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## Successful Colonization of a New Invasive Pest, the Chestnut Gall Wasp *Dryocosmus kuriphilus* (Hymenoptera: Cynipidae), in Taiwan 【Scientific note】

### 新發生外來種害蟲板栗瘿蜂於臺灣成功拓殖【科學短訊】

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### Abstract

*Dryocosmus kuriphilus* Yasumatsu, a global invasive pest of chestnuts, was first recorded in 2010 in Taiwan, its lowest latitude distribution in the northern hemisphere. The growth of galls induced by this insect pest disrupts the development of young shoots on chestnut trees and reduces fruit production. To monitor its occurrence in Taiwan, field surveys conducted between November 2012 and March 2013 revealed that this chestnut gall wasp occurs within a wide range of elevations, from ca. 220 m in Chiayi County to ca. 2100 m in

Nantou County. They were found on two chestnut species, *Castanea mollissima* Blume and *C. crenata* Siebold & Zucc. Photographs illustrating the morphological characters of this adult gall wasp and the appearance of the galls are provided. The significance of this occurrence in Taiwan is discussed.

Follow-up field surveys and control trials are ongoing.

### 摘要

栗樹的全球性入侵害蟲板栗瘿蜂 (*Dryocosmus kuriphilus* Yasumatsu) 於2010年首次在台灣被記錄。此害蟲誘發蟲瘿生長，阻斷新梢之發育並導致果實減產。為監測此害蟲在台灣發生之情形，於2012年11月至2013年3月執行田間調查，結果顯示板栗瘿蜂發生之海拔範圍變化幅度大，於嘉義縣約220 m，於南投縣約2,100 m。寄主植物有兩種，包括板栗與日本栗。本文提供彩色圖版說明瘿蜂成蟲形態特徵與蟲瘿外觀，同時探討此蟲在台灣發生的特性，進一步的田間調查與防治試驗刻正進行中。

**Key words:** *Dryocosmus kuriphilus*, chestnut, *Castanea mollissima*, *Castanea crenata*

**關鍵詞:** 板栗瘿蜂、栗樹、板栗、日本栗

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# Successful Colonization of a New Invasive Pest, the Chestnut Gall Wasp *Dryocosmus kuriphilus* (Hymenoptera: Cynipidae), in Taiwan

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## ABSTRACT

*Dryocosmus kuriphilus* Yasumatsu, a global invasive pest of chestnuts, was first recorded in 2010 in Taiwan, its lowest latitude distribution in the northern hemisphere. The growth of galls induced by this insect pest disrupts the development of young shoots on chestnut trees and reduces fruit production. To monitor its occurrence in Taiwan, field surveys conducted between November 2012 and March 2013 revealed that this chestnut gall wasp occurs within a wide range of elevations, from ca. 220 m in Chiayi County to ca. 2100 m in Nantou County. They were found on two chestnut species, *Castanea mollissima* Blume and *C. crenata* Siebold & Zucc. Photographs illustrating the morphological characters of this adult gall wasp and the appearance of the galls are provided. The significance of this occurrence in Taiwan is discussed. Follow-up field surveys and control trials are ongoing.

**Key words:** *Dryocosmus kuriphilus*, chestnut, *Castanea mollissima*, *Castanea crenata*

## Introduction

### The global invasion history of *Dryocosmus kuriphilus*

Human activities, including the exchanging of goods, have facilitated many biological invasions. Many cases have shown that the introduction of exotic organisms into an environment that provides no natural enemies or diseases to

that organism result in the rapid growth and spread of that organism, causing great economic and environmental damages (Ricciardi, 1998; Pimentel *et al.*, 2005; Ascunce *et al.*, 2011). The chestnut gall wasp *Dryocosmus kuriphilus* Yasumatsu (Yasumatsu, 1951) (Hymenoptera: Cynipidae: Cynipini) is a notorious invasive pest. While the majority of species in the tribe Cynipini induce galls on the genus *Quercus* L. in the family Fagaceae, *D.*

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*kuriphilus* is the only species that induces galls on different species of chestnut (*Castanea* Mill., Fagaceae) (Csóka *et al.*, 2005). *Dryocosmus kuriphilus* is native to mainland China, but was accidentally introduced into many countries. After its first outbreak in Japan in 1941 (Yasumatsu, 1951; Moriya *et al.*, 2003; Aebi *et al.*, 2006), it spread over all of Japan within 25 years (Oho and Shimura, 1970). In the following decades, it reached the Asian countries adjacent to China, as well as countries in Europe, the USA and Canada (Aebi *et al.*, 2006; Abe *et al.*, 2007; Rieske, 2007; Huber and Read, 2012). Chestnut galls were observed in 2010 in Taiwan, a region with only a short history of commercial cultivation of chestnut. The infestation of *D. kuriphilus* can cause significant yield loss, with up to 80% reduction of fruit yield recently reported in China (EFSA Panel on Plant Health, 2010).

#### **Known biology of *D. kuriphilus***

*Dryocosmus kuriphilus* is univoltine and parthenogenetic (Moriya *et al.*, 2003; Aebi *et al.*, 2006; Abe *et al.*, 2007). Females lay eggs in the dormant buds of chestnut trees during the summer, leaving visible scars of oviposition on a small portion of buds (ca. 25% of infested buds in orchards and ca. 12% in copse wood) (Bernardo *et al.*, 2012). A dissection of infested buds reveals a proliferation of meristematic tissues and a red coloration of the surrounding tissues triggered by secretions from the eggs of *D. kuriphilus* (Bernardo *et al.*, 2012). The first-instar larvae hatch in 30-40 days and the larval growth continues slowly through autumn and winter (EPPO, 2005). The fast growth of the larvae the following spring results in a simultaneous and rapid development of galls (Fig. 1A) synchronized with the flushing of the host plants. Galls are either multi-chambered or single-chambered with a larva inhabiting each

chamber. Gall emergence can interrupt growth of shoots and blossoms on the trees. As a result, the yield of fruits is decreased, and severe infestations can even be fatal to the host plant.

#### **Adult morphology**

Adult body of *D. kuriphilus*, 2.5~3.0 mm long, black and glabrous (Fig. 1B). The legs, scape and pedicel of antenna and mouth parts are yellow. Antenna has 12 flagellomeres with similar diameter without forming a club at the tip (Fig. 1C). A pair of impressed notauli run longitudinally across the entire length of the mesoscutum from the margin between mesoscutum and pronotum, and converge posteriorly at the margin between mesoscutum and mesoscutellum (Fig. 1D). A pair of lateral propodeal carinae are present on the propodeum, with a longitudinal carina at the center (Fig. 1E). The prominent part of the ventral spine is short, not longer than the valves of the hypopygium, with setae forming a tuft at the apical (Fig. 1F). The surfaces of the mesoscutum, mesopleuron, and metasoma are smooth, while the head, mesoscutellum, and propodeum are sculptured.

#### **Chestnut in Taiwan**

There is little information on the history of chestnut cultivation in Taiwan. However, based on the local folklore, it can be traced back to more than a century ago. These plants, introduced into Taiwan from Japan (the Japanese chestnut *Castanea crenata* Siebold & Zucc.) and mainland China (the Chinese chestnut *C. mollissima* Blume) in the late 1800s or early 1900s, were sparsely planted around Taipei, Hsinchu, Nantou, Chiayi, Kaohsiung, and Taitung (Liao, 1996). The chestnut industry remains relatively limited in terms of cultivated area and production. At present there are approximately 40 acres of chestnut trees with an annual

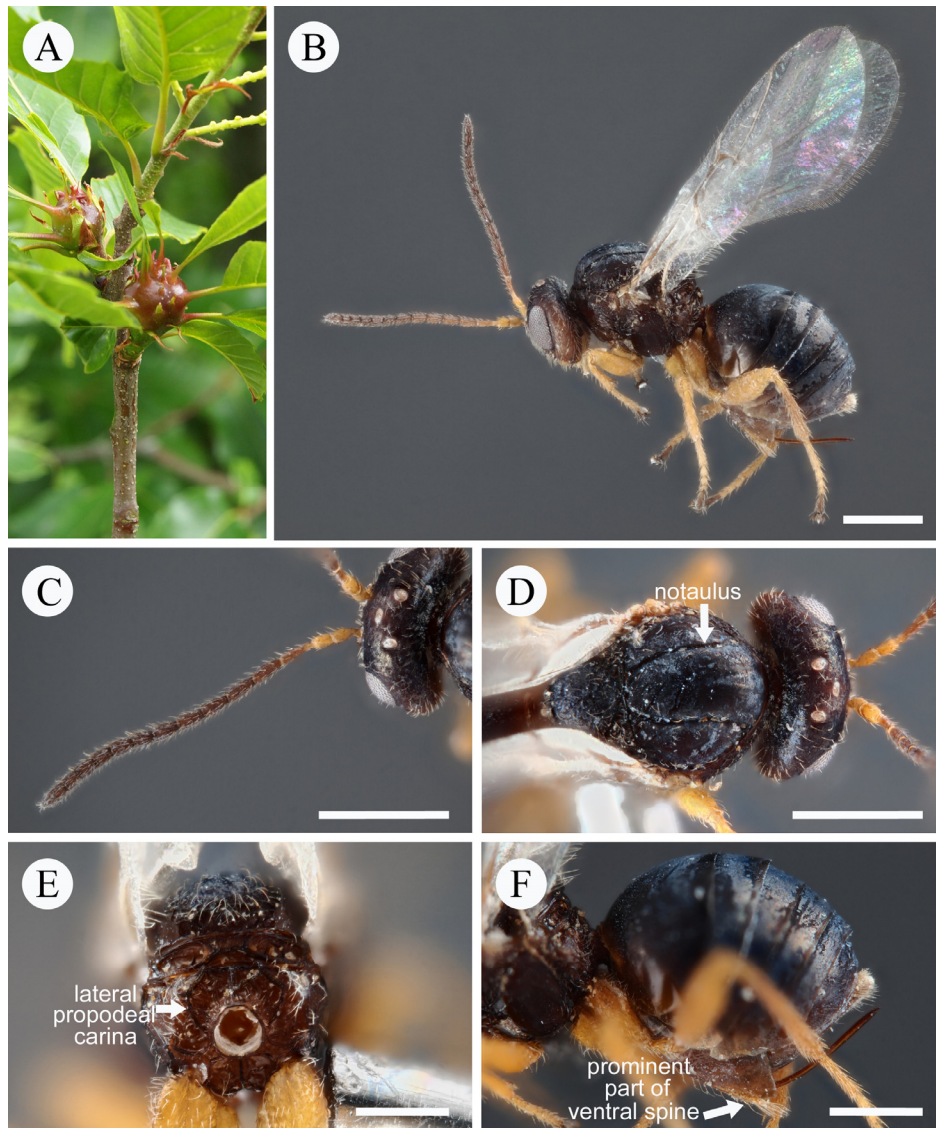


Fig. 1. *Dryocosmus kuriphilus*, asexual female collected in Taiwan: A, galls; B, habitus, lateral view; C, antenna, dorsal view; D, head and mesosoma, dorsal view; E, propodeum, posterior view; F, metasoma, lateral view. Scale bar = 0.5 mm in B-D, scale bar = 0.25 mm in E, F.

production of ca. 60 tons in Chungpu Township in Chiayi County, which is the lowest latitude (N23°) known for chestnut plantations in the northern hemisphere. These “golden chestnuts” as they are called by the local people have a distinct flavor and color. They taste rather sweet and are often seasoned with salt rather

than with sugar. Due to their special taste and rarity, the demand exceeds the supply in the local markets. Considering that the chestnut gall wasp has proven to be a devastating invasive pest in other countries, it is important that we take effective action to protect this unique industry in Taiwan. When this pest was

also detected on *C. crenata* on the edge of the primary forest at Beidongyen mountain in Nantou County in mid-2012, we immediately carried out intensive surveys throughout the entire region in order to understand its distribution and host range. Examination of museum collections also found the earliest record of *D. kuriphilus* in 2010 on *Castanea mollissima* in Taiwan (Taiwan Forestry Research Institute collection, 2010; collected by GS Tung). Training courses were then provided as a first control measure, to help growers remove galls whenever they detected any in their orchards.

### Distribution in Taiwan

Field surveys covering Hsinchu, Nantou, Chiayi, and Taitung counties, were conducted to monitor the occurrence of *D. kuriphilus* and to record its hosts in Taiwan from November 2012 to March 2013. Chestnut plants showing *D. kuriphilus* galls were recorded and identified. The elevation of each location was recorded using GPS map 60CSx, GARMIN. All specimens examined were deposited in the insect museum of National Chung Hsing University (NCHU).

Galls were found on chestnut plants in a wide range of elevations, from 220 m to 2100 m, with the distribution being confined to two counties, Chiayi and Nantou, in central Taiwan (Fig. 2). Two species of host plants that were being attacked by these chestnut gall wasps were identified. The host plant attacked the most, *C. mollissima*, was found at 5 sites (sites 1-5, Fig. 2). Both site 1 (23°26' N, 120°34' E, 220 m a.s.l.) and site 2 (23°24' N, 120°33' E, 348 m a.s.l.) are located in Chungpu, Chiayi County. While site 1 is a monoculture orchard, site 2 has cultivated chestnut trees that are sparsely mixed with betel nut. In site 3 at Dapu (23°22' N, 120°33' E, 343 m a.s.l.) and site

4 at Fanlu (23°26' N, 120°38' E, 719 m a.s.l.) both also located in Chiayi County, the chestnuts cultivated are sparsely mixed with betel nut as well. Site 5, which is located in downtown Puli Township, Nantou County (23°58' N, 120°58' E, 465 m a.s.l.) has chestnut trees growing on the side of the roads as ornamental chestnut trees. Chestnuts in site 6, Guoshing Township, Nantou County (Fig. 2; 24°05' N, 120°51' E, 738 m a.s.l.) have been cultivated for the past 7 years, and were raised from acorns. Here the infestation of *D. kuriphilus* was only detected in 2015. This case represents the first known example of the inland spread of *D. kuriphilus*. The other host, *C. crenata*, was recorded on the edge of the primary forest on Beidongyen mountain (site 7, Fig. 2; 24°04' N, 121°07' E, 2,100 m a.s.l.), a highland agricultural experimental station of National Chung Hsing University in Nantou.

### The significance of *D. kuriphilus* colonization in Taiwan

After *D. kuriphilus* spread across the borders of China, it colonized in many countries in the temperate zone of the northern hemisphere. In these invaded regions, *D. kuriphilus* remained univoltine. However, in Taiwan we observed highly variable times of emergence by the adults. Taiwan is an island that spans the Tropic of Cancer and the approximately 36,000 km<sup>2</sup> land area is divided into the sub-tropic and tropic climate zones. The climate conditions in Taiwan usually cause occasionally enhanced temperatures (> 25°C) during the winter which often induces a small amount of dormant buds on deciduous chestnuts to sprout. In some fields galls were observed to grow during the winter, between mid-November and early February. This is in contrast to the well-known univoltine life cycle of *D. kuriphilus* where the gall formation is synchronized with the bud burst in spring,

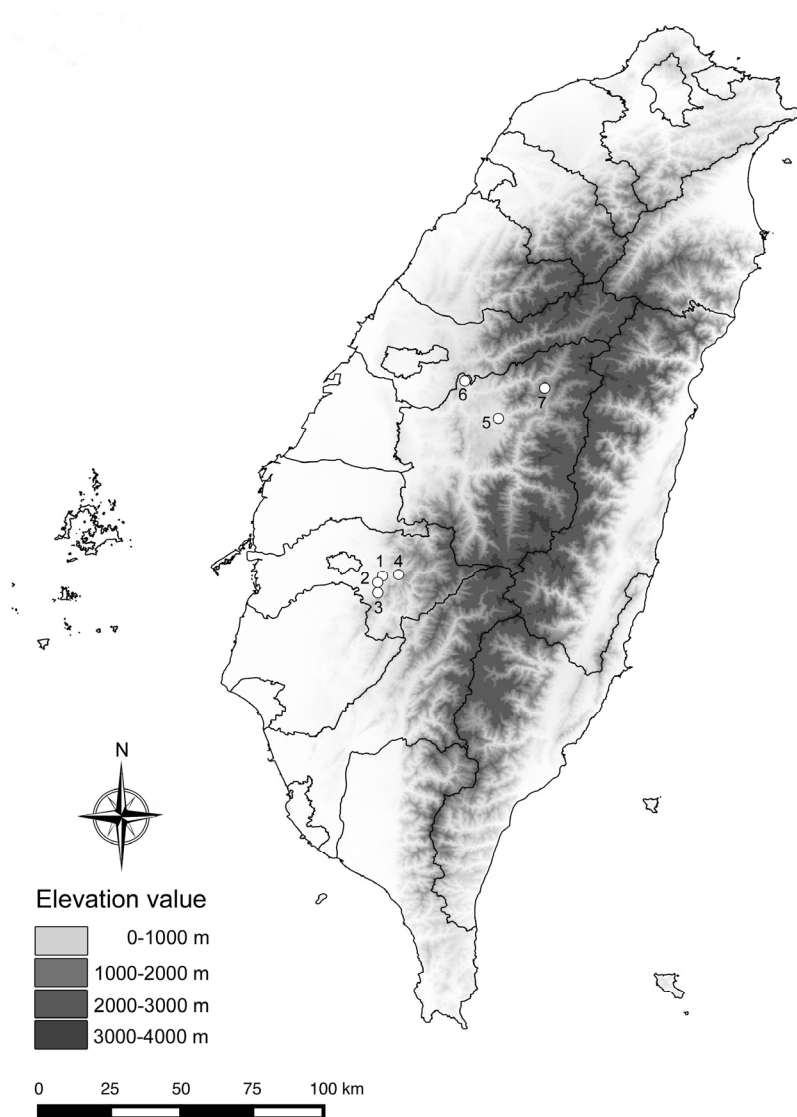


Fig. 2. Distribution of *D. kuriphilus* in Taiwan. Site 1: chestnut orchards in Chungpu, Chiayi county, site 2: Chungpu, Chiayi County, site 3: Dapu, Chiayi County, site 4: Fanlu, Chiayi County, site 5: Puli downtown Nantou County, site 6: Guoshing Township, Nantou County, and site 7: Beidongyen mountain, Nantou County.

which in Taiwan is around March. The early gall growth during winter is apparently aberrant, but it does suggest that more than one generation could occur in Taiwan. The Australian eucalyptus gall wasp (*Leptocybe invasa* Fisher and La Salle) has been reported to invade many countries. A shorter developmental period

of approx. 60 days, was reported in tropical India compared to the Israel and Iran, which are both located at a higher latitude, which reported a developmental period of 126-138 days (Mendel *et al.*, 2004; Hesami *et al.*, 2005; Kumari *et al.*, 2010). Considering that the aberrant development of *D. kuriphilus* was observed during three

consecutive winters (2012-2014) in Taiwan, a long-term and extensive field survey will provide answers to whether this is obligate or facultative, and whether the insect performs a plasticity in life history to adapt to their subtropical environment.

### Ongoing phytosanitary measures

Simberloff *et al.* (2005) stated that eradicating a new pest, when it is still confined to a limited region, could be effective. As soon as this gall wasp was detected, the Bureau of Animal and Plant Health Inspection and Quarantine (BAPHIQ) alerted the growers. Lectures were given on galling biology of *D. kuriphilus* and guidelines were provided to remove the new pest by pruning fresh galls or epicormic shoots. However, eradication is both costly and difficult to accomplish, especially for an insect capable of parthenogenesis. In addition, routine movement of plant materials often increases the probability of dispersal of *D. kuriphilus* (EPPO, 2005). For the long-term management of *D. kuriphilus*, several measures should be taken, including a study of its biology in Taiwan, monitoring its impacts on the economy and the environment, investigating native natural enemies as potential agents for biological control, and avoiding transplantation of infested seedlings.

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# 新發生外來種害蟲板栗癭蜂於臺灣成功拓殖

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## 摘 要

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