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Description of the sexual generation of *Trichagalma acutissimae* (Hymenoptera: Cynipidae) and notes on its heterogonic life cycle

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ABSTRACT

The adults and galls of the sexual generation of the oak gall wasp *Trichagalma acutissimae* (Monzen, 1956) (Hymenoptera: Cynipidae) (=*T. glabrosa* Pujade-Villar n. syn.) are described for the first time. The heterogonic life cycle of *T. acutissimae* has been established experimentally in a field trial. We also provide information on the taxonomy, biology and host plant. A key to species of *Trichagalma* including both sexual and asexual generation is given.

Introduction

The oak gall wasps (Hymenoptera: Cynipidae: Cynipini) are the most species-rich group of gall wasps, including about 1000 species in 25 genera worldwide (Ronquist, 1999; Liljeblad, 2002; Stone et al., 2002; Abe et al., 2007; Pujade-Villar and Wang, 2012) gall wasps induce galls on the twigs, roots, and buds of oaks, belonging to the family Fagaceae (mostly *Quercus* (oak trees), but also *Castanea*, *Chrysolepis* and *Lithocarpus*) (Ronquist et al., 2015). In China, there is a large variety of *Quercus*, *Castanea*, *Chrysolepis* and *Lithocarpus*, but the gall wasp taxonomy and biology is poorly understood in this region (Abe et al., 2007, 2014; Wang et al., 2010, 2013; Tang et al., 2011; Zhu et al., 2015). The main reason for this study is not only to have more information of an understudied area, but also, as most oak-galling cynipids are heterogonic (Stone et al., 2002; Abe et al., 2007), to have more knowledge of the existing fauna.

Two altering generations occur, one is sexual (with males and females) and the other is asexual (only females), both generations have to alter in order to close the cycle; the sexual galls are different to the asexual ones and also the female adult wasps morphology is different (Pujade-Villar et al., 2001; Nieves-Aldrey, 2001; Stone et al., 2002; Melika, 2006; Pujade-Villar, 2013).

Trichagalma is a small group of gall wasps, which includes 3 species: *T. formosana* Melika & Tang, *T. serratae* (Ashmead) and *T. acutissimae* (Monzen) (after considering here *T. glabrosa* Pujade-Villar as the same species of *T. acutissimae*). Only distributed in Eastern Asia (Melika et al., 2010; Pujade-Villar and Wang, 2012), the heterogonic life cycle was only described in *T. serratae* with a description of its sexual generation (Abe, 2006).

Trichagalma acutissimae originally described as *Aphelonyx acutissimae* (Monzen, 1953). Melika et al. (2010) transferred this species from *Aphelonyx* to *Trichagalma*. Asexual generation of *T. acutissimae* was only described, and asexual adults emerge from their galls in late November to December (Melika et al., 2010), but they could not live through winter. A few branches of *Q. variabilis* were caged with nylon bags at the end of March 2012, at Shuihe Village, Linzhou City, Henan Province, China. Galls of asexual of *T. acutissimae* appeared only on leaves without bags instead of those with bags. This indicated that there must be adults of sexual generation of *T. acutissimae* after the end of March. For this reason, the main objectives of field trial were to study the life cycle and demonstrate that the populations have alternating generations between sexual and asexual generations.

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Materials and methods

Morphological study

Terminology of morphological structures mainly follows Richards (1977), Ronquist and Nordlander (1989), Melika (2006) and Liljeblad et al. (2008); description of surface sculpture mainly follows Harris (1979).

Abbreviations for the fore wing venation follow Ronquist and Nordlander (1989). Abbreviations used in this paper include: F1–F12, 1st and subsequent flagellomeres; POL (post-ocellar distance) is the distance between the inner margins of the posterior ocelli; LOL, the distance between lateral and frontal ocelli; OOL (ocellar-ocular distance) is the distance from the outer edge of a posterior ocellus to the inner margin of the compound eye.

The environmental scanning electron microscope (ESEM) pictures were taken with a FEI Quanta 200 (USA) at a high voltage (15 kV) and without coating, in order to preserve the specimens for sexual generation; and with a Stereoscan Leica-360 at a low voltage (700 V) and without coating for asexual generation, according to Pujade-Villar and Wang (2012).

The insect material studied is deposited in the Department of Plant Protection, Henan Institute of Science and Technology; and Anyang Institute of Technology, China.

Field experiment

Galls of *T. acutissimae* were collected in July 2013 at Shuihe Village, Linzhou City, Henan Province, China. Collected galls were placed in five plastic containers with vented mesh lids for emergence of the asexual generation of *T. acutissimae*. Each container was about 2000 cm^3 with 2 cm damp sand covering the bottom. In early October 2013, five not-yet-flowering young oak trees *Q. variabilis* (three to 5 years old) and five mature oak trees (fifteen to 20 years old) were chosen for caged branches studies. On each tree, two gall-free branch tips 50–70 cm long were caged using bags of fine white nylon mesh. In late November and December, tens of emergent asexual females from the collected galls were released onto only one of two caged branches on each tree, leaving the other caged branch wasp-free on each tree as control treatment.

Five branches from a same oak tree (*Q. variabilis*) were caged with mesh bags in late March 2014. There was no leaf and flowers on these caged branches yet. In mid-April, galls from the previously caged gall-

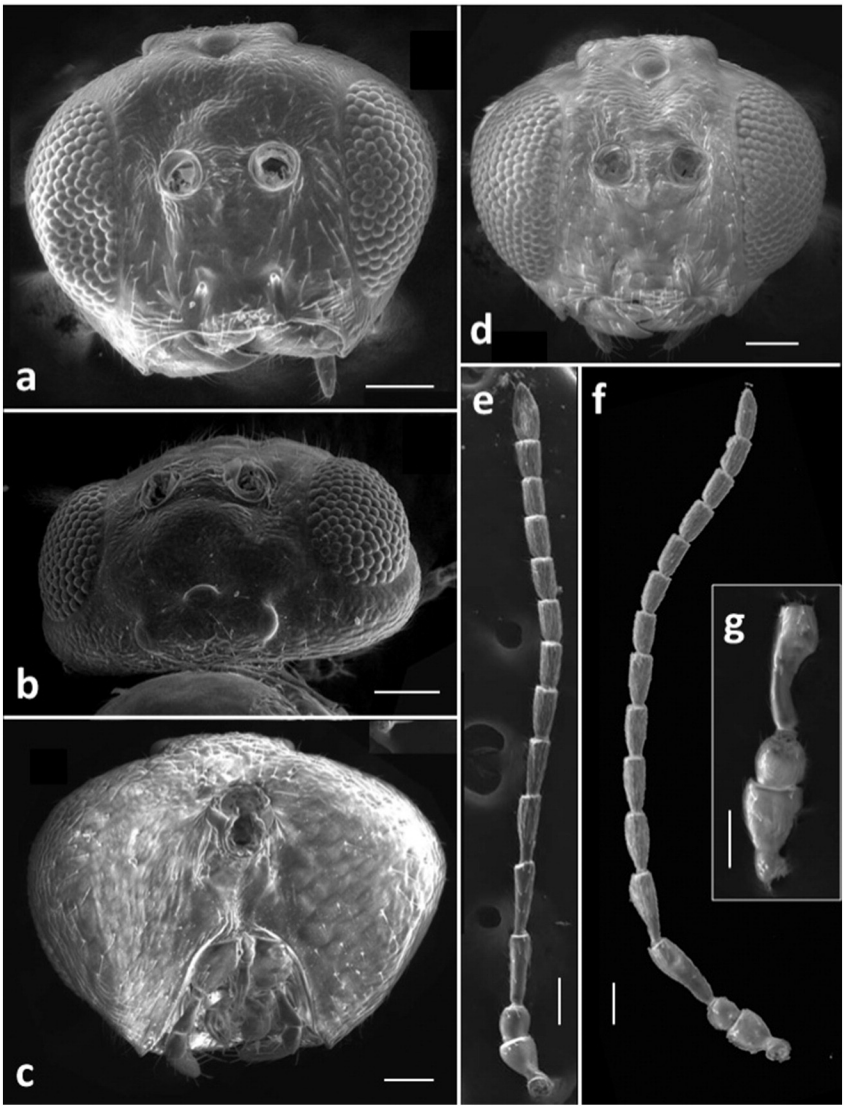

Fig. 1. Sexual generation of *Trichagalma acutissimae*, (a) female head in frontal view, (b) female head in dorsal view, (c) female head in posterior view, (d) male head in frontal view, (e) female antenna, (f) male antenna, (g) detail of first antennomeres. Scale bars: 0.1 mm.