characters such as: the antenna with 11–12 flagellomeres; toruli usually located above the mid height of the head; pronotum laterally with delicate parallel striae; the mesoscutum reticulate, mesopleuron completely sculptured, entirely striate or striato-reticulate; lateral propodeal carinae bent outwards at their mid-height or in posterior 1/3; in some cases lateral propodeal carinae inconspicuous or absent; the prominent part of the ventral spine of hypopygium as long as broad in ventral view (Cuesta-Porta *et al.* 2022).

Quercus laceyi Small is a white oak (Fagaceae: *Quercus* L. sect. *Quercus*) with a relatively small range, occurring from central Texas to northern Mexico (Nixon & Muller 1992). Little is known about the oak cynipid gall diversity on *Q. laceyi*. Weld listed 9 morphospecies, including two named species *Atrusca cava* (Weld, 1926) and *Disholcaspis pruniformis* Kinsey, 1920 in his treatment of cynipid galls of eastern United States (Weld 1959).

Since its launch back in 2008, the social network iNaturalist has gained tremendous growth and popularity among professional and hobbyist naturalists as a useful platform to share, learn, and discover biodiversity. Numerous iNaturalist observations have led to scientific publications of new species and distribution records (e.g. Jones *et al.* 2019, Wilson *et al.* 2020, Winterton 2020). Through the careful documentation and rearing of galls by citizen scientists in Texas using iNaturalist, we hereby describe one new species *Druon laceyi* **sp. nov.** found on *Q. laceyi*, restablish *Andricus lustrans* Beutenmüller, 1913 **comb.rev.**, and transfer *Striatoandricus aciculatus* (Beutenmüller, 1909) **comb. nov.** from *Andricus*.

Material and methods

The specimens of *D. laceyi* were first observed by RO and KS on iNaturalist (https://www.inaturalist.org/observations/62427355). After confirming it was likely an undescribed species, galls (Figs. 1–3) were collected in the fall of 2020 and reared by KS. Adult specimens (Fig. 4) were sent to YMZ for identification in comparison with exemplars from the Smithsonian National Museum of Natural History (NMNH) collection and cross-checked based on existing resources (Weld 1959, Melika & Abrahamson 2002, Melika *et al.* 2021b, Zimmerman 2018, Cuesta-Porta *et al.* 2022). Host plant was identified by RO.

We follow Melika (2006) and Melika *et al.* (2021b) for terminology on Cynipidae morphological structures and abbreviations for fore wing venation, and Harris (1979) for patterns of cuticular sculpture. The following measurements and abbreviations were used: F1–Fn, the first and the following flagellomeres; POL (post-ocellar length), the distance between the inner margins of posterior ocelli; OOL (ocellar-ocular length), the distance from the outer margin of lateral ocellus to the inner margin of compound eye; LOL (lateral-ocular length), the distance between lateral and frontal ocellus; Transfacial line, distance between inner margins of compound eyes measured across the toruli; width of radial cell, measured as the distance between the upper margin of the fore wing and the Rs vein. Images of specimens were captured using a Canon 7D Mark II with a Mitutoyo M Plan Apo 10× objective mounted onto the Canon EF Telephoto 70–200mm zoom lens, and the Canon MT–24EX Macro Twin Lite Flash (Tokyo, Japan) with custom-made diffusers to minimize hot spots. Image series were merged into a single in-focus, composite image with the program Zerene Stacker v1.04. Post-imaging processing was completed with the editing tools in Photoshop CC, and plates were generated using Inkscape. Vouchers are deposited at NMNH and collections of Barcelona University (UB).

Taxonomy

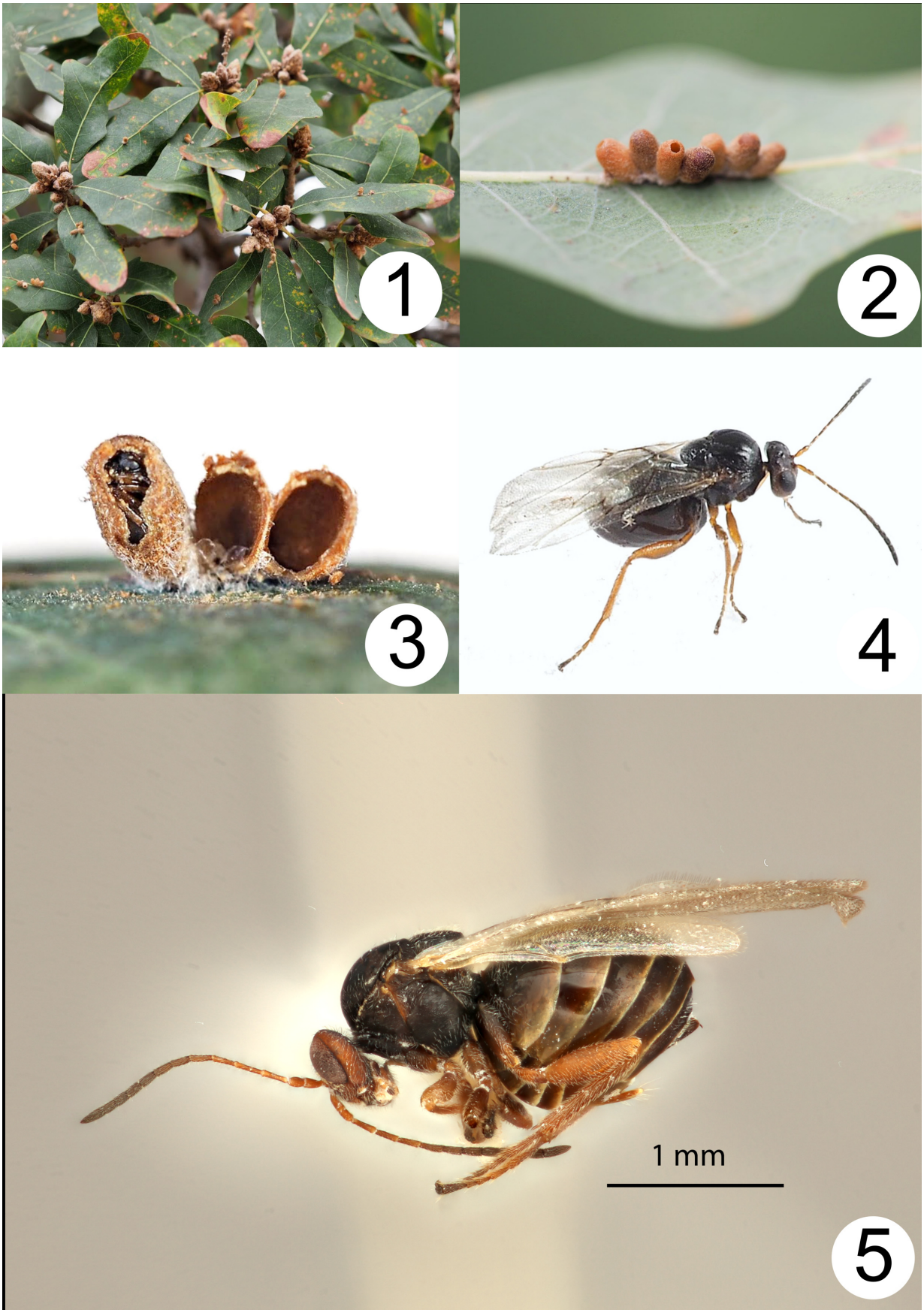
***Druon laceyi* Zhang, Sasan & O'Kennon sp. n.**
Figs. 1–18
urn:lsid:zoobank.org:act:26073933-835C-4BFC-8B93-B0FC4D50A05A

Materials examined: Holotype ♀, USA, TX, Fort Worth, Botanical Research Institute, 24.IX.2020, 32.7419, -97.3638., K.Sasan & R.O'Kennon Leg., reared from midrib leaf galls on *Quercus laceyi*. Paratypes 8♀, same locality as holotype, USNM. 3♀, same locality as holotype, UB.

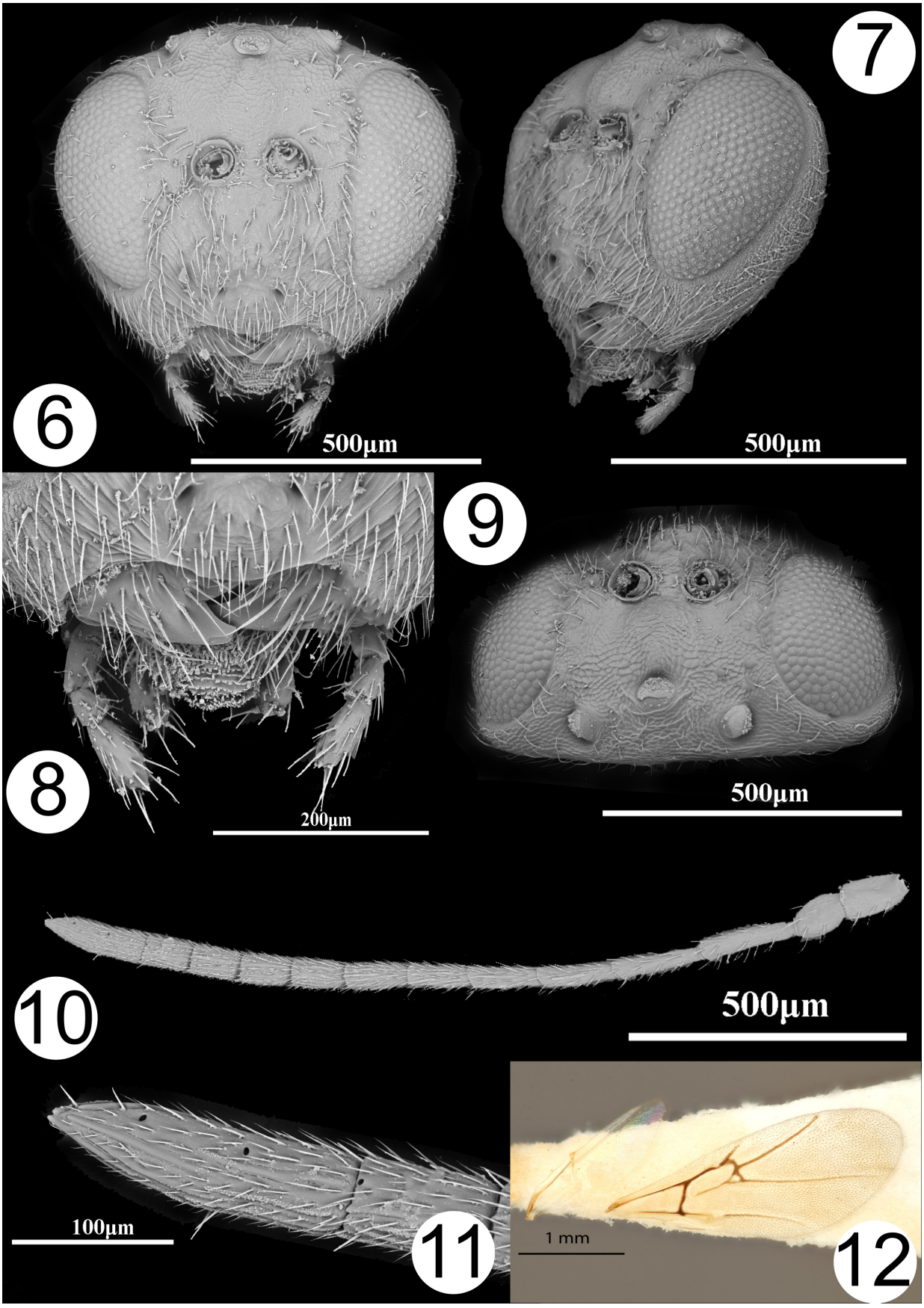
Diagnosis. *Druon laceyi* belongs to the *Druon* group in which the front of the head is rusty brown and the posterior part of the head and mesosoma are dark brown to black (Cuesta-Porta et al. 2022). It keys to couplet 8 of the key in Cuesta-Porta (2022), and is morphologically similar to *Druon fullawayi* (Beutenmüller, 1913) and *Druon gregori* Melika, Nicholls & Stone, 2022. *Druon laceyi* can be distinguished from *D. fullawayi* by the incomplete notauli, and the presence of a broad rugose elevated central carina dividing the mesoscutellar foveae. Whereas *D. fullawayi* has the notauli complete and well-delimited, and the mesoscutellar foveae divided by a thin, strong carina. *Druon laceyi* can also be distinguished from *D. gregori* by the incomplete notauli, scutellar foveae divided by an alutaceous elevated triangle, smooth speculum, and T2 of the metasoma very short (not reach ⅓ of the length), all tergites smooth, and the bi-colored head. Whereas *D. gregori* has complete notauli, speculum sculpted as the rest of the mesopleuron, T2 occupies at least half of the length, T3 and following punctured, and an uniformly black head. Additionally, *D. laceyi* is only known from the oak Series 'Texas White Oak' (*sensu* Hipp et al. 2020) in central Texas, whereas *D. fullawayi* is known only from Series Dumosae in California and Zacatecas in Mexico, while *D. gregori* only from Series Leucomexicanae found on the Santa Catalina and Chiricahua Mountains in Arizona.
Description. ASEXUAL FEMALE (holotype). Body length 2.2mm. Head dark brown, except lower face and gena light brown; antenna scape to F3 light brown, F3–F11 dark brown; mesosoma and metasoma dark brown except edges of metasomal tergites light brown, legs light brown except tarsal claws dark brown. Wing veins are dark brown (Fig. 4, 5).

Head alutaceous, trapezoid, with sparse setae, denser on lower face (Fig. 6, 7), 1.8× as broad as long in dorsal view and subequal to mesosoma. Gena alutaceous, not broadened behind eye; malar space with striae radiating from clypeus and reaching eye, 0.3× as long as height of eye. Ratio of POL:OOL:LOL is 2.1:1:1; all ocelli ovate, of the same size (Fig. 9). Transfacial distance equal to height of eye, toruli located in mid height of head; diameter of antennal torulus 1.6× as large as the distance between them; distance between torulus and inner margin of eye subequal the diameter of torulus; inner margins of eyes slightly converge ventrally. Lower face strigose, with dense white setae, the median elevated area coriaceous; clypeus rounded, anterior tentorial pits distinct, epistomal sulcus and clypeo-pleurostomal line indistinct (Fig. 8). Frons alutaceous, with few white setae; interocellar area microreticulate. Vertex and occiput delicately coriaceous to alutaceous. Antenna with 11 flagellomeres; placodeal sensilla on F3–F11, absent on F1–F2 (Fig. 10). Ratio of scape:pedicel:flagellomeres 1–11 is: 1.6:1:2.4:2.3:2.3:1.8:1.6:1.6:1.6:1 .3:1.3:2.6. Placodeal sensilla on F3–F11; three coeloconica present on the apical flagellomeres in the form of small rounded black pits, with one on the distal margin of F11, and one on the distal margin and a second ⅔ way down the F12 (Fig. 11).

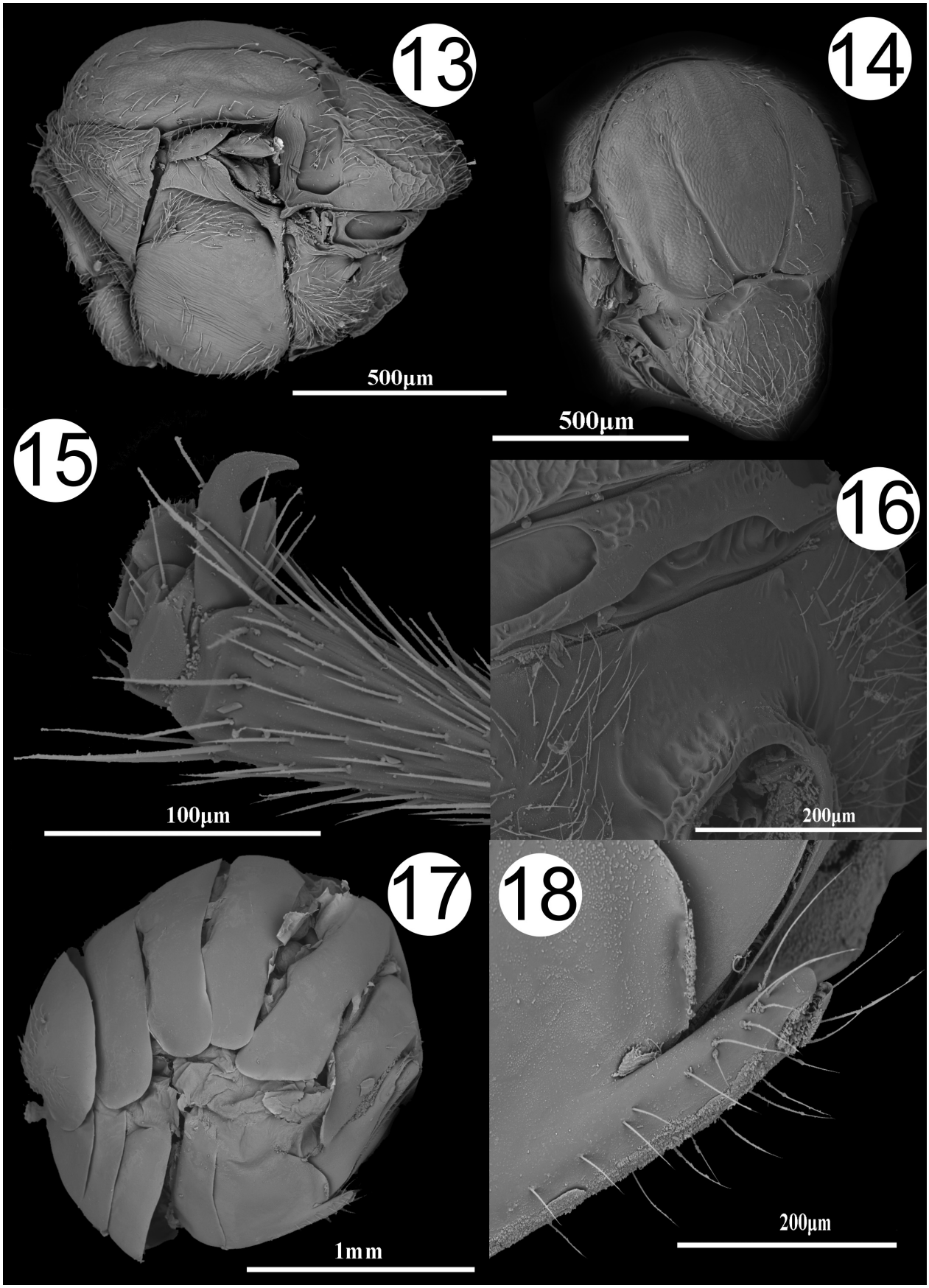
Mesosoma convex, 1.2× as long as high (Fig. 13). Pronotum with transverse striate laterally, with dense white setae; Mesoscutum reticulate; Notauli incomplete on the anterior 1/3, narrow, weakly impressed, slightly converging and broadened at the posterior end, with few white setae along notauli; anterior parallel and parapsidal lines very faint, posterior medial sulcus absent (Fig. 14). Mesoscutellum coriaceous, setose, rounded in dorsal view; Mesoscutellar foveae distinct, transversely ovate, 1.9× as broad as high, smooth, shiny, separated by a broad rugose elevated central carina. Mesopleural triangle rugose. Mesopleuron striato-reticulate, with setae on the dorsal and ventral edges; speculum smooth; axillar area reticulate, glabrous; axillula setose, with parallel longitudinal striae; subaxillar bar area smooth. Metapleural area setose, metapleural sulcus reaching ½ way of the mesopleuron. Metanotal trough smooth, glabrous; propodeum central propodeal area smooth, with few irregular rugae, lateral propodeal carinae curved outwards in posterior 1/3; lateral propodeal area with dense long white setae (Fig. 16). Nucha with numerous rugae. Tarsal claws with tooth (Fig. 15). Fore wing longer than body, hyaline, with dense cilia on margin, radial cell open, 3.8× as long as broad; R1 not reaching wing margin, Rs nearly straight, nearly reaching wing margin; areolet large, triangular, closed and distinct. Rs+M distinct on 3/4 of distance to M and its projection reaching M at its half height (Fig. 12).



FIGURES 1–5. *Druon laceyi* **sp. nov.**. 1. *Quercus laceyi* with mature galls. 2. Mature galls with an emergence hole. 3. Cross section of gall showing adult and empty chambers. 4. Live anterodorsal habitus . 5. Lateral habitus of holotype.



FIGURES 6–12. *Druon laceyi* **sp. nov.**. 6. Frontal view of head. 7. Anterolateral view of head. 8. Clypeus. 9. Dorsal view of head. 10. Antenna 11. Closeup of antenna with coeloconica sensillae. 12. Wings.



FIGURES 13–18. *Druon laceyi* **sp. nov.**. 13. Lateral view of mesosoma. 14. Dorsal view of mesosoma. 15. Tarsal claw. 16. Propodeum. 17. Lateral view of metasoma. 18. Ovipositor tip.

Metasoma longer than head + mesosoma, higher than long in lateral view; T2 very short (not reach ⅓ of the metasomal length), all tergites smooth; T2 with setae on the anterior half, T7 and hypopygium setose (Fig. 17). Ventral spine of hypopygium slender, prominent part at least 2.4× as long as broad, with sparse, long white setae, extending beyond the apex of spine (Fig. 18).

Gall. Small clusters of 1-10 individual (unilocular) brown oval cells in the center of the leaf, emerging perpendicular from the midrib on both upper and lower leaf sides of *Q. laceyi* in the fall (Figs. 1–2). Seen in abundance on nearly every leaf of each affected host. The cell surface when examined with a microscope shows numerous minute papillae covered with a crystalline material and sparse long white woolly hairs. The hairs weather away as the galls age, except near the base. Inside is a single thin-walled chamber (Fig. 3). Cells stay firmly attached to the leaf when it falls. Leaf petioles frequently display a small darkened area, presumably where eggs were inserted. Approximately 2–3mm long and 1.5mm in diameter. Seen in Fort Worth, TX in October. Adults emerge the following February (Fig. 4).

Biology. Only the asexual generation of this species is known, inducing aggregated detachable leaf galls on the top and bottom of the midrib of *Q. laceyi*. In addition to the gall inducer, inquilines (Cynipidae: *Synergus* Hartig, 1840) and parasitoids (Eupelmidae: *Brasema* Cameron, 1884 & Ormyridae: *Ormyrus* Westwood, 1832) have also been reared from galls of the same collection (iNaturalist observations: 66896457, 66896459, 68692701, 80260145, 80260150, 80260151, 80260156).

Distribution. Currently known only from Texas. It is possible that this species also occurs in Oklahoma and northern Mexico, where the host plant is known. Further research is necessary to establish the distribution of this species.

Etymology. Named after its host plant, *Quercus laceyi*.

Andricus lustrans Beutenmüller 1913, comb. rev.

Figs. 19–22

Zopheroteras vaccinii Burks, 1979.
Callirhytis lustrans Weld, 1926.
Andricus dimorphus verifactor, Kinsey, 1922.
Andricus impositus, Beutenmüller, 1918.
Acraspis vaccinii (erroneously associated with gall only) Ashmead, 1887.

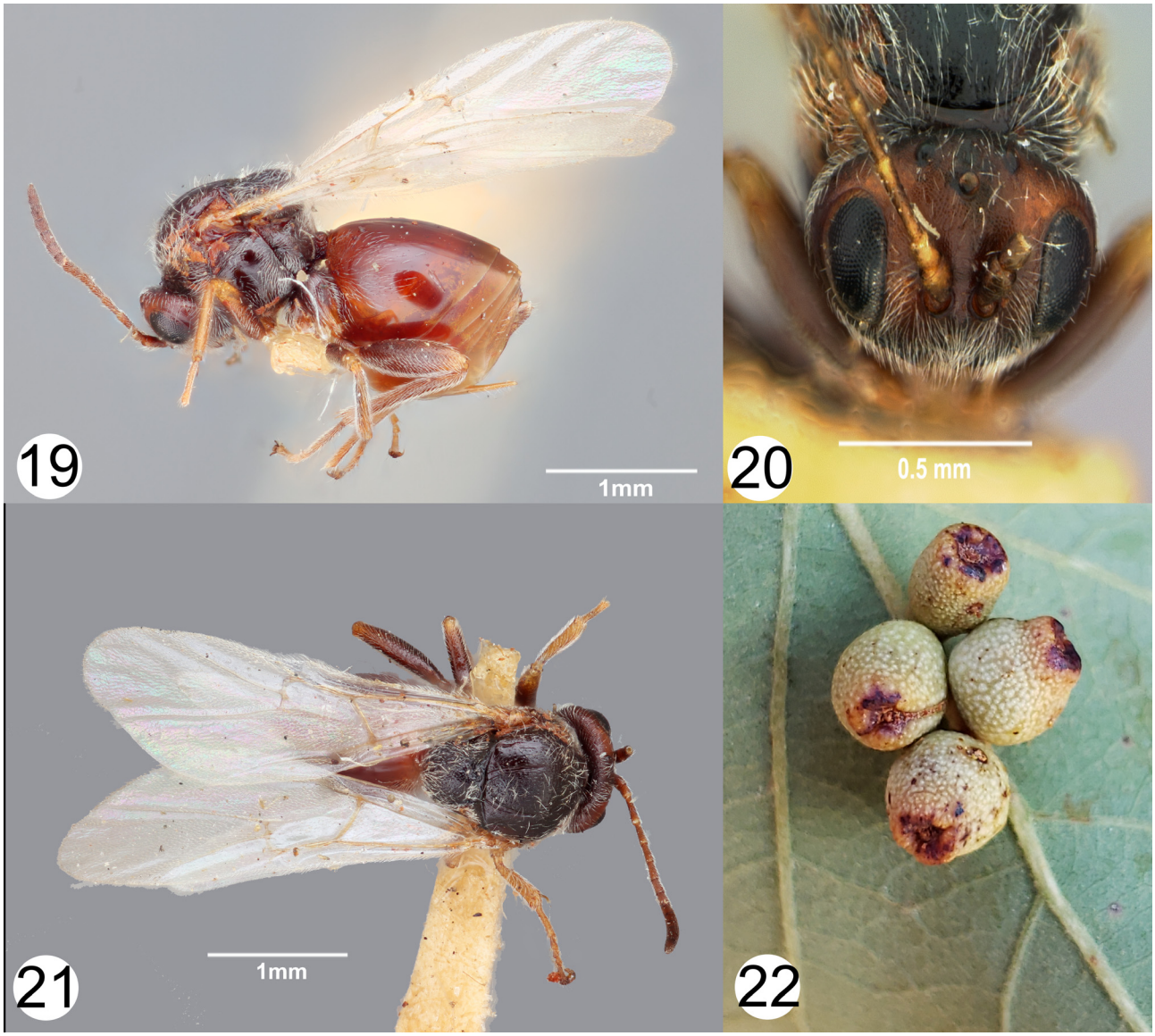
Materials examined: Holotype: ♀, USA, TX, Austin, C. Hartman Leg.; USNM; Cotype No. 24649 USNMENT00802158. Other material: 106♀, NY, New York City, Bronx Park, 11/16, *Quercus*, mid-Nov., W. Beutenmüller leg., Cotype No. 21784 USNMENT00802136. 2♀, TX, Austin, 12.III.1922., Patterson Leg., USNM 26015, USNM. 3♀, TX, Keller, Bourland Cemetery, 32.9474, -97.2436, 13.XI.2020. K. Sasan Leg., *Quercus stellata*, USNM.

The gall of *A. lustrans* was first described by itself (without the larva or adult wasp) from *Quercus stellata* Wangenh. (Osten Sacken, 1862). As this name based on gall alone was established before 1931, it is considered valid according to ICZN article 23.3.2. Ashmead described a new wingless wasp and erroneously associated it with the gall Osten Sacken had described as *Acraspis vaccinii* Ashmead, 1887 (later transferred to *Zopheroteras vaccinii* by Beutenmüller in 1909a), while reprinting Osten Sacken's description of the gall (Ashmead 1887).

In 1913 Beutenmüller described the wasp (Fig. 19–21) without the gall as *Andricus lustrans* Beutenmüller, 1913, and the same species with its gall a few years later which he named *Andricus impositus* Beutenmüller, 1918. He commented that the gall of *A. impositus* is similar to *Z. vaccinii* but the wasp did not match (Beutenmüller, 1918). Kinsey also separately described this species under the name *Andricus dimorphus* var. *verifactor* Kinsey, 1922, reared from Texas, Oklahoma, and Louisiana. In 1926, Weld concluded that *A. impositus* and *A. dimorphus* var. *verifactor* are the junior synonyms of *A. lustrans*, and transferred the species to *Callirhytis* (Weld, 1926). Most recently, the species was then erroneously synonymized with *Z. vaccinii* by Burks (1979) based on Ashmead's error. The senior author examined the holotype specimen and freshly collected materials (Figs. 19–22), reinstating the name *A. lustrans* as the species lacks the diagnostic characteristics of *Callirhytis.* In the Nearctic Cynipini phylogeny by Ward *et al.* (2022), *A. lustrans* was recovered as the sister group to an undescribed "pentagonal cluster" gall, both of which are related to *Andricus pisiformis* Beutenmüller, 1911 and *Andricus quercusstrobilanus* (Osten Sacken, 1862). A similar-looking gall was recently described as *Andricus chapmanii* Melika & Abrahamson, 2021,

but the adults of *A. lustrans* can be easily separated using characters such as the incomplete notaulus (Fig. 21), and metasomal tergites smooth (Fig. 19) (Melika *et al.* 2021a).

There is a large series of over 100 specimens collected from Bronx Park in NY that are identified as *A. lustrans* (identified as *A. impositus*) collected by Beutenmüller (1918) at NMNH, which he stated as common in the region but is becoming urbanized. There are no current records of this species on iNaturalist outside of TX, which could suggest a reduction in their distribution, despite *Q. stellata* being found across eastern US. Additional host records include *Quercus sinuata var. breviloba* (Torr.) C.H.Mull. (Weld 1959).



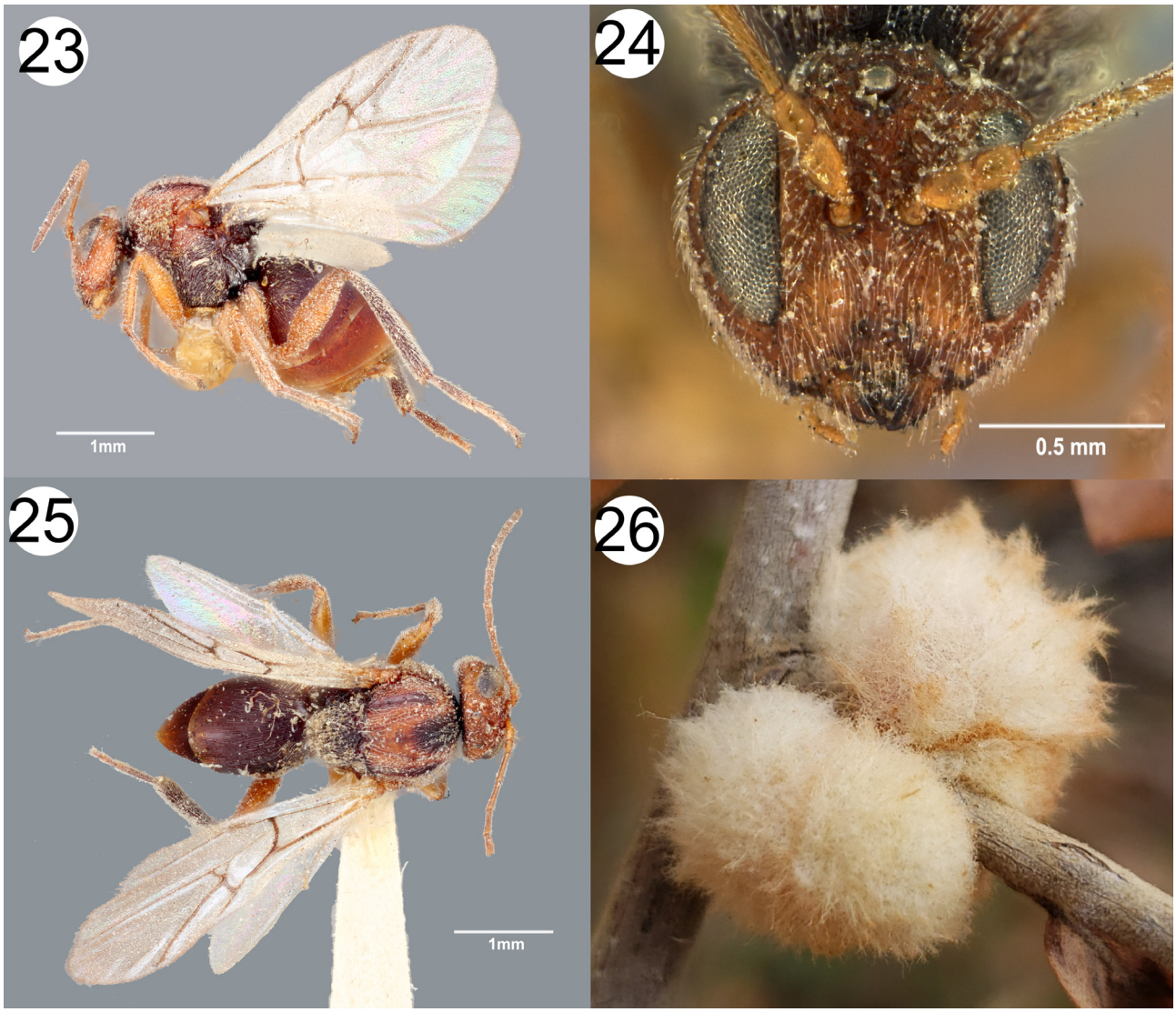
FIGURES 19–22. *Andricus lustrans*. 19. Holotype lateral habitus. 20. Holotype head frontal. 21. Holotype dorsal habitus. 22. Asexual generation gall.

***Striatoandricus aciculatus* (Beutenmüller, 1909), comb. nov.**
Figs. 23–26

Andricus aciculatus Beutenmüller, 1909

Materials examined: Holotype: ♀, USA, TX, College Station, G.H. Herrick Leg.; USNM; Type No. 13719 USNMENT00779882. Paratype: 9♀, same information as holotype, USNM. Other material: 11♀, AR, Hoxie, L. H. Weld Leg., *Quercus lyrata*, Beutenmüller Coll. rec'd 1935, USNM. 14♀, TX, Houston, L. H. Weld Leg., 4–31.III.1918. *Quercus minor*, Beutenmüller Coll. rec'd 1935, USNM.

Striatoandricus aciculatus was first described based on specimens reared in College Station, TX from post oak (*Quercus minor* (Marshall) Sarg. = *Q. stellata*) (Beutenmüller 1909b), and have also been reported from *Quercus durandii* Buckley (= *Quercus sinuata* Walter) and *Quercus lyrata* Walter (Weld 1959). This species fits the morphological characteristics of *Striatoandricus* such as the striated metasoma (Figs. 23–25), and is therefore transferred herein. Similar galls have been observed on iNaturalist across multiple US states surrounding the Gulf of Mexico (e.g. on *Quercus austrina* Small, iNaturalist observation 94165953), but specimens are needed to confirm the true range of *S. aciculatus*.



FIGURES 23–26. *Striatoandricus aciculatus*. 23. Holotype lateral habitus. 24. Holotype head frontal. 25. Holotype dorsal habitus. 26. Asexual generation gall.

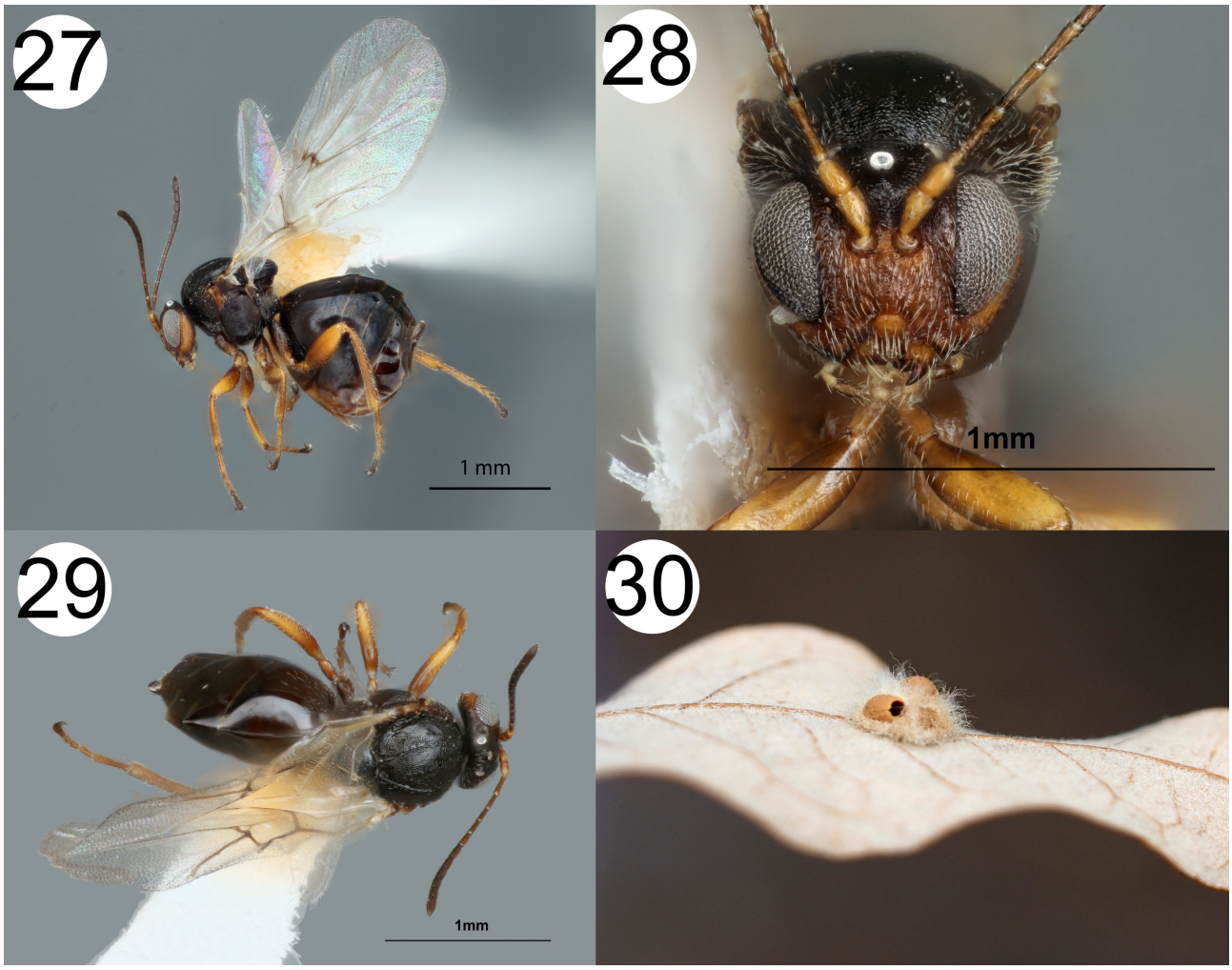
Druon gregori Melika, Nicholls & Stone 2022

Figs. 27–30

Materials examined: Other material: 2♀, TX, Big Spring, Comanche Trail Park, 32.2134, -101.4757, 17.XII.2021, ex. 25.III.2022, K. Sasan Leg., *Quercus mohriana* × *Quercus havardii*, USNM. 2♀, same information as before, UB.

Druon gregori is a new species described earlier this year in Cuesta-Porta *et al.* (2022), known only from the Santa Catalina and Chiricahua Mountains in Arizona on oaks in the Series *Leucomexicanae*. Our record (Figs. 27–30) represents both a new state record (TX), and new plant record (*Quercus mohriana* Buckley × *Quercus havardii* Rydberg hybrid, iNaturalist observation 109484892, 103440540, 103440538) for the species. Additionally, a similar

gall has been observed in New Mexico on *Quercus turbinella* Greene (iNaturalist observation 107224635), which would suggest that *D. gregori* can be found across these southwestern US states on *Leucomexicanae* oaks.



FIGURES 27–30. *Druon gregori*. 27. Lateral habitus. 28. Head frontal. 29. Dorsal habitus. 30. Asexual generation gall.

Discussion

Using iNaturalist as a tool for identification and a platform for scientific collaboration between taxonomists and citizen scientists, we described a new species of oak gall wasps in the recently resurrected *Druon*, along with state/host plant records. Cybertaxonomy and citizen science has become increasingly valuable and important in the age of rapid habitat and biodiversity loss. For example, the website Gallformers.org is a community funded database that is quickly becoming the go-to resource for North American plant galls north of Mexico, and its data is linked with iNaturalist records and scientific literature. With these resources readily available, we expect an increased rate of new gall wasp species discovery in the Nearctic region, especially in areas with a high diversity of oak species such as Texas.

Acknowledgement

We thank the staff and volunteers of iNaturalist and Gallformers.org for maintaining the wonderful platforms upon which this work was built. We would also like to thank Chang-Ti Tang, Victor Cuesta-Porta, and Juli Pujade-Villar for valuable comments on earlier drafts of the manuscript and diagnoses of *Druon* species. USDA is an equal opportunity employer and provider. Mention of trade names herein is for informational purposes only and does not reflect endorsement by USDA. YMZ is supported by Oak Ridge Institute for Science and Education (ORISE) fellowship.

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