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Short Communication

Damaging Effect of Gall-Forming Insects (Diptera: Cecidomyiidae) on *Castanopsis hystrix* in China

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ABSTRACT

Damaging effect of two species of gall midges (Diptera: Cecidomyiidae) have been investigated on *Castanopsis hystrix* Miq. (Fagales: Fagaceae) in Pubei County of Guangxi, China were investigated from December 2012 to December 2013. *Jaapiella* sp. damaged leaves, while *Contarinia* sp. damaged stems and leafstalks. The damage ratio and the index of *Jaapiella* sp. in December 2012, March, July and December 2013 were 9.7±2.0%, 14.8±1.9%, 24.1±1.5%, 12.3±0.6% and 25.6%, 31.3%, 35.6%, 26.2%, respectively, while those of *Contarinia* sp. were 33.2±3.4%, 38.4±4.3%, 43.2±3.1%, 31.6±3.5% and 29.6%, 30.9%, 36.0%, 30.9%, respectively. The results will provide essential information to develop strategies that can be used for their control.

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Authors' Contributions
XLZ, ZHX and ZDY conceived and designed the study, and wrote the article. XHY identified the species. WL analyzed the data.

Key words
***Castanopsis hystrix*, Gall midge, *Jaapiella* sp., *Contarinia* sp., Damage ratio, Damage index.**

Numerous microorganisms and arthropods interact intimately with plants and induce a specialized structure-galls. The cecidogenous parasites are especially common among insects with more than 13,000 known gall-forming species from several orders (Raman *et al*., 2005; Raman, 2012). Many hypotheses on the formation of insect-galls were summarized including nonadaptive, plant protection, mutual benefit, nutrition, microenvironment and enemy hypotheses (Price *et al*., 1987). Although the theoretical studies are helpful for understanding the interaction between plants and gall-forming insects, problems of practical crop protection are also important.

Castanopsis hystrix Miq. (Fagales: Fagaceae: *Castanopsis*) is one of the most important species of south subtropical evergreen broad leaved forest in southern provinces of China as well as Vietnam, Laos, Cambodia, Burma, Nepal, Bhutan, and India (Kayini and Pandey, 2010; Xu *et al*., 2013). These trees can be used for furniture, shipbuilding and military industry based on many merits, including fast growth, ironwood, stem straightness, strong adaptability, corrosion resistance, *etc.* (Xu *et al*., 2013). Therefore, *C. hystrix* became an important species of plantation. In China, the largest area of natural forest and plantation (approximately 1.3×10^5 km^2) of *C. hystrix* is located at Pubei County of Guangxi Zhuang Autonomous Region (Gan and Liu, 2014). The number of pest species sharply increased with the expansion of the cultivated area of this tree. Among of the pest species, gall-forming insects are the most important. Understanding the species and damage status of gall-forming insects on *C. hystrix* will provide essential information to develop strategies that can be used for their control.

The objective of this study is to investigate (a) the species composition of gall-forming insects on *C. hystrix* and (b) the damage status of these insects.

Materials and methods

The study was conducted in Pubei County (22°16′ °N, 109°33′ °E) located at the south of Guangxi Zhuang Autonomous Region in China (annual-average air temperature 21.5 °C and precipitation 1,760 mm). The natural forests and plantations of *C. hystrix* in Pubei County are the largest in China so that the protection is important. By the end of 2012, few large plantations of *C. hystrix* were developed at Longmen, Beitong, Dacheng and Zhanghuang towns in Pubei County.

To find out the species composition and damage status of gall-inducing insects on *C. hystrix*, sampling surveys were conducted in the Maojia village (109.25′ °E, 22.09′ °N), Zhongnan village (109.25′ °E, 22.08′ °N) and Liutonglu village (109.26′ °E, 22.10′ °N), in December 2012, March, July and December 2013, respectively. Three

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sampling sites were established in each village, and the area of each site was 10,000 m^2. Five-plot sampling model was adopted, and the area of each plot was 500 m^2. A total of 200 trees was investigated in each plot. Morphological characteristics of insect-galls and damage symptoms of gall-inducing insects were taken with a digital camera (Sony HX60, Sony Corporation, Tokyo, Japan). The species of gall-inducing insects, the number of damaged trees and the damaged degree of each tree were recorded. The damage was divided into five levels (Table I). The classification critera of each degree of damage were (a) the number of insect-galls per meter of stem and (b) the number of damaged leaves per 100 leaves. Both criteria were correlated and enabled unequivocal distinguishing of the degree of damage in all observed cases.

Table I.- Damage degree of gall-induced insects on *Castanopsis hystrix*.

Damage degree	No. of insect galls/m of stem	No. of damaged leaves/100 leaves
0	0	0
I	1-5	10-20
II	6-10	21-30
III	11-15	30-40
IV	>15	>40

The damage ratio and the index of gall-inducing insects were calculated by the following formulas (Mensah *et al*., 2005; Zhang *et al*., 2010):

$$\text{Damage ratio (\%)} = \frac{\text{Number of damaged tree}}{\text{Total number of investigated tree}} \times 100 \quad \ldots\ldots\ldots\ldots (1)$$

$$DI = \frac{\Sigma (V_i \times n)}{N \times V_a} \times 100\% \quad \ldots\ldots\ldots\ldots (2)$$

Where, DI means damage index, n is the number of damaged trees in the classification criterion as showed in Table I, N is the total number of investigated trees, V_i is the scale value, V_a is the maximal scale value, respectively.

Statistical analysis was performed using SPSS 16.0 (SPSS, Chicago, IL, USA). The damage ratios of gall-inducing insects on *C. hystrix* among different months were compared using one-way ANOVA followed by Tukey's test for multiple comparisons. Proportion data were arcsin transformed prior to analysis. A level of $P < 0.05$ significance was accepted in all statistical analyses.

Results

Two species of gall-inducing insects were found on *C. hystrix*, which belongs to Cecidomyiidae (Diptera). *Jaapiella* sp. only damaged the leaves where it formed the cone-shaped galls. Gall formation began soon after the eggs were laid. Oviposition site gradually became henna coloured and where it formed a circle of 5-8 mm diameter (Fig. 1A). At this place began to form a cone-shaped gall whose colour changed from green to crimson (Fig. 1B). Subsequently, epidermis of the cone-shaped gall slightly intumesced and the color became crimson (Fig. 1C). Finally, the cone-shaped gall formed that inner is a hollow space which is the nest of *Jaapiella* sp. (Fig. 1D). Each gall has one chamber and one larva, and the larval color was pink (Fig. 1E). The top of cone-shaped gall had a hole after the adults emerged (Fig. 1D), which could be the emergence hole.

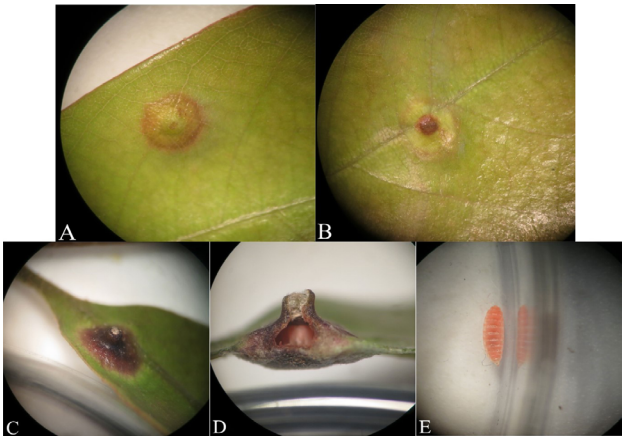

Fig. 1. Gall from 1st to 4th developmental stages (A-D) induced by the *Jaapiella* sp. on *C. hystrix* leaves and the morphological characteristic of the gall midge larvae (E).

Contarinia sp. mainly damaged the old stems, young shoots and leafstalks. Adults laid eggs on the old stems or bifurcations of branches (Fig. 2A, B). The oviposition site slowly expanded and formed a wholly enclosed gall (the same as the trunk tumor). There were some galls around the stem. Others only located at the oviposition site (Fig. 2C). A total of 5-10 galls allocated on the stem per meter (Fig. 2C). Each gall had 3-7 larvae, and each larva owned an ellipse chamber (Fig. 2D). Larval color was faint yellow (Fig. 2E).In one gall, each chamber was not communicated. Generally, larvae bited a gap as emergence hole when they were ready to pupate (Fig. 2F). On the young shoots, it would slowly die after attacked by *Contarinia* sp. (Fig. 2G, H). On the leafstalk, it would defoliate after attacked by *Contarinia* sp. Although, 1-3 galls were usually found on the leafstalk, only one gall located on the leafstalk was the most common.

During the period of investigation, the larvae and pupae were always found in galls. In March 2013, a few emergence holes appeared on galls tagged in December

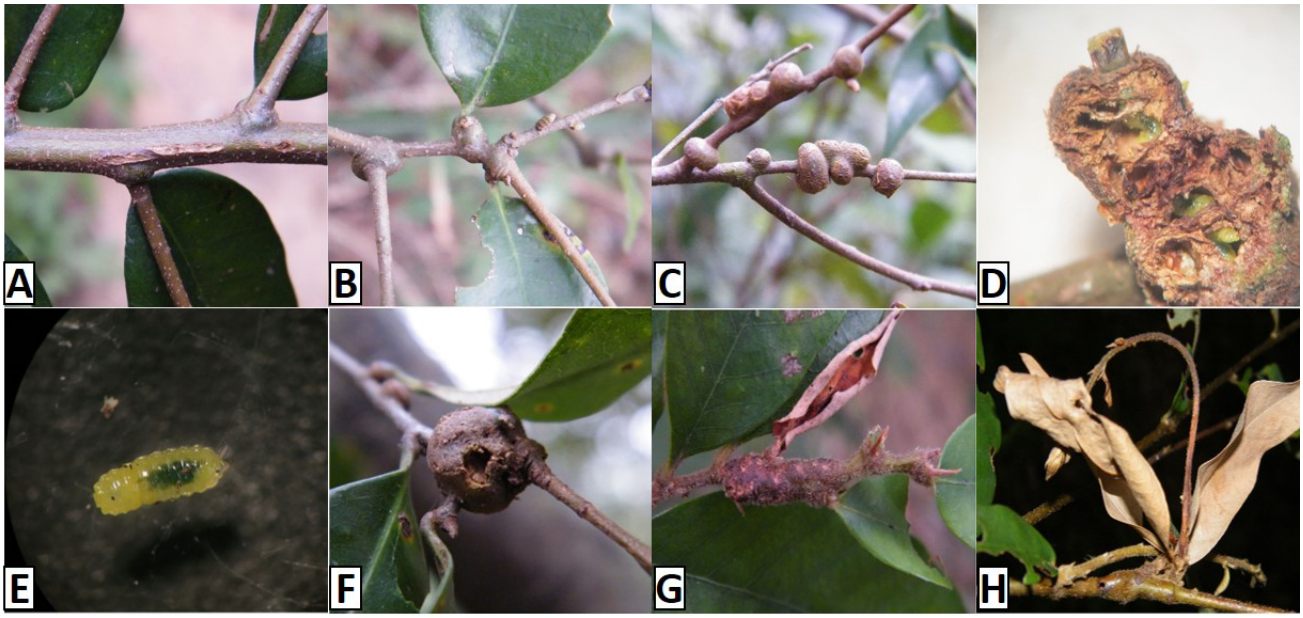

Fig. 2. Formation of galls induced by the *Contarinia* sp. on *C. hystrix* stem and leafstalk, and the morphological characteristics of gall midge larvae.

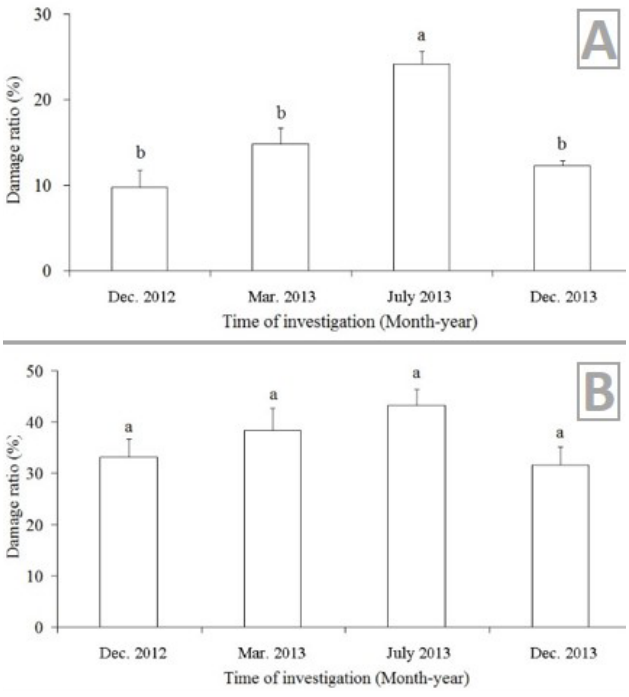

Fig. 3. Damage ratio of *Jaapiella* sp. (A) and *Contarinia* sp. (B) on *C. hystrix*. Error bars indicate SE. The same letter indicates no significant difference among different treatments (Tukey's test, $P < 0.05$).

2012. Up to July 2013, many emergence holes were found on galls marked in December 2012 and March 2013.

Damage of *Jaapiella* sp. significantly varied with the course of the season (F=15.668, df=3,11, $P < 0.01$) (Fig. 3A). The damage ratio was the lowest (9.7 ± 2.0%) in December, and the highest (24.1 ± 1.5%) in July. Although the variation in damage ratio of the *Contarinia* sp. had similar tendency with *Jaapiella* sp., seasonal differences were not significant ($F = 2.118$, df = 3,11, $P = 0.176$) (Fig. 3B). The damage index of *Jaapiella* sp. and *Contarinia* sp. were 25.6%, 31.3%, 35.6%, 26.2%, and 29.6%, 30.9%, 36.0%, 30.9% in December 2012, March, July and December 2013, respectively.

Discussion

Two species of gall-inducing insects, belonging to *Jaapiella* sp. and *Contarinia* sp. (Diptera) but their precise species identification needs further study. Both species had a multivoltine life cycle and overwintered as larval or pupal stage. However, biology and ecology of the two species are unclear. Caged experiment in the field should be made to study the biological characteristics and population dynamics of both species. Galls should be regularly dissected to establish the development of particular stages and number of generations.

The family of Cecidomyiidae has subfamilies of Lestremiinae, Porricondylinae and Cecidomyiinae. Species of the first two subfamilies are primitive and feed on fungi in decaying organic matter. The Cecidomyiinae (3,850 described species) represents about 80% of all known cecidomyiid species. Some of these are fungus

feeders, but most are plant feeders or predators (Stone and Schönrogge, 2003). Two genera of Cecidomyiinae were studied in this study. *Jaapiella* sp. only damaged leaves while *Contarinia* sp. damaged the perennial stems, young shoots and leafstalk. The external morphology and inner structure of the galls of both species are completely different. Of the hypotheses that have been advanced for the adaptive significance of gall induction (Cornell, 1983; Price *et al*., 1987), three are relevant to attempts to explain gall morphology: the nutrition hypothesis, microenvironment hypothesis and enemy hypothesis (Abrahamson and Weiss, 1997; Harris *et al*., 2003; Stone and Schönrogge, 2003). Gall provides nutrition to the larvae since its tissues are rich in soluble amino acids and sugars. In gall, it can enhance the protein synthesis by cells and transport of nutrients from the vascular system of the plant (Rohfritsch, 1992). We suppose that the galls induced by *Jaapiella* sp. and *Contarinia* sp. supported the nutrition hypothesis. Mechanism of gall forming should be further studied.

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Conflict of interest statement

The authors have declared that no competing interests exist.

References

Abrahamson, W.G. and Weiss, A.E., 1997. *Evolutionary ecology across three trophic levels: goldenrods, gall makers and natural enemies*. Princeton University Press, Princeton, USA, pp. 456.

Cornell, H.V., 1983. *Am. Midl. Nat.*, **110**: 225–234. https://doi.org/10.2307/2425263

Gan, J.W. and Liu, D.F., 2014. *For. Guangxi*, **2**: 21.

Harris, M.O., Stuart, J.J., Mohan, M., Nair, S., Lamb, R.J. and Rohfritsch, O., 2003. *Ann. Rev. Ent.*, **48**: 549–577. https://doi.org/10.1146/annurev.ento.48.091801.112559

Kayini, A. and Pandey, R.R., 2010. *J. Am. Sci.*, **6**: 118–124.

Mensah, C., Difonzo, C., Nelson, R.L. and Wang, D., 2005. *Crop Sci.*, **45**: 2228–2233. https://doi.org/10.2135/cropsci2004.0680

Price, P.W., Fernandes, G.W. and Waring, G.L., 1987. *Environ. Ent.*, **16**: 15–24. https://doi.org/10.1093/ee/16.1.15

Raman, A., 2012. *J. Pl. Interact.*, **7**: 29–44. https://doi.org/10.1080/17429145.2011.630847

Raman, A., Schaefer, C.W. and Withers, T.M., 2005. *Biology, ecology and evolution of gall-inducing arthropods*. Science Publisher Ltd., Hampshire, UK, pp. 817.

Rohfritsch, O., 1992. Patterns in gall development. In: *Biology of insect-induced galls* (eds. J. Shorthouse and O. Rohfritsch). Oxford University Press, New York, UK, pp. 60–86.

Stone, G.N. and Schönrogge, K., 2003. *Trends Ecol. Evol.*, **18**: 512–522. https://doi.org/10.1016/S0169-5347(03)00247-7

Xu, B., Zhang, F.Q., Pan, W. and Liu, Y.C., 2013. *Sci. Silv. Sin.*, **49**: 162–166.

Zhang, G.R., Gu, C.H. and Wang, D.C., 2010. *Theor. appl. Genet.*, **120**: 1183–1191. https://doi.org/10.1007/s00122-009-1245-5