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DESCRIPTION OF THE SEXUAL GENERATION OF *CALLIRHYTIS QUERCUSCORNIGERA* AND A NEW INQUILINE (HYMENOPTERA: CYNIPIDAE)

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ABSTRACT

The alternate, sexual generation of *Callirhytis quercuscornigera* (Osten Sacken), comb. rev. was found by experimental rearing and field observations. Descriptions of the adult, gall, biology, and host plants of the sexual generation are given. A new species of cynipid inquiline, *Ceroptres cornigera* Melika & Buss, reared from galls of the sexual and asexual generations of *Callirhytis quercuscornigera* (Osten Sacken) of the eastern United States is also described and illustrated. This is the first known species of *Ceroptres* to inhabit galls from alternating generations of its host cynipid. Descriptive data, diagnostic characters, distribution, and biological information are given.

Key Words: Taxonomy, morphology, inquiline, *Ceroptres cornigera*, horned oak gall

RESUMEN

Por observaciones de campo y cría experimental, se descubrió la generación alterna sexual de *Callirhytis quercuscornigera* (Osten Sacken), combinación revisada. Se describen el adulto, la agalla, el desarrollo y las plantas huésped de esta generación sexual. Se describe e ilustra también una especie nueva de cynípido inquilino, *Ceroptres cornigera* Melika y Buss, criada de las agallas producidas por las generaciones sexuales y asexuales de *Callirhytis quercuscornigera* en el este de los Estados Unidos. Esta es la primera especie de *Ceroptres* descrita que habita las agallas de ambas generaciones de su huésped. Se presentan datos, caracteres descriptivos, distribución e información biológica.

The greatest diversity of cynipid gall wasps (Hymenoptera: Cynipidae, Cynipini) in the world is found in the Nearctic region, especially in the United States and Mexico, with more than 600 described species. Burks (1979) listed 485 species of Cynipini in the United States, but several additional species have since been described (Melika & Abrahamson 1997a, b, 2000; Abrahamson et al. 1998a, b). However, the alternate generations are known for only a few species (Doutt 1959, 1960; Dailey & Sprenger 1973a, b; Dailey et al. 1974; Evans 1967, 1972; Lyon 1959, 1963, 1964, 1969a, b, 1970, and others).

Diagnosis. The galls of the asexual generation of *Callirhytis quercuscornigera* (Osten Sacken) are similar to those of *C. pomiformis* (Bassett), *C. punctata* (Osten Sacken), *C. quercusclavigera* (Ashmead), *C. quercuspunctata* (Bassett), *C. quercussuttonii* (Bassett), and *C. seminosa* (Bassett) (McCracken & Egbert 1922, Weld 1959, Lyon 1969b). However, the only other gall in which the larval chambers protrude externally is induced by *C. pomiformis* (McCracken & Egbert 1922).

Wasps from the tiny, blister-like leaf galls were previously known as the alternate generation (Felt 1940). These galls resemble the leaf galls in-

duced by *C. pomiformis* (McCracken & Egbert 1922), but leaf galls induced by *C. quercuscornigera* occur on the midveins, large lateral veins, and infrequently on petioles and tiny lateral veins (Eliason & Potter 1960).

Taxonomic comments. Osten Sacken (1862) first described the gall-maker, based on stem gall characteristics, as *Cynips quercus cornigera*. He later reared two specimens, a female and possibly a male, from the same gall and named the wasp *Cynips cornigera* based on the female (Osten Sacken 1865). Because species names based on gall descriptions before 1930 are valid, the appropriate name for this species is *Callirhytis quercuscornigera* (Osten Sacken 1862), **comb. rev.**

Description. Sexual generation. Female. Head, except mandible, scutum, and scutellum black; mesopleuron, propodeum, metasoma dark brown; antenna, mandible, and legs uniformly yellow brown. Head as broad as mesosoma, rounded, as high or very slightly higher than broad in front view; gena not broadened behind eye; malar space without sulcus, 3.5-3.7 times as short as eye height. Ocelli small, ocellar-ocular distance shorter than post-ocular distance; distance between antennal sockets nearly equal to diameter, shorter than dis-

tance to inner margin of eye. Head finely coriaceous, except rugose lower face; clypeus separated from face by deep depression. Antenna 14-segmented (sometimes suture which indicated F12 indistinct); scape as long as pedicel, nearly twice as long as broad; F1-F4 filiform, subsequent flagellomeres broadened (Fig. 3). Mesosoma longer than high in lateral view (Fig. 1), scutum slightly broader than long in dorsal view, alutaceous, shiny, without setae, with complete notauli, median dorsal line absent or present in a form of very short triangular depression; anterior parallel and parapsidal lines absent. Mesopleuron uniformly finely coriaceous. Scutellum elongate, longer than broad in dorsal view, finely coriaceous anteriorly, with more dull sculpture posteriorly (Fig. 2); scutellar foveae narrow with distinct carina separating them (Fig. 2). Forewing 1.4 times as long as body, pubescent, with cilia on margin, veins brown and with areolet closed; radial cell narrow, elongate, nearly 6.0 times as long as broad; cubitalis (Rs+M) joint basalis in upper $\frac{1}{3}$ (Fig. 4). Tarsal claws without basal lobe, simple. Central portion of propodeum smooth, shiny, limited by distinct lateral longitudinal carinae, which only slightly bend outward posteriorly; side of propodeum coriaceous. Metasoma smooth, shiny, slightly longer than high in lateral view, ventral spine of hypopygium short, with a few sparse white setae, its prominent part only slightly longer than broad (Fig. 1). Length 1.6-1.9 mm. Male differs from female in that head higher than broad in front view, eye larger, antenna 15-segmented, filiform throughout length; forewing darker with more dense pubescence; metasoma shorter than head and mesosoma together. Length 1.5-1.7 mm.

Material examined. The description of the sexual female and male was made on the basis of nine females and 11 males which were reared from leaf galls and labeled as "USA, Fayette Co., Lexington, Kentucky, *Q. palustris*, 6-8.06.1999, leg. E. A. Eliason". Voucher specimens were deposited in the insect collection of the Department of Entomology, University of Kentucky and in the cynipid collection of the Systematic Parasitoid Laboratory, Koszeg, Hungary.

Distribution. Canada: Ontario; USA: New York, Massachusetts, Connecticut, District of Columbia, Maryland, west to Illinois, Indiana, Montana, Iowa, Arkansas, Tennessee, Colorado, Texas, south to Virginia, North Carolina (Croatan National Forest, Carperet Co. and Camp Sea Gull, near Arapahoe, Pamlico Co., on *Q. hemisphaerica* Bartr. ex Willd. and *Q. falcata* Michaux), Alabama, Georgia. New for Florida (Archbold Biological Station, Highlands Co.; Lake Manatee State Recreation Area, Manatee Co.; Eglin Air Force Base, Okaloosa and Walton Cos.; Winegarner's property in the vicinity of De Funiak Springs, Walton Co.; Wakulla Spring State Park, Wakulla Co.—all were on *Q. hemisphaerica*.

Trees in May 1995 were heavily infested; entire branches were killed by the galls and inducers).

The asexual generation develops on *Q. incana* Bartr., *Q. imbricaria* Michaux, *Q. ilicifolia* Wangenh., *Q. laevis* Walt., *Q. nigra* L., *Q. palustris* Muenchhausen, *Q. rubra* L., and *Q. velutina* Lamarck (Weld 1959). This species was very common on *Q. hemisphaerica*, *Q. laurifolia* Michaux, *Q. phellos* L., and *Q. myrtifolia* Willd. in Florida, and on *Q. falcata* in North Carolina. Sexual leaf galls were observed on *Q. palustris* and *Q. phellos*.

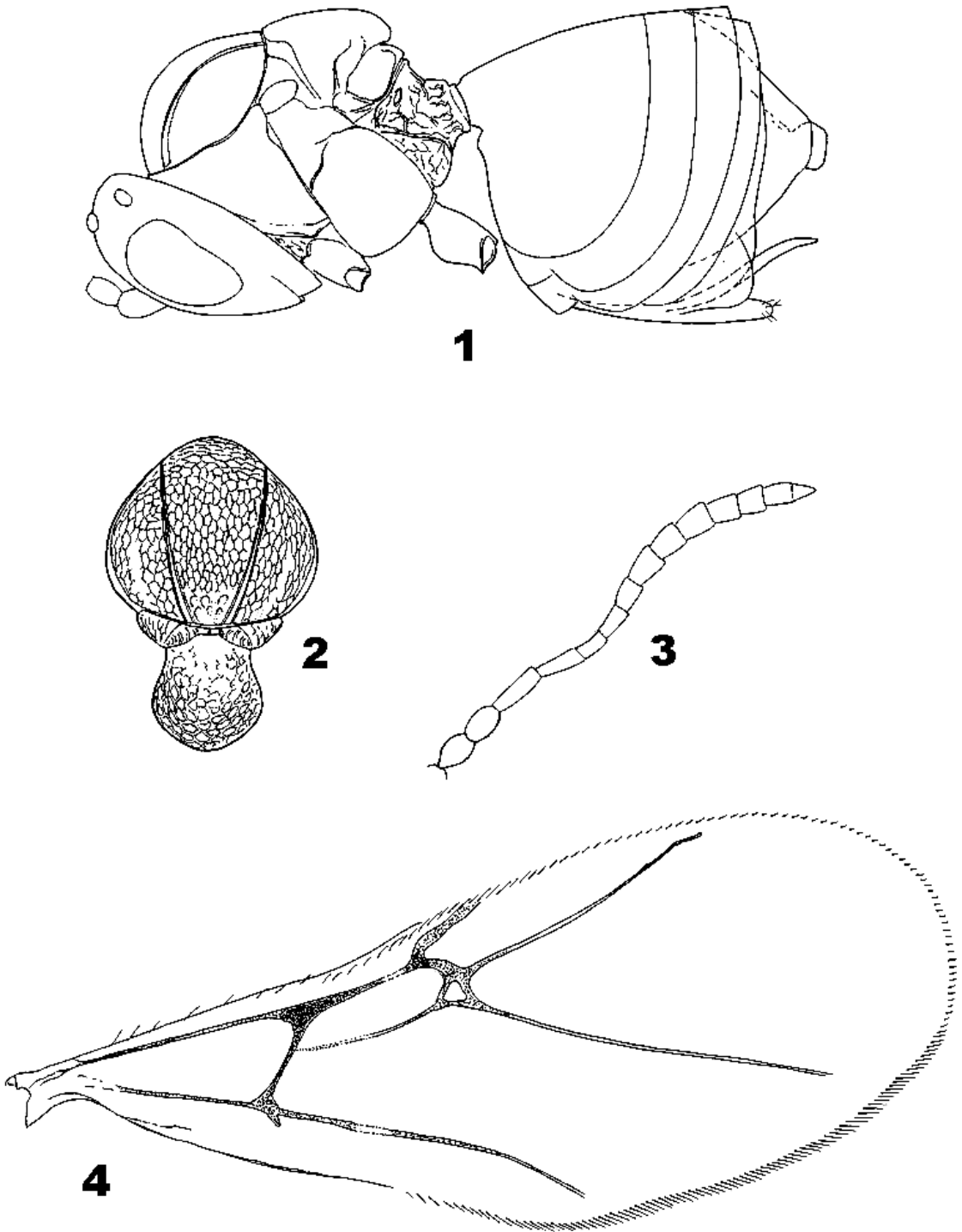
Biology. The biology of both generations of *C. quercuscornigera* was recently described in Lexington, Kentucky (Eliason & Potter 2000). Sexual females lay eggs into young shoots, and the subsequent stem galls, in which the asexual generation develops, begin visibly growing the following spring. Twelve-month-old galls appear as slight swellings on small diameter branches. Twenty-two month old stem galls are smooth in texture, green-colored externally, and the internal gall tissue is pale yellow. The larval chambers, or horns, begin to push through the thin gall epidermis when galls are ~24 months old. Horns project up to 6 mm from the rounded, succulent stem galls, and harden after about a month. One asexual *C. quercuscornigera* larva develops at the base of the larval chamber. Horns break off several months after adults chew a circular exit hole and leave the galls at bud burst in the spring.

Asexual females exit ~33-month-old stem galls and oviposit into swelling buds (Eliason & Potter 2000). Eggs are deposited next to the midvein or large lateral veins, and are slightly embedded into the leaf tissue on the abaxial leaf surface. One larva lives in each leaf gall, but two or more galls may develop next to each other. Maximum leaf gall length (~2.0 mm) occurs by late May. Larvae completely consume the moist nutritive tissue, leaving only a thin gall layer around the final instar. Pupation occurs in May and adults exit in late May or early June.

CEROPTRES CORNIGERA MELIKA AND BUSS,
NEW SPECIES
(Figs. 5-11)

We describe a new species of inquiline, *Ceroptres cornigera*, reared from galls of the sexual and asexual generations of a cynipid gall wasp, *Callirhytis quercuscornigera*, on stem and leaf galls of pin oak, *Quercus palustris*. We also include relevant biological information potentially useful in distinguishing this species from other *Ceroptres* species.

Diagnosis. Similar to *Ceroptres quercusarbus* (Fitch, 1859) and *C. quercustuber* (Fitch, 1859), both reared from stem-swelling like galls of *Callirhytis clavula* (Osten Sacken). In *Ceroptres cornigera* submedian pits on the pronotum are distinct and large, separated with a strong carina; the entire body is black, antenna and legs are bright



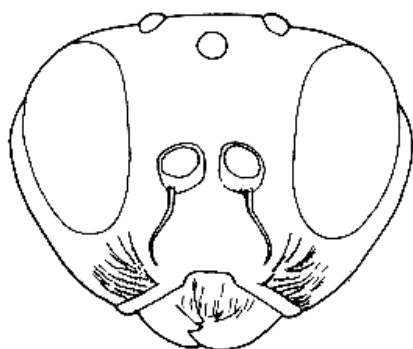
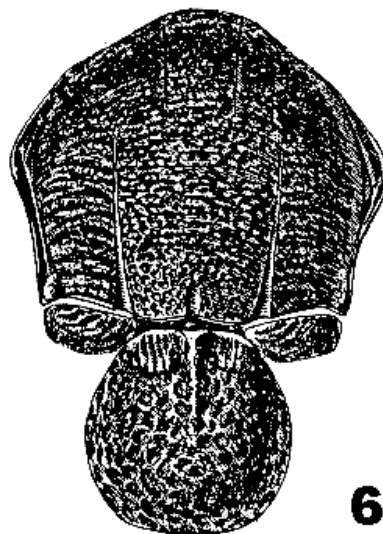
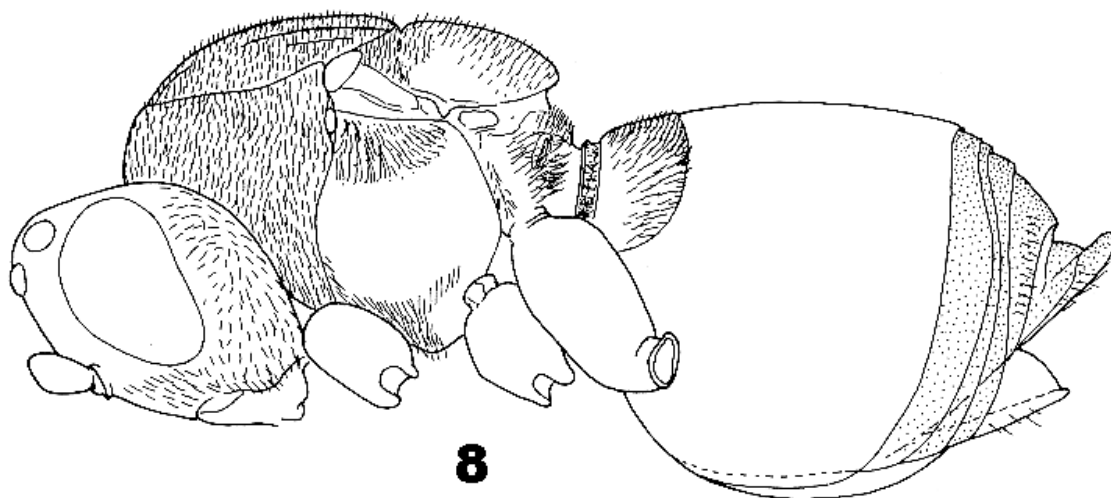
Figs. 1-4. *Callirhytis quercuscornigera*, sexual female. 1, Body, lateral view. 2, Scutum and scutellum, dorsal view. 3, Antenna. 4, Forewing (without indication of pubescence).

brown. In *C. quercusarbos* and *C. quercustuber* submedian pits of the pronotum are indistinct and separated by a weak, narrow carina; the me-

sosoma only is black, gaster brown, face and mouthparts lighter than the rest of the head; antennae and legs are yellow.

Description. Female. Head, mesosoma, and gaster uniformly black; antenna and legs bright brown. Head broader than thorax, broader than high in front view, gena very slightly broadened behind eye, indistinct striae converging toward clypeus, malar space 0.37 times eye length (Fig. 5); entire head very finely punctate, with dense

short white setae on face. Antenna 12-segmented (suture between F10 and F11 invisible), filiform; F1 very slightly longer than F2, F3 equal F2, subsequent flagellomeres progressively shorter, but F10 longer than F8+F9 (Fig. 7). Mesosoma shorter than gaster (Fig. 8); pronotum with two elliptical submedian pits with smooth shiny bot-

**5****6****7****8**

Figs. 5-8. *Ceroptres cornigera*. 5, Head of female, front view. 6, Mesosoma of female, dorsal view. 7, Antenna of female. 8, Side view of female, general.

toms, broadly separated medially. Scutum nearly as long as broad in dorsal view, finely transversely rugose, with notauli distinct in posterior $\frac{2}{3}$; median line short, anterior parallel lines distinct in anterior $\frac{1}{3}$ (Fig. 6). Scutellum rounded, rugose, with much rougher sculpture than scutum (Fig. 6). Mesopleuron smooth and shiny. Fore wing hyaline, pubescent, with cilia on margin; radial cell closed, 2.62.7 times as long as broad; veins pale yellow (Fig. 9). Tarsal claws with strong teeth. Metasoma nearly as long as mesosoma and head together, as high as long; terga 2 and 3 fused into one large segment occupying nearly whole of gaster, smooth, shiny, with white setae at the base; indistinct fine suture present between terga 2 and 3. Subsequent terga are finely punctate (Fig. 8). Ventral spine of hypopygium short, slender. Length 1.62.1 mm.

Male. Differs from female in having 15-segmented antenna, F1 slightly curved and extended proximally (Fig. 10); petiole distinct, longer than in female (Fig. 11); legs and antenna lighter. Length 1.5-1.8 mm.

Types. Holotype female from Lexington, Fayette Co., Kentucky, from asexual galls of *Callirhytis quercuscornigera*, collected on *Quercus palustris* (Muenchhausen), 21 April 1998, emerged 18 May 1998. Also 17 female and 18 male paratypes from the same locality, from sexual and asexual galls of *C. quercuscornigera* on *Q. palustris*. Holotype, 5 female and 5 male paratypes in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM); 5 female and 5 male paratypes in the American Museum of Natural History, New York City (AMNH); 2 female and 3 male paratypes in the Department of Entomology, University of Kentucky, and 5 female and 5 male paratypes in the collection of Systematic Parasitoid Laboratory, Koszeg, Hungary.

Material examined. We examined two similar *Ceroptres* species from the eastern USA, *Ceroptres quercusarbores* and *C. quercustuber*, known as inquiline in stem swelling-like galls of *Callirhytis clavula*. The type material for the first species, deposited in the USNM, was destroyed with only Fitch's original label remaining without an insect on the pin. Barnes (1988) mentioned only one type locality for this species: "Salem, NY, 28.iii.1857, irregular knobs from tips of twigs of white oak in brother Harvey's field, south of Battle Hill, placed in vial, small *Cynips* found dead, May 27th". Five females and three males of *C. quercusarbores* from the USNM, labelled as "Ag. Coll. Mich.", "Collection Ashmead" were examined. Syntypes of *C. quercustuber*, deposited in the USNM, were examined. They were mounted on one pin (1 female and 1 male, the third insect totally destroyed) and labeled as "Fitch's Type", Fitch's Coll., red "Type No 1809 USNM," and a handwritten label "*Cynips Quercus tuber*, Fitch." Barnes (1988) gave the next type locality "Salem,

NY, 19.iv.1859, find several of these galls on Titus's Hill." Five females and one male from the USNM were also examined. Two females are labeled as "Accession No 6032d AD Hopkins W. Va., "*Ceroptres tuber* Fitch;" 1 female as "N. Brunsw. NJ", "Coll. Ashmead", "*Ceroptres tuber* Fitch;" 1 female "Portsmouth, 6.28.97;" 1 female "Riley Coll., Marlat", "*Ceroptres tuber* Fitch," and 1 male "Toronto, Ont.," "*Ceroptres tuber* Fitch".

Ceroptres quercusarbores was described by Fitch (1859) on the basis of one male as "a small black gall-fly having all its legs and antennae of a bright pale yellow color." This is the only description of the wasp given by the author. Such a coloration is typical for nearly all *Ceroptres* species. Fitch (1859) described *Ceroptres quercustuber* as "a small black gall-fly with dull pale yellow antennae, mouth and legs, its hind shanks and its antennae towards their tips being dusky, its length 0.08 and to the tips of its wings 0.13". This species was described on the basis of both the female and male. Fitch (1859) thought that he had described the gall-inducing insects, but they were inquilines.

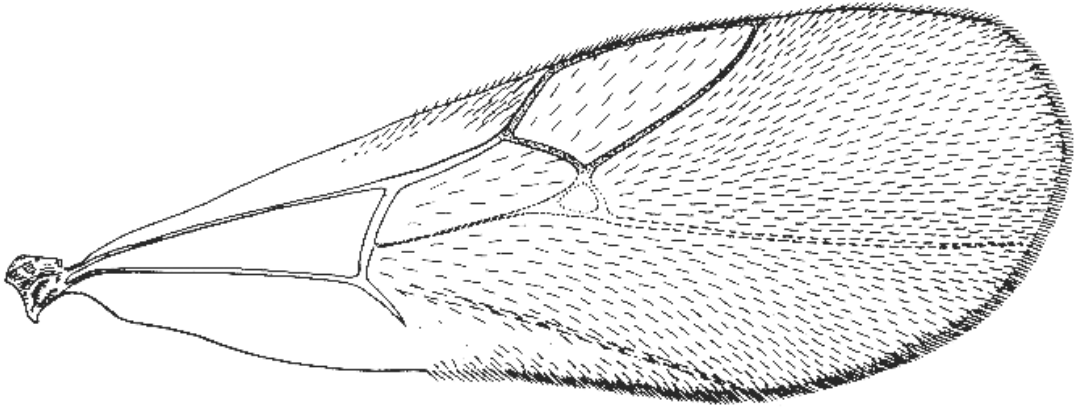
Other *Ceroptres* species known from the eastern USA differ strongly from this new species not only in the morphology of the adults, but also in their distribution and trophic associations. Thus, we did not compare the new species to them.

Distribution. Kentucky (Fayette Co., Lexington).

Etymology. Named from the host gall, *Callirhytis quercuscornigera*, from which it was reared.

Biology. Members of this species are inquilines in galls of the asexual and sexual generations of *Callirhytis quercuscornigera*, which associates with *Q. palustris* and other red oaks (Burks 1979).

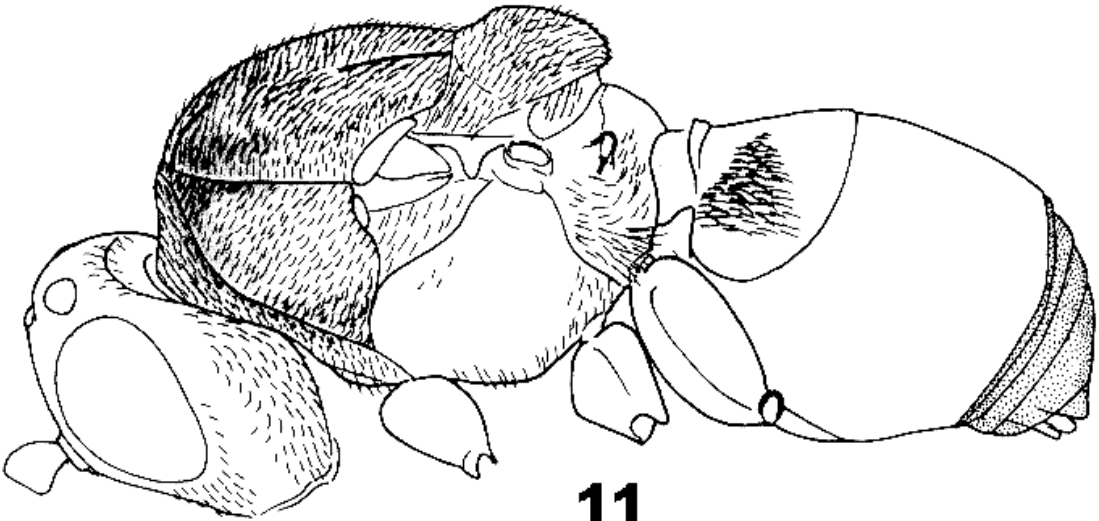
Ceroptres cornigera is one of several inquilines and opportunistic insects living within stem galls, but it is the only inquiline of the leaf galls. It is the first known species of *Ceroptres* to inhabit galls from both alternating generations of its host cynipid. *Ceroptres cornigera* larvae develop in the succulent tissue below a *Callirhytis quercuscornigera* larval chamber in young stem galls. It is uncertain whether or not this inquiline contributes to gall-maker mortality. Twenty-four female and 17 male *Ceroptres cornigera* adults emerged from stem galls collected in spring 1998. Most galls from which *Ceroptres* adults emerged (219 adults from 86 galls reared in 1999) lacked external horns and were of small diameter (2.5 ± 0.1 cm). However, horns typically protrude when galls are 25 months old. Adults may live as many as 6 days without a water or sugar source. Mean female body length is 2.2 ± 0.1 mm, and mean ovipositor length, when dissected and uncoiled, is also 2.2 ± 0.1 mm (Eliaeson & Potter 2000). When adults emerge in May, female ovaries are not fully mature, and may contain >100 eggs per female.



9



10



11

Figs. 9-11. *Ceroptres cornigera*. 9, Forewing of female. 10, Antenna of male. 11, Side view of male, general.

Individual *Ceroptres cornigera* develop in each leaf gall, and kill the gall-maker larva while feeding on the succulent gall tissue. In 1998, more than 1000 leaf galls were placed in individual

transparent gelatin capsules in the laboratory. Of the 713 galls from which wasps emerged, 37.3% were *Ceroptres cornigera* (138 female, 128 male). Adults may live as many as 4 days without a wa-

ter or sugar source. When adults emerge in June and July, female ovaries are not fully mature (Eliaison & Potter 2001).

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