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Short Communication

An Efficient Method for the Collection of Coffee Berry Borer [*Hypothenemus hampei* (Ferrari)] Adults

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Abstract

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The coffee berry borer (CBB) [*Hypothenemus hampei* (Ferrari)] is one of the most serious coffee pests worldwide. Existing methods to collect CBB adults from infested coffee berries are extremely labor intensive and time consuming. In order to develop an productive technique to collect CBBs, a commercial insect breeder was selected as a prototype of the collection device to evaluate the effectiveness of the additional bridge, the bridge texture, and light source of the device. The results showed that the device had the optimal collection efficiency when a strip of paper was added as a bridge to connect the berries in the bottom container to the top collection cup, and when the funnel and the bottom container were covered with aluminum foil to make the light source come only from the top, while the textures of the paper bridge had mininal effect on collection efficiency. This modified collection device provides a better way to collect CBB adults for further research or applications.

Key words: Coffee berry borer, *Hypothenemus hampei*, Collection method.

INTRODUCTION

The coffee berry borer (CBB), *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae: Scolytinae), is one of the most serious pests in coffee plantations worldwide (Damon 2000; Jaramillo *et al*. 2006; Vega *et al*. 2009; Pérez *et al*. 2015). The CBB causes large economic losses on coffee plantations, which was estimated over US$500 million dollars annually around the world (Vega *et al*. 2002). Adult females bore a hole into the endosperm of the coffee seed and deposit their eggs inside the berry, and the larvae feed on the coffee seed until the resource is depleted. The CBB was first discovered in Taiwan in 2007 (Lin *et al*. 2010), and its population had spread exponentially afterwards throughout coffee growing areas in western parts of Taiwan nowadays, inculding Townships of Gukeng, Dongshan, Alishan, Yuchi, Shuili, Meishan and Zhongpu, causing serious damage (unpublishied data).

Field collection is one of the important steps for starting research on agricultural pests. Different types of collection devices were developed to collect specific pests based on the life cycles, behaviors, and habits of the insects (Cloyd *et al*. 2001; Doğramaci *et al*. 2011; Thomas 2012). One of the previously reported methods to collect CBBs from the field was tearing apart the infested coffee berries and picking up each CBB by featherweight forceps

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(Brun *et al*. 1989, 1993). However, this method was labor intensive and time consuming, due to the tiny body size (*ca*. 1.4–1.7 mm in length) of the CBB (Mitchell & Maddox 2010), and tearing the berries often harmed the CBBs and decreased the survival rate of individuals for further study. The other method to collect CBB from infested berries was using a series of sieves with different mesh sizes to separate CBBs from berry fragments and CBB feces when the females were leaving the berries, and then picking them up by forceps. This method was hardly feasible due to the unpredictability regarding timing of leaving of berries for the female. It is equally time consuming to collect the adults by forceps. Concerning the disadvantages of these methods, this study attempted to develop a more convenient method to facilitate CBB collection from infested berries.

MATERIALS AND METHODS

Source of insects

The CBB-infested dry coffee berries retained on the trees were collected in non-insecticide usage coffee orchards in Townships of Meishan and Zhongpu, Chiayi County. The CBBs outside the berries were removed by sieving with baskets (38.5 cm × 31.0 cm × 10.0 cm, I400, Chen Jung Plastic Co., Ltd., Tainan, Taiwan).

The design of the collection device

The Mini Insect Breeder (BD7001, Mega-View Science Co., Ltd., Taichang, Taiwan), which consisted of a bottom container, a funnel, and a top collection cup (Fig. 1A), was used as the prototype of the collection device. Three experiments were conducted to evaluate the effects of the additional bridge, bridge textures, and the light source on collecting CBB adults. For each experiment, 500 infested coffee berries were placed in the bottom container and the collecting period started from 10:00 a.m. to 4:00 p.m. At the end of the collection, CBB adults in the top collection cups (Fig. 1B) were immersed in 75% alcohol and the numbers of CBBs were counted.

In the first experiment, a strip of qualitative filter paper (No. 1, 185 mm, Advantec, Toyo Roshi Kaisha, Ltd., Tokyo, Japan; cut into 1 cm × 17 cm) was put inside the device to connect the bottom container and the top collection cup (Fig. 1A), and an identical device without the paper bridge was used as the control. There were four replicates for this experiment.

In the second experiment, qualitative filter paper, bristol board (200 pound, white wood free paper, Xin Guan Stationery Co., Ltd., Changhua, Taiwan) and copy paper (800 gsm, double A, Advance Paper Co., Ltd., Caloocan, Philippines) were used as the paper bridge of the device to evaluate the effect of its texture on collecting CBB adults. There were three replicates in this experiment.

To evaluate the effect of light on collection efficiency, in the third experiment, the bottom container and the funnel of the device were covered with aluminum foil, and a strip of qualitative filter paper was used as the bridge (Fig. 1D). An identical device without the aluminum foil was used as the control. There were four replicates for this experiment.

Statistical analysis

All analyses were performed with SAS Enterprise Guide 7.1 (SAS Institute Inc., Cary, NC, USA). Student's *t*-test was used to examine differences between the means of the number of CBBs collected by the device with or without a paper strip and aluminum foil. The effects of paper bridge textures were examined through an analysis of variance (ANOVA) followed by Fisher's least significant difference (LSD) test. Statistical significance was set at $P < 0.05$.

RESULTS AND DISCUSSION

Effect of the bridge on collecting CBB adults

The results showed that the addition of the bridge in the device had significant advance-

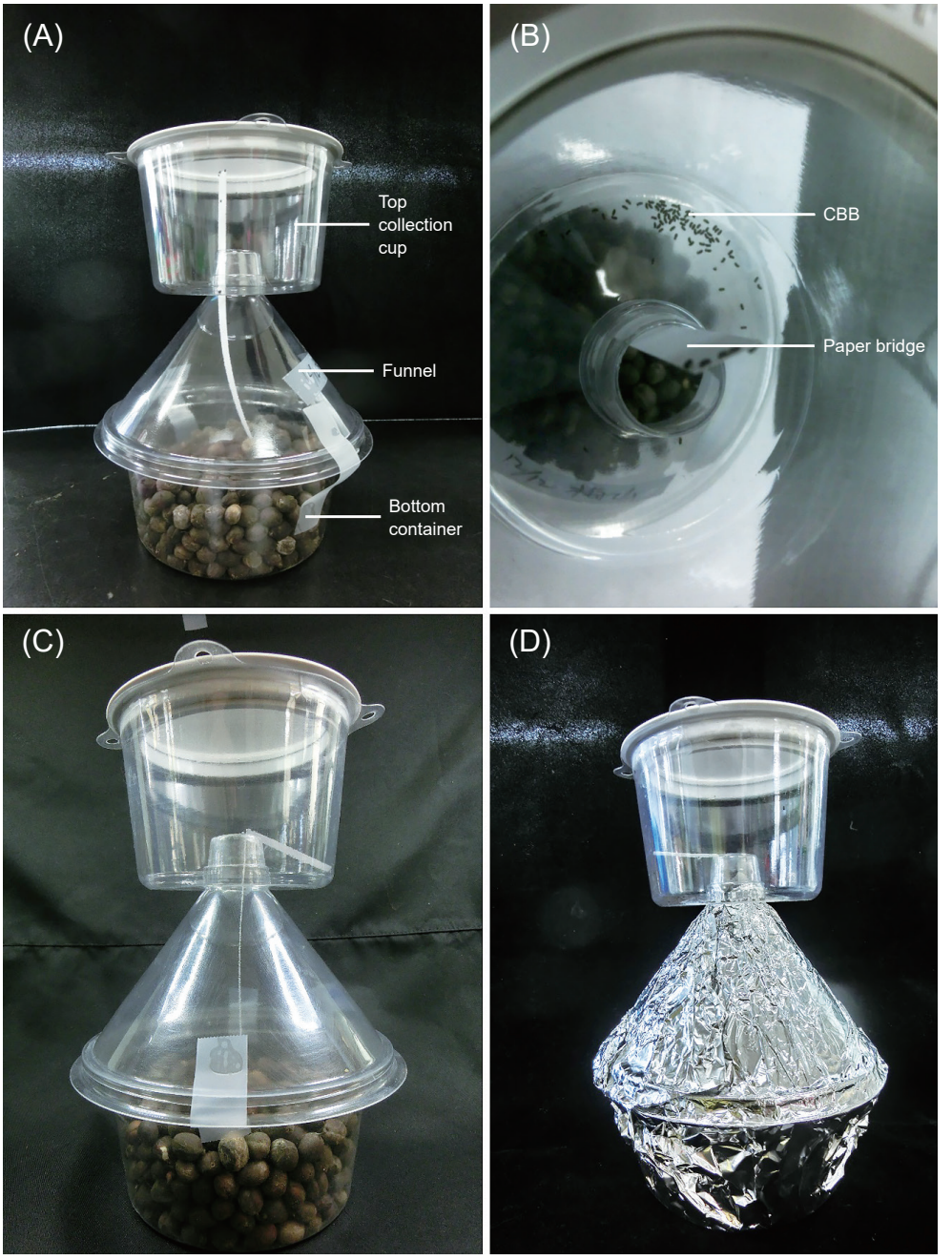

Fig. 1. The rapid collection device consisted of a Mini Insect Breeder with a paper strip as a bridge (A); coffee berry borers (CBB) climbed the paper strip to the top collection cup (B); bending the paper strip into "L" shape could avoid it from slipping down (C); and covering the funnel and the bottom container with aluminum foil could increase the collection efficiency (D).

ments in CBB collection efficiency. The device without a bridge only collected 14.0 ± 2.2 CBB adults on average, while the device with a filter paper bridge inside collected 114.0 ± 12.6 CBB adults (Student's *t*-test, $P = 0.0035$) [Table 1(a)].

Table 1. Means (± SE) of coffee berry borer adults collected from the device with or without a bridge (a), with different paper bridges (b), and covered with or without aluminum foil (c).

Treatment	Number
(a) No bridge	14.0 ± 2.2 a[z]
Bridge	114.0 ± 12.6 b
(b) Bristol board	103.0 ± 12.6 a[y]
Copy paper	118.0 ± 22.5 a
Filter paper	106.0 ± 12.5 a
(c) No aluminum foil	101.3 ± 27.8 a[z]
Aluminum foil	229.0 ± 12.6 b

[z] Means followed by the same letter(s) are not significantly different at 5% level by Student's *t*-test.
[y] Means followed by the same letter(s) are not significantly different at 5% level by Fisher's least significant difference (LSD) test.

Effect of bridge textures on collecting CBB adults

From the observation of the collecting process in the first experiment, we found that most CBB adults reached the top collection cup by climbing the paper bridge, while only a few of them reached directly by flying (Fig. 1B). Considering the texture of the paper bridge might affect its climbing ability, we further used two other cheaper and easily available kinds of paper to evaluate if the texture of the bridge could affect the collection efficiency. In this experiment, the device collected 103.0 ± 12.6, 118.0 ± 22.5, and 106.0 ± 12.5 CBB adults by using bristol board, copy paper and filter paper as the bridge, respectively. The number of collected CBB adults were not significantly different (LSD, $P = 0.8014$) [Table 1(b)], indicating that the textures of the bridges used in this study might have less effect on the collection efficiency.

A disadvantage of this device is the paper bridges used in this study could easily be softened by the moisture from coffee berries and then slipped down during the collection process. To overcome this problem, the paper strip should be bent into "L" shape and hung on the funnel (Fig. 1C).

Effect of light on collecting CBB adults

During the first two experiments, we observed that CBB adults were slightly attracted to light, and they wandered on the transparent funnel instead of moving directly towards the top collection cup. Therefore, in the third experiment, the funnel and the bottom container of the device were covered with aluminum foil to concentrate the light source only on the passage towards the top collection cup. The results showed that the device covered with aluminum foil collected significantly more CBBs than the one without covered. The device without aluminum foil collected 101.3 ± 27.8 CBB adults on average, while the one covered with aluminum foil collected 229.0 ± 12.6 CBB adults (Student's *t*-test, $P = 0.0058$) [Table 1(c)]. The results supported the theory that the CBB is attracted to light. The use of opaque materials as bottom parts can serve as effective tool to maximize the collection efficiency.

In all experiments, the collected CBB adults were all female. A previous report suggested that the female to male ratio of CBB was 13 to 1 in Taiwan (Chu *et al*. 2017). Besides, female CBB adults leave originally infested coffee berries and attack new berries, while the males have degenerate wing and stay in the berries (Damon 2000). Therefore, it is reasonable that the device collected only the females. However, sometimes we found that very few male adults come out to the surface of infested coffee berries, which suggested that this collection device could possibly collect both female and male adults.

The experiments also revealed that 500 infested coffee berries could produce over 100 CBB adults within 6 h (Table 1), which indicated that leaving these infested berries in orchards could provide the source of re-infesting CBBs in the field. Therefore, these data suggested that eliminating infested dry berries could reduce the CBB population in the field (Aristizábal *et al*. 2011), and leaving fewer than 5 dry berries on each tree was recommded

to be an effectively cultural control method for the integrated pest management program for CBB in Colombia (Aristizábal *et al*. 2012, 2016).

CONCLUSIONS

Based on the CBB's tendency to crawl up and towards light, a commercial insect breeder was modified by adding a paper bridge to connect the berries in the bottom container to the top collection cup, and covering the funnel and the bottom container with aluminum foil to focus the light source from the top. In contrast to existing picking and sieving methods, this novel collection device can easily separate CBB adults from infested coffee berries without time consuming or labor intensive processes, and has been proved to efficiently collect enough number of CBB adults from infested coffee berries. We suggest that this device could be applied in collecting CBB adults for mass rearing, pesticide efficacy trials, and other experiments which require a large number of CBB adults.

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REFERENCES

Aristizábal, L. F., M. Jiménez, A. E. Bustillo, and S. P. Arthurs. 2011. Monitoring cultural practices for coffee berry borer *Hypothenemus hampei* (Coleoptera: Curculionidae: Scolytinae) management in a small coffee farm in Colombia. Fla. Entomol. 94:685–687.

Aristizábal, L. F., O. Lara, and S. P. Arthurs. 2012. Implementing an integrated pest management program for coffee berry borer in a specialty coffee plantation in Colombia. J. Integ. Pest Mngmt. 3:G1–G5. doi:10.1603/IPM11006

Aristizábal, L. F., A. E. Bustillo, and S. P. Arthurs. 2016. Integrated pest management of coffee berry borer: Strategies from Latin America that could be useful for coffee farmers in Hawaii. Insects 7:6. doi:10.3390/insects7010006.

Brun, L. O., C. Marcillaud, V. Gaudichon, and D. M. Suckling. 1989. Endosulfan resistance in *Hypothenemus hampei* (Coleoptera: Scolytidae) in New Caledonia. J. Econ. Entomol. 82:1311–1316.

Brun, L. O., V. Gaudichon, and P. J. Wigley. 1993. An artificial diet for continuous rearing of the coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae). Intl. J. Trop. Insect Sci. 14:585–587.

Chu, Y. F., M. H. Yang, S. F. Chang, P. H. Chen, and T. C. Wang. 2017. The composition of life satges of coffee berry borer (Scolytidae: *Hypothenemus hampei*) in the coffee berry and the control efficacy of different insecticides for the pest. J. Taiwan Agric. Res. 66:318–325. (in Chinese with English abstract)

Cloyd, R. A., D. F. Warnock, and K. Holmes. 2001. Technique for collecting thrips for use in insecticide efficacy trials. HortScience 36:925–926.

Damon, A. 2000. A review of the biology and control of the coffee berry borer, *Hypothenemus hampei* (Coleoptera: Scolytidae). Bull. Entomol. Res. 90:453–465.

Doğramaci, M., J. Chen, S. P. Arthurs, C. L. McKenzie, F. Irizarry, K. Houben, M. Brenan, and L. Osborne. 2011. Mini-aspirator: A new device for collection and transfer of small arthropods to plants. Fla. Entomol. 94:22–27.

Jaramillo, J., C. Borgemeister, and P. Baker. 2006. Coffee berry borer *Hypothenemus hampei* (Coleoptera: Curculionidae): Searching for sustainable control strategies. Bull. Entomol. Res. 96:223–233.

Lin, M. Y., Y. F. Wu, and S. K. Chen. 2010. Monitoring survey of coffee berry borer, *Hypothenemus hampei* and its control. Bull. Tainan Dist. Agric. Res. Ext. Sta. 56:35–44. (in Chinese with English abstract)

Mitchell, A. and C. Maddox. 2010. Bark beetles (Coleoptera: Curculionidae: Scolytinae) of importance to the Australian macadamia industry: An integrative taxonomic approach to species diagnostics. Aust. J. Entomol. 49:104–113.

Pérez, J., F. Infante, and F. E. Vega. 2015. A coffee berry borer (Coleoptera: Curculionidae: Scolytinae) bibliography. J. Insect Sci. 15:83. doi:10.1093/jisesa/iev053

Thomas, D. B. 2012. Comparison of insect vacuums for sampling Asian citrus psyllid (Homoptera: Psyllidae) on citrus trees. Southwest. Entomol. 37:55–60.

Vega, F. E., R. A. Franqui, and P. Benavides. 2002. The presence of the coffee berry borer, *Hypothenemus hampei*, in Puerto Rico: Fact or fiction? J. Insect Sci. 2:13. doi:10.1093/jis/2.1.13

Vega, F. E., F. Infante, A. Castillo, and J. Jaramillo. 2009. The coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae): A short review, with recent findings and future research directions. Terr. Arthropod Rev. 2:129–147.

一個有效率地收集咖啡果小蠹成蟲 [*Hypothenemus hampei* (Ferrari)] 的方法

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摘要

王泰權、程子軒、梁鈺平。2019。一個有效率地收集咖啡果小蠹成蟲 [*Hypothenemus hampei* (Ferrari)] 的方法。台灣農業研究 68(3):254–260。

咖啡果小蠹 [*Hypothenemus hampei* (Ferrari)] 為咖啡生產過程中危害最嚴重的全球性害蟲之一。以往自受害咖啡果實中收集咖啡果小蠹成蟲之方法非常耗費人力與時間，因此為了開發有效率地大量收集方式，本研究利用市售的小型昆蟲羽化裝置為收集裝置的原型，測試此裝置有無紙條橋接、橋接材質及光源對於咖啡果小蠹成蟲的收集效果。試驗結果顯示，最有效率的收集方式，為於裝置中放置一紙條使其連結上方的收集盒與下方放置受害咖啡果實的底盒，並利用鋁箔紙包覆底盒及連接兩端的漏斗裝置，使光源集中來自上方；而以不同材質之紙條 (濾紙、西卡紙與影印紙) 作為橋接紙張的收集效果，則無顯著差異。綜合上述試驗，本研究所描述的收集裝置及方法，可有效率地自受害咖啡果實中收集大量咖啡果小蠹成蟲，未來可應用於需要大量咖啡果小蠹成蟲活體之研究。

關鍵詞：咖啡果小蠹、*Hypothenemus hampei*、收集方法。

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