Research note

Status of Forest Trees Infested with *Endoclita sinensis* (Lepidoptera: Hepialidae)

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【Summary】

A field study on the status of forest trees infested with *Endoclita sinensis* (Lepidoptera: Hepialidae) was conducted in a natural forest around Renyi Lake in Chiayi County, southwestern Taiwan. Host plants of *E. sinensis* included *Macaranga tanarius* and *Mallotus paniculatus* in the family Euphorbiaceae, as these plants showed the highest infestation rates. *Endoclita sinensis* larvae bored into the trunks of 6~24 cm diameter and 10~200 cm high and fed on callus tissue around the hole, which was covered with silk, debris, and feces. Normally, only 1 larva was found per tree; however, when the trunk diameter was larger than 10 cm, more than 2 well-separated larvae could be found. In the forest, larvae dispersed in a cluster or in a clumped pattern. Female larvae were significantly larger than male larvae in body length and weight, head capsule width, and pupal length and weight. Field-collected *E. sinensis* larvae exhibited a male to female ratio of 1: 1.2 after being fed an artificial diet.

Key words: *Endoclita sinensis*, Hepialidae, forest tree.

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研究簡報

中華蝠蛾為害林木現況

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摘 要

本研究調查嘉義縣仁義潭天然林中華蝠蛾[*Endoclita sinensis* (Moore)] (鱗翅目：蝙蝠蛾科)幼蟲對林木之危害現況。中華蝠蛾之寄主植物主要為大戟科之血桐(*Macaranga tanarius*)和白匏子(*Mallotus paniculatu*)。中華蝠蛾幼蟲主要入侵直徑6~24 cm之樹幹並在樹幹高度10~200 cm之部位鑽孔蛀食。幼蟲會取食孔口周圍之癒傷組織，並以絲、碎屑及排泄物封閉蛀食孔口。通常一棵樹中只有一隻中華蝠蛾幼蟲，若樹幹直徑大於10 cm以上，則會有兩隻分離之幼蟲存在。在森林中幼蟲為群狀分佈。中華蝠蛾雌蟲的終齡幼蟲之體長、體重、蛹長及蛹重均顯著大於雄蟲者，田間採集之中華蝠蛾幼蟲以人工飼料飼養後，其成蟲之雌雄比率為1：1.2。

關鍵詞：中華蝠蛾、蝙蝠蛾科、林木。

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INTRODUCTION

The Hepialidae is one of the more-primitive families in the Lepidoptera. Its habitat is similar to those of the Lymantriidae, Notodontidae, and Noctuidae, but it can be distinguished from other species based on its short and underdeveloped antennae (Johnson and Triplehorn 2005). Grehan (1989) pointed out that the bore hole of Hepialidae larvae is closely associated with predators; larvae of some species feed on plant roots or stems while other species feed on plant callus tissue at the opening of the hole. Hepialidae larvae do not feed on leaves of trees or shrubs, which differs from other families of the Lepidoptera in terms of feeding behavior on angiosperms. Although it is certain that angiosperms are the hosts of many species of Hepialidae larvae, host records for many species are only briefly described, incomplete, or completely lacking (Wagner 1988).

In previous studies, species that have more-detailed records of larval development and infestation in the family Hepialidae were mostly those species that feed on plant roots or underground stems of herbs. The biology of species that feed on other plant tissues is poorly known.

Endoclita sinensis, of the Hepialidae, Lepidoptera, has been recorded in China, Hong Kong, Japan, Korea, and Taiwan (Ades and Kendrick 2004). Its adult is easily identified by a white spot in the cell of the adult forewing. Although Moore (1877) studied the morphological characteristics of *E. sinensis*, its life history and host plants still remain unknown. The aims of this study were to study the biology and investigate the host range of *E. sinensis* in a forest of southwestern Taiwan.

MATERIALS AND METHODS

Biology

Fifty larvae of *E. sinensis* were collected in a natural forest habitat at Renyi Lake, Fan-

lu Township, Chiayi County in March 2010. Larvae were dug out from the trunks of damaged trees and brought back to the laboratory for identification and rearing. All ultimate instar larvae were numerated and photographed; the body length, width of the head capsule, and body weight were measured individually. After the morphological characters were recorded, larvae were kept in a round glass jar (9 cm in diameter and 15 cm high) and provided an artificial diet (a mixture of 50 g wood powder of *Macaranga tanarius*, 15 g yeast power, 1.5 g vitamin C, 0.15 g L-histidine monohydrochloride monohydrate, 9.4 g agar, and 300 ml distilled water). Development of larvae was observed daily. After pupation, the length and weight of each pupa were measured before being moved to an artificial chamber for emergence. Females and males were identified and counted according to the characters of the pupa and adult.

Investigation of host plants and infestation rates

Host plants of *E. sinensis* were investigated by a line transect sampling technique at the Renyi Lake Reservoir. All infested trees were examined, and the scientific name of each infested tree was keyed to investigate the host range. Infestation symptoms and the behavior of tunneling were also described at the same time.

A sampling site of 50 x 50 m near Renyi Lake Reservoir was established to investigate the infestation rate of *E. sinensis*. In total, 206 plants were examined, infested plants were marked, and the taxon of each infested tree was identified. Arc Gis 9 was employed to study the spatial distribution of larvae in the forest.

Statistical analysis

Data were analyzed by Statistical Products and Services Solutions (SPSS, San Francisco, CA, USA) software. Analysis of variance (ANOVA) was employed, and then the *t* value was used to compare differences between treatments with significance at the $p < 0.05$ level.

RESULTS AND DISCUSSION

Biology

Endoclita sinensis larvae fed mainly on plant callus tissue at the opening of the bore hole (Fig. 1a). A larva began tunneling from the trunk surface into the center and formed a longitudinal duct; the tunnel angle was slightly tilted upward, and then moved along the wood grain with a 30~50-cm duct (Fig. 1b). Notably, *E. sinensis* larvae showed territorial behavior; if the tunnels of 2 larvae were too close to each other, they tended to attack each other.

After feeding field-collected *E. sinensis* larvae an artificial diet for 30 d, the body lengthes of the last instar larvae of females and males were 86.5±11.5 and 64.0±12.8 mm, respectively; the body weights of the last instar larvae of females and males were 6.5±2.0 and 2.8±1.3 g, respectively; and widths of the head capsule of the last instar larvae of females and males were 8.7±1.0 and 6.9±0.9 mm, respectively. Body lengths of pupae of females and males were 58.0±6.9 and 50.0±8.1 mm, respectively; body weights of pupae of females and males were 4.8±1.4 and 2.3±0.9 g, respectively. Significant differences were found between females and males in larval body length and body weight. The same trend was also observed for pupae. The sex ratio of males to females was 1: 1.2 (Table 1).

Grehan (1988) pointed out that the larvae of some species of the Hepialidae feed on plant roots or stems and gnaw on host tissues for food when they make the tunnel.

Another type of food may be the plant callus tissue around the opening of the bore hole. In our study, larvae of *E. sinensis* were found to feed on the callus instead of other parts of the

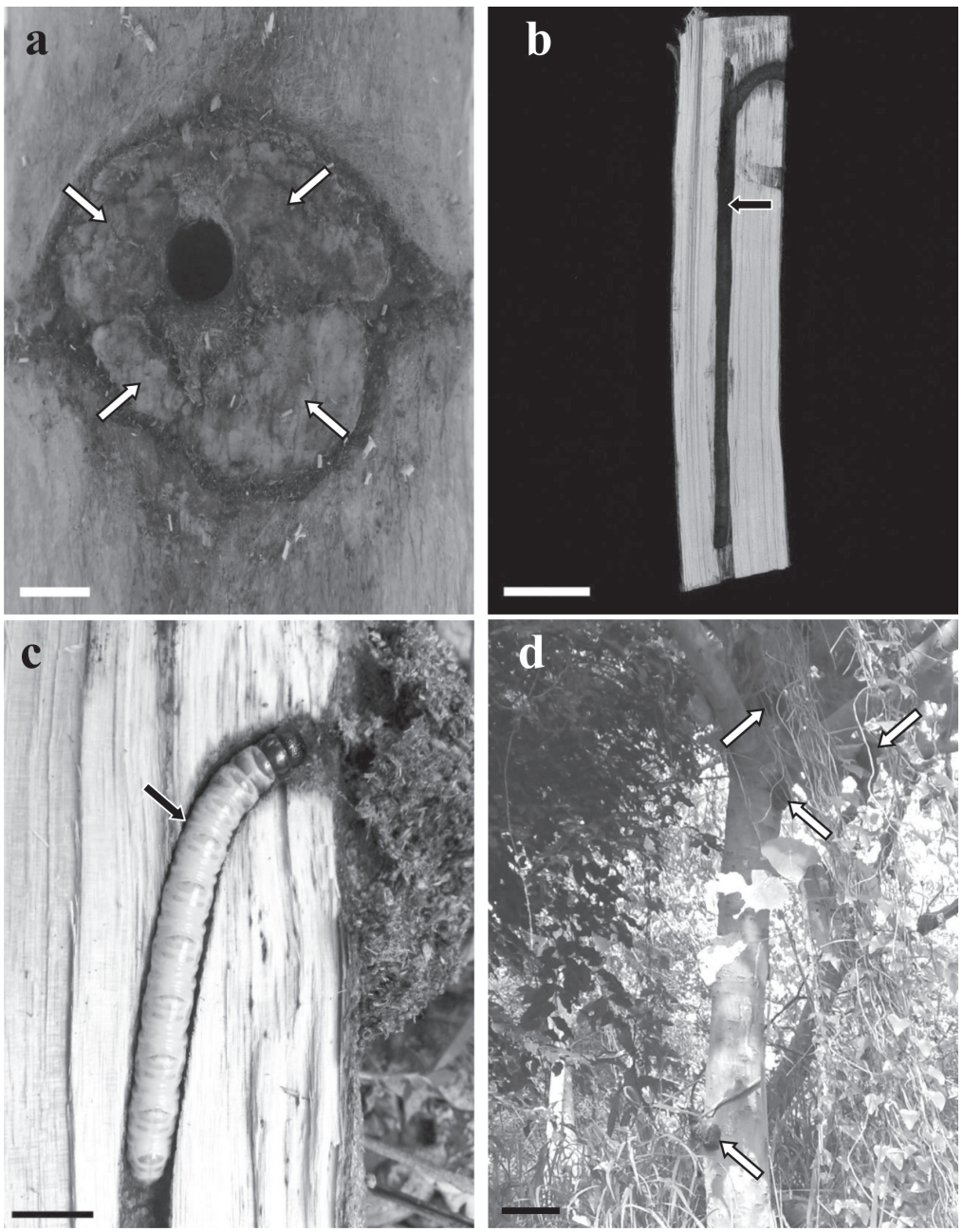

Fig. 1. Infestation by *Endoclita sinensis*. a, Calli (arrows) of a host plant around the tunnel of an *E. sinensis* larva (bar = 1 cm); b, tunnel (arrow) inside a host tree damaged by an *E. sinensis* larva (bar = 5 cm); c, *E. sinensis* larva (arrow) and the cover of a bore hole (bar = 2 cm); d, infestation sites (arrows) on a host tree trunk (bar = 20 cm).

Table 1. Body length, body weight, head capsule width, pupa length, and pupa weight of mature male and female ultimate instar larvae of *Endoclita sinensis*

Sex	N	Larva			Pupa	
		Length (mm)	Weight (g)	Head capsule width (mm)	Length (mm)	Weight (g)
Female	23	86.5±11.5[a]	6.5±2.0[a]	8.7±1.0[a]	58.0±6.9[a]	4.8±1.4[a]
Male	27	64.0±12.8[b]	2.8±1.3[b]	6.9±0.9[b]	50.0±8.1[b]	2.3±0.9[b]

N, The number of observed larvae.
Means in the same column with different letters significantly differ at the 5% significance level.

plant. The impacts of this feeding behavior on the tree require further study.

The males and females of most Lepidoptera insects can be distinguished by adult external morphological characters, or by external genital characters of pupae, but not at the larval stage (Zou et al. 2006). However, our data clearly showed that females and males of *E. sinensis* can easily be distinguished at the last larval stage by body length, body weight, head capsule width, pupa length, and pupa weight. These data could benefit its control in the future, as male and female larvae can be distinguished at an early developmental stage.

Host plants and infestation rate

The study of host plants of *E. sinensis* in the area of Renyi Lake showed that among the plants examined, 2 species of Euphorbiaceae, i.e. *Macaranga tanarius* and *Mallotus paniculatus*, were infested by *E. sinensis* (Table 2). The infestation rates in 206 plants in 6 families were examined. Among them, *Mac. tanarius* was the dominant species (n = 76), followed by *Machilus zuihoensis* (n = 42). Only *Mac. tanarius* and *Mal. paniculatus* were infested by *E. sinensis*, with infestation rates of 38 and 10%, respectively.

In the forest, a larva normally formed a single opening of the bored hole near the center part of the tree trunk, which was usually covered with web-like materials composed of silk, debris, and fecal pellets (Fig. 1c). Bore holes were found at 10~200 cm in height

Table 2. Survey of trees attacked by *Endoclita sinensis* in a natural forest at Renyi Lake, Chiayi County

Family	Scientific name	No. of trees examined	No. of tree damaged	Infestation rate (%)
Euphorbiaceae	*Macaranga tanarius*	76	29	38
Euphorbiaceae	*Mallotus paniculatus*	10	1	10
Lauraceae	*Machilus zuihoensis*	42	0	0
Lauraceae	*Glochidion philippicum*	22	0	0
Lauraceae	*Cinnamomum camphora*	8	0	0
Lauraceae	*Litsea kostermansii*	26	0	0
Meliaceae	*Melia azedarach*	3	0	0
Mimosaceae	*Acacia confuse*	7	0	0
Moraceae	*Broussonetia papyrifera*	6	0	0
Sapindaceae	*Dimocarpus longan*	6	0	0
Total		206	30	14.6

from the tree base, with trunk diameters of 6~24 cm (Fig. 1d). Generally, a tree had only 1 larva inside; however, when the trunk diameter was > 10 cm, 2 or more larvae may have been present in the trunk. The 2 bore holes and tunnels of larva were separated from each other and did not join together.

At the sampling sites, the 2 species of host plants were uniformly distributed. Infested plants were in 4 locations and showed a clumped dispersion pattern (Fig. 2).

In an early study by Speight and Wainhouse (1989), it was found that larvae of forest pests belonging to the Cossidae and He-

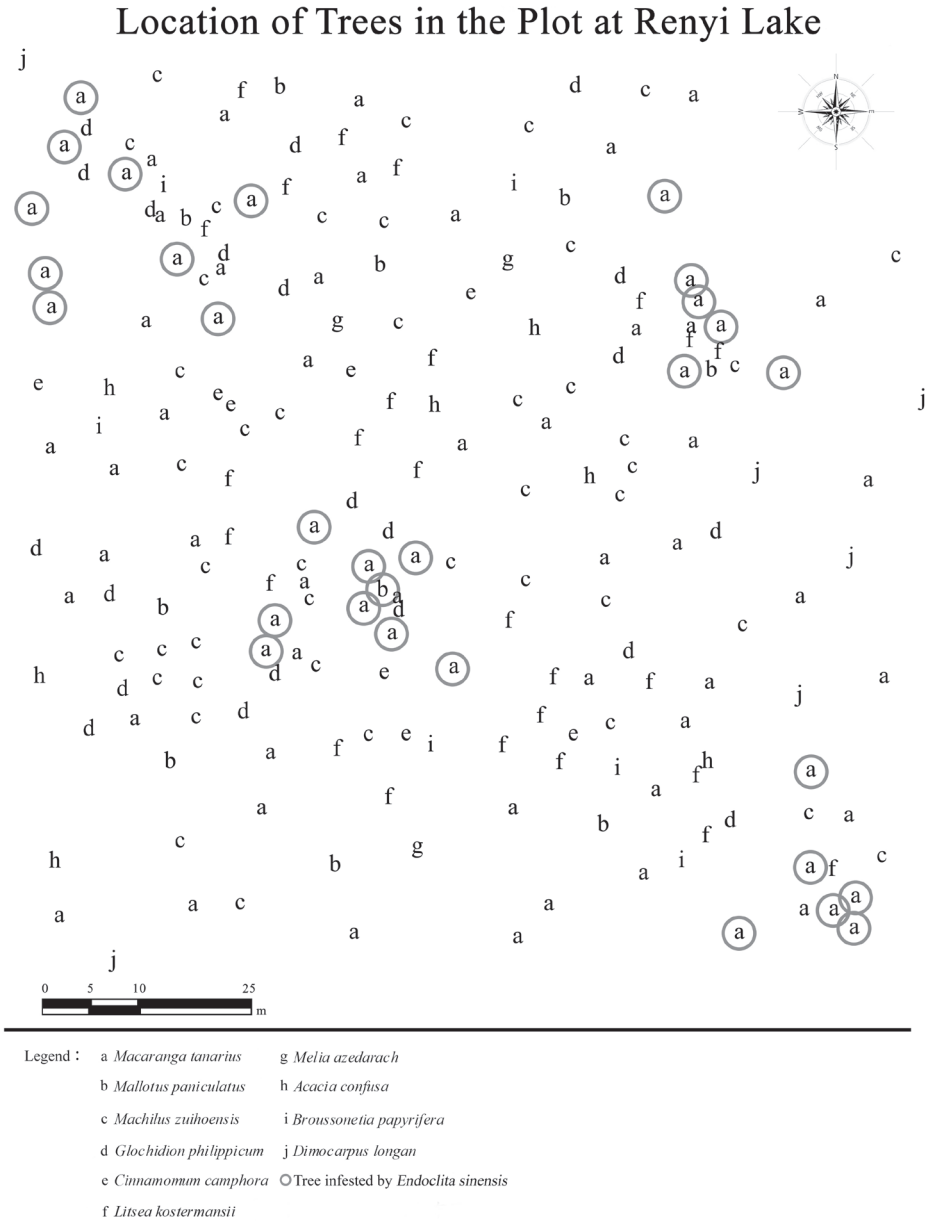

Fig. 2. Distribution of infested trees by *Endoclita sinensis* at Renyi Lake.

pialidae live and grow up in trunks. Our data with *E. sinensis* agree with their findings. According to our field study, the 206 trees were uniformly distributed in a natural forest, belonging to the families Euphorbiaceae, Lauraceae, Meliaceae, Mimosaceae, Moraceae, and Sapindaceae (Table 2). However, *E. sinensis* larvae only infested *Mac. tanarius* and *Mal. paniculatus* of the Euphorbiaceae. These data suggest that *E. sinensis* has a preference for species of the Euphorbiaceae. This preference might be related to the female adult oviposition behavior. Tindale (1932) also reported that females of the Australian ghost moth do not lay eggs in a specific location but scatter-broadcast them while in flight. The results from this study may facilitate the control of *E. sinensis* in the future.

CONCLUSIONS

Our study showed that *E. sinensis* was present in a natural forest around Renyi Lake in Chiayi County, southwestern Taiwan. The major host plants of *E. sinensis* included *Mac. tanarius* and *Mal. paniculatus* in the family Euphorbiaceae, with infestation rates of 38 and 10%, respectively. Usually, *E. sinensis* larvae infested trees of 6~24 cm diameter, bored into the trunks at 10~200 cm in height, and fed on host calli around the hole. *Endoclita sinensis* larvae covered the hole with silk, debris, and feces. For small-diameter host trees, only 1 larva was found per tree. However, 2 or more larvae could be found when the host tree diameter was > 10 cm. *Endoclita sinensis* larvae dispersed in a cluster pattern in the natural forest. The results indicated that female larvae were significantly larger than male larvae in body length and weight, head capsule width, and pupal length and weight. Artificially reared *E. sinensis* larvae exhibited a male to female ratio of 1: 1.2.

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